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USE OF DRIED CARROT POMACE IN THE TECHNOLOGY OF WHEAT BREAD FOR ELDERLY PEOPLE

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Abstract. The paper considers the technological properties of dried carrot pomace obtained in the technology of organic direct pressing juices. Its use as a valuable source of food fibre and β-carotene in bread technology for elderly people has been substantiated. It has been established that dried carrot pomace has a larger particle size than flour, and its water absorption capacity is higher by 65%. A 5–15% dose of pomace makes the formation of dough longer by 1.5–6.5 min, significantly increases its viscosity and stability, as well as acidity. Due to the content of sugars available for yeast fermentation, the pomace contributes to the intensification of gas formation. The amount of wet gluten in pomace-containing dough decreases, as well as its water absorption capacity, and its resilience increases. This affects the structural and mechanical properties of dough, which has a decisive effect on the porous structure of finished products and their specific volume. A high quality of bread is achieved when the dose of dried carrot pomace is up to 5%, which helps to improve the colour and the taste. With an increasing dose, the specific volume and porosity of the products decrease. It has been proved that, due to the content of pectin and high hydrophilic properties, carrot pomace slows down the process of staling of bakery products. Calculations have shown that with the addition of 5% of the pomace, the content of β-carotene in 100 g of bread increases by 15 times, and the fibre content by 3.4 times. With the consumption of 277 g of such bread, elderly people's daily requirement of β-carotene is satisfied by 100.8%, and the that of dietary fibre by 4.1%.

Key words: dried carrot pomace, β-carotene, special-purpose bread, elderly people.

ВИКОРИСТАННЯ СУШЕНИХ МОРКВЯНИХ ВИЧАВКІВ В ТЕХНОЛОГІЇ ПШЕНИЧНОГО ХЛІБА ДЛЯ ЛЮДЕЙ СТАРШИХ ВІКОВИХ ГРУП

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Анотація. У статті розглянуто технологічні властивості сушених морквяних вичавків, які отримають в технології органічних соків прямого віджиму. Обґрунтовано застосування вичавків як цінного джерела β-каротину та харчових волокон у технології хліба для людей похилого віку. Встановлено, що морквяні вичавки мають більші розміри часточок, ніж борошно, та вищу на 65% водопоглинальну здатність. За дозування 5–15 %, зумовлюють подовження тривалості утворення тіста на 1,5–6,5 хв, значне збільшення його в'язкості та стійкості, підвищення кислотності. Вичавки сприяють інтенсифікації газоутворення, оскільки містять цукри, доступні для зброджування дріжджами. У тісті з вичавками зменшується кількість сирої клейковини, знижується її гідратаційна здатність, підвищується пружність. Це впливає на погіршення структурно-механічних властивостей тіста, що має вирішальний вплив на структуру пористості готових виробів та питомий об'єм. Висока якість хліба досягається за дозування сушених морквяних вичавків до 5%, що сприяє поліпшенню забарвлення, покращанню смаку та аромату. За більшого дозування зменшується питомий об'єм виробів, погіршується пористість, з'являється виражений запах вичавків. Доведено, що внесення вичавків сприяє затриманню процесу черствіння хлібобулочних виробів через високий вміст пектину, який обумовлює гідрофільні властивості морквяних вичавків. Розрахунки показали, що за дозування 5% вичавків до маси борошна вміст β-каротину в 100 г хліба збільшується в 15 разів, а вміст клітковини – в 3,4 рази. За умови вживання 277 г такого хліба, добова потреба для людей похилого віку в β-каротині покривається на 100,8%, а потреба в харчових волокнах – на 4,1%.

Ключові слова: сушені морквяні вичавки, β-каротин, хліб спеціального призначення, люди похилого віку.

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Introduction. Formulation of the problem

In Ukraine, bread is a product of daily consumption. Naturally, wheat flour products are in great demand among young and elderly people. However, studies and calculations indicate the unbalanced chemical composition of wheat bread, which leads to depletion of the diet [1]. The increase in the nutritional value of wheat bakery products is achieved as a result of the use of raw materials with a high content of proteins (flour of leguminous origin, protein isolates and hydrolysates, proteins of animal origin), food fibres (bran, fruit fibre concentrates, purées, and hydrolysates of vegetables), minerals (dairy products enriched with mineral substances, premixes, natural minerals) [1]. Such supplements make products more expensive.

Thus, increasing the nutritional value of wheat bread is a topical problem, and many works of scientists are devoted to it. Nowadays, it is important to use inexpensive available supplements in order to make products cheaper and make them available to all social groups, including elderly people with low income.

