Assessment of quality of vegetable powder by mixed method of heat supply

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Abstract

Introduction. The processes of structure formation in emulsion-type sauces using phyto- and oil carotene containing semi-finished product – a mixture fine powders of spicy-aromatic and carotene containing raw materials and oil in the environment. The prospect of using the technology developed semi low-calorie sauces emulsion type is the manifestation of surface-active properties of said plant material.

Material and methods. Structural and mechanical properties of the finished sauce was studied using a rheometer AR 2000EX. Forms of communication research in water samples sauces determined on derivatograph Q-1500D. Emulsifying properties of powders spicy-aromatic and carotene containing materials described by phase inversion points.

Results and Discussion. Due to the content of polysaccharides and essential oils, crushed and dried raw of spicy-aromatic and carotene containing able to create stable colloidal systems – emulsion type oil in water. Research emulsifying ability and fine powders of spicy-aromatic and carotene containing raw materials in emulsion oil in water showed that the emulsifying ability parsley powder is 16% and 36%, which is higher than the powder with dill and carotene containing raw materials respectively.

A determination of rheological properties depending on the concentration sauces phyto- and oil carotene containing semi-finished product. Ready sauce with a mass fraction phyto- and oil carotene containing semi-finished product 30% shear rate of 200 s^{-1} has an effective viscosity in the range of 22–50 Pa·s, which is optimal for the type of emulsion sauces.

Value Relations moisture in the form of emulsion-type sauces approaching the optimal concentration phyto- and oil carotene containing semi-finished product 30% by weight of the sauce. Thus there is a stronger binding moisture promotes aggregative stability system prevents their separation.

Conclusions. Sauces emulsion type, made on the basis of the developed intermediate product, have optimal rheological parameters. Thus, we can recommend phyto- and oil carotene containing semi-finished product for sauces emulsion type of high nutritional value without the use of additional emulsifiers, structure-synthetic nature.

Introduction

Expanding of restaurant network Bistro facilities, cafes, students dining, as the rapidly growing and dynamically developing sector of economy, which is characterized by deficiency of products that are with balanced nutritional and biological value, especially with using of vegetables [1]. In assortment, there are mainly carbohydrate-fat foods and in result, this is leading to a destruction of the structure of nutrition and growing of different illnesses of different nature, especially to obesity. So, it is an actual scientific and technical deal to involve dry vegetables to process streams production of culinary products in the network Bistro and it helps to particular or complete resolution of the problem. It is important to consider rehydration properties of dry vegetables in developing food products because they mostly effect on organoleptic, physical-chemical quality parameters and structural-mechanical properties of food products with their use.

The aim of research was to study rehydration properties of powder of cabbage for using in a number of food product technologies.

Materials and methods

In researches we have chosen powder of cabbage with a final humidity content of 7% which was received by mixed method of heat supply [2]. Powder of cabbage consists mainly from particles of 5..50 mm. In order to predict the behavior in a multi component food systems we researched its rehydration properties in polar environments: solutions of sodium chloride (0,5 and 1,7%), sucrose (1,1 and 5%), dimethyl acid (pH = 4.5) and sodium bicarbonate (pH = 6) at 20 and 40 °C by coefficient of water absorption [3] and microstructure researches.

Microstructure of powder was learned by optical (MBI-15) microscope with «passing» light. For preparing microscope preparations we have done preliminary recovery of powder in water at 25 °C with an exposure of 5 minutes [4].

The resulting slurry was applied to a glass slide and was wrapped with a cover.

Microstructure of researching powders study was performed by 400 times increase. Most common fields of view were photographed while watching preparations [5].

The size of the pores was determined to install Mac-Ben adsorption of water vapor [6].

We used thermal method of analyses for humidity connects in native and restored powders exploring which helps us to make sample temperature measuring, changes of its mass, changes of mass speed and enthalpy changes [14]. Curves were shot on Pauli-Erden Q-1500D derivatograph system on air with speed of temperature increasing at 5 C/min. Weight of samples was 150…250 mg. Speed of samples was 2 mm/min Alumina oxy at 2500°C was chosen as inert material.

