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Contents

Infrared spectroscopy of milk

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Abstract

Introduction. Most dairy producers are seeking modern instrumental methods of milk component testing to provide milk quality and production efficiency improvement.

Objectives. The main objective of this investigation is to study the characteristic infrared spectral properties of milk and its components and provide comparative analysis of methods of Infrared Spectroscopy.

Materials and methods. Methods of Infrared Spectrophotometry and Near-Infrared Reflectance Spectroscopy (NIRS) were used for a quantitative assessment of principal components of milk. A model of Infrared Spectrophotometer that can be used for determination of milk composition is proposed.

Results and discussion. A serious limitation of the Infrared Spectrophotometry is that a milk sample should be diluted to obtain the linear dependence of optical density on the concentration of milk sample which must be evaluated.

NIRS method provides the analysis of milk samples which contain a high proportion of water and demonstrate high level of opacity. 50 samples of milk were used to study the correlation dependence between results of chemical and NIR analysis of milk components (fat, protein, non-fat solids, and total solids). It was shown that the highest level of correlation was indicated between the content of fat and total solids that was determined by NIR method.

Conclusions. The method of Infrared Spectrophotometry requires diluting samples and can be used in laboratory conditions. Method of Near-Infrared Reflectance Spectroscopy provides fast and non-destructive testing of milk composition with high accuracy and can be used in dairy industry to estimate the composition of the milk on the conveyor, in a stream.

Introduction

Milk is a complex mixture of fat, protein, lactose, vitamins, salts and other compounds which can exist in colloidal dispersion or in an aqueous solution of milk components. Approximate composition of milk of European breeds includes 87.00% water, 3.80% non-fat solids, 3.40% protein, 4.50% lactose and 1.30% solids.

Infrared spectrophotometry of milk is a study of absorption (transmission) properties of a sample as a function of wavelength.

Infrared (IR) absorption of milk is related to the presence of certain structural groups in it [1,2]. Each fat molecule consists of three carbonyl groups (C=O) of triglyceride which are responsible for absorption at 5.73 μm (1,745 cm^{-1}); in addition, carbon-hydrogen groups (CH_2) of triglyceride take part in absorption at 3.4-3.5 μm (2,941-2,857 cm^{-1}). Each molecule of protein consists of amide units which are linked by peptide bonds; the absorption of the amide II band at 6.46 μm (1,548 cm^{-1}) can be used for determination of the total protein content. Each molecule of lactose consists of hydroxyl groups (OH) which absorb at 9.6 μm (1,042 cm^{-1}). Besides, a molecule of water absorbs at 4.3 μm (2,326 cm^{-1}).

The traditional methods for determining the quality of milk and its major components are slow and expensive [3]. Methods of Infrared Spectroscopy offers the possibility of assessing and improving the quality of milk produced [4]. One of these methods, Infrared Spectrophotometry, has a very quick process of measurement and is characterised with non-destructive action and high sensitivity [5]. The another method of Near Infrared Spectroscopy compared to the present methods include a higher rapidity and a simultaneous, non-destructive measurement of a number of milk constituents as well as a great potential for on-line analysis [3,6-11, 21].

Materials and Methods

50 samples of milk with different content of fat, protein, dry residues, and dry substances were used during this investigation. Samples were prepared in the experimental farm of the Department of Animal Nutrition and Feed Technology of National University of Life and Environmental Sciences of Ukraine, Kyiv, Ukraine.

The infrared spectrophotometer for milk analysis was developed by the authors of this paper.

Near-infrared (NIR) spectrum of milk was investigated with infrared analyzer 4250 “Pacific Scientific”.

Infrared spectrophotometer for milk analysis

An optical design of infrared spectrophotometer for milk analysis [12-18] is illustrated in Fig.1. The instrument consists of source 1 of infrared radiation, concave mirror 2, diaphragm 3, modulator 4 of radiation, lens 5, cuvette 6 with a sample, interference filter 7, detector 8, power supply 9 and readout system 10.

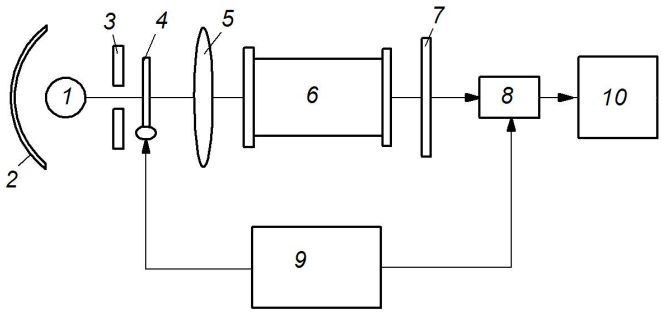

Fig. 1. An optical design of infrared spectrophotometer for milk analysis: 1 - source of infrared radiation; 2 - concave mirror; 3 - diaphragm; 4 - modulator of radiation; 5 - lens, 6 - cuvette with a sample; 7 - interference filter; 8 - detector; 9 - power supply; 10 - readout system [Posudin and Kostenko, 1991, Patent N 1698715]

Source of Infrared Radiation. A nichrome coiled filament that was used as the main component of the source of infrared radiation is characterized by the following parameters: voltage 6-8 V; electric current 2.5-3.0 A; power 15-24 W. Maximum of spectral emission is near 3-6 μm. Diameter of filament 0.4 mm, and the length 23 mm; diameter and length of the coil 5 and 12 mm correspondingly. The source was located in the focus of a concave aluminium mirror to provide maximal reflection and radiation density.

A Sample Cuvette. The windows of cuvette (thickness 300 μm) were performed with germanium; the total transmission of such a system was 70%. The air gap between the windows was equal 150 μm; such a value made it possible to avoid possible interference effects with a narrow gap and to keep the sensitivity of readout system.

Interference Filters. It was necessary to use the interference filters which were tuned at the maximum and at the base of absorption band of each component of milk (Fig. 2).

The main parameters of interference filters are presented in Table 1.

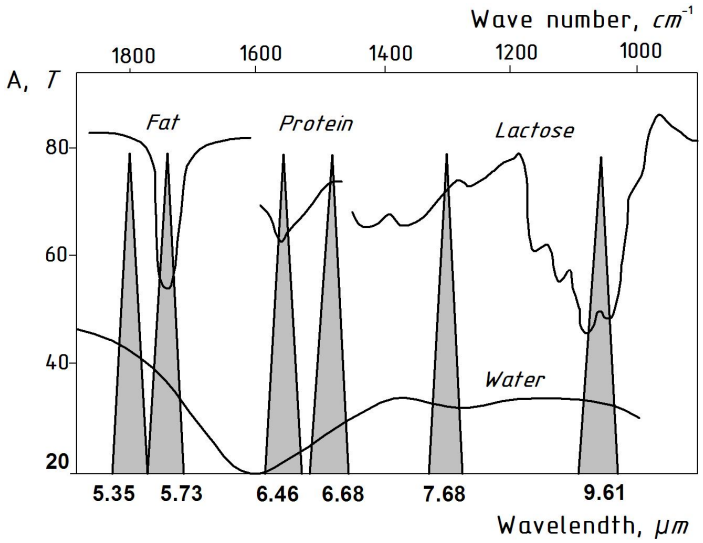

Fig. 2. The position of transmission bands of the interference filters which were tuned at the maximum and at the base of absorption band of each component of milk [13]

Table 1

Parameters of interference filters which were used in infrared spectrophotometer [13]

Position Relative to Absorption Band of Milk Component	λ (μm)	*T(%)*	$\Delta_{0.5}$ (μm)	$\Delta_{0.1}$ (μm)
Basis of absorption band of water	4.50 + 0.03	43	0.11	0.42
Maximum of absorption band of water	4.42 - 0.05	43-44	0.10	0.35
Basis of absorption band of fat	5.35 - 0.02	44-45	0.13	0.38
Maximum of absorption band of fat	5.70 + 0.03	42	0.17	0.46
Basis of absorption band of protein	6.68 - 0.02	40-43	0.22	0.56
Maximum of absorption band of protein	6.46 - 0.04	40	0.18	0.57
Basis of absorption band of lactose	7.68 0.03	50	0.23	0.54
Maximum of absorption band of lactose	9.61 + 0.01	42	0.26	0.65

If the direction of radiation flow is deviating from normal to the surface of the interference filter, the spectral shift of absorption band and broadening of this band can take place. The value of the shift depends on the angle of incidence and refractive index of filter material. The dependence of refractive index of germanium on the wavelength of radiation can be expressed by the following equation [19]:

$$N = A + BL + CL^2 + DA^2 + E\lambda^4 \quad (1)$$

where $A = 3.99931$; $B = 0.391707$; $C = 0.163492$; $D = 0.000006$; $E = 0.00000053$;
$L = (\lambda^2 - 0.028)^{-1}$.

Thus, refractive index according to this equation is changing from 4.108 (λ = 2 μm) to 4.005 (λ = 8 μm).

The values of spectral shift $\Delta\lambda_0/\lambda_0$ can be calculated due the following expression:

$$\Delta\lambda_0/\lambda_0 = [n^2 - \sin^2\theta)/n]^{1/2} \quad (2)$$

where λ_0 is the wavelength of incident radiation. These values are presented in Table 2.

Table 2. Dependence of spectral shift of absorption band on the deviation of radiation flow direction from normal to the surface of interference filter [13]

θ^0	$\lambda = 2\ \mu m$ ($n = 4.108$)	$\lambda = 2\ \mu m$ ($n = 4.024$)
0	1	1
5	0.99977	0.99976
10	0.99910	0.99907
15	0.99800	0.99790
20	0.99650	0.99640
25	0.99470	0.99450

Readout System. Infrared radiation that was transmitted by the sample entered the pyrometric element PIP with the following characteristics: spectral range 0.5-15 μm; coefficient of transformation $2 \cdot 10^3$ V/W; sensitivity threshold 10^{-8}-10^{-9} W; area of sensitive surface 2×2 mm^2.

Procedure of Measurement. The concentration of milk component is determined as follows:

$$C_i = K\ln(1 - \beta_i^{max} + \beta_i^0) \quad (3)$$

where K is the coefficient of proportionality; β_i^{max} and β_i^0 are the values of absorption at the maximum, and at the base of absorption band of i-component of milk.

The effect of water absorption is taken into account by the following formula:

$$\beta_i^{\lambda_i}\text{(sample)}\cdot 100\% = [\, I_i^{\lambda_i}\ (H_2O) - I_i^{\lambda_i}\ \text{(sample)}]/\, I_i^{\lambda_i}\ (H_2O) \quad (4)$$

where $I_i^{\lambda_i}$ (sample) and $I_i^{\lambda_i}$ (H_2O) is the intensity of absorption band for milk sample and water at the wavelength λ_i.

Optical Density of Milk. The measurement of milk particles concentration demands the elimination of light scattering - the condition of unitary scattering of optical radiation by milk particles can be performed if:

the value of optical density is equal $D = \lg I/I_0 << 1$;

there is a linear dependence of optical density on the concentration of milk particles $D = f(C)$, if $D << 1$.

The dependence of I/I_0 and $\lg I/I_0$ on the level of dilution of milk sample was measured with the photocalorimeter KFK-2MP in spectral region 315-980 nm. The results are shown in Fig. 3*a,b*. It is clear that the dependence $D = f(C)$ demonstrates a linear character for diluted samples of milk.

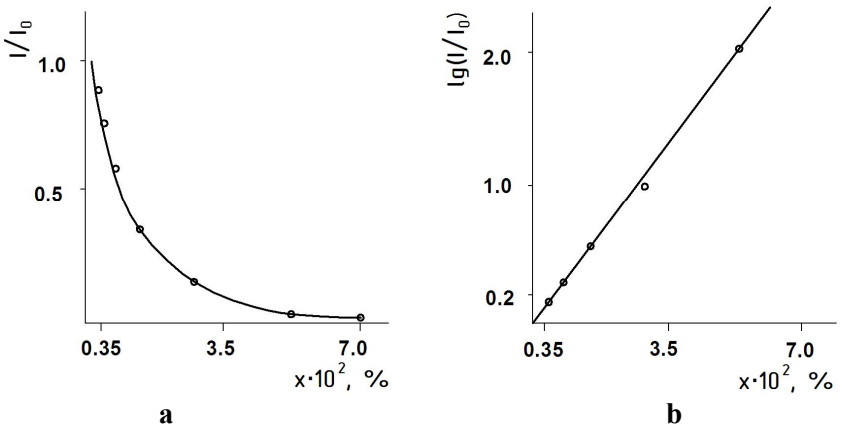

Fig.3. Dependence of I/I_0 (*a*) and $\lg(I/I_0)$ (*b*) on the level of dilution of milk sample

The main conclusion of this investigation is as follows: a milk sample should be diluted to obtain the linear dependence of optical density on the concentration of milk sample which is to be evaluated. This is a serious limitation of the method of absorption/transmission IR spectroscopy.

The advantage of the chosen scheme of spectrophotometer is the lack of dispersion elements and associated complex control systems. Also, simple optical system (interference filters) allows to use large apertures, that makes it possible to increase sensitivity of the system and to minimize unwanted reflections of the radiation from the optical elements; the radiation source does not require limiting diaphragms or slits. Note also a compact and simple construction of the device. The process of measurement is very quick.

The disadvantage of this scheme of spectrophotometer is high sensitivity to changes of ambient temperature and water vapour. At the same time, this method requires frequent calibrations to retain the accuracy and precision of the instrument [5].

Near-infrared spectroscopy of milk

Near-infrared (NIR) analyzer 4250 "Pacific Scientific" has three spectral regions at 1,620-1300 nm; 1,890-2,115 nm; 2,050-2,320 nm. The following grading equation was used for elaboration of the results of measurements:

$$Y = B_0 + B_1OP(\lambda_1) + B_2OP(\lambda_2) + ... + B_NOP(\lambda_N) \quad (5)$$

where Y is the result of infrared analysis; B_0, B_1, … B_N are the coefficients of grading equation; $OP(\lambda_1)$ is the optical parameters of spectrum at a given wavelength. Optical density D was used as an optical parameter:

$$D = \lg[1/R(\lambda)] \quad (6)$$

where $R(\lambda)$ is diffused reflectance at wavelength λ.

In addition, the analyzer provides the determination of first D_1 and second D_2 derivatives:

$$D_1 = \lg[1/R(\lambda - d\lambda)] - \lg[1/R(\lambda + d\lambda)] \quad (7)$$

$$D_2 = \lg[1/R(\lambda - d\lambda)] - 2\lg[1/R(\lambda)] + \lg[1/R(\lambda + d\lambda)] \quad (8)$$

where $d\lambda$ is a step of derivative.

The main objective of this investigation was to determine the principal spectral characteristics of milk samples with different contents of components, to estimate level of correlation between these components, and to compare the results of determination of milk components which were obtained due to NIR method and traditional chemical method. The results of chemical and NIR analysis of 50 samples of milk are given in Table 3.

The following coefficient of correlation R was used for comparison of the results of measurements by NIR (Y_{NIR}) and chemical (Y_{chem}) methods:

$$R = \frac{N\sum(Y_{chem} \cdot Y_{NIR}) - \sum(Y_{chem} \cdot Y_{NIR})}{\left[N\sum Y_{chem}^2 - (\sum Y_{chem})^2\right]^{1/2} \times \left[N\sum Y_{NIR}^2 - (\sum Y_{NIR})^2\right]^{1/2}}. \quad (9)$$

The results of calculation of coefficients of grading equation (Eqn. 5) are presented in Table 4.

Table 3

Results of chemical and infrared analysis [13]

Sample number	Fat	Protein	Dry residue	Dry substance	Sample number	Fat	Protein	Dry residue	Dry substance
1	8.40	2.90	8.20	16.60	1	7.69	3.44	8.76	16.68
2	4.40	3.70	8.60	13.00	2	4.73	3.02	8.25	12.92
3	4.10	2.90	8.30	12.40	3	4.27	2.67	7.98	12.04
4	4.50	2.50	7.90	12.40	4	4.48	2.65	8.00	12.32
5	1.40	3.80	9.10	10.50	5	1.82	3.30	8.46	9.91
6	3.80	2.70	8.00	11.80	6	3.86	2.76	8.16	12.14
7	4.40	3.50	8.70	13.10	7	4.45	2.61	8.80	12.25
8	5.40	3.20	8.70	14.10	8	5.36	2.95	8.39	13.44
9	4.00	2.70	8.00	12.00	9	4.14	2.66	8.17	12.24
10	5.00	3.00	8.20	13.20	10	5.05	2.88	8.26	J 3.29
11	2.10	2.30	7.50	9.60	11	2.03	2.99	7.98	10.07
12	2.65	2.80	8.00	10.65	12	2.44	2.80	7.99	10.40
13	3.90	2.40	7.50	11.40	13	3.74	2.58	7.97	11.75
14	3.90	3.20	8.60	12.50	14	3.99	2.63	8.19	11.87
15	3.50	2.70	7.50	11.00	15	3.60	2.71	8.23	11.53
16	4.50	2.70	7.60	11.10	16	4.43	2.88	7.93	12.35
17	5.70	3.00	8.30	14.00	17	4.91	2.87	8.14	13.34
18	4.10	3.40	8.70	12.80	18	4.14	2.69	8.10	11.83
19	3.30	2.80	7.90	11.20	19	3.70	3.37	8.38	11.18
20	3.80	3.00	8.30	12.10	20	3.86	3.01	8.33	12.40
21	5.00	3.20	8.70	13.70	21	5.20	2.75	8.32	13.56
22	3.50	2,60	8.10	11.60	22	4.33	2.61	7.81	11.67
23	4.00	2.80	8.10	12.10	23	4.14	2.75	8.36	12.31
24	3.10	2.80	8.00	11.10	24	3.09	2.78	8.18	11.40
25	4.00	2.00	7.30	11.30	25	3.94	2.47	7.84	11.57
26	3.30	2.60	7.50	10.80	26	2.85	2.59	7.48	10.76
27	3.70	2.45	7.40	11.10	27	3.52	2.61	7.79	11.32
28	3.20	2.10	7.20	10.40	28	3.03	2.50	7.52	10.46
29	4.70	3.10	8.40	13.10	29	4.69	2.87	7.89	12.93
30	2.70	2.70	7.90	10.60	30	2.72	2.78	7.76	10.63
31	4.00	2.90	8.30	12.30	31	4.06	2.70	7.88	12.01
32	3.90	3.00	8.20	12.10	32	3.80	2.92	7.83	12.18
33	4.10	2.25	7.30	11.40	33	4.85	2.57	7.53	12.46
34	3.40	2.50	7.60	11.00	34	3.36	2.95	8.22	11.76
35	3.30	2.50	7.60	10.90	35	3.26	2.50	7.66	11.30
36	3.90	2.90	8.30	12.20	36	3.90	2.96	8.03	12.39
37	3.20	1.20	7.50	10.70	37	3.15	2.51	7.62	10.94
38	3.90	2.50	8.40	12.30	38	3.80	2.57	7.79	11.38
39	4.60	2.40	7.60	12.20	39	4.59	2.43	7.66	11.96
40	4.90	3.10	8.00	12.90	40	4.89	2.62	7.76	12.58
41	3.90	2.60	7.70	11.60	41	3.85	2.52	7.68	11.37
42	3.20	2.65	7.80	11.00	42	3.16	2.64	7.60	10.79
43	4.60	2.90	8.20	12.80	43	4.65	2.94	7.78	12.55
44	2.80	2.20	7.30	10.10	44	2.52	2.52	1.58	10.18
45	4.60	2.35	7.40	12.00	45	4.36	2.65	7.75	12.12
46	3.50	2.90	7.70	11.20	46	3.20	2.70	7.73	11.51
47	5.00	2.80	7.30	12.30	47	5.62	2.72	7.52	13.33
48	4.10	3.20	8.00	12.10	48	3.96	2.77	7.77	12.06
49	4.70	2.60	7.60	12.30	49	4.50	2.58	7.64	11.95
50	4.00	2.70	7.50	11.50	50	3.96	2.71	7.77	11.78

Table 4

Results of calculation of coefficients of grading equation (Eqn. 5) [13]

Coefficient of Regression Equation	F-criterion for Given Equation	Scale Division	Wave Number, cm^{-1}
Protein			
B(0) = 8.719			
B(1) = 64.680	14.02	285	2,197
B(2) = 230.190	14.79	93	1,792
B(3) = -69.974	19.95	35	1,705
B(4) = -73.980	62.69	264	2,131
Fat			
B(0) = 6.918			
B(1) = 316.151	44.84	88	1,789
B(2) = -108.606	506.08	24	1,679
Non-fat Solids			
B(0) = 14.539			
B(1) =-36.935	58.48	186	2,062
B(2) = -82.348	77.57	24	1,679
Total Solids			
B(0) = 21.224			
B(1) = -81.700	35.03	271	2,154
B(2) = 135.838	11.23	293	2,219
B(3) = 243.213	21.40	350	2,315
B(4) = -172.508	66.10	28	1,688

The correlation dependence between results of chemical and NIR analysis of milk components are presented in Fig. 4 for fat, Fig. 5 for protein, Fig. 6 for non-fat solids and Fig. 7 for total solids. The values of coefficients of correlation which were obtained during analysis of 50 samples of milk are given in Table 5.

Table 5

Values of coefficients of correlation dependence between results of chemical and NIR analysis of milk components [13]

Type of Analysis	Component	Mean Content (%)	Deviation	SEP	SEP(C)	R	R_2
Chemical	Fat	3.99	1.028	0.284	0.287	0.960	0.922
NIR	Fat	3.99	0.987				
Chemical	Protein	2.75	0.439	0.375	0.379	0.504	0.254
NIR	Protein	2.75	0.221				
Chemical	Non-fat Solids	7.95	0.465	0.357	0.361	0.630	0.397
NIR	Non-fat Solids	7.95	0.293				
Chemical	Total Solids	11.94	1.198	0.433	0.437	0.931	0.867
NIR	Total Solids	11.94	1.115				

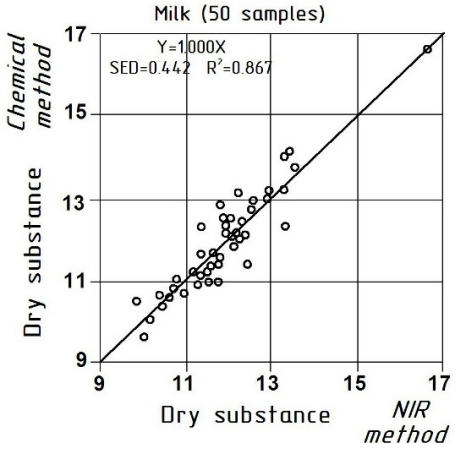

Fig. 4. The correlation dependence between results of chemical and NIR analysis of fat in milk

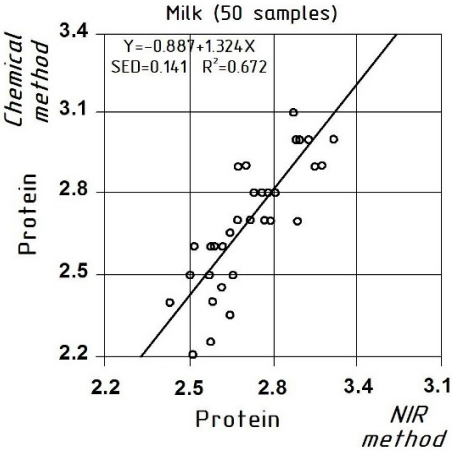

Fig. 5.The correlation dependence between results of chemical and NIR analysis of protein in milk

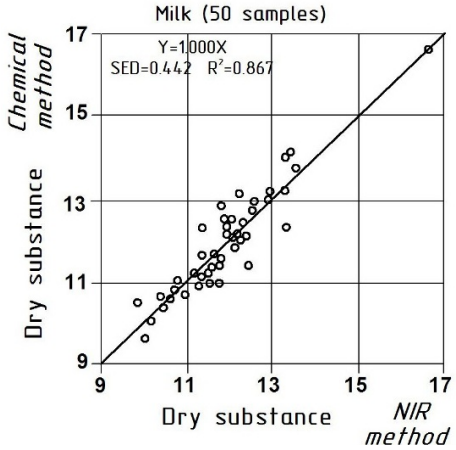

Fig. 6. The correlation dependence between results of chemical and NIR analysis of non-fat solids in milk

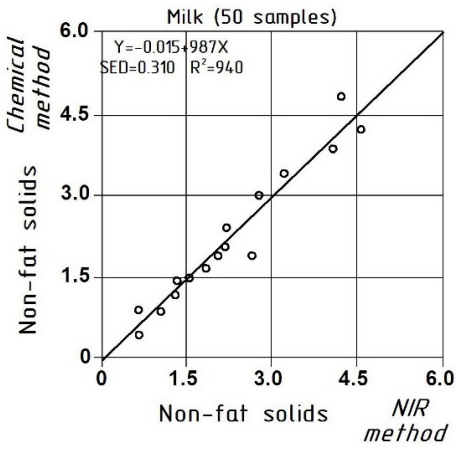

Fig. 7. The correlation dependence between results of chemical and NIR analysis of total solids in milk

Near-infrared spectra of milk samples with different contents of fat (1.82%; 4.27%; 4.48%; 4.73%; 7.69%) are presented in Fig.8.

It is clear that the amplitude of these spectra depends strongly on the fat content. It was also interesting to compare the NIR spectra of the samples that had the same fat (Fig. 9) and protein (Fig. 10) concentration according to the chemical testing: the results demonstrate some divergence which are caused by inaccuracy of the chemical method. The derivative spectra are rather informative - they make it possible to find extreme points of the reflectance spectra (samples N 1, 5 and 7) (Fig. 11).

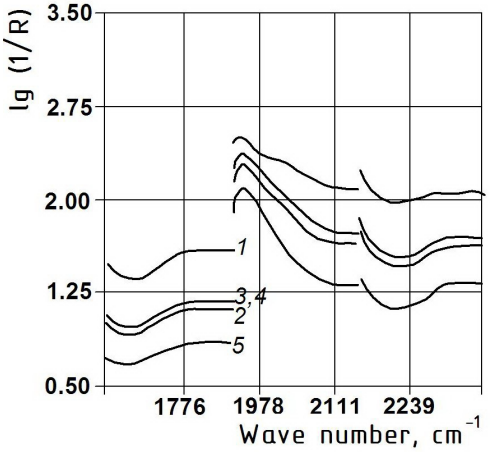

Fig. 8. The near-infrared spectra of milk samples with different contents of fat: 1 - 1.82%; 2 - 4.27%; 3 - 4.48%; 4 - 4.73%; 5 - 7.69%

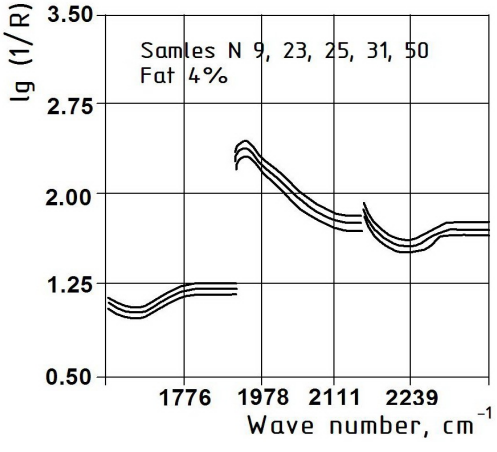

Fig.9. The near-infrared spectra of the samples that had the same fat concentration according to the chemical testing

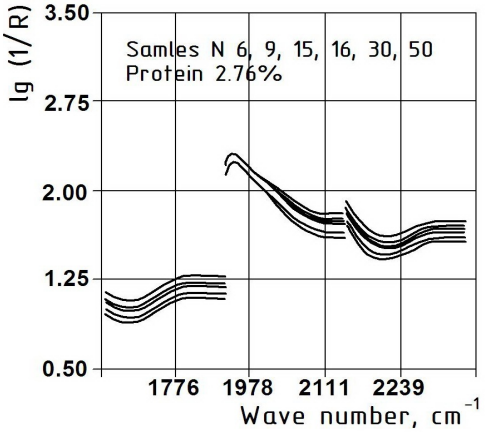

Fig. 10. The near-infrared spectra of the samples that had the same protein concentration according to the chemical testing

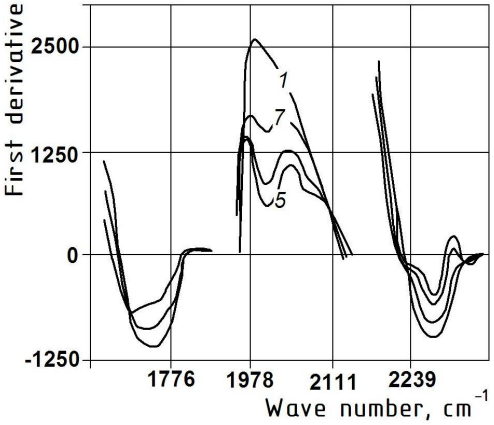

Fig. 11. The derivative spectra of milk. Samples N 1 , 5 and 7

The next step of investigation was the clearing up of the level of correlation between separate components of milk which were determined by chemical and NIR methods. The correlation dependence between the main components of milk (fat, protein, total solids, and non-fat solids) are presented in Figs. 12-17.

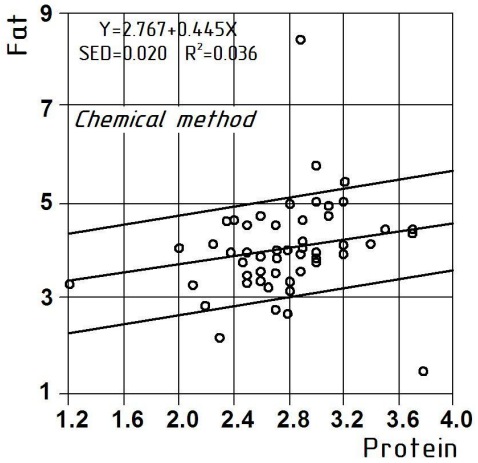

Fig. 12. The correlation between fat and protein content of milk which was determined by chemical method

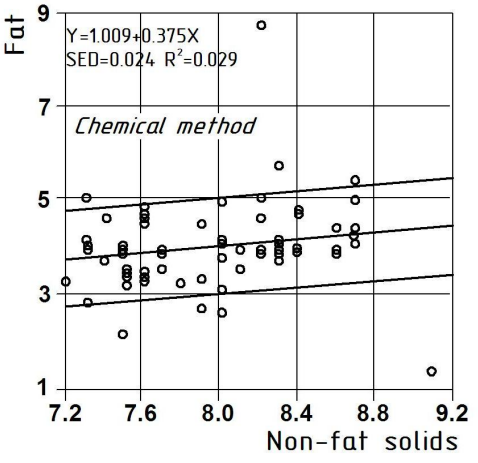

Fig. 13. The correlation between fat and non-fat solids content of milk which was determined by chemical method

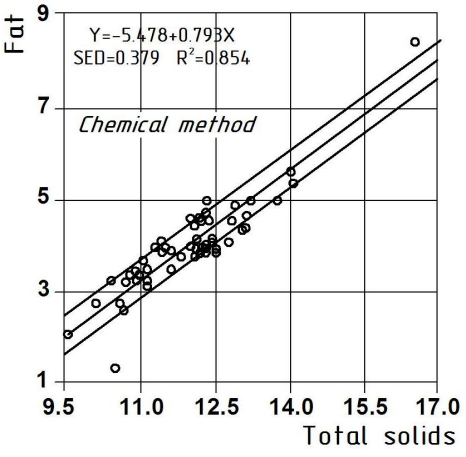

Fig. 14. The correlation between fat and total solids content of milk which was determined by chemical method

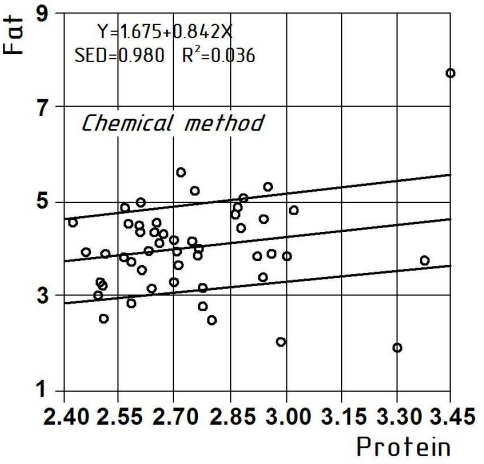

Fig.15. The correlation between fat and protein content of milk which was determined by NIR method

The highest level of correlation was indicated between the content of fat and total solids that was determined by NIR method (Fig. 17). The values of coefficients of correlation are given in Table 6.

NIR method provides the analysis of milk samples which contain a high proportion of water and demonstrate high level of opacity. The NIR method is rapid, non-destructive and offers a high level of accuracy in comparison with traditional chemical methods. This method can realise simultaneous, non-destructive measurements of a number of milk constituents. Method of Near-Infrared Spectroscopy allows to control milk in a stream; this technology is actual for today's industry.

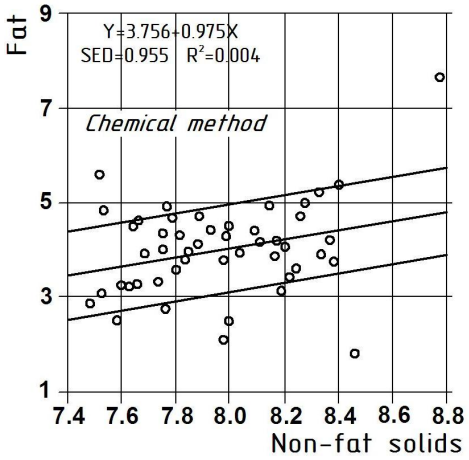

Fig. 16. The correlation between fat and non-fat solids content of milk which was determined by NIR method

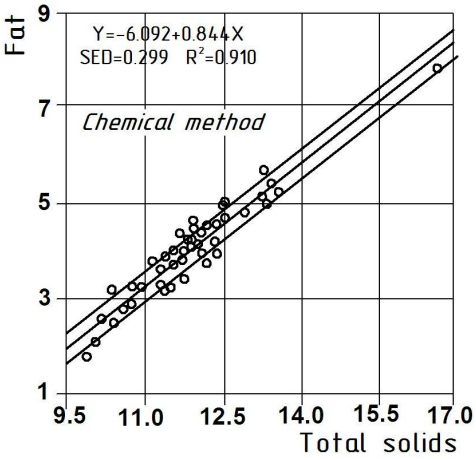

Fig. 17. The correlation between fat and total solids content of milk which determined by NIR method

However, it should also be noted that devices that implement the principle of reflectance spectroscopy in the NIR region require calibration and are expensive ($5,000 - $100,000).

Table 6

Values of coefficients of correlation between separate components of milk which were determined by chemical and NIR methods [13]

Component	Fat	Protein	Non-fat Solids	Total Solids
Fat	-	0.036	0.084	0.910
Protein	0.036	-	0.519	0.123
Non-fat Solids	0.084	0.519	-	0.200
Total Solids	0.910	0.123	0.200	-

Conclusions

The method of Infrared Spectrophotometry requires diluting samples and can be used in laboratory conditions. Method of Near-Infrared Reflectance Spectroscopy provides fast and non-destructive testing of milk composition with high accuracy and can be used in dairy industry to estimate the composition of the milk on the conveyor, in a stream.

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Effects of different pasteurizers on the microbial quality of raw milk samples

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Abstract

Introduction. This study was conducted to determine the effect of different pasteurizing temperatures on the microbial quality of raw milk samples from different breeds.

Materials and methods. The raw milk samples were analyzed chemically for pH in the range of 5.670 to 3.240 and microbiologically for Total Viable Counts, Coliform Counts, Fecal Coliform Counts, and Lactobacillus Counts, for all treatment combinations. These samples were pasteurized at pasteurized at 71◦C for 15seconds, 66◦C for 15minutes and 61◦C for 30minutes collected from White Fulani breed, New Jersey breed and the breed mixture (White Fulani and New Jersey) using pasteurizer made of aluminium, stainless steel and galvanized steel

Results and discussion. Mean results of TVC, CC, FCC, LBC for White Fulani before pasteurizing were in the range of $6.833x10^5$ -0.000 Cfu/ml and FC (2.433×10^3Cfu/ml) respectively and that of New Jersey were within $7.800x10^5$ - 0.000 Cfu/ml and FC (0.115×10^3Cfu/ml) respectively, also that of the breed mixture were within $9.400x10^5$ -0.000 Cfu/ml and FC ($5.167x10^5$Cfu/ml). The mean counts was decreased for aluminium, stainless steel and galvanized steel pasteurizer at the temperature and microbial range of 61◦C-71◦C and for TVC(7.233-1.400 Cfu/ml), CC(5.633-0.000 Cfu/ml), FCC(3.033-0.000Cfu/ml), LBC (3.000-0.000Cfu/ml), FC (5.033-1.000Cfu/ml) for the White Fulani and was also decreased for the New Jersey at the same materials and temperature combinations for TVC(6.533-1.800 Cfu/ml), CC(4.800-1.233 Cfu/ml), FCC(0.000-0.000 Cfu/ml), LBC (1.800-0.000Cfu/ml), FC (3.833-1.033Cfu/ml). Finally, the microbial counts was also decreased for the breed mixture at the same materials and temperature combination for TVC(5.800-1.200 Cfu/ml), CC(4.300-1.000 Cfu/ml), FCC(0.000-0.000 Cfu/ml), LBC(1.033-0.000 Cfu/ml) and FC(3.300-1.200 Cfu/ml).

Conclusion. Raw milk samples should be pasteurized at atemperature of 71^oC in a stainless steel for 15 seconds in order to record a low bacterial counts.

Introduction

Milk is a nutritious food for human beings. It also serves as a good medium for the growth of many microorganisms such as Staphylococcus and Coliform. Bacterial contamination of raw milk can originate from different sources, including low quality raw milk, improper refrigeration and an inadequate packaging system. Raw milk deteriorates in few days and pasteurized milk with high temperature short time treatment (HTST) has a shelf life of about seven days. Contaminations of raw milk and the consequent high bacterial count in milk originates from milking wet dirty udders, the milking system used, the cooling and storage temperature and the holding time [1].

Milk harbors a complex microbial community, including microorganisms of industrial importance, that possess health-promoting features and that are of concern from a food quality or safety perspective. Thus, the milk microbiota is the focus of constant attention. The microbial composition of milk is influenced by several different parameters such as, in the case of raw milk, the microorganisms present in the teat canal, on the surface of teat skin, in the surrounding air, in feed, as well as other environmental factors including housing conditions, the quality of the water supply, and equipment hygiene[2] **.**

Raw milk is milk in its natural (unpasteurized) state. Contaminated raw milk can be a source of harmful bacterial, such as those that cause undulant fever, dysentery, salmonellosis and tuberculosis. "Certified" milk, obtained from cows certified as healthy is unpasteurized milk with a bacterial count below a specified standard, but it still can contain significant numbers of disease producing organisms. Different heat and treatments are given to raw milk in order to remove pathogenic organisms to increase the shelf life, to help subsequent processing. For example, for warming before separation and homogenization or as an essential treatment before cheese making, yoghurt manufacture and production and production of evaporated and dried milk products[3] **.** Batch (or "vat") pasteurization is the simplest and oldest method for pasteurizing milk. Milk is heated to 154.4°F (63°C) in a large container and held at that temperature for 30minutes. This process can be carried out at home on the stove top using large pot or, for small scale dairies with steam-heated kettles and fancy temperature control equipment. In batch processing the milk has to be stirred constantly to make sure that each particles of milk is heated.

Ultra-high temperature (UHT or ultra-heat treatment) is also used for milk treatment. UHT processing holds the milk at a temperature of 138°C (250°F) for a fraction of a second. Milk simply labeled "pasteurized" is usually treated with the HTST (high temperature short time) method, whereas milk labeled "ultra-pasteurized" or simply "UHT" has been treated with the UHT method [4] **.** The problem of post treatment contamination of "in container" sterilized product can either be through "poor seal" or through "pin hole" in the container. Post treatment contaminants in UHT milk may be either by spores which would not be expected to be heat resistant enough to survive the heat treatment or non-heat resistance vegetative organisms. Organisms of the first type will probably have entered from the ineffective sterilization of plant downstream from the heat treatment stage of the process, which includes spores of *Bacillus cereus* [5]

Contamination of raw milk from cow can be as a result of the introduction of foreign materials into the milk before or during the milk production, by pathogens through vectors, humans and flies or disease causing organism like bacterial. Also, contamination can occur after the pasteurization of raw milk product through careless handling of the product in an unhygienic environment.

Therefore, certain requirements should be fulfilled in order to produce safe and clean milk. These requirements include: clean milking and cooling of milk immediately after transference of milk to processing in ideal plants with strict quality control [1].

Pasteurization is done locally using temperature which cannot be quantified, therefore there is need for a thermocouple heater which can be used to stabilize and quantify the different pasteurizing temperature, and it will reduce labor cost. This is also expected to lower the microbial counts compared to the unpasteurized milk.

Materials and methods

The various material and devices used in this work and the basis of their selection as well as some of their standard properties are discussed as follow.

Heating Medium. An electric stove with an AC voltage of 220V, a frequency of 50/60Hz and a thermal coil element rating of 1000w was selected for heating the milk at regulated temperatures. The cost of the stove is relatively cheap and it is available and can provide the desired power rating required.

K-type Thermocouple. The thermocouple is a sensor attached to the material and connected to a temperature regulator. It senses the temperature of the milk and conveys this information to the regulator which then adjust the temperature if necessary to a predetermined set point. The K-type (Chromel - Alumel) was selected because of unlike other types of thermocouples (B, C, E, J, N, R, S, T types), it is well suited for oxidizing atmospheres; that is, it resist corrosion and has a useable temperature range of 95^0C to 1260^0C. It is has a good degree of sensitivity of 39μV/ºC, durable and readily available **(Watlow, 2015).**

Temperature Controller. The temperature controller is a device used to maintain the desired temperature for the different pasteurization treatments of the milk. It was selected because of the need to maintain the different temperatures for specific periods. It works on the principles of a temperature control loop. The sensor (k-type thermocouples) measures the temperature of the milk to be controlled and converts the measured value into a travel signal. The information is received by the regulator and compared to the set point (pasteurizing temperature) and make adjustment when necessary.

General Description of the Experimental Setup and the Working Principle. The experimental or design setup consist of different material (aluminium, stainless and steel pots) in which the milk is poured. Stirrers are from the top attached to these mediums to allow uniformity in heat transfer while heating the different raw milk samples to be tested. A K-type thermocouple is also attached to the materials; for the purpose of sensing the temperature difference during the milk heating and to relate the sense heat to the controller. The controller then makes necessary adjustment after comparing it to the preset temperature to prevent over or under heating of the milk. The heater to be used is also connected to the controller in order to regulate the amount of power to be supplied to it when necessary. If the heat transferred by the heater to the materials is high enough that the milk temperature gets to a set point as relayed by the thermocouple, the controller stops the power supply and once there is a slight drop in the temperature, the controller immediately supply power to maintain the set point. The controller terminals are connected to a power source through the socket outlet.

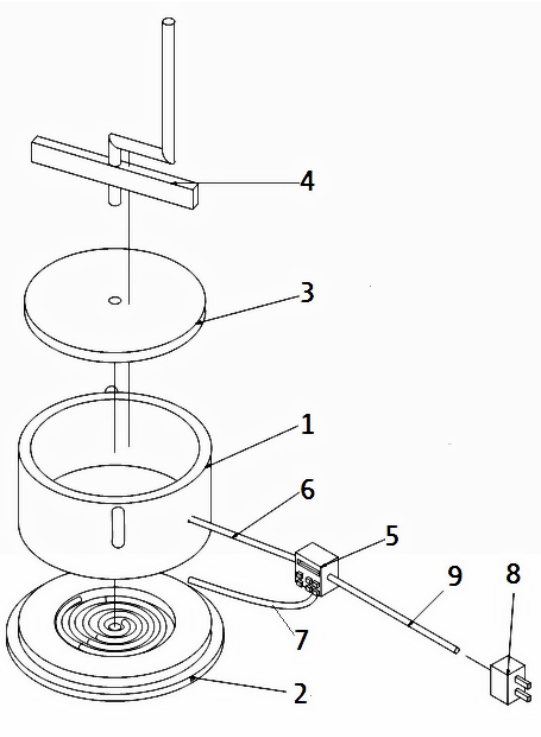

Figure 1. Exploded view of the experimental set up:
1 – Container/Port, 2 – Electric heater, 3 – Lid, 4 – Stirrer, 5 – Temperature regulator, 6 – Thermocouple, 7 – Electric heater cable, 8 – Connecting probe, 9 – Connecting probe wire

Milk from the New Jersey breed already undergo basic preparation process like clarification carried out in a clarifier at shonga farm holdings after being collected from a milking machine. It is transported down in an ice van to maintain it temperature at 3^0C to 5^0C.

Preparation of culture Media. The media to be used for this analysis are Nutrient Agar (NA) for total bacteria, Mac Conkey agar for enumeration of coliform bacteria, Eosin Methylene Blue agar for fecal coliform enumeration, Demann Rogossa Sharpe agar for enumeration of lactobacillus, Yeast Extraction agar for enumeration of yeast and Potato Dextrose Agar (PDA) for enumeration of fungi. count. The said culture media were prepared in line with the manufacturer's instruction. The colonies were counted and associated microorganisms were isolated, characterized and identified according to the techniques described by[7] in the laboratory manual of microbiology.

Sensitivity Analysis. The effect of different pasteurizing temperature and materials on the fungi and bacterial counts of raw milk samples would be investigated using ANOVA at $p \leq 0.05$ and the level of significant means would be further evaluated using Duncan's Multiple Range Test (DNMRT).

Results and discussion

It can be deduced from table 1 that after the pasteurization process, aluminium material had high average bacterial count of 7.23 x 10^5 for TVC, 5.37 x 10^5 for CC, 0.00 for FCC and LBC and 5.03 x 10^3Cfu/ml for FC respectively at 71°C. This indicates an increase in the microbial load of the raw sample which had an initial average count of 6.83 x 10^5 for TVC, 5.3 x 10^5 for CC, 0.00 for FCC and LBC and 2.43 x 10^3 Cfu/ml for FC respectively. This post treatment contamination could be through "poor seal" or through "pin hole" in the container used in conveying the milk samples to the laboratory after pasteurization or ineffective heat treatment of heat resistance organisms [5].

Also, comparing the raw and control samples from table 1, it shows that besides aluminium material which shows contamination at 71°C for White Fulani breed only, the remaining samples had a decreased microbial load, showing the effect of pasteurization. Furthermore, it can be added that the reason for the very high microbial counts in the raw milk samples was due to the microorganisms present in the teat canal, on the surface of teat skin, in the surrounding air, in feed, as well as other environmental factors including housing conditions of the dairy animal [2], while that of the locally pasteurized samples (nono) could be due to the quality of the water supply, and equipment hygiene used in milking The results in table 1 also showed that depending on the materials and the temperature applied in the pasteurization process, there are variations in total viable count of the pasteurized milk from the various source. Similarly, variances were also observed in coliform count of the pasteurized milk from the different source along the various levels of applied temperature and materials. Similar observation also exist for faecal coliform count, LB count and fungi count. These may imply that fungal count of milk pasteurized using the selected applied temperature and in the different materials were not same with regard to the milk source. Raw milk pH ranges from 6.4 to 6.8, with an average pH of 6.6 making it slightly acidic. It is a complex biological fluid and by its nature, a good growth medium for many microorganisms. Most bacteria especially in milk normally grow within the neutrophilic pH. The pH of raw milk therefore plays an important role as it has an effect on the distribution and growth rate of microorganisms in the milk [8]. In this research work, the pH ranges within 5.67 to 3.240 which would also have supported the total growth of microorganisms present.

Table 1

Summary statistics of the data generated

Materials	Temperatures	Source	pH	TVC	CC	FCC	LBC	FC
Aluminium	61	White Fulani	4.640	4.233	2.500	3.033	0.000	3.200
		New Jersey	4.760	4.200	3.000	0.000	0.000	2.833
		Mixture	4.950	4.267	1.133	0.000	0.000	1.300
	66	White Fulani	4.600	6.300	5.633	0.000	0.000	3.133
		New Jersey	4.950	6.533	4.800	0.000	0.000	3.167
		Mixture	4.370	1.233	1.100	0.000	1.033	1.233
	71	White Fulani	4.550	7.233	5.367	0.000	0.000	5.033
		New Jersey	5.010	3.767	2.100	0.000	0.000	3.833
		Mixture	5.120	2.100	1.500	0.000	0.000	3.300
Stainless Steel	61	White Fulani	5.400	1.400	1.133	0.000	0.000	1.800
		New Jersey	4.530	1.800	1.233	0.000	0.000	1.833
		Mixture	4.730	5.200	3.800	0.000	2.400	1.200
	66	White Fulani	4.870	3.033	2.233	0.000	3.000	1.233
		New Jersey	4.620	2.700	2.000	0.000	1.800	1.033
		Mixture	4.600	1.600	1.000	0.000	0.000	1.500
	71	White Fulani	4.490	3.500	2.867	0.000	0.000	2.067
		New Jersey	4.420	2.033	1.400	0.000	0.000	1.200
		Mixture	5.060	1.400	1.033	0.000	0.000	1.233
Galvanized Steel	61	White Fulani	3.510	2.800	2.133	0.000	0.000	1.000
		New Jersey	3.240	3.067	2.500	0.000	2.833	1.633
		Mixture	4.250	2.333	1.700	0.000	0.000	2.100
	66	White Fulani	4.080	1.800	1.200	0.000	0.000	2.067
		New Jersey	5.630	4.233	3.367	0.000	0.000	2.700
		Mixture	4.130	5.800	4.300	0.000	0.000	2.800
	71	White Fulani	4.640	3.700	2.433	0.000	0.000	2.467
		New Jersey	3.290	2.500	1.800	0.000	2.667	1.167
		Mixture	4.560	1.200	1.000	0.000	0.000	1.633
Control	Raw	White Fulani	6.833	5.300	0.000	0.000	2.433	5.670
		New Jersey	7.800	5.533	0.000	0.000	3.800	4.520
		Mixture	9.400	6.833	0.000	0.000	5.167	4.750
	Fermented	White Fulani	9.567	7.900	0.000	0.000	3.500	3.420
		New Jersey	8.700	6.200	0.000	1.867	3.733	3.480
		Mixture	9.800	8.233	0.000	0.000	3.300	4.390

Materials (M1 = Aluminium, M2= Stainless steel, M3= Galvanized Steel), Temperature (T1=71°C, T2=66°C, T3=61°C) and Source (S1=White Fulani, S2= New Jersey, S3=Mixture), RAW S1 =White Fulani Breed Raw Milk Sample, RAW S2= New Jersey Breed Raw Sample, RAW S3= Mixture of White Fulani and New Jersey Breed Raw Sample, FM S1 =Fermented /Nono Milk for White Fulani Breed, FM S2 =Fermented/Nono Milk for New Jersey Breed, FM S3 =Fermented/Nono Milk for the Mixture of White Fulani and New Jersey Breed, TVC =Total Viable Counts, CC= Coliform Counts, FCC= Fecal Counts, LBC=Lactobacillus Counts, FC= Fungi Counts, Cfu= Colony Forming Unit, R1, R2 and R3= First, Second and Third replicates respectively.

.**Table 2**

Multivariate analysis of variance for measured parameters

Source	Dependent Variable	Sum of Squares	df	Mean Square	F	Sig.
M	TVC	52.572	2	26.286	1936.000	0.000*
	CC	18.631	2	9.316	5390.000	0.000*
	FCC	2.045	2	1.022	8281.000	0.000*
	LBC	6.763	2	3.382	9130.000	0.000*
	FC	33.745	2	16.873	2485.000	0.000*
T	TVC	5.844	2	2.922	215.164	0.000*
	CC	8.889	2	4.445	2571.000	0.000*
	FCC	2.045	2	1.022	8281.000	0.000*
	LBC	1.886	2	0.943	2546.000	0.000*
	FC	4.290	2	2.145	315.873	0.000*
S	TVC	13.460	2	6.730	495.555	0.000*
	CC	13.603	2	6.802	3935.000	0.000*
	FCC	2.045	2	1.022	8281.000	0.000*
	LBC	3.737	2	1.868	5044.000	0.000*
	FC	5.429	2	2.714	399.764	0.000*
MT	TVC	7.458	4	1.865	137.300	0.000*
	CC	10.610	4	2.653	1535.000	0.000*
	FCC	4.089	4	1.022	8281.000	0.000*
	LBC	15.401	4	3.850	10400.000	0.000*
	FC	15.796	4	3.949	581.591	0.000*
MS	TVC	43.203	4	10.801	795.323	0.000*
	CC	38.434	4	9.608	5559.000	0.000*
	FCC	4.089	4	1.022	8281.000	0.000*
	LBC	17.862	4	4.465	12060.000	0.000*
	FC	12.399	4	3.100	456.518	0.000*
TS	TVC	53.066	4	13.267	976.905	0.000*
	CC	22.067	4	5.517	3192.000	0.000*
	FCC	4.089	4	1.022	8281.000	0.000*
	LBC	7.628	4	1.907	5149.000	0.000*
	FC	4.815	4	1.204	177.273	0.000*
MTS	TVC	56.320	8	7.040	518.402	0.000*
	CC	33.580	8	4.198	2429.000	0.000*
	FCC	8.179	8	1.022	8281.000	0.000*
	LBC	28.387	8	3.548	9581.000	0.000*
	FC	3.448	8	0.431	63.477	0.000*
Error	TVC	0.733	54	0.014		
	CC	0.093	54	0.002		
	FCC	0.007	54	0.000		
	LBC	0.020	54	0.000		
	FC	0.367	54	0.007		
Total	TVC	1131.990	81			
	CC	604.820	81			
	FCC	27.610	81			
	LBC	102.640	81			
	FC	450.210	81			

**Significant at 5% level*

M=Materials (M1=Aluminium, M2=Stainless steel, M3=Galvanized Steel), T=Temperature (T1=71°C, T2=66°C, T3=61°C) and S=Source (S1=White Fulani, S2= New Jersey, S3=Mixture), MT= Material and and Temperature Combination, MS= Material and Source Combination, TS=Temperature and Source Combination, MTS= Material, Temperature and Source Combination, TVC=Total Viable Counts, CC=Coliform Counts, FCC=Feacal Counts, LBC=Lactobacillus Counts, FC= Fungi Counts, df= degree of freedom.

Table 2 showed the analysis of variance test. The analysis of variance test shows the effect of the measured parameters on microbial counts of pasteurized milk. The test shows that pasteurized milk using the three selected materials (aluminum, stainless and steel) under the three selected applied temperature had significantly different total viable count, coliform count, faecal coliform count, LB count and fungal count at 5% level. The source of the milk was also a function of the variances observed and lastly the interactions between study parameters were also significant at 5%. The bacterial count is a useful method to measure milk quality, a bacterial count ranging between 9×10^5 - 9×10^6 Cfu/ml is acceptable[9], and the mean standard plate count of raw milk is 1.29×10^6 cfu/ml (Ramanjaneyulu, 1985). From the summary statistics, i.e. table 4.3 and table 4.4, the mean results of TVC, CC, FCC, LBC, FC and pH for White Fulani breed before pasteurizing were 6.833 x 10^5, 5.300 x 10^5, 0.000 x 10^5, 0.000 x 10^5, 2.433 x 10^3 Cfu/ml and 5.670 respectively and that of New Jersey breed were 7.800 x 10^5, 5.533 x 10^5 , 0.000 x 10^5, 0.000 x 10^5, 3.800 x 10^3 Cfu/ml and 4.520, also that of the breed mixture were 9.400 x 10^5, 6.833 x 10^5, 0.000 x 10^5, 0.000 x 10^5, 5.167 x 10^3 Cfu/ml and 4.750. Therefore, according to [10], it shows that the average initial count before pasteurizing is within acceptable range The mean counts was decreased for aluminium, stainless steel and galvanized steel pasteurizer at the temperature and microbial range of 61°C-71°C within range of 7.233 x10^5 to 0.000 Cfu/ml for the bacterial count and 5.67 x 10^3 Cfu/ml to 1 x 10^3 Cfu/ml for the fungi count. Also, the pH was decreased in the range of 5.67 to 3.240. Therefore, according[9] it is acceptable at significant difference of 5%.

The new Duncan multiple range test on Table.3 shows the different mean values of the fungal counts in the materials assuming all other parameters were fixed. It can be inferred from Table 3 that the total viable count of pasteurized milk in aluminum was significantly higher than those of stainless steel and galvanized steel irrespective of the applied temperature and or source of the milk. The total viable count observed in stainless steel was statistically different from that observed in galvanized steel material. The mean coliform count of pasteurized milk in aluminum material was 3.015 x 10^5Cfu/ml and this value was significantly higher than the coliform count of 2.270 x 10^5Cfu/ml and 1.856 x 10^5Cfu/ml observed in galvanized steel and stainless steel respectively. Fecal coliform count was only observed in milk pasteurized in aluminum material. Milk pasteurized using galvanized steel and stainless steel material had significantly higher LB count than milk pasteurized in aluminum. Lastly, fungal count was higher in milk pasteurized in aluminum than those of stainless steel and galvanized steel.

The total viable count of pasteurized milk at temperature of 66°C (3.693 x 10^5Cfu/ml) was significantly higher than the total viable count observed 61°C (3.256 x 10^5Cfu/ml) and that observed at 71°C (3.048 x 10^5Cfu/ml) on the average irrespective of the source and material used. Milk pasteurized at 66°C also had higher coliform count compared to those pasteurized at the other two levels of the temperature use (see Table 4.5). Similarly, milk pasteurized at 66°C had statistically higher LB count (0.648 x 10^5Cfu/ml) than those pasteurized at 61°C and 71°C respectively. Also the fungal count of milk pasteurized at 71°C was significantly higher (2.437x 10^3Cfu/ml) compared to the fungal count of milk pasteurized at 66°C and at 61°C.

The white Fulani had significantly higher total viable count (3.778 x 10^5Cfu/ml) than all other milk used in the experiment after pasteurization and this was followed by the New Jersey total viable count of 3.426 x 10^5Cfu/ml. The mixture of the two milk sourced from white Fulani and the New Jersey had the lowest total viable count. Table 4.3 also shows that white Fulani milk had significantly higher coliform count when pasteurized compared

to New Jersey and the mixture of the two. Again this was followed by the New Jersey with a coliform value of 2.467 x 10^5Cfu/ml. The coliform value of mixture was 1.841 x 10^5Cfu/ml. Similar trend was also observed for the faecal count. However, the LB count of New Jersey was significantly higher than all Fulani and the mixture.

Table 3

Multiple comparison using the new duncan range test

		TVC	CC	FCC	LBC	FC
Materials	Aluminum	4.430a	3.015a	0.337a	0.115a	3.004a
	Stainless steel	2.519b	1.856b	0.000b	0.800b	1.456b
	Galvanized Steel	3.048c	2.270c	0.000b	0.611c	1.952c
Temperature	61	3.256a	2.126a	0.337a	0.582a	1.878a
	66	3.693b	2.848b	0.000b	0.648b	2.096b
	71	3.048c	2.167c	0.000b	0.296c	2.437c
Source	White Fulani	3.778a	2.833a	0.337a	0.333a	2.444a
	New Jersey	3.426b	2.467b	0.000b	0.811b	2.156b
	Mixture	2.793c	1.841c	0.000c	0.382a	1.811c

Mean with the same alphabet are not significantly different from each other
TVC =Total Viable Counts, CC= Coliform Counts, FCC= Feacal Counts, LBC=Lactobacillus Counts, FC= Fungi Counts

Graphical illustrations of the fungal counts of pasteurized milk disaggregated by temperature and milk source.