Despite the large number of studies, a complex task not solved yet is that of enriching bread with several nutrients at a time, the deficit of which is observed in the diet of elderly people. There is still a problem of enrichment of bakery products with vitamins. For elderly people, there is a risk of cardiovascular and gastrointestinal diseases, eye disorders, oncology. In this case, a proper diet, enriched with all the necessary elements, can reduce the risk [2-4].

For example, the anti-sclerotic orientation of the diet does not only reduce caloric intake, but also provides adequate consumption of vegetables and fruit containing food fibres. Dietary fibre helps to lower the cholesterol level in the blood and prevents the absorption of fatty substances in the intestines [5]. According to the results of monitoring the diets of elderly people in different countries, there is a general tendency towards inadequate use of vegetables and fruit, which leads to a significant shortage of dietary fibre. With the daily rate of food fibres consumption 25–30 g a day, the actual amount of consumption is 15.6–16.6 g a day [5].

Carotenoids contribute to the prevention of diseases of the organs of vision, cardiovascular system, cancer [6-8], but the lack of these substances is observed in the diet of elderly people [2]. Scientists have proved that carotenoids of natural origin that are not produced by chemical or microbial synthesis are the most favourable for the human body [9,10].

Taking into account the above-mentioned, it is reasonable to suggest the use of natural sources of carotenoids and food fibres for the enrichment of bakery products for elderly people.

Analysis of recent research and publications

In order to enrich the chemical composition of bakery products, products of vegetable origin are used: fruit and vegetable powders (apple, carrot, pumpkin, etc.) [11,12], pectin, bran, and oil meal [13,14], powder and herbal extracts [15], hydrolysed vegetables and fruit purées [16,17]. Such raw materials are used to enrich not only bakery products, but also confectionery products [18-20]. However, the raw materials which are processed specially (purée, hydrolyzate, cryopowder) or extracted (pectin, extracts of phytoplankton, etc.) with the use of complex and energy-intensive technological processes increase the production cost of products, which can make them unavailable for people.

Secondary products of vegetable processing can be prospective raw materials for the enrichment of bakery products with vitamins, minerals, and fibre. In particular, it is advisable to use available carotene-containing products with a significant amount of dietary fibre, pectin, minerals that are relatively low-costing.

Resulting from the growing popularity of blended juices, the volume of carrot juice production increases, and hence, so does the volume of such a valuable by-product as pomace. For the technology of direct pressing, only fresh vegetables and fruit without damage are used during the harvesting period, so the pomace obtained contains practically no foreign microflora, nor pesticides, heavy metals, etc. if organic raw materials are used.

Carrots are the most important sources of carotene. Inclusion of carrots in the diet is particularly useful in case of vitamin A deficiency, liver and kidney disease, to improve intestinal motility [4]. The limits of the carotene content in carrots vary from a few milligrams to 25 mg/100 g of the product [21-23]. A great part of carotene enters the juice during pressing. However, the results of studies indicate that the content of valuable ingredients in pomace significantly exceeds their content in juice [22]. Besides, dried pomace, compared to juice and purée, has a much longer shelf life, so it can be easily transported and used in production throughout the year. Loss of carotene does not exceed 25% provided that dried products with carotene are stored at a temperature of 5°C for 12 months. It has been established that the average content of carotene in dried carrot pomace (for the convection method of drying) is approximately 160 mg/100 g of dry matter (DM), and in the powder (additionally crushed pomace), 136 mg/100 g of DM. Pectin (about 5 mg/100 g of DM) and fibre (~ 11 mg/100 g of DM) are valuable, too [22].

So dried carrot pomace is a raw material that can be used to enrich bakery products with functional ingredients: carotenoids, pectin, and food fibres. Due to the trends in the diet of elderly people, bakery products with carrot pomace can be recommended for making nutrition better.

The purpose of the work was to investigate the technological properties of dried carrot pomace and to establish its influence on the quality of wheat bread in order to increase its nutritional value and organoleptic parameters, and to prolong its freshness.

To achieve this goal, the following **tasks** have been solved:

1) to study the technological properties of dried carrot pomace;

2) to determine the influence of dried carrot pomace on the characteristics of the technological process;

3) to investigate the influence of dried carrot pomace on the quality of wheat bread and the processes of its staling,

4) to establish how pomace-containing bread satisfies the daily needs for carotene and food fibre.

Research materials and methods

The object of research is carrot dried pomace obtained in industrial conditions by the convective drying method. Samples of wheat dough and wheat bread with different doses of carrot pomace have been compared in the work.