Combined derivatograph curves consideration – differential-thermal analyses (DTA), thermogravimetric (TG), differential thermogravimetric (DTG) curves and temperature (T) gives us an opportunity to estimate chemical and physical transformations in researched sample while boiling with a given temperature increasing speed and to make quality and quantity assessment of this transformations [15].

According to obtained derivatogrames we made determining of the temperature peaks and intervals of its removing with different types of connection. Quantity of removed humidity was determined by TG curve in percents.

Results and discussions

Powder of cabbage by mixed method of heat supply process at temperatures of 50 and 70°C is selected as deemed «marginal», investigated the pore sizes by setting Mak-Ben. It presents results of investigations on the isotherms of water vapor in the samples from cabbage powders and the pore distribution curve radii (Figure 1, a-d).

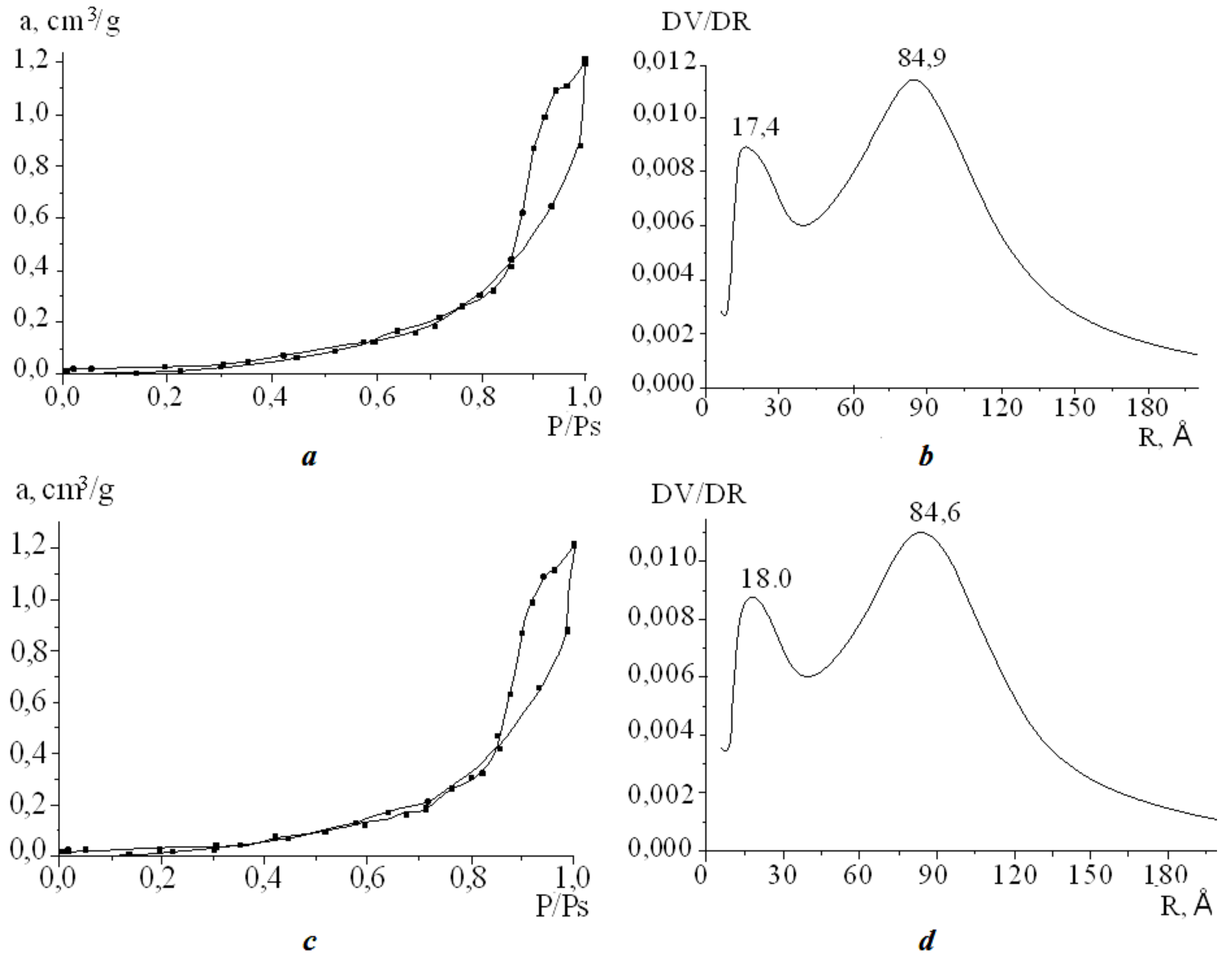


Figure 1. The adsorption isotherms of water vapor (a, c) and the distribution of pore radii (b, d) of the powder-dryer cabbage-mixed supply of heat

Structural characteristics of vegetable powders, MSH-derived and convective drying method, which have been removed in the water vapor, in Table 1.

By the analysis of adsorption isotherms of water vapor vegetable powders – Figure 1 – it can be concluded that the experimental samples MSH drying with same structure of adsorption. When this difference is insignificant in the presence of somewhat larger amounts of sample powder in the pores of the cabbage, which obtained 50 °C, as compared with the sample of 70 °C (Figure 1, a and c), since the first adsorption isotherm is somewhat higher that similarly in the graph the distribution of radius of pore. Therefore, the area under the curve of the powder sample of cabbage ZTP-drying 70 °C is greater, indicating that the more he has.