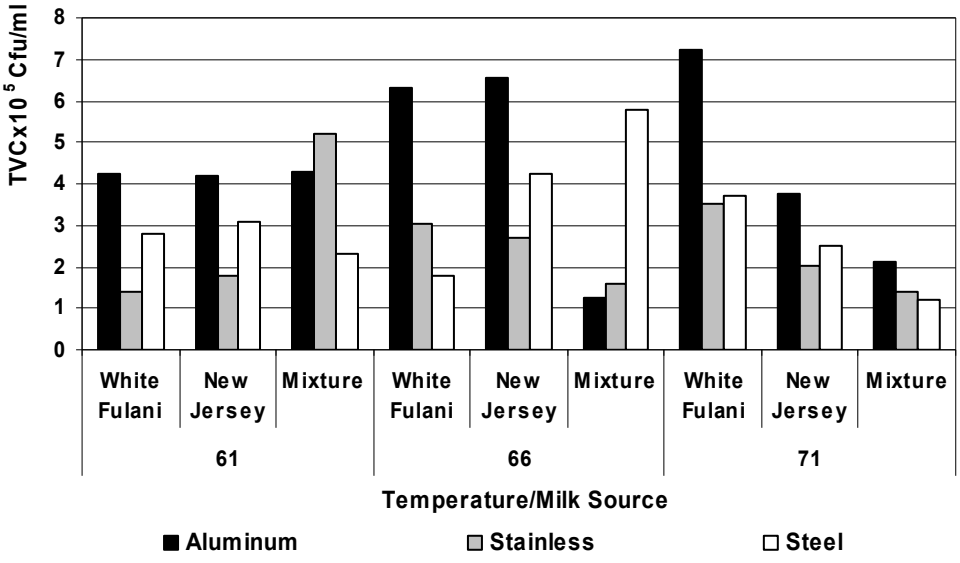

Figure 1. Chart showing the graphical illustration of the total viable count in applied temperature and milk Source

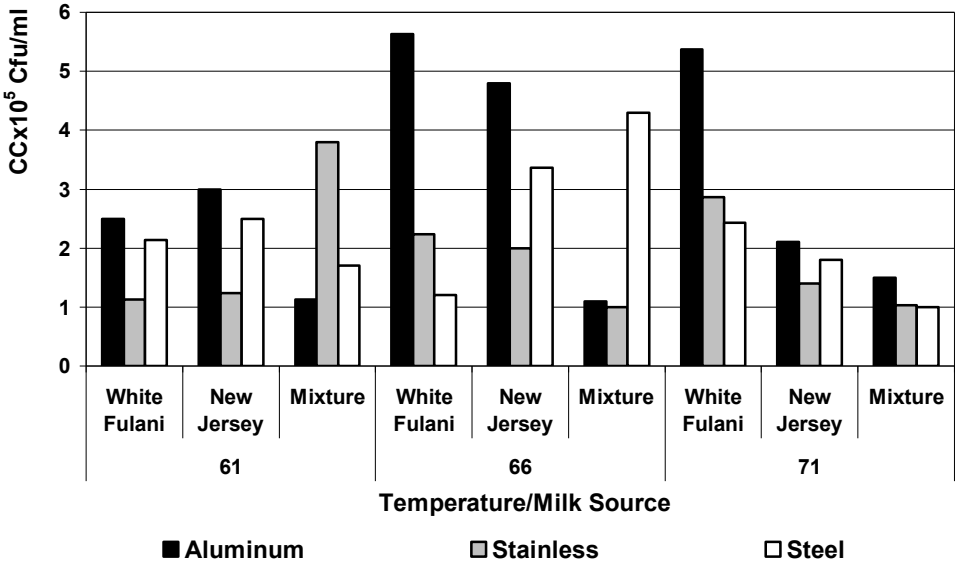

Figure 2. Chart showing the graphical illustration of the coliform count in applied temperature and milk source

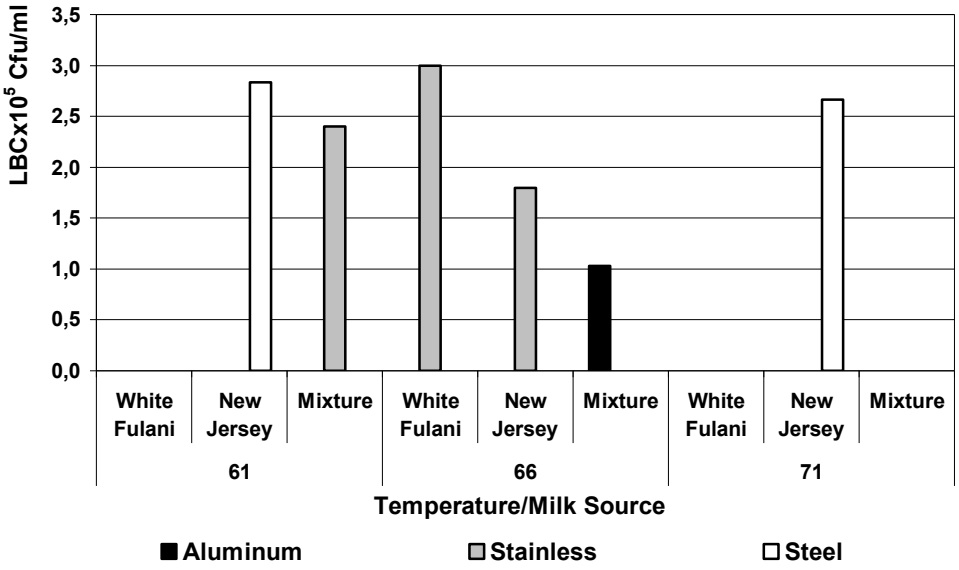

Figure 3. Chart showing the graphical illustration of the LB count in applied temperature and milk source

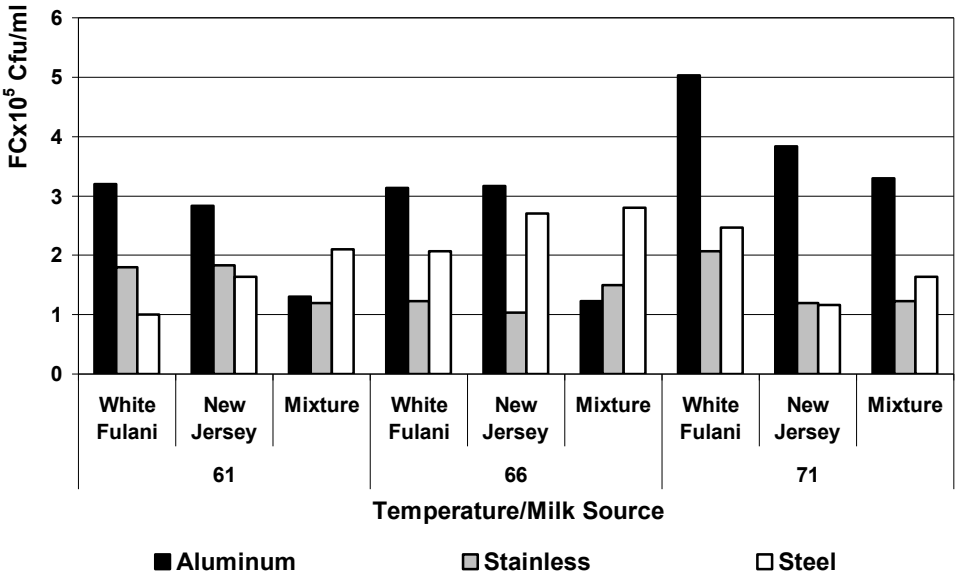

Figure 4. Chart showing the graphical illustration of the fungal count in applied temperature and milk source

It could observed that at 61°C, aluminium has the highest fungi count (5.55%) of the total fraction for the White Fulani breed then followed by stainless steel (3.12%) and galvanized steel (1.73%), then same trend in the New Jersey breed also followed with aluminium (4.98%), stainless steel (3.18%) and galvanized steel (2.83%). This was reduced in the breed mixture where galvanized steel (3.64%) has the highest fungi count, then aluminium (2.25%) and stainless steel (2.08%) at the same temperature. Also, at 66°C aluminium material showed the highest FC both in the local (5.49%) and the foreign breed (5.43%) of the total fraction, which is then followed by galvanized steel (3.58%, 4.68% and 4.85%) for the White Fulani, New Jersey and the breed mixture respectively, leaving stainless steel with the least count of (2.14%, 1.79% and 2.6%) for the local breed, foreign breed and breed mixture respectively. Finally, at 71°C, aluminium has the highest count (8.72%, 6.64% and 5.72) for the White Fulani, New Jersey and the breed mixture respectively. For stainless steel, the percentage count were (3.58%, 2.08% and 2.13%) for the White Fulani, New Jersey and the breed mixture respectively, and for the galvanized steel the percentage count of the whole fractions are; 4.28%, 2.02% and 2.83% for the White Fulani, New Jersey and the breed mixture respectively. In this study, stainless steel showed the lowest microbial growth probably due to it thermal properties or density. It could be the same reason why it is preferred by farmers for milk storage as reported by [11].

Conclusions

It can be concluded that within the scope of this research, in order to get a low bacterial counts, the temperature of 71°C should be used for pasteurizing using a stainless

steel for 15second indicating high temperature short time pasteurization. Also, in order to get a low fungi counts, the temperature 61°C should be used for pasteurizing using a stainless steel for 30minutes. It can also be concluded that the milk sourced from the New Jersey breed (foreign breed) will cause little health risk compared to the locally sourced white Fulani breed.

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Classification of maturity indices of mango fruit for safe harvesting and storage

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Abstract

Introduction. Immature harvesting, latex burn and poor postharvest handling practices result in high postharvest losses of mango fruit. Traditionally, Harvesting of mangoes usually takes place before the fruit begins to ripen. Prolonging mango harvesting in order to collect fruits of different maturity stages helped to characterize and analyze their aptitude in regards to ripening.

Materials and methods. Chemical parameters which have established some usefulness for decisive maturity of the fruit before harvest are the solid content, acidity, carbohydrate content, volatile compounds, vitamin content, sugar and phenolic constituents. Physical parameters, such as shape and size, surface and flesh color and hardness, shoulder development, specific gravity, heat units have been used. None of these parameters are foolproof methods for determining internal quality of the fruit.

Result and discussion. This situation acquires more complicated when different varieties are involved. Assessing maturity requires a combination of parameters coupled with considerable experience. Therefore, variations in fruit maturity are bound to be inevitable in commercial harvest using existing practices. Artificial stimulated ripening could result in poor quality mango fruit. Therefore, harvesting at optimum stage of maturity using maturity indices is extremely important. In different countries numerous studies have been carried out to determine the optimum stage of maturity for harvesting of mango fruit. The criteria used are based on physical characters, chemical constituents and respiratory pattern. The decision as to time of harvest for a given fruit must be made to provide margin of safety for marketing and to supply the consumer with fruit of good quality. This situation must be improved in order to compete in the profitable export and local marketing of mango.

Conclusion. Emulating the manual judgment of maturity which involves pressing the fruit with fingers, by measuring the fruit response & color, may provide a reliable method closely related to consumer acceptance.

Introduction

Mango (*Mangifera indica*) is produced in most frost free tropical and sub-tropical climates. About 100 countries grow mangoes, about 80% of production comes from the top nine countries in order of production i.e., India, China, Indonesia, Mexico, Thailand, Pakistan, Brazil, Philippines and Nigeria. The main exporting nations include Mexico (23% of production), Brazil (14.3%), Pakistan (3.2%), Peru (10.3%) and India (9.71%). The largest importing destinations are the European community (34%), USA (20%), Arabian Peninsula (14%) and Asia (27%) (FAO STAT, 2005). Mango is one of the major fruits of Pakistan which is mainly grown in the Punjab and Sindh provinces. Mango season starts with harvest from Sindh province in late May and finishes in Punjab in late August. Major mango varieties grown are *Sindhri* and *Chounsa* whereas other varieties *Dosehri, Malda, Swarnarika, Langra, Siroli, Alphonso, Gulab Khas, Fajri, Golden, Anwar Ratol and Began Phali* are also grown in some parts of the Sindh and Punjab provinces. Sindhri is mainly grown in Sindh as against Chounsa which dominates in Punjab, both are deliberated by industry as good varieties in terms of perception in the domestic and international markets (PHDEB, 2005).

The decline in export of mangoes can be attributed to lack of proper post-harvest handling which is yet a significant reason of poor quality of this fruit. Factors such as a fruit shelf life, ripening and low temperature storage facilities available at the export destination and good agricultural practice certification are significant limitations to the trade. Moreover, farmers are not able to decide the proper time of fruit maturity. Despite stronghold in global production, leading mango producing countries are not the market leaders. Pakistan enjoys fourth position in the mango exporting countries, contributing about 9% in global mango exports. Mexico standing fifth in the mango-producing countries, occupies first position in mango exporting countries and enjoys 23% share in global mango exports followed by India and Brazil which contribute 17% and 12% respectively. (FAO STAT, 2007).

Mango being a climacteric fruit possesses a very short shelf life and reaches to respiration peak of ripening process on 3 or 4 day after harvesting at ambient temperature. Fruit fly infestation is one of the major factors affecting exports of mango from Pakistan. All major mango varieties especially chounsa, sindhri and other late season mango varieties in Pakistan are prone to fruit fly infestations. In the global market the attractiveness of mango is owing to its stunning colour, striking fragrance, pleasing flavour, good taste and healthy nutritional profile. While considering the losses of mango fruit after harvesting especially considering the developing countries, then the post-harvest losses of other fruits are extremely conspicuous. The losses are basically due to the mango fruit harvesting at inappropriate maturity, offensive field handling, chilling injury, fruit softening, mechanical injure, decay of mango fruit, squishy tissue, sap burn and pest or disease damage. The basic nutritive and quality losses occur due to poor harvesting, rigid fruit packing, by using inappropriate transportation and meager field management. (Narayana *et al.,* 1996).

Ability of exporters to comply with the requirements of importing countries has established their stronghold in mango exports. Export of mango from Pakistan is highly concentrated in few markets. Major markets for Pakistani mangoes include United Arab Emirates, Saudi Arabia and Oman. Increased shipping facilities at cheaper rates, flexible and less stringent food safety requirements are other factors affecting export of mangoes in these markets. Although, Pakistan is one of the leading producers of mango, it is unable to harvest its full potential for exports. Traditional varieties of mango, improper orchard management, poor post-harvest handling, marketing practices and lack of compliance to

international standards are some major factors which have set limits in the expansion of mango exports from Pakistan. Many Importers in the developed markets particularly demand traceability of food along with compliance to HACCP, Euro-GAP, Global GAP and other standards. Mango requires careful handling in the supply chain. Controlled temperature, proper packaging and transportation in reefers determine freshness of mango and its shelf life. Infrastructural development (particularly roads and storage) can enhance marketing efficiency of this delicate fruit. International market for mangoes is characterized by increasing competition due to supplies coming from various geographical sources throughout the year. As such, export of mango is very competitive at the global level and demands improvement in the production and marketing systems in line with changing requirements of the international markets.(PHDEB, 2005). Countries which developed this capability overtime have surpassed others in the export of mangoes.

Poor post-harvest management affects quality and volume of marketable surplus. These factors caused huge post-harvest losses which ranged from 25-40% of total mango production in the country. Current status of infrastructure is identified as one of the major reasons for these losses as significant portion of national highways is in poor condition significantly adding to transportation cost thus reducing export competitiveness of the country in international market especially for perishable products. Limited shelf life is another reason limiting export of mangoes from Pakistan mainly in the Middle Eastern markets. As such, export to distant markets is lifted increasing marketing cost and reducing competitiveness of Pakistani mangoes as compared to other mango exporting countries. Enhancing shelf life and developing sophisticated storage techniques are suggested as possible measures to increase export of mangoes from Pakistan. (PHDEB, 2005).

Quality of fruit consists of various attributes and is defined differently by various researchers. One of the major quality characteristics, however, which is directly related to consumer acceptance, is the fruit maturity at harvest. While in general usage, "mature" is a term that is synonymous with "ripe," most postharvest technologists consider "mature" to the stage at which a commodity has reached sufficient development that after harvesting and postharvest handling, its external and internal quality will be at least the minimal acceptable. External fruit maturity indices such as color, size, and shape provide only approximate information on the internal quality characteristics. If an immature mango fruit is harvested, it will not ripen at all, or ripe improperly. On the other hand, an over-ripe mango fruit will decay rapidly after harvest. In addition, mangos on the same tree mature at different times, making harvesting at the right time a handicap for farmers, exporters. An optimal index of maturity for harvest is especially crucial for fruit destined for export because of the long shelf-life required. Consumers generally prefer to buy ripe fruits, and it is important to maintain a consistent quality of fruit on the shelves. (Medlicott et al., 1988).

Ripening process takes place within 9-12 days postharvest at ambient temperature, depending on cultivar and stage of fruit maturity at harvest. Mango fruit are usually harvested at the green stage (unripe) when they are physiologically mature but before the onset of the climacteric rise. Mature hard green mango fruit attains superior eating quality when ripe while immature ones do not. Therefore, discrimination between mature and immature fruit at harvest and measurement of harvest quality of hard green mango fruit is very important from the marketing point of view. The process of mango fruit involves numerous biochemical changes including increased respiration, ethylene production, fruit softening, and development of pigments, metabolic activities leading to changes in carbohydrates, organic acids, lipids, phenolics, volatile compounds, structural polysaccharides and softening of texture to acceptable quality (Gomez-Lim, 1997). The ripening time greatly depends on the maturity stage of fruits at the harvest. Fruits harvested

at a less mature stage stay green for a long time before ripening, than those harvested later. This fact is apparently typical of climacteric fruits, and has been observed on many cultivars of mango (Baldwin, 1999).

Harvesting fruit at optimum maturity to maximize the eating quality when ripe has traditionally been done using visual signals from fruit shape internal flesh colour and skin colour. Some visual signals are weak, making maturity determination difficult in immature fruit. Over recent years several instruments and methods have been developed. Immature mangoes do not ripen naturally. Artificial stimulated ripening could result in poor quality mango fruit. Therefore, harvesting at optimum stage of maturity using maturity indices is extremely important. In different countries numerous studies have been carried out to determine the optimum stage of maturity for harvesting of mango fruit. The criteria used are based on physical characters, chemical constituents and respiratory pattern. (Bally 2011)

Materials and methods

Chemical parameters which have established some usefulness for decisive maturity of the fruit before harvest are the solid content, acidity, carbohydrate content, volatile compounds, vitamin content, sugar and phenolic constituents. Physical parameters, such as shape and size, surface and flesh color and hardness, shoulder development, specific gravity, heat units have been used. None of these parameters are foolproof methods for determining internal quality of the fruit.

Result and discussion

Maturity Indices. Maturation is the stage of development leading to the attainment of physiological maturity or horticultural maturity. This stage is very important for deciding when a given commodity should be harvested to provide marketing flexibility and to ensure the attainment of acceptable eating quality to the consumer. Commercial maturity of a plant or plant part is a stage of development at which those parts are ready for use by consumers for a specific purpose (Hofman, 2009, Dhatt and Mahajan, 2007). The decision as to time of harvest for a given fruit must be made to provide margin of safety for marketing and to supply the consumer with fruit of good quality. There is no particular parameter for judgment of fruit maturity. Physical, biochemical, and physiological parameters are used to define the maturity stage for harvesting of fruits usually (Jha and Matsuka, 2000).

Maturity at harvest plays an important role for postharvest life and eating quality, in particular for climacteric fruits where ripening is regulated by ethylene (Dhatt and Mahajan, 2007, Lelièvre, 1997). Harvest date, a parameter going along with maturity of fruit, contributes to quality and maturity of fruit. Fruits harvested at an immature stage may not achieve normal ripening characteristics (Léchaudel and Joas, 2006). On the other hand, an overripe fruit may deteriorate quickly after harvest (Tefera et al. 2007). Fruits take more time for lesser mature fruits, which ripen at the same thermal regime. If fruits are harvested too early their consumption quality is not acceptable (Bron and Jacomino, 2006). Jha et al. (2006a) reported that the storage longevity of fruits was closely related with the level of maturity at which the fruit was harvested. Maturity stage of fruit contributed to quality not only of fresh fruits but also of processing products as canned and canned puree fruit (Olaeta et al., 2003).

Normally, several harvest indices are used to determine picking times such as size, skin and pulp color, acidity, sugar content, flesh firmness, and calendar day from bloom to harvest (Crane et al., 2009). Mango picked at wrong stage of maturity develops physiological disorders in storage and exhibit poor quality in market. More over ripe mangoes are prone to physical damage, decay and bruising. Fruit harvested before it reaches to full maturity may not be ripened adequately after harvest, or never ripen. On the other hand fruits harvested when over-ripe are very sensitive to bruising, decay, water loss and quality deterioration with shorter postharvest life. In addition, fruit harvested over-ripe shows defects, such as jelly seeds or jelly pulp very shortly after harvest, and major quantitative and qualitative losses occur (Yahia, 1999).

Harvest in the fully mature, firm, green, pre-climacteric stage and thus shipment is due primarily to airfreight charges, but air transport does have the advantage of speed over sea transport. Sea transport in this condition has been recommended. Based on the degree of ripening changes that occurs under the storage conditions, immature fruit appeared to show extended storage capacity compared to fruit harvested at a more advanced stage of physiological maturity (Medlicott, 1990). The apparent quality of mangoes greatly reliant on time of harvest and maturity stages. Generally there are many parameters can be used to determine maturity stages. These include age, size, skin colour, firmness, and smell. Mango is a climacteric fruit, which means that its core biochemical changes happen during respiration and it undergoes further changes after it is harvested. Volatile compounds, such as ethylene and aromatic hydrocarbons are released during the ripening process. Generally, during maturity stages, the fruits experience a rapid burst in ethylene release, a sharp rise in CO_2 production and a decrease in oxygen levels. (Zakaria et al., 2012).

The ripening process at ambient temperature depends on the cultivar and stage of fruit maturity at harvest. External criteria for determination of harvest maturity has led to the search for additional parameters that are able to reflect a more reliable criterion on the basis of which the harvested mango fruit should develop optimal organoleptic traits after ripening. Therefore, colour of the pulp, sugar levels evaluated by soluble dry extract, titratable acidity and external appearance of mango fruit are assessed in relation to the maturity stage. (Lalel et al., 2003)

Fruits could be categorized into three stages of maturity; immature, half-mature and fully mature based on the morphological characteristics. The immature fruits had the shoulders below the pedicel insertion whereas the half-mature fruits had the shoulders in line with the stem. The selection of adequate maturity indices is very important. The quality during postharvest life of mango fruit is strongly dependent upon the stage of maturity at harvest. To determine the harvest quality, accumulation of starch and dry matter (DM) during maturation has been well defined. An increase in fruit density, or specific gravity (SG) is well correlated with eating quality and suggested the use of flesh color or flesh carotenoids as maturity indices. Harvest maturity of mangoes is observed by using different methods. (Tandon and Kalra, 1983 Kapse and Katrodia, 1997; Ueda et al. 2000; Kudachikar et al. 2001).

1.Total degree days
2.Total soluble solids (TSS)
3.Titratable Acidity
4.Firmness
5.Total Sugar
6.Skin and pulp color

Total degree days. The minimum length of time taken for maturity of fruits varies between 85-95 days after fruit set, but appears to be dependent on the variety and climatic conditions. Since mango trees flower over several weeks and set. Physico-chemical characteristics would not be useful in determining the proper maturity stage for harvesting from one plantation or even from one tree on commercial basis. Mangoes of same variety take different time to set. Harvesting usually takes place after 15–16 weeks of fruit set when they are physiologically mature. It seems as a better index of maturity provided the number of days from flowering to fruiting. recorded some external properties such as the numbers of days after full bloom (DAFB) or days after fruit set (DAFS), shoulder growth, peel color, and an existence of powdery material called "bloom" on the fruit surface; however, these properties may not have a direct impact on the eating quality. On the other hand, chemical properties such as starch or DM might be more appropriate as they are directly related to the eating quality. Nevertheless, measuring the chemical properties is invasive, and thus prohibits the use of the same sample to evaluate eating quality. Due to environmental fluctuations, it varies considerably from one year to year, location to location. It varies from variety to variety such as for 'Dasheri' and 'Langra' 84 days and for 'Chausa' and 105 days. (Kosiyachinda et al. 1984; Amarakoon et al., 1999; Saranwong *et al*. 2004; Anon, 2006).

Color. Development of specific colour of skin & pulp observed for Mango at optimum stages of maturity could be used as an index to determine the stage of harvesting. Even though development of light green color at latter stages of maturity observed. During ripening of the fruits harvested at the optimum stage of maturity, a marked increase in the intensity of yellow colour and reddish yellow colour is observed. Disappearance of chlorophyll from the peel and change of colour from green to red are closely linked to the respiratory action. These changes are due to destruction of chlorophyll thereby revealing the carotene and xanthophyll. There is a change in flesh color during maturation but not noticed to relate with eating quality. Moreover, using flesh color as a harvest index might easily lead to problems with immature fruit. (Amarakoon et al., 1999).

Although skin is the non-edible portion of mango, the mangoes of some varieties contained skin significantly different from others. A gradual increase in weight of stone is also observed with the increase of maturity. The seed (stone) content of some variety differs significantly from others. In ripe stage, Fazli and Gopalbhog have 11.2 % and 13.1 % seed respectively which had analysed statistically and LSD results found significant both at 0.05 % Levels. The inapplicability of fruit density was due to the relatively small air cavity between the seed and endocarp in this cultivar, as it is the main cause of density change in other mangoes (Jaipet et al., 1987).

Total Soluble Solids, Titratable Acidity and pH. Sugars are the major soluble solids in fruits, therefore TSS can be used as an estimate of sugar content. Organic acids, aminoacids and soluble pectins also contribute to TSS. Sugar concentration is expressed in degrees Brix. Total soluble solids (°Brix) is used in some cases as an index of quality and maturity, and mostly as a compliment to other indices such as shoulder development and pulp color. Mostly markets require mango to be harvested with about 9 to 11% total soluble solids (Yahia, 1999). Average TSS of immature, mature and over mature Chaunsa fruits observed 8.0°, 10.5° and 11.5° Brix respectively. TSS at 8 Brix have been taken as indices for full maturity of some varieties of mango (Malik and Mazhar, 2007; Jha *et al*., 2010). The slight variation might be due to the storage conditions and variation of varieties. Similar views were expressed by Manzano *et al*. (1997) who observed that temperature of storage also affect TSS as low (14.15%) at high temperature (25^{o}C) as compared to higher

TSS contents (16.6%) at low temperature (12°C) during 20 days of storage. A series of physico-chemical changes and the major changes increased in TSS content from 8.55 to 19.0 during ripening stored at 18-34°C (Doreyappa- Gowda and Huddar, 2001). Generally, the mango fruit soluble dry extract (SDE), or soluble sugar are higher after ripening than at harvest. After ripening, the values become double those obtained at the time of harvest. The more the harvest time of fruits is delayed, the more the soluble dry extract increased, both with green fruits after harvest and with full yellow ones after ripening. (Dick et al., 2009)

Fruit ripened as evidenced by decreasing acids and increasing solids for all harvest maturities, which is typical for mango (Mitra and Baldwin, 1997). Increase in soluble sugars is a major change during mango fruit ripening, and sweetness is the most important compositional change related to mango flavour (Ho *et al.,* 1997). The increase in TSS with storage might be due to the alteration in cell wall structure and breakdown of complex carbohydrates into simple sugars, hydrolytic changes in starch and conversion of starch to sugar being an important index of ripening process in mango (Kittur *et al*., 2001). As for the effect of storage period on fruit T.S.S content gradually increased with storage. This could be due to the losses in water through the respiration and evaporation during storage and hence the decline in fruit weight (Hussein *et al*., 2001)

Titratable acidity can be expressed as mixture of citric acid, malic acid and tartaric acid.

Percent titratable acidity of Dosehari mango ranged from 0.5% to 0.094% with an average means of 0.28% during storage. Which might be due to the degradation of citric acid or conversion into sugars and their further utilization in metabolic process in the fruit.) who found that titratable acidity values of Alphonso mango either packed in carton or control sample also showed a decreasing trend from 2.17% to 0.08% on 12th day when stored at ambient temperature 27±1°C and 65% RH. (Srinivasa *et al*. 2002; Rathore *et al*. 2007. It is evident that the TSS content increases and % TA decreases with maturity. This is supported by the evidence that the fruits harvested at mature and half-mature stages had higher TSS and lower TA than the immature fruits. Decrease in acidity is due to changes of organic acids, particularly dicarboxylic and tricarboxylic acid in the kreb cycle. Acidity of about 1% have been taken as indices for full maturity of some varieties of mango ((Medlicott *et al,* 1986; Jha *et al*., 2010).

Kudachikar *et al*. (2001) stated that mango (Neelum) at Total degree days (110) after the fruit set predicted lower pH value (3.0) and high acidity (1.9%). Later, pH slightly increase (3.1) and acidity slightly decreased (1.5%) at 110 days after fruit set. pH of the mangoes ranged from 2.5 to 3.5, 2.7 to 4.2 and 4.2 to 5.4 for immature, mature and ripe mangoes respectively. The percent acidity (citric acid) ranged from 0.12 to 0.41 for the different cultivars. The highest titratable acidity was in 'Dabsha' (2%) fruit, but the lowest one was detected in 'Langra' (1.5%), 'El- Madam' (1.8%) and 'Alphonso' (1.5%) fruits. The highest titratable acidity (0.49%) was observed in Sindhri followed by Anwar Ratual (0.41%). The acidity of Samar Bahisht (Chaunsa) and Fajri are non-significant among each other with 0.12% and 0.14% value. (Naz et al., 2014). The acidity of mangoes decreased with maturity. It is due to the breakdown of starch into more sugars thereby lowering down the percentage of acidity of the fruits. As the level of sugars increases weakly on the tree, so the rate of titratable acidity slowly reaches the maximum value, then decreases. Concomitant increase in sugar and acidity during ripening supports the fact that the taste of fruits depends on the sugar-acid balance. (Shafique et al., 2006; Lebrun *et al*. 2008).

pH generally increases with increasing harvest maturity, but for ripe fruit, there were no differences between harvest dates (Lebrun *et al*., 2008). The pH varied significantly and was the highest (5.47) in the fruit pulp of cv. Samar Bahisht Chaunsa. The lowest pH (4.02)

was observed from the pulp of Sindhri. The level of titratable acidity in fruits decrease continuously with the development of skin color and increase in sugar contents till ripening. (Naz et al., 2014)

Firmness. It is degree of softness or hardness, often measured using an instrument called penertometer. It is a measure of hardness of the mango fruit and it plays a crucial role in postharvest activities like stacking, packaging, transportation towards the fruits perishability arising from mechanical damages. Proper units are used for expressing firmness i.e., Newton. Loss in fruit firmness with the progress of storage period is due mainly to decomposition, enzymatic degradation of insoluble protopectins to more simple soluble pectins, solubilization of cell and cell wall contents as a result of the increasing in pectin esterase activity and subsequent development of juiciness and the loss in peel and pulp hardness. Fruit softening and cell wall changes are principal changes associated with fruit ripening. Firmness measurements, as an indicator of product quality, have been extensively studied; some instruments such as the Magness-Taylor fruit pressure tester and its various derivatives have been widely used. Firmness of eight mango hybrids under ambient storage using a TA + Di Texture Analyzer was analyzed. Peel and pulp firmness decreased about 30% and 5%, respectively, during the storage period of thirty days. Peel firmness of 5 N and pulp firmness of 0.3 N could be considered as threshold point below which the fruit may not be acceptable for consumption. (Yaptenco et al., 2013).

Vitamin C. Ascorbic acid (vitamin C) percentage varied significantly according to mango varieties. Gradual decrease in vitamin C content is observed with the increase of maturity. The decreased vitamin C contents in fruits during ripening may be ascribed to the vulnerability of vitamin C to oxidative destruction. Fazli contains 90.3 %, 56.5 % and 43.5 % vitamin C at immature, mature and ripe stages respectively (Shafique *et al*., 2006). Vitamin C percentage in some mango increased up to maturity, thereafter decreased at ripe stage (Abourayya et al., 2011). The highest vitamin C contents were obtained from pulp of mango. Langra (165.0 mg/100g) followed by Fajri (159.0 mg/100g). The lowest vitamin C was found in mango Anwar Ratual (126 mg/100g). (Naz et al., 2014)

Sugar. A gradual decrease in non-reducing and reducing sugars is evident until maturity attains. When the fruits started to ripen on the tree i.e. after about 96 days from fruit set, a decrease in reducing sugar was noted. The soluble sugars of the fruit pulp consist mainly of glucose, fructose and sucrose. Increase in the percentages of fruit reducing sugars content could be due to the hydrolysis of sucrose during storage, yielding reducing sugars (glucose and fructose) (Hassan *et al*., 2004; Shafique *et al*., 2006).

The rate of starch accumulation was rapid at the beginning of fruit growth and slowed down later but it continued to increase up to maturity. (Shafique et al., 2006)

There is no significant difference in total sugar, reducing sugar, fructose and sucrose contents. Glucose content decreased slightly during maturation, however this amount was too small to affect the total sugar changes. (Saranwong et al., 2004). Contrary, reducing sugars content, gradually, increased in the fruits during the cold storage. At the beginning of ripening, reducing sugars make up most of the sugar content, while there are more non-reducing than reducing sugars in completely ripe fruit (Brecht and Yahia, 2009). Maximum sugar content are found in fruit of Langra, followed by Dusehri. Non-significant variation among Langra, Samar Bahisht Chaunsa and Anwar Ratual. While minimum sugar contents are found in cv. Sindhri (16.00%). (Jilani *et al*., 2010; Naz et al., 2014).

Conclusion

Extending harvest of mangos in order to collect fruits of different maturity stages helped to characterize the fruit and to analyse their aptitude in regards to ripening. Fruit should be harvested at the ideal stage in order to develop the most adequate organoleptic quality and the longest postharvest life by using appropriate equipments.

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Investigation of water binding in sponge cake with extruded corn meal

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Abstract

Introduction. Using of extruded corn meal in sponge cake technology affects the water binding with the material, and therefore, the final product quality.

Materials and methods. The water binding in sponge cake with extruded corn meal (ECM) and wheat flour (WF) in the ratio of ECM to WF as 20 to 80% as well as 50 to 50% have been studied by using thermal analyzer DERIVATOGRAPH Q-1500D in dynamic mode.

Results and discussion. The results of the differential thermal analysis of the sponge cake suggest similar behavior and properties for all samples. There are three temperature ranges present based on the DTG and DTA curves showing three endothermic effects associated with different types of water release. They differ in strength of water binding with components. The differences in binding strength of polysaccharides adsorption centers and protein's hydroxyl groups have been established. They are revealed in peak asymmetry of DTA curves and presence of several peaks. The most significant division of endothermic peak into several partial peaks has been identified in the sample containing 50 % of extruded corn meal.

Adding extruded corn meal causes redistribution of water binding. It has established that the amount of bulk and easy bound water reduces, and amount of strongly bound water increases. Such relation becomes evident with increase of extruded corn meal to 50%; moreover the amount of strongly bound water within the range of 227-308°C also increases. The presence of greater amount of bound water within the system will enable improving technological properties of sponge cake during its baking and storage. It has been also proved by slowdown of water loss in baked product during its storage.

Conclusion. Taking into account the water binding in sponge cake with extruded corn meal allows improving of technological properties of sponge cake during its baking and storage.

Introduction

In pastry industry the wheat flour is traditionally used, however, its technological capacity for some types of dough, including egg sponge dough, is not always reasonably used due to expected decline of flour "force". Moreover, pastry producing technology does not require white flour since the recipies include food colourings and flavorings that can significantly affect sensory properties of the final product. Expanding pastry assortment due to identifying the alternative products able to replace wheat flour partially or completely for the purpose of reasonable baking is actual and its importance has been confirmed by several studies [1,2, 3, 4, 5, 6].

This tendency is also supported due to the fact that alternative cereal meals do not contain fibrinous protein that in large amount negatively affect egg sponge dough structure. It is known that for sponge cake cooking it is recommended to use low or medium gluten wheat flour [7], otherwise the crumb will be dense with underdeveloped sponginess. One possible solution to it is using extruded corn meal that has good taste and aromatic properties and that are good enough for sponge cake technology [8].

Sponge cake is a fluffy, fine-porous pastry, with soft elastic crumb. It is obtained by whipping egg with sugar and following stirring of the whipping mix into flour and subsequent baking. Forming and maintaining of the sponge cake quality significantly depends on water binding. Water of wheat dough exists in several different forms, namely bulk water, adsorption bound water and osmotically bound water [9].

The final quality of cakes depends on kinetic characteristics of production process, namely water release during high temperature treatment. In the process of baking the dough is influenced by heat treatment after which it acquires qualitatively new features, which form sensory, structural and mechanical properties, nutrition value, and stipulate transporting and storage conditions. At this stage the egg sponge dough structure fixation occurs due to denaturation of proteins, starch gelatinization and air bubbles expansion with further bubble division and coacervation. Besides the loss of water from product surface due to evaporation with its subsequent migration to product surface and release into furnace atmosphere happens. [10, 11].

Formation of the porous structure of sponge cake mainly occurs during the first third of total baking time. Its fixing happens on the last baking stage and during cooling and resting. Obtaining homogeneous structure with rounded pores vary depending on baking parameters. The temperature and duration of baking affect expansion of the dispersed air phase and formation of foam structure of the final product, being fixed during starch gelatinization, denaturation of proteins and hardening through evaporation [2, 10, 11]. Studying the water binding in sponge cake and their modification during heat treatment will allow controlling baking parameters and quality of the final product.

Studying the change of water state in foods during heat treatment can be carried out based on kinetic parameters of endothermic processes that occur with change in weight showed by differential thermal analysis. This method is based on the assumption that at constant heating rate the weight variation or heat absorption by the system at the beginning of the fixed area, as well as maximum process development are proportional to conversion rate constant for each temperature [12, 13].

The aim of this work is the studying of water binding and its influence on sponge cake structure by adding extruded corn meal with applying the method of differential thermal analysis.

Materials and methods

The study objects are:

- Sample 1: sponge cake, prepared following the standard recipe and technology (control sample);
- Sample 2: sponge cake, made with adding extruded corn meal (ECM) in the proportion to wheat flour (WF) as 20: 80%;
- Sample 3: sponge cake, made with adding extruded corn meal (ECM) in the proportion to wheat flour (WF) as 50:50%;

Studies ware carried out 8 hours after sponge cake baking and resting. The samples of sponge cake were kept unpacked at (20 ± 2)°C and relative humidity (75 ± 2)%.

Thermogravimetric observations were made in ceramic crucibles under quartz cap with 2g sample weight, in thermal analyzer DERIVATOGRAPH Q-1500D set in dynamic mode. The Al_2O_3, heated to 1500°C was used as a standard reference material. The samples were heated to 500°C with the rate of heating 2,5°C/min. Determination of water binding amount was made by analyzing the temperature curve (T curve), weight change (TG curve) and its derivative (DTG curve) as well as enthalpy (DTA curve) [13, 14, 15].

Weight loss of sponge cake during baking was defined by standard method, as the difference between the dough weight before baking and the weight of the baked product [16, 17, 18].

Results and discussion

The proportion between bulk and bound water, also bound water distribution within the product biopolymer are significant in studying of sponge cake properties and its capacity to maintain freshness. The main water binding components in baked goods are starch, egg white and pentosan. The total amount of water absorbed by the dough is calculated as follows: 31.1% is adsorbed by proteins, mainly osmotically, 45.5% is adsorbed by starch, and 23.4% is adsorbed by pentosan [1].

It is known that the bound water is divided into three groups: physic-chemical bound, physic-mechanical bound and chemical bound water. Physical and chemical group includes structurally and osmotically bound water; however, it is free-bound water due to low binding energy. The free water is the water of physical and mechanical binding. Chemically bound water makes part of solids and may release only by thorough heating, so it is generally not considered with foods.

The differential termographs obtained during analysis of the control sample, the sample made of flour mixtures of extruded corn meal (ECM) in proportion to wheat flour (WF) as 20:80% and as 50:50% after 8 hours of resting are shown in Fig. 1- 3.

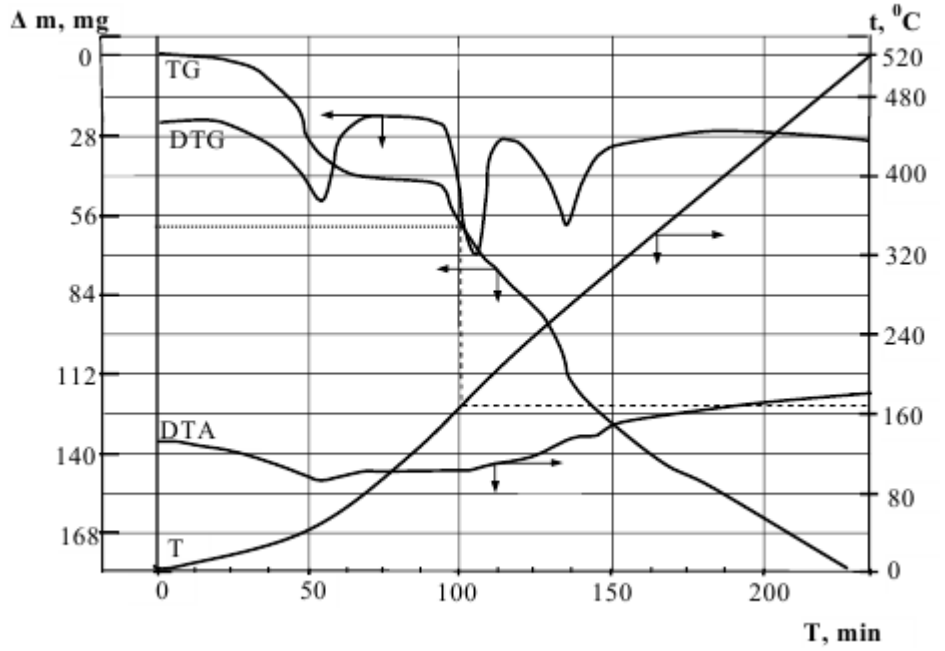

Fig. 1. Differential termographs of sponge cakes (control sample)

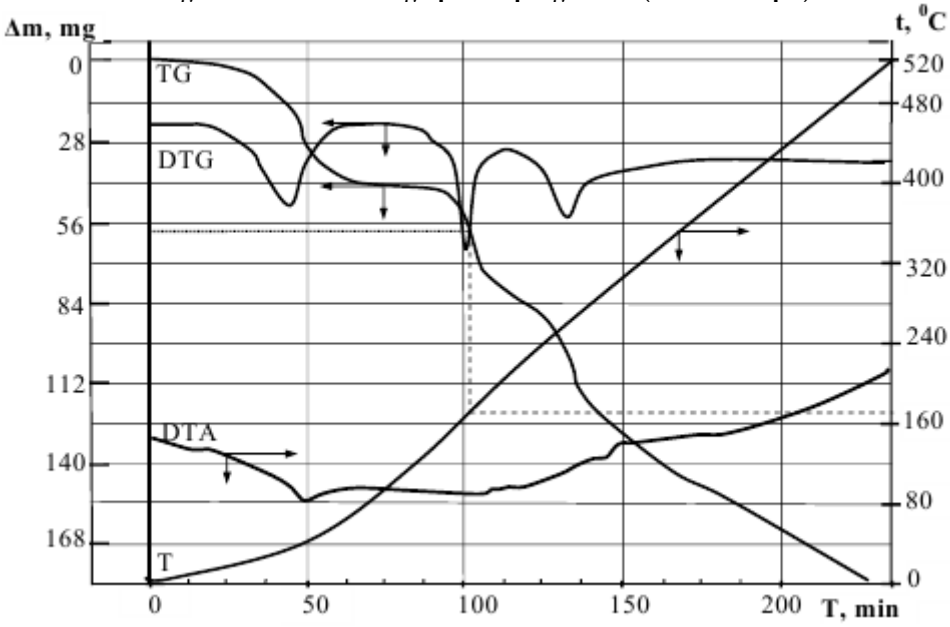

Fig. 2. Differential termographs of sponge cakes (ECM:WF is 20:80%)

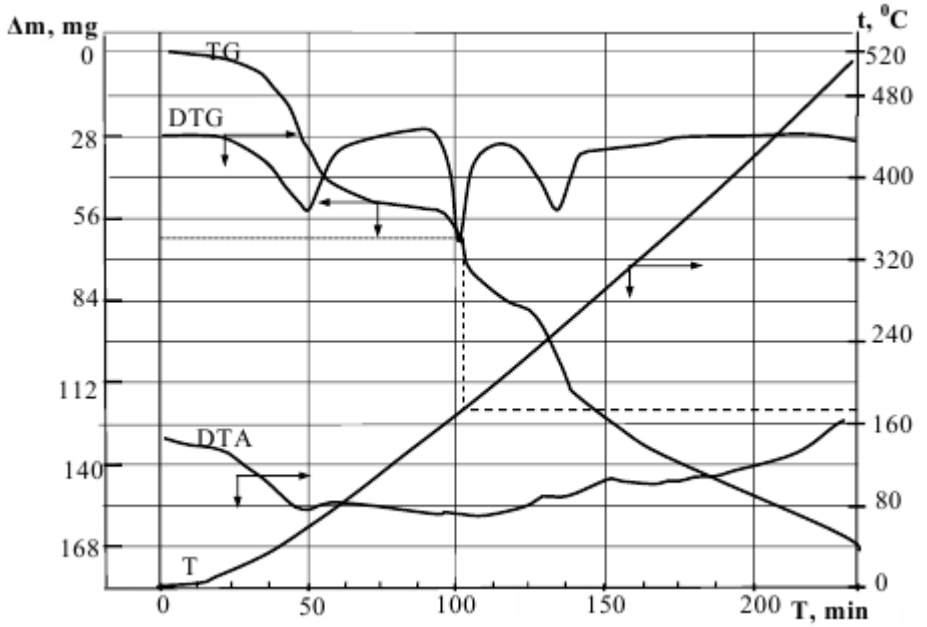

Fig. 3. Differential termographs of sponge cakes (ECM:WF is 50:50%).

DTG curve peaks indicate to the processes occurring with the loss of the sample's wight. It may be assumed that weight reduction happens due to loss of water in the studied sponge cake. The process of water release from all the test samples occurs in three stages since the DTG and DTA curves show three endothermic effects.

The analysis of differential termographs of sponge cakes suggests some similar patterns for all dough samples. In particular, all three temperature ranges are present, each associated with release of various water types differing by strength of binding with other components.

During the first phase within the temperature range 40-100°C almost linear change of sample weight loss and insignificant water loss up to 6% occurs. Such phenomenon is common to all samples. Obviously, during this stage release of bulk water in large capillaries and sponge cake pores takes place.

Within 140 - 205°C temperature range the intensity of water release out of the dough increases and temperature change rate of the sample slows down. It may be assumed that within this interval the water bound with polysaccharides adsorption centers and protein's hydroxyl groups releases. The differences in binding strength of such centers are revealed in asymmetry peak of DTA curves and presence of several peaks. The greatest division of endothermic peak into several partial peaks occurs for the sample containing extruded corn meal 50%.

The significant amount of water releases with further increase of temperature: up to 22.8% for the control sample at the temperature of 295°C; for the sample containing 20% of extruded corn meal up to 25.6% water releases at the temperature of 308°C; for the sample containing 50% of extruded corn meal up to 27.2% water releases at the temperature of 303°C. The information on the content of bulk and bound water in the cake samples during heat treatment is shown in the Table 1.

Table 1

Water content of sponge cake

Stage	Sample 1 Контроль – 100% WF			Sample 2 ECM:WF – 20:80 %			Sample 3 ECM:WF – 50:50 %		
	Temperature maximum, °C	Released water, mg	Water content out of total water, %	Temperature maximum, °C	Released water, mg	Water content out of total water, %	Temperature maximum, °C	Released water, mg	Water content out of total water, %
Bulk water									
1	77	30	6	75	26	6	88	30	6
	83	36	7	100	34	8	100	42	9
	100	42	8						
Bound water									
2	140	44	9	145	38	9	150	48	10
	198	60	12	198	58	14	205	60	13
3	227	74	15	230	72	15	240	76	16
	268	100	20	275	92	22	280	100	20
	295	114	23	308	110	26	303	128	26

To obtain the data on the mechanism of water release on TG curves the degree of weight change α of control cake sample and the one containing extruded corn meal (Fig. 2) was calculated; then the relation | -lg α | to inverse temperature value1000/K was plotted down.

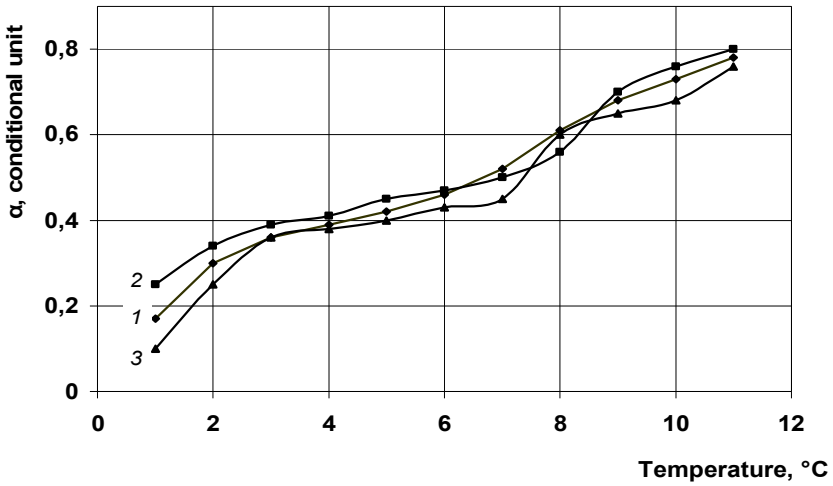

Fig. 4. The relation of weight change on temperature of sponge cake:
sample 1 – control;
sample 2 – ECM:WF is 20:80%;
sample 3 – ECM:WF is 50:50%.

The rate of weight change corresponding to the process was used to obtain the relation of weight changes on temperature. With this purpose the sample weight change Δm_1 corresponding to the amount of evaporated water at the given temperature was defined at continuous 20°C temperature internals on TG curve.

The weight change α was calculated as Δm_1 at 20°C interval with the total water contained in a sponge cake, and released at the end of the dehydration process.

The resulting curves in the coordinates α-t (Fig. 4) describe different forms of interaction between water and solids in a sponge cake. The similarity of the curves of water release rate during heat treatment is shown as the result of this interaction. The relation between sponge cake weight change and temperature allows studying the kinetics of water binding. It reflects nearly the same dehydration rate.

On the first stage at temperatures 40 - 100 ° C (Fig. 5, the segment AB) bulk water or mechanically bound water is released. It has low energy of binding with components. In the beginning the water bound by hydrogen bonds is released. Capillary water desorption is characterized by lower values of activation energy compared to the water being released on the second heat treatment stage (segment BC). On the second stage (at temperatures 100-160°C) the release of osmotically bound water that may remain in the molecule cells of proteins occurs. This type of water is released during deployment of polypeptide chains after breakdown of hydrophobic albumen and water reaction. The release of weakly bound adsorption water is also possible. On the third stage (segment CD) at the temperatures of 160-240°C the release of strongly bound adsorption chemically bound water may be assumed.

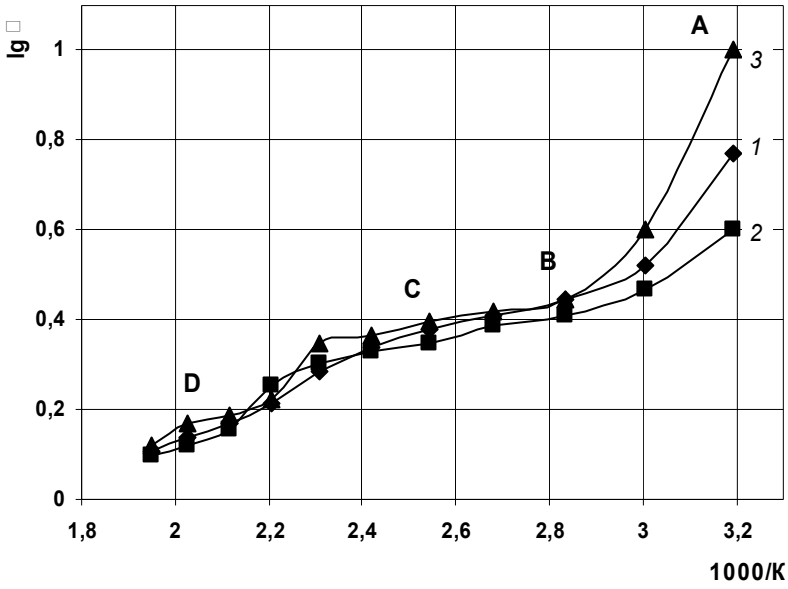

Fig. 5. The relation of weight change degree logarithm on temperature of sponge cake: sample 1 – control;
sample 2 – ECM:WF is 20:80%;
sample 3 – ECM:WF is 50:50%.

The obtained relations show the features associated with the effect of adding meal mixture onto the state of water in a sponge cake. The use of extruded corn meal calls up redistribution of water binding, the amount of bulk and easy bound water decreases and strongly bound water increases. With increase the amount of extruded corn meal to 50%, this relation becomes evident, and strongly bound water increases, corresponding to the range of 227 - 308°C.

More bound water within the system will enable improving the technological properties of sponge cake during its baking and storage.

Baking is the final and the most difficult phase of the process of sponge cake production. During baking physical, chemical and colloidal changes of the dough occur. They define the quality of the final products. During baking weakly bound water is released out of egg sponge dough. The loss of a certain amount of water during baking leads to reducing in weight. The weight loss of a sponge cake depends on baking temperature and duration, also relative humidity of the furnace atmosphere and recipe specifications [7, 10, 11]. Considering the importance of weight loss for the technological process, the influence of extruded corn meal on sponge cake weight loss during baking was defined. It was calculated immediately after baking.

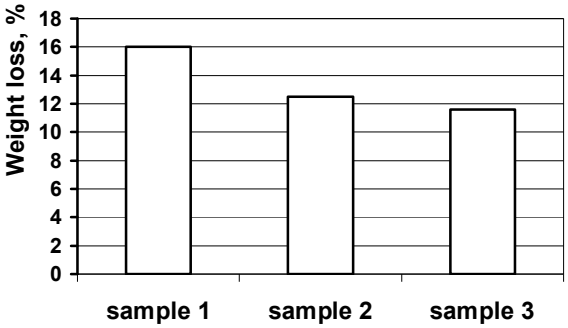

Fig. 6. Weight loss of sponge cakes with extruded corn meal:
sample 1 - control;
sample 2 – ECM:WF is 20:80%;
sample 3 – ECM:WF is 50:50%.

The carried research proves that adding extruded corn meal in the proportion of 20% reduces the product weight loss during baking by (20,0…22.0%), and adding extruded corn meal in the proportion of 50% reduces the weight loss of sponge cake during baking by 27 % (Fig. 6). It happens due to presence of extruded corn meal components that have higher water binding energy compare to wheat flour starch, therefore, they are capable of retaining extra water (confirmed by thermogravimetric analysis of the studied samples).

After being baked sponge cake is supposed to rest at room temperature (15…25°C) according to technological requirements during (6…8) hours for structure fixing. At this time restructuring of water between crust and crumb layers and its loss from the surface occurs. Due to it fixed sponge structure is formed that allows slicing cake without crumb deformation [7, 19, 20]. With account to established capacity of extruded corn meal to better retain water in the system, the studied samples were examined for water loss (drying) after cooling (after 1 hour) and resting at the temperature (20±1)°C (after 8 hours). The research results are reported in the Table 2.

Table 2

Water loss after baking

Samples	Drying values, %	
	1 hour	8 hours
Sample 1 (control)	1,3±0,1	3,4±0,1
Sample 2: ECF:WF – 20:80%	1,2±0,1	2,4±0,2
Sample 3: ECF:WF – 50:50%	1,0±0,2	2,1±0,2

It is seen herewith that adding extruded corn meal to sponge cake slows down the loss of water out of the baked product during its storage. At increasing the proportions of extruded corn meal from 20% to 50 % the weight loss after an hour reduces by 8…20%, and in 8 hours by 18…39%. The obtained results prove the possibility of improving technological features of sponge cake due to partial replacement of wheat flour with extruded corn meal. The established relations may serve prerequisites to slowing down staling of the given pastry group.

Conclusion

The thermogravimetric analysis of sponge cake with different amount of extruded corn meal demonstrates the presence of three temperature ranges, each associated with release of different water types varying in strength of binding with cake components. With increase of extruded corn meal to 50% the amount of bound water increases corresponding to the range of 227-308°C. It enables improving technological properties of sponge cake during its baking and storage.

It has been proved that increase of the final product output and reduce process of weight losses due to using extruded corn meal in the amount of 20% that reduces product weight loss during baking by (20.0 - 22.0)%, and adding of extruded corn meal in the amount of 50% reduces this value by 27%.

Increasing the amount of bound water in sponge cake by adding extruded corn meal, will contribute to extending the shelf life of the product. It has been proved the slowdown of water loss in baked cake during its storage.

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Process conditions governing the drying rate and quality of tomato powder obtained from foam-mat dried tomato paste

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Abstract

Introduction. One of the most effective ways of reducing postharvest losses in food materials is drying. However, prolonged time of drying has the tendency of reducing the quality characteristics of highly perishable produce like tomato.

Materials and methods. Fresh tomato ("dan UTC" variety), foaming agent (egg white), foam stabilizer (Carboxyl Methyl Cellulose), digital scale (OHAUS 3001), laboratory air-oven (model MINO50–10G039), blender (400 W, model number FPO12A). Vitamin C and protein content were determined using AOAC (2002) standard.

Results and discussion. Increase in the quantity of foaming agent (from 5 – 10 %) caused a decrease in drying rate from 20.63 g/h to 18.57 g/h, however, a further increase in foaming agent (10-15 %) caused the drying rate to increase from 18.57g/h to 20.63g/h. Increase in the percentage of foaming agent (5 % to 15 %) led to a slight increase in the values of protein content (from 24.65% to 24.7889 %).Increase in the quantity of foaming agent did not cause the vitamin C content of the dried tomato powder to fall below 1.3 %, however, as the foaming agent increased, the vitamin C content showed a reduction in its values. Increase in the percentage of foam stabilizer (0.15 – 0.75 %) caused an increase in drying rate from 19.33 g/h to 20.62 g/h. The trend in drying rate was also noticed for protein content only that no significant effect in the mean values was noticed at 0.15% (24.69 %) and 0.45% (24.72 %) of foam stabilizer. For vitamin C content, all the mean values were between 1.4 % - 1.49% as the foam stabilizer increased from 0.15 to 0.75 %. Increase in whipping time (3 min to 7 min) caused a progressive increase drying rate (18.9411 g/h to 20.67 g/h) and protein content (24.71 % to 24.72%). However, the vitamin C content did not reduce below 1.4% with increase in whipping time.