The coarseness of pomace was studied by screen sizing, acidity by a water extract [24]. The water absorption capacity of the pomace was determined by centrifugation [1]. The effect of carrot pomace on the resilience of the dough was determined with a farinograph Brabender. To evaluate the structural and mechanical properties of the dough, the change in the specific volume and the dough ball running during fermentation were determined. The amount of gluten was determined by washing out from the dough, and its quality was valuated [24].

Dough for laboratory baking was prepared by the straight dough procedure, with the mass fraction of moisture 45%, with adding 3% of compressed baking yeast, 1.5% of salt. The dough was mixed in a two-speed kneading machine. Dry carrot pomace was dosed in the dry form and mixed for 2–3 minutes in a kneading machine with flour. Resting of the dough samples was carried out at the temperature (37±2)°C and relative humidity (75±2)% to readiness. The products were baked in an oven with the temperature 210–220°C.

Biochemical processes in the dough were characterized by the accumulation of total acidity and gas formation. The gas-forming ability of the dough was estimated by the amount of released CO_2 during the fermentation by the volumetric method on the AG-1M apparatus [24].

The quality of bread was determined by physical and chemical properties (acidity, porosity, specific volume, shape stability, structural and mechanical properties of the crumb [24]), and organoleptic parameters (appearance, surface condition, colouring of the crust, structure of porosity, taste, smell [24]). The influence of additives on the duration of storage of products was investigated by changing the structural and mechanical properties of the crumb. The general deformation of the crumb was determined on a penetrometer AP 4/1 after 72 hours of storage. The content of vitamin A and food fibres in the products was counted by using the Optima programme [1]. The results of the experimental studies were statistically analysed using standard software packages Microsoft Office.

Results of the research and their discussion

Dried carrot pomace is a powdered raw material, pale orange, with a faint scent of carrots. It is known that the technological properties of raw materials significantly depend on the granulometric composition. The water absorption capacity and the susceptibility of biopolymers to the action of enzymes depends on the dispersion. The density of carrot pomace powder was determined using sieves with different mesh sizes.

The analysis of the granulometric composition has shown that carrot powder has a larger particle size than wholemeal flour. For wholemeal flour, when the mesh size is 670 microns, the sieve residue does not exceed 2% according to the standard, and for carrot powder, this parameter is 13.3% (Table 1).

The water absorption capacity of the pomace was determined by centrifugation. It is an important technological property of the raw material, which the water absorption capacity of dough and its rheological properties depend on. It has been established that the water absorption capacity of the flour is 240%, and that of the pomace is 367%. Carrot pomace has the water absorption capacity greater by 56% than that of wheat flour, which is evidently due to the high content of pectin substances and hemicellulose. In addition, the pomace particles have a porous structure formed during grinding carrots, pressing, and drying. It has been established that the acidity of the pomace (analysing the water batter) is 4.8 degrees, which indicates the presence of organic acids in its composition.

The test baking was conducted to determine the effect of dried carrot pomace on the quality of wheat bread. For this purpose, 5, 10, and 15% of pomace was added.

The research has made it possible to establish that pomace has a slight effect on the parameters of the technological process, but worsens the quality of finished products (Table 2).

The dough with pomace required longer kneading to form a homogeneous consistency and had more plastic properties, which, in our opinion, is due to an increase in the water absorption capacity. It has been established that the moisture content of the dough with pomace is lower than it was pre-estimated, which indicates the pomace biopolymers bind the moisture. This factor significantly influenced the specific volume of finished products, their porosity. Thus, with 15% of pomace added, the porosity dropped by 14%, and the specific volume by 95 cm^3/100 g. However, the shape stability of the products with pomace has significantly improved (Fig. 1). The deterioration of structural and mechanical properties of the dough plays a decisive role in the formation of the porosity and the volume of products, since gas formation in the dough with the pomace significantly increases. This is due to the high content of sugars in pomace [17,22], which is available for fermentation by yeast. Considering the chemical composition of carrots, it can be stated that carrot pomace contains mono and disaccharides [22], which are easily fermented by yeast.