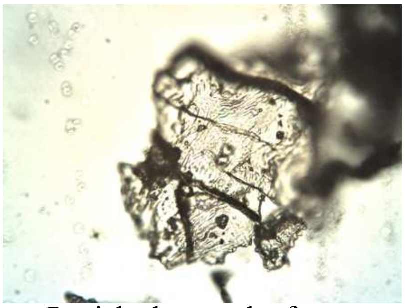
Table 1
Structural characteristics of vegetable powders, which have been removed in water vapor

Index	Meaning cabbage powders obtained by drying:		
	convection	MSH with 50 °C	MSH with 70 °C
The energy of activation of water, kJ/mol	4,5	3,1	3,2
Structer characteristics:			
The specific surface of the sample S, m^2/g	126	115	79
Square error of calculation of the surface, R^2	0,92	0,70	0,69
Sorption pore volume, V_s, cm^3/g	1,56	1,16	1,20
Diameter of the pores, D, 10^{-10}, m	792	403	608

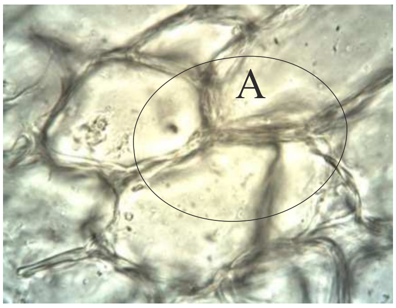
Hysteresis curve (Figure 1, b and d) of samples of powder cabbage MSH drying indicates presence of small sizes of pore, and removing moisture from the delayed samples. This we see in the graphs and distribution of pore radius where the available time with the size of 17,4 and 18,0 · 10^{-10} m (Table. 1).

Image of powder particles cabbage MSH-drying of native and reduced in polar media at different temperatures are shown in Figure 2. Analyzing the images of the microstructure (Figure 2) powder particles recovered from the cabbage, it can be stated that in the dehydration process is influenced by the type and temperature of the medium. Thus, it is seen that at 20 °C in various media on the surface of cells of vegetable tissue between the constituent components of the powder and water molecules solvate formed complexes (A) and is clearly seen in the images associated moisture adsorption layer (B) provided on the microstructure photographs. Moreover, a greater degree of dehydration process takes place in a medium with the pH of 6. The tissue regeneration powder in dilute solutions of sodium chloride (0,5%) and sucrose (5,0%) takes place in a similar way to the aqueous medium.