Conclusions. Increase in foaming agent (egg white), foam stabilizer (carboxyl methyl cellulose) caused the drying rate and protein content of the foam-mat dried tomato powder to increase to values not below 20 g/h and 24 % respectively. However, the mean vitamin C content reduced but was not less than 1.3 %.

Introduction

Tomato (*Lycopersicum esculentum*) is an important food condiment which belongs to the fruits and vegetable class. It is rich in carotene, vitamins B, ascorbic acid (vitamins C) and other nutrients that are valuable for human growth and health. Tomato is highly perishable in its natural state after harvest due to its high moisture content and high rate of metabolic activities; hence, it is prone to high postharvest losses. In Nigeria, tomatoes are usually produced on a seasonal basis and due to lack of good storage facility, a lot of wastage occurs during the production season and immense scarcity occurs during off seasons. Fresh tomatoes contain 33 % of vitamin C and 3 % of protein per 180 g [1].

Past research has revealed that drying is one of the most practically and economically feasible method of reducing postharvest losses, preventing wastage and prolonging shelf lives of tomato fruits. Also, drying offers significant weight and volume savings, minimizing packaging and transportation costs, and enabling storage of the product at ambient temperature.

Other importance of drying were as reported in [2, 3, 4]. However, a more viable option that can be readily acceptable to the food processing industry is the conversion of tomato paste to powder without any or little change to the quality characteristics via foam-mat drying technology.

The foam-mat drying technology involves drying thin layers of foamed material in heated, un-dehumidified air at atmospheric pressure and it is considerably cheaper than vacuum, freeze and spray drying methods. Before the drying takes place, there is need to first turn the products to be dried into a foamy substance, followed by spreading on mat (flat surface) to form a thin layer. Foam is made up of two phase system having a dispersed phase (usually air) and a continuous phase. The dispersed phase is larger than the continuous phase [5, 6].

A good understanding of the nature of the foams and their physical properties would lead to having a good control over them [7]. Maintenance of the honey comb structure of the foam throughout the period of drying is very important, if not, the purpose of using foam mat method of drying would not be achieved. To ensure this, foam stabilizers such as gelatin, carboxyl methyl cellulose (CMC) and so on are usually added to the material together with foaming agents like egg white or milk. After this, the products are turned to foam via any of the following methods: (i) addition of unlimited amount of air to limited amount of liquid (for example, shaking and whipping); (ii) addition of limited amount of liquid with limited amount of air; and (iii) in-situ bubble development in the liquid [8,5].

Foam stabilizers basically increase the interfacial visco-elasticity of foam lamellae, which subsequently increase the stability of the foam [9]. Xanthan gum as a foam stabilizer is highly adaptable for industrial applications because the temperature of water does not affect its solubility irrespective of the processing temperature [10]. In forming foam, the addition of unlimited amount of air to limited amount of substance to be foamed is popular because of its ease of operation; hence, it is widely used in foam making [11].

One of the most effective ways of reducing postharvest losses in agricultural and food materials is drying. However, prolonged time of drying has the tendency of reducing the nutritional and sensory characteristics of highly perishable produce like tomato. This situation is very common especially when the temperature of drying is high. Converting tomato paste to a foamy substance before drying is a viable option of addressing the aforementioned problems because it will make it to dry faster than the conventional drying process and enhance retention of qualities after drying. Therefore, the objective of this research was to determine the effects of the foaming agent (egg white), foam stabilizer (carboxyl methyl cellulose) and whipping time on drying rate, protein content and vitamin C content of foam-mat dried tomato powder.

Materials and methods

Experimental design. A 3^3 factorial experiment in a Randomized Complete Block Design (RCBD) was used for the study. The factors considered in the experiment were 3 levels each of foaming agent (egg white): 5 %, 10 % and 15 %, foam stabilizer (carboxyl methyl cellulose): 0.15 %, 0.45 % and 0.75 % and whipping time: 3 min, 5 min and 7 min. Each treatment combination was replicated three times, and this made all the experimental runs tested and measured to be 81 in all. The experiment was conducted in the Chemical Engineering Laboratory of University of Ilorin, Ilorin, Nigeria. The average room temperature was about 30˚C and the average relative humidity was not less than 60 % throughout the period of the experiment.

Preparation of samples. Freshly harvested riped tomato fruits ("dan UTC" variety) free from blemish, were procured from a popular market in Ilorin metropolis (Kwara State, Nigeria). They were further graded in order to get better quality for the experiment. After the grading operation, they were washed with clean water to get rid of all external foreign materials. After washing, all the tomatoes were blanched for 30 seconds; the blanching process was done to minimize or stop enzymatic action which would have led to loss of flavor, colour and texture. All the blanched samples were sliced and deseeded with stainless steel knife on a stainless steel tray. After which they passed through the blending process to form tomato paste.

100ml each of the formed tomato paste was then poured into small containers (81 containers). Each container was foamed with varying concentration of egg white (5% 10% and 15%), Carboxyl Methyl Cellulose (CMC) (0.15% 0.45% and 0.75%) according to the experimental treatment combinations. The mixture was then agitated (whipped) to form the foam at whipping time of 3 minutes, 5 minutes and 7 minutes, the 400 W jug-type blender(400 W, model number FPO12A) was used for this process of whipping which was opened at the top to allow the entrance of air to the foam. The digital scale (OHAUS 3001) was used for taking all the weight measurements of this experiment.

Drying procedure. At the end of foam formation, all the samples were spread on flat stainless steel trays (mat) in thin layers (3mm) in preparation for drying in the oven. All the drying operations were carried out in a laboratory air-oven (model MINO50–10G039). A temperature of 70˚C was maintained in the oven for the drying operation of the main experiment. This temperature was in between what was used by [12] and [13] for foam mat drying. Also, the temperature (70˚C) gave better results after using temperatures 70˚C, 75˚C, 80˚C and 85˚C for preliminary experiments in terms of; increased drying rate, good quality of powder and better reconstitution property; this result confirmed what was observed by [12] and [13].The mass of samples on trays were taken on hourly basis in order to determine their drying rates of the drying process. This process of weight measurement continued until the moisture content of samples reduced to an average value of 4.5 % (db) with crispy texture. The average time of drying to achieve this moisture content was approximately 4 hours, however, the control sample took about 8.5 hours to reach 4.5 %(db) moisture content. After the drying process, each sample (dried tomato powder) was immediately scraped from the stainless steel tray and allowed to cool. All cooled samples in small sterilized containers were immediately kept inside desiccators and were taken to the laboratory for quality analysis.

Measurement of output parameters.

Drying rate. The drying rate was estimated using the equation below:

$$d = \frac{d_m}{d_t} = \frac{m_i - m_f}{t} \quad (1)$$

where d is drying rate in g/h;d_m is change in mass sample in g; d_t is change in time in h; m_i is initial mass sample in g; m_f is final mass of sample in g; and t is time in h.

Post-drying qualities. The post-drying qualities of tomato powder were determined using [14] procedures at the Chemistry Laboratory of University of Ilorin, Ilorin, Nigeria. The following post-drying qualities were determined: Protein Content and Vitamin C.

Statistical analysis. All the data obtained from the experiment were subjected to statistical Analysis of Variance (ANOVA) at significant level of ≤ 0.05 in SPSS 16.0 statistical computer software package. A further analysis to compare the means of result among different levels of experimental conditions was also carried out with Duncan's New Multiple Range Test (DNMRT).

Results and discussion

Table 1 presents the result of statistical analysis of variance (ANOVA) of data obtained from the experiment carried out. From the table, foaming agent and whipping time had significant effect on the drying rate with the exception of foam stabilizer at P≤ 0.05. For protein content of the dried sample, only the whipping time had no significant effect. Lastly, all the process conditions had no significant effect on the vitamin C content of the dried sample at P≤ 0.05.The interpretation of the above statement is that all the factors that had significant effect on the output parameters (drying rate, protein content and vitamin C) of the process should be given special attention in this kind of research.

Effect of foaming agent on drying rate, protein content and vitamin C content of foam-mat dried tomato powder. Table 2 shows the effect of foaming agent on drying rate, protein content and vitamin C contents of foam-mat dried tomato powder. From the table, increase in the quantity of foaming agent (from 5 – 10 %) caused a decrease in drying rate (20.63 g/h to 18.57 g/h), however, a further increase in drying rate (10 -15 %) caused the drying rate to increase (from 18.57 g/h to 20.63 g/h). There is no significant difference in the mean values of drying rate for 5 % and 15 % foaming agent. For the protein content, increase in the percentage of foaming agent led to a slight increase in the values of protein content (24.65% to 24.79%); this trend could be attributed to the fact that the foaming agent used (egg white) is usually high in protein. Furthermore, increase in the quantity of foaming agent did not cause the vitamin C content of the dried tomato powder to fall below 1.3 %, however, as the foaming agent increased, the vitamin C content showed a reduction in its values. The result of the quality analysis of foam-mat dried mango pulp showed a significant reduction in ascorbic (vitamin C) with increase in foam thickness [15]. The losses experienced in vitamin C could be due to the heat sensitive nature of vitamins and water soluble nature of vitamin C (i.e. some vitamin C could have escaped along with the moisture during the drying operation). The highest value of protein content (1.55%) was achieved at 5 % foaming agent, although all the mean values were significantly different from each other.

Table 1

Results of the Analysis of Variance (ANOVA) of the effect of process conditions on the drying rate, protein content and vitamin C content of foam-mat dried tomato powder

SV	DF	SS	MS	F	Sig.
	Drying Rate (g/h)				
Foaming Agent	2	25.57	12.79	6.50	0.01*
Foam Stabilizer	2	7.56	3.78	1.92	0.17
Whipping Time (min)	2	14.48	7.24	3.68	0.04*
Error	20	39.36		1.97	
Total	26	10827.85			
	DF	**SS**	**MS**	**F**	**Sig.**
	Protein Content (%)				
Foaming Agent	2	0.09	0.05	31.47	0.00*
Foam Stabilizer	2	0.13	0.01	4.65	0.02*
Whipping Time	2	0.01	0.01	0.40	0.67
Error	20	0.03		0.01	
Total	26	16502.22			
	DF	**SS**	**MS**	**F**	**Sig.**
	Vitamin C content (%)				
Foaming Agent	2	0.15	8.17	309.31	0.09
Foam Stabilizer	2	0.02	0.01	2.76	0.69
Whipping Time	2	0.01	0.01	0.20	0.82
Error	20	0.53		0.03	
Total	26	57.70			

*Significant at P ≤0.05

SV-Sources of Variation; DF-Degree of Freedom; SS-Sum of Squares; MS-Mean Squares; F-variance of group means per mean of within group variances; Sig.-Significant, P- estimated probabilities from experimental data.

Table 2

Effect of foaming agent on drying rate, protein content and vitamin C content of foam-mat dried tomato powder

Foaming Agent (%)	5	10	15
Drying Rate (g/h)	20.63^{a}	18.57^{b}	20.63^{a}
Protein Content (%)	24.65^{a}	24.73^{b}	24.79^{c}
Vitamin C (%)	1.55^{a}	1.44^{a}	1.37^{a}

Means with the same letter are not significantly different from each other at P≤ 0.05

Effect of foam stabilizer on drying rate, protein content and vitamin C content of foam-mat dried tomato powder. Table 3 presents the effect of foam stabilizer on drying rate, protein content and vitamin C content of foam-mat dried tomato powder. From the table it is clearly seen that increase in the percentage of foam stabilizer caused an increase

in drying rate from 19.33 g/h to 20.62 g/h. However, there was no significant difference in the mean values at 0.15 %and 0.75 % foam stabilizer. This clearly showed that the higher the quantity foam stabilizer, the better the structure and durability of the foam. This condition caused a faster escape of moisture during drying, and thus led to higher drying rate. The latter statement was similar to the submission of [9]. The trend in drying rate was also noticed for protein content only that no significant effect in the mean values was noticed at 0.15% (24.6944%) and 0.45% (24.7233%) of foam stabilizer. For vitamin C content, all the mean values were between 1.4 % - 1.49% and they were all insignificant from each other.

Table 3

Effect of foam stabilizer on drying rate, protein content and vitamin C content of foam-mat dried tomato powder

Foam Stabilizer (%)	**0.15**	**0.45**	**0.75**
Drying Rate(g/h)	19.33^{a}	19.88^{b}	20.62^{a}
Protein Content (%)	24.69^{a}	24.72^{a}	24.75^{b}
Vitamin C (%)	1.43^{a}	1.49^{a}	1.44^{a}

Means with the same letter are not significantly different from each other at P≤ 0.05

Effect of whipping time on drying rate, protein content and vitamin C content of foam-mat dried tomato powder. The effect of whipping time on the drying rate and post-drying qualities of foam-mat dried tomato paste is presented in Table 4. The general deduction from the table is that the mean values of all the output parameters were not significantly different from each other with increase in whipping time at $P \leq 0.05$. The aforementioned condition also justified what was noticed on the ANOVA table (Table 1). Specifically, increase in whipping time caused a progressive increase drying rate and protein content. However, the vitamin C content maintained values between 1.42% - 1.48 % with increase in whipping time from 5 min to 7 min.

Table 4

Effect of whipping time on drying rate, protein content and vitamin C content of foam-mat dried tomato powder

Whipping Time (min)	**3**	**5**	**7**
Drying Rate (g/h)	18.94^{a}	20.23^{a}	20.67^{a}
Protein Content (%)	24.72^{a}	24.72^{a}	24.72^{a}
Vitamin C (%)	1.42^{a}	1.48^{a}	1.45^{a}

Means with the same letter are not significantly different from each other at P≤ 0.05

Conclusions

In conclusion, foaming agent had significant effect on drying rate and protein content; while foam stabilizer and whipping time had significant effect on protein content and drying rate respectively of the foam-mat dried tomato powder at $P \leq 0.05$.

Also, increase in foaming agent (egg white), foam stabilizer (carboxyl methyl cellulose) caused the drying rate and protein content of the foam-mat dried tomato powder to increase to values not below 20 g/h and 24 % respectively. However, the mean vitamin C content reduced but was not less than 1.30 % at $P \leq 0.05$.

Furthermore, to get maximum drying rate of 20.67 g/h and maximum protein content of 24.74 % the following combinations of process conditions should be used: foaming agent (15%), foam stabilizer (0.75%) and whipping time (7 min). Also for vitamin C to attain maximum value of 1.47 %, foaming agent should be 5%, form stabilizer- 0.5 % and whipping time should be 5 min.

Lastly, it was generally observed via physical examination that foaming agent at 10% and 15% together with other combinations of form stabilizer and whipping time gave better attractive color of dried tomato powder in terms of deep red and light red. This is in contrast with brown and deep brown colors that were noticed for 5% foaming agent with combinations of other levels of form stabilizer and whipping time.

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Structure stabilization of fermented-milk pastes

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Abstract

Introduction. To prevent moisture separation in fermented-milk products we suggest using unroasted buckwheat grains, which possess moisture-retaining and stabilizing qualities due to the content of mucus, protein, dietary fiber etc.

Methods and materials. In the process of research we have studied stabilizing qualities of granulated to different degree of dispersion unroasted buckwheat grains as the components of the fermented-milk pasta and the effect of its milk-based dosing on the rheological qualities of the products.

Results and discussion. It is experimentally established that a rational ratio between granulated buckwheat grains and solvent (lactoserum) equals to duty of water 4. It is also established that the swelling of unroasted buckwheat grains depends on the size of the particles. The lowest degree of swelling was observed when the particle was not more than 3 mm (15,8%). The highest degree of swelling was observed in samples sized less than 1 mm (22%). This dependence can be explained by the complication of moist diffusion inside indestructible grains' particle. The sample sized less than 2 mm had slightly different figure. Thus the sufficient degree of grain refining is not less than 2 mm. Water-retaining capacities of model samples have increased due to the rising degree of particles' dispersion. The water-retaining capacity was 74% if the particle's size did not exceed 1 mm whereas the particle's size was more than 3 mm, the water-retaining capacity lowered to 65%.

In order to assess the stabilizing effect of the unroasted buckwheat grains we have investigated the rheological qualities of fermented-milk pastes. The amount of serumal-buckwheat and serumal-starch pastes was 10%.

From the analysis of the rheological curves it was found that the model samples of fermented-milk pastes are similar in nature, shear stress in the samples with stabilizing substances is higher (320 Pa for the fermented-milk paste with granulated buckwheat grains, 270 Pa for the fermented-milk paste with a modified starch and 258 Pa for the fermented-milk paste without stabilizer). The stabilizing effect is sufficient to prevent spontaneous whey separation (synaeresis). Thus granulated grains of unroasted buckwheat are not inferior to the stabilizer of industrial production – a modified starch.

Conclusions. The usage of granulated grains of unroasted buckwheat ensures essential rheological features of the fermented-milk pastes and its stability in the storage process, indicating the prospects for further research on the development of fermented-milk pastes' technology with such type of filler.

Introduction

Nowadays, various food fillers and additives are widely used in the dairy industry. It allows to enrich products with biologically active substances, to expand production spectrum, to improve taste characteristics, technological properties, quality. But often the usage of food stuff may lead to spontaneous separation of moisture as in the fresh-made products but also during its storage. To prevent this process one can use the fillers that bind moisture and perform a function as structure's stabilizers [1, 2].

The most commonly used in the dairy industry are: pectin, carbossimetilcellulose, carrageenin, modified starches, both independently and as part of the stabilizing systems. Thanks to this it becomes possible to reduce fat concentration, adjust moisture content and maintain aromatic components [3].

The authors propose to use the stabilizing qualities of unroasted buckwheat, allowing further products' enrichment by biologically active substances. For this research unroasted buckwheat grains *(Fagopyrum esculentum Moench)* were used. Common buckwheat is an annual herbaceous plant. Its grains are often trihedral with an average diameter from 3 to 5 mm. Buckwheat has cream coloring with a yellowish or greenish powdery shades of color and texture. Buckwheat is characterized by its highly nutritious value. It is known that buckwheat consists of 13 – 15% of protein, 2,5 – 3% of fat, 2,0 – 2,5% of sugar and 70% of starch, 1,1 – 1,3% of fiber, which is 1,5 – 2 times higher than in oats, pearl barley, millet and rice [4].

The buckwheat proteins help the body to get rid of radioactive substances and to normalize the growth of children's body. Mainly buckwheat contains globulins (64,5%), albumins (12,5%), glutelins (8,0%) and alcohol-soluble protein (2,9%). Buckwheat protein contains 18 amino acids, grains are rich of arginine and lysine. Buckwheat protein has a high water-retaining capacity, emulsifying and foam forming qualities. These characteristics can be used to change the structure and enhance the nutritional value of products [5].

Thus the buckwheat protein is safe and reliable food ingredient.

The content of unsaturated fatty acids in the buckwheat lipids is about 83,2%, including oleic acid – 47,1% and linoleic acid – 36,1% [4, 6].

Buckwheat is a valuable source of many essential minerals: iron, potassium, phosphorus, copper, zinc, calcium, magnesium, boron, iodine, nickel, cobalt, etc. [4, 7].

Unroasted buckwheat grains contain vitamin E, which has antioxidant properties. Buckwheat is the leading cereals by the content of vitamins B [4, 8].

Unground buckwheat contains a complex of phenolic compounds – quercetine, kaempferol, maurines – besides that it contains the largest amount of rutin, which reduces the level of cholesterol, evinces high antioxidant activity and is widely used in the treatment of some chronic diseases such as diabetes and hypertension, as well as some cardio vascular diseases [4, 9].

Buckwheat's nutritive fibers and mucus possess high water-resistance ability. They can form chelate compounds with heavy metals and cholesterol, suppress the activity of tumour cells and improve metabolism [10].

Traditionally buckwheat is hydrothermally manufactured by hydration and steaming under the pressure of 0,25…0,30 mPa and the temperature of 100°C for 3 – 5 minutes, then it is dried at the temperature of 133…158°C under the pressure of 0,2…0,5 mPa to the humidity level of 12…14%. As a result the shell's adhesives destroy, meanwhile the ferments (such as lipase and lipoxygenase), which contribute to the fat bitterness, inactivate. The process of breathing almost terminates, buckwheat membranes become

more flexible and the core becomes more solid. But during such processing starch gelatinization occurs, dextrin forms, protein coagulates, chlorophyll destroys.

During such processing buckwheat grains lose its stabilizing qualities. Therefore for stabilization it is advisable to use unroasted buckwheat grains. Moreover, unroasted buckwheat is characterized by its low-taste and low-aroma. This fact allows using unroasted buckwheat in the dairy technology.

Analysis of published data. Investigation results of the College of Agriculture and the University of Northwest A&F, Yanhlinn (China) have shown that buckwheat starch granules are mainly polygonal, rarely spherical and oval and the surface of the particles is rough. These characteristics indicate that buckwheat starch can not only be used as the food but also as a food thickener and stabilizer.

Resistant starch is needed to reduce the moisture content in the product. It does not affect the organoleptic qualities and texture of the product, like nutritive fibers do: the starch of white buckwheat in the food does not change its color. The buckwheat starch has low absorbing capacity. As a conventional starch, it can be used as a food additive. Finally, due to the fact that the temperature of gelatinization is high, buckwheat starch can be added to any product which undergoes thermal processing. It will not affect the nutritional functions [11, 12].

Materials and methods

In the process of research we have studied stabilizing qualities of granulated to different degree of dispersion unroasted buckwheat grains as the components of the fermented-milk pasta and the effect of its milk-based dosing on the rheological qualities of the products.

For this purpose entire grains were ground with a help of hammermill and distributed according to its size with a help of wire sieves with the holes of different diameters (1,0; 2,0; 3,0 mm).

Model samples based on whey with a duty water curve 5 were prepared:

sample №1 – whey and buckwheat grain ground to the size of 1 mm and less;

sample №2 – whey and buckwheat grain sized from 1 mm and to 2 mm;

sample №3 – whey and buckwheat grain sized from 2 mm and to 3 mm;

sample №3 – whey and buckwheat grain sized more than 3 mm.

We used the whey from the cheese production. We heated the whey to 40 – 45°C. Constantly mixing we added ground buckwheat grains and heated to 90 – 95° C within 3 – 5 minutes. Then we cooled an obtained serumal-buckwheat paste to (20±2)°C. The usage of entire grains was proved to be impractical, because in the process of boiling heterogeneous consistence with the flakes of intact membranes was observed. Moreover it was needed much more time for grains' boiling (10 – 15 minutes). Therefore it was decided to add the buckwheat in the granulated form.

To determine the degree of swelling of the granulated buckwheat grain we added the whey and heated the mixture to 80°C, keeping it up for 2 min. We were centrifuging the mixture at frequency of 1000 revs/min. for 1 min. After that we withdrew free moisture and determined the mass of the swell granulated buckwheat. To define the rational correlation between granulated grain and serum we have prepared samples with a water duty from 2 to 5.

Water-retaining capacity was determined by Grau-Hamm's gravimetric method in A. Alexeyev's modification, based on the definition of the moisture content released from the

product in the course of mild pressing. For this purpose a batch weighing precisely 0.3 g, is placed on a soft waterproof plate (diameter of 40 mm) and covered with a slowly absorbing ashless filter (diameter of 40 mm) then covered again with a glass plate (diameter of 100 mm). A weight of 500 g is placed on the glass plate. After 7 minutes, the plate is removed, and the plate with a batch is weighed. Water-retaining capacity is estimated by the formula:

$$MRC = (100 \times (a-b))/a$$

MRC – moisture-retaining capacity, %;
a – moisture content in the hanging position, mg;
b – moisture content in released from the cheese hinge, mg.

$$a = 300\ MC/100$$

where 300 is the cheese hinge, mg;
MC – moisture content, %.

An active acidity of the samples was measured using a pH meter/millivolt, with a full scale range of 0 – 14 pH units.

In order to determine the stabilizing qualities of ground unroasted buckwheat grains we have researched the rheological qualities of fermented-milk pastes:

sample №1 – fermented-milk paste without the addition of stabilizer (control);

sample №2 – fermented-milk paste with the addition of a stabilizer of the modified starch (E-1410)

sample №3 – fermented-milk paste with the addition of ground unroasted buckwheat (particles' size is up to 2 mm).

A sample with a modified starch as a stabilizer was prepared as follows. Estimated amount of serum was heated to the temperature of 35...45°C 5% of starch was applied under constant mixing. The mixture was heated to the temperature of 85...90°C. Obtained serumal-buckwheat paste was cooled to the temperature of 20...22°C and brought into fermented-milk base. Dietary soft curd was used as a fermented-milk base. Observations were done with a help of a rotational viscometer. Having immersed viscosimetric rotor in the cylinder, the test product was added in the sufficient amount to fill the cylinder. The indicator of shear stress during viscosimetric rotor rotation at variable speed deformation was determined. The rate of strain was changed by frequency drift of rotor rotation which had been set by the gear switching.

Shear stress was determined by the formula:

$$\tau = Z^{*}\alpha$$

Z – a cylinder constant, Pa/U. of the instrument scale;
α – instrument readings.

Results and discussion

Sensory evaluation has been carried out with the addition of fermented-milk paste of ground unroasted buckwheat with varying degrees of dispersion. Samples' taste and smell – purely fermented, with a slightly perceptible pleasing taste. Samples' color – with the usage of buckwheat grains sized less than 3 mm – is white with a cream tint, without variations.

The consistency is homogeneous, without tangible tactile inclusions. On addition of ground grain, sized more than 3 mm, the samples' color remained uniform with inclusions of lighter color. It is still easily chewed. As can be seen from the above, ground unroasted buckwheat grains sized not more than 3 mm can be used in the formulations of fermented-milk pastes with homogenous consistency. Ground buckwheat grain having a particle size of more than 3 mm is recommended to use in the fermented-milk pastes with inhomogeneous consistency due to flavor fillers (ground nuts, fruit pieces, berries etc.).

Active acidity of the mixture of ground buckwheat and serum also varies depending on the application of dry granulated buckwheat.

When the water duties were 2 and 3, active acidity was 4,7pH units and when the water duty was 5, active acidity was 4,3pH units. In other words increasing dose of buckwheat leads to certain reduction of the acidity, which is explained by the fact that buckwheat contents proteins and dietary fibers, which have free acid functionalities. However, the pH meaning is within the norms typical for fermented-milk pastes and additional dose of unroasted buckwheat is not required.

Experiments proved that the optimal ratio between the ground buckwheat grain and solvent (buttermilk) is a water duty 4. At a lower value of the water duty, consistency of the mixture became too liquid, which indicates significant free moisture content. When the water duty is 4, the consistency of the mixture becomes too dense and loses its fluidity.

The dependence of the swelling of unroasted buckwheat grains on particles' size is shown in Figure 1.

It is found that the swelling of unroasted buckwheat grains depends on the particles' size. The lowest degree of swelling was observed at ground grain sized up to 3 mm (15,8%). The highest degree of swelling was observed in samples sized less than 1 mm (22%). This dependence can be explained by the increasing complexity of the moisture diffusion into the undistorted grain particles. Consequently, only the components of outer layers take part in the structure formation, while the components of inner layers remain inside the grains.

The figure of the sample sized less than 2 mm slightly differs. Thus, the fineness degree of unroasted buckwheat grains sized less than 2 mm is sufficient.

Analyzing data of the Figure 2 one can notice that the moisture-retaining capacity of model samples has risen with increasing degree of fineness of ground particles. The moisture-retaining capacity was 74% in case that particles' size was less than 1 mm. When it was more than 3 mm, the moisture-retaining capacity lowered to 65%. Higher moisture-retaining capacity of model samples with an increasing degree of dispersion of the ground buckwheat grains is associated with better accessibility to aquation, resulted from grains' destruction caused by mechanical processing.

In terms of these results, we can conclude that the samples of buckwheat grains having a degree of grinding less than 2 mm have the best qualities of the moisture-retaining capacity and swelling. It ensures efficiency of the stabilizing effect of the ground buckwheat grains.

To assess the stabilizing effect of the ground unroasted buckwheat grains we investigated the rheological qualities of fermented-milk pastes. The amount of serumal-buckwheat and serumal-starch pastes was 10%.

In accordance with the results of the samples we have drawn rheological curves of shear stress and straining rate shown in Figure 3.

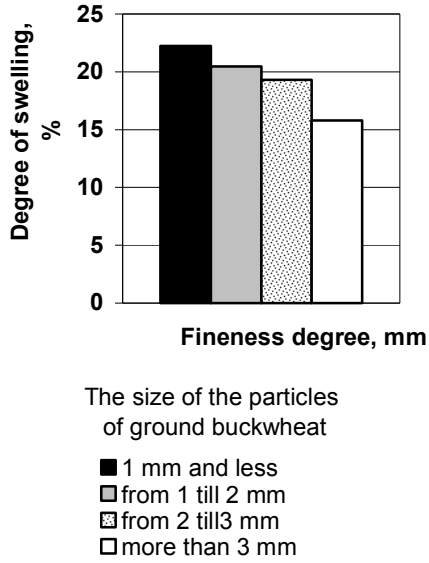

Fig. 1. Dependence degree of swelling modeling samples of particle size of crushed buckwheat

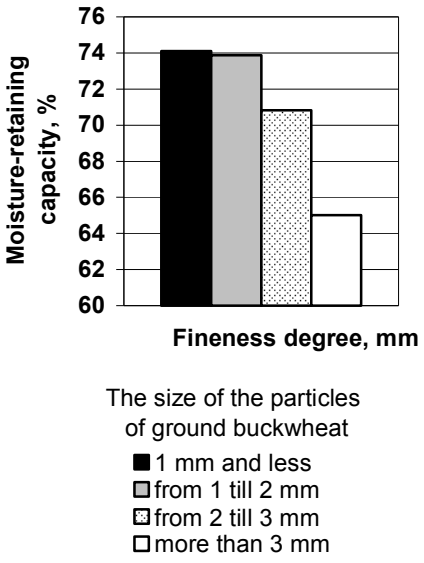

Fig. 2. Dependence of the moisture-retaining capacity of the buckwheat-serum paste on the fineness degree

From the analysis of the rheological curves it was established that the represented model samples of fermented-milk pastes are similar in nature. The shear stress of the samples with stabilizing substances is somewhat higher (320 Pa for fermented-milk paste with granulated buckwheat grains, 270 Pa for fermented-milk paste with a modified starch and 258 Pa for fermented-milk paste without stabilizer). The stabilizing effect is sufficient to prevent spontaneous whey separation (syneresis). Thus granulated grains of unroasted buckwheat are not inferior to the stabilizer of industrial production – a modified starch.

In the following steps we have determined the stability of the rheological parameters of the abovementioned model samples of fermented-milk pastes during its storage. Proceed from the premise that in accordance with the requirements of the regulatory documents, a guaranteed storage life of the curd-based pastes is not more than 4 days at a temperature of 4 ± 2°C. The research was carried out for 6 days, control observations were done in the 2^{nd} and 4^{th} days. Sample storage was carried out at a temperature of 4 ± 2°C. The results are presented in the Figures 4 – 6.

From these data it is apparent that the structure of the samples is fairly permanent. Upon storage a slight decrease (in average 28 Pa) in the index of the shear stress was observed. It is caused by a decrease in the hydrophilic characteristics of the cheese curd. While the shear stress index for the fermented-milk paste with a modified starch as a stabilizer has decreased by an average of 30 Pa, while for the fermented-milk paste without any stabilizer by 46 Pa.

During this investigation organoleptic characteristics were established. They showed that the color for 6 days remained stable; taste and flavour were pure fermented. The samples of unroasted buckwheat grains had a pleasant filler's taste and flavour. On the 6^{th} research day the samples had more expressive fermented flavor. During the storage period the consistency remained homogeneous without ant characteristics of whey separation.

During the storage period active acidity index has slightly decreased – from 4,5 to 4,3pH units. It was caused by the development of lactic-acid florula of fermented-milk pastes.

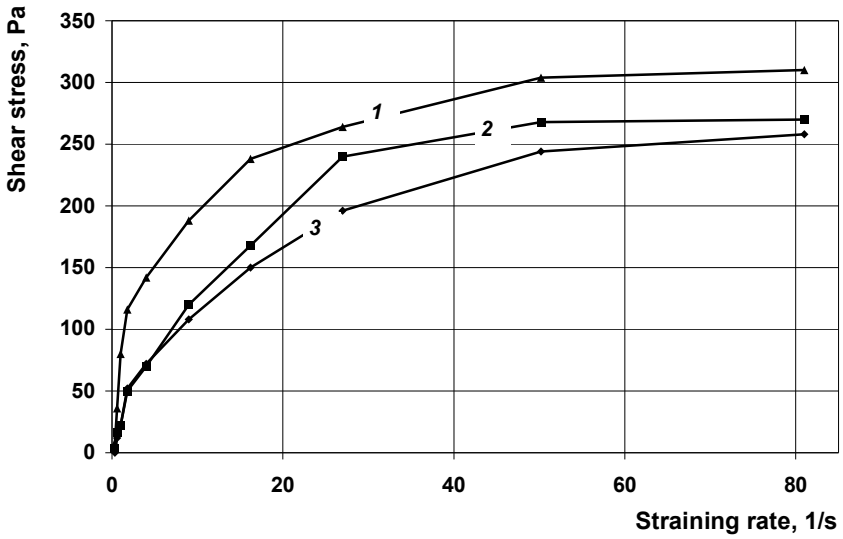

Fig. The dependence of the shear stress of fermented-milk pastes on straining rate:
1 - fermented-milk paste without the addition of stabilizer (control)
2 - fermented-milk paste with the addition of a stabilizer of the modified starch
3 - fermented-milk paste with the addition of ground unroasted buckwheat (particles' size is up to 2 mm)

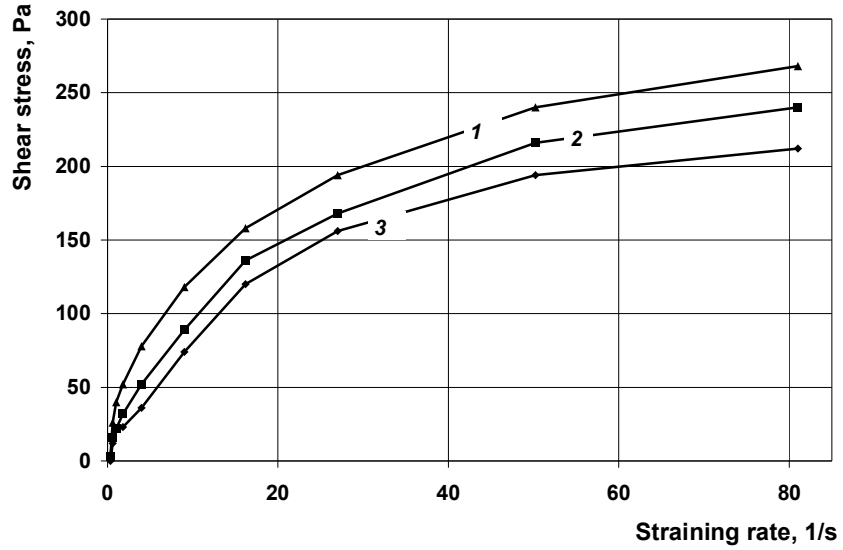

Fig. 4. The dependence of the shear stress of fermented-milk pastes on straining rate on the 2nd day of storage:
1 - fermented-milk paste without the addition of stabilizer (control)
2 - fermented-milk paste with the addition of a stabilizer of the modified starch
3 - fermented-milk paste with the addition of ground unroasted buckwheat (particles' size is up to 2 mm)

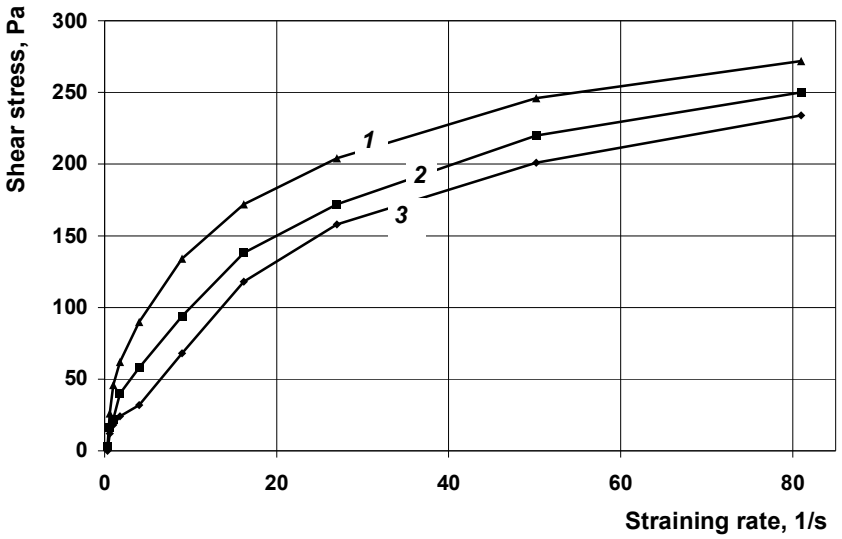

Fig. 5. The dependence of the shear stress of fermented-milk pastes on straining rate on the 4th day of storage:

1 - fermented-milk paste without the addition of stabilizer (control)
2 - fermented-milk paste with the addition of a stabilizer of the modified starch
3 - fermented-milk paste with the addition of ground unroasted buckwheat (particles' size is up to 2 mm)

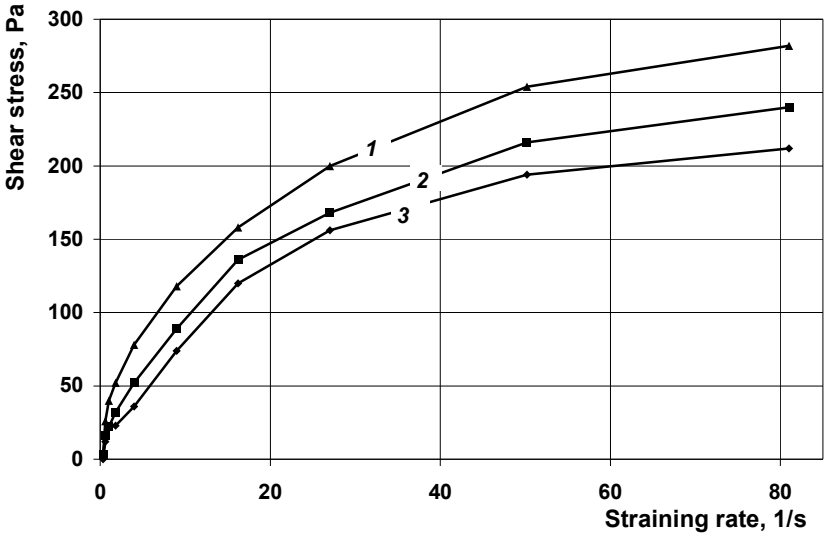

Figure 6. The dependence of the shear stress of fermented-milk pastes on straining rate on the 6th day of storage:

1 - fermented-milk paste without the addition of stabilizer (control)
2 - fermented-milk paste with the addition of a stabilizer of the modified starch
3 - fermented-milk paste with the addition of ground unroasted buckwheat (particles' size is up to 2 mm)

Conclusions

The usage of granulated unroasted buckwheat grains of 2 mm in combination with water duty 4 on the lactoserum under the subsequent thermal processing at 85...90°C and further cooling to 20...22°C, ensures definitive results of moisture-retaining capacity of serumal-buckwheat paste.

Technological characteristics of ground unroasted buckwheat grains achieve the required rheological qualities of fermented-milk pastes in comparison with the usage of a stabilizer. It has been proven that during its guaranteed shelf life the stability of quality characteristics of fermented-milk pastes with ground buckwheat is up to 4 days at the temperature (4 ± 2)°C.

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Rheological properties of probiotic yoghurts with phytosterol ester

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Abstract

Introduction. Probiotics are live microorganisms of human intestinal origin. Phytosterols have the ability to block cholesterol absorption, thus lowering serum cholesterol levels, which decreases the risk of cardiovascular and coronary heart diseases. Phytosterols are currently being added to a number of commercially available foods, including yogurt to facilitate reduction of serum cholesterol levels.

Materials and methods. Skim cow`s milk or milk mixture (skim cow's milk: ultrafiltered double-concentrated skim cow's milk in the ratio of 1:1) was used as raw material for the preparation of probiotic yogurt variants with the probiotic starter MZ_2 with different percentage of phtosterol ester (0,26% or 0,36%).

Results and discussion. With the addition of phytosterol ester the appearance of yield stress was observed which changed the rheological behavior of the probiotic yogurt variants and converted them from pseudo-plastic to non-ideal plastic bodies. The rheology of these yogurts was described by the equation of Herschel-Bulkeley. The yield stress and the consistency constant increased with the increase in the content of the phytosterol ester, which was an evidence for the structuring of the product. The flow index was not substantially influenced by the increase in the content of the phytosterol ester in the skim cow`s milk. At small values of the velocity gradients, the dynamic viscosity of the yogurts increased with the increase in the concentration of phytosterol ester as compared to that of the blank yogurt variant. The highest dynamic viscosity was established for the yogurt prepared with the addition of 0,36% phytosterol ester. Analogical trend in the rheological behavior of the probiotic yogurt variants obtained from milk mixture with different concentration of phytosterol ester was observed in a similar manner to the pattern with the yogurts obtained from skim cow's milk with the addition of different concentration of phytosterol ester. Therefore, similar rheological behavior could be expected. The yield stress of the probiotic yogurt variants prepared from milk mixture increased taking higher values than those of the probiotic yogurts, obtained from skim cow's milk. The consistency constant of the yogurt variant prepared from milk mixture with 0.26% phytosterol ester was close to that of the blank. The yogurt obtained from milk mixture with 0,36% phytosterol ester had the highest consistency constant value of all tested yogurt variants. The flow indexes of the probiotic yogurt variants prepared from milk mixture was close to that of the respective blank yogurt. At low velocity gradient, the probiotic yogurts containing 0.36% phytosterol ester had a dynamic viscosity of 24.60 Pa, and those with 0.26% phytosterol ester - 15.34 Pa. Upon increase of the velocity gradient, destruction of the structure of the tested yogurt variants was observed.

Conclusions. The probiotic yogurt variants obtained from milk mixture with the inclusion of 0,36% phytosterol ester had the best quality as they had the highest values of the yield stress (5.88 Pa), consistency constant (7.95 $Pa.s^n$) and dynamic viscosity. All resulting probiotic yogurts can be included in the diet of contemporary man as functional foods to improve human health.

Introduction

Probiotics are defined as 'live microorganisms of human intestinal origin, which when ingested in adequate amounts, impart health benefits to the consumer beyond basic nutrition'. Lactic acid bacteria, especially *Lactobacillus* species have been widely used as probiotics in the composition of functional foods and beverages [1].

Ultrafiltration is a pressure-driven process using a semi-permeable membrane to separate macromolecules or colloids from liquids and is based on a simple sieving mechanism [2, 3]. Membrane processes are used in dairy industry to produce concentrated milk (skim or whole), which is added for normalization of milk to produce yogurts, yogurt beverages and soft cheese. The resulting products are characterized by better texture, viscosity, taste and viability of cells in comparison with the traditional production methods [3].

Phytosterols are a group of naturally occurring sterol compounds found in plants with chemical structures close to those of cholesterol, differing only in their side-chain configuration or extra double bond [4]. Although phytosterols have been used to treat hypercholesterolemia since the 1950s [5], in the last few decades they have become available to consumers as ingredients in the composition of functional foods. They are able to block cholesterol absorption, thus lowering serum cholesterol levels, which decreases the risk of cardiovascular and coronary heart disease [6]. Phytosterols are now being added to a number of commercially available foods, including fat-based spreads, salad dressing, yogurt, and cheese, to facilitate reduction of serum cholesterol levels [7], turning these foods into functional foods. Phytosterols may also have antimicrobial activity and provide an added benefit as a food preservative [8].

The purpose of the present work was to obtain probiotic yogurt variants using a yogurt starter MZ_2 with a probiotic strain of *Lactobacillus delbrueckii* ssp. *bulgaricus* from skim cow`s milk or milk mixture with the addition of different percentage of phytosterol ester and to study the rheological properties of the resulting yogurts.

Materials and methods

Microorganisms. The probiotic yogurt starter MZ_2 containing the probiotic strain *Lactobacillus delbrueckii* ssp. *bulgaricus* NBIMCC 3708 and a *Streptococcus thermophilus* strain, provided by the Department of "Microbiology" at the University of Food Technologies, was used for the production of the yogurts.

Phytosterol ester. The used phytosterol ester was Phytosterol ester (Soybean) by HSFBiotech®.

Membrane filtration. The membrane filtration experiments were carried out on laboratory equipment with a replaceable plate and frame membrane module fitted with a UF25-PAN polyacrylnitrilic ultrafiltration membrane ("Ekofilter" Ltd, Bulgaria) with 25 kDa molecular weight cut-off (Fig. 1).

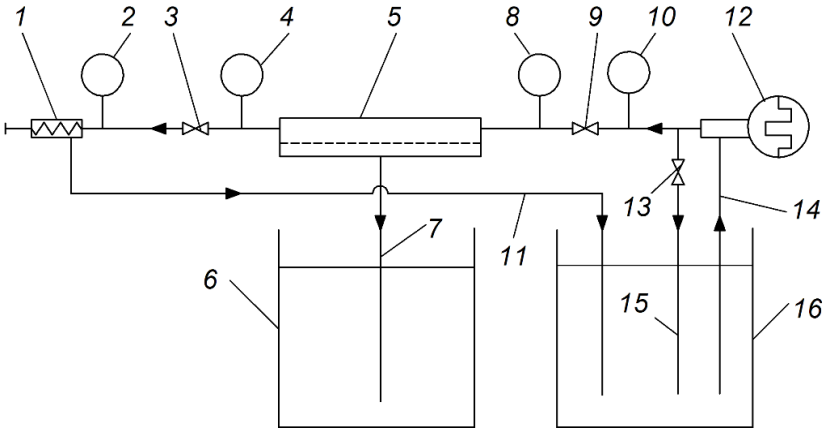

Fig. 1. Scheme of laboratory equipment with a replaceable plate and frame membrane module:
1 - valve; 2 - manometer (0–5 MPa); 3 - valve; 4 - manometer (0–0.6 MPa);
5 - replaceable plate and frame membrane module; 6 - tank; 7 - pipeline;
8 - manometer (0–0.8 MPa); 9 - valve; 10 - manometer (0–15 MPa); 11 - pipeline;
12 - pump; 13 -valve; 14 - pipeline; 15 - pipeline; 16 - tank.

This equipment was fitted with a plate and frame membrane module with membrane surface area of 1,250 cm^2; a threeplunger high-pressure pump (max 15 MPa) with a capacity of 330 dm^3/h; a pipeline system with two manometers (0-15 MPa) for measuring the inlet and outlet pressure; and a special working pressure regulating valve [9].

The experiments were carried out under the following operating conditions: transmembrane pressure 0,5 MPa, volume reduction ratio (VRR) – 2, temperature of 50°C and input flow of 330 dm^3/h [10].

Preparation of probiotic yogurts. Skim cow`s milk or milk mixture (skim cow's milk/ultrafiltered double-concentrated skim cow's milk in the ratio of 1/1) was used as raw material for the preparation of the probiotic yogurt variants. Maltodextrin and carrageenan were added to the variants with the inclusion of different percentage of phytosterol ester (PSE) and their amounts were calculated according to the ratio, given in [8]. The used milk was pasteurized at 65°C for 10 min and cooled to ~43°C. The milk was then inoculated with the probiotic yogurt starter MZ_2 and fermented at 41±1°C for 2,5 – 3 hours or until coagulation (Table 1).

Table 1

Probiotic yoghurt variants

	Skim cow's milk			Milk mixture		
	Blank	0,26% PSE	0,36% PSE	Blank	0,26% PSE	0,36% PSE
Phytosterol ester (PSE)	-	0,26%	0,36%	-	0,26%	0,36%
Maltodextrin	-	0,186%	0,258%	-	0,186%	0,258%
Carregeenan	-	0,018%-	0,018%	-	0,018%	0,018%
Probiotic starter MZ_2	1 %	1 %	1 %	1 %	1 %	1 %

Determination of the concentration of viable cells. Appropriate serial dilutions in saline solution of the obtained probiotic yogurts were prepared and the spread plate method was applied. 0.1 cm^3 of the last three dilutions was used to inoculate LAPTg10-agar. The inoculated Petri dishes were incubated for 3 days at 37°C until the appearance of countable single colonies. The count of the colonies was then used to estimate the number of bacteria in the original sample.

Determination of the titratable acidity. Ten cm^3 of each sample were mixed with 20 cm^3 of distilled water. The titratable acidity was determined by titration of each sample with 0.1 N NaOH using phenolphthalein as an indicator until the appearance of a pale pink colour persisting over 1 min. One Torner degree (°T) corresponds to 1 cm^3 0.1 N NaOH, needed for the neutralisation of an equivalent amount of organic acid, contained in 100 cm^3 of the cultural medium [11].

Rheological examination. The rheological tests were carried out with a rotary viscometer Rheotest-2 with a cylinder S1 and sample volume 25 ml. Samples were homogenized before measuring. The parameters of the rheological model were calculated using software "Curve Expert Professional" [12].

Results and discussion

Probiotic yogurt variants with the probiotic starter MZ_2 with the inclusion of phytosterol ester in a concentration of 0.26% or 0.36% were prepared using skim cow's milk or milk mixture as raw materials. The number of viable cells (Fig. 1a), the titratable acidity (Fig. 1b) and the organoleptic characteristics of the obtained probiotic yogurt variants (Table 2) were determined [13].

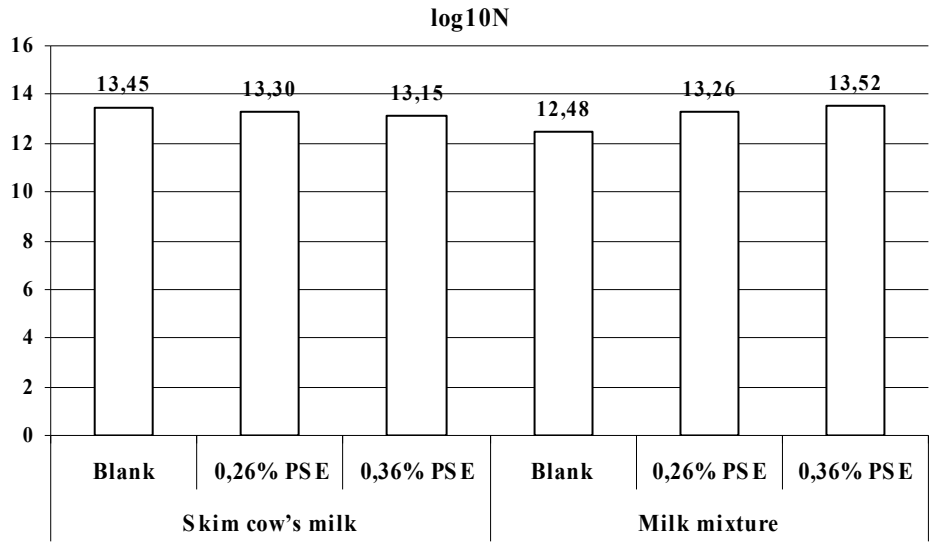

Fig. 1a. Concentration of viable cells of probiotic yogurts obtained from skim cow's milk and milk mixture with the addition of phytosterol ester [13]

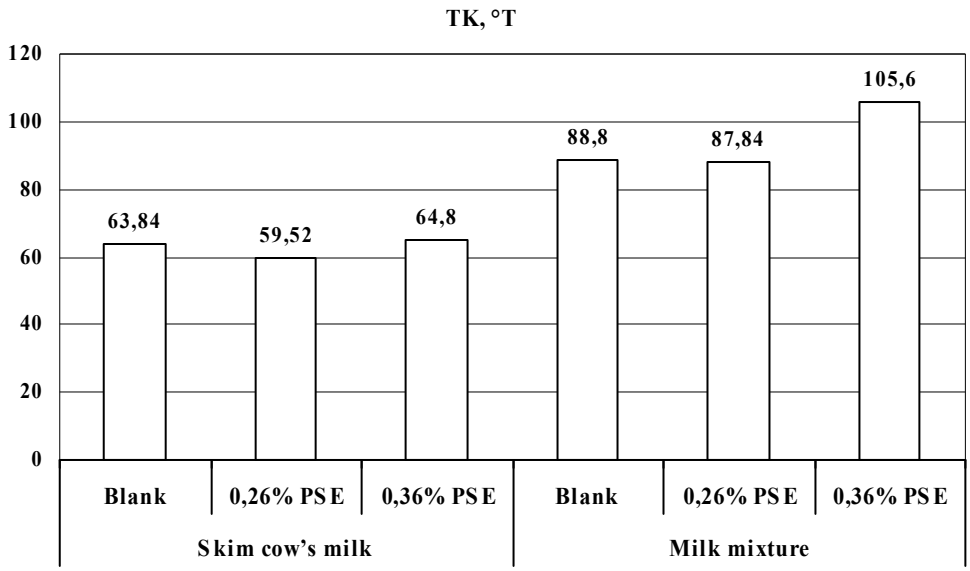

Fig. 1b. Titratable acidity of probiotic yogurts obtained from skim cow's milk and milk mixture with the addition of phytosterol ester [13]

Table 2

Organoleptic characteristics of probiotic yogurts obtained from skim cow's milk and milk mixture with the addition of phytosterol ester [13]

Skim cow's milk			Milk mixture		
Blank	0,26% PSE	0,36% PSE	Blank	0,26% PSE	0,36% PSE
Pleasant yoghurt taste, dense coagulum	Pleasant yoghurt flavor, thicker in texture, more acidic, enhanced creamy taste	Pleasant yoghurt flavor, thicker in texture, stronger creamy taste	Pleasant yoghurt flavor, dense coagulum	Pleasant yoghurt flavor, dense coagulum, low acidity	Pleasant yoghurt flavor, dense coagulum, low acidity

The rheological behavior of the obtained probiotic yogurts was examined as well. The flow curves of the probiotic yogurt variants obtained from skim cow's milk and milk mixture without the addition of the phytosterol ester are given on Fig. 2.

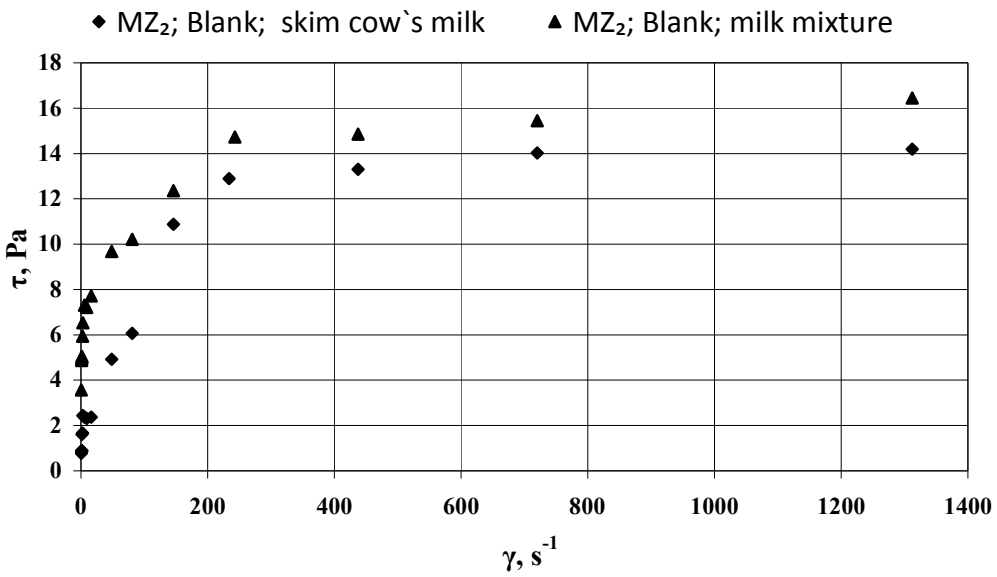

Fig. 2. Flow curves of probiotic yogurts obtained from skim cow's milk and milk mixture without the addition of phytosterol ester

The flow curves of the two blanks were curvilinear without yield stress. The examined probiotic yogurts were pseudo-plastic bodies and their rheological behavior could be described by the power-law of Ostwald–de Waele:

$$\tau = K\gamma^n \quad (1)$$

wherein:

K - consistency constant, $Pa.s^n$ (shows the texture of the product);

γ - shear rate, s^{-1};

τ - shear stress, Pa;

n - flow index, indicating the degree of deviation from Newton's law

The flow curve of the probiotic yogurt obtained from milk mixture was greater than that of the probiotic yogurt from skim cow's milk, which showed an increase in the viscosity at the addition of ultrafiltered double-concentrated skim cow's milk. The parameters of the model (1) for both yogurt variants are given in Table 3.

The probiotic yogurt produced from milk mixture had a higher consistency constant (4,244 $Pa.s^n$) compared to that obtained only from skim cow's milk. In contrast to that tendency, the flow index was sharply reduced with the increase in the values of the dry matter content.

Table 3

Parameters of the model of Ostwald–de Waele for the two blank probiotic yogurt variants

Probiotic yogurt variant	K, Pa.s^n	n	R^2
MZ_2; Blank, skim cow`s milk	1,047	0,4070	0,9590
MZ_2; Blank, milk mixture	4,244	0,1820	0,9850

According to the classification of Mikhailov and Rebidier, lactic acid products are divided into two groups: the first group includes products without yield stress, and the second – products with yield stress (static or dynamic). It is of great importance for the change in the dynamic viscosity at different velocity gradients for these two groups to be known [14]. Therefore the changes in the dynamic viscosity of both blank yogurt variants as a function of the changes in the velocity gradient was monitored.

For calculation of the dynamic viscosity, the following equation was used:

$$\eta = K\gamma^{n-1} \tag{2}$$

wherein:

η - dynamic viscosity, Pa·s

The equations for the calculation of the dynamic viscosity are given in Table 4 and the results thereof are shown on Fig. 3.

At low shear rates the blank probiotic yogurt variant obtained from milk mixture had a significantly higher dynamic viscosity (7,13 Pa.s) compared with the blank obtained only from skim cow's milk (1,51 Pa.s). At high values of the shear rate, complete destruction of the structure in both yogurt variants occurred and the dynamic viscosity curves overlapped.

Table 4

Equations for calculating the dynamic viscosity of the two probiotic blank yogurt variants

Probiotic yogurt variant	Equations for calculating the dynamic viscosity
MZ_2; Blank, skim cow`s milk	$\eta = 1.047\gamma^{-0.593}$
MZ_2; Blank, milk mixture	$\eta = 4.244\gamma^{-0.818}$

The rheology of the probiotic yogurt variants obtained from skim cow's milk with added phytosterol ester in a concentration 0.26% or 0.36% compared to the volume of the skim cow`s milk was examined. The data from these studies are shown on Fig. 4.

