

The refinement of technology of macaroni products enriched with whortleberry

Tatjana Golikova, Oksana Babich

National University of Food Technologies, Kyiv, Ukraine, e-mail:

tanyayev@ukr.net

Анотація

Вступ. Досліджено використання чорниці у технології макаронних виробів з хлібопекарського борошна, що є актуальним для поліпшення харчової цінності та удосконалення асортименту макаронних виробів.

Матеріали і методи. Досліджено макаронні вироби з хлібопекарського борошна, порошок чорниці, отриманий подрібненням висушеної чорниці. Якість макаронних виробів оцінювали за комплексним показником, що включає показники варильних властивостей, органолептичні, фізико-хімічні та харчову цінність. Структурно-механічні властивості тіста оцінювали на фаринографі Брабендера. Оптимальні технологічні параметри встановлювали методом Бокса-Уїлсона.

Результати та обговорення. Макаронні вироби з внесенням чорничного порошку в кількості 5 – 10 % до маси борошна набувають фіолетового кольору, поліпшуються їх варильні властивості. Зростання дозування до 15 % призводить до підвищення кислотності та зниження міцності виробів на 30 %. Чорничний порошок зумовлює зниження вмісту клейковини та її гідратаційної здатності. Це пов'язано тим, що компоненти чорниці виявляють дегідратуючий вплив у макаронному тісті і перешкоджають біополімерам пшеничного борошна утворювати тісто. При цьому клейковина виявляє більш пружні властивості. Чорничний порошок забезпечує утворення більш дрібнокрихтуватого тіста, що зумовлює певне прискорення випресовування виробів. Встановлені оптимальні технологічні параметри для приготування макаронних виробів з чорничним порошком: дозування порошку чорниці – 4 % до маси борошна, температуру води для приготування тіста – 37 °С. Таке дозування забезпечує збагачення виробів вітаміном С у кількості 2.3 мг/100 г (у разі споживання 100 г макаронних виробів денна потреба в цьому вітаміні покривається на 2,6 %).

Висновки. Результати досліджень рекомендуються для розширення асортименту макаронних виробів, для дієтичного, вегетаріанського, дитячого харчування, а також у разі перероблення борошна, здатного до потемніння.

Ключові слова: макаронні вироби, чорниця, якість, збагачення.

Усовершенствование технологии макаронных изделий, обогащенных черникой

Татьяна Голикова, Оксана Бабич

Аннотация

Вступление. Исследовано использование черники в технологии макаронных изделий из хлебопекарной муки, что является актуальным для повышения пищевой ценности и усовершенствования ассортимента макаронных изделий.

Материалы и методы. В работе исследованы макаронные изделия из хлебопекарной муки, порошок черники, полученный измельчением высушенной черники. Качество макаронных изделий оценивали по комплексному показателю, который включает показатели варочных свойств, органолептические, физико-химические показатели и пищевую ценность. Структурно-механические свойства теста определяли на фаринографе Брабендера. Оптимальные технологические параметры определяли методом Бокса-Уилсона.

Результаты и обсуждение. Макароны с внесением порошка черники в количестве 5 – 10 % к массе муки приобретают фиолетовый цвет, улучшаются их варочные свойства. Увеличение дозировки порошка черники до 15 % приводит к повышению кислотности и снижению прочности изделий на 30 %. Черничный порошок приводит к снижению содержания клейковины и ее гидратационной способности. Это объясняется тем, что компоненты черники проявляют дегидратирующее действие в макаронном тесте и препятствуют биополимерам пшеничной муки образовывать тесто. При этом клейковина проявляет более упругие свойства. Черничный порошок обеспечивает образование более мелкокрошковатого теста, что способствует некоторому ускорению выпрессовывания изделий. Установлены оптимальные технологические параметры для приготовления макаронных изделий с черничным порошком: дозировка порошка черники – 4 % к массе муки, температура воды для приготовления теста – 37 °С. Такая дозировка обеспечивает обогащение изделий витамином С в количестве 2.3 мг/100 г (в случае потребления 100 г макаронных изделий суточная потребность в этом витамине покрывается на 2,6 %).

Выводы. Результаты исследований рекомендуются для расширения ассортимента макаронных изделий, для диетического, вегетарианского, детского питания, а также в случае использования муки, способной к потемнению.

Ключевые слова: макаронные изделия, черника, качество, обогащение.

The refinement of technology of macaroni products enriched with whortleberry

Tatjana Golikova, Oksana Babich
National University of Food Technologies, Kyiv, Ukraine

Annotation

Introduction. Using of whortleberry powder in macaroni production from bread flour was researched that is actual for the quality improving and increasing of macaroni nutritional value.

Materials and methods. Macaroni products were made from wheat baking flour and whortleberry powder. The quality of macaroni products was estimated by means of complex quality index, that includes sensorial, physical, chemical indexes as well as nutritional value. Structural and mechanical properties of dough were determined at Brabender farinograph. Optimal technological parameters were determined by Box-Wilson method.