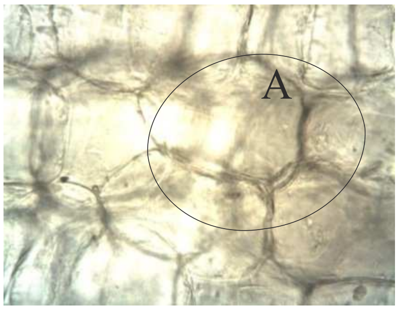
Powder of cabbage by mixed method of heat supply and restored in polar environments in different temperatures particle image is shown on Figure 2. Analyzing microstructure photos (Figure 2) of restored particles of powder of cabbage we can say that type and temperature of polar environment affect on hydratation process. On microstructure photos you can see that solvate complexes form in different polar environments on vegetable tissue surface cell between components of powder and molecules in 20 °C temperature. Bound of adsorption-connected humidity is clearly visible on photos. At the same time we have to determine that restoration process effects on pH environments. Mostly rehydratation process takes place in environment with pH = 6. Restoring of powder tissue in weak solutions of sodium chloride (0.5%) and sucrose (5,0%) is similar to water environment. Increasing of sodium chloride and sucrose concentration to 1,7 and 5,0 percents respectively is leading to deterioration of cell rehydratation process. This can be explained by high concentration and hydratation properties of this substances. And plasmolysis of cells appears with increasing of solutions temperature from 20 to 40 °C. On microstructure photos it is seen that restoration in milk at 20 °C is happening same to week solutions of sodium chloride and sucrose. Besides fat globules and milk proteins are kept on cells surface because of high presence of polysaccharides in this raw. With the increasing of restoring environment temperature, rehydration properties of powder from cabbage by mixed method of heat supply are increased to.



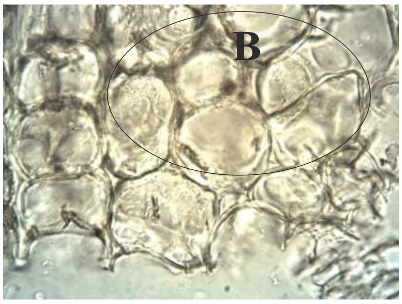
Particle the powder from cabbage



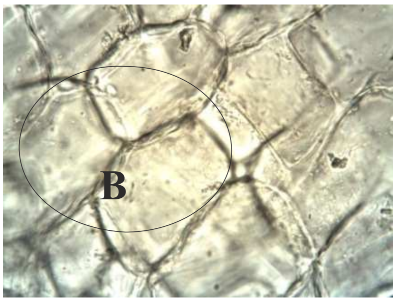
Sodium hydrogencarbonate solution, pH=6, (18 ± 2) °C



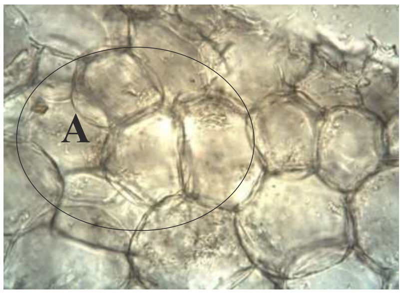
Sodium hydrogencarbonate solution, pH=6, (48 ± 2) °C



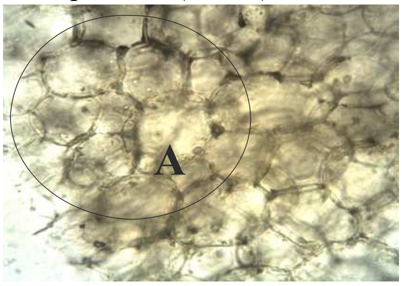
Ethanoic acid solution pH=4,5, (18 ± 2) °C



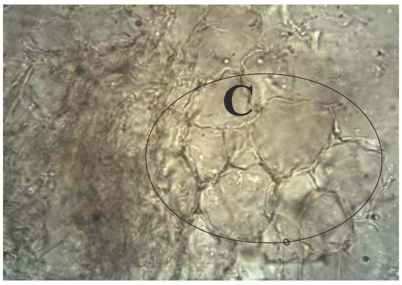
Ethanoic acid solution pH=4,5, (48 ± 2) °C