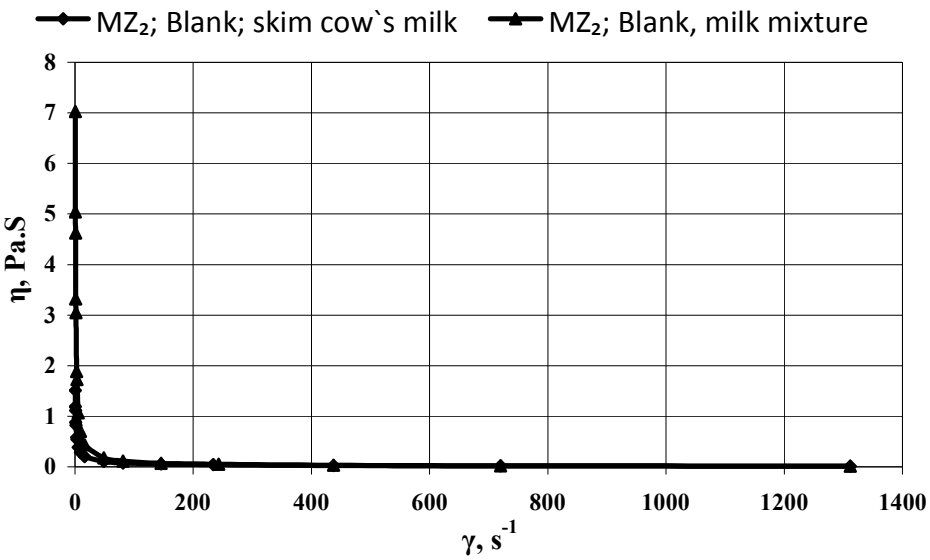

Fig. 3. Dependence of the dynamic viscosity on the velocity gradient of the blank probiotic yogurt variants

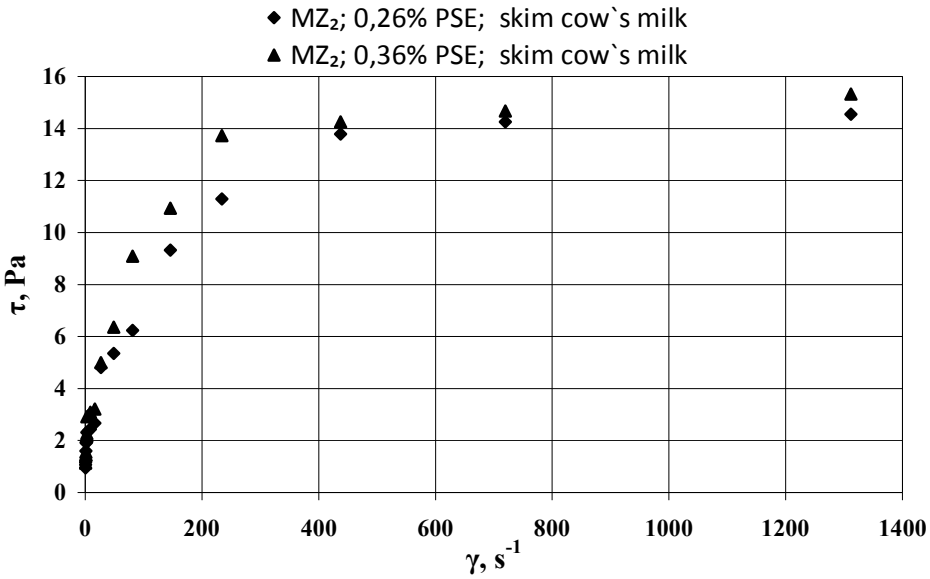

Fig. 4. Flow curves of the probiotic yogurt variants obtained from skim cow's milk containing different percentage of phytosterol ester

The flow curves were close one above the other; therefore, comparable values for the rheological parameters of the two yogurt variants can be expected. In contrast to the blank yogurt, with the addition of phytosterol ester the appearance of yield stress was observed which changed the rheological behavior of the probiotic yogurt variants and converted them

from pseudo-plastic to non-ideal plastic bodies. Thus, the rheology of these yogurts can be described by the equation of Herschel-Bulkeley:

$$\tau = \tau_0 + K\gamma^n \quad (4)$$

wherein τ_0 – yield stress, Pa.

The parameters of the model of the Herschel-Bulkeley equation are given in Table 5.

Table 5

Rheological parameters of the model of Herschel-Bulkeley of the probiotic yogurt variants obtained from skim cow`s milk with the addition of different percentage of phytosterol ester

Probiotic yogurt variant	τ_0 , Pa	K, Pa·s^n	n	R^2
MZ_2; 0,26% PSE, skim cow`s milk	0,95	1,316	0,3640	0,9750
MZ_2; 0,36% PSE, skim cow`s milk	1,13	1,561	0,3560	0,9710

The yield stress increased with the increase in the content of the phytosterol ester, which was an evidence for the structuring of the product. The consistency constant increased as well in comparison with that of the blank variant. At a concentration of phytosterol ester of 0.36% its value reached 1.561 Pa.s^n. The flow index was not substantially influenced by the increase in the content of the phytosterol ester in the skim cow`s milk.

The dynamic viscosities of the resulting probiotic yogurts were calculated using the equation:

$$\eta = \frac{\tau_0}{\gamma} + K\gamma^{n-1} \quad (5)$$

The equations for the calculation of the dynamic viscosity of the yogurt variants obtained from skim cow`s milk with the addition of different percentage of phytosterol ester are given in Table 6. Fig. 5 reflects the dependence of the dynamic viscosity on the velocity gradient for both yogurt variants.

Table 6

Equations for the calculation of the dynamic viscosity of the probiotic yogurt variants obtained from skim cow`s milk with the addition of different percentage of phytosterol ester

Probiotic yogurt variant	Equations for calculating the dynamic viscosity
MZ_2; 0,26% PSE, skim cow`s milk	$\eta = \frac{0.95}{\gamma} + 1,316\gamma^{-0.636}$
MZ_2; 0,36% PSE, skim cow`s mil	$\eta = \frac{1,13}{\gamma} + 1,561\gamma^{-0,644}$

At small values of the velocity gradients, the dynamic viscosity of the yogurts increased with the increase in the concentration of phytosterol ester as compared to that of the blank yogurt variant. The highest dynamic viscosity was established for the yogurt prepared with the addition of 0,36% phytosterol ester (Fig. 5).

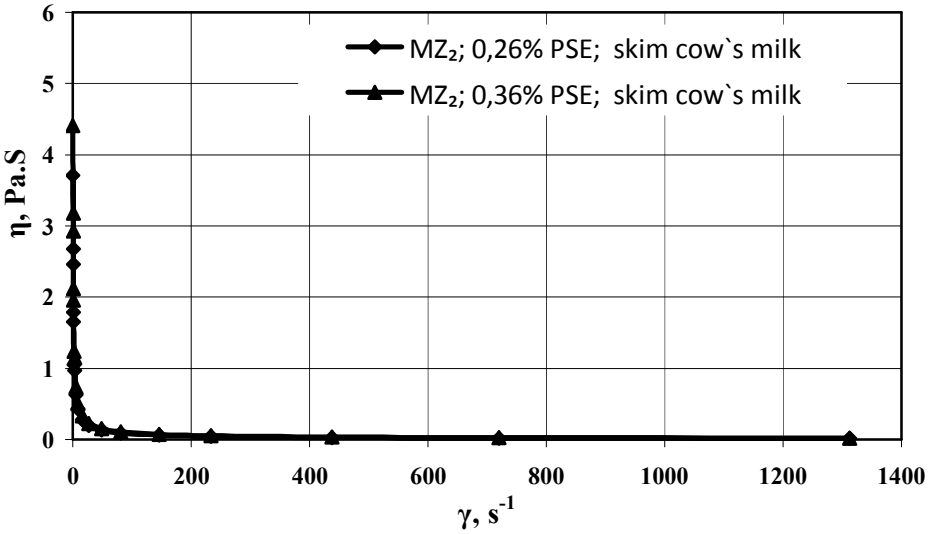

Fig. 5. Dependence of the dynamic viscosity on the velocity gradient of the probiotic yogurt variants obtained from skim cow's milk containing different percentage of phytosterol ester

The flow curves of the probiotic yogurts obtained from milk mixture with the addition of phytosterol ester in concentration 0.26% or 0.36% are plotted on Fig. 6. Analogical trend in the rheological behavior of the probiotic yogurt variants obtained from milk mixture with different concentration of phytosterol ester was observed.

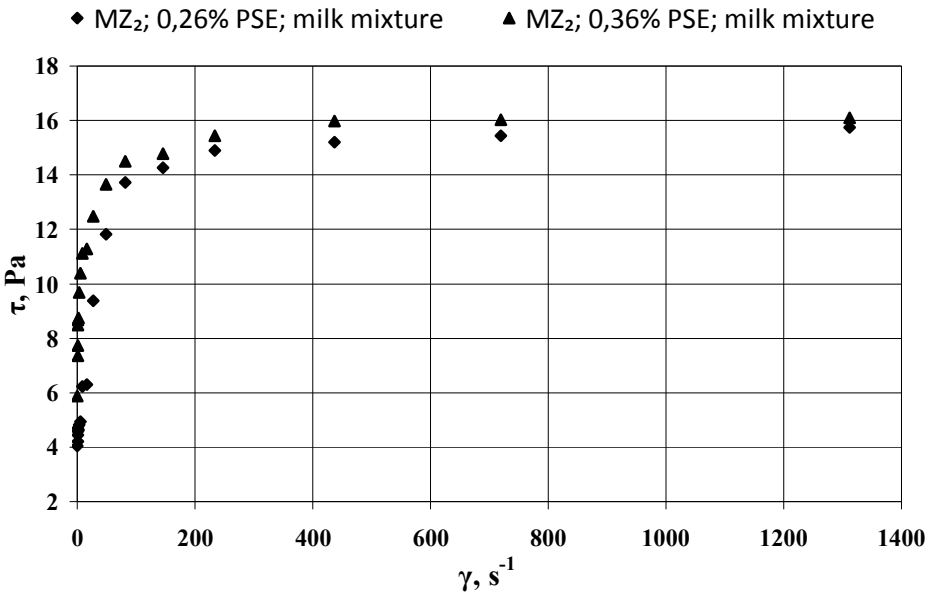

Fig. 6. Flow curves of probiotic yogurt variants obtained from milk mixture with different percentage of phytosterol ester

The flow curves of the two probiotic yogurt variants stood very close one above the other, in a similar manner to the pattern with the yogurts obtained from skim cow's milk with the addition of different concentration of phytosterol ester. Therefore, similar rheological behavior can be expected.

The curves were curvilinear with an intercept and could be described by the model of Herschel-Bulkeley. The model parameters for the yogurt variants obtained from milk mixture with the addition of different percentage of phytosterol ester are presented in Table 7.

Table 7

Rheological parameters of the model of Herschel-Bulkeley of the probiotic yogurt variants obtained from milk mixture with the addition of different percentage of phytosterol ester

Probiotic yogurt variant	τ_0, Pa	K, Pa.s^n	n	R^2
MZ_2; 0,26% PSE, milk mixture	4,04	4,832	0,2110	0,9370
MZ_2; 0,36% PSE, milk mixture	5,88	7,959	0,1170	0,9260

The yield stress of the probiotic yogurt variants prepared from milk mixture increased taking higher values (4.04 Pa for the yogurt with 0,26% phytosterol ester and 5.88 Pa for the yogurt with 0,36% phytosterol ester) than those of the probiotic yogurts, obtained from skim cow's milk (0.95 Pa and 1.13 Pa, respectively). The consistency constant of the yogurt variant prepared from milk mixture with 0.26% phytosterol ester was close to that of the blank yogurt (4,832 Pa.s^n and 4,244 Pa.s^n, respectively). The yogurt obtained from milk mixture with 0,36% phytosterol ester had the highest consistency constant value of all tested yogurt variants (7.959 Pa.s^n) (Table 7). The flow indexes of the probiotic yogurt variants prepared from milk mixture were close to that of the respective blank yogurt.

The equations for calculating the dynamic viscosity of the probiotic yogurts obtained from milk mixture with the inclusion of different concentrations of the phytosterol ester are given in Table 8.

Table 8

Equations for calculating the dynamic viscosity of the probiotic yogurts obtained from milk mixture with the inclusion of different concentrations of the phytosterol ester

Probiotic yogurt variant	Equations for calculating the dynamic viscosity
MZ_2; 0,26% PSE, milk mixture	$\eta = \frac{4.04}{\gamma} + 4,832\gamma^{-0.789}$
MZ_2; 0,36% PSE, milk mixture	$\eta = \frac{5.88}{\gamma} + 7.959\gamma^{-0.883}$

The dependence of the dynamic viscosity on the velocity gradient is shown on Fig. 7. At low velocity gradient, the probiotic yogurts containing 0.36% phytosterol ester had a dynamic viscosity of 24.60 Pa, and those with 0.26% phytosterol ester - 15.34 Pa. Upon increase of the velocity gradient, destruction of the structure of the tested yogurt variants was observed and the curves showing the changes in the dynamic viscosity overlapped (Fig. 7).

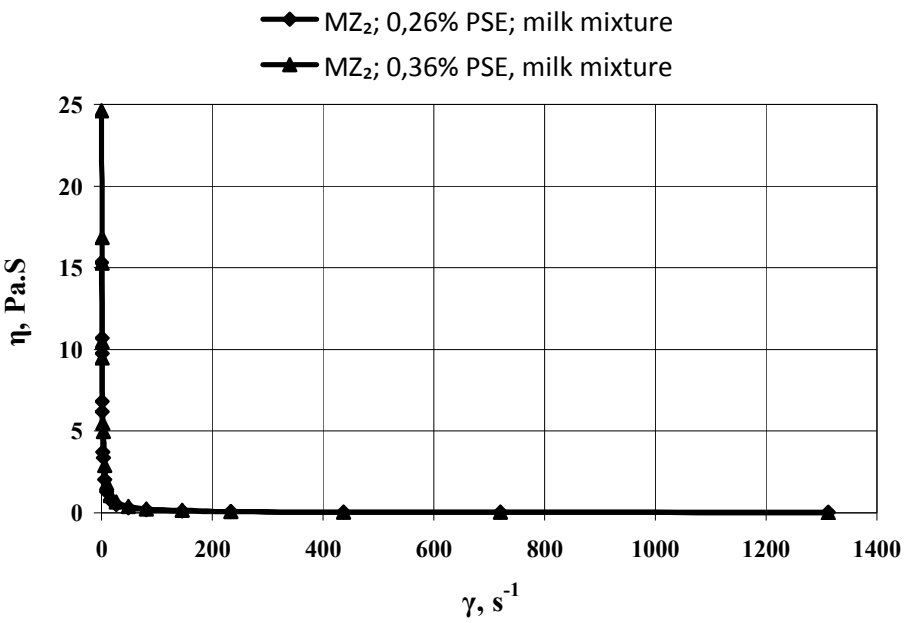

Fig. 7. Dependence of the dynamic viscosity on the velocity gradient of probiotic yogurt variants, obtained from milk mixture containing different percentage of phytosterol ester

Conclusions

The probiotic yogurt variants obtained from milk mixture with the inclusion of 0,36% phytosterol ester had the best quality as they had the highest values of the yield stress (5.88 Pa), consistency constant (7.95 Pa.s^n) and dynamic viscosity. All resulting probiotic yogurts can be included in the diet of contemporary man as functional foods to improve human health.

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New non-traditional sources of food protein

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Abstract

Introduction. The productivity of animal origin protein has practically reached its biological limits, and searching for other sources of protein would be possible among the plants. This became the factor of relevance of the proposed topic.

Materials and methods. The subjects for researching are the green parts (tops) of beets, ramsons, nettle, garlic, pea husk, and onion skin. The authors of this article used the standard physical and chemical methods of estimating the plant raw. The amino acid composition in green mass of plants was defined by ion-changing chromatography; biological value of protein faction was studied by methods of O. Pokrovsky.

Results and discussion. The experimental data show that green mass of plants is a very rich source of a complex of biologically active substances: 1.93 to 4.76 % of protein; 4.76 to 6.22 % of carbohydrates; 0.88 to 2.23 % of ashes. We confirmed the high content of indispensable amino acids – 87 to 283 mg per 100 g of leucine; 72 to 205 mg per 100 g of lysine; 504 to 1375 mg per 100 g in total. Dispensable amino acids in maximal amount are represented by glycine (83 to 377 mg per 100 g), alanine (87 to 251 mg per 100 g); total amount is vacillating from 592 to 1767 mg per 100 g for various cultures. Proteins in researched materials are outstanding with high grade of proteolysis (28.61 % for garlic; 28.81 % for nettle; 29.37 % for sugar beet), which slightly differs from the control index (milk proteins, 30.01 %).

Conclusion. Taking green mass for a base to create the biologically active additives and polyfunctional ingredients is grounded scientifically, expedient technologically, and profitable economically. We have recommended using the green mass of plants for enrichment of any food bases in production of foodstuffs for both domestic and foreign markets.

Introduction

Widening the production of food protein and formation of its structure are the most important and difficult tasks for common and healthy nutrition. Constantly deepening deficit of food protein is conditioning the searches for its new sources, including those non-traditional.

The attempts to obtain proteinaceous concentrates out of tops of plants were accomplished simultaneously in the former Soviet Union and England in 1942. The first publication about leaf protein appeared in 1773 although the term 'protein' itself had been firstly proposed by Dutch chemist I. Mulder in 1838 (Peary, 1980).

Nowadays, there are studied only a few sorts of cultivated plants suitable for obtaining proteinaceous concentrates. These are legumes, alfalfa, rice, rape, clover, green peas. The prominent industrially developed countries have established the powerful agro industrial enterprises dealing with production of food proteins from plant raw materials (dried wheat gluten, high-concentrated forms of protein from soy, wheat and peas) at the end of the 20th century (Kudryashova, 2000). Today the total annual volume of high-concentrated protein production makes up circa 400…500 thousands of tons.

Involving traditional and novelty plant cultures into the sphere of production of protein and protein concentrates would provide solving of an array of social and economical problems, including:

- significant liquidation of food protein deficit, which would foresee both gaining its level in diets and improvement of protein quality;
- organization of industrial production of foodstuffs with definite protein composition, first of all those related to category of healthy food;
- production of high-quality, safe and effective foodstuffs on the base of optimal combination of proteins of both plant and animal origin, which would condition the proper nutritional value and the quantitative and qualitative composition of protein complex;

The following factors condition the choice of the new raw sources of protein:

- the quantitative and qualitative composition of protein complex;
- functional properties of proteins;
- biological value of proteins;
- the possible volumes of raw harvesting and laying-in (in separate regions and throughout the country);
- technological capacity of raw and its liability to procession on enterprises with different levels of productivity;
- the possibility to obtain several valuable half products with various functional action out of one certain kind of raw;
- maximal compatibility of components from proteinaceous green mass with nutrients of food environments exposed to enrichment;
- shelf-life conditions;
- the cost of proteinaceous half products, regarding their biological value and economic efficiency of an enterprise.

The majority of researches in the field of protein technologies is oriented at obtaining of either high-concentrated proteins (concentrates, isolates, proteinates) or chemically modified, including composites *protein-polysaccharide, protein-lipid* etc.

As for the authors of this article, the more expedient method is the wasteless procession of plant raw materials with further obtaining of proteinaceous concentrates. Those may differ by their rich nutrient composition, first of all – by the optimal natural

correlation between proteins and other components of raw (pectin substances and other polysaccharides, lipids and vitamins); thanks to this, the efficiency and functionality of proteins will be enhanced. This technology would become more efficient from economic point of view as well, because it can eliminate the expensive and complicated processes of proteins' purification (in production of concentrates and isolates), their etherification and structuring.

Therefore, the objectives of this article are to prove scientifically and to confirm experimentally the expedience of using the tops of various plants.

The main tasks of the research are to study the amino acid content and biological value of tops of plants, and also to define the grade of proteolysis of proteins from researched materials in comparison with control substance (milk protein).

Materials and methods

We chose the tops of the following plants for researches: sugar beet; garlic; pea husk; nettle; ramsons; garlic; onion skin. It is well-known that green plants contain 1.5 to 3.5 % of protein on the average; about 85 % of it is concentrated in leaf cells. Leaf protein is represented mostly with two types. First are cytoplasm proteins (ca 30 % of the total amount of protein, with molecular mass of 30…50 kD) contained in the solution and free of pigments. Second are insoluble colloid-disperse proteins with molecular mass of about 100 kD, which are constrained to chloroplasts and compose about 35 % of total amount of protein.

Young tender tops of sugar beets, garlic, ramsons and nettle were collected randomly from the wild and farmlands in Kyiv region, Ukraine. The samples were identified by a Taxonomist. Several plants of each species were combined to get representative samples. The samples were washed with distilled water, cut into small pieces, air dried (away from sunlight) and ground into fine powder using porcelain mortar and pestle.

The well-known ways to process the plant raw containing the biologically active substances are drying with further disintegration and, if necessary, extraction; thus, the plant half products in the shape of dried slices, particles with defined measure, or small-disperse powders are used in food industry in topmost grade.

The authors of this article used the standard physical and chemical methods of estimating the plant raw (Yermakov et al., 1987).

The amino acid composition in tops of plants was defined by ion-changing chromatography (Spackman, 1988). The essence of this method is to hydrolyze proteins from the sample to amino acids and then to identify them by the method of high-effective liquid chromatography on the LC-5 device (produced by Shimazu). The dry sample had been hydrolyzed with a 6-n solution of hydrochloric acid in the temperature of (108 ± 2) Celsius degrees during 24 hours (the method was described in Magomya, 2014).

Results and discussions

The tops of noticed plants were previously cleaned and inspected. Afterwards, they were disintegrated and their general chemical content was investigated. The obtained results are shown in Table 1.

Table 1

Chemical composition of tops of proteinaceous plants

Indicators	The raw material					
	Sugar beet	Garlic	Pea husk	Nettle	Ramsons	Onion skin
Dry substances, %	13.26	10.61	9.8	11.86	10.90	8.34
Protein, %	3.25	2.96	4.71	2.61	2.18	1.93
Lipid, %	0.67	1.32	0.83	0.49	0.02	0.03
Carbohydrates, %	6.22	5.65	5.04	5.72	5.97	4.76
Ashes, %	2.23	1.88	1.77	1.41	1.35	0.88

The analysis of the obtained data shows the following facts.

The amount of protein in dry substances allowed arranging the researched objects in the following order: sugar beet (24.5 %), dioecious nettle (22.0 %), ramsons (20.0 %).

Our researches have shown that all of the studied objects contain the significant amount of carbohydrates. This indicator is about 55 % of general amount of dry substances in ramsons; 48.2 % in nettle; 47 % in sugar beet.

Garlic is the richest in lipids (1.32 % of general amount of dry substances); the poorest one is ramsons leaves (0.18 %).

Dependently on the amount of ashes in dry substance, the researched objects have been arranged the following: sugar beet (16.8 %), ramsons (12.4 %), and nettle (ca 12 %).

Table 2 shows the content of indispensable amino acids in researched plants.

Table 2

The content of indispensable amino acids in researched plants

Amino acids	The amount, mg / 100 g					
	Sugar beet	Garlic	Pea husk	Nettle	Ramsons	Onion skin
Isoleucine	125	113	99	110	143	38
Leucine	283	280	269	155	87	97
Lysine	205	194	188	145	98	72
Phenylalanine + tyrosine	290	225	221	178	135	108
Methionine + cysteine	113	105	98	84	76	20
Tryptophan	42	39	40	41	38	45
Threonine	151	127	125	125	92	49
Valine	166	153	150	133	93	75
Total	1375	1236	1190	971	762	504

The necessity of using the products made of the researched raw materials may be well apprehended on the example of lysine.

As it is well-known, lysine is an essential (indispensable) amino acid necessary for human health; yet, the body cannot synthesize it itself. A human has to get lysine from food or supplements.

Amino acids, particularly lysine, are building blocks for proteins. Lysine is important for proper growth, which is actual now in Ukraine considering the bad ecological situation; and it also plays essential role in the production of carnitine (a nutrient responsible for

converting fatty acids into energy and helping lower cholesterol; there are used worldwide two well-known preparations of carnitine, L-Carnitine and Cardonate to control body weight).

Lysine appears to help the body absorb calcium and form collagen. Both of these factors are crucially important for functioning of skeleton, muscles and so on (See University 2014).

The index of lysine amount in researched plant is the highest for sugar beet (205 mg / 100 g), garlic (194 mg / 100 g), and pea husk (188 mg / 100 g).

Table 3 contains the results of researching the dispensable amino acid content in mentioned plants.

Table 3

The content of dispensable amino acids in researched plants

Amino acids	The amount, mg / 100 g					
	Sugar beet	Garlic	Pea husk	Nettle	Ramsons	Onion skin
Alanine	251	187	236	115	87	94
Arginine	172	197	185	235	207	86
Aspartic acid	250	243	264	90	148	138
Hystidine	78	75	67	123	135	43
Glutamine	248	198	221	411	141	124
Glycine	377	334	325	83	183	96
Proline	220	199	138	80	104	63
Serine	171	146	124	65	107	42
Total	1767	1579	1560	1202	1112	592

As one of the most important among dispensable acids, glutamine is the most abundant in human body, and the body can synthesize enough glutamine for its needs. However, during times of extreme physical and psychic stress (especially for Ukrainian armed forces who take part in anti-terroristic operation in East regions), the body may need more glutamine than it can make.

Certain medical conditions, including injuries, surgery, infections, and prolonged stress, may lower the level of glutamine; in these cases, taking a glutamine-containing supplement may be very helpful (University 2014). The products made of raw materials researched in this article (especially nettle – 411 mg / 100 g, sugar beets – 248 mg / 100 g, and garlic – 198 mg / 100 g) may complete the body needs in glutamine (and other dispensable amino acids, too).

The further perspective of using the foodstuffs that include the studied raw supplements is their implementation into diets for military personnel.

Both of the tables given above represent the general amino acid composition of plant raw and half-processed (pea husk, onion skin) materials. The data show that the entire researched raw contains 18 amino acids including all of those indispensable. It is to mark that the content of indispensable amino acids relatively to the general amino acid amount is about 38…45 per cent, which evidences the significantly balanced amino acid composition in all of the studied objects.

The obtained data show the biological value of proteins in researched green mass of plants. It is well-known that the correlations between dispensable and indispensable amino acids play the crucial role in formation of optimal conditions for catabolic processes. There

was experimentally confirmed that the maximal biological effect of food proteins may be reached with the general nitrogen amount of 42 % of indispensable; the other 58 % may be taken from the dispensable amino acids.

The important characteristic for proteins is their grade of digestion by proteolythic enzymes in the alimentary canal. The results of researching this parameter are given in table 4.

These results showed that digestion of proteins extracted from tops of sugar beets reached 78…82 per cent and therefore varies very little from the analogical indices for control proteins (milk proteins) and slightly exceeds those for nettle and garlic.

Generally, proteins of all the researched materials in entering the alimentary canal would be easily dissociated into amino acids under the impact of proteolythic enzymes and be absorbed into blood wholly.

Table 4

The amount of hydrolyzed *in vitro* proteins in researched materials, per cent

Material	Proteolysis stage							
	Pepsin	σ±	Tripsin	σ±	Peptidase	σ±	General proteolysis	σ±
Milk proteins (control)	3.50	0.76	11.24	0.39	15.27	0.34	30.01	1.46
Green mass of sugar beet	3.14	0.34	11.19	1.44	15.04	0.19	29.37	0.94
Green mass of nettle	1.22	0.14	11.07	0.56	16.52	2.32	28.81	1.16
Green mass of garlic	2.65	0.82	11.04	0.48	14.92	0.11	28.61	0.32

In enriching the diets with amino acids, it is necessary to represent them in optimal correlations. Either deficit or surplus of a certain amino acid may cause the misbalance, or a violation of amino acid balance. The symptoms of misbalance can be exposed more apparently in low-protein diet with a small amount of indispensable amino acids.

The data about the biochemical composition of separate plant samples show their wide possibilities in use for human nutrition and production of new foodstuffs. Generally, the plant raw materials chosen as the objects for researches are outstanding due to comparatively high content of protein (20…25 per cent of the whole amount of dry substances).

Moreover, the nutritional value of protein extracted from the studied plants is pretty high and stands close to animal origin proteins. During the researches, we had found out that the proteins of green mass of various beets have got the highest biological value. Henceforth, we may make a conclusion that the proteins from tops of plants, as being digested in an alimentary canal, would be dissociated by proteolythic enzymes to amino acids and then absorbed into blood wholly.

The further researches foresee the production of dry proteinaceous half-products with wide array of extremely precious biologically active substances. They are chlorophyll and the products of its dissociation; ascorbic acid; carotenoid group, first of all β-carotene. These products would become the most important for the population strata, which take the small doses of green leafy vegetables and suffer from the vitamin A deficit.

Conclusion

Therefore, the experimental data obtained during our research show that green mass of plants is a very rich source of a complex of biologically active substances, which would allow obtaining the new foodstuff with increased biological value. Taking plant tops for a base to create the biologically active additives and polyfunctional ingredients is grounded scientifically, expedient technologically, and profitable economically; henceforth, the expected products from green mass of plants would have a great demand on both domestic and foreign markets.

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UEffect of different thawing methods on the quality of bonito (Sarda sarda, Bloch 1793)

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Abstract

Introduction. In this study, the changes on quality of whole frozen bonito (*Sarda sarda*) thawed in the refrigerator (at 4 ±2° C, 22 hours), in the water (12.1 ±0.8°C, 1.5 hours) and in the microwave (160 W, 7 min) were identified.

Materials and methods. The quality control of bonito were carried out by the analyses of rational weight loss, TVB-N, TMA-N, TBARs, pH value, water activity (Aw), total mesophilic and total psychrotrophic bacterial amount.

Results and discussion. After thawing process, water loss, pH, water activity, TVB-N, TBARs, TMA-N values, total mesophilic and psychrotrophic bacteria counts were found as; 2.01, 1.66 and 2.54%; 5.95, 5.98 and 5.86; 0.98, 0.98 and 0.99; 20.83, 20.35 and 14.87 mg/100g; 0.51, 0.45 and 0.54 mgMDA/kg; 0.89, 0.47 and 0.48 mg/100g; 3.58, 3.47 and 3.35 Log CFU/g; 3.25, 2.86 and 2.84 Log CFU/g, respectively. Significant differences ($p>0.05$) were not found between rational weight loss (%) and pH values of different thawing methods. The lowest TVB-N value of the bonito was observed in microwave oven with 7 minutes thawing time, the maximum TVB-N value of the fish was determined in refrigerator-thawed group for 22 hours. The analysis showed that the amount of TVB-N increased with increasing thawing duration. Therefore, in terms of time and quality of bonito thawing in microwave oven gives better results than the other methods. Thawing in the microwave gave the best results in terms of TMA-N value. The microbial amounts were found less than 4 Log CFU/g in all samples. Based on these results; less thawing time of microwave thawing and water-thawing method were obtained better quality fish.

Conclusion. In this research, effects of thawing methods on pH value and sensory characteristics of bonito were not important statistically ($p>0.05$) while affect the other quality parameter. Based on the chemical and microbiological analysis results increasing thawing period were negatively affect the quality of fish.

Inroduction

Bonito (*Sarda sarda*) is a very important commercial species in Turkey. 13158 tons of bonito were caught in 2013 and its amount 45 tons were exported as frozen [1]. Freezing technology is commonly used method in fish particularly exported. On the other hand, people prefer freezing to canning because of the ease of use at home. In order to extend the duration of food storage, especially fishery products, freezing minimizes the disruption and economic loss, and plays an important role in the control of food-borne pathogens. Frozen products compared to products preserved by other methods, has higher quality in terms of nutritional value [2].

The quality of frozen fish and storage life depends on the freezing speed, packaging, storage temperature and continuity and pre-cooling conditions. One of the most important quality criteria of frozen stored fish is water loss. Water loss is the form of evaporation during storage or leakage while thawing the frozen product. If freezing, storage and thawing processes performed in appropriate conditions, water loss is less than 10% [3].

Minimal processing methods have emerged with the development of means different industrial thawing like vacuum thawing, electrical methods and high pressure But still, the most use thawing methods of consumers are traditional methods. Frozen fish are usually thawed in four different ways such as in the refrigerator, microwave oven, room temperature and under cold water. However, thawing process at room temperature have a much higher risk for microbial growth which is not preferred [4,5,6].

Many authors studied the effect of thawing methods on quality changes of different fish; megare [7], trout [8], mackerel [9], bluefish [10], anchovy [10,11,12], eel [13], sardina and sea bream [11]. But there is no much information about the impact on the quality of different thawing methods of bonito. The aim of this study was to investigate widely used three thawing methods [thawed in the refrigerator (at 4±2°C, 22 hours), in the water (12.1±0.8°C, 1.5 hours) and in the microwave (160 W, 7 min)], which were different thawing time, in point of water loss, chemical, organoleptic and microbiological on quality of whole frozen bonitos.

Material and methods

Materials. In this study, 6 bonitos (*Sarda sarda*, Bloch, 1793) (mean weight 460.20±18.65 g) were used. Bonitos were obtained from İstanbul Fish Market and each bonito was put in sealed refrigerator pouches. After packaging, bonitos were placed with leaf type ice into styrofoam containers. Bonitos frozen in a deepfreeze at -25°C were stored at -20±2°C for 3 months period. Bonitos were thawed in a refrigerator (as packaged, 4±1°C, 22 hours), microwave oven (160 W, 7 min) and in water (packaged, 12.1±0.8°C, 1.5 hours) with two replications till reached -1°C the central temperature of fish. After thawing bonitos, were homogenized and physical, chemical and microbiological properties were analyzed.

Methods. Rational weight loss was calculated according to the Santos and Regenstein [14]. pH was determined according to the Manthey et al. [15]. Total volatile basic nitrogen (TVB-N mg N/100 g fish flesh) was determined according to the modified method of Lücke-Geidel [16]. Trimethylamine (TMA-N mg/100 g fish flesh) analysis was carried out according to the method proposed by Boland and Paige [17].

Thiobarbituric acid reactive substance (TBARs mg malonaldehyde/ kg fish flesh) was determined according to the method proposed by Erkan & Özden [18]. Automatic water activity machine (Novasina) was used for determination of water activity (aw). Total

aerobic mesophilic plates were incubated at 28°C for 48 hours [19] and total aerobic psychrotrophic plates stored at 7°C in the refrigerator for 10 days period [20]. For sensory analysis, fish thawed with 3 different methods without addition of salt, spices, etc. were wrapped with aluminum foil, baked at 180°C for 25 minutes and evaluated by 5 experienced panelists [21,22].

Differences between means were analyzed by one-way analysis of variance (Anova) followed by Tukey test (Minitab 17 Release). The results are presented as means ±Se.

Results and discussion

The values of rational weight loss (%), pH, TVB-N, TBARs, TMA-N and a_w were given in Table 1. During thawing penetration to water loss in the range of 5% to 15% are indicated by Pigott and Tucker [3]. In this study, the less water loss (%1.66) was observed in water thawed bonito. In practical terms, the other two thawing method results seems better than thawing proccess in microwave oven for heat could be vaporized more water. However, There was no statistically significant difference between groups in terms of weight loss ($p > 0.05$). In addition, less water loss shows that fish is frozen and stored in good condition.

Knowledge about the pH of fish meat may give valuable information about its condition. Most spoilage bacteria possessing decarboxylase activity do so in response to acidic pH, presumably so that the organisms may raise the pH of the growth medium through the production of amines [23]. The previous studies reported that fresh fish pH values should be between 6-6.5 [24]. Despite the three months of frozen storage, pH values obtained from the thawing fish showed that very good quality. Significant differences ($p>0.05$) were not found between pH values of different thawing methods. Turan et al. [8] evaluated the effects of thawing in water, microwave, room and refrigerator temperature on quality of rainbow trout. Our pH results were found to be similar with this study. And the ph values of thawed bonito samples were low and didn't exceed 6.00. It has been reported that the pH value of thawed eel (in water, microwave and refrigerator) was similar with our results [13]. Mol et al. [9] reported that pH values of mackerel were not affected from different thawing methods (in water, refrigerator and room temperature). It can be said that pH analysis are not useful as quality indicator for determining the differences between the thawed bonitos.

Table 1

Rational weight loss (%), pH, TVB-N, TBARs, TMA-N and a_w values of thawed bonito

Analyses	Microwave (7 min).	Water (1 hour 30 min.)	Refrigerator (22 hours)
Weight loss (%)	2.54±0.34 a	1.66±0.00 a	2.01±0.17 a
pH	5.86±0.01 a	5.98±0.01 a	5.95±0.07 a
TVB-N (mg/100g)	14.68±0.78 b	20.35±0.19 a	20.83±0.30 a
TBARs (mgMDA/kg)	0.54±0.02 ab	0.45±0.01 b	0.51±0.02 a
TMA-N (mg/100g)	0.48±0.03 b	0.47±0.01 b	0.89±0.05 a
Water Activity (Aw)	0.99±0.01 b	0.98±0.00 a	0.98±0.01 ab

Values are shown as mean± standard error of triplicates, n=3

a→b Within the line with different letters are significantly different ($p<0.05$)

Total volatile basic amines (TVB) is one of the most widely used measurements of seafood quality. It is a general term which includes the measurement of trimethylamine (produced by spoilage bacteria), dimethylamine (produced by autolytic enzymes during frozen storage), ammonia (produced by the deamination of amino-acids and nucleotide catabolites) and other volatile basic nitrogenous compounds associated with seafood spoilage [23]. The value of TVB-N in sea foods are classified as 25 mg/100 g and below very good, between 25-30 mg/100 g good, between 30-35 mg/100 g marketable, 35 mg/100 g or more spoilage [24]. According to these criteria, for the three different thawing method, thawed bonitos were very good quality. However, while the lowest TVB-N value of the fish was observed in microwave oven with 7 minutes thawing time, the maximum TVB-N value of the fish was determined in refrigerator-thawed group for 22 hours. TVB-N values of the samples thawed in the refrigerator in 22 hours and thawed in the water in 1 hour and 30 minutes were significantly higher ($p<0.05$) according to microwave oven thawing. The analysis showed that the amount of TVB-N increased with increasing thawing duration. Therefore, in terms of time and quality of bonito thawing in microwave oven gives better results than the other methods. For anchovy, sardine, sea bream [11], and rainbow trout [8] thawed under same methods, minimum TVB-N values were similar with determined in microwave group, despite that Genç et al. [7] stated that TVB-N values of refrigerator, water and microwave oven- thawed meagre fillets were not significant differences between those treatments.

TMAO is an osmoregulating agent in salt water fish muscle [11]. Trimethylamine is a pungent volatile amine often associated with the typical "fishy" odour of spoiling seafood. Its presence in spoiling fish is due to the bacterial reduction of trimethylamine oxide (TMAO) which is naturally present in the living tissue of many marine fish species [23].TMA-N value used to the measure of freshness, for fish 4 mg/100 g is good, 10 mg/100 g is marketable, 12 mg/100 g and above is considered as spoiled [25,26]. All of the fish were good quality and there is no statistical difference ($p>0.05$) between microwave thawed bonito and water thawed bonito. There was statistically significant difference found thawing in the refrigerator according to the other two groups ($p<0.05$). Thawing in the microwave gave the best results similarly with Turan et al. [8] and Dinçer et al. [11].

The highly unsaturated fatty acids found in fish lipids are very susceptible to oxidation. The primary oxidation products are the lipid hydroperoxides. In later stages of oxidation *secondary oxidation products will* usually be present and thus be indicative of a history of autoxidation. These products comprise aldehydes, ketones, short chain fatty acid and others, many of which have very unpleasant odours and flavours, and which in combination yield the fishy and rancid character associated with oxidized fish lipid. Some of the aldehydic secondary oxidation products react with thiobarbituric acid (TBA), forming a reddish coloured product that can be determined spectrophotometrically [23]. TBA value used to the measure of freshness, for fish 3 mg/1000 g is very good, 5 mg/1000 g is good, 7-8 mg/1000 g marketable, and above is considered as spoiled [24].Thawed fish in the water had the lowest TBA value due to protected from the oxygen in the air. Thawing in the microwave caused the higher TBA value due to the application of heat during thawing proccess. The similar results were reported by Ersoy et al. [13]. Besides, three thawing method was found quite low than value of 8 mg MDA/kg [27] which is maximum consumable value for thawed fish. This situation is an indication that fish was frozen and stored in good conditions.

The a_w value varies between 0.98 and 1 in fresh seafood. Although the storage temperature for frozen fish was tried to be kept stable, even minimal changes in temperature changes the ambient humidity and causes the required moisture to be met from

fish. This leads to water loss in fish and thus a change in the a_w value. In this research, the water activity of thawed bonito were found between 0.98-0.99. The water activity of thawed fish in microwave and water were different significantly ($p<0.05$).

Considering the results in Table 2, at the end of thawing process, the amount of total mesophilic bacteria in the water or in the refrigerator thawing conditions were similar ($p>0.05$), the lowest value was thawing with microwave oven ($p<0.05$). This state of degradation products in fish meat, thawing time is directly related to the increase in microbial spoilage and that it was part of a clearly reveal. Although the thaw period in the refrigerator more than water, because it contains more cold conditions the number of bacteria in both thawing methods were similar. In terms of the total number of psychrotrophic bacteria difference between in the water thawing and microwave oven thawing methods, was not significant ($p>0.05$). In terms of total psychotropic and total mesophilic bacteria, microwave oven thawing gave better results than the other methods and it's followed by water thawing. All groups remained within the consumable limit in terms of mesophilic and psychrotrophic aerobic bacteria amount which is acceptable value 10^6 [28]. These results were similar with Genç et al. [7] and Ersoy et al. [13].

Table 2

Microorganisms counts of thawed bonito (Log CFU/g)

Total Bacteria (Log CFU/g)	Microwave (7 min).	Water (1 hour 30 min.)	Refrigerator (22 hours)
Mesophilic Bacteria	3.35±0.04 b	3.47±0.02 a	3.58±0.04 a
Psychrotrophic Bacteria	2.84±0.04 b	2.86±0.11 b	3.25±0.02 a

Values are shown as mean± standard error of triplicates, n=3

a→b Within the line with different letters are significantly different ($p<0.05$)

According to the sensorial panel results, microwave thawing method showed higher scores on the attributes for odor, texture, flavor and overall rating (Table 3). Similar results were reported by Dinçer et al.[11]. However, no statistical difference was observed between the groups except the odor criteria ($p>0.05$).

Table 3

Sensorial panel results of values of thawed bonito

Sensory evolution	Microwave (7 min).	Water (1 hour 30 min.)	Refrigerator (22 hours)
Odor	5.00±0.00 a	4.40±0.20 b	4.70±0.20 ab
Texture	4.50±0.20 a	4.20±0.30 a	4.30±0.30 a
Flavor	4.80±0.10 a	4.20±0.10 a	4.40±0.40 a
Overall Rating	4.90±0.10 a	4.30±0.20 a	4.50±0.10 a

Values are shown as mean±standard error of triplicates, n=3

a→b Within the line with different letters are significantly different ($p<0.05$)

Conclusion

According to the pH value and sensorial panel results, the quality of thawed bonito were not effects with different thawing methods ($p>0.05$). But, according to chemical and microbiological analyse results, increasing thawing period were negatively affect the quality of fish. Therefore, when the consumers and small business owners desired thawing frozen fish in small quantities, firstly can be suggested in the microwave thawing compared to other thawing methods for the best quality.

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Impact of freezing processing on nutritive and antioxidant properties of leafy vegetables consumed in Southern Côte d'Ivoire

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Abstract

Introduction. Leafy vegetables are highly perishable food items and require special processing treatments to prevent post-harvest losses. The purpose of this study is to evaluate the influence of freezing treatment on the nutritive potential of five (5) leafy vegetables consumed in Southern Côte d'Ivoire.

Materials and methods. Leafy vegetables (*Solanum melongena*, *Basella alba*, *Talinum triangulare*, *Colocasia esculenta* and *Corchorus olitorius*) were freshly collected, destalked, washed with deionized water and packed in polyethylene bags at -18°C in freezer for one, two and three months. After the storage time, chemical and nutritive parameters were determined.

Results and discussion. The results of experiment showed that freezing application during long time (3 months) caused losses in some nutrients and anti-nutrients as indicated in percentage: ash (3.51-11.44%), proteins (6.91-23.93%), vitamin C (15.22-33.94%), carotenoids (1.78-12.96%), phenolics (2.11-5.81%), oxalates (4.17-28.27%) and phytates (13.44-24.82%). Contrary to the registered losses, freezing processing highlighted increase of the following parameters after 1 month of storage: moisture (83.20 ± 0.35 % to 90.39 ± 0.78 %), crude fibres (11.60 ± 0.26 % to 24.05 ± 0.42 %) and carbohydrates (46.85 ± 0.88 % to 63.04 ± 1.29 %). The residual minerals contents of frozen leafy vegetables after 1 month were: calcium (367.66-784.9 mg/100g), magnesium (227.3-743.79 mg/100g), phosphorus (224.5-779.33 mg/100g), potassium (2238.35-4865.86 mg/100g), iron (72.40-128.04 mg/100g), sodium (26.38-478.15 mg/100g) and zinc (22.74-65.65 mg/100g).

Conclusions. This work showed that freezing could be used as valuable preservation method of tropical leafy vegetables during a period not exceeding one month in order to avoid some nutritional losses and contribute therefore to the food security of Ivorian populations.

Introduction

Vegetables are important protective foods, which are beneficial for the maintenance of good health and prevention of diseases [1]. Sub-Saharan Africa grows an enormous variety of vegetables among which the green leafy vegetables (GLVs) constitute essential components of human diet particularly in West Africa

[2, 3]. In Côte d'Ivoire (Ivory Coast), more than twenty (20) species of leafy vegetables are widely consumed and cultivated. Moreover, the consumption of these leafy vegetables is linked to the region and ethno-botanical studies have stated that most people in Southern Côte d'Ivoire consume indigenous leafy vegetables such as *Solanum melongena*, *Basella alba*, *Talinum triangulare*, *Colocasia esculenta* and *Corchorus olitorius*. These leafy vegetables are usually consumed in combination with starchy staples and represent a quality food to the poor segment of population both in urban and rural areas. Leafy vegetables are important components of the human diet, providing fibres, minerals and vitamins [4, 5]. These are also sources of antioxidants necessary in neutralizing free radicals in human body [6]. The ethno-botanical reports offer information on medicinal properties of green leafy vegetables like anti-diabetic, anti-histaminic, anti-carcinogenic, hypolipidemic and antibacterial activities [4, 7, 8]. Furthermore, leafy vegetables occupy a modest place as potential source of micronutrients including nutraceuticals of importance like β-carotene, iron, calcium, magnesium, phosphorus, potassium, fiber, folic acid, vitamins K, C and E [9, 10].

In view to their biochemical composition, leafy vegetables are typically over 90% moisture and this fact makes them highly perishable. Indeed, after harvesting they begin to undergo higher rates of respiration, resulting in moisture loss, quality deterioration and potential microbial spoilage [11]. Therefore, these valuable plant foods require special processing treatments to prevent post-harvest losses. Among the various preservation methods used, freezing might extend their shelf life. The freezing process includes pre-freezing treatments, freezing, frozen storage, and thawing. Even though freezing is regarded as the simplest and most important preservation process for fruits and vegetables, it is not a perfect process since it is well known that some nutritional value (vitamins and minerals) may be lost during the freezing process. The losses of nutrients during freezing can be the result of physical separation (peeling and trimming prior to freezing, or exudates loss during thawing), leaching or chemical degradation such as oxidation [11]. Indeed, some authors have reported for vitamin C and phenolics, losses estimated to 50 and 12%, respectively during freezing of vegetables [12]. Furthermore, all the results obtained in the current literature are based on the freezing effect on nutrients contents of exotic leafy vegetables and these data are subjected to variations since retention of nutrients during freezing is highly dependent on the cultivar, production location, maturity stage, season and processing conditions [13].

So, the main objective of this work was to evaluate the effect of freezing storage on nutrients contents of five leafy vegetables (*Solanum melongena*, *Basella alba*, *Talinum triangulare*, *Colocasia esculenta* and *Corchorus olitorius*) cultivated and widely consumed in Southern Côte d'Ivoire in order to predict the delay of post-harvesting preservation and provide nutritional information to consumers.

Materials and methods

Samples collection. Leafy vegetables were collected fresh and at maturity from cultivated farmlands located at Dabou (latitude: 5°19′14″ North; longitude: 4°22′59″ West) (Abidjan District). The samples were harvested at the early stage (between one and two weeks of the appearance of the leaves). These plants were previously authenticated by the National Floristic Center (University Felix Houphouët-Boigny, Abidjan-Côte d'Ivoire).

Samples processing. The fresh leafy vegetables were destalked, washed with deionized water and edible portions were separated from non edible portions. The edible portions were allowed to drain at ambient temperature and separated into two portions of 250 g each. The first portion (250 g) was packed in polyethylene bags and were stored at -18°C in freezer for one, two and three months [2, 14]. After freezing period, the leaves were defrosted at ambient temperature and subjected to drying in oven (Memmert, Germany) at 60°C for 72 h. The dried samples were ground with a laboratory crusher (Culatti, France) equipped with a 10 µm mesh sieve and stored in air-tight containers for further analysis. The second 250 g portion of fresh leafy vegetables was used as the control (raw) and subjected to the same treatement of drying and gridding.

Proximate analysis. Ash, proteins and lipids were determined using official methods [15]. For crude fibres, 2 g of dried powdered sample were digested with 0.25 M sulphuric acid and 0.3 M sodium hydroxide solution. The insoluble residue obtained was washed with hot water and dried in an oven (Memmert, Germany) at 100 °C until constant weight. The dried residue was then incinerated, and weighed for the determination of crude fibres content. Carbohydrates and calorific value were calculated using the following formulas [16]:

Carbohydrates: 100 – (% moisture + % proteins + % lipids + % ash + % fibres).

Calorific value: (% proteins x 2.44) + (% carbohydrates x 3.57) + (% lipids x 8.37).

The results of ash, fibres, proteins, lipids and carbohydrates contents were expressed on dry matter basis.

Mineral analysis. The dried powdered samples (5g) were burned to ashes in a muffle furnace (Pyrolabo, France). The ashes obtained were dissolved in 10 mL of HCl/HNO3 and transferred into 100 mL flasks and the volume was made up using deionized water. The mineral composition of each sample was determined using an Agilent 7500c inductively coupled argon plasma mass spectrometer [17]. Calibrations were performed using external standards prepared from a 1000 ppm single stock solution made up with 2% nitric acid.

Anti-nutritional factors. Oxalates content was performed using a titration method [18]. One (1) g of dried powdered sample was weighed into 100 mL conical flask. A quantity of 75 mL of sulphuric acid (3 M) was added and stirred for 1 h with a magnetic stirrer. The mixture was filtered and 25 mL of the filtrate was titrated while hot against KMnO4 solution (0.05 M) to the end point. Phytates contents were determined using the Wade's reagent colorimetric method [19]. A quantity (1 g) of dried powdered sample was mixed with 20 mL of hydrochloric acid (0.65 N) and stirred for 12 h with a magnetic. The mixture was centrifuged at 12000 rpm for 40 min. An aliquot (0.5 mL) of supernatant was added with 3 mL of Wade's reagent. The reaction mixture was incubated for 15 min and absorbance was measured at 490 nm by using a spectrophotometer (PG Instruments, England). Phytates content was estimated using a calibration curve of sodium phytate (10 mg/mL) as standard.

Vitamin C and carotenoids. Vitamin C content was determined by titration [20]. About 10 g of ground fresh leaves were soaked for 10 min in 40 mL metaphosphoric acid-acetic acid (2%, w/v). The mixture was centrifuged at 3000 rpm for 20 min and the supernatant obtained was diluted and adjusted with 50 mL of bi-distilled water. Ten (10) mL of this mixture was titrated to the end point with dichlorophenol-indophenol (DCPIP) 0.5 g/L. Carotenoids were extracted and quantified by using a spectrophotometric method [21]. Two (2) g of ground fresh leaves were mixed three times with 50 mL of acetone until loss of pigmentation. The mixture obtained was filtered and total carotenoids were extracted with 100 mL of petroleum ether. Absorbance of extracted fraction was then read at 450 nm by using a spectrophotometer (PG Instruments, England). Total carotenoids content was subsequently estimated using a calibration curve of β-carotene (1 mg/mL) as standard.

Polyphenols. Phenolics were extracted and determined using Folin–Ciocalteu's reagent [22]. A quantity (1 g) of dried powdered sample was soaked in 10 mL of methanol 70% (w/v) and centrifuged at 1000 rpm for 10 min. An aliquot (1 mL) of supernatant was oxidized with 1 mL of Folin–Ciocalteu's reagent and neutralized by 1 mL of 20% (w/v) sodium carbonate. The reaction mixture was incubated for 30 min at ambient temperature and absorbance was measured at 745 nm by using a spectrophotometer (PG Instruments, England). The polyphenols content was obtained using a calibration curve of gallic acid (1 mg/mL) as standard.

Antioxidant activity. Antioxidant activity assay was carried out using the 2, 2-diphenyl-1-pycrilhydrazyl (DPPH) spectrophotometric method [23]. About 1 mL of 0.3 mM DPPH solution in ethanol was added to 2.5 mL of sample solution (1 g of dried powdered sample mixed in 10 mL of methanol), filtered through Whatman No. 4 filter paper and allowed to react for 30 min at room temperature. Absorbance values were measured with a spectrophotometer (PG Instruments, England) set at 415 nm. The average absorbance values were converted to percentage antioxidant activity using the following formula:

Antioxidant activity (%) = 100 – [(Abs of sample – Abs of blank) x 100/Abs positive control]

Statistical analysis. All the analyses were performed in triplicate and data were analyzed using EXCELL and STATISTICA 7.1 (StatSoft). Values were expressed as means ± standard deviation.

Results and discussion

Nutritive properties. The proximate composition of frozen leafy vegetables is presented in Table 1.

The slight increase ($p = 0.05$) in moisture content (0.02 – 1.03 to 0.3 – 1.60 %) of leafy vegetables stored at – 18°C may be due to the adsorption of water. Similar results were obtained during storage of *Cassia tora* and *Corchorus tridens* at – 18 °C for 3 months [2]. Ash content of the analyzed samples ranged after 1 month from 8.37 ± 0.05 % to 22.05 ± 1.89 %. The decrease in ash contents could be attributed to the loss water carrying off the minerals during freezing storage. Indeed, freezing of tissues at high moisture content results in the formation of ice crystals within the cells. The sharp edges of the crystals so formed are capable of lacerating the cell membranes resulting in cell leakage and its contents [24, 25]. In spite of ash losses, the studied samples may suggest that these leafy vegetables are

good sources of minerals because leaves contain about 3 % ash has been reported as suitable for human nutrition [26]. Crude fibres are general term for plant cell wall components that are poorly digested by humans, such as cellulose and lignin [27]. The crude fibres increased ($p = 0.05$) after 1 month and 3 months of freezing respectively to 0.20 – 0.95 % and to 0.5 – 1.89 %. These results were similar to values reported for freezing storage (10-12 months) of white asparagus and red delicious apples [28, 29]. Increasing in fibres content could be exploited in human nutrition because intake of dietary fibres appears to be useful for the treatment of both obesity and diabetes [30]. After 1 month of freezing storage, proteins and lipids contents averaged from 8.89 ± 0.12 to 20.97 ± 0.42 % and from 3.03 ± 0.00 to 7.09 ± 0.01 %, respectively. The relativity low lipids contents at 1 month of freezing processing corroborates the finding of many authors which showed that fresh leafy vegetables were found to be poor sources of lipids [31]. The slight decrease in protein and lipids contents caused by freezing could be attributed to the leaching off by water during freezing, but leafy vegetables lose more lipids during storage owing to oxidation [11]. The studied leafy vegetables were poor sources of lipids and their consumption could be advantageous for individuals suffering from obesity. Indeed, diet providing 1 – 2 % of its caloric energy as fat is said to be sufficient to human requirements because excess fat consumption yields to cardiovascular disorder such as atherosclerosis, cancer and aging [32].The low calorific values could be due to low proteins, lipids and total carbohydrate contents and relatively high levels of moisture [33].

Anti-nutritional factors (oxalates and phytates) contents of the studied leafy vegetables are presented in Figure 1. Analysis of the oxalates and phytates in fresh and frozen samples showed that oxalates and phytates concentration decreased with freezing time. The values ranged after 1 month from 82.01 ± 1.94 to 773.03 ± 3.77 mg/100g for the oxalates and from 17.75 ± 0.00 to 37.45 ± 0.00 mg/100 g for phytates. The decreasing effect of freezing on oxalates and phytates concentration corroborates with the reported results of researchers [34, 35]. These reductions in oxalates and phytates contents during freezing storage could be advantageous for improving the health status of consumers. Indeed, oxalates and phytates are anti-nutrients which chelate divalent cations such as calcium, magnesium, zinc and iron thereby reducing their bioavailability [36].

The mineral composition in vegetables depends on species, cultivar, plant age, production techniques, and post-harvest handling, beside other environmental factors [37, 38]. Minerals are essential protective micronutrients needed for the maintenance of essential physicochemical processes, having a vital role in metabolic functions, normal growth and development [39]. The concentrations of the minerals (Ca, Mg, P, K, Fe, Na and Zn) showed decreasing effect ($p = 0.05$) of freezing (Table 2). The residual mineral contents after 1 month of freezing were: calcium (367.66-784.9 mg/100g), magnesium (227.3-743.79 mg/100 g), phosphorus (224.5-779.33 mg/100 g), potassium (2238.35-4865.86 mg/100 g), iron (72.40-128.04 mg/100 g), sodium (26.38-478.15 mg/100 g) and zinc (22.74- 65.65 mg/100 g). With regards to the recommended dietary allowance (RDA) for minerals [40]: calcium (1000 mg/day), magnesium (400 mg/day), iron (8 mg/day) and zinc (6 mg/day), the level of iron and zinc in the samples could cover RDA. Iron (Fe) is critical component of several proteins, including enzymes, cytochromes, myoglobin and hemoglobin while zinc (Zn) is involved in the maintenance of the structural integrity of proteins and regulation of gene expression [41, 42].