Table 1 – Granulometric composition of dried carrot pomace

Number of sieve	Mesh size of the sieve, microns	The remainder on the sieve, %
№ 008 № 007 № 005 № 003	670 329 264 219	13.3 13.4 14.8 4.4
Sieve residue, %		
№ 003	219	54.1

Table 2 – Influence of dried carrot pomace on the parameters of the technological process and the quality of wheat bread

Parameters	Control sample	With addition of pomace, % of the mass of flour		
		5	10	15
Dough				
Mass fraction of moisture, %	45.0	44.6	44.3	43.8
Acidity, degrees: initial final (3 hours of fermentation)	 1.4 1.8	 1.7 1.9	 2.1 2.6	 2.4 3.6
Duration of resting, min	33	34	39	42
Gas-forming ability during 3 hours of fermentation, cm^3/100 g of dough	618	684	762	796
Bread				
Specific volume cm^3/100 g	300	285	250	205
Shape stability, H/D, of oven-bottom bread	0.44	0.42	0.48	0.57
Porosity, %	72	68	62	58
Acidity, degrees	1.4	1.8	2.3	2.8
Surface condition and colour	Smooth pale cream-coloured	Smooth pale yellow	Golden, with visible particles of pomace, rough	Light brown, with visible particles of pomace, very rough
The colour of the crumb	Light cream-coloured	Light yellow, with barely noticeable impurities of powder	Dark yellow, with impurities of powder	Light brown with a yellow tint
Structure of porosity	Thin-walled, medium, even	Thin-walled, medium, even	Small, thin-walled, uneven	Small, thin-walled, poorly developed
Taste and flavour	Pronounced, typical of bread	Barely pronounced, pleasant, taste and flavour of carrots	Pronounced, pleasant, taste and flavour of carrots	Very pronounced taste and aroma of dried pomace

1 2 3 4

Fig.1. Bread from wheat flour with the addition of dried carrot pomace:
1 – control sample (without pomace); with pomace in the amount: 2 – 5 %; 3 – 10 %, 4 – 15 %

The colour of products with pomace is more intense, compared to the control sample, which is due to carotenoids contained in carrots and the intensified reaction of melanoidin formation during baking. For the 5% dose of the pomace, the taste and flavour of the products are pleasant, with a subtle aroma of carrots, the colour of the crumb is light yellow. The sample with the addition of 5% of pomace had the best organoleptic characteristics.

Consequently, due to the physical and chemical parameters of the quality of dough, and the sensory characteristics of the quality of bread, it is advisable to add carrot pomace in an amount of no more than 5% of the mass of the flour.

The study of the farinograms has shown (Table 3) that the pomace contributed to a significant increase of water absorption capacity of dough. In the future, this may be a prerequisite for increasing the moisture content of the dough and increasing the yield of finished products.

The analysis of farinograms confirms the necessity of lengthening the duration of kneading dough until the moment of absorption of water not only by particles of flour, but also by particles of carrot pomace. Since the pomace has a high water absorption capacity, it increases the viscosity and reduces the running of the dough during kneading. Carrot pomace absorbs water and swells when kneading the dough, while it acts as a competitor for water, that is, limiting the swelling of gluten, as evidenced by the studies of dough gluten (Table 4). The amount of raw gluten decreases, it is strengthened and its expansibility decreases. In our opinion, this is due to the significant content of pectin and food fibre in the carrot pomace.

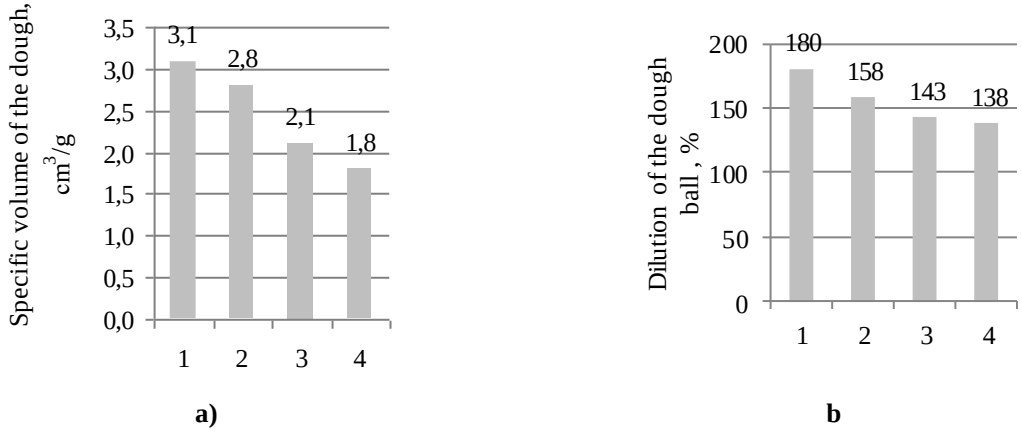
As a result, these factors influence the structural and mechanical properties of the dough. It has been established that the specific volume of the dough and the dilution of the ball of the dough with pomace are smaller, com pared with the control sample (Fig. 2).