A solution of sodium chloride 0,5 %, (18 ± 2) °C

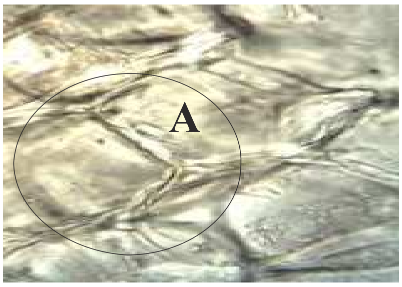


A solution of sodium chloride 0,5 %, (48 ± 2) °C

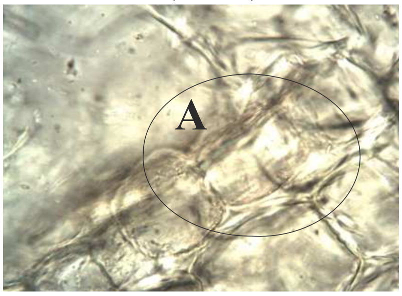


A solution of sodium chloride 1,7 %, (18 ± 2) °C

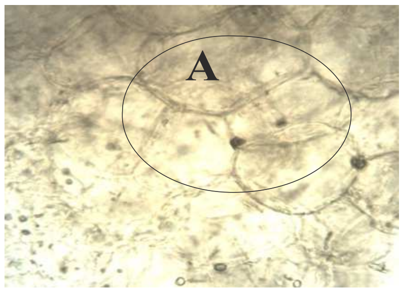
A solution of sodium chloride 1,7 %, (48 ± 2) °C



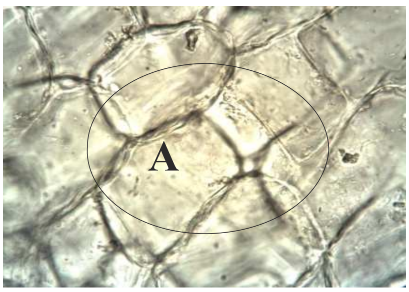
Sucrose solution 1,1 %, (18 ± 2) °C



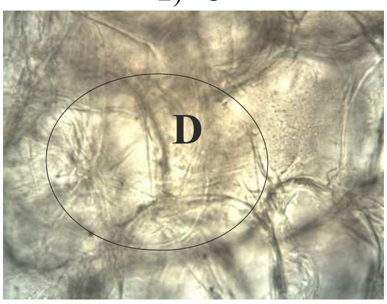
Sucrose solution 1,1 %, (48 ± 2) °C



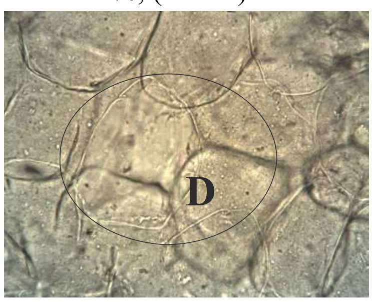
Sucrose solution 5 %, (18 ± 2) °C



Sucrose solution 5 %, (48 ± 2) °C



Milk (18 ± 2) °C



Milk (48 ± 2) °

Figure 1. Microscopic Structure of Powder of Cabbage which was recovered in different polar environments by different temperature (increase 400 times)

Detected of water absorption coefficient of the powder from cabbage (CWA) in these polar media at a temperature 20 ± 2 °C presented in Table 2. As seen from the table, the greatest value of CWA characterized vegetable powder samples MSH-drying in comparison to the convective manner regardless of the medium for recovery. Moreover, the CWA value is somewhat reduced in sodium chloride and sucrose in higher concentrations of 1,7 and 5,0% respectively, which was confirmed by microstructure powders (Figure 2).