Table 1

Proximate composition of raw and frozen leafy vegetables consumed in Southern Côte d'Ivoire

	Moisture (%)	Ash* (%)	Fibres* (%)	Proteins* (%)	Lipids* (%)	Carbohyd.* (%)	Energy (kcal /100g)
C. esculenta							
Raw	82.35 ± 2.83a	15.03± 0.23a	24.00 ± 0.46a	9.80 ± 0.16a	8.35 ± 0.15a	42.85 ± 2.68d	252.34 ± 1.55c
1 month	83.20 ± 0.35a	14.26± 0.08a	24.05 ± 0.42a	9.65 ± 0.00a	7.09 ± 0.01b	48.54 ± 0.34c	256.22 ± 1.24c
2 months	83.22 ± 0.33a	13.53± 0.09b	24.10 ± 0.24a	9.05 ± 0.02b	6.88 ± 0.01b	51.03 ± 0.15b	261.86 ± 0.50b
3 months	83.33 ± 0.25a	13.31± 0.61b	24.12 ± 0.37a	8.41 ± 0.44c	6.32 ± 0.02c	57.54 ± 0.68a	278.89 ± 1.30a
B. alba							
Raw	89.82 ± 1.24a	19.79± 0.44a	16.50 ± 0.30a	9.86 ± 0.10a	6.85 ± 0.05a	47.00 ± 0.89c	249.18 ± 2.41b
1 month	90.39 ± 0.78a	18.65± 2.87a	16.62 ± 0.36a	8.89 ± 0.12b	6.55 ± 0.02a	57.37 ± 3.26b	281.36 ± 1.49a
2 months	90.44 ± 0.57a	18.45± 0.11a	16.74 ± 2.27a	8.67 ± 0.28b	4.84 ± 0.02b	62.47 ± 2.17a	284.76 ± 8.36a
3 months	90.50 ± 0.81a	18.18± 0.18a	16.81 ± 0.28a	7.50 ± 0.35c	4.13 ± 0.01c	65.67 ± 0.68a	287.33 ± 1.52a
S. melongena							
Raw	74.38 ± 0.72a	20.32 2.36a	13.70 ± 0.65a	12.34 ± 0.09a	2.73 ± 0.06a	50.91 ± 3.16c	277.57 ± 3.54b
1 month	74.49 ± 0.63a	20.27± 0.69a	13.78 ± 0.40a	11.55 ± 0.34b	2.54 ± 0.00b	63.04 ± 1.29b	274.55 ± 4.14b
2 months	74.55 ± 0.50a	19.46± 0.74a	13.85 ± 0.25a	10.85 ± 0.50b	2.22 ± 0.02c	65.10 ± 0.09a	277.49 ± 3.45b
3 months	74.61 ± 1.15a	19.33± 0.13a	13.96 ± 0.13a	10.72 ± 0.00b	2.17 ± 0.00c	66.51 ± 0.26a	281.80 ± 0.94a
T. triangulare							
Raw	90.20 ± 0.21a	22.20± 0.37a	13.98 ± 1.50a	17.18 ± 0.05a	4.90 ± 0.06a	52.77 ± 2.08a	271.32 ± 8.17a
1 month	90.22 ± 1.55a	22.05± 1.89a	14.06 ± 0.61a	16.17 ± 0.50a	4.86 ± 0.00a	46.85 ± 0.88b	247.41 ± 4.38c
2 months	90.85 ± 0.09a	21.59± 0.03a	14.13 ± 0.07a	15.14 ± 0.01c	4.57 ± 0.00b	51.21 ± 0.05a	258.02 ± 0.18b
3 months	91.23 ± 0.12a	21.42± 0.42a	14.16 ± 0.07a	14.50 ± 0.35d	4.05 ± 0.00c	53.65 ± 0.40a	260.84 ± 1.58b
C. olitorius							
Raw	84.28 ± 0.34a	8.53 ± 0.15a	11.49 ± 0.03a	21.12 ± 0.05a	3.28 ± 0.30a	55.58 ± 0.84b	277.40 ± 1.26a
1 month	84.66 ± 1.57a	8.3± 0.05a	11.60 ± 0.26a	20.97 ± 0.42a	3.03 ± 0.00a	51.92 ± 0.74c	261.90 ± 1.62b
2 months	85.14 ± 1.38a	8.21± 0.07a	11.65 ± 0.05a	20.53 ± 0.36b	2.09 ± 0.00b	54.91 ± 0.48b	263.63 ± 0.83b
3 months	85.63 ± 0.35a	8.1± 1.24a	11.67 ± 0.29a	19.66 ± 0.28c	1.17 ± 0.00c	59.48 ± 1.00a	270.16 ± 4.06a

Data are represented as mean ± SD (n = 3). Means in the column with no common letter differ significantly ($p<0.05$) for each leafy vegetable. *: values given on dry matter basis.

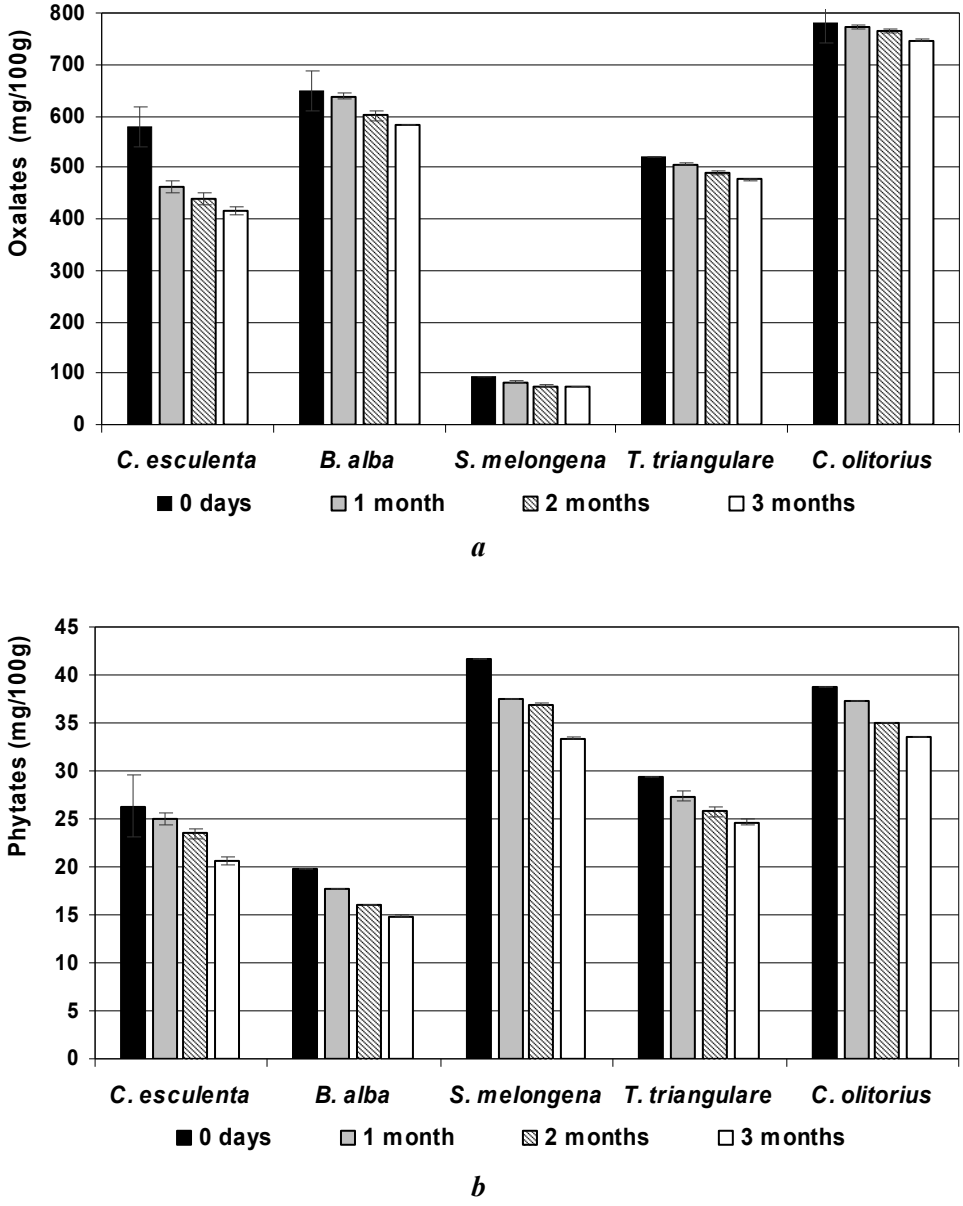


Fig. 1. Effect of freezing processing on oxalates (a) and phytates (b) contents of leafy vegetables consumed in Southern Côte d'Ivoire

Table 2

Mineral composition (mg/100g dry matter) of raw and frozen leafy vegetables consumed in Southern Côte d'Ivoire

	Ca	Mg	P	K	Fe	Na	Zn
C. esculenta							
Raw	587.24 ± 0.55a	347.29 0.32a	788.00± 0.74a	2281.63 ± 2.14a	143.37 ± 0.13a	39.45± 0.16a	37.29 ± 0.03a
1 month	579.26± 7.39a	338.28± 3.04b	779.33 ± 5.54b	2245.69 ± 8.15b	125.57 ± 0.66b	31.12 ± 1.67b	34.03 ± 0.06b
2 months	560.04 ± 5.98b	347.49 ± 2.26a	762.05 ± 5.64c	2228.24 ± 5.96c	116.92 ± 0.21c	28.66 ± 0.07c	32.34 ± 0.06c
3 months	500.96 ± 5.83c	312.85 ± 7.60c	759.06 ± 3.41c	2194.40± 6.57d	110.31± 1.22d	27.12 ± 2.88c	29.20 ± 0.26d
B. alba							
Raw	750.34 ± 0.53a	753.88 ± 0.53a	390.14 ± 0.27a	2709.43 ± 1.93a	77.47 ± 0.05a	555.01 ± 5.99a	67.25 ± 0.72a
1 month	722.25 ± 9.49b	729.79 ± 8.39b	388.69 ± 9.16a	2631.40 ± 5.74b	72.40 ± 4.04a	478.15 ± 2.71b	65.65 ± 0.13a
2 months	699.47 ± 8.63c	703.18 ± 4.26c	382.46 ± 4.15a	2436.61 ± 5.75c	61.80 ± 0.18b	452.94 ± 4.92c	62.44 ± 0.11b
3 months	679.13 ± 8.45d	677.80 ± 7.65d	371.85 ± 2.61b	2269.98 ± 9.77d	58.47 ± 0.21c	428.44 ± 1.75d	60.65 ± 0.86b
S. melongena							
Raw	796.54 ± 0.55a	481.90 ± 0.33a	374.46 ± 0.26a	2256.10 ± 1.57a	139.48 ± 0.09a	323.13 ± 2.96a	64.64 ± 0.04a
1 month	784.9 ± 9.92a	467.67 ± 9.79b	362.01 ± 2.71b	2238.35 ± 7.77b	128.04 ± 0.77b	320.23 ± 3.89a	57.42 ± 0.17b
2 months	757.43 ± 4.58b	450.20 ± 5.42c	355.02 ± 2.50c	2182.59 ± 3.97c	111.87 ± 3.54c	318.42 ± 2.64a	54.65 ± 0.51c
3 months	734.89 ± 3.00c	428.23 ± 8.00d	352.3 ± 3.40c	2156.08 ± 5.32d	102.96 ± 2.29d	314.20 ± 0.26b	51.55 ± 0.14d
T. triangulare							
Raw	601.37 ± 0.38a	755.97 ± 0.48a	239.59 ± 0.81a	5053.23 ± 3.21a	102.28 ± 0.06a	260.25 ± 0.75a	36.10 ± 0.02a
1 month	594.98 ± 6.75a	743.79 ± 4.14a	224.5 ± 5.28b	4865.86 ± 4.44b	101.43 ± 1.37a	248.43 ± 0.95b	34.76 ± 0.53b
2 months	564.23 ± 1.59b	726.78 ± 7.90b	218.34 ± 4.10b	4670.16 ± 4.38c	99.92 ± 3.37a	234.73 ± 6.97c	33.50 ± 0.13b
3 months	548.19 ± 4.62c	716.47 ± 2.13c	216.28 ± 1.03b	4522.75 ± 1.56d	98.57 ± 0.05a	214.3 ± 6.12d	32.18 ± 0.00c
C. olitorius							
Raw	369.02 ± 2.33a	234.51 ± 0.38a	316.82 ± 0.52a	2622.57 ± 6.56a	97.60 ± 0.16a	27.75 ± 0.08a	24.71 ± 0.04a
1 month	367.66 ± 4.42a	227.3 ± 1.55b	310.97 ± 3.55a	2569.52 ± 1.29b	95.84 ± 0.12b	26.38 ± 1.57a	22.74 ± 0.06b
2 months	365.18 ± 5.91a	220.29 ± 1.94b	301.97 ± 4.99c	2459.59 ± 8.67c	94.50 ± 0.13b	25.70 ± 5.92a	17.57 ± 0.06c
3 months	360.23 ± 8.29a	214.78 ± 3.21c	294.37 ± 4.13d	2419.12 ± 4.85d	93.34 ± 0.49b	25.00 ± 0.29a	13.68 ± 0.63d

Data are represented as mean ± SD (n = 3). Means in the column with no common letter differ significantly ($p<0.05$) for each leafy vegetable

Table 3 shows the calculated (anti-nutrients/mineral) ratios. The calculated ratios [phytates]/Ca, [phytates]/Fe and [oxalates]/Ca were below the critical levels of 0.5, 0.4 and 2.5, respectively [36]. Consequently, this study revealed that phytates and oxalates may not hinder calcium and iron bioavailability in the freezing leaves after 3 months of storage.

Table 3

Mineral composition (mg/100g dry matter) of raw and frozen leafy vegetables consumed in Southern Côte d'Ivoire

	[Phytates]/Ca	[Phytates]/Fe	[Oxalates]/Ca
C. esculenta			
Raw	0.04	0.18	0.98
1 month	0.04	0.20	0.79
2 months	0.04	0.20	0.78
3 months	0.04	0.10	0.83
B. alba			
Raw	0.02	0.25	0.87
1 month	0.02	0.24	0.88
2 months	0.02	0.60	0.85
3 months	0.02	0.25	0.85
S. melongena			
Raw	0.05	0.29	0.12
1 month	0.04	0.29	0.10
2 months	0.04	0.33	0.09
3 months	0.04	0.32	0.09
T. triangulare			
Raw	0.04	0.28	0.86
1 month	0.04	0.27	0.85
2 months	0.04	0.25	0.86
3 months	0.04	0.25	0.87
C. olitorius			
Raw	0.10	0.40	2.11
1 month	0.10	0.38	2.10
2 months	0.09	0.37	2.09
3 months	0.09	0.35	2.07

Antioxidant properties. The antioxidant properties of vegetables are one of the most label claims due to the high levels of carotenoids, tocopherols, ascorbic acid and phenolics that have benefits on human health [43, 44]. Freezing resulted in a decrease of vitamin C and carotenoids contents in the studied leafy vegetables (Fig. 2). Vitamin C losses were estimated to 5.24-17.58 %, at 1 month of storage and this observed decrease during freezing storage is partly due to the enzymatic activities of vitamin C oxidase, cytochrome oxidase and vitamin C peroxidase that are endogenously present [45]. The results obtained from this study showed that carotenoids content decreased with freezing time. The losses were estimated to 1.78-12.96 % at 3 months of storage and could be as a result of enzymatic activity coupled with oxidation associated with conjugate double bond in the compound [46]. Several epidemiological studies suggest that diets rich in phytochemicals and antioxidants such as vitamin C and carotenoids fulfill a protective role in health and disease and vegetables has been associated with a lowered risk of cancer, heart disease and hypertension [47, 48, 49, 50].

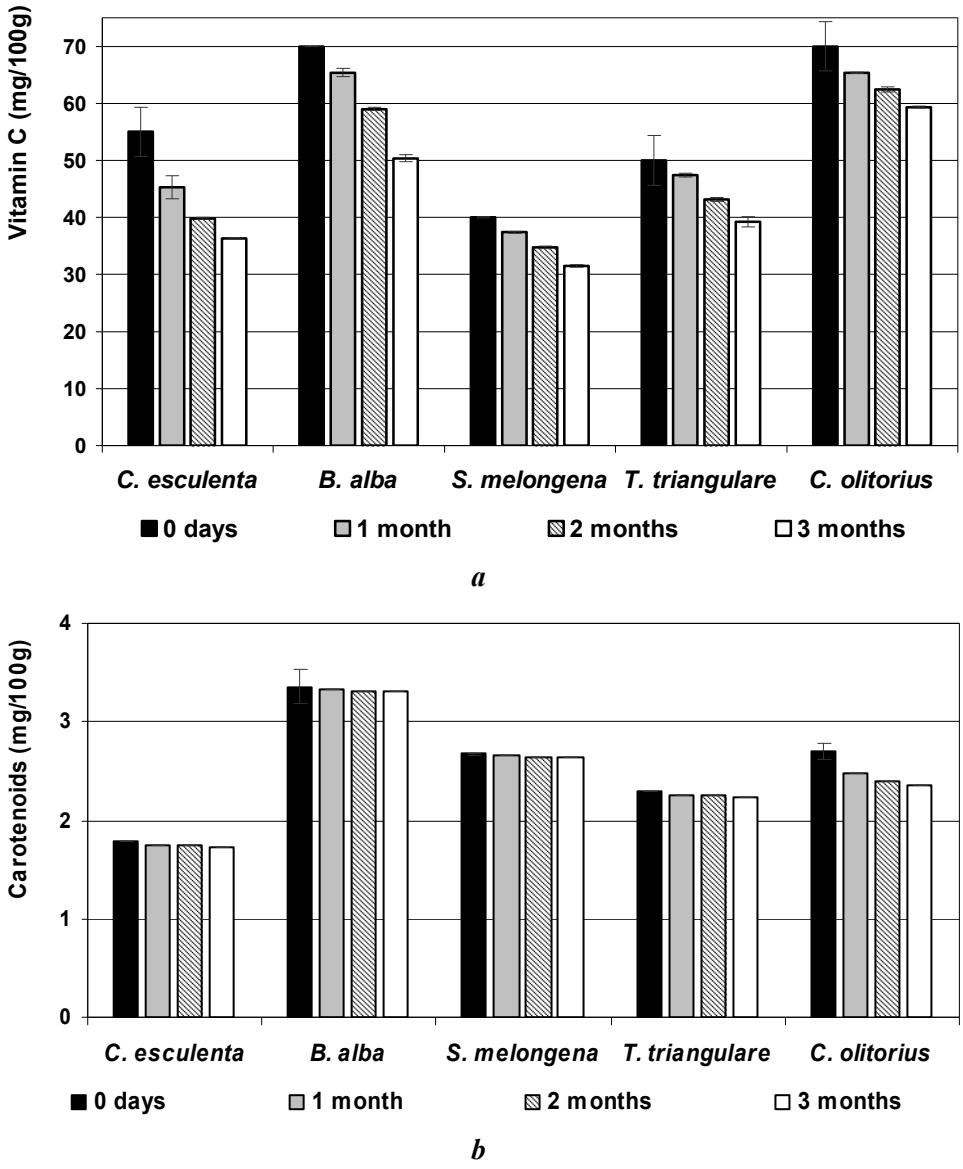
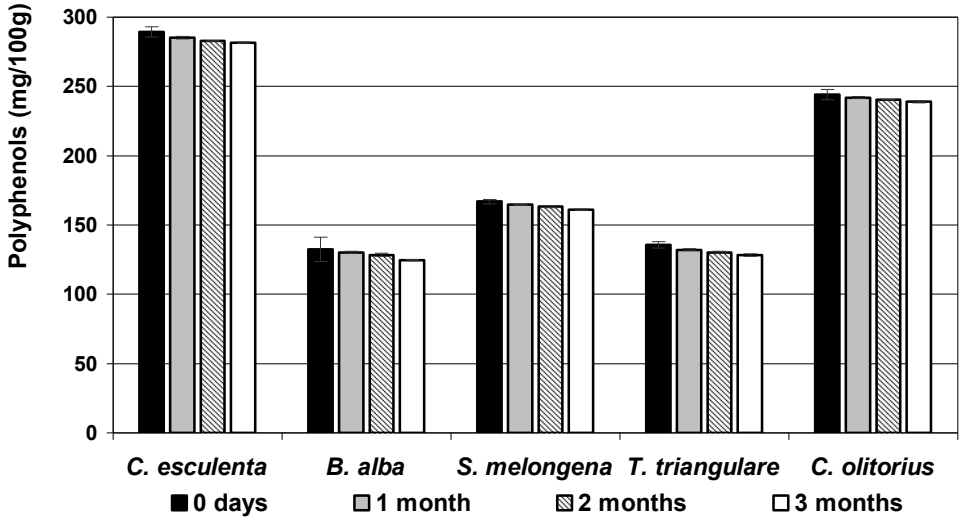


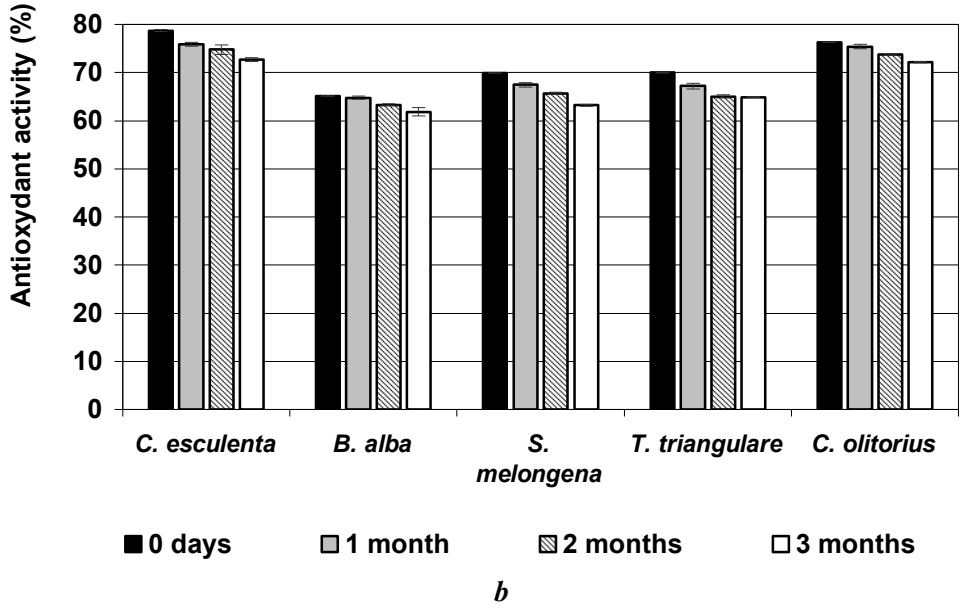
Fig. 2. Effect of freezing processing on vitamin C (*a*) and carotenoids (*b*) contents of leafy vegetables consumed in Southern Côte d'Ivoire

The results of phenolic compounds and antioxidant activity of the leafy vegetables are presented in Figure 3. Generally, freezing causes minimal destruction of phenolic compounds with retention levels dependent on vegetable cultivar. The phenolic compounds decreased during freezing storage with losses estimated to 2.11-5.81 % at 3 months of storage. Moreover, this decreases in phenolic contents leads to the decrease of antioxidant

activity because there is a direct correlation between phenolic compounds and antioxidant activity [51]. Antioxidant activity ranged from 64.75 ± 0.31 to 75.90 ± 0.37 % after 1 month of freezing storage. However, the studied leafy vegetables showed antioxidant activity which averaged 60 % after 3 months of freezing storage. It could be important to reduce the freezing time to ensure best antioxidant value for these leafy vegetables.



a



b

Fig. 3. Effect of freezing processing on polyphenols content (*a*) and antioxidant activity (*b*) of leafy vegetables consumed in Southern Côte d'Ivoire

Conclusions

This study was undertaken to evaluate the effect of freezing storage on nutritive potential and antioxidant properties of five leafy vegetables (*C. esculenta, B. alba, S. melongena, T. triangulare and C. olitorius*) widely consumed in Southern Côte d'Ivoire. The present work revealed that freezing processing appears as a valuable preservation method for leafy vegetables but storage for 3 months showed negative impact by the decrease of some nutrients contents such as vitamin C, carotenoids, phenolics and minerals. Consequently, this study highlighted that the best time of freezing for leafy vegetables should not exceed 1 month in order to preserve their nutritive potential.

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Mathematical simulation of fouled membrane modules regeneration

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Abstract

Introduction. The purposes of this research are: development of mathematical model of regeneration of spiral wound membrane modules, calculation of regeneration time and permeate flux after regeneration.

Materials and methods.. The target of this research is process of regeneration of fouled spiral wound membrane module and theoretical description of that process. Theoretical analysis was carried out for commercial available membranes MICROFILTER TFC-75, FS-TFC 1812–50, CSM RE-1812-50 GPD and USTM M-1261-75G.

Results and discussion. The proposed mathematical model is based on osmotic pressure model and includes mass transfer equation and equation for determination regeneration coefficient. The mass transfer coefficient was determinated from dimensionless equation. Using this mathematical model the calculations of time of cake layer dissolution and regeneration coefficients time was carried out in a range of Reynolds numbers from 10 to 50.

The results of calculations shown that for low Reynolds number values (10-25) time of full cake layer dissolution is dramatically decreased (from 9215 seconds (about two hours and half) for Re=10 to 6545 seconds (less than two hours) for Re=15 and to 5143 seconds (less than one hour and half) for Re=20) with Reynolds number increasing.

But for higher Reynolds numbers the decreasing of regeneration time become slower. For instance for increasing Reynolds number value from 25 to 30 time the regeneration time decrease only from 4275 seconds to 3650 seconds (for 625 seconds or few more than 10 minutes).

The results of calculations suggest that most rational regime of regeneration correspond Reynolds number values from 15 to 25.

Conclusions. The mathematical model that can predict regeneration time and permeate flux after regeneration was formed. It can be used for development of regeneration strategy of existing membrane systems and for designing new plants.

Introduction

Fresh water is one of most important resource. It is used for potable purpose, which is one of most significant biological demand, and also for production almost all food products and beverages. But, nowadays, problem fresh water shortage due to anthropogenic and technological factors gets on a global level. Moreover, problem is expected to grow worse in coming decades [1]. In such situation importance of fresh water treatment technologies becomes more and more significant.

In recent decades membrane processes, in particular reverse osmosis and nanofiltration, are widely used for production potable water and water purification not only in food industry. These methods are applied in chemical, textile, pharmaceutical, pulp and paper, semi-conductor, tanning and leather processing, and biotechnology as well for water and wastewater treatment [2]. In food industry membrane technology also used for fruit juices clarifying [3], milk and dairy products treatment [4], alcohol beverages treatment [5, 6], etc. The wide range of application is determinated by reduction of unit operation, continues and automatic operation, easy scale-up, high effectiveness of separation and lower energy consumption in compare with competitive processes, such as thermal distillation [7, 8].

But there are some limitation for membrane process development and full incorporation. One of major limitation arise from membrane fouling caused by different solid particles, inorganic salts, organic substance, which reduce productivity, increases necessary feed pressure, decrease product quality and ultimately shortens membrane lifetime [2, 9]. Many efforts have been done to resolve that problem, which include water pretreatment, changing membrane properties, changing hydrodynamic conditions in membrane module and membrane cleaning process [10].

The pretreatment is one of most effective way to prevent membrane fouling and it is considered as critical step in designing reverse osmosis equipment [11]. It may include disinfection, flocculation, coagulation conventional filtration, microfiltration, ultrafiltration, beachwell intake systems, and antiscalants dosing – chemicals which reduce scaling. Using membrane pretreatment may almost completely remove solid practice deposition and organic fouling and also significant decrease mineral salts depositions [11, 12, 13, 14]. However it is unlikely to completely eliminate fouling that is why periodical membrane regeneration is necessary needed [15].

Some developed regeneration methods was developed. They include backpulsing [16, 17], chemical cleaning with different cleaning agents (citric acid, sodium hydroxide, etc.) [18, 19], enzymatic cleaning [20, 21] and others. Most of them are based on empirical data and require large amount of chemical cleaning agents. Also it difficult to predict membrane properties, primarily permeate flux, after regeneration.

In our recent works it was developed method regeneration of spiral wound membrane module using local boil under subatmospheric pressure [22] and mathematical model which describe mass transfer of fouling layer (cake layer) dissolution in cleaning solution in spiral wound membrane modules channels [23]. Those results allowed us to develop mathematical model which can predict membrane productivity after regeneration. In this work, regeneration of spiral wound membrane type modules, which is used for reverse osmosis and nanofiltration will be considered. For that case the mineral salt scaling is most typical fouling type. The analysis will be represented for cake layer which is formed from individual component (mineral salt only), and following results can be extended to multicomponent cake layer with some amendments.

The purposes of this research are: development of mathematical model of regeneration of spiral wound membrane modules, calculation of regeneration time and permeate flux after regeneration.

Objectives of research are following:

- Couch the physical model of regeneration of spiral wound membrane modules;
- Develop of the equations and starting condition which describe mass transfer in spiral wound membrane modules channels during regeneration process;
- Choose of the numerical solution method;
- Make calculation of regeneration time;
- Make calculation of permeate flux after regeneration;
- Determinate of influence hydrodynamic condition on duration of regeneration time.

Materials and methods

The target of this research is process of regeneration of fouled spiral wound membrane module and theoretical description of that process. Theoretical analysis was carried out for commercial available membranes (MICROFILTER TFC-75, FS-TFC 1812–50, CSM RE-1812-50 GPD and USTM M-1261-75G) which had been used in our recent experimental investigations [22].

The physical model of cake layer dissolution process is based on assumption that was accepted and based on the analysis of cake formation mechanism [10] and on the visual observation of membrane surface of dissected fouled membrane module.

The mathematical model was developed on the base of osmotic pressure model [2]. This basis has been chosen because the main type of membrane fouling which was studied in our research was mineral scaling formed during reverse osmosis and nanofiltration. For these processes the osmotic pressure is one of key factors which impact on the process conditions, especially when separation is performed at a high permeate flux with high rejection levels [2, 10]. The mathematical model also includes mass transfer equation which describes dissolution of solid material in the cake layer [24].

For solution of proposed mathematical model should be used numerical methods, in particular Runge-Kutta method which is one of most accurate and commonly used numerical method [25].

Procedure of calculations will be represented after description of equation that forms proposed mathematical model.

Results and discussion

Background of theory. The first basis of theoretical approach was assumption of cake layer structure. Since fouling is formed from feed solution components, the cake substance may be dissolved and removed from in a form of solution and/or colloidal suspension. Taking into account spiral wound membrane module design this is only way of removing fouling from narrow membrane channel. The visual observation of cake layer shows that cake substance (mineral salts) is almost uniformly distributed on the membrane surface (Fig. 1) so that mass transfer surface area can be assumed constant and approximately equal of membrane surface area. The deviation of cake layer surface area from accepted assumption can be taken into account by using correction index.

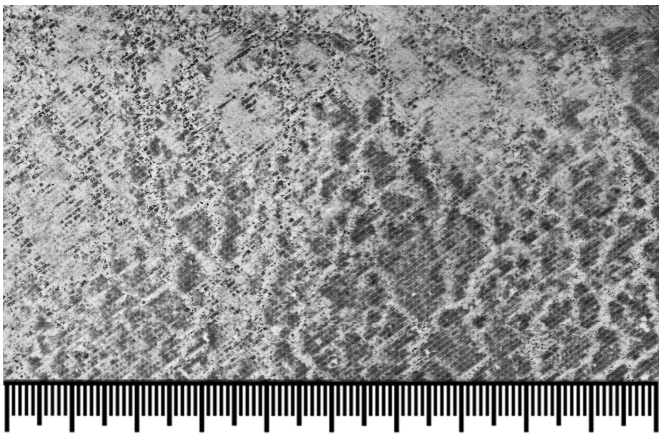

Fig. 1. Cake layer on the membrane surface

Physical model of cake layer dissolution. The main process during membrane regeneration is dissolution which take place when cleaning solution flowing in membrane channel contact with solid mater. Type of cleaning solutions should be chosen depending of cake later substance nature. The dissolving process is considered as diffusion-controlled mass transfer processes in which mass are transported from solid phase (cake layer) to liquid phase (bulk of cleaning solution). Process take place in membrane channel formed two coils of membrane and spacer betwen them (Fig. 2). The channel width is determined by spacer dimension, which is less than one millimeter.

In the beginning of dissolving process on the solid substance surface diffusion sublayer is formed instantly. The concentration of soluble material of cake layer in that sublayer is equal to equilibrium concentration. If concentration of that material in bulk of cleaning solution is less mass transfer occurs as shown on Fig. 3 and on Fig. 4 (removal element A of Fig. 3) .

The main mass transfer resistance is concentrated in diffusion sublayer. The cleaning solution usually flows under laminar conditions so possibility of hydrodynamic intensification is limitated. To reduce resistance of diffusion sublayer it was proposed to use subatmospheric pressure and temperature of evaporation of cleaning solution under operating pressure (when operating pressure is equal to saturation vapor pressure) [22]. In this case in the bulk of cleaning solution the steam bubbles will be formed, then collapsed and destroyed in cleaning solution stream. Forming and collapsing of steam bubbles will be caused intensive mixing in bulk of cleaning solution and in diffusion sublayer. This provides refreshing of mass transfer area and intensification mass transfer process (Fig. 5).

Relying on conditions of high intercity evaporation, the steam bubbles may create additional mass transfer resistance. In order to avoid this effect it was proposed to use periodic increasing of operating pressure during regeneration time.

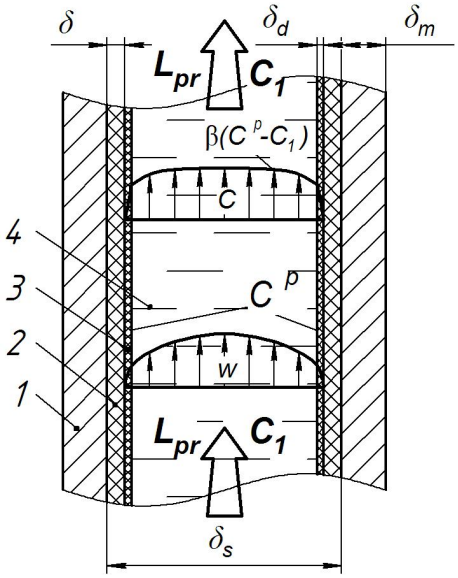

Fig. 2. Scheme of mass transfer in membrane channel

1 – membrane, 2 – cake layer, 3 – diffusion sublayer; 4 – bulk of cleaning solution; L_{pr} – flow rate of cleaning solutions; C_1 – concentration of soluble material of cake layer in cleaning solution; C^p – equilibrium concentration; β – mass transfer coefficient; w – scheme of cleaning solution velocity distribution in channel cross section; c – scheme of concentration of soluble material of cake layer distribution in channel cross section; δ_m – membrane thickness; δ – cake layer thickness; δ_d – diffusion sublayer thickness; δ_s – channel width (spacer thickness).

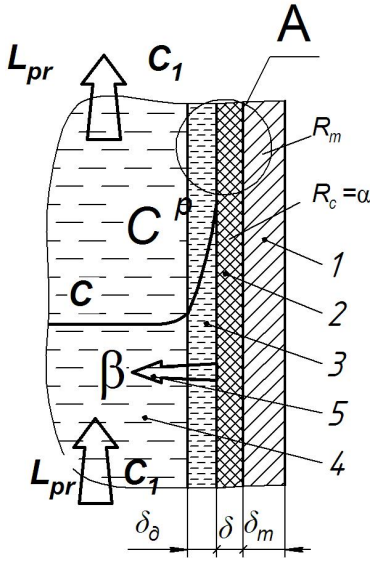

Fig. 3. Scheme of mass transfer on the cake layer surface

1 – membrane, 2 – cake layer, 3 – diffusion sublayer; 4 – bulk of cleaning solution; 5 – direction of mass transfer; L_{pr} flow rate of cleaning solutions; C_1 – concentration of soluble material of cake layer in cleaning solution; C^p – equilibrium concentration; β – mass transfer coefficient; c – scheme of concentration changing; δ_m – membrane thickness; δ_c – cake layer thickness; δ_d – diffusion sublayer thickness; R_m – membrane resistance; R_c –cake layer resistance; α – specific cake layer resistance, A – removal element shown on Fig. 4

Mathematical model. The mathematical model is based on osmotic pressure model, in which permeate flux can be expressed as [2]:

$$J = \frac{\Delta p - \Delta \pi}{\mu \cdot R_T}, \quad (1)$$

where Δp is pressure difference, Pa; $\Delta \pi$ is osmotic pressure difference, Pa; μ is dynamic viscosity, Pa·s; R_T is total resistance, m^{-1}.

For assumption accepted in this study total resistance can be expressed as:

$$R_T = R_m + \alpha \cdot \delta, \quad (2)$$

where R_m is membrane resistance, m^{-1}; α is specific cake layer resistance, m^{-2}, δ is cake layer thickness, m.

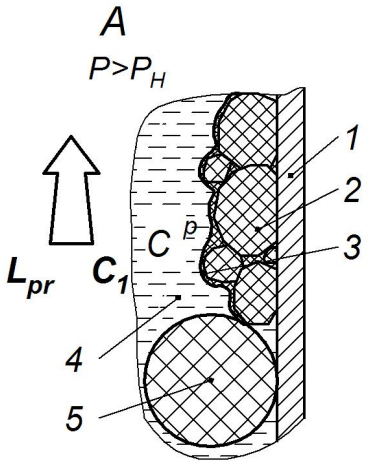

Fig. 4. Scheme of mass transfer on the cake layer surface (removal element A on Fig.3)
1 – membrane, 2 – cake layer, 3 – diffusion sublayer; 4 – bulk of cleaning solution; 5 – spacer; L_{pr} flow rate of cleaning solutions; C_1 – concentration of soluble material of cake layer in cleaning solution; C^p – equilibrium concentration; P – operating pressure; P_H – saturation vapor pressure;

When permeate flux decrease to 50-70% from beginning value it is necessary to carry out regeneration procedure. The effectiveness of regeneration is evaluated by using regeneration coefficient:

$$y = \frac{J_{i+1} - J_i}{J_i} = \frac{J_{i+1}}{J_i} - 1, \tag{3}$$

where J_i is permeate flux before regeneration, $m^3/(m^2 \cdot s)$; J_{i+1} is permeate flux after regeneration, $m^3/(m^2 \cdot s)$.

By substitution equations (1) and (2) into equation (3) it can be obtained:

$$y = \frac{\Delta p_{i+1} + \Delta \pi_{i+1}}{\mu_{i+1}\left(R_m + \alpha\delta_{i+1}\right)} \cdot \frac{\mu_i\left(R_m + \alpha\delta_i\right)}{\Delta p_i + \Delta \pi_i} - 1. \tag{4}$$

The initial cake layer thickness may be expressed:

$$\delta_i = \frac{M_o}{\rho_c F}. \tag{5}$$

where F is mass transfer area, m^2; ρ_c is substance density in a cake layer, kg/m^3; M_0 is initial mass of cake layer, kg.

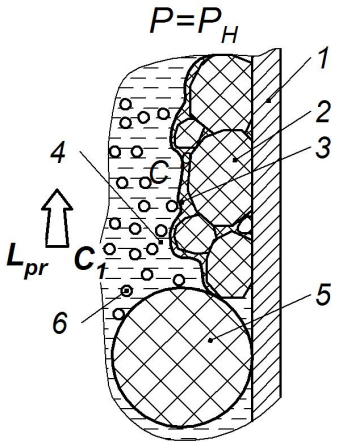

Fig. 5. Scheme of mass transfer under subatmospheric pressure and temperature of evaporation of cleaning solution under operating pressure:
1 – membrane, 2 – cake layer, 3 – diffusion sublayer; 4 – bulk of cleaning solution; 5 – spacer; 6 – steam bubbles; L_{pr} flow rate of cleaning solutions; C_1 – concentration of soluble material of cake layer in cleaning solution; C^p – equilibrium concentration; P – operating pressure; P_H – saturation vapor pressure;

The cake layer thickness after regenerayion will be decrease because of reduction its mass for mass of dissolved material wich can expressed [24]:

$$M = \beta \cdot \left(C^p - C_1 \right) F \tau \,, \tag{6}$$

where β is mass transfer coefficient, m/s; C^p is equilibrium concentration, kg/m^3, C_1 is concentration in bulk of cleaning solutions, kg/m^3, τ is regeneration time, s.

After mathematical transformations using equations (5) and (6) equation (4) can be rewritten in a form:

$$y = \frac{\alpha \cdot \beta \cdot \left(C^p - C_1 \right) \cdot \tau \cdot F}{R_m \cdot \rho_c \cdot F + \alpha \cdot \left(M_0 - \beta \cdot \left(C^p - C_1 \right) \cdot \tau \cdot F \right)} \,, \tag{7}$$

The equilibrium concentration and substance density for known cake layer material may be found in reference books for example [26]. The mass transfer area as described above may be assumed equal to membrane surface area which is may be known from membrane manufactures. The membrane resistance and specific cake layer resistance may be determinated by experimental way as it was shown in [27]. The initial mass of cake layer also may be defined experimentally by balance measurement clean and fouled membrane module.

The regeneration time may be calculated from mass transfer equations [24]:

$$\frac{dM}{d\tau} = \beta \cdot \left(C^p - C_1 \right) F \,, \tag{8}$$

The concentration in bulk of cleaning solutions is varying during dissolving and equation which describes that variation may be obtained from mas balance:

$$M = M_0 - (M_0 - M) = V \cdot (C_1 - C_0) \tag{9}$$

where M_0 is initial cake layer mass, kg; C_0 is initial concentration in cleaning solution, kg/m^3; V is volume of cleaning solution, m^3.

From equation (9) it can be obtained:

$$C_1 = C_0 + \frac{M_0}{V}\left(1 - \frac{M_0 - M}{M_0}\right) \tag{10}$$

By substitution equation (10) in equation (8) it can be achieved:

$$\frac{dM}{d\tau} = \beta \cdot \left(C^p - C_0 + \frac{M_0}{V}\left(1 - \frac{M_0 - M}{M_0}\right)\right) F \tag{11}$$

It respect that in initial moment dissolution did not occur, the starting condition may be expressed as follows:

$$M(0) = 0 \tag{12}$$

The equation (11) with starting condition (12) may be derived using numerical methods (for example Runge-Kutta [25]).

The mass transfer coefficient usually is determinated from dimensionless equations. In our previous work [23] it was defined form of dimensionless equation for solid dissolution in channel of spiral wound membrane module, with after determination of coefficients and mathematical powers may be presented in a form:

$$\mathrm{Sh} = 0,394 \cdot \mathrm{Re}^{0,84} \cdot \mathrm{Sc}^{0,33} \left(\frac{d_e}{L}\right) \tag{13}$$

where $\mathrm{Sh} = \beta d_e / D$ is Sherwood number; $\mathrm{Re} = w \cdot d_e \cdot \rho / \mu$ is Reynolds number; $\mathrm{Sc} = \mu / D \cdot \rho$ is Schmidt number; $d_e = 2\delta_c$ is equivalent diameter, m; L is membrane channel length, m; D is diffusion coefficient, m^2/s; w is cleaning solution velocity, m/s; ρ is cleaning solution density, kg/m^3; μ is cleaning solution dynamic viscosity coefficient, Pa·s.

Diffusion coefficient for electrolyte solutions may be calculated from Wilkey-Cheng equation [28]:

$$D = 5,06 \cdot 10^{-11} \frac{T_s}{\mu_l \cdot V_s} \tag{14}$$

where T_s is solvent absolute temperature, K; μ_l is solvent dynamic viscosity coefficient, mPa·s; V_s is solute molar volume, cm^3/mol.

Equation (13) is valid in range Reynolds numbers from 0,4 to 60.

Procedure of calculations. The equations represented above allow to calculate regeneration time and permeate flux after regeneration. Procedure of calculations for known cake layer properties is following:

- Choosing regime parameters of regeneration (cleaning solution composition, cleaning solutions volume, operate temperature, cleaning solutions velocity etc.) and finding physical constants for cleaning solution in chosen regime;
- Determination of flow regime of cleaning solution and calculating mass transfer coefficient, using equation (13);
- Numerical solution of equations (11) and finding time that needed to dissolve necessary part of cake layer and kinetic characteristics of dissolution process;
- Finding final cleaning solution concentration and/or its time dependence, using equation (10);
- Calculations of regeneration coefficient using equation (7);
- Determinations of permeate flux from equation (3).

Initial data and results of simulation. Using the procedure of calculations described above the estimation of dissolution time and regeneration coefficients time was carried out under different flow regimes (different values of Reynolds number). It was embraced following initial data:

- Initial cake layer mass $M_0 = 0{,}125$ kg;
- Operating temperature $t = 20°C$;
- Cleaning solutions volume $V = 5 \cdot 10^{-3}$ m^3;
- Initial concentration cake layer material in cleaning solution $C_0 = 0$ kg/m^3.

All calculations was carried out for commercial available membrane USTM M-1261-75G. Membrane characteristics are following:

- Membrane surface area – $F = 0{,}46$ m^2;
- Equivalent diameter of membrane channel – $d_e = 7 \cdot 10^{-4}$ m;
- Membrane module length $L = 0{,}26$ m;
- Membrane resistance $R_m = 8{,}073 \cdot 10^{13}$ m^{-1}.

It was assumed that membrane is fouled and cake layer is made from iron (III) chloride, specific cake layer resistance $\alpha = 8{,}568$ m^{-2}. This choice is determinated by parallel experimental study of membrane fouling and membrane cleaning which include simulation of fouling under working condition using compounds of calcium and magnesium as model foulants and under emergency situation when breakdown of pretreatment system is happened using compounds of iron and humates. For cake layer formed from iron (III) chloride the specific cake layer had been recently determined experimentally and additional experiments for conducting calculations has not been necessary. In assumed conditions membrane flux of fouled membrane is half of clean membrane flux.

The equation (11) with starting conditions (12) has been solved using Runge-Kutta numerical algorithm [25]. The calculation was carried out in a range of Reynolds numbers from 10 to 50 with step 5. The Reynolds number change has been achieved by changing velocity of cleaning solution circulating in cleaning network. The result of calculations is plotted on the diagram shown on the Fig. 6.

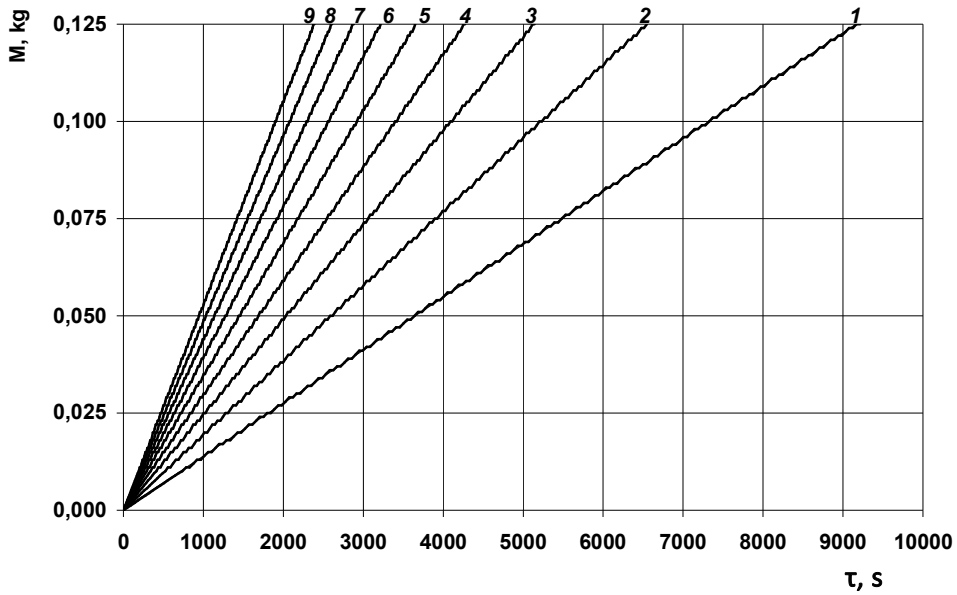

Fig. 6. The mass of dissolved cake layer material M as a function of time τ:
1 – Re = 10; 2 – Re = 15; 3 –Re = 20; 4 – Re = 25; 5 –Re = 30;
6 – Re = 35; 7 – Re = 40; 8 – Re = 35; 9 - Re = 50

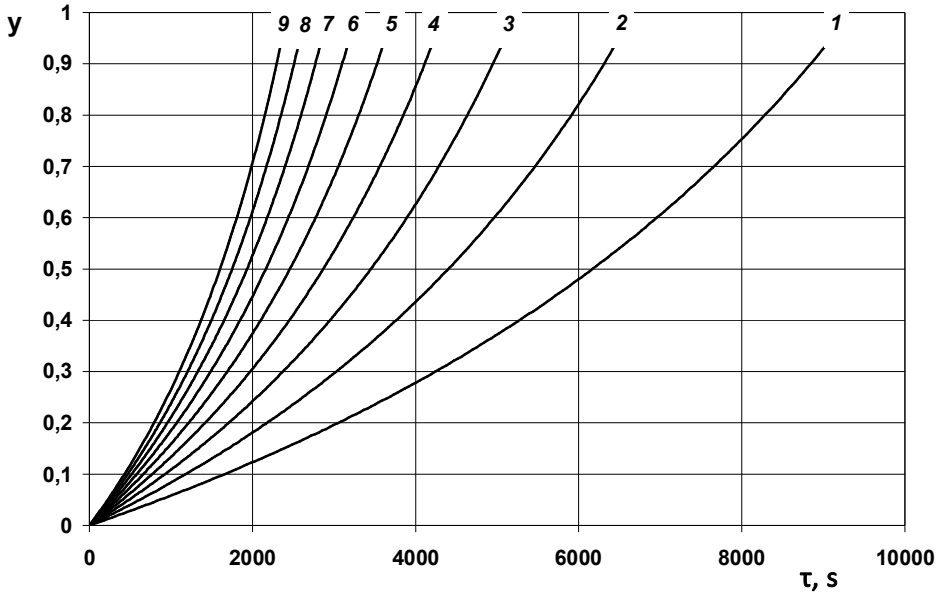

Fig. 7. The regeneration coefficient y as a function of time τ:
1 – Re = 10; 2 – Re = 15; 3 –Re = 20; 4 – Re = 25; 5 –Re = 30;
6 – Re = 35; 7 – Re = 40; 8 – Re = 35; 9 - Re = 50

The known mass of dissolved solid matter in each moment of time (according the step in numerical algorithm) allows determining changes in cleaning solution concentration during regeneration procedure from equation (10) and calculating values of regenerations coefficient in the same moments of time using equation (7). The results of calculations are presented on the diagram shown in the Fig. 7.

The results of calculations shown that for low Reynolds number values time of full cake layer dissolution is dramatically decreased (from 9215 seconds (about two hours and half) for Re=10 to 6545 seconds (less than two hours) for Re=15 and to 5143 seconds (less than one hour and half) for Re=20) with Reynolds number increasing. Thereby in this range increasing Reynolds number (increasing cleaning solution velocity) can be consider as effective way for intensification of membrane module regeneration procedure which can reduce regeneration time for 50%.

But for higher Reynolds numbers the decreasing of regeneration time become slower. For instance for increasing Reynolds number value from 25 to 30 time the regeneration time decrease only from 4275 seconds to 3650 seconds (for 625 seconds or few more than 10 minutes). In such condition increasing Reynolds number value cannot be accepted as effective technique for membrane regeneration intensification since increasing cleaning solution velocity is associated with energy consumption increasing. For Reynolds numbers values more than 25 increasing of energy demands did not provide significant decreasing in regeneration time. This means that most rational regime of regeneration correspond Reynolds number values from 15 to 25. The results of mathematical simulation represented below may be explained by form of equation (13) which was used for determination of mass transfer coefficition. The mathematical power of Reynolds number is 0.84 therefore for Re>30 the Sherwood number dependence from Reynolds number become close to linear, whereas for lower values of Reynolds number the Sherwood number increase more rapidly (the curvature of graphic chart of dependence represented by equation (13) grows).

More accurate value may be founded using optimization algorithm.

The presented resultants of mathematical simulation have been used for describing dissolution of monocomponent cake layer. In most cases cake layer is polycomponent system. For such condition mathematical model should be modificated by replacement of equation (11) for system of differential mass transfer equations for each individual component of cake layer.

The results presented above require experimental verification which is next step is our research.

Conclusions

The mathematical model proposed in this study can predict regeneration time and permeate flux after regeneration.

The mathematical simulation of spiral wound membrane module regeneration was carried out for cake layer made of individual component (iron (III) chloride). The results of calculation shows significant decreasing in regeneration time for Reynolds numbers values increasing from 10 to 25. For higher Reynolds number it was observed low regeneration time decreasing which suggest that ineffectiveness of such conditions in regard of energy consumptions.

The proposed mathematical model may be extended for multicomponent cake layer.

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Experimental and theoretical study of ice formation on vertical cooled pipes

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Abstract

Introduction. The use of cold accumulators based on the principle of ice build up on the cooled surfaces during off-peak periods and ice melting during on-peak periods is an effective method of electricity bills reduction.

Materials and methods. Dynamics of ice accumulation on the surface at different Δt (refrigerant evaporation temperature and the temperature of water that overflows surface) has been studied. Series of experiments have been carried out with 2 refrigerants (R12 and R22). The temperatures of water and that of refrigerant evaporation have varied within the intervals $+1,5 \div +4,5^0$C; $-10 \div -20^0$C, respectively. The mass flow rate and the velocity of water within the experimental sections were kept constant during a whole series of experiments. The ice-layer thickness was measured by means of optical method. The instantaneous images of the experimental pipe with the ice layer were processed with the graphic processing software.

Results and discussion. Since within comparatively short periods of on-peak demand a noticeable amount of thermal energy related to ice melting is to be released, it becomes clear that the sizing of ice accumulators based on a simple balance calculations is actual, but also the determination of time periods of ice accumulation and ice thawing becomes critical. The derivation of a simple differential equation of ice formation on the vertical cooled pipe, which then is used as a core for semi-empirical correlation of experimental data obtained on a special experimental unit is presented. This approach allowed elimination of a number of regime parameters used in the differential equation, which could not be determined directly. A correction factor which correlates the numerical solution of the differential equation and experimental data has been obtained. The asymptotic values of ice thickness varied within 4...16 mm at different Δt and water flow rates. Thus deneralized correlations will allow to determine an optimal amount of ice to be stired in the cold accumulator and eventually to significantly reduce energy consumption by approximately 10-15 %. The process differential equation has been derived with the following suggestions: the problem is one dimensional, the ice is growing in radial direction. Given were: the heat transfer coefficient from water to ice surface and from copper pipe to evaporating refrigerant. The equation has been derived with taking into account the infinitesimal increment of ice build at a time interval $\Delta\tau$ and corresponding heat balance.

Conclusions. Differential equation can be used for the determination of time period necessary for the accumulation of a given amount of water ice.

Introduction

Electrical motors of refrigeration compressors are the biggest energy consumers at food industry. Dairy industry is characterized by a significant refrigeration capacity for water cooling and extremely uneven energy consumption charts. Ice water is being used in raw milk pasteurization which usually happens right after milk reception at dairy plant. This peak cooling load usually is accompanied by a serious growth of cooling load due to the increased sensitive head influx through the building envelope, increased input of product. Unfortunately, the factory on-peak electricity consumption coincides with the grid on-peak energy demand, and thus, energy consumed during peak periods has to be paid at the highest tariff.

Modern office building and malls are equipped with powerful air-conditioning plants (Installed power up to 12-20 MW). Growth in energy consumption takes place at mid days and coincides with mild peaks or on-peak period of grid power demand. A typical energy demand chart registered at a Ukrainian dairy plant (a) along with the modified energy consumption chart (b) and hourly money flow chart (c) are shown in Fig.1.

The original chart of power demand can be modified by reducing the morning on-peak load between $09^{\underline{00}}$ and $10^{\underline{00}}$ then by lowering load during the semi-peak period and eventually cutting the on-peak within $18^{\underline{00}} – 20^{00}$ period. This cooling load can be shifted to the night period between $00^{\underline{00}}$ and $06^{\underline{00}}$. The redistribution of loads is shown by the red zone marked with "+" sign on the lines 1 and 2 which mean a load increase at night. The reduction of load is shown by greenish zones marked with "--" sign on the line 1.

The result of the modification can be seen on Fig.1 (c) by dotted lines beneath the solid lines 1 and 2 showing money flow for the original case and beneath the dotted lines after loads shift.

A total of 5,1% reduction in daily electricity bills thus is easily attainable. An extended analysis of the possible options of power demand shifts is given in [3, 4].

The shifting of energy consumption can be achieved by using cold storages in which cold is accumulated by ice formation during night lowest greed demand periods and release of the stored cold during on-peak demand periods by melting ice and partially unloading refrigeration compressors [5].

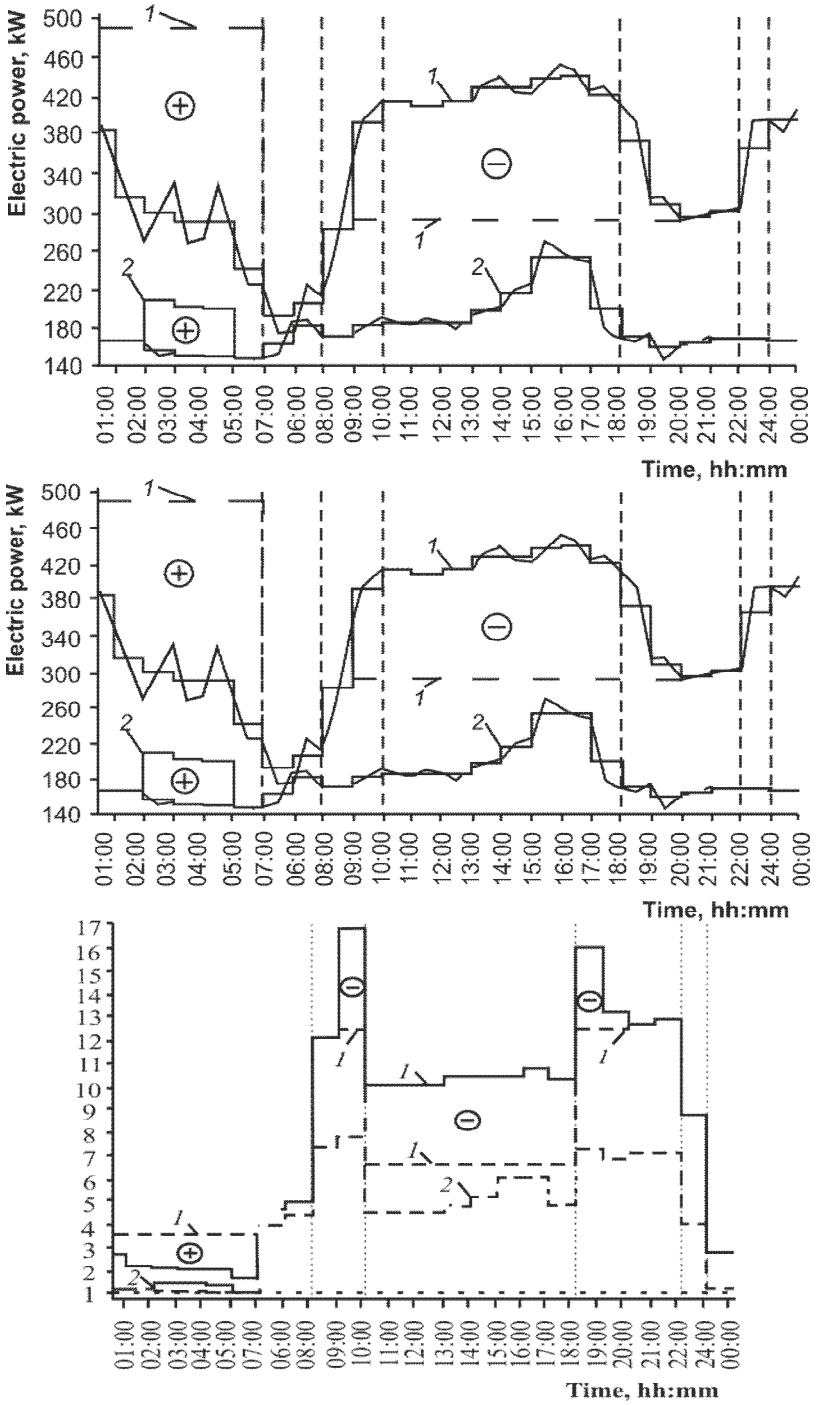

Fig. 1. Power demand and money flow chart

a – Original power demand for refrigeration compressors on lines 1 and 2;
b – Modified power demand by shifting time load of compressors;
c – Hourly expenses for consumed electricity, relative units.