Table 3 – The properties of the dough with the addition of carrot pomace (n=3)

Parameter	Control sample (without additives)	Carrot pomace added, %		
		5	10	15
Water absorption capacity, %	61.0	63.0	65.2	68.5
Duration of dough formation, min	3.5	5.0	7.5	10.0
Dough stability, min	6.0	8.5	9.5	12.0
Elasticity, units of ph.	120	125	130	145
Running of the dough, units of ph.	45	40	30	10

Table 4 – Quality parameters of gluten

Parameter	Control sample (without additives)	Carrot pomace added, %		
		5	10	15
The amount of raw gluten, %	25.81	24.42	23.62	23.10
IDG, units of device	69.5	65.0	54.2	48.0
Extensibility, cm	16	15	12	8
Hydration ability, %	173	160	156	138



a) **b**

Fig.2. Influence of dried carrot pomace on the structural and mechanical properties of the dough:
a) – specific volume of the dough after 3 hours of fermentation; b) – running of the dough ball after 3 hours of fermentation; 1 – control sample without pomace; 2 – with 5% of pomace; 3 – with 10% of pomace; 4 – with 15% of pomace

The running of the dough ball (Fig. 2b) decreases, which is due to an increase in its water absorption capacity, strengthening of gluten.

Pectin in pomace contributes to inhibiting the staling of finished products. For products containing pomace, the deformation of the crumb during storage is less reduced than for products without pomace (Table 5). A significant difference in structural and mechanical properties of the crumb after 4 hours of baking is due to the undeveloped porosity structure, which in the future can be improved by selecting the optimum technological parameters (for example, increasing the moisture content of the dough, using additional operations to prepare pomace before kneading the dough, etc.).

In order to justify how practical it is to use carrot pomace as a raw material for the enrichment of bakery products with carotene and food fibres, calculations have been made of the chemical composition of bread with the addition of 5% of the pomace (Table 6). The degree of maintenance of daily requirement in β-carotene and food fibres in accordance with the recommended norms has been calculated, too [25].

Table 5 – Effect of dried carrot pomace on the staling of bread

Sample of bread	Deformation of bread crumb, units of penetrometer		Retaining freshness, %
	4 hours	72 hours	
Control sample	65	45	69.2
With addition of carrot pomace:			
5%	60	44	73.3
10%	52	39	75.0
15%	47	37	78.7

Table 6 – Providing daily need for carotene and food fibres

Substance	Daily rate of consumption	Wheat bread (control sample)			Wheat bread (with the addition of 5 % of the pomace)		
		in 100 g of bread	in 277 g of bread	Daily requirement coverage, %	in 100 g of bread	in 277 g of bread	Daily requirement coverage, %
Cellulose, g	25	0.11	0.30	1.2	0.37	1.02	4.1
Vitamin A (β-carotene), mg	2.5 (15)	0.06 (0.36)	0.17 (0.96)	6.5	0.91 (5.44)	2.52 (15.12)	100.8

In the norms approved by the Ministry of Education and Science of Ukraine, there is a daily need for vitamin A, but in carrot pomace there is provitamin β-carotene. Recalculation has been carried out according to the ratio [5]: 1 mg of vitamin A=6 mg of β-carotene. In the calculations, the average value of the carotene and cellulose content was taken [19,22]. It has been estimated that the content of β-carotene in 100 g of bread increases by 15 times, and the content of cellulose by 3.4 times. That is why, such products should be used by elderly people in order to improve the diet and prevent age-related diseases.

Conclusions

As a result of the conducted researche, the following conclusions have been made:

1. It has been established that carrot pomace has a larger particle size, and a higher water absorption capacity than wheat flour.
2. Dried carrot pomace prolongs the formation of dough, increases gas formation in the dough and its acidity. Pomace increases the viscosity of dough, which is also due to its effect on the quantity and quality of gluten.
3. Adding 5% of dried carrot pomace does not lead to a significant deterioration of the quality characteristics of bakery products, but adding more of it results in a decrease in the specific volume of bread, a reduction in porosity, and a deterioration in its structure. Pomace slows down the process of drawing, due to high hydrophilic properties and the content of pectin.
4. Bread with the addition of 5% of pomace contains: β-carotene in the amount 5.44 mg/100, and cellulose in the amount 0.37 mg/100 g, so, when consuming 277 g of bread, it covers the daily requirement for carotene by 100% and daily fibre intake by 4.1%.

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