Table 2

The coefficient of water absorption in polar mediums powder of cabbage

Polar mediums	Coefficient of water absorption, відн. од., powder of cabbage	
	Convection	MSH-drying
Sodium bicarbonate (pн = 6,0)	4,0 ± 0,1	6,2 ± 0,1
Solution of ethanoic acid (pн = 4,5)	4,0 ± 0,1	6,0 ± 0,2
Solution of sodium chloride 0,5 %	4,0 ± 0,2	6,2 ± 0,1
Sucrose 1,1 %	4,3 ± 0,2	6,1 ± 0,1
Sucrose 5,0 %	4,1 ± 0,1	5,0 ± 0,1

Connectives between components of structure in their enter play important role in forming structure of finished products, what effects on redistribution of humidity connects form and processes of fat phase crystallization. To establish the influence of drying method on the redistribution of humidity connects forms held by thermogravimetry method, we have done exploring of powder of cabbage water phase obtained by convective drying method and mixed heat supply after their recovery. Thermogravimetric method which is based on changes of mass and product enthalpy during the heating with given speed was used for exploring of humidity connectives forms in powder of cabbage samples. In result of exploring we obtained derivatohrames which were used for determining of removed humidity quantity, temperature peaks and intervals of its removing. According to our data we identified humidity connects forms and calculated their percentage – figure 3.

Rebinder standard classification of humidity connects forms was used during analyses of water phase connectives with powder components [9]. Energy of connects with material or thermodynamic principle was assigned as classification basis, that's why it has universal. According to given classification all connectives forms are divided into three big groups: physical-chemical, physical-mechanical and chemical.

Powder of cabbage derivatohrames obtained by different drying methods before the recovery are shown on Figure 4 b. Describing the DTA curves of exploring samples we can say that removing of humidity in them is same but in different temperature intervals.

Thus, for powder of cabbage obtained by convective drying, temperature peaks of removing firmly connected humidity are in range 65…160 °C. At the same time in unrecovered powder of cabbage obtained by mixed method of heat supply temperature interval of removing firmly connected humidity is shifted toward higher temperatures – 78…175 °C. Increasing temperature peak of removing humidity on 2 °C and diffuse peak on 9 °C also is observed in given sample. Received results show that in unrecovered powder of cabbage by mixed method of heat supply, the residual humidity is stronger connected with its components than in powder by traditional convective drying.