Mathematical model

A cylindrical problem is used for the ice build-up model formulation. The following simplifications and suggestions have been taken: one-dimensional case, constant physical parameters of water and refrigerant, no super cooling of water, no water density anomaly.

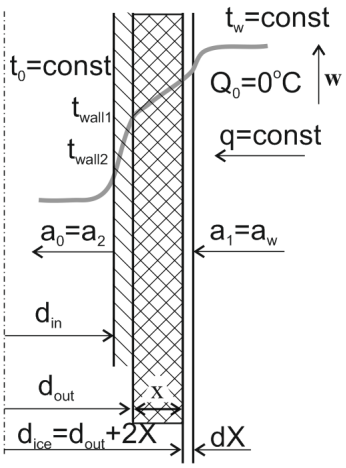

Fig. 2. Ice build-up model

The heat released during dτ due to the water friction on the water-ice interface is determined by:

$$q_{fr} = \frac{h_w \cdot \omega^2 \cdot \pi \cdot \left(d_{out} + 2 \cdot x\right) \cdot \left(2 + \frac{1}{\mathrm{Pr}^w}\right)}{3 \cdot C_p^w} \cdot d\tau \,, \tag{1}$$

as it is recommended in [6].

The amount of heat to be absorbed in order to build-up an ice layer of 2x thickness equals:

$$q_{ice} = \frac{\pi \cdot \rho \cdot 2 \cdot dx}{4} \cdot \left(2 \cdot d_{out} + 4 \cdot x + 2 \cdot dx\right) = \pi \cdot \rho \cdot dx \cdot \left(d_{out} + 2 \cdot x\right) \tag{2}$$

The amount heat that has to be transferred through the multi layer cylindrical wall to the evaporating refrigerant inside the tube is:

$$q_0 = \frac{\pi \cdot \left(\theta_0 - t_0\right)}{\frac{1}{2 \cdot k_{ice}} \cdot \ln \frac{d_{out} + 2 \cdot x}{d_{out}} + \frac{1}{2 \cdot k_m} \cdot \ln \frac{d_{out}}{d_{in}} + \frac{1}{h_r \cdot d_{in}}} \cdot d\tau \tag{3}$$

The heat gain due to the heat transfer from water to the ice surface may be described as:

$$q_w = \pi \cdot d_{ice} \cdot h_w \cdot \left(t_w - \theta_0\right) \cdot d\tau = \pi \cdot \left(d_{out} + 2 \cdot x\right) \cdot h_w \cdot \left(t_w - \theta_0\right) \cdot d\tau \tag{4}$$

It is clear that the amount of heat transferred to the evaporating refrigerant (3) equalizes the heat gained from the out flowing water (4), ice fusion (2) and interface friction (1), thus giving a differential equation if ice build-up time rate:

$$\frac{dx}{d\tau} = \frac{\left\{ \begin{array}{l} \dfrac{\theta_0 - t_0}{\dfrac{1}{2\cdot k_{ice}}\cdot \ln\dfrac{d_{out}+2\cdot x}{d_{out}} + \dfrac{1}{2\cdot k_m}\cdot \ln\dfrac{d_{out}}{d_{in}} + \dfrac{1}{h_r \cdot d_{in}}} - \\ -h_w \cdot (d_{out}+2\cdot x)\cdot \left[(t_w - \theta_0) + \dfrac{\omega^2 \cdot \left(2+\dfrac{1}{\mathrm{Pr}^w}\right)}{3\cdot C_p^w} \right] \end{array} \right\}}{\rho \cdot H (d_{out}+2\cdot x)}, \quad (5)$$

with the boundary condition : $\tau = 0$, $x = 0$.

Heat transfer coefficients h_w and h_r were calculated by the empirical correlations [7, 11].

$$Nu = Nu_\infty + f(\frac{d_i}{d_0}) \cdot \frac{0.19 \cdot \left[Pe \cdot \left(\frac{d_h}{L} \right) \right]^{0.8}}{1 + 0.117 \cdot \left[Pe \cdot \left(\frac{d_h}{L} \right) \right]^{0.467}},$$

$$Nu_\infty = 3.66 + 1.2 \cdot \left(\frac{d_i}{d_0} \right)^{-0.8},$$

$$f(\frac{d_i}{d_0}) = 1 + 0.14 \cdot (\frac{d_i}{d_0})^{0.5} \quad \text{and} \quad h_r = 3.1 \cdot p^{0.25} \cdot q^{\frac{2}{3}}. \quad (6)$$

From the analysis of equations (1-6) it can be seen that the coefficient h_r depends on heat flux q (6), at the same time the value of q is determined by the thickness of ice layer which grows gradually, x in equation (3 and 5).

The equation (5) can be solved numerically on the time intervals beginning with $\tau=0$. The thickness of ice x_{i-1} achieved on the previous interval should be used as a boundary condition for the next time interval. Similarly, a new value of h_{ri} which has to be introduced in (5) is to be determined by solving (6) with a new value of q.

The piecewise solution so obtained has to be compared with the data obtained experimentally.

Experimental rig

A lay-out of the experimental rig designed and constructed for the determination of ice formation time rate is shown in Fig.3

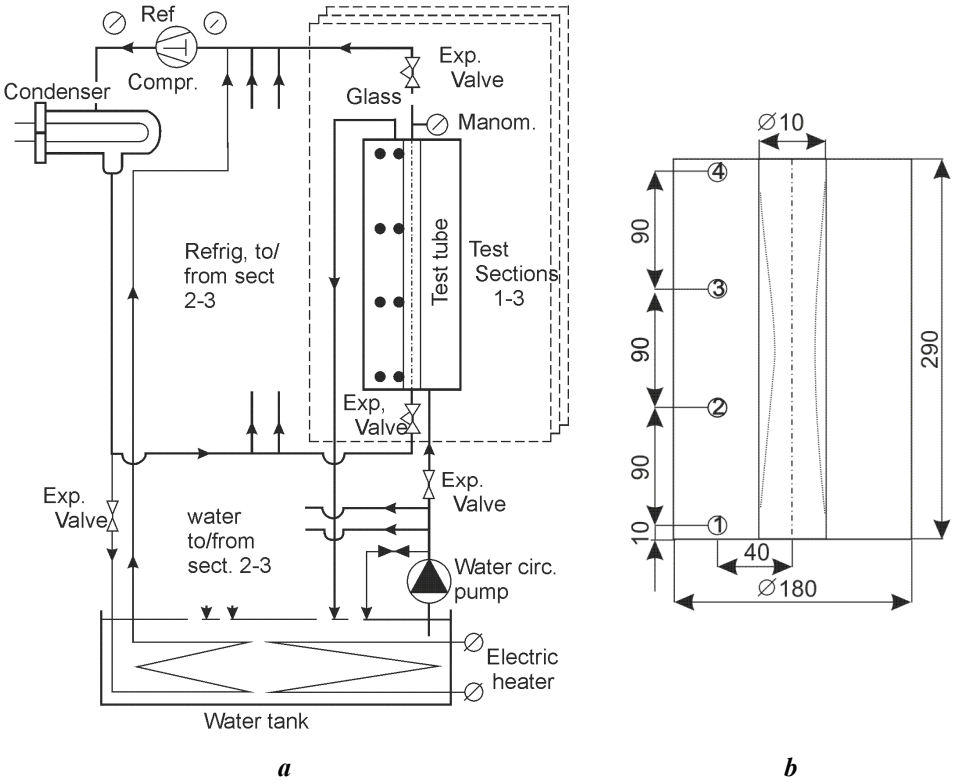

Fig. 3. Experimental rig:
***a* – lay out, *b*- cross sections of thermocouples' location**

The rig consists of three similar blocks (Test sections 1-3). The main part of a section is a test copper tube 290 mm height, 10 mm outer diameter, 1 mm wall thickness. Each tube is mounted inside of water jacket of 180 mm diameter.

A water circulation contour consists of a pump, water piping, water tank, measurement and control systems including regulation and stop valves.

Circulating water was fed in parallel and supplied from the bottom of the jackets and removed from the upper part, so that an upward flow of water inside all jackets took place. The flow rate of water was controlled by a rotameter, adjusted and kept constant during every experimental run by precision needle valves, and precisely measured by the volumetric method. The water flow rate could be maintained individually for each test unit.

A given temperature at the entry to the jackets has been maintained by switching on / off of a cooling coil or electric heater in the water tank.

The test tubes were hooked up to the refrigeration (R12, R22) contour in parallel on the refrigerant. The refrigeration unit has been equipped with all necessary systems

allowing control, measurements and regulation of the evaporation pressure (evaporation temperature) inside each test tube and condensation pressure in the condenser.

A set of thermocouples installed in four equally spaced cross sections along the tube, see Fig.3 (b) allowed measurements of temperature of water at a distance 40 mm from the tube surface and tube outer surface temperature at the same cross section.

Time rate of ice layer thickness formed during the experiments was measured by means visual technique. Photographs of the test sections of pipes covered with ice were taken from the front of the transparent water jackets. Immediately before the experiments, an adjustment session had been carried out including testing of different lighting techniques and light sources, and calibration procedures which aimed at the determination of the best measurement arrangements.

Photographs were taken with a digital camera Canon 350 D 8.2 MP and simultaneously with a web camera HP HD-4110 (13 MP). Web cameras attached to each test section operated by the Active WebCam software which allowed taking pictures of the test pipes at any chosen frequency and storing individual video files for every section. Along with taking pictures with the web cameras the individual pictures were taken with the frequency 1 picture per 30 second with a Canon 350 D camera. Synchronization of the pictures taken by the Canon photo camera on the time scale of the web camera has been made by shooting a laser pointer beam on the test pipe simultaneously with taking picture with the Canon camera along with the continuous filming the process with the web camera. The picture made by the Canon camera with the red point collated with the individual shot of the web camera film with the same red point.

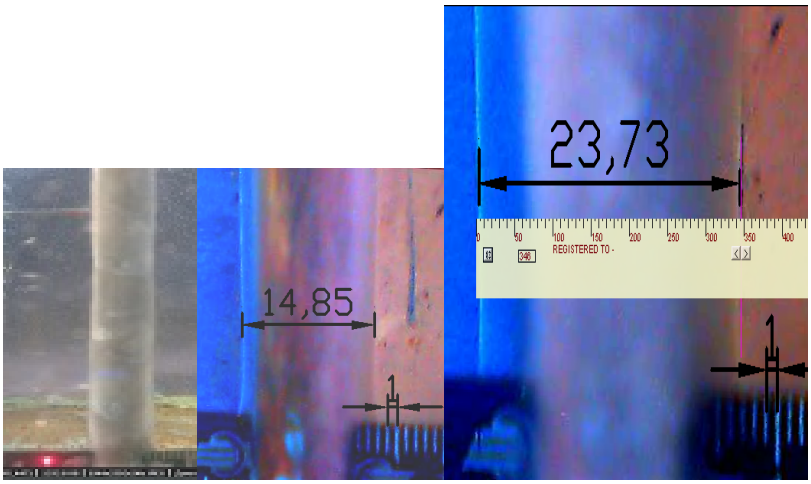

Figure 4. Synchronization of individual cadres

The measurements of iced pipe diameters have been performed by a set of on screen measurements software (ScreenRuler, PixRuler, Acad). All of them gave the results with the deviation of 0.2...0.4 mm.

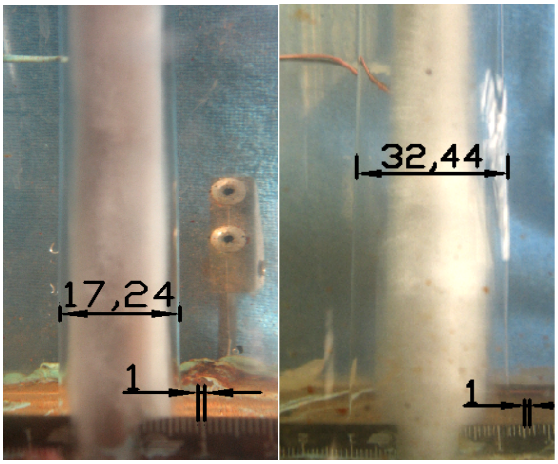

Fig. 5. Ice layer thickness measurements

Results and discussions

Experiments were carried out at a fixed water flow rate at which corresponds to Re= 0÷16560 and at three water inlet temperatures +1.5^{0}C, +3^{0}C, and +5^{0}C. The temperature of evaporation inside test sections was kept constant within one run of experiments. The evaporation temperatures were kept at -5^{0}C, -9^{0}C, -15^{0}C and -20 ^{0}C. Visual observations show that ice formed at different temperature differences (water-evaporating refrigerant) looks different. At bigger temperature difference especially at higher water temperatures, ice formed is dim, non-transparent with rough porous surface, whereas the ice formed at moderate temperature difference and water temperature 1.5...3^{0}C is dense, completely transparent, although the ice layer thickness reaches 30 mm and more. The surface of ice is glassy. The later is shown in Fig.5. The data arranged in series at a constant temperature (a- +1.5^{0}C, b- +4.6^{0}C) of overflowing water are shown in Fig. 6.

It is quite apparent that each series of data tends to reach a certain asymptotic value, which could be termed as a terminal for a given temperature difference value of ice thickness. Since a growing ice layer acts as a gradually increasing thermal insulation, the terminal value of ice thickness reflects a heat balance at which a state of thermal equilibrium is achieved. In this state only heat transferred from the overflowing water on the ice-water interface can be transferred to the refrigerant. No additional ice may be formed after the state of equilibrium has been achieved.

Similarly, the time intervals for reaching the terminal asymptotic values increase as the temperature difference increases. The asymptotic character of the experimental data allows choosing an optimal time interval of ice formation i.e. charging of a cold accumulator, since working after an asymptotic value of ice layer thickness has been reached leads to the direct loss of energy spent by the refrigeration compressors. Comparison of the data depicted in Fig.6 with the results of numerical solutions of the equation (5) with respective boundary conditions is given in Fig. 7.

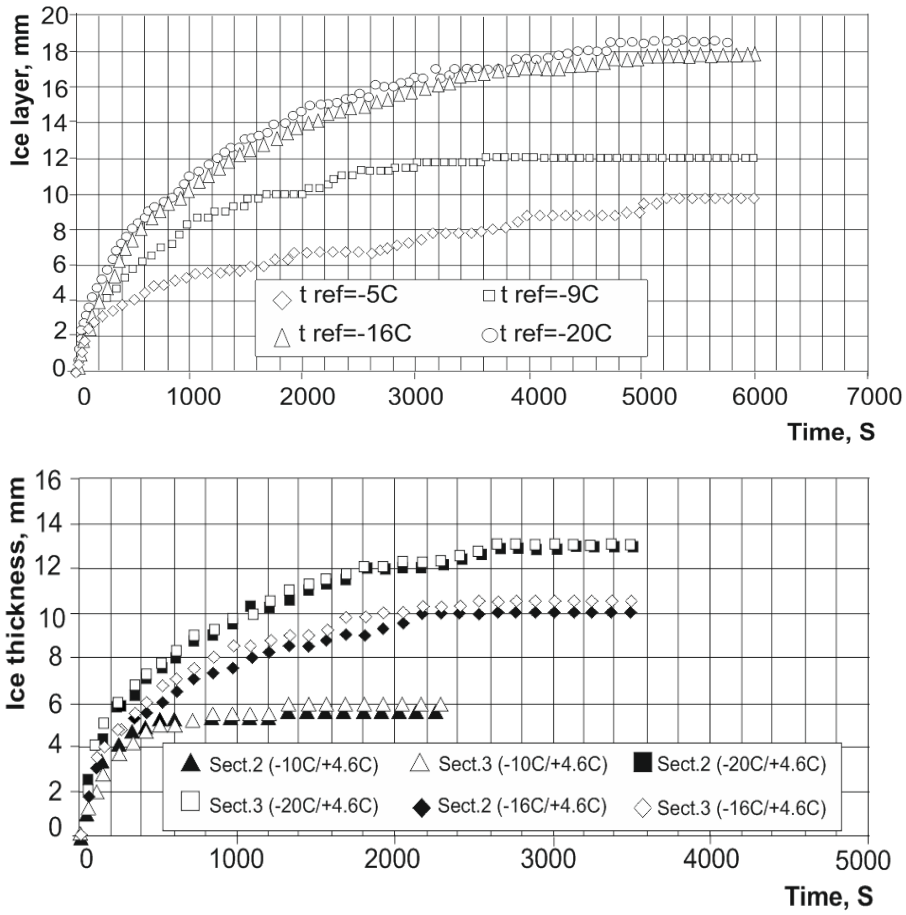

Figure 6. Time rate of ice formation:
1st - t_{ref} :-5^{0}C, -9 C, -16^{0}C, -20^{0}C, t_{water}:+1.5^{0}C
2nd - t_{ref} :-10^{0}C, -16^{0}C, -20^{0}C, t_{water}:+4.6^{0}C

The similar experiments have been conducted with the use R22 refrigerant within the temperature regimes that correspond to the experiments with R12 refrigerant. Given are the plots of experimental data with R22 which compared to the numerical solution of differential equation (5). The deviation from the given above plots is that the mentioned above solution have been carried out by 2 methods.

The first method of solution had been carried put at given boundary and initial conditions and was kept constant during a whole period of calculation. Therefore it could be termed as a continuous one. The second method had been carried out within a set of time intervals with the duration of 100...200 seconds. At the end of each time intervals the thickness of the build-up layer of ice had been determined, which in turn determined the reduction of interval heat transfer coefficient. This set of calculations allowed to determine a set of new boundary and initial conditions which were used for the calculation of differential equation of the following time interval. The solution thus obtained therefore can be termed as piecewise solution.

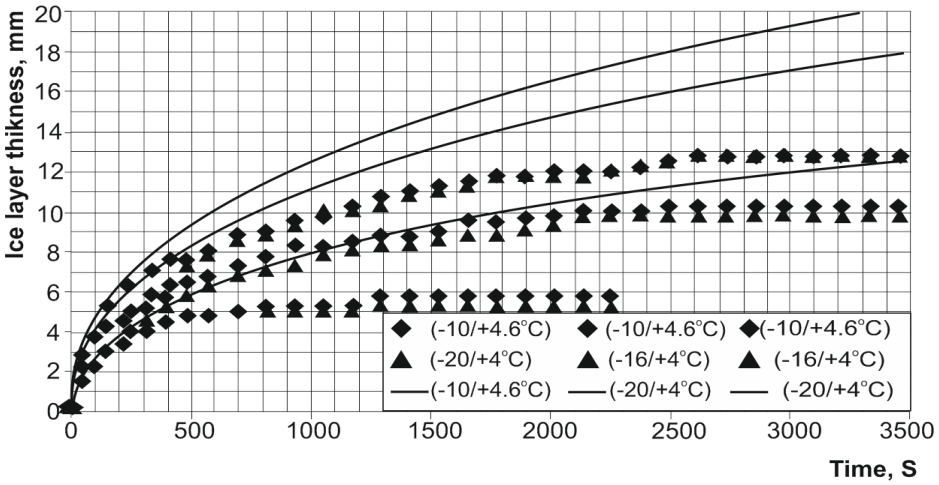

Fig. 7. Comparison of experimental data and results of numerical solution of (5) Lines 1,2,3 link a numerical solution to the correspondent data set

Therefore the proposed method of thermal resistance calculations in certain periods of time and substitution of the obtained data into differential equation allows to obtain more steep calculation curve which lays closer to the experimental data.

Given below the data which depict maximum ice-layer thickness at different feed-water temperature which obtained with 2 different frions. The experiment have shown that at similar regime parameters the series of experimental data have clear exponential character which characteristic to both Frions. This proves that the dynamic of generation on the external cylindrical vertical cooled surface at different Δt (temperature difference between that of water and boiling refrigerant) has exponential character which is clearly shown in figures given above.

As it follows from Fig.7 experimental data tend to deviate from the lines depicting numerical solutions and lie beneath the lines. This deviation can be explained by the inadequate estimation of the heat transfer coefficients h_r to evaporating Freon inside the pipe, since the local heat fluxes are far lower than those in experiments [7]. Unfortunately, there are no reliable recommendations on heat transfer calculations valid in conditions similar to those in our experiments. In order to further examine the developed model (5), a comparison has been done by application of the proposed model to the data [8]. The data [8] were obtained on the experimental rig which provided zero heat flux from the water to ice surface. Cooling of the pipe has been organized by flowing ethylene glycol cooled in a special heat exchanger. The same approach has been employed in [9]. These particulars allowed to exclude the effect of heat transfer coefficient h_w by putting it 0 in (5) and to determine h_r precisely by Dittus-Boelter correlation. Comparison of numerical solution with the data presented in [8] is given in Fig.10.

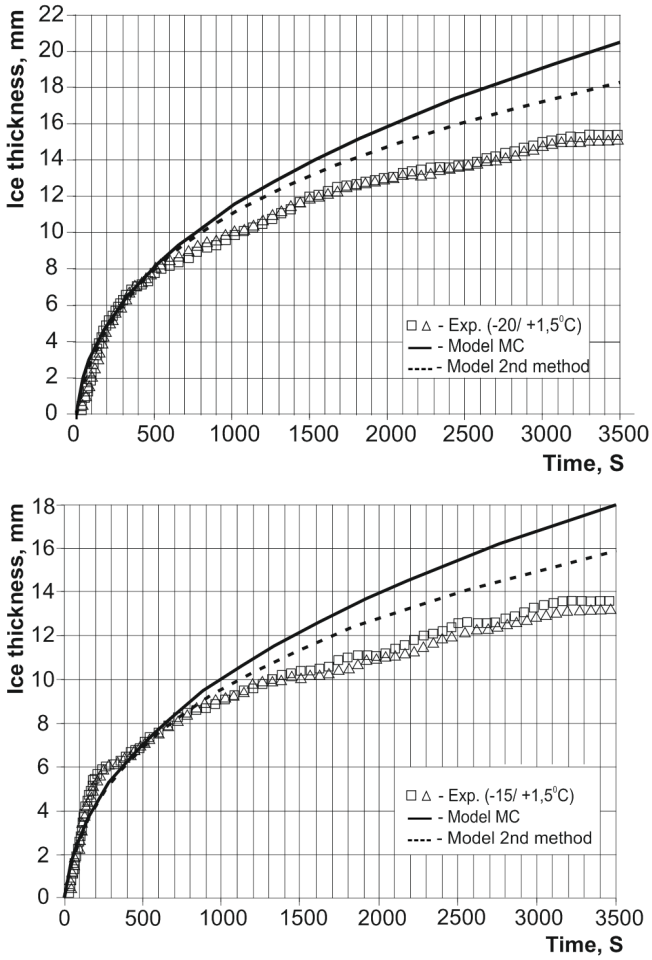

Fig. 8. Comparison of experimental data and numerical solution of equation (5)

As it is clearly seen from Fig.8,the results of calculations match closely experimental data [8].

This proves the adequacy of the proposed model but also witnesses that use of adequate values of heat transfer coefficients is critical for obtaining results matching those observed (5).

Since for the time being no reliable correlations for determination of heat transfer coefficients within the range of low heat fluxes and low refrigerant mass flow rates can be found, it seems advisable to formulate a simple semi empirical correlation in which a correction coefficient representing a ratio between the numerical solution and respective experimental result at the same ice layer thickness is determined. A correlation plot thus obtained is shown in Fig.11.

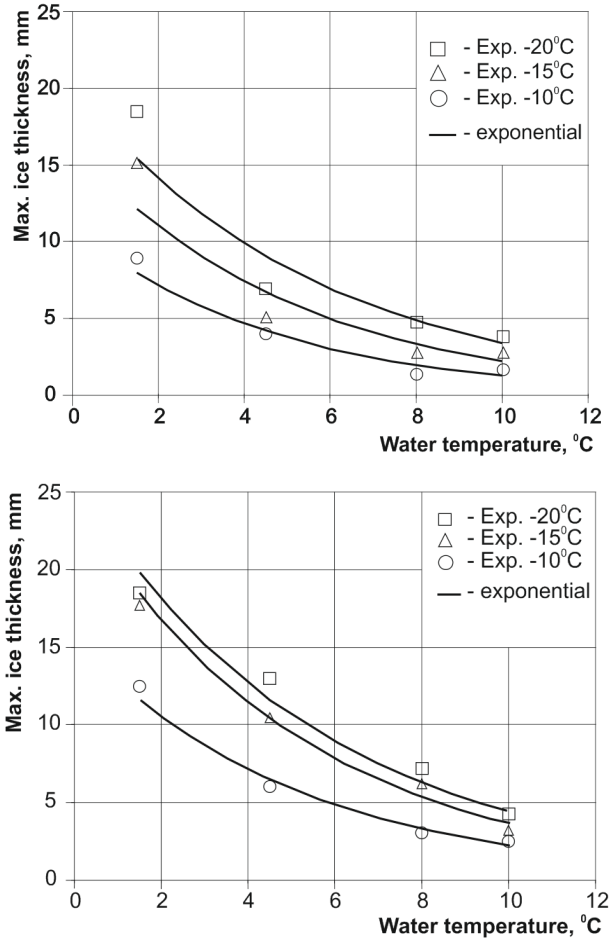

Fig. 9. Variation of maximum ice thickness with water temperature (for R-22 and R-12 respectively)

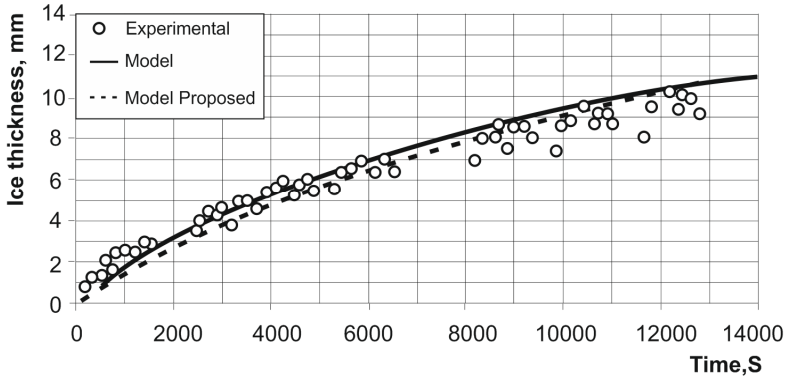

Fig. 10. Comparison of experimental data [8] with the results of calculation of (5). Cooling liquid inlet temperature- -4.3^{0}C.

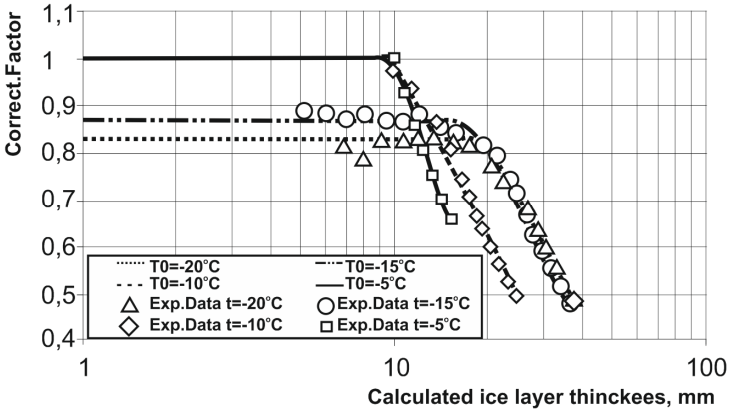

Fig. 11. Correction factor X_{exper} / X_{num} variation

Conclusions

1. Close correspondence of the data available in literature with the results of numerical solution of (5) proves its adequacy in application to the processes for which heat transfer mechanism is well established and heat transfer coefficients may be calculated.

2. Deviation of experimental data obtained in the present work from the calculated curve is determined by the incorrect values of heat transfer coefficients of evaporating refrigerant (6). Since due to the decrease of heat transfer flux as a result of ice layer growth, nucleate pool boiling heat transfer coefficient of refrigerant decreases. This determines the fact that the thickness of ice layer reaches its asymptotic value within a comparatively short period of time.

3. When cooled by the flow brine at forced convection with a constant heat transfer coefficient, the period of reaching an asymptotic ice thickness is much longer.

4. Ice formation time rate on the pipes cooled by evaporating refrigerants may be determined by calculating a time curve by (5) for the respective conditions with heat transfer coefficients determined by (6) at first. By utilizing a correction factor determined by Fig.9, an actual time curve of ice buildup can be calculated.

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Analysis of Text Mining methods in Web search

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Abstract

Introduction. The aim of this research is to investigate existing search engine marketing which increase effectiveness of marketing information search on the Internet.

Materials and methods. Search engines marketing are the material of this study. Cluster analysis method is used to construct methods and algorithms of non-hierarchical clustering.

Results and discussion. In Search Engine Marketing (SEM) Text Mining method is used to search for documents in the Web engines. This method is used to process unstructured (textual) information, extract meaningful numeric indices from the text, and, thus, to make the information contained in the text accessible for the various data mining (statistical and machine learning) algorithms. Information can be processed to derive statistics of the words contained in the documents or to compute statistics for the documents based on the words contained in them. The algorithm of web pages cleaning from information noise and optimal sequence constructing of viewing search results in web systems is proposed. This algorithm can help to present required information in a convenient form for user, and create positive impact on the results of web-search and classification of information.

The scientific novelty of the results is to construct a search algorithm solving marketing problems with the use of Text Mining technology.

Conclusions. The results are valuable for accelerating the search and selecting of relevant information on the Internet and they can be used to fill the ontology of knowledge about the results of marketing research.

Introduction

Data search problem in the context of rapid development of the modern information technologies lies in the center of the modern information theory and is important in the digital data processing. The aim of the further research is to develop effective systems for specialized data search focused on personal needs of professional users in limited information operating environment.

The aim is automation of the process of finding and ranking information documents to provide the most relevant results and qualitative analysis of the results for different input data sets and when you change the configuration operation algorithms search. In the development of search algorithms provides the exploitation of advances for the parallel efficiency of local search.

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The advent of the Internet and its further development has changed modern view on advertising means and communication. The Internet combines interactive feature of communication and possibilities of personalization. The peculiarity of the internet environment is associated with the active role of consumers (in traditional media their role is passive) due to the control over the information search through various search and navigation mechanisms. The interactive nature of the network environment allows to increase efficiency of the interaction between participants of communication.

Thus, the impact of the Internet technologies on the marketing activities of the company is increasing. In today's global market new information technologies and the Internet can reduce the cost of marketing functions of the company.

Text Mining is the one of the methods of the in-depth study of Internet technologies application in marketing.

The purpose of Text Mining is to process unstructured (textual) information, extraction of meaningful numeric indices from the text, and, thus, to make the information contained in the text accessible for the various data mining (statistical and machine learning) algorithms. Information can be retrieved to derive summaries for the words contained in the documents or to compute summaries for the documents based on the words contained in them. Hence, you can analyse words, clusters of words used in documents, etc., or you can analyse documents and determine similarities between them or how they are related to other variables important for the data mining analysis. In general terms, text mining "turns text into numbers" (meaningful indices), which can then be incorporated in other analyses such as predictive data mining projects, the application of unsupervised learning methods (clustering), etc.

Text analysis processes:

- Information retrieval or identification of a corpus is a preparatory step. At this stage textual materials are collected and identified to be analised in the Web or in a file system, in database or in content management system.
- Although some text an alysis systems apply only advanced statistical methods, many others apply more extensive processing of natural language, such as lexico-grammatical analysis, syntactic analysis and other types of linguistical analysis.
- To recognize the object (text) gazetteers or statistical techniques are used to identify text features such as people, organizations, toponyms, certain abbreviations, and so on. Clarification is the use of contextual clues, which may be necessary, for instance, "Ford" refers to the former U.S. president, a vehicle manufacturer, a movie star.

- Recognition of Pattern Identified objects, such as telephone numbers, e-mail addresses, quantities (with units), can be recognized via regular expressions or other pattern matches.
- Coreference: identification of noun phrases and other terms that refer to the same object.
- Relationship between a fact, and an event: identification of associations among entities and other information in text.
- Quantitative text analysis is a set of techniques connected with social sciences, so either a human or a computer recognize semantic or grammatical relationships between words in order to find out the meaning or stylistic patterns of a text [1].

Materials and methods

Search engines marketing are the material of this study. Cluster analysis method is used to construct methods and algorithms of non-hierarchical clustering.

Research methods are based on usage of data for evaluating the content, methods and algorithms of clustering and classification, for finding the best ways to view information, Data Mining and Text Mining technologies for processing and data analysis methods and algorithms for information retrieval.

The difference between Text Mining technology, Data Mining technology and search engines work scheme is defined by using the analysis of modern scientific sources [2-5] based on the subject areas:

1. Intelligent analysis of data
2. Intelligent analysis of documents
3. Tasks of marketing

The development of structural and functional domain structure can be described through two functions: “Search engine development for global networks” and “Search component development based on the Data Mining methods”.

Difference between Text Mining and Data Mining. The difference between regular data mining [2-4] and text mining is that in text mining the patterns are extracted from natural language text rather than from structured fact databases. Text mining is used in bioinformatics where details of experimental results can be automatically extracted from a large text corpus and then processed computationally. Text-mining techniques are used in information retrieval systems as a tool to help users to narrow their queries and to help them to explore other contextually related subjects.

Text Mining seems to be an extension of the well known Data Mining. Data Mining is a technique that analyses billions of numbers to extract statistical date and tendencies, which follow from company's data. This kind of analysis is successfully applied in business as well as for military, social, government purposes. But, only about 20% of the data on intranets and on the World Wide Web are numbers - the rest is text. The information contained in the text (about 80% of the data) is invisible to the data mining programs that analyse the information flow in corporations. Text mining tries to apply these techniques of Data mining to unstructured text databases.

Text mining is a complex technique. Text mining uses data mining techniques. Its object is not only structural data but also semistructural data or non-structural data. The mining results are not only general situation of one text document but also classification and clustering of text sets.

Text Mining applications. The main Text Mining applications [1, 2] are most often used in the following sectors:

- Publishing and media.
- Telecommunications, energy and other servicing industries.
- Information technology and Internet.
- Banks, insurance and financial markets.
- Political institutions, political analytical centers, public administration and legal documents.
- Pharmaceutical and research companies and healthcare institutions.

These sectors are characterized by a fair variety of applications which are being experimented now. However, it is possible to identify some sectorial specifications of Text Mining usage connected with the type of production and the objectives of knowledge management. The publishing sector, for example, is characterized by prevalence of «Extraction, Transformation, Loading applications» for the production and optimization of the information retrieval.

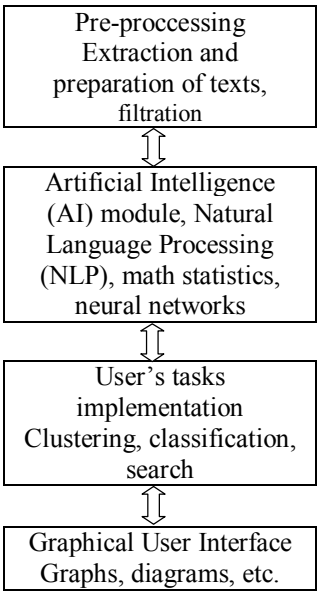

Fig. 1. Document Analysis Technology in Text Mining

Document Analysis Technology. In general, text analysis technology consists of 4 main stages (Figure 1) [3,4]:

1. Preprocessing combine technologies for extraction and filtration of texts in processing.
2. Artificial intelligence module is responsible for the "recognition" of texts in a natural language.
3. User Tasks Implementation provides a set of technological solutions for a variety of tasks such as: classification and clustering of data, structural information retrieval, definition of subject or area of expertise, automatic abstracting of documents, annotation, summarization, creation of taxonomies and thesauri, automatic content filtering tasks, semantic relationships defining, patterns of data, keyword search, respond to query.
4. The graphical interface integrates tools that form the presentation of the processing results. Information which is presented in a convenient form, allows the user to see additional hidden patterns that cannot be found by other methods.

A compulsary tool for Text Mining is data warehouse, which contains processed information.

Domain description of "The Search Pertinence Improvement Mechanism in global and local networks". The technology of search engine development consists of several independent elements that are connected with functional relationships is shown in Fig. 2 [5].

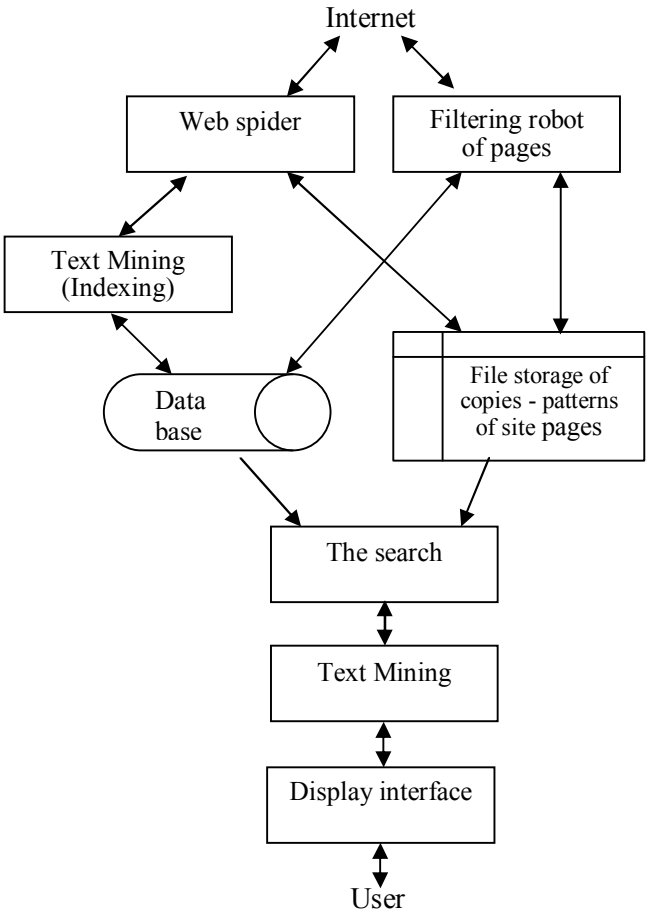

Figure 2. The general scheme of search engineoperation

Search web spider is an application that performs indexing and downloading of pages from the Internet resources. Its functions are the following:

- to remove noise information from the page and to turn it into the form required for storage in a database;
- to search any links and add them to the waiting list for indexing;
- to deposit or reload a purified page in file storage;
- to convert pages into a single coding system;
- to perform an analysis of error responses of the Web server and assign status to these pages.

Filtering Robot is an application that autonomously analyses Internet resources whenever possible. Its main objectives are to test the existence, relevance of already existing resources and to search for new ones [6].

The search engine performs operations for ensuring search and indexing of documents and is described in more detail in the following sections.

File storage is used for storing purified duplicate pages using data compression.

Display interface allows the user to interact with the search engine [7-8].

Structural and functional domain structure can be described through two functions: “Search engine development for global networks” and “Search component development based on the Text Mining method”.

Results and discussion

The functional structure of the domain "Search engine development for global networks". To determine the tasks which must to be performed to build a search engine it is necessary to determine the content of required functions represented on a tree of diagram functions (fig. 3).

The function "Indexing of documents, keywords and phrases" is designed to convert received information from the user into optimal system type and add it to the database.

The function "Formation of relevant results and ranking of documents" provides ranking of documents upon request.

The function "Dictionary search” is used to work with glossaries, stop words, and other attributes, which necessary to speed up search.

The function "Formation of key sequence on inquiry" is necessary to convert the user's request into a view appropriate for a system.

The functional structure of the domain "Development of search components with Text Mining». The list of required functions to determine the tasks which must be performed, is presented in the tree diagram of functions (fig. 4).

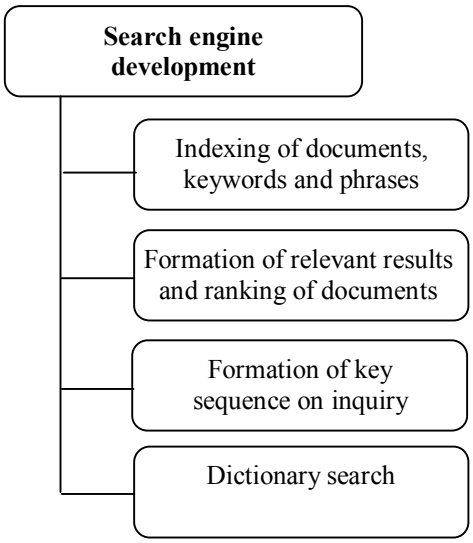

Fig. 3. The tree of functions " Search engine development for global networks"

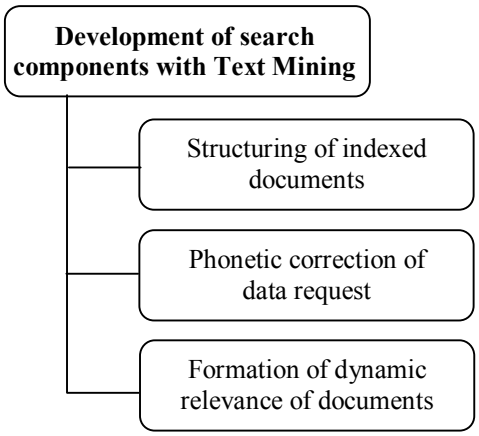

Fig. 4. The tree of functions "Development of search components with Text Mining»

The function "Structuring of indexed documents" is designed to convert received data into a structured form to increase speed of text processing and improve its quality.

The function "Phonetic correction of data request" takes improve the relevance of search engine by correcting erroneous information requests.

The function "Formation of dynamic relevance of documents" analyzes inquiry and on the basis of obtained results lowers or increases relevance of the document.

Modelling of search engine work is done by IDEF functional simulation methodologies and BPWin software with IDEF0 methodologies [9].

Description of the business process domain "Functioning of the mechanism of data search speed up in the global and local networks". In the process of domain analysis on the basis of tree of functions functional model is developed, which is presented in a context diagram in fig. 5.

Contextual diagram is represented by three processes: "Indexing of meta keywords", "Search for relevant documents" and "Administration of search engine" (Fig. 6).

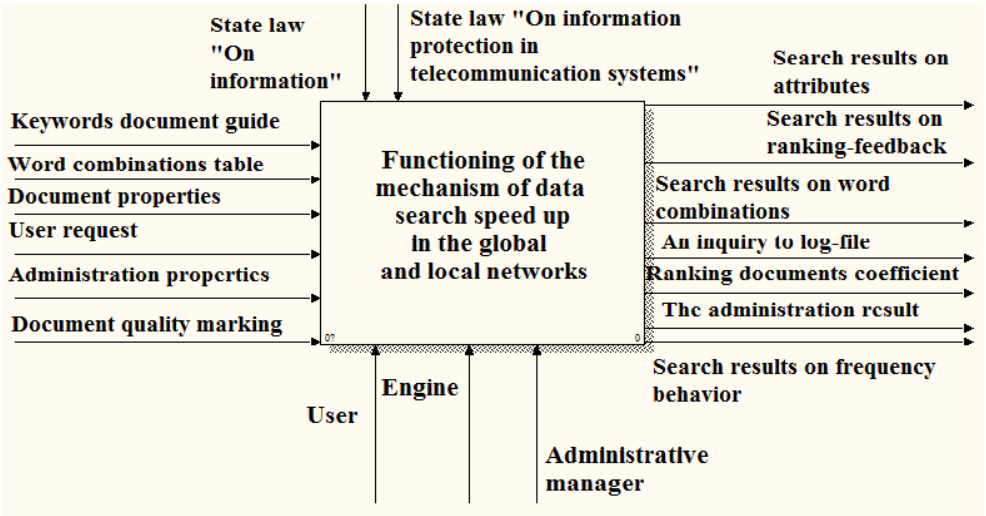

Fig. 5. Contextual diagram for domain describing " Functioning of the mechanism of data search speed up in the global and local networks "

"Indexing document" is divided into four unit of work which are responsible for consistent processing of a document indexed into acceptable for the system view (Fig. 7). It consists of following business processes: "To delete common terms", "Processing of keywords and phrases", "Updating of data warehouse", "Structuring of documents".

"Structuring of documents" is used for forming of structured terms by the Text Mining method, and to find patterns in the data and for evaluation and interpretation of results.

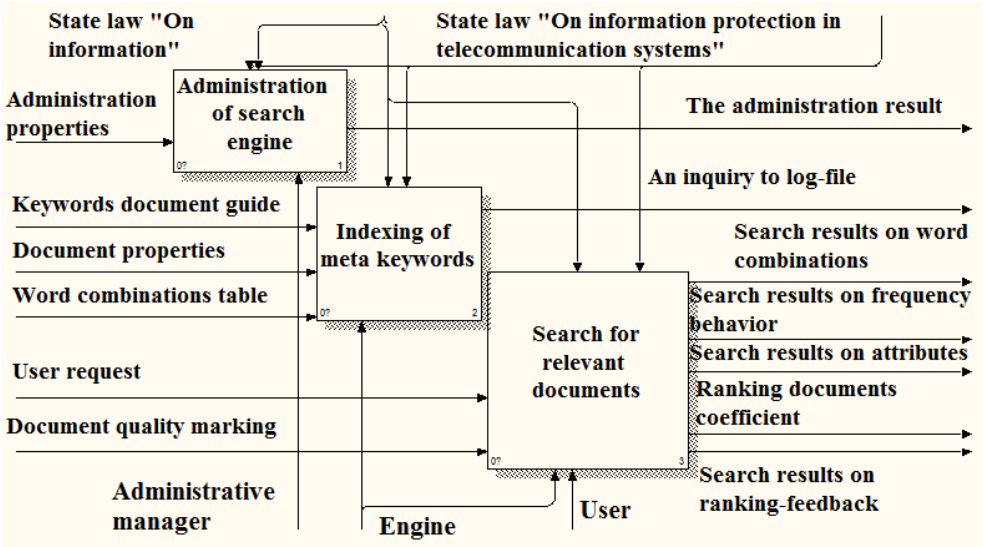

Fig. 6. The diagram levels 1of decomposition for the business process "Functioning of the mechanism of data search speed up in the global and local networks"

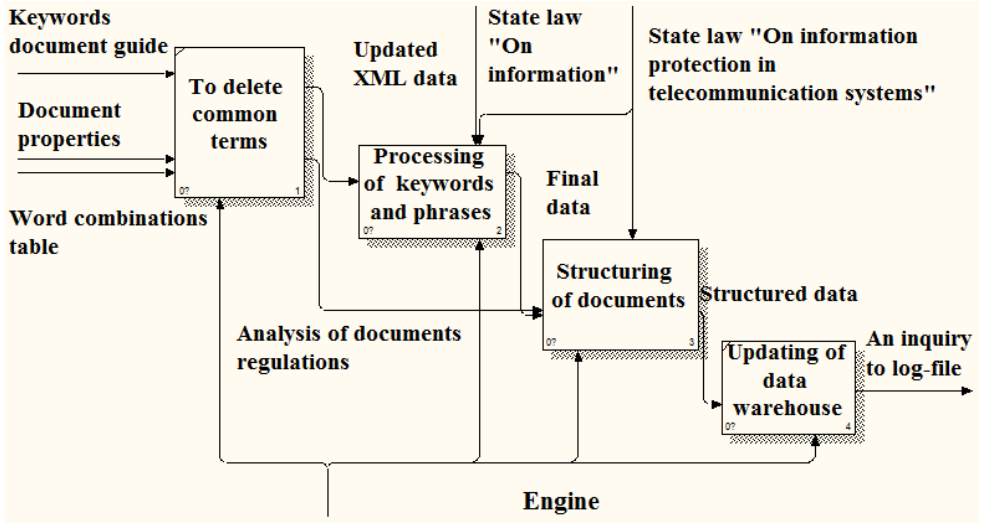

Fig. 7. The diagram level 2 of decomposition for the function "Indexing of a document"

Description of the search engine algorithm. The purpose of the search engine is to arrange the search by spontaneous query. The purpose of system is to find in collection of documents those that are most relevant to arbitrary user's information needs, and which are known through the system of single, user-initiated queries. The document is called relevant if, from user's perspective, it contains valuable information that satisfies his information

need. The operation mechanism of the search engine can be arranged under the user"s search query and indexed documents in a system [10].

The basis of the search is an algorithm of search process on the level of a system shown in Fig. 8.

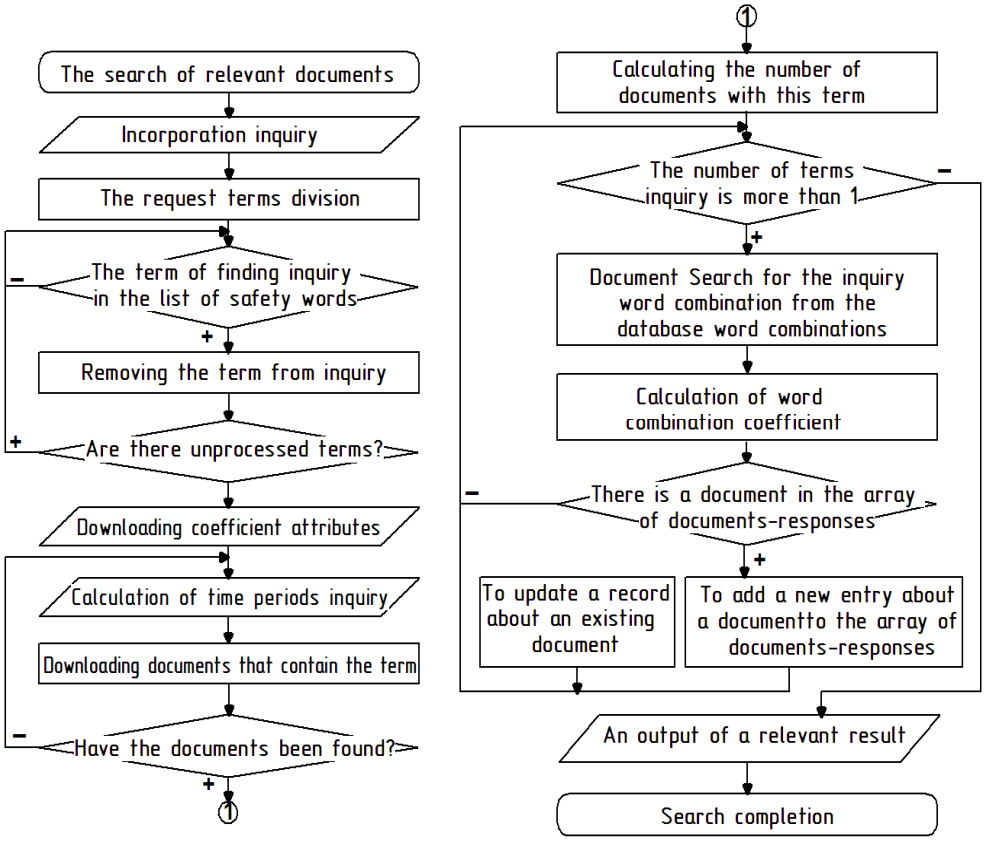

Fig. 8. An algorithm of search process on the level of a system

Modeling of local domain ontologies marketing information system. A complex of analytical procedures, for which domain ontology is created, must be performed in order to develop ontologies for local projections. This approach to solving the problem of information projections modeling can provide ontological specifications at a conceptual level and give an integrated description of heterogeneous, semistructured data resources, which allows to make their further efficient processing and semantic interpretation in a distributed environment by different groups of marketing specialists. Using these general approaches and results of morphological analysis of structural and functional characteristics of real Search Engine Marketing (SEM), we have developed ontological specifications for each of the projections (we will call them Local Domain Ontologies (LDO). [9, 10] They are presented below in the form of verbal description and as appropriate models of class diagrams in Unified Modeling Language (UML) notation:

• Search system of marketing data is an aggregated set of basic abstract classes: «Set of object – Set of processes – Problem space». In its turn, the abstract class «Problem space» is associated with subclasses «Problem solving – Totality of problems – Method selection – Scope of problem». The corresponding UML - Diagram of these classes are shown in Fig. 9.

• Search Engine Marketing solve the following problems: «Search of new markets, customers, products, applications of traditional products which can provide the highest profitfor enterprise», «Study of effective demand for the products and markets», «Evaluation of degree of risk of uncalled of products», «Evaluation of the stability and efficiency of production and product distribution» (Fig. 10).

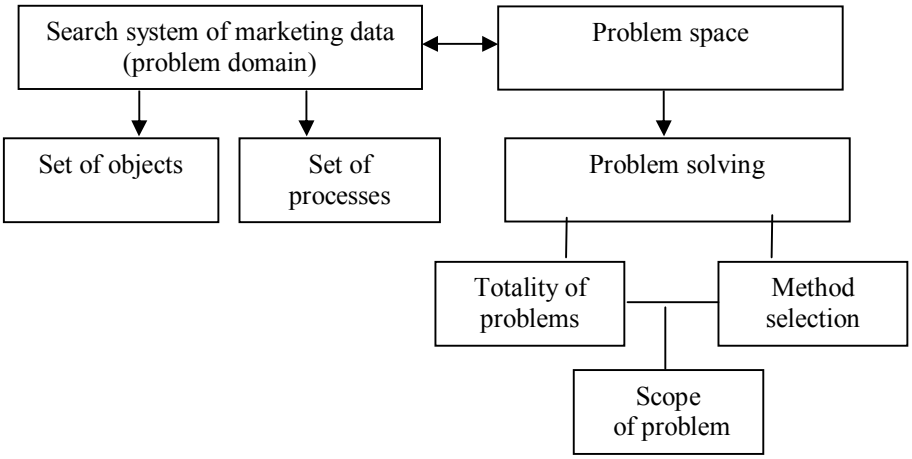

Fig. 9. Domain ontology search system of marketing

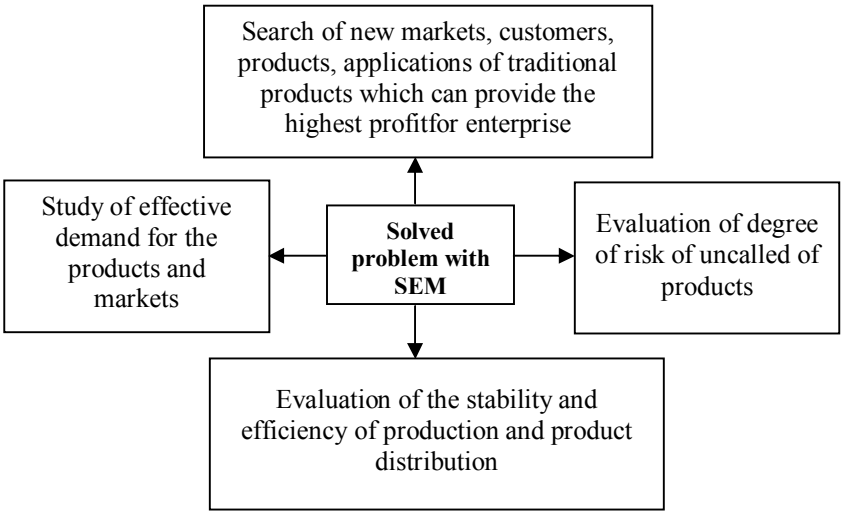

Fig. 10. Solved problem with SEM

Conclusions

Text Mining is also known as Text Data Mining or Knowledge-Discovery in Text (KDT), refers generally to the process of extracting required information and knowledge from an unstructured text. Text mining is a young interdisciplinary field which use information retrieval, data mining, machine learning, statistics and computational linguistics. Since most information (over 80%) is stored as text, text mining is believed to have a high commercial potential value. Knowledge may be discovered from many sources of information, yet, unstructured texts remain the most available source of knowledge.

The purpose of the search engine is to arrange the search by spontaneous query. The purpose of system is to find in collection of documents those that are most relevant to arbitrary user's information needs, and which are known through the system of single, user-initiated queries. The document is called relevant if, from user's perspective, it contains valuable information that satisfies his information need. The operation mechanism of the search engine can be arranged under the user"s search query and indexed documents in a system [10].

Visualization uses feature extraction and key term indexing in order to build a graphical representation of the document collection. This approach helps the user to identify quickly the main topics or concepts by their importance in the representation. Additionally, it is easy to discover the location of specific documents in a graphical document representation. The ability to visualize large sets of text data give users opportunity to explore the semantic relationships that exist in a large collection of documents.

To visualize a text document, we convey the information about relationships between documents to the analyst. We must preserve certain visualization characteristics in a geometrical manner to be meaningful. For example, documents that are close to each other in content should also be geometrically close to each other.

The users must have access to the Visualization in order to express their own point of view. That is, users must be able to interpret the rendered data in order the document relations were clearly defined.

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Strategic decisions on distribution channels

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Abstract

Introduction. The decision-making of management problems systems and distribution channels as important constituent of marketing politics of the enterprise are sanctified in the article. The aim of the research is to determine the strategic position and reasonable strategic decision forming in relation to the distribution channels. A research object is the enterprise's distribution policy.

Materials and methods. The methods of systems analysis of the points of the systems and channels of distribution of products management, method of analysis and synthesis of the economic phenomena in relation to determination of strategies structure of products distribution, method of scientific abstraction in relation to determination of strategic decisions in the distribution channels.

Results and discussion. Unsolvedness questions reasons of effective management of channels distribution are: absence of the complex approach to the problem decision; aspiration of the distribution system only on the task to expand sales markets and scope of target markets; limitation of administrative decisions in the distribution channels only by communication character strategies and strategies that are used to every participant of channel distribution.

For the problem decision-making is offered: from three constituents of distribution strategy the special attention is devoted to channels strategies of products distribution; using the strategies matrix of ("part of profit yield is created on indexes from products realization, provided with the corresponding distribution channel" and "profitability sale in the channel") for determining the strategic position of channel distribution; to ground the acceptance of administrative decisions in relation to the distribution channels on the basis of the corresponding recommended strategies ("deep penetration to the market", "maintenance of positions", "market development", "optimization of sale charge", "channel liquidation").

Conclusion. Matrix strategies distribution channels that gives an opportunity to define their strategic decisions, recommended for practical application of productive enterprises activity are offered at first.

Introduction

In the process of management economic activity modern enterprise appear the tasks of effective production distribution organization with the special sharpness, the decision of its success depends at the market. A company lives for the sale account, or according to I. Vitt, "sales are a bridge from a company to the market" [1]. The central link of forming sale policy of the enterprise decisions come forward in relation to management the systems and distribution channels of the enterprise. Distribution is one of marketing complex element. Therefore, all problems of the optimal distribution system forming must be settled as other constituents of marketing - mix could function effectively.

The aim of the research is determination of strategic position and reasonable strategic decisions forming in relation to the distribution channels in accordance with the enterprise's aims. A research object is the enterprise's distribution policy.