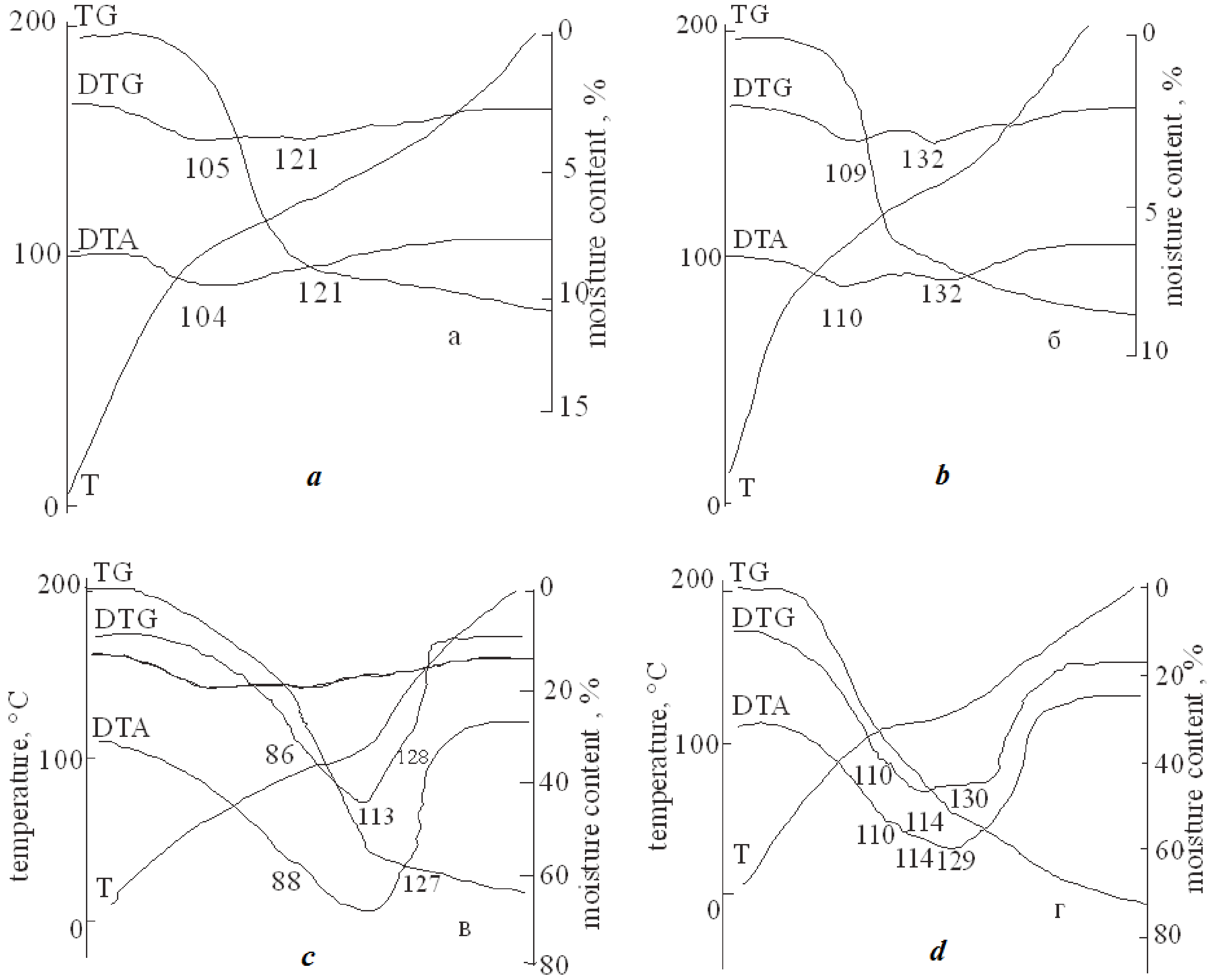


Figure 3. Powder of cabbage derivatohrames:
a – convective drying; b – mixed method of heat supply;c – convective drying, recovered in water; d – mixed method of heat supply, recovered in water

Comparing derivatohrames of recovered powder of cabbage (fig 3 c and d) it is seen that their ability to connect and retain humidity is different and depends of drying method. Thus, overall quantity of connected humidity in powder of cabbage received by convective drying is 71% and in powder by mixed method of heat supply – 80 %.

Describing DTA curve of recovered powder by convective drying (Figure 3 c), it is seen that peak of removing humidity us wide in low temperature interval – 32…102 °C. The relative amount of removed humidity is 63%. This indicates on blending of humidity removing temperature intervals with different forms of connection. According to Rebinder classification, this humidity is characterized by weak osmotic and mechanical connections with powder components [11].

Process of removing firmly connected humidity is characterized by a sharp peak at 110 °C and this shows that polymolecular connections are predominance. Comparing derivatohrames of explored powder samples it is seen that mixed method of heat supply process promotes the growth of firmly connected humidity quantity with poli- and monomolecular connections. Character of DTA and DTG curves of recovered powder indicates it (Figure 3 d).

The relative quantity of mechanical and osmosis humidity in the recovered sample is 47%. Firmly connected humidity is removed differentiated in two temperature intervals with removing peaks of 114 and 130°C, indicated humidity with poly- and monomolecular connections respectively. Relative quantity of it is 53%.

So, the results of exploring shows that using of mixed method of heat supply method promotes forming of powder of cabbage rehydration properties, that are more than in 1.5 times able to connect humidity with strong connections in comparing with convective drying. From the literature it is known [8] that systems in which microcapillaries are with a diameter not longer than 10^{-7} cm are demonstrated wide and characterized by large amount of strong connected humidity. Using the known literature data we can make a conclusion that hardware design and technological modes of mixed method of heat supply process contribute receiving powder with larger amount of micropores and microcapillaries in nanoscale range.