Literature review

The basis of the conducted literary sources review were set that products distribution is the activity that is sent to the effective systems functioning and commodities distribution channels with the aim of overcoming of spatial, sentinels and quantitative commodity differences between the sphere of production and consumption, and also property transfer right on the commodity with the aim of consumers' necessities satisfaction and enterprise's income [2-7].

To the basic tasks of the distribution policy belong:

1. Organization and management of enterprise's system distribution (type determination, organization and strategies of the distribution system principles).
2. Forming and management of distribution channels within the enterprise's distribution system framework (determination of channel distribution descriptions, organization and optimization of their activity depending on the enterprise's aims, making decision in relation to the channels of distribution strategies).
3. Organization and management of turnover and products sale (determination of mediators types, with whom the firm will work, and work strategies) [8-10].

Questions that touch the first and third aspects are widely observed in economic literature. In relation to the second administrative aspect, as the acceptance of strategic decisions in the distribution channels, it is not almost examined or carries superficially-descriptive character. Although the effective products distribution channels management must be base on the development and application of certain strategies.

Theoretical distribution channels systems management bases are given in works of A.T. Coughlan, E. Anderson, L.W.Stern, A.I. El-Ansary, I. Ansoff, Zh.-Zh. Lamben, P. Doylen, A. Khovanov, I. Poliezhaieva, P. Kotler, K. Keller, S. Burton, G. Armstrong, O. Bilovodska, R. Cooper, P. Winkelmann, J. Witt, D. Ahlert, S. Efimova, J. Dent, E. Berkowitz, R. Kerin, S. Hartley, W. Rudelius, L. Gorchels, E. Marien, Ch. West, G. Lankaster, D. Jobber, G. Bolt, Linders M.R., Firon G.E., Scott G.J., Voychak A.V., Kardash V.Ya., Pylypchuk V.P., Pavlenko A.F., Balabanyts' A.V., Balabanova L.V.

In scientific literature there are a few approaches for forming and management of the distribution channels, that are construction basis of the distribution system of the enterprise. Classic approaches are studied by L. Stern and F. Kotler [11-12]. The investigated research was also studied by O.A. Bilovodska, R. Cooper, S.A. Efimova, A.A. Khovanov, Zh.-Zh.

Lamben and P. Winkelmann. The scientists examined narrow questions of distribution channels management, or communication policy in the distribution channels.

Generalization of results of home and foreign developments in industry of distribution policy testifies that they highlight the problems of forming and functioning distribution channels are examined from the different points of view. But there is not sharpness understanding of question in relation to the determination of strategic decisions in the distribution channels. It is, therefore, possible to consider that on this time not all questions of this problem are decided.

Materials and methods

The researches' results of foreign and home scientists of the method of systems analysis in the relation to the questions of systems and channels products distribution management are described in the article. Authors are also use the method of analysis and synthesis of the economic phenomena in relation to the determination of products distribution strategies, that is suggested to accept on three levels (products distribution, channels of products distribution and participants of products distribution channels). A method of scientific abstraction gave an opportunity to define position of channels distribution and offer strategic approaches in relation to their further development.

Result and discussion

On the basis of scientists' ideas analysis were considered that the process of forming and management of distribution channels consists of the following stages: concordance of firm's aims with the aims of distribution channels construction; determination of sale methods that are used at commodities distribution; choice of distribution channel structure; evaluation of distribution channel participants; a choice of optimal structure of distribution channel and acceptance of strategic decisions in relation to every distribution channel [11-14].

The critical review of scientific literature showed that there are some approaches of strategies forming in the distribution channels.

To the strategic decisions of the enterprises' sale activity belong question of its markets expansion and scope of target markets. These strategies are global for the enterprise and closely constrained with of assortment policy strategies, pricing and products advancement, they can not be considered as distribution channels strategies.

Some scientists (A. El-Ansari, L. Shtern, E. Koflan) examine a decision in relation to the scope of market as distribution channels strategy. They observe intensity of distribution channels (intensive, selective and exclusive sale) strategies [11]. I. Ansoff gives the determination to "strategy" as the «set of rules for making decision that organization follows in the activity» [15]. Strategy is a long-term plan that is accompanied by a permanent analysis and monitoring of its realization. Thus, intensity of distribution is not strategy, but one of decisions that is accepted in the process of forming of distribution channels.

Other approach in relation to the acceptance of strategic decisions in the distribution channels determines only strategies of advancement: reaching and promotion [16]. These strategies rather behave to the sphere of communication policy and regulate the aspects of products advancement.

To our opinion, the enterprise carries out products distribution management onto three levels: distribution, distribution channels and participants of systems distribution channels.

Most scientific sources do not distinguish the strategy after these three directions, and all strategies are determined as strategies in the distribution channels.

So, for example, integration (vertical, horizontal) strategies can be used only for distribution of the enterprise, their appendix system to the separated channel is improper.

Very often, the distribution channels strategies call the co-operating strategies with every channel participant, determining them as strategies in the distribution channels. For example, O. Bilovodska in the process of distribution channel choice suggests to apply the distributors matrix that is based on profitability and potential of mediator increase and gives description to strategies for every type of channel participants («red ink», «reorientation», "alarmed" and «new generation») [3]. And P. Vinkelman determines strategies for every category of clients («Interrogative signs", «Star», «Milch cows» and «Dogs») depending on relative part of deliveries and height of client's turnover [17]. Accordingly, these authors in the works determine strategies of co-operating with every participant of distribution channel.

Consider to divide the distribution strategies into three composition:

- determination of integration strategies for the distribution system,
- determination of strategies of distribution channels height,
- determination of strategies of co-operating with every channel's participant.

The special attention is suggested to every distribution channels strategies, e.g. this direction practically is not overcame in scientific literature.

For the acceptance of strategic decisions in relation to every distribution channel, it is suggested to apply methodology that takes into account the part of profit yield from products realization that is sold by the certain distribution channel and profitability sale channel, it is suggested to apply the methodology developed by authors.

The essence of the offered methodology consists of position-finding of every distribution channel on the matrix field, built on indexes of «the part of profit yield from products realization that is sold by the certain distribution channel» and "profitability in a sale channel».

Part of profit is provided with the corresponding distribution channel from products realization as attitude of profit yield to distribution channel of toward the general enterprise's profit.

For the evaluation of commodities sale profitability by the channel, it is needed to educe necessary resources, count total charges on their use and compare these charges with these channels' profits [11]. The calculation of different types of activity behaves to the method of charges allocation between commodities with taking into account actions necessary for the production of these commodities [18]. This conception is also applied for efficiency comparison by the uses of resources of one channel comparatively with the second or for comparing the sale results of one commodity to the sale results of other [11]. If to estimate profitability of concrete channel, it is necessary to educe used resources, to count total charges on their use and compare these charges with these channels' profits.

The incomes of every channel settle accounts as a difference between profits and charges in the channel. Profitability of products realization through the channel is a share from the division of income from products realization on the net profit, got through the investigated distribution channel that multiplied on 100%.

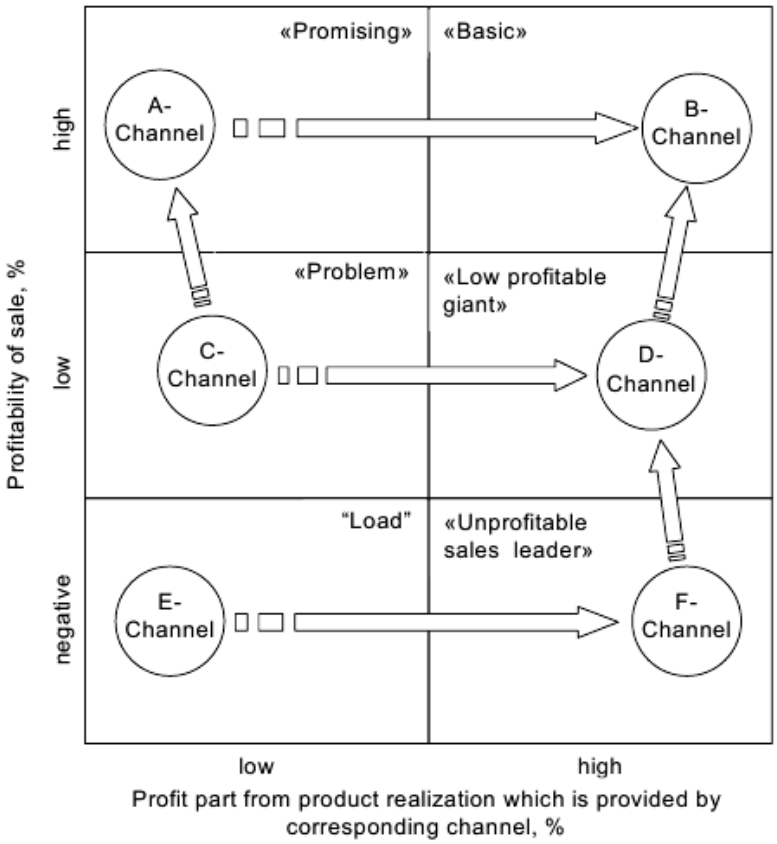
Charges in every distribution channel are carrying the elements of charges after the streams of functions and determination of middle charges in every stream. The general sale charges of every channel is determined by the product middle stream charges and numerical values of corresponding stream constituent [11].

If the enterprise will have information on these indexes, it can lay down the matrix of "distribution channel strategies", that envisages distribution channels on six groups (Table 1):

- Quadrant «Perspective» are distribution channels that got to this zone have relatively small turnover, but high profitability.
- Quadrant «Basic» are the distribution channels that characterized by the large stake of profit yield and high profitability.
- Quadrant "Low profitable giant» are the distribution channels where the large volume of company's sale passes through that, but they do not bring substantial returns.
- Quadrant "Problem" this zone includes the distribution channels that have low profitability and turnover.
- Quadrant «Unprofitable leader sale» is the distribution channels bring losses to the enterprise, but have large turnover.
- Quadrant «Load» are channels that losses coincide with low turnover.

Table 1

Matrix "Channel Distribution Stretegy"
Source: developed by authors



Let's describe each of groups and will define their possible strategic decisions.

The high index of profitability level and low part index of profit yield from to the quadrant «Perspective» realization, provided with corresponding channels, predetermines the achievement of primary purpose: to get high incomes. It is possible to consider the profit yield increase of perspective aim from realization through the this zone channels at the same profitability sale.

In relation to the channels of this group depending on the degree of market saturation such strategic solutions are offered:

1. «Deep market penetration» and «market development» with the aim of turnover stimulation without the loss of profitability. At successful application of such strategy the channels of «Perspective» group can pass to the «Basic» quadrant. This strategy is recommended at terms, if a target market on that products distributed channel is nonsaturated;
2. «Position maintenances» for further high incomes obtaining in the channel. Used in case, if a target market on products by this channel are distributed is saturated.

Distribution channels from the «Basic» quadrant have advantageous combination with large volumes sale with the high level of profitability. Due to the channels of this zone the enterprise arrives the aimed profit in relation to the high incomes and scope of large market segments.

The recommended strategic decision in relation to this zone is strategy of «position maintenance» that envisages various support and further development of long-term connections of partners in the channel.

Large volume of profit yield from realization in the «Low profitability giant" quadrant explain about its perspective.

The primary purpose the enterprise try to attain, when uses these channels there is a survival at the market or expansion of market scope. Perspective aim: is to control of sale charge, increase the channels profitability.

For the "Low profitability giant" quadrant can be recommended such strategic decisions that are adequate to the position touched by the enterprise:

1) "optimization of sale charge» is the strategy sent to the cost cutting and profitability increase in the channel due to the exposure of «bottlenecks» in sell off and their liquidation. It is priority strategy for the channels of this type. At successful application of this strategy this channel will pass to the «Basic» group;

2) «market development» is the strategy sent to further of new market fascination and expansion of existent distribution channels segments.

Channels of «Problem» zones occupy unattractive position: profit is not made or not enough for further activity, the turnover is also insignificant. By a primary purpose in relation to a problem zone it can be: control of sale charge or increase of sale volumes of the channel.

Possible channels strategies for the «Problem» quadrant:

1. «Market development» or «deep penetration to the market», if enterprises have presence resources for mastering of new markets or increase sales through a channel, to transfer to the zone of "Low profitable giants»;
2. «Optimizations of sale charges» is for channel passing to the «Perspective» zone, if the enterprises have not sufficient resources.

Distribution Channels of the quadrant "Unprofitable leader sale" have large turnover but brings losses to the enterprise. Thus, markets fascination of sale belongs for a primary purpose. A perspective aim is the profitability increase due to hard control of sales charge.

For this group of channels is recommended the strategy of «optimization of sale charge», sent to the exposure of all possibilities in relation to the cost cutting and profitability increase. On condition of successful application of this strategy these channels can pass to the group of «Low profitability giant».

Channels that losses coincide with the low volumes realization get to the «Load» group. If the enterprise already long time works through this channel, but profitability and profit yield do not increase, it is needed to leave off to work with these channels. Thus not a single aim that was put by the enterprise, it was not attained. Only possible strategy for these channels there can be «liquidation».

The group «Load» consists of new channels with the enterprise only began to work. They bear loss from the activity and have low turnover, but this situation can become better in the future.

The offered methodology passed approbation at research of distribution channels at JSC "Obolon".

For comfort of realization of analysis and presentation results, every distribution channel was in code, taking into account the market type, that it serves (industrial, consumer and foreign), its functional and regional signs, going out such reasoning:

- the code of distribution channel is begun with denotation and numeration of market where enterprise works, and then denotation and numeration of channel;
- distribution channels, that work at the industrial market, the capital letter of "B" (business), at the user market is by the letter "C" (consumer);
- marking of channels denotation of 0th level with the capital letter "Z" (zero);
- the channels of 1th level is the capital letter "R" (retail);
- the channels of 2th level is the capital letter "D" (distributor), exclusive distributors (exclusive of Distributor) is "DE", foreign exclusive distributors (abroad exclusive of Distributor) is "Ade".

It was found out during realization of researches, that JSC "Obolon" works on industrial and Ukrainian and foreign markets, using nineteen distribution products channels. An internal consumer market can be divided on functional (on trade and off trade) and after regional signs. Consumers-visitors of establishments of public food consumption to the market of C1 (distribution channel of C1HoReCa). The consumer market of the North region will designate C2 (distribution channels of C2Z, C2R, C2D, C2DE), consumer market of the Central region is C3 (distribution channels of C3Z, C3R, C3D, C3DE), consumer market of the Western region is C4 (distribution channels of C4Z, C4R, C4D), consumer market of the East region is C5 (distribution channels of C5Z, C5R, C5D), consumer market of the South region is C6 (distribution channels of C6R, C6D), foreign consumer market is C7 (distribution channel of C7ADE). An industrial market JSC "Obolon" is marked B1 (distribution channel of B1Z).

The results of determination of strategic position of products distribution channels of JSC "Obolon" in 2013-2014 is presented on tables 2 and 3.

It is educed on the basis of this research, that the state of all objects became worse considerably. If in 2013 more than half of channels behaved to the group "Perspective" and "Basic", then in 2014 practically all channels planted in groups "Problem" and "Low-profitable giant" that testifies worsening economic position of company. A positive moment is that not a single distribution channel got to the groups "Load" and the "Unprofitable leader sale".

The erected information about placing of distribution channels in the matrices of "strategies of products distribution channels", and also perspective objectives, strategic decisions and measures, that appropriated to them are given in the table 4.

Table 2

Matrix of "Strategies of products distribution channels"

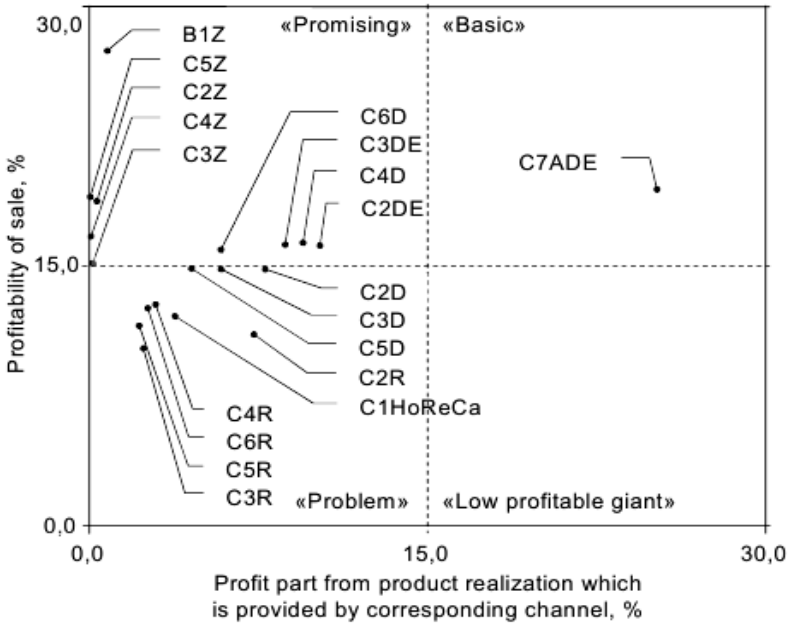


Table 3

Matrix of "Strategies of products distribution channels" of JSC "Obolon" in 2014

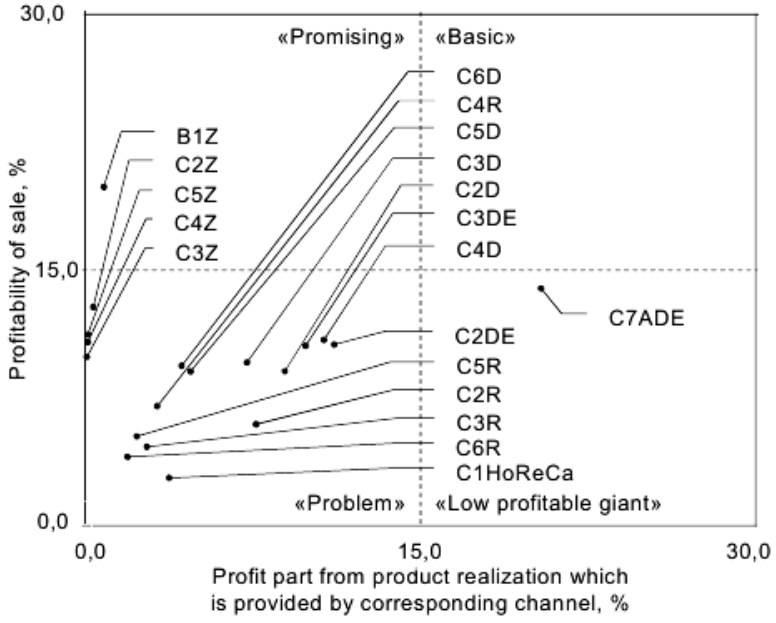


Table 4

Types of products channels distribution of JSC "Obolon" and appropriate strategy decision in 2014

Quadrant	Distribution channel	Perspective objective	Strategy decision	Measures according to the strategy
«Promising»	B1Z	Waste production distribution	«position supporting»	To support relationship with existence clients
«Basic»	-	-	-	-
«Low-profitable giant»	C7ADE	Reorientation to European and Asian markets	«market development», «optimization of sale charges»	To expand new foreign distribution markets
«Problem»	C1 HoReCa	Image supporting of producer trade marks	«position supporting»	hard control of sale charges and application of the self-weighted communication policy
	R2(3,4,5,6)	Providing of products proof suggestion, image supporting, getting information	«position supporting», «reorientation»	application of sales consumers measures and mediators, entering into contracts promotion about the long-term collaboration with large retailer, reorientation of retail chandlers on collaboration with distributors
	D2(3,4,5,6) та DE2(3)	increase of profitability and channel part of net profit	«optimization of sale charges», «deep penetration to the market»	control of sale charges, a close collaboration with every distributor
«Unprofitable sale leader»	-	-	-	-
«Load»	-	-	-	-

A decline of work efficiency of all distribution channels of JSC "Obolon" is caused by a general economic and political situation in a country, as demand for goods of brewing industry straight depends on solvency of population. At present moment, one of priority tasks for a company is surviving at the market and, on possibility, keeping competition positions.

Conclusions

Offered approach in-process helps to define the provision of distribution channels on the matrix of «distribution channels strategies», that consists of six quadrants «Perspective», «Basic», «Low profitable giant», «Problem», «Unprofitable leader sale» and «Load». This methodology takes into account the part of profit yield from products realization, provided with the certain distribution channel, and profitability sale in the channel. It gives an opportunity to define strategic decisions in the distribution channels that will assist successful activity of the enterprise at the market, will allow managing the distribution system of the enterprise.

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Assessment of development of the food industry in Poland against European Union countries

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Abstract

Introduction. This article aims at assessing the position of the Polish food industry in comparison tofood producers in the European Union.

Material and methods. The development of the Polish food industry was assessed compared to selected EU food producers for 2003-2013 based on Eurostat data. Comparability of food industry data in individual EU Member States was obtained by adjusting the value of production at current prices with the EUR purchasing power index (parity) in individual EU Member States.

Results and discussion. The Polish food industry stands out from the other EU Member States. The share of Poland in the value of marketed production of the EU-28 food industry is nearly 9%, which ranks us sixth in the EU. In 2003-2013, the value of food industry production in Poland increased by 60%, compared to 20% in the EU-15 and 42%in the EU-12/13. In 2003-2013,such animprovement in labour productivity in the food industry was a common phenomenon throughout the EU Member States. The largest increase in this period was recorded in Lithuania (96%), Bulgaria (77%) and Poland (61%). In the EU-12/13,labour productivity grew by 1/2, while in the EU-15 – by 1/4. This was due to a large investment boom and a drop in the number of employees. The processes of consolidation and concentration of the food industry continue. The average turnover value per food company in Poland (EUR 7.2 million) is nearly twice higher than the EU average (EUR 3.7 million), but much lower than in states with the highest production concentration in this sector, i.e.: Ireland (EUR 36.8 million), the UK (EUR 13.3 million), the Netherlands (EUR 10.2 million) or Denmark (EUR 9.7 million). However, it is higher than in Germany (EUR 5.9 million).

Conclusion. Having analyzed the phenomenon, it can be concluded that the gap between the development of the food sector in Poland and the EU-15 is narrowing, while structures of the industry and market players are increasingly similar to the largest EU food producers. In the past decade, the pace of development of the Polish food industry was one of the fastest in the EU, thus improving the standing of our food industry in the Single European Market.

Introduction

The share of Polish production in the production of the EU-28 food sector in 2013 amounted to nearly 9%. In terms of the value of marketed production, Poland is the sixth food producer in the EU. Integration with the European Union had a positive impact on accelerating growth in the value of marketed production of the Polish food industry, while several years of adaptation to EU requirements significantly changed the image of Polish food companies in the Single European Market. The Polish food industry became a major food producer in the European market and Polish food processing plants are considered among the most advanced in the European Union. Food product export, growing rapidly upon accession, was one of the main factors contributing to the development of the food industry in Poland. Currently, the standing of the Polish food industry is stronger than in the pre-accession period, making Poland one of the leading EU Member States.

This article aims at assessing the position of the Polish food industry in comparison to food producers in the European Union.

Material and methods

The development of the Polish food industry was assessed compared to selected EU food producers for 2003-2013based on Eurostat data (value of marketed production of the food industry, employment and the number of enterprises), including the production of tobacco products.

Comparability of food industry data in individual EU Member States was obtained by adjusting the value of production at current prices with the EUR purchasing power index (parity) in individual EU Member States.

Variability of marketed production of the meat industry was calculated using the average annual dynamics of change, applying analysis of linear regression of trend function (in absolute terms) or a compound interest formula[1] (in relative terms).

$$K_n = K_0(1+\frac{r}{100})^{n-1}$$

$$r = \left(\sqrt[n-1]{\frac{K_n}{K_0}} - 1 \right) \cdot 100$$

where:

K_o – initial characteristic value,
K_n– final characteristic value,
r – growth rate, average annual rate of change.

[1] S. Plaskacz, *Compound Interest*, Scientific Society for Organisation and Management, Toruń 1998; M. Podgórska, J. Klimkowska, *Financial Mathematics*, Polish Scientific Publishers PWN, Warsaw 2005.

Results and discussion

1. Comparative analysis of the development of the EU food industry

The European Union has been a major global food producer for many years. In 2003-2013, the value of production of the food industry (at current prices) in the EU-27/28 increased by 27% to EUR 1 015 billion, while at comparable prices – to EUR 1 045 billion (Table 1). Over 80% of this production is produced in the EU-15 and its major producers are as follows: Germany with a share of 17.4% in the value of marketed production of the EU food industry, France (12.8%), Italy (11.6%), the UK (10.5%) and Spain (10.3%). Poland is the sixth food producer in the EU with a share of 8.7% in the EU production of the food industry. In 2013,the production of the Polish food industry, including tobacco products and alcohol (at comparable prices), reached EUR 91.3 billion, i.e. the highest in the EU-13 (Figure 1). However, this value is more than two times lower than in Germany (EUR 182.4 billion), but higher than in the Netherlands (EUR 51.5 billion) and Belgium (EUR 40.3 billion) (Figure 1).

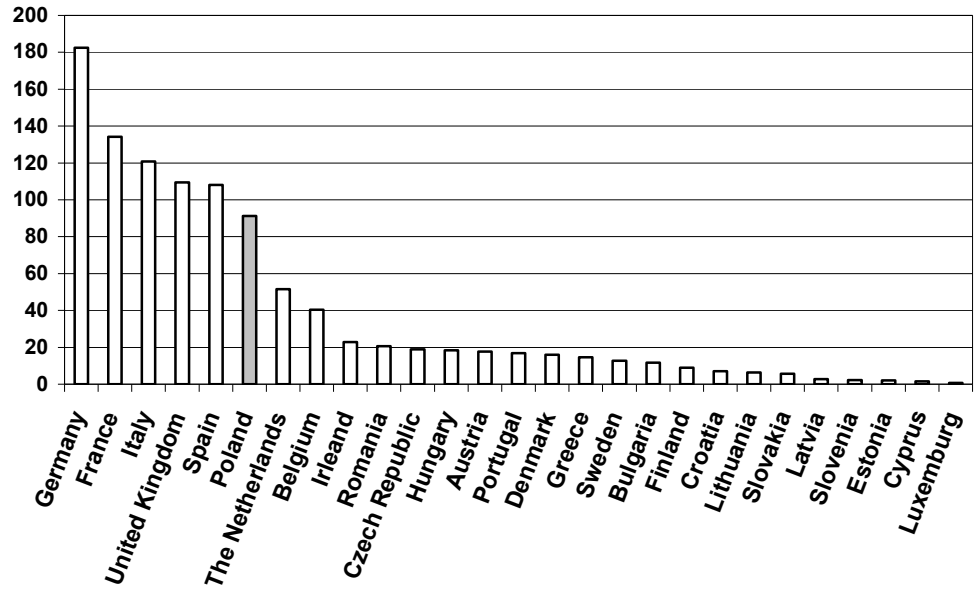

Figure 1. Largest EU-28food producers in 2013 (EUR '000 000 000) (by purchasing power parity)
Source: Own elaboration based on Eurostat data.

Significance of the food industry for the Polish economy is considerably greater than in the EU Member States, as evidenced by the ratio of the value of the food industry to GDP (Table 1). In 2013, the trading value of the Polish food industry was 13.6% of GDP produced, while the average in the EU-15 was 7.6%, in the EU-13–10.6%, and in the entire

EU-28– 8.0%. Only in Ireland (15.3%), the ratio was higher than in Poland. In Germany, the UK and France, it was nearly a half lower than in Poland and amounted to 7%.

The level of food industry development measured by the trading value per capita in 2013 amounted in Poland to EUR 2.4 thousand and was similar to that of the largest food producers in the EU (Table 1), i.e.: Germany (2.2), France (2.0), the UK (1.6) and the EU-15 average (2.1). In 2003-2013, the value of marketed production of the food industry per capita in Poland increased on average by 4.9% per year, in Germany – by 2.8%, while in the EU-15the said turnover increased by 1.2% per year, and in the EU-12/13 – by 3.9%. In that period, the greatest average annual increase in turnover per capita was recorded in Lithuania (6.0%) and Bulgaria (5.5%), while high – in Romania (3.6%).

In 2003-2013, the value of marketed production of the food industry in the EU-27/28 increased on average by 2.2% per year, while in Poland the growth rate was 4.8%, compared to 2.8%,1.3% and 0.8% per year in Germany, the UK and France, respectively. Therefore, the value of production in the analyzed period increased the most in Poland, i.e.by more than one and a half from EUR 57.1 billion to EUR 91.3 billion and its dynamics was twice that in Germany (32%), Spain (24%) or Italy (19%) (Tables 1.1, 1.2).

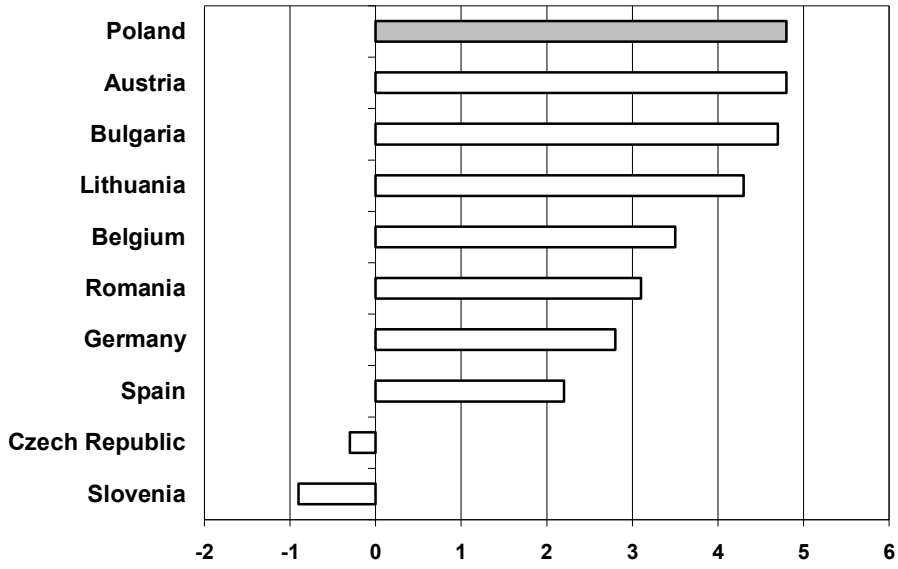

Fig. 2. Yearly average pace of development of food industry production in selected EU-28 Member States in 2003-2013 (in per cent per annum) at comparable prices
Source: Own elaboration based on Eurostat data.

This diversity of food industry development in the EU makes it decreases the gap between the EU-15 and EU-13. The food industry in the EU-15 is slowly losing its position in favor of companies from the EU-13, and the Polish food industry from year to year is becoming stronger in the Single European Market.

Table 1.1

Food industry in the EU Member States in 2013

EU Member States	Value of production (EUR '000 000 000)				Production[a] in2013 (EUR '000 per capita)	Ratio of the value of the food industry to GDP (%)	Share in EU-28 production[a] (%)
	at current prices		at comparable prices				
	2003	2013	2003	2013			
Austria	11.8	19.7	11.1	17.7	2.1	6.3	1.7
Belgium	29.1	45.3	28.6	40.3	3.6	11.9	3.9
Germany	147.8	190.0	138.2	182.4	2.2	7.0	17.4
Denmark	20.8	22.1	15.4	15.9	2.8	8.8	1.5
Spain	73.2	98.2	87.1	108.0	2.3	9.6	10.3
France	138.9	150.8	123.6	134.2	2.0	7.3	12.8
Finland	8.2	11.0	6.9	8.9	1.6	5.7	0.9
Greece	9.1	12.5	12.5	14.6	1.3	6.9	1.4
Ireland	21.1	25.0	18.5	22.8	5.0	15.3	2.2
Italy	101.2	122.0	101.2	120.8	2.0	7.8	11.6
Netherlands	47.4	56.6	45.2	51.5	3.1	9.4	4.9
Portugal	10.7	13.7	13.6	16.9	1.6	8.3	1.6
Sweden	13.9	17.0	11.9	12.8	1.3	4.1	1.2
UK	103.7	119.0	96.4	109.5	1.7	6.3	10.5
Luxembourg	0.7	0.9	0.7	0.7	1.3	1.9	0.1
Poland	**27.6**	**52.8**	**57.1**	**91.3**	**2.4**	**13.6**	**8.7**
Czech Republic	9.5	13.0	19.4	18.9	1.8	8.7	1.8
Hungary	9.6	10.5	17.2	18.3	1.8	10.8	1.8
Slovakia	2.3	3.9	4.9	5.7	1.1	5.4	0.5
Slovenia	1.7	1.8	2.4	2.2	1.1	5.0	0.2
Lithuania	1.9	3.9	4.2	6.4	2.2	11.3	0.6
Latvia	1.1	1.9	2.5	2.8	1.4	8.0	0.3
Estonia	0.8	1.5	1.7	2.0	1.5	7.9	0.2
Cyprus	1.0	1.4	1.1	1.6	1.9	8.3	0.2
Malta						0.0	
Romania	5.5	10.5	15.2	20.6	1.0	7.4	2.0
Bulgaria	2.4	5.3	7.3	11.6	1.6	13.3	1.1
Croatia		4.6		7.1	1.7	10.7	0.7
EU-15	737.6	903.8	710.9	857.0	2.1	7.6	82.0
EU-12	63.4	111.1	133.0	188.5	1.8	10.6	18.0
EU-28	801.0	1 014.9	843.9	1 045.5	2.1	8.0	100.0

[a]at comparable prices (adjusted by the EUR purchasing power index in the Member States referred to above)

Source: Own calculations based on Eurostat data.

Table 1.2

Food industry in the EU Member States in 2013

EU Member States	Dynamics[a] 2013/2003	Average growth rate of meat industry production[a] in 2004-2013	Number of food industry companies (‘000)	Employment (‘000 persons)
Austria	159.5	4.8	3.73	76.9
Belgium	140.9	3.5	6.93	90.0
Germany	132.0	2.8	31.10	859.1
Denmark	103.2	0.3	1.63	63.4
Spain	124.0	2.2	27.16	349.9
France	108.6	0.8	58.87	592.6
Finland	129.0	2.6	1.73	38.0
Greece	116.8	1.6	14.45	81.3
Ireland	123.2	2.1	0.62	39.2
Italy	119.4	1.8	57.20	346.3
Netherlands	113.9	1.3	5.03	125.7
Portugal	124.3	2.2	10.42	100.4
Sweden	107.6	0.7	3.80	56.3
UK	113.6	1.3	8.24	403.3
Luxembourg	100.0	0.0	0.15	5.2
Poland	**159.9**	**4.8**	**12.66**	**406.6**
Czech Republic	97.4	-0.3	8.42	106.2
Hungary	106.4	0.6	6.58	101.3
Slovakia	116.3	1.5	2.78	38.2
Slovenia	91.7	-0.9	1.94	15.3
Lithuania	152.4	4.3	1.47	41.8
Latvia	112.0	1.1	0.96	26.1
Estonia	117.6	1.6	0.49	14.2
Cyprus	145.5	3.8	0.80	12.5
Malta				
Romania	135.5	3.1	8.57	187.2
Bulgaria	158.9	4.7	5.85	94.4
Croatia			3.24	63.8
EU-15	120.6	1.9	231.06	2 227.6
EU-12	141.7	3.5	54.26	1 107.6
EU-28	123.9	2.2	285.32	4 335.2

[a]at comparable prices (adjusted by the EUR purchasing power index in the Member States referred to above)

Source: Own calculations based on Eurostat data.

2. Labour productivity in the EU food industry

The Polish food industry employs nearly 407 thousand persons, representing nearly 10% of total employment in the EU food industry. It ranks Poland third in the EU-28. Higher employment (‘000 persons) is reported only in Germany (859) and France (593), while slightly lower – in the UK (403), Spain (350) and Italy (346). In 2003-2013,the number of employees in the food industry in the EU-27/28 dropped by 4%, in the EU-15 – by 3%, and in the EU-12/13 – by 6%. In Poland, employment fell by 1%. The largest decline in employment in the food sector was reported in Hungary (by 26%), Latvia (by 26%) and Denmark (by 24%). However, employment in the food industry increased in, among others: Greece (by 25%), Germany (by 4%) and Italy (by 2%).

In 2013, one employee in the food industry in Poland generated EUR 224.5 thousand of marketed production which was more than in Germany (EUR 212.3 thousand), but twice less than in Ireland (EUR 581.6thousand), Belgium (EUR 447.8 thousand) and the Netherlands (EUR 409.7 thousand) (Table 2).

Table 2

Labour productivity[a)] in the EU food industry (EUR ‘000 per employee)

Member States	2003	2008	2013	Annual change (%) in		
				2004-2008	2009-2013	2004-2013
EU-15	213.6	254.5	265.5	3.6	0.8	2.2
EU-12/13	113.0	141.5	170.2	4.6	3.8	4.2
EU-27/28	187.3	224.9	241.2	3.7	1.4	2.6
Ireland	370.7	432.4	581.6	3.1	6.1	4.6
Netherlands	343.7	435.0	409.7	4.8	-1.2	1.8
Belgium	315.7	355.9	447.8	2.4	4.7	3.6
Italy	298.5	314.6	348.8	1.1	2.1	1.6
Spain	243.6	273.8	308.7	2.4	2.4	2.4
UK	199.1	255.0	271.5	5.1	1.3	3.2
France	200.7	252.6	226.5	4.7	-2.2	1.2
Germany	167.7	203.8	212.3	4.0	0.8	2.4
Greece	192.0	189.2	179.6	-0.3	-1.0	-0.7
Poland	**139.4**	**172.5**	**224.5**	**4.4**	**5.4**	**4.9**
Czech Republic	142.7	156.2	178.0	1.8	2.6	2.2
Hungary	125.6	154.2	180.6	4.2	3.2	3.7
Estonia	91.9	112.5	140.8	4.1	4.6	4.4
Lithuania	78.1	102.3	153.1	5.5	8.4	7.0
Bulgaria	69.3	107.5	110.0	9.2	0.5	4.7
Romania	75.9	101.6	100.8	6.0	-0.2	2.9

[a)] at comparable prices

Source: Own elaboration based on Eurostat data.

Labour productivity in the Polish food industry is the highest in the EU-12/13 and higher than the EU-12/13 average by nearly 1/3 (EUR 170.2 thousand). Increasing employment infrastructure expenditure had a material impact on its improvement. This was due to a large investment boom, especially after Poland's accession to the EU, and a drop in the number of employees. In the past decade, such animprovement in labour productivity in the food industry became widespread and occurred in all the EU Member States.

In 2000-2010, labour productivity in the Polish food industry increased on average by 4.9% per year, in the EU-15 – by 2.2% per year, and in the EU-12/13 – by 4.2% per year (Table 3). The highest growth rate of labour productivity in the last decade was reported in Lithuania (7.0% per year). In 2004-2008, i.e. a period of robust development of the food sector in most of the EU Member States, average annual labour productivity growth in the EU-15 amounted to 3.6% and in the EU-12 –to 4.6%. In the same period, labour productivity in the Polish food industry increased on average by 4.4% per year, while in Germany – by 4.0%. In 2009-2013, however, its growth rate was slightly lower, while certain states saw a decline in this respect as a result of the global financial and economic crisis. Only a few states, including Poland (+5.4%), recorded an increase in labour productivity in the food industry.

3. Production concentration in the EU food industry

In 2013, approx. 12.7 thousand enterprises in Poland were engaged in food production. This represented4.4% of EU food enterprises and ranked Poland fifth in the EU-28. In 2003-2013, this number in Poland decreased by nearly 30%, while in the EU-15 and the EU-12/13– by 11% and 0.7%, respectively. Recent years brought the largest drop in the number of companies in operation in the Polish food industry which was due to the global economic crisis of2008-2009. At this time, the number of food enterprises in Poland decreased by 14.5%, while in the EU –by 2%. Turnover of an average company demonstrates an increase in the economic strength and competitiveness of Polish food enterprises in the European market. In 2013, the trading value of food processing enterprises in Poland amounted to EUR 7.2 million per company and was more than twice higher than in 2003 and 60% higher than in 2008. In 2013, the average turnover of a food company in the EU-15 was EUR 3.7 million. The standing of Polish food companies against all the Community states is rather good. The average turnover generated by one enterprise in Poland is higher than that of a German company by EUR 1.3 million and much higher than in: Italy, France, Portugal or Greece. However, it is much lower than in: Ireland (EUR 36.8 million), the UK (EUR 13.3 million) and the Netherlands (EUR 10.2 million).

The processes of concentration and consolidation of the food industry continue throughout the European Union. In Poland, they run much faster than in most of the other EU Member States. The gap between Poland and the other EU Member States with high production concentration in this sector is narrowing. In 2003-2013, the average turnover value of an average Polish food company increased by 8.4% per year. This was the fastest growth rate among all the EU Member States. In the EU-15,the average growth rate was 3.2% per year, while in the EU-12/13 – 3.8% per year. As for major EU food producers, this increase varied from 4.2% per year in Germany to 0.1% in the UK (Table 3).

Table 3

Average turnover value of an average EU food company (EUR '000 000)

Member States	2003	2008	2013	Annual change (%) in		
				2004-2008	2009-2013	2004-2013
EU-15	2.7	3.3	3.7	4.1	2.3	3.2
EU-12/13	2.4	3.2	3.5	5.9	1.8	3.8
EU-27/28	2.7	3.3	3.7	4.1	2.3	3.2
Ireland	27.6	27.5	36.8	-0.1	6.0	2.9
Netherlands	9.5	12.8	10.2	6.1	-4.4	0.7
Belgium	3.6	4.1	5.8	2.6	7.2	4.9
Italy	1.4	1.8	2.1	5.2	3.1	4.1
Spain	2.9	3.6	4.0	4.4	2.1	3.3
UK	13.2	14.4	13.3	1.8	-1.6	0.1
France	1.8	2.1	2.3	3.1	1.8	2.5
Germany	3.9	5.2	5.9	5.9	2.6	4.2
Greece	0.9	0.9	1.0	0.0	2.1	1.1
Poland	**3.2**	**4.5**	**7.2**	**7.1**	**9.9**	**8.4**
Czech Republic	3.0	2.8	2.2	-1.4	-4.7	-3.1
Hungary	2.4	2.5	2.8	0.8	2.3	1.6
Estonia	3.8	4.4	4.1	3.0	-1.4	0.8
Lithuania	3.1	3.9	4.3	4.7	2.0	3.3
Bulgaria	1.1	2.2	2.0	14.9	-1.9	6.2
Romania	1.4	2.2	2.4	9.5	1.8	5.5

*a)*at comparable prices

Source: Own elaboration based on Eurostat data.

Conclusions

The Polish food industry stands out from the other EU Member States. The share of Poland in the value of marketed production of the EU-28 food industry is nearly 9%, which ranks us sixth in the EU. In 2003-2013, the value of food industry production in Poland increased by 60%, compared to 20% in the EU-15 and 42%in the EU-12/13. In 2003-2013,such animprovement in labour productivity in the food industry was a common phenomenon throughout the EU Member States. The largest increase in this period was recorded in Lithuania (96%), Bulgaria (77%) and Poland (61%). In the EU-12/13,labour productivity grew by 1/2, while in the EU-15 – by 1/4. This was due to a large investment boom and a drop in the number of employees. The processes of consolidation and concentration of the food industry continue. The average turnover value per food company in Poland (EUR 7.2 million) is nearly twice higher than the EU average (EUR 3.7 million), but much lower than in states with the highest production concentration in this sector, i.e.: Ireland (EUR 36.8 million), the UK (EUR 13.3 million), the Netherlands (EUR 10.2 million) or Denmark (EUR 9.7 million). However, it is higher than in Germany (EUR 5.9 million).

Having analyzed the phenomenon, it can be concluded that the gap between the development of the food sector in Poland and the EU-15 is narrowing, while structures of the industry and market players are increasingly similar to the largest EU food producers. In the past decade, the pace of development of the Polish food industry was one of the fastest in the EU, thus improving the standing of our food industry in the Single European Market.

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Анотації

Безпека харчових продуктів

Інфрачервона спектроскопія молока

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Вступ. Більшість виробників молочної продукції перебувають у пошуках сучасних інструментальних методів тестування компонентів молока з тим, щоб домогтися поліпшення якості молока і підвищення ефективності виробництва. Основна мета даного дослідження полягає у вивченні характерних інфрачервоних спектральних властивостей молока та його компонентів та порівняльному аналізі методів інфрачервоної спектроскопії.

Матеріали та методи. Методи інфрачервоної спектрофотометрії та спектроскопії відбивання в ближній інфрачервоній області (БІЧ) спектра були використані для кількісного оцінювання основних компонентів молока. Було запропоновано модель інфрачервоного спектрофотометра, який може бути використаний для визначення складу молока.

Результати і обговорення. Серйозним обмеженням інфрачервоної спектрофотометрії є те, що зразок молока повинний бути розведений з тим, щоб отримати лінійну залежність оптичної густини від концентрації молока, яку слід визначати. Метод спектроскопії в ближній інфрачервоній області (БІЧ) спектра передбачає аналіз проб молока, які містять високу частку води і демонструють високий рівень непрозорості. 50 зразків молока було використано для вивчення кореляції між результатами хімічного та БІЧ аналізу компонентів молока (жир, білок, знежирені тверді речовини та загальний вміст твердих речовин). Було доведено, що найвищий рівень кореляції було зазначено між вмістом жиру і загальної кількості твердих речовин, які визначали методом БІЧ аналізу.

Висновки. Метод інфрачервоної спектрофотометрії вимагає розведення проб і може бути використаний в лабораторних умовах. Метод відбивальної спектроскопії в ближній інфрачервоній області спектра забезпечує швидкий і неруйнівний контроль складу молока з високою точністю і може бути використаний в молочній промисловості для визначення складу молока на конвеєрі, в потоці.

Ключові слова: *молоко, жир, білки, лактоза, інфрачервона спектроскопія.*

Вплив виду пастеризатора на мікробіологічні показники зразків сирого молока

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Вступ. Дослідження присвячене впливу температури пастеризації на мікробіологічні показники зразків сирого молока від різних порід корів.

Матеріали і методи. Був проведений хімічний аналіз зразків сирого молока для визначення pH в діапазоні від 5,670 до 3,240, а також мікробіологічний аналіз для

визначення загальної кількості життєздатних організмів, бактерій кишкової групи, фекальних колиформных бактерій і лактобактерій для усіх комбінацій умов. Зразки молока від корів порід білий фулани і джерсийская, а також змішаної породи (білий фулани і джерсийская) були пастеризированы при температурі 71 °С протягом 15 секунд, за 66 °С протягом 15 хвилин і за 61 °С протягом 30 хвилин, з використанням пастеризаторів з алюмінію, нержавіючої сталі і оцинкованої сталі.

Результати і обговорення. Для молока корів породи білий фулан середні значення показників загальної кількості життєздатних організмів, бактерій кишкової групи, фекальних колиформных бактерій і лактобактерій до пастеризації варіювалися в діапазоні від 6,833x105 до 0,000 Cfu/ml, а кількість грибків склала 2,433 x 103 Cfu/ml. Для молока корів джерсийской породи це показники склали 7,800x105-0,000 Cfu/mli 0,115 x 103 Cfu/ml, а для змішаної породи - 9,400x105-0,000 Cfu/ml і 5.167x105 Cfu/ml. За використання пастеризаторів з алюмінію, нержавіючій сталі і оцинкованій сталі і температурі пастеризації 61◦С - 71◦С середні значення показників знизилися. Для породи білий фулан середні значення показників загальної кількості життєздатних організмів склали 7,233-1,400 Cfu/ml, бактерій кишкової групи - 5,633-0,000 Cfu/ml, фекальних колиформных бактерій - 3,033-0,000 Cfu/ml, лактобактерій - 3,000-0,000 Cfu/ml і грибків - 5,033-1,000 Cfu/ml. Для молока корів джерсийской породи ці показники склали відповідно до 6,533-1,800 Cfu/ml, 4,800-1,233 Cfu/ml, 0,000-0,000 Cfu/ml, 1,800-0,000 Cfu/ml і 3,833-1,033 Cfu/ml. Для молока, отриманого від корів змішаної породи, значення цих показників за тих же умов експерименту також знизилися і склали відповідно до 5,800-1,200 Cfu/ml, 4,300-1,000 Cfu/ml, 0,000-0,000 Cfu/ml, 1,033-0,000 Cfu/ml і 3,300-1,200 Cfu/ml

Висновки. Для того, щоб набути низьких значень середніх показників кількості мікроорганізмів в зразках сирого молока, слід проводити пастеризацію протягом 15 секунд в пастеризаторі з нержавіючої сталі.

Ключові слова: *молоко, пастеризація, мікроорганізм, грибок.*

Харчові технології

Класифікація показників стиглості плодів манго для забезпечення безпечного збору і зберігання урожаю

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Вступ. Основними причинами післяжнивних втрат манго є збір незрілих плодів і неправильне поводження із зібраними плодами. Зазвичай збір урожаю манго починається до дозрівання плодів. Продовження термінів збору урожаю дозволило отримати плоди різної міри стиглості, за допомогою чого вдалося досліджувати і проаналізувати їх характеристики.

Матеріали та методи. Перед збиранням врожаю перевіряли наступні хімічні показники стиглості плодів: зміст сухої речовини, кислотність, зміст вуглеводів, леткі з'єднання, вітамінний склад, вміст цукру і фенольних компонентів. Також були проаналізовані такі фізичні властивості, як форма і розмір, колір і щільність шкірки і м'якуша, діаметр плоду, питома вага і кількість калорій. Проте жоден з цих параметрів не є абсолютно надійним методом визначення якості плодів манго.

Результати та обговорення. Коли треба проаналізувати різні міри стиглості, ситуація все більше ускладнюється. Для того, щоб оцінити стиглість плоду, треба мати

значний досвід і уміти аналізувати відразу декілька характеристик. Таким чином, при зборі урожаю в промисловому масштабі не усі плоди будуть однаково стиглими. Штучно прискорене дозрівання призводить до отримання неякісних плодів манго. Таким чином, слід збирати урожай з плодів необхідної міри стиглості, орієнтуючись на певні показники. У різних країнах проводилися численні дослідження для визначення оптимальної міри стиглості для збору плодів манго. Критеріями є показники фізичних і хімічних характеристик, а також показники органолептичного дослідження. Приймаючи рішення про момент збору урожаю манго, необхідно витримати баланс між інтересами отримання прибули і інтересами покупця. Дослідження по цій темі потрібні, щоб вигідно експортувати манго, а також дозволити виробникові бути конкурентоздатним на місцевому ринку.

Висновки. Технології, засновані на симуляції ручного методу визначення стиглості плодів шляхом натискання на них і наступного аналізу реакції і зміни кольору плоду, є надійним методом визначення стиглості манго.

Ключові слова: *манго, щільність, вітамін С, стиглість, зберігання.*

Дослідження форм зв'язку вологи в бісквітному напівфабрикаті з використанням екструдованого кукурудзяного борошна

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Вступ. Використання екструдованого кукурудзяного борошна у технології бісквітного напівфабрикату впливає на форми зв'язку вологи з матеріалом, і відповідно, на якісні показники готового продукту.

Матеріали та методи. Досліджено форми зв'язку вологи із компонентами бісквітного напівфабрикату з використанням борошняних сумішей екструдованого кукурудзяного борошна (ЕКБ) з пшеничним борошном вищого ґатунку (ПБ) у співвідношенні ЕКБ:ПБ – 20:80% та ЕКБ:ПБ – 50:50% на аналізаторі DERIVATOGRAPH Q-1500D, в динамічному режимі.

Результати і обговорення. Результати дериватографічного дослідження бісквітних напівфабрикатів свідчать про спільні закономіоллдрності для всіх зразків тіста. Характерною є наявність трьох температурних діапазонів так як на кривих DTG та DTA зафіксовано по три ендоефекти, що пов'язані з видаленням вологи різних типів, та відрізняються міцністю зв'язку з складовими компонентами. Встановлено, відмінності в міцності зв'язку з адсорбційними центрами полісахаридів та гідроксильних груп білків, що виявляються в асиметрії піку на кривих DTA та наявністю декількох піків. Найвираженіший поділ ендотермічного піку на декілька часткових піків має місце для зразка з вмістом екструдованого кукурудзяного борошна 50%.

Використання екструдованого кукурудзяного борошна викликає перерозподіл форм зв'язку вологи, зменшується кількість вільної та легкозв'язаної вологи та збільшується кількість міцнозв'язаної вологи. Із збільшенням кількості екструдованого кукурудзяного борошна до 50% ця залежність чітко прослідковується, причому зростає кількість сильно зв'язаної вологи, що відповідає діапазону від 227 – 308 °С. Наявність більшої кількості зв'язано вологи у системі надасть можливість покращити технологічні характеристики бісквітного напівфабрикату під час його випікання та зберігання, про що також свідчить сповільнення втрати вологи із випеченого продукту під час зберігання.

Висновки. Врахування форм зв'язку вологи в бісквітному напівфабрикату з використанням екструдованого кукурудзяного борошна дозволяє покращити технологічні характеристики бісквітного напівфабрикату під час його випікання та зберігання.

Ключові слова: *екструдування, кукурудза, борошно, бісквіт, волога.*

Технологічні умови, що регулюють швидкість сушіння і якість томатного порошку, отриманого з томатної пасти методом пінного сушіння

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Вступ. Одним з найбільш ефективних способів зниження післяжнивних втрат поживних речовин є сушка. Проте тривалий час сушки знижує якість швидкопсувних продуктів, таких як томати.

Матеріали і методи. Матеріали - свіжі томати (сорт "dan UTC"), вспінювач (яєчний білок), стабілізатор піни (карбоксиметилцелюлоза). Прилади - цифрова шкала (OHAUS 3001), лабораторна сушарна шафа (модель MINO50 - 10G039), блендер (400 Вт, номер моделі FPO12A). Вміст вітаміну С і білка визначався за стандартом AOAC (2002).

Результати і обговорення. Збільшення кількості пінного агента (з 5 до 10%) привело до зниження швидкості сушки з 20,63 г/год до 18,57 г/год, проте, подальше збільшення кількості пінного агента (з 10 до 15%) підвищило швидкість сушіння з 18,57 г/год до 20.63 г/год. Збільшення долі вспенивающего агента (з 5% до 15%) привело до незначного збільшення змісту білку (з 24,65% до 24,7889%). Збільшення кількості пінного агента не привело до зменшення вмісту вітаміну С в сухому томатному порошку більше ніж на 1,3%, проте, зі збільшенням кількості пінного агента вміст вітаміну С зменшився. Збільшення відсотка стабілізатора піни (0,15 - 0,75%) привело до збільшення швидкості сушіння з 19,33 г/ч до 20,62 г/ч. Було також відмічено, що швидкість сушіння не чинить істотного впливу на середні показники вмісту білку за 0,15% (24,69%) і 0,45% (24,72%) вмісті стабілізатора піни. Показники вмісту вітаміну С склали 1,4-1,49% зі збільшенням відсотка стабілізатора з 0,15 до 0,74%. Збільшення часу збивання (з 3 до 7 хвилин) викликало інтенсивне збільшення швидкості сушіння (з 18,9411 г/год до 20,67 г/год) і вмісту білку (з 24,71% до 24,72%). Проте, зі збільшенням часу збивання вміст вітаміну С не зменшувався більше, ніж на 1,4%.

Висновки. Збільшення кількості вспінювача (яєчний білок) і стабілізатора піни (карбоксиметилцелюлоза) в томатному порошку, отриманому методом пінного сушіння, привело до збільшення швидкості сушіння до 20 г/год і збільшення вмісту білку на 24%. Середній показник вмісту вітаміну С зменшився, проте, був не нижче 1,3%.

Ключові слова: *сушіння, піна, томат, паста, порошок.*

Стабілізація структури кисломолочних паст

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Вступ. Для запобігання відділення вологи в кисломолочних продуктах пропонуємо використовувати несмажені зерна гречки, які виявляють вологоутримуючі та стабілізуючі властивості завдяки вмісту слизей, білків, харчових волокон тощо.

Матеріали і методи. В процесі досліджень вивчались стабілізуючі властивості подрібнених до різного ступеню дисперсності несмажених ядер гречки у складі кисломолочної пасти та вплив дози її введення до молочної основи на реологічні властивості продуктів.

Результати і обговорення. Експериментальним шляхом встановлено, що раціональним співвідношенням між подрібненим зерном гречки і розчинником

(молочною сироваткою) є гідромодуль 4. Встановлено, що набухання зерен несмаженої гречки залежить від розміру частинок. Найменший ступінь набухання спостерігався при подрібненні зерен до розміру більше 3 мм (15,8%). Найвищий ступінь набухання спостерігався у зразках із розміром подрібнених зерен менше 1 мм (22%). Цю залежність можна пояснити ускладненням дифузії вологи усередину незруйнованої частинки зерна. Незначно відрізнявся цей показник для зразка із розміром частинок менше 2 мм. Таким чином, достатнім є ступінь подрібнення несмаженої гречки до розміру частинок не більше 2 мм.

Вологоутримуюча здатність модельних зразків збільшувалась із підвищенням ступеня дисперсності подрібнених частинок і становила 74%, якщо розмір частинок не перевищував 1 мм, тоді як при розмірі частинок більше 3 мм – всього 65%.

Для оцінки стабілізуючої дії подрібнених зерен несмаженої гречки досліджували реологічні властивості кисломолочних паст. Доза введення сироватково-гречаного та сироватково-крохмального клейстеру становила 10%.

Із аналізу реологічних кривих встановлено, що представлені модельні зразки кисломолочних паст мають подібний характер, дотичне напруження зсуву у зразках із стабілізуючими речовинами є дещо вищим (320 Па для кисломолочної пасти з подрібненим зерном гречки, 270 Па для кисломолочної пасти з модифікованим крохмалем і 258 Па для кисломолочної пасти без стабілізатору). Стабілізуючий ефект був достатнім для запобігання спонтанного відділення сироватки (синерезису). Таким чином, подрібнені зерна несмаженої гречки не поступаються стабілізатору промислового виробництва – модифікованому крохмалю.

Висновки. Використання подрібнених зерен несмаженої гречки забезпечує необхідні реологічні показники кисломолочних паст та їх стабільність у процесі зберігання, що вказує на перспективність подальших досліджень щодо розроблення технології кисломолочних паст з даним видом наповнювача.

Ключові слова: *кисле молоко, паста, гречка, стабілізація.*

Властивості реологій пробіотичних йогуртів із змістом складного ефіру фітостеролу

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Вступ. Нині фітостероли додають в комерційно доступні продукти, включаючи йогурти, з метою зниження рівня холестерину в сироватці крові.

Матеріали і методи. Знежирене коров'яче молоко або молочна суміш (знежирене коров'яче молоко і ультраконцентрат знежиреного коров'ячого молока подвійної концентрації в співвідношенні 1:1) використовувалися як сировина для приготування пробіотичних варіантів йогурту з пробіотичною закваскою mZ2 з різним вмістом складного ефіру фітостеролу (0,26% або 0,36%).