Conclusions

1. Powders obtained by drying of cabbage mixed method of heat supply at temperatures of 50 and 70 °C. Established by setting Mack Ben that the volume of pores cabbage powder obtained at 50 °C is greater than 70 °C. Most 1,5 times the surface adsorption of cabbage powder 70 °C allows us to conclude that the absorption of moisture in the powder will be correspondingly larger sample.
2. The results of the researches show that the receiving powder of cabbage by mixed method of heat supply promotes maximum saving of vegetable tissue microstructure and native properties of its components.
3. Hardware design and technological modes of mixed method of heat supply are proportional influenced on the formation of pores and capillaries in micro- and nanoscale range what helps to receive a dry product with high rehydration properties.
4. Hardware design and technological modes MSH-drying process is directly proportional to affect for size of pores and capillaries, in micro- and nano-range, to provide dried products with high rehydration properties.

References

1. Antypov S.T., Zhashkov A.A. (2010), Sovremennye texnologyy pry poluchenyy plodovo-yagodnyx poroshkov, *Vestnyk TGTU*, 16(2), pp. 332–336.
2. Potapov V. A., Yakushenko E. N., Zherebkyn M. V. (2013), Analyz sposobov sushky y ocenka kachestva sushenoj vynogradnoj vyzhymky, *Vostochno-evropejskyj zhurnal peredovyx texnologyj*, 6/11(66), pp. 15–20
3. Gasilova E.R., Saprykina N.N., Zamyshlyayeva O.G., Semchikov Yu.D., Bochkarev M.N. (2010), Hyperbranched perfluorinated poly(phenylenegermanes) obtained by polycondensation of A2B2 and AB3 monomers, *J. Phys. Org. Chem*, 23, pp. 1099–1107.
4. Boltenko Yu.A., Rodycheva N.V. (2015), Reologiia ovoshhnyh poroshkov, *Nauchnyj rezultat*, *Seriia «Texnologii biznesa i servisa»*, 1, pp. 39–44
5. Shtanskyj D.V. (2002), Prosvechivaiushhaia elektronnaia mikroskopiia vysokogo razresheniia v nanotexnologicheskih issledovaniiax, *Ros. chim. zh.,* 5, pp. 81–89.
6. Kamalyan O.A. (2007), Poluchenie i issledovanie sorbcionnyx svoistv karbonizirovannogo kremnezema, *Uchebniie zapyski erevanskogo gosudarstvennogo universyteta*, 3, pp. 91–96.
7. Esther Laduni, Adewumi Toyin Oyeyinka, Samson Adeoye Oyeyinka, Charles Ogugua Aworh (2015), Effect of drying method and cereal type on functional and pasting properties of ogi powder, *Ukrainian Food Journal*, 4(1), pp. 587–595.
8. Michael Mayokun Odewole, Zainab Oyinlola Ayodimeji, Kehinde Peter Alabi (2015), Post-storage qualities of pre-treated dried red bell pepper, *Ukrainian Food Journal*, 4(1), pp. 605–616.
9. Matveenko V.N., Kyrsanov E.A (2011), Viazkost i struktura dispesnyx sistem, *Vestn. mosk. un*-ta., 52(4), pp. 243–276.
10. Cherevko O., Kiptela L., Zagorulko A., Borysova A. (2013), Ir-drying of non-traditional plant raw material, *Journal of Food and Packaging Science, Technique and Technologies*, 2(1), pp. 65–70
11. Al-Muhtaseb A.H., McMinn W.A.M., Magee T.R.A. (2002), Moisture Sorption Isotherm Characteristics of Food Products: A Review, *Food and bioproducts processing*, 80(2), pp. 118–128.
12. Marcel Avramiuc (2013), Some chemical aspects during white cabbage pickling process, *Food and Environment Safety*, XII(1), pp. 161 – 168
13. Olena Onopriychuk, Olena Grek, Alla Tymchuk *(2015),* Optimization of the composition of the mixture by simplex method, *Ukrainian Food Journal*, 4(1), pp. 49–58.
14. Grega Klančnik, Jožef Medved, Primož Mrvar (2010), Differential thermal analysis (DTA) and differential scanning calorimetry (DSC) as a method of material investigation, *RMZ – Materials and Geoenvironment,* 57(1), pp. 127–142
15. Yurchak V., Mank V., Voloshchuk G. (2005), Vliyanie ovoshchnykh poroshkov na kachestvo makaronnykh izdeliy, *Khleboprodukt*, 12, pp. 44–46.