Результати і обговорення. При додаванні складного ефіру фітостеролу спостерігалися напруження текучості і зміна реологічних властивостей зразків пробіотичного йогурту, а також їх перехід з псевдопластичного стану в неідеальний пластичний. Реологічні властивості цих йогуртів були описані рівнянням Гершеля-Балклі. Напруга текущості і густина постійно збільшувалися з підвищенням вмісту складного ефіру фітостеролу, що доводить структуризацію продукту. Збільшення вмісту складного ефіру фітостеролу в знежиреному коров'ячому молоці не зробило істотного впливу на показник текучості. За малих значеннь градієнтів швидкості, динамічна в'язкість йогуртів зростає із збільшенням концентрації складного ефіру фітостеролу в порівнянні із зразком йогурту, який не містить цей складний ефір. Найбільша динамічна в'язкість була визначена у йогурту, приготованого з додаванням 0,36% складного ефіру фітостеролу. Аналогічні зміни

властивостей реологій зразків пробіотичних йогуртів, отриманих з молочної суміші з різною концентрацією складного ефіру фітостеролу, спостерігалися і для йогуртів, отриманих із знежиреного коров'ячого молока з додаванням різної концентрації складного ефіру фітостеролу. Таким чином, можна чекати набуття подібних реологічних властивостей Межа текучостіі для зразків пробіотичного йогурту, отриманого з молочної суміші, збільшилася, в порівнянні з відповідними показниками у пробіотичних йогуртів, отриманих зі знежиреного коров'ячого молока. Зразки йогурту, приготованого з молочної суміші із змістом складного ефіру фітостеролу в 0,26%, мали схожі показники щільності з йогуртом, що не містить цей ефір. Найбільше значення показника густини спостерігалося у йогуртів, приготованих із молочної суміші із змістом складного ефіру фітостеролу в 0,36%. Зразки йогурту, приготованого з молочної суміші із змістом складного ефіру фітостеролу в 0,26%, мали схожі показники щільності з йогуртом, що не містить цей ефір. При низькому градієнті швидкості, пробіотичні йогурти, 0,36% складного ефіру фітостеролу, що містять, мали динамічну в'язкість 24.60 Па, а йогурти, 0,26% складного ефіру фітостеролу, що містять, - 15,34 Па. При збільшенні градієнта швидкості спостерігалося руйнування структури дослідних зразків йогурту.

Висновки. Зразки пробіотичного йогурту, отриманого з молочної суміші із змістом 0,36% складного ефіру фітостеролу, мають найвищу якість, оскільки вони мають найвищі показники напруження текучостіі (5,88 Па), щільності і динамічної в'язкості (7,95 Pa·s). Усі отримані пробіотичні йогурти можуть бути включені в раціон як функціональні продукти харчування для поліпшення здоров'я людини.

Ключові слова: *пробіотик, фітостерол, йогурт, реологія, щільність, в'язкість*.

Нові нетрадиційні джерела харчового білку

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Вступ. Продуктивність білку тваринного походження практично досягла своєї межі, тому нові джерела білку доцільніше шукати в рослинному світі, що й зумовило актуальність даної статті**.**

Матеріали і методи. Предметом досліджень стала надземна частина цукрових буряків, черемші, кропиви, стулки гороху та лушпиння цибулі. Автори статті застосовували традиційні методи оцінки рослинної сировини . Амінокислотний склад зеленої маси рослин визначали методом іонообмінної хроматографії; біологічну цінність білкових фракцій – за методикою, запропонованою О. Покровським.

Результати та обговорення. Експериментальні дані, отримані під час досліджень, показують, що зелена маса рослин – дуже багате джерело комплексу біологічно активних речовин: від 1,93 до 4,76 % білку; від 4,76 до 6,22 % вуглеводів; від 0,88 до 2,23 % золи. Установлено високий вміст незамінних амінокислот – від 87 до 283 мг / 100 г лейцину; від 72 до 205 мг / 100 г лізину; від 504 до 1375 мг / 100 г загалом. Виявлено максимальний вміст замінних амінокислот, зокрема гліцину (від 83 до 377 мг / 100 г), аланіну (від 87 до 251 мг / 100 г); загальний вміст становить від 592 до 1767 мг / 100 г для різних культур. Білки досліджених матеріалів відзначаються високим ступенем протеолізу (28,61 % для часнику; 28,81 % для кропиви; 29,37 % для цукрового буряку), який майже не відрізняється від контрольного показника – білків молока (30,01 %).

Висновки. Науково доведене застосування зеленої маси для створення біологічно активних добавок та поліфункціональних інгредієнтів є технологічно доцільним та економічно вигідним. Ми рекомендуємо зелену масу рослин для збагачення різних харчових середовищ при виробництві харчових продуктів як для внутрішнього, так і для зовнішнього ринків.

Ключові слова: *зелена маса, рослина, білок, протеоліз, амінокислота*.

Вплив різних способів розморожування на якість скумбрії (Sarda sarda, Bloch, 1793)

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Вступ. У статті досліджено зміни якості цілої замороженої скумбрії (Sarda Sarda) при відтаванні в холодильній шафі (при температурі 4 ± 2 ° C протягом 22 годин), у воді (12,1 ± 0,8 ° C, 1,5 години) і в мікрохвильовій печі (160 Вт, 7 хв).

Матеріали і методи. Якість скумбрії визначалася за допомогою аналізу втрати маси, загальної кількості азоту летких основ, триметиламіну-N, реактивних речовин тіобарбітурової кислоти, величини pH, водної активності, загальної кількості мезофільних і психотропних бактерій.

Результати і обговорення. Після розморожування значення показників втрати вологи, pH, водної активності, значення загальної кількості азоту летких основ, реактивних речовин тіобарбітурової кислоти, триметиламіну-N, загальної кількості мезофільних і психотропних бактерій склали, відповідно, 2,01, 1,66 і 2,54% ; 5,95, 5,98 і 5,86; 0,98, 0,98 і 0,99; 20,83, 20,35 і 14,87 мг / 100 г; 0,51, 0,45 і 0,54 мг MDA / кг; 0,89, 0,47 і 0,48 мг / 100 г; 3,58, 3,47 і 3,35 Log КУО / г; 3,25, 2,86 і 2,84 Log КУО / г. Не було виявлено значної різниці ($p > 0,05$) між показниками втрати маси (%) і значеннями pH при використанні різних методів розморожування. Найменше значення показника загальної кількості азоту летких основ спостерігалося для зразка скумбрії, який розморожували 7 хвилин у мікрохвильовій печі, найбільше - для зразка, який розморожували 22 години на холодильній шафі. Результати дослідження показують, що кількість азоту летких основ збільшується при збільшенні часу розморожування. Таким чином, найкраще співвідношення між якістю скумбрії і часом її розморожування досягається, якщо використовувати для цієї мети мікрохвильову піч. Розморожування в мікрохвильовій печі дозволяє отримати оптимальні показники загальної кількості азоту летких основ. Мікробні показники для всіх зразків склали менше 4 Log КУО / р Отже, при розморожуванні скумбрії в мікрохвильовій печі і у воді можна отримати рибу кращої якості.

Висновки. Метод заморожування не впливає на чисельні значення pH і органолептичних показників скумбрії ($p > 0,05$), однак впливає на якість риби. За допомогою хімічного і мікробіологічного аналізу зразків було встановлено, що тривалий період розморожування впливає на якість риби.

Ключові слова: *скумбрія, заморожування, розморожування, якість.*

Вплив заморожування на поживні і антиоксидантні властивості листових овочів, що споживаються в південній частині Кот-д'Івуара

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Вступ. Листові овочі є швидкопсувними продуктами харчування і вимагають спеціальної обробки для запобігання втратам після збору урожаю. Мета цього дослідження полягає в оцінці впливу заморожування на харчову цінність п'яти видів листових овочів, споживаних в південній частині Кот-д'Івуара.

Матеріали і методи. Листові овочі (Solanum melongena, Basella alba, Talinum triangulare, Colocasia esculenta і Corchorus olitorius) були зібрані, очищені від непридатних в їжу частин, промиті деіонізованою водою, упаковані в поліетиленових тари і прибрані в морозильну камеру з температурою - 18° С на один, два або три місяці. Після періоду зберігання виміряли їх хімічні і поживні властивості.

Результати і обговорення. Результати експерименту показали, що заморожування овочів на тривалий термін (3 місяці) привело до зменшення змісту наступних поживних і антипоживних речовин : золи (3,51-11,44%), білків (6,91-23,93%), вітаміну С (15,22-33,94%), каротиноїдів (1,78-12,96%), фенольних смол (2,11-5,81%), оксалатів (4,17-28,27%) і фитатов (13,44-24,82%). Окрім описаних вище втрат, після 1 місяця зберігання овочів в замороженому виді збільшилося значення наступних параметрів : вологості (з 83,20 ± 0,35 % до 90,39 ± 0,78 %), грубих волокон (з 11,60 ± 0,26 % до 24,05 ± 0,42 %) і вуглеводів (з 46,85 ± 0,88 % до 63,04 ± 1,29 %). Залишковий зміст мінералів в заморожених листових овочах після 1 місяця зберігання склав: 367,66-784,9 міліграм / 100 г кальцію, 227,3-743,79 міліграм / 100 г магнію, 224,5-779,33 міліграм / 100 г фосфору, 2238,35-4865,86 міліграм / 100 г калію, 72,40-128,04 міліграм / 100 г заліза, 26,38-478,15 міліграм / 100 г натрію і 22,74-65,65 міліграм / 100 г цинку.

Висновки. Тропічні листові овочі можуть зберігатися в замороженому виді не довше за один місяць, щоб виключити погіршення поживних властивостей продуктів і, отже, підвищити рівень харчової безпеки жителів Кот-д'Ивуара.

Ключові слова: *заморожування, живлення, антиоксидант, лист, овоч.*

Процеси і обладнання харчових виробництв

Математичне моделювання регенерації забруднених мембранних модулів

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Вступ. Метою цього дослідження є розвиток математичної моделі регенерації рулонованого мембранного модуля та розрахунок часу регенерації та потоку пермеату після регенерації.

Матеріали та методи. Об’єктом цього дослідження є процес регенерації забрудненних рулонованих мембранних модулів та теоретичний опис цього процесу. Теоретичний аналіз був проведений для комерційно доступних мембран MICROFILTER TFC-75, FS-TFC 1812–50, CSM RE-1812-50 GPD та USTM M-1261-75G.

Результати і обговорення. Запропонована математична модель ґрунтується на моделі осмотичного тиску і включає рівняння масовіддачі та рівняння для визначення коефіцієнта регенерації. Коефіцієнт масовіддачі визначався з критеріального рівняння. З використанням цієї математичної моделі проведено розрахунки часу розчинення шару осаду та коефіцієнта регенерації в діапазоні зміни критерію Рейнольдса від 10 до 50.

Результати розрахунків показали, що для низьких значень критерію Рейнольдса (10-25) час повного розчинення шару кеку різко зменшується (від 9215 секунд (близько двох з половиною годин) для Re=10 до 6545 секунд (менше, ніж дві години) для Re=15 та до 5143 секунд (менше, ніж півтори години) для Re=20) зі зростанням значення критерію Рейнольдса.

Але для вищих значень критерію Рейнольдса зменшення часу регенерації стає повільнішим. Наприклад, при зростанні значення критерію Рейнольдса від 25 до 30 час

регенерації зменшується лише з 4275 лише 3650 секунд (на 625 секунд або трохи більше за 10 хвилин).

Результати розрахунків показують, що найбільш раціональний режим регенерації відповідає значенням критерію Рейнольса від 15 до 25.

Висновки. Сформульована математична модель, що може передбачити час регенерації та потік пермеату після регенерації. Вона може бути використана для розвитку стратегії регенерації в існуючих мембранних системах та при проектуванні нових установок.

Ключові слова: *мембрана, вода, забруднення, регенерація, масообмін.*

Експериментальне і теоретичне дослідження наморожування льоду на вертикальних охолоджуваних трубках

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Вступ. Використання акумуляторів холоду засновано на принципі генерації льоду на охолоджуваних поверхнях у нічний період і танення намороженого льоду протягом «пікових» періодів. Це є ефективним методом економії коштів на оплату електроенергії.

Матеріали і методи. Досліджується динаміка намерзання льоду на вертикальній циліндричній поверхні при різних Δt(температура кипіння холодоагенту та температура води, що омиває поверхню теплообміну). Серії дослідів проведено на двох фреонах марки R12 та R22. Під час дослідів температура води, а також температура кипіння холодильного агенту змінювалися в межах +1,5÷+4,5°C; -10÷-20°C, відповідно. Швидкість та витрата води в дослідних секціях залишалися сталими упродовж усієї серії дослідів. Серія дослідів проводилась при сталих параметрах: масова витрата води, температура води на вході, тиск і температура кипіння. Товщина шару льоду, утворена в процесі наморожування, фіксувалась за допомогою оптичного методу. Зображення експериментальної труби із шаром льоду, оброблені за допомогою графічно-програмного забезпечення.

Результати і обговорення. Оскільки реалізація значної кількості теплової енергії, яка пов'язана з таненням льоду, повинна відбуватись протягом відносно короткого періоду пікового навантаження, розрахунок та підбір акумуляторів холоду повинен базуватись не лише на балансових співвідношеннях, а враховувати динаміку танення льоду. Представлене диференціальне рівняння намороження льоду на вертикальній охолоджуваній трубі використовується в якості основи для напівемпіричних кореляцій експериментальних даних, отриманих на спеціальній дослідній установці. Такий підхід дозволив уникнути урахування ряду режимних параметрів, що використовувались в диференціальному рівнянні, які неможливо було визначити безпосередньо. Було отримано коригуючий коефіцієнт, який співвідносить експериментальні дані з чисельним рішенням диференціального рівняння.

Виведене диференціальне рівняння процесу з наступними припущеннями: задача є одновимірною, генерація льоду відбувається в радіальному напрямку. Прийнято значення коефіцієнтів теплопередачі від води до поверхні шару льоду та до киплячого холодильного агента. Диференціальне рівняння було отримано з відповідного теплового балансу та урахування нескінченно малого приросту льоду на інтервалі часу Δτ.

Висновки. Диференціальне рівняння можливо використати для визначення часу (періоду), необхідного для накопичення заданої кількості водного льоду.

Ключові слова: *коефіцієнт тепловіддачі, лід, вода.*

Автоматизація техноогічних процесів

Аналіз методів TEXT MINING у роботі з пошуковою системою

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Вступ. Мета цього дослідження – дослідити існуючі пошукові системи з точки зору їх ефективності для пошуку маркетингової інформації в мережі Інтернет.

Матеріали і методи. Матеріалом дослідження являються пошукові системи. Для побудови методів і алгоритмів неієрархічної кластеризації використовується метод кластерного аналізу.

Результати та обговорення. У Маркетинговій Пошуковій Системі (МПС) для пошуку документів у веб-системах доцільно використовувати метод Text Mining. Метод полягає в обробці неструктурованої (текстової) інформації, вибірці важливих числових індексів з тексту і таким чином, формуванні з інформації, що міститься у тексті, придатної для застосування різноманітних алгоритмів інтелектуального аналізу даних.

Інформація може бути оброблена з метою отримання статистики про слова, що містяться в документах або для того, щоб обчислити статистичну інформацію про документи на основі слів, що містяться в них.

Запропоновано алгоритм очищення веб-сторінок від інформаційного шуму, побудови оптимальної послідовності перегляду результатів пошуку у веб-системах, який допоможе подати шукану користувачем інформацію в зручному для нього вигляді, а також позитивно позначиться на результатах web-пошуку та класифікації інформації.

Наукова новизна отриманих результатів полягає в побудові алгоритму пошуку маркетингових даних на основі використання технології Text Mining.

Висновки. Результати є цінними для прискорення пошуку і відбору необхідної інформації в мережі Internet і можуть бути використані для наповнення онтології знать про результати маркетингових досліджень.

Ключові слова: *ключові слова, аналіз, пошук, система, маркетинг.*

Економіка і управління

Стратегічні рішення стосовно каналів розподілу

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Вступ. Стаття присвячена вирішенню проблем управління системами та каналами розподілу продукції як важливої складової маркетингової політики підприємства. Метою дослідження є визначення стратегічного становища і формування обґрунтованих стратегічних рішень щодо каналів розподілу продукції. Об'єктом дослідження є збутова політика підприємства.

Матеріали та методи дослідження. В роботі застосовуються методи системного аналізу щодо питань управління системами та каналами розподілу продукції, метод аналізу і синтезу економічних явищ щодо визначення структури стратегій розподілу продукції, метод наукової абстракції щодо визначення стратегічних рішень в каналах розподілу.

Результати і обговорення. Причинами невирішеності питань ефективного управління каналами розподілу є: відсутність комплексного підходу до вирішення проблеми; спрямування системи розподілу лише на завдання виходу на ринки збуту та охоплення цільових ринків; обмеження управлінських рішень у каналах розподілу тільки

стратегіями комунікаційного характеру та стратегіями, що застосовуються до кожного учасника каналу розподілу.

Задля вирішення проблеми запропоновано: із трьох складових стратегії розподілу особливу увагу приділити стратегіям каналів розподілу продукції; використовувати розроблену матрицю стратегій (будується за показниками «частка виручки від реалізації продукції, забезпечена відповідним каналом розподілу» та «рентабельність (прибутковість) продаж в каналі») для визначення стратегічного становища каналів розподілу; обгрунтовувати ухвалення управлінських рішень щодо каналів розповсюдження на основі відповідних рекомендованих стратегій («глибоке проникнення на ринок», «розвиток ринку», «підтримання позицій», «оптимізація витрат на збут», «ліквідація каналу»).

Висновки. Запропонована матриця стратегій каналів розподілу, яка дає можливість визначити стратегічні рішення у них, рекомендується для практичного застосування у діяльності виробничих підприємств.

Ключові слова: *розподіл, канал, стратегія, матриця.*

Харчова промисловість Польщі у загальній структурі продовольчого сектору Європейського Союзу

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Вступ. У статті проаналізовано особливості харчової промисловості Польщі і її місце на ринку Європейського Союзу.

Матеріали і методи. Динаміка розвитку оцінювалася при порівнянні з даними Євростату для певних виробників харчових продуктів у Європейському Союзі за період з 2003 р. по 2013 рік. Дані про стан харчової промисловості для кожної з країн Євросоюзу були отримані при порівнянні поточної вартості продукції та індексу покупної спроможності у євро.

Результати і обговорення. Харчова промисловість Польщі відрізняється від інших країн Європейського Союзу. Оскільки польські підприємства забезпечують 9% від усієї вартості реалізованої продукції харчової промисловості EU-28, то за цим показником Польща посідає шосте місце серед країн Європейського Союзу. За період з 2003 р. по 2013 р. вартість реалізованої продукції харчової промисловості в Польщі збільшилася на 60% порівняно з 20-відсотковим збільшенням цього параметра для EU-15 і 42% для EU-12/13. Протягом цього періоду найбільше зростання спостерігалося в Литві (96%), Болгарії (77%) та Польщі (61%). Для EU-12/13 продуктивність праці зросла на 1/2, а для EU-15 - на 1/4. Такі зміни можна пояснити масштабним збільшенням інвестицій і скороченням кількості співробітників. Ріст і централізація харчової промисловості тривають. Показник середньої кількості обороту на кожне підприємство харчової промисловості у Польщі (7200000 євро) майже в два рази перевищує середній показник по Євросоюзу (3700000 євро), проте він значно нижчий, ніж у країнах, у яких цей сектор промисловості найбільш розвинений, а саме: в Ірландії (36,8 млн євро), Великобританії (13,3 млн євро), Нідерландах (10200000 євро) або Данії (9700000 євро). Однак цей показник у Польщі вищий, ніж у Німеччині (5,9 млн євро).

Висновки. Результати проведеного аналізу свідчать про те, що різниця між рівнем розвитку продовольчого сектору промисловості Польщі та EU-15 зменшується, а структура промисловості й учасники ринку схожі з іншими країнами Євросоюзу. В останнє десятиліття темпи розвитку харчової промисловості Польщі були одними з найбільш активних у Європі, що дозволило країні поліпшити своє становище на єдиному європейському ринку харчової промисловості.

Ключові слова: *продукт, промисловість, виробництво, праця, продуктивність.*

Аннотации

Безопасность пищевых продуктов

Инфракрасная спектроскопия молока

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Введение. Большинство производителей молочной продукции находятся в поисках современных инструментальных методов тестирования компонентов молока с тем, чтобы добиться улучшения качества молока и повышения эффективности производства. Основная цель данного исследования заключается в изучении характерных инфракрасных спектральных свойств молока и его компонентов и сравнительном анализе методов инфракрасной спектроскопи.

Материалы и методы. Методы инфракрасной спектрофотометрии и спектроскопии отражения в ближней инфракрасной области (БИК) спектра были использованы для количественного оценивания основных компонентов молока. Была предложена модель инфракрасного спектрофотометра, который может быть использован для определения состава молока.

Результаты и обсуждение. Серьезным ограничением инфракрасной спектрофотометрии является то, что образец молока должен быть разведен с тем, чтобы получить линейную зависимость оптической плотности от концентрации молока, которую следует определять. Метод спектроскопии в ближней инфракрасной области (БИК) спектра предусматривает анализ проб молока, которые содержат высокую долю воды и демонстрируют высокий уровень непрозрачности. 50 образцов молока было использовано для изучения корреляции между результатами химического и БИЧ анализа компонентов молока (жир, белок, обезжиренные твердые вещества и общее содержание твердых веществ). Было доказано, что самый высокий уровень корреляции был отмечен между содержанием жира и общего количества твердых веществ, которые определяли методом БИК анализа.

Выводы. Метод инфракрасной спектрофотометрии требует разведения проб и может быть использован в лабораторных условиях. Метод отражательной спектроскопии в ближней инфракрасной области спектра обеспечивает быстрый и неразрушающий контроль состава молока с высокой точностью и может быть использован в молочной промышленности для определения молока на конвейере, в потоке.

Ключевые слова: *молоко, жир, белки, лактоза, инфракрасная спектроскопия*.

Влияние вида пастеризатора на микробиологические показатели образцов сырого молока

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Введение. Исследование посвящено влиянию температуры пастеризации на микробиологические показатели образцов сырого молока от разных пород коров.

Материалы и методы. Был проведен химический анализ образцов сырого молока для определения pH в диапазоне от 5,670 до 3,240, а также микробиологический анализ для определения общего количества жизнеспособных организмов, бактерий кишечной группы, фекальных колиформных бактерий и лактобактерий для всех комбинаций условий. Образцы молока от коров пород белый фулани и джерсийская, а также смешанной породы (белый фулани и джерсийская) были пастеризированы при температуре 71◦C в течение 15 секунд, при 66◦C в течение 15 минут и при 61◦C в течение 30 минут, с использованием пастеризаторов из алюминия, нержавеющей стали и оцинкованной стали.

Результаты и обсуждение. Для молока коров породы белый фулани средние значения показателей общего количества жизнеспособных организмов, бактерий кишечной группы, фекальных колиформных бактерий и лактобактерий до пастеризации варьировались в диапазоне от 6,833x105 до 0,000 КОЕ/мл, а количество грибков составило 2,433 x 103 КОЕ/мл. Для молока коров джерсийской породы это показатели составили 7,800x105–0,000 КОЕ/мл и 0,115 x 103 КОЕ/мл, а для смешанной породы – 9,400x105–0,000 КОЕ/мл и 5.167x105 КОЕ/мл. При использовании пастеризаторов из алюминия, нержавеющей стали и оцинкованной стали и температуре пастеризации 61◦C-71◦C средние значения показателей снизились. Для породы белый фулани средние значения показателей общего количества жизнеспособных организмов составили 7,233-1,400 КОЕ/мл, бактерий кишечной группы – 5,633-0,000 КОЕ/мл, фекальных колиформных бактерий – 3,033-0,000 КОЕ/мл, лактобактерий – 3,000-0,000 КОЕ/мл и грибков – 5,033-1,000 КОЕ/мл. Для молока коров джерсийской породы эти показатели составили соответственно 6,533-1,800 КОЕ/мл, 4,800-1,233 КОЕ/мл, 0,000-0,000 КОЕ/мл, 1,800-0,000 КОЕ/мл и 3,833-1,033 КОЕ/мл. Для молока, полученного от коров смешанной породы, значения этих показателей при тех же условиях эксперимента также снизились и составили соответственно 5,800-1,200 КОЕ/мл, 4,300-1,000 КОЕ/мл, 0,000-0,000 КОЕ/мл, 1,033-0,000 КОЕ/мл и 3,300-1,200 КОЕ/мл.

Выводы. Для того чтобы получить низкие значения средних показателей количества микроорганизмов в образцах сырого молока, следует проводить пастеризацию в течение 15 секунд в пастеризаторе из нержавеющей стали.

Ключевые слова: *молоко, пастеризация, микроорганизм, грибок.*

Пищевые технологии

Классификация показателей спелости плодов манго для обеспечения безопасного сбора и хранения урожая

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Введение. Основными причинами послеуборочных потерь манго являются сбор незрелых плодов и неправильное обращение с собранными плодами. Обычно сбор урожая манго начинается до созревания плодов. Продление сроков сбора урожая позволило получить плоды разной степени спелости, с помощью чего удалось исследовать и проанализировать их характеристики.

Материалы и методы. Перед уборкой урожая проверяли следующие химические показатели спелости плодов: содержание сухого вещества, кислотность, содержание углеводов, летучие соединения, витаминный состав, содержание сахара и фенольных

компонентов. Также были проанализированы такие физические свойства, как форма и размер, цвет и плотность кожуры и мякоти, диаметр плода, удельный вес и количество калорий. Однако ни один из этих параметров не является абсолютно надежным методом определения качества плодов манго.

Результаты и обсуждение. Когда нужно проанализировать различные степени спелости, ситуация всё больше усложняется. Для того чтобы оценить спелость плода, нужно обладать значительным опытом и уметь анализировать сразу несколько характеристик. Таким образом, при сборе урожая в промышленном масштабе не все плоды будут одинаково спелыми. Искусственно ускоренное созревание приводит к получению некачественных плодов манго. Таким образом, следует собирать урожай из плодов необходимой степени спелости, ориентируясь на определенные показатели. В разных странах проводились многочисленные исследования для определения оптимальной степени спелости для сбора плодов манго. Критериями являются показатели физических и химических характеристик, а также показатели органолептического исследования. Принимая решение о моменте сбора урожая манго, необходимо выдержать баланс между интересами получения прибыли и интересами покупателя. Исследования по этой теме необходимы, чтобы выгодно экспортировать манго, а также позволить производителю быть конкурентоспособным на местном рынке.

Выводы. Технологии, основанные на симуляции ручного метода определения спелости плодов путем надавливания на них и последующего анализа реакции и изменения цвета плода, являются надежным методом определения спелости манго.

Ключевые слова: *манго, плотность, витамин С, спелость, хранение.*

Исследование форм связи влаги в бисквитном полуфабрикате с использованием экструдированной кукурузной муки

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Введение. Использование экструдированного кукурузной муки в технологии бисквитного полуфабриката влияет на формы связи влаги с материалом, и соответственно, на качественные показатели готового продукта.

Материалы и методы. Исследованы формы связи влаги с компонентами бисквитного полуфабриката с использованием мучных смесей экструдированной кукурузной муки (ЕКМ) с пшеничной мукой высшего сорта (ПМ) в соотношении ЕКМ: ПМ – 20:80% и ЕКМ: ПМ – 50:50% на анализаторе DERIVATOGRAPH Q-1500D, в динамическом режиме.

Результаты и обсуждение. Результаты дериватографичного исследования бисквитных полуфабрикатов свидетельствуют о совместных закономерностях для всех образцов теста. Характерно наличие трех температурных диапазонов так как на кривых DTG и DTA зафиксировано по три ендоефекты, связанных с удалением влаги различных типов, и отличающихся прочностью связи с составляющими компонентами. Установлено, различия в прочности связи с адсорбционными центрами полисахаридов и гидроксильных групп белков, выявляемых в асимметрии пика на кривых DTA и наличием нескольких пиков. Наиболее выраженные разделение эндотермической пика на несколько пиков имеет место для образца с содержанием экструдированой кукурузной муки 50%.

Использование экструдированой кукурузной муки вызывает перераспределение форм связи влаги, уменьшает количество свободной и легко связанной влаги и увеличивается количество сильно связанной влаги. С увеличением количества экструдированной кукурузной

муки до 50% эта зависимость четко прослеживается, причем возрастание количества сильно связанной влаги соответствует диапазону от 227 - 308 ° С. Наличие большего количества связано влаги в системе позволит улучшить технологические характеристики бисквитного полуфабриката при его выпечки и хранения, о чем также свидетельствует результаты о замедление потери влаги из выпеченного продукта при хранении.

Выводы. Принятие во внимание форм связи влаги в бисквитном полуфабриката с использованием экструдированой кукурузной муки позволяет улучшить технологические характеристики бисквитного полуфабриката при его выпечки и хранения.

Ключевые слова: *экструдирование, кукуруза, мука, бисквит, влага.*

Технологические условия, регулирующие скорость сушки и качество томатного порошка, полученного из томатной пасты методом пенной сушки

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Введение. Одним из наиболее эффективных способов снижения послеуборочных потерь питательных веществ является сушка. Однако длительное время сушки снижает качество скоропортящихся продуктов, таких как томаты.

Материалы и методы. Материалы - свежие томаты (сорт «dan UTC»), вспениватель (яичный белок), стабилизатор пены (карбоксиметилцеллюлоза). Приборы - цифровая шкала (OHAUS 3001), лабораторный сушильный шкаф (модель MINO50-10G039), блендер (400 Вт, номер модели FPO12A). Содержание витамина С и белка определялось по стандарту AOAC (2002).

Результаты и обсуждение. Увеличение количества вспенивающего агента (с 5 до 10%) привело к снижению скорости сушки с 20,63 г/ч до 18,57 г/ч, однако, дальнейшее увеличение количества вспенивающего агента (с 10 до 15%) повысило скорость сушки с 18,57 г/ч до 20.63 г/ч. Увеличение доли вспенивающего агента (с 5% до 15%) привело к незначительному увеличению содержания белка (с 24,65% до 24,7889%). Увеличение количества вспенивающего агента не привело к уменьшению содержания витамина С в сухом томатном порошке больше чем на 1,3%, однако, при увеличении количества вспенивающего агента содержание витамина С уменьшилось. Увеличение процента стабилизатора пены (0,15 – 0,75%) привело к увеличению скорости сушки с 19,33 г/ч до 20,62 г/ч. Было также отмечено, что скорость сушки не оказывает существенного влияния на средние показатели содержания белка при 0,15% (24,69%) и 0,45% (24,72%) содержании стабилизатора пены. Показатели содержания витамина С составили 1,4-1,49% при увеличении процента стабилизатора с 0,15 до 0,74%. Увеличение времени взбивания (с 3 до 7 минут) вызвало прогрессирующее увеличение скорости сушки (с 18,9411 г/ч до 20,67 г/ч) и содержания белка (с 24,71% до 24,72%). Однако, при увеличении времени взбивания содержание витамина С не уменьшалось больше, чем на 1,4%.

Выводы. Увеличение количества вспенивателя (яичный белок) и стабилизатора пены (карбоксиметилцеллюлоза) в томатном порошке, полученном методом пенной сушки, привело к увеличению скорости сушки до 20 г/ч и увеличению содержания белка на 24%. Средний показатель содержания витамина С уменьшился, однако, был не ниже 1,3%.

Ключевые слова: *сушка, пена, томат, паста, порошок.*

Стабилизация структуры кисломолочных паст

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Введение. Для предотвращения отделения влаги в кисломолочных продуктах предлагаем использовать нежареные зерна гречихи, которые проявляют влагоудерживающие и стабилизирующие свойства благодаря содержанию слизи, белков, пищевых волокон и т.п.

Материалы и методы. В процессе исследований изучались стабилизирующие свойства измельченных до разной степени дисперсности нежареных ядер гречки в составе кисломолочной пасты и влияние дозы ее введения в молочную основу на реологические свойства продуктов.

Результаты и обсуждение. Оптимальным соотношением между измельченным зерном гречихи и растворителем (молочной сывороткой) является гидромодуль 4. Установлено, набухание зерен нежареной гречки зависит от размера частиц. Наименьшую степень набухания наблюдался при измельчении зерен до размера более 3 мм (15,8%). Наивысшая степень набухания в образцах с размером измельченных зерен менее 1 мм (22%). Эту зависимость можно объяснить усложнением диффузии влаги внутри неразрушенной частицы зерна. Незначительно отличался этот показатель для образца с размером частиц менее 2 мм. Таким образом, достаточным является степень измельчения нежареной гречки с размером частиц не более 2 мм. Влагоудерживающая способность модельных образцов увеличивалась с повышением степени дисперсности измельченных частиц и составила 74%, если размер частиц не превышал 1 мм, тогда как при размере частиц более 3 мм – всего 65%. Для оценки стабилизирующего действия измельченных зерен нежареной гречки исследовали реологические свойства кисломолочных паст. Доза введения сывороточно-гречневой и сывороточно-крахмального клейстера составила 10%. С анализа реологических кривых установлено, что представленные модельные образцы кисломолочных паст имеют сходный характер, касательное напряжение сдвига в образцах с стабилизирующими веществами являются несколько выше (320 Па для кисломолочной пасты с измельченным зерном гречихи, 270 Па для кисломолочной пасты с модифицированным крахмалом и 258 Па для кисломолочной пасты без стабилизатора). Стабилизирующий эффект был достаточным для предотвращения спонтанного отделения сыворотки (синерезиса). Таким образом, измельченные зерна нежареной гречки не уступают стабилизатору промышленного производства – модифицированному крахмалу.

Выводы. Использование измельченной нежареной гречки обеспечивает необходимые реологические показатели кисломолочных паст, их стабильность в процессе хранения, указывает на перспективность дальнейших исследований по разработке технологии кисломолочных паст с данным видом наполнителя.

Ключевые слова: *кислое молоко, паста, гречка, стабилизация.*

Реологические свойства пробиотических йогуртов с содержанием сложного эфира фитостерола

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Введение. В настоящее время фитостеролы добавляют в коммерчески доступные продукты, включая йогурты, с целью снижения уровня холестерина в сыворотке крови.

Материалы и методы. Обезжиренное коровье молоко или молочная смесь (обезжиренное коровье молоко и ультраконцентрат обезжиренного коровьего молока двойной концентрации в соотношении 1: 1) использовалась в качестве сырья для приготовления пробиотических вариантов йогурта с пробиотической закваской mZ_2 с различным содержанием сложного эфира фитостерола (0,26% или 0,36%).

Результаты и обсуждение. При добавлении сложного эфира фитостерола наблюдалось напряжение текучести и изменение реологических свойств образцов пробиотического йогурта, а также их переход из псевдопластичного состояния в неидеальное пластичное. Реологические свойства этих йогуртов были описаны уравнением Гершеля-Балкли. Напряжение текучести и плотность постоянно увеличивались при повышении содержания сложного эфира фитостерола, что доказывает структурирование продукта. Увеличение содержания сложного эфира фитостерола в обезжиренном коровьем молоке не оказало существенного влияния на показатель текучести. При малых значениях градиентов скорости, динамическая вязкость йогуртов возрастает с увеличением концентрации сложного эфира фитостерола по сравнению с образцом йогурта, который не содержит этот сложный эфир. Наибольшая динамическая вязкость была определена у йогурта, приготовленного с добавлением 0,36% сложного эфира фитостерола. Аналогичные изменения реологических свойств образцов пробиотических йогуртов, полученных из молочной смеси с различной концентрацией сложного эфира фитостерола, наблюдались и для йогуртов, полученных из обезжиренного коровьего молока с добавлением различной концентрации сложного эфира фитостерола. Таким образом, можно ожидать получение подобных реологических свойств. Предел текучести для образцов пробиотического йогурта, полученного из молочной смеси, увеличился, по сравнению с соответствующими показателями у пробиотических йогуртов, полученных из обезжиренного коровьего молока. Образцы йогурта, приготовленного из молочной смеси с содержанием сложного эфира фитостерола в 0,26%, имели схожие показатели плотности с йогуртом, не содержащим этот эфир. Наибольшее значение показателя густоты наблюдалось у йогуртов, приготовленных их молочной смеси с содержанием сложного эфира фитостерола в 0,36%. Образцы йогурта, приготовленного из молочной смеси с содержанием сложного эфира фитостерола в 0,26%, имели схожие показатели плотности с йогуртом, не содержащим этот эфир. При низком градиенте скорости, пробиотические йогурты, содержащие 0,36% сложного эфира фитостерола, имели динамическую вязкость 24.60 Па, а йогурты, содержащие 0,26% сложного эфира фитостерола - 15,34 Па. При увеличении градиента скорости наблюдалось разрушение структуры исследуемых образцов йогурта.

Выводы. Образцы пробиотического йогурта, полученного из молочной смеси с содержанием 0,36% сложного эфира фитостерола, имеют наивысшее качество, поскольку они обладают наивысшими показателями напряжения текучести (5,88 Па), плотности и динамической вязкости (7,95 Pa·s). Все полученные пробиотические йогурты могут быть включены в рацион в качестве функциональных продуктов питания для улучшения здоровья человека.

Ключевые слова: *пробиотик, фитостерол, йогурт, реология, плотность, вязкость.*

Новые нетрадиционные источники пищевого белка

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Введение. Производительность белка животного происхождения практически достигла своего предела, поэтому новые источники белка целесообразнее искать в растительном мире, что и обусловило актуальность данной статьи.

Материалы и методы. Предметом исследований стала надземная часть сахарной свеклы, черемши, крапивы, створки гороха и шелуха лука. Авторы статьи использовали

традиционные методы оценки растительного сырья. Аминокислотный состав зеленой массы растений определяли методом ионообменной хроматографии; биологическую ценность белковых фракций – по методике, предложенной А. Покровским.

Результаты и обсуждение. Экспериментальные данные, полученные во время исследований, показывают, что зеленая масса растений – очень богатый источник комплекса биологически активных веществ: до 1,93 до 4,76 % белка; от 4,76 до 6,22 % углеводов; от 0,88 до 2,23 % золы. Установлено высокое содержание незаменимых аминокислот – от 87 до 283 мг / 100 г лейцина; от 72 до 205 мг / 100 г лизина; от 504 до 1375 мг / 100 г в целом. Выявлено максимальное содержание заменимых аминокислот, в частности глицина (от 83 до 377 мг / 100 г), аланина (от 87 до 251 мг / 100 г); общее содержание составляет от 592 до 1767 мг / 100 г для разных культур. Белки исследованных материалов отличаются высокой степенью протеолиза (28,61 % для чеснока; 28,81 % для крапивы; 29,37 % для сахарной свеклы), который почти не разнится с контрольным показателем – белками молока (30,01 %).

Выводы. Научно доказанное применение зеленой массы для создания биологически активных добавок и полифункциональных ингредиентов является технологически целесообразным и экономически выгодным. Мы рекомендуем зеленую массу растений для обогащения различных пищевых сред при производстве пищевых продуктов как для внутреннего, так и для внешнего рынков.

Ключевые слова: *зеленая масса, растение, белок, протеолиз, аминокислота.*

Влияние различных способов размораживания на качество скумбрии (Sarda sarda, Bloch, 1793)

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Введение. В работе были исследованы изменения качества цельной замороженной скумбрии (Sarda Sarda) при оттаивании в холодильном шкафу (при температуре 4 ± 2 °C, в течение 22 часов), в воде (12,1 ± 0,8 ° C, 1,5 часа) и в микроволновой печи (160 Вт, 7 мин).

Материалы и методы. Качество скумбрии определялось с помощью анализа потери массы, общего количества азота летучих оснований, триметиламина-N, реактивных веществ тиобарбитуровой кислоты, величины pH, водной активности, общего количества мезофильных и психотропных бактерий.

Результаты и обсуждение. После размораживания, значения показателей потери влаги, pH, водной активности, значения общего количества азота летучих оснований, реактивных веществ тиобарбитуровой кислоты, триметиламина-N, общего количества мезофильных и психотропных бактерий составили, соответственно, 2,01, 1,66 и 2,54%; 5,95, 5,98 и 5,86; 0,98, 0,98 и 0,99; 20,83, 20,35 и 14,87 мг / 100 г; 0,51, 0,45 и 0,54 мг MDA / кг; 0,89, 0,47 и 0,48 мг / 100 г; 3,58, 3,47 и 3,35 Log КОЕ / г; 3,25, 2,86 и 2,84 Log КОЕ / г. Не было обнаружено значительной разницы ($p>0,05$) между показателями потери массы (%) и значениями pH при использовании различных методов размораживания. Наименьшее значение показателя общего количества азота летучих оснований наблюдалось для образца скумбрии, который размораживали 7 минут в микроволновой печи, наибольшее – для образца, который размораживали 22 часа в холодильном шкафу. Результаты исследования показывают, что количество азота летучих оснований увеличивается при увеличении времени размораживания. Таким образом, наилучшее

соотношение между качеством скумбрии и временем её размораживания достигается, если использовать для этой цели микроволновую печь. Размораживание в микроволновой печи позволяет получить оптимальные показатели общего количества азота летучих оснований. Микробные показатели для всех образцов составили менее 4 Log КОЕ / г. Следовательно, при размораживании скумбрии в микроволновой печи и в воде можно получить рыбу лучшего качества.

Выводы. Метод размораживания не влияет на численные значения pH и органолептических показателей скумбрии ($p>0,05$), однако влияет на качество рыбы. С помощью химического и микробиологического анализа образцов было установлено, что длительный период размораживания влияет на качество рыбы.

Ключевые слова: *скумбрия, замораживание, размораживание, качество.*

Влияние замораживания на питательные и антиоксидантные свойства листовых овощей, потребляемых в южной части Кот-д'Ивуара

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Введение. Листовые овощи являются скоропортящимися продуктами питания и требуют специальной обработки для предотвращения потерь после сбора урожая. Цель данного исследования заключается в оценке влияния замораживания на пищевую ценность пяти видов листовых овощей, потребляемых в южной части Кот-д'Ивуара.

Материалы и методы. Листовые овощи (Solanum melongena, Basella alba, Talinum triangulare, Colocasia esculenta и Corchorus olitorius) были собраны, очищены от непригодных в пищу частей, промыты деионизированной водой, упакованы в полиэтиленовые тары и убраны в морозильную камеру с температурой -18° С на один, два или три месяца. После периода хранения измерили их химические и питательные свойства.

Результаты и обсуждение. Результаты эксперимента показали, что замораживание овощей на длительный срок (3 месяца) привело к уменьшению содержания следующих питательных и антипитательных веществ: золы (3,51-11,44%), белков (6,91-23,93%), витамина С (15,22- 33,94%), каротиноидов (1,78-12,96%), фенольных смол (2,11-5,81%), оксалатов (4,17-28,27%) и фитатов (13,44-24,82%). Кроме описанных выше потерь, после 1 месяца хранения овощей в замороженном виде увеличилось значение следующих параметров: влажности (с 83,20 ± 0,35 % до 90,39 ± 0,78 %), грубых волокон (с 11,60 ± 0,26 % до 24,05 ± 0,42 %) и углеводов (с 46,85 ± 0,88 % до 63,04 ± 1,29 %). Остаточное содержание минералов в замороженных листовых овощах после 1 месяца хранения составило: 367,66-784,9 мг / 100 г кальция, 227,3-743,79 мг / 100 г магния, 224,5-779,33 мг / 100 г фосфора, 2238,35-4865,86 мг / 100 г калия, 72,40-128,04 мг / 100 г железа, 26,38-478,15 мг / 100 г натрия и 22,74-65,65 мг / 100 г цинка.

Выводы. Тропические листовые овощи могут храниться в замороженном виде не дольше одного месяца, чтобы исключить ухудшение питательных свойств продуктов и, следовательно, повысить уровень пищевой безопасности жителей Кот-д'Ивуара.

Ключевые слова: *замораживание, питание, антиоксидант, лист, овощ.*

Процессы и оборудование пищевых производств

Математическое моделирование регенерации загрязненных мембранных модулей

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Введение. Целью этого исследования является развитие математической модели регенерации рулонированого мембранного модуля и расчет времени регенерации и потока пермеата после регенерации.

Материалы и методы. Объектом данного исследования является процесс регенерации загрязненных рулонированых мембранных модулей и теоретическое описание указанного процесса. Теоретический анализ был проведен для коммерчески доступных мембран MICROFILTER TFC-75, FS-TFC 1812–50, CSM RE-1812-50 GPD и USTM M-1261-75G

Результаты и обсуждение. Предложенная математическая модель основана на модели осмотического давления и включает уравнение масоотдачи и уравнение для определения коэффициента регенерации. Коэффициент масоотдачи определялся с критериального уравнения. С использованием этой математической проведены расчеты времени растворение и коэффициента регенерации в диапазоне изменения критерия Рейнольдса от 10 до 50.

Результаты расчетов показали, что для низких значений критерия Рейнольдса (10-25) время полного растворения шара кека резко уменьшалось (от 9215 секунд (около двух с половиной часов) для Re=10 до 6545 секунд (меньше, чем два часа) для Re=15 та до 5143 секунд (меньше, чем полтора часа) для Re=20) с увеличением значения критерия Рейнольдса.

Но для более высоких значений критерия Рейнольдса увеличение времени регенерации становится более медленным. Например, при возрастании значений критерия Рейнольдса с 25 до 30 время регенерации уменьшается с 4275 всего лишь до 3650 секунд (на 625 секунд или немного больше чем 10 минут).

Результаты расчетов показывают, что наиболее рациональный режим регенерации соответствует значениям критерия Рейнольдса от 15 до 25.

Выводы: Сформулирована математическая модель, которая может спрогнозировать время регенерации и поток пермеата после регенерации. Она может бать использована для развития стратеги регенерации в сущесвующих мемьбранных системах и при проектировании нових установок.

Ключевые слова: *мембрана, вода, загрязнение, регенерация, массообмен.*

Экспериментальное и теоретическое исследование намораживания льда на вертикальных охлаждаемых трубах

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Введение. Использование аккумуляторов холода основан на принципе генерации льда на охлаждаемых поверхностях в ночное время и таяния намороженного льда в течение «пиковых» периодов. Это является эффективным методом экономии средств на оплату электроэнергии.

Материалы и методы. Исследуется динамика намерзания льда на вертикальной цилиндрической поверхности при различных Δt (температура кипения хладагента и

температура воды, омывающей поверхность теплообмена). Серии опытов проведено на двух фреонах марки R12 и R22. Во время опытов температура воды, а также температура кипения хладагента изменялись в пределах + 1,5 ÷ + 4,5°C; -10 ÷ -20°C, соответственно. Скорость и расход воды в исследовательских секциях оставались постоянными на протяжении всей серии опытов. Серия опытов проводилась при постоянных параметрах: массовый расход воды, температура воды на входе, давление и температура кипения. Толщина слоя льда, образованная в процессе намораживания, фиксировалась с помощью оптического метода. Изображение экспериментальной трубы со слоем льда, обработанные с помощью программного обеспечения.

Результаты и обсуждение. Поскольку реализация значительного количества тепловой энергии, которая связана с таянием льда, должна происходить в течение относительно короткого периода пиковой нагрузки, расчет и подбор аккумуляторов холода должен базироваться не только на балансовых соотношениях, а учитывать динамику таяния льда. Представлено дифференциальное уравнение намораживания льда на вертикальной охлаждаемой трубе используется в качестве основы для полуэмпирических корреляций экспериментальных данных, полученных на специальной экспериментальной установке. Такой подход позволил избежать учета ряда режимных параметров, используемых в дифференциальном уравнении, которые невозможно было определить непосредственно. Было получено корректирующий коэффициент, который соотносит экспериментальные данные по многочисленным решениям дифференциального уравнения.

Выведено дифференциальное уравнение процесса со следующими предположениями: задача является одномерной, генерация льда происходит в радиальном направлении. Принято значения коэффициентов теплопередачи от воды к поверхности слоя льда и до кипящего холодильного агента. Дифференциальное уравнение было получено из соответствующего теплового баланса и учета бесконечно малого прироста льда на интервале времени $\Delta\tau$.

Выводы. Дифференциальное уравнение, возможно, использовать для определения времени (периода), необходимого для накопления заданного количества водного льда.

Ключевые слова: *коэффициент теплоотдачи, лед, вода.*

Автоматизация технологических процессов

Анализ методов TEXT MINING в работе с поисковой системой

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Введение. Цель этого исследования - исследовать существующие поисковые системы с точки зрения их эффективности для поиска маркетинговой информации в сети Интернет.

Материалы и методы. Материалом исследования являются поисковые системы. Для построения методов и алгоритмов неиерархические кластеризации используется метод кластерного анализа.

Результаты и обсуждение. В Маркетинговой поисковых системах (МПС) для поиска документов в веб-системах целесообразно использовать метод Text Mining. Метод заключается в обработке неструктурированной (текстовой) информации, выборке важных числовых индексов в тексте и таким образом, формировании из информации, содержащейся в тексте, пригодной для применения различных алгоритмов интеллектуального анализа данных.

Информация может быть обработана с целью получения статистики о словах, содержащихся в документах или для того, чтобы вычислить статистическую информацию о документах на основе слов, содержащихся в них.

Предложен алгоритм очистки веб-страниц от информационного шума, построения оптимальной последовательности просмотра результатов поиска в веб-системах, который поможет подать искомую пользователем информацию в удобном для него виде, а также положительно скажется на результатах web-поиска и классификации информации.

Научная новизна полученных результатов заключается в построении алгоритма поиска маркетинговых данных на основе использования технологии Text Mining.

Выводы. Результаты являются ценными для ускорения поиска и отбора необходимой информации в сети Internet и могут быть использованы для наполнения онтологии знать о результатах маркетинговых исследований.

Ключевые слова: *ключевые слова, анализ, поиск, система, маркетинг*.

Экономика и управление

Стратегические решения относительно каналов распределения

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Введение. Статья посвящена решению проблем управления системами и каналами распределения продукции как важной составляющей маркетинговой политики предприятия. Целью исследования является определение стратегического положения и формирование обоснованных стратегических решений относительно каналов распределения продукции. Объектом исследования является сбытовая политика предприятия.

Материалы и методы исследования. В работе применяются методы системного анализа в вопросах управления системами и каналами распределения продукции, метод анализа и синтеза экономических явлений в определении структуры стратегий распределения продукции, метод научной абстракции в определении стратегических решений в каналах распределения.

Результаты и обсуждения. Причинами нерешенности вопросов эффективного управления каналами распределения являются: отсутствие комплексного подхода к решению проблемы; устремление системы распределения лишь на задание выходу на рынки сбыта и охватывания целевых рынков; ограничение управленческих решений в каналах распределения только стратегиями коммуникационного характера и стратегиями, применяемыми к каждому учаснику канала распределения.

Для решения проблемы предложено: из трех составляющих стратегии распределения особое внимание уделить стратегиям каналов распределения продукции; использовать разработанную матрицу стратегий (строится по показателям «часть выручки от реализации продукции, обеспеченная соответствующим каналом распределения» и «рентабельность (прибыльность) продажа в канале») для определения стратегического положения каналов распределения; обосновывать принятие управленческих решений относительно каналов распространения на основе соответствующих рекомендованных стратегий («глубокое проникновение на рынок», «развитие рынка», «поддержания позиций», «оптимизация расходов на сбыт», «ликвидация канала»).

Выводы. Впервые предложенная матрица стратегий каналов распределения, которая дает возможность определять стратегические решения в них, рекомендуется для практического применения в деятельности производственных предприятий.

Ключевые слова: *распределение, канал, стратегия, матрица.*

Пищевая промышленность Польши в общей структуре продовольственного сектора Европейского Союза

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Введение. В статье проанализированы особенности пищевой промышленности Польши и ее место на рынке Европейского Союза.

Материалы и методы. Динамика развития пищевой промышленности Польши оценивалась по сравнению с данными Евростата для выбранных производителей продуктов питания в Европейском Союзе за период с 2003 г. по 2013 год. Данные о состоянии пищевой промышленности для каждой из стран Евросоюза были получены при сравнении текущей стоимости продукции и индекса покупательной способности в евро.

Результаты и обсуждение. Пищевая промышленность Польши отличается от других стран Европейского Союза. Поскольку польские предприятия обеспечивают 9% от всей стоимости реализованной продукции пищевой промышленности EU-28, то по этому показателю Польша занимает шестое место среди стран Европейского Союза. За период с 2003г. по 2013 г. стоимость реализованной продукции пищевой промышленности в Польше увеличилась на 60% по сравнению с 20-процентным увеличением этого параметра для EU-15 и 42% для EU-12/13. В течение этого периода наибольший рост наблюдался в Литве (96%), Болгарии (77%) и Польше (61%). Для EU-12/13 производительность труда выросла на 1/2, а для EU-15 – на 1/4. Такие изменения можно объяснить масштабным увеличением инвестиций и сокращением количества сотрудников. Рост и централизация пищевой промышленности продолжаются. Показатель среднего количества оборота на каждое предприятие пищевой промышленности в Польше (7,2 млн евро) почти в два раза превышает средний показатель по Евросоюзу (3,7 млн евро), однако он значительно ниже, чем в странах, у которых этот сектор промышленности наиболее развит, а именно: в Ирландии (36,8 млн евро), Великобритании (13,3 млн евро), Нидерландах (10,2 млн евро) или Дании (9,7 млн евро). Однако этот показатель у Польши выше, чем у Германии (5,9 млн евро).

Выводы. Результаты проведенного анализа свидетельствуют о том, что разница между уровнем развития продовольственного сектора промышленности Польши и EU-15 уменьшается, а структура промышленности и участники рынка схожи с остальными странами Евросоюза. В последнее десятилетие темпы развития пищевой промышленности Польши были одними из наиболее активных в Европе, что позволило стране улучшить своё положение на едином европейском рынке пищевой промышленности.

Ключевые слова: *пища, продукт, промышленность, производство, труд, производительность.*

Instructions for authors

Dear colleagues!

The Editorial Board of scientific periodical
«**Ukrainian Food Journal**»
invites you to publication of your scientific research.

Requirements for article:
Language – English, Ukrainian, Russian
Size of the article – 8-15 pages in Microsoft Word 2003 and earlier versions with filename extension *.doc (!)
All article elements should be in Times New Roman, font size 14, 1 line intervals, margins on both sides 2 cm.

The structure of the article:
1. The title of the article
2. Authors (full name and surname)
3. Institution, where the work performed.
4. Abstract (2/3 of page). The structure of the abstract should correspond to the structure of the article (Introduction, Materials and methods, Results and discussion, Conclusion).
5. Key words.

Points from 1 to 5 should be in English, Ukrainian and Russian.

6. The main body of the article should contain the following obligatory parts:
   - Introduction
   - Materials and methods
   - Results and discussing
   - Conclusion
   - References

   If you need you can add another parts and divide them into subparts.

7. The information about the author (Name, surname, scientific degree, place of work, email and contact phone number).

All figures should be made in graphic editor, the font size 14.

The background of the graphs and charts should be only in white color. The color of the figure elements (lines, grid, text) - in black color.
Figures and EXCEL format files with graphs additionally should submit in separate files.
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Extended articles should be sent by email to: ufj_nuft@meta.ua

Шановні колеги!

Редакційна колегія наукового періодичного видання «**Ukrainian Food Journal**» запрошує Вас до публікації результатів наукових досліджень.

Вимоги до оформлення статей

Мови статей – англійська, українська, російська
Рекомендований обсяг статті – **8-15 сторінок** формату А4**.**
Стаття виконується в текстовому редакторі Microsoft Word 2003, в форматі *.doc.
Для всіх елементів статті шрифт – **Times New Roman**, кегль – **14**, інтервал – 1.
Всі поля сторінки – по 2 см.

Структура статті:

1**.** УДК**.**
2. **Назва статті.**
3. Автори статті (ім'я та прізвище повністю, приклад: Денис Озерянко).
4. *Установа, в якій виконана робота.*
5. Анотація. Обов'язкова структура анотації:
   - Вступ (2-3 рядки).
   - Матеріали та методи (до 5 рядків)
   - Результати та обговорення (пів сторінки).
   - Висновки (2-3 рядки).
6. Ключові слова (3-5 слів, але не словосполучень).

Пункти 2-6 виконати англійською, українською та російською мовами.

7. Основний текст статті. Має включати такі обов'язкові розділи:
   - Вступ
   - Матеріали та методи
   - Результати та обговорення
   - Висновки
   - Література.

За необхідності можна додавати інші розділи та розбивати їх на підрозділи.

8. Авторська довідка (Прізвище, ім'я та по батькові, вчений ступінь та звання, місце роботи, електронна адреса або телефон).
9. Контактні дані автора, до якого за необхідності буде звертатись редакція журналу.

Рисунки виконуються якісно. Скановані рисунки не приймаються. Розмір тексту на рисунках повинен бути **співрозмірним** (!) тексту статті. **Фотографії бажано не використовувати.**

Фон графіків, діаграм – лише білий. Колір елементів рисунку (лінії, сітка, текст) – чорний (не сірий).

Рисунки та графіки EXCEL з графіками додатково подаються в окремих файлах.

Скорочені назви фізичних величин в тексті та на графіках позначаються латинськими літерами відповідно до системи СІ.

В списку літератури повинні переважати статті та монографії іноземних авторів, які опубліковані після 2000 року.

Правила оформлення списку літератури

В Ukrainian Food Journalвзято за основу загальноприйняте в світі спрощене оформлення списку літератури згідно стандарту Garvard. Всі елементи посилання розділяються **лише комами**.

1. Посилання на статтю:

Автори А.А. (рік видання), Назва статті, Назва журналу (курсивом), Том (номер), сторінки.

Ініціали пишуться після прізвища.

Всі елементи посилання розділяються комами.

1. Приклад:
   Popovici C., Gitin L., Alexe P. (2013), Characterization of walnut (Juglans regia L.) green husk extract obtained by supercritical carbon dioxide fluid extraction, *Journal of Food and Packaging Science, Technique and Technologies,* 2(2), pp. 104-108.

2. Посилання на книгу:

Автори (рік), Назва книги (курсивом), Видавництво, Місто.

Ініціали пишуться після прізвища.

Всі елементи посилання розділяються комами.

Приклад:

2. Wen-Ching Yang (2003), *Handbook of fluidization and fluid-particle systems*, Marcel Dekker, New York.

Посилання на електронний ресурс:

Виконується аналогічно посиланню на книгу або статтю. Після оформлення даних про публікацію пишуться слова ***available at:*** та вказується електронна адреса.

Приклади:

1. (2013), *Svitovi naukovometrychni bazy*, availableat:http://www1.nas.gov.ua/publications/q_a /Pages/scopus.aspx
2. Cheung T. (2011), *World's 50 most delicious drinks [Text]*, available at: http://travel.cnn.com/explorations/drink/worlds-50-most-delicious-drinks-883542

Список літератури оформлюється лише латиницею. Елементи списку українською та російською мовою потрібно транслітерувати. Для транслітерації з української мови використовується паспортний стандарт, а з російської - стандарт МВД (в цих стандартах використовуються символи лише англійського алфавіту, без хвостиків, апострофів та ін).

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УДК 663/664

Ukrainian Food Journal публікує оригінальні наукові статті, короткі повідомлення, оглядові статті, новини та огляди літератури.

Тематика публікацій в Ukrainian Food Journal:

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Якість та безпека харчових продуктів	Здоров'я

Періодичність виходу журналу 4 номери на рік.

Результати досліджень, представлені в журналі, повинні бути новими, мати чіткий зв'язок з харчовою наукою і представляти інтерес для міжнародного наукового співтовариства.

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