Results and discussion. The quality of macaroni products with addition of 5 – 10 % whortleberry powder to the weight of flour have got violet color, improved cooking properties. The increasing of whortleberry dosage till 15 % effects more acidity of macaroni and lower durability on 30 %. Whortleberry powder causes decreasing of gluten content and its hydration. It is explained by fact that components of whortleberry effect dehydration of macaroni dough and prevent biopolymers wheat flour to form a dough. In this case gluten has got more elastic properties. Whortleberry powder encourages forming of small friability dough that fasten pressing of products. The optimal technological parameters have been determined, such as dosage of whortleberry powder – 4 % to the weight of flour, temperature of water for the dough kneading – 37 °C. Such dosage fortifies macaroni products with this nutrient in 2,3mh / 100 g (consumption of 100 grams of macaroni products ensures daily requirement for vitamin C by 2.56%).

Conclusion. Researched results are recommended to varying of the assortment of macaroni products from baking flour and for dietary, vegetarian and children's nutrition and in case of using of flour with enhanced ability to darkening.

Keywords: macaroni products, whortleberry, quality, enrichment.

Introduction

Macaroni products are produced at specialized food enterprises, at the restaurants by equipment of small capacity and at home. The popularity of macaroni products in restaurant enterprises increases last time due to widening of Italian cuisine in the world.

Macaroni products have a non-balanced chemical composition (oversaturated of carbohydrates, low content of macro- and micro-elements, absence of fat-soluble vitamins A and E). It causes the search of ways for enriching of macaroni products with essential nutrients [1, 2, 3, 4, 5]. Investigations of scientists concerning applying of wild raw materials (barbaris, hawthorn, blackberry, rowan, whortleberry) in the technology of nutrition appears last years [6, 7]. Wild raw material is the source of valuable bioactive nutrients – vitamins, macro- and micro-elements, food fibers that give the functional properties to the products. The wild fruits are not processed by the chemical matters in the growth period as cultivated raw materials [6].

On author opinion, using of whortleberry powder is a perspective way in increasing of nutritional value of macaroni products. Whortleberry (*Vaccinium myrtillus L.*) in dry matters contain of food fibers 12,6 g/100 g, β -carotene – 9 mg/100 g, vitamin C – 57,14 mg/100 g, macro-element Ca – 91,4mg/100 g, K – 291,4 mg/100 g, Fe – 40 mg/100 g [8]. These components are limited in macaroni products made from wheat flour. Applying of whortleberry powder in macaroni producing has not been investigated. Research of technological processes and proving of technological regimes of macaroni products with whortleberry powder producing will provide enriching of macaroni with bioactive substances and varying of assortment of macaroni made by wheat baking flour.

Methods of research

The wheat baking flour of higher grade is used as the main raw material for producing the macaroni products. The quality of the flour was characterized by the following parameters: moisture 12.5...13.0 %, content of gluten 25 ... 27 % of average quality. Whortleberry powder was obtained by grinding of dried whortleberry at the laboratory pulverizer with further scattering onto the metal sieve with sizes of opening 1 mm. Whortleberry powder had homogenic texture, dark violet colour, moisture content 12 ± 0.5 %, acidity 4.2 ± 0.2 degree, ash assay 2.3 ± 0.1 %.

Raw macaroni products were shaped as noodles and twisted goods with 100 g mass by extrusion of pressed dough via die with inserts of cuprum matrix without teflon coating at laboratory press by 10 kg/hour capacity. Dough with moisture content 33 ... 35 % was kneaded during 10 minutes, warm kneading with water of 40 ... 60 °C was used. Whortleberry powder was added in dry kind and in mixture with water in proportions of 5 %, 10 % and 15 % per weight of flour. Raw macaroni products were laid on nylon sieve cassettes and ware dried at laboratory condition with temperature 20 ± 2 °C.

Macaroni products were analyzed in 6 ... 14 days after producing. Each series of the experiments was triplicated. By measuring the basic quality factors of semi-finished and finished products, a sample sufficient for statistical processing was identified.

The organoleptic and cooking properties of the macaroni products were determined, as well as its physical and chemical quality characteristics, including moisture content, acidity and strength. Structural and mechanical characteristics of dough were determined by means of Brabender farinograph.

The structure (crumbliness) of macaroni dough samples was studied by scattering the batch onto the system of metal sieves (No. 7, 5, 3, 1) and by determining the mass of dough fractions different in size according to the methodology developed by prof. Yurchak V.G. The amount of crumbs of each dough fraction was proportioned in percentage per batch. The speed of macaroni extrusion (mm/s) was determined by measuring the length of the raw product extruded within 30 seconds. The productivity of press, kg/h, was determined by weighting the product.

The quality estimation of macaroni products was implemented by complex index [9]. This index includes estimation of organoleptic, cooking properties, physical and chemical characteristics, nutritional value of macaroni products and is calculated by 100 balls range.

For the installing of optimal technological parameters of macaroni with whortleberry powder producing the method of experimental and statistical analysis of the results has been used, including the identification of errors, calculation of regression coefficients of the mathematical model, assessment of the significance of mathematical model and verification its adequacy. The optimization of the process was performed using the Box-Wilson complex method by plan of full factor experiment 2^2 [10].

The chemical content, biological value by aminoacid content and nutritional value of macaroni products were calculated by means of integral score [11].

Results and discussions

Firstly, the effect of whortleberry powder (5 %) to the quality of macaroni products has been investigated (*table 1*). It has been installed that macaroni products with whortleberry powder get light violet colour, pleasant taste and better cooking properties: mass and volume of cooked products increases. But, passing of dry matter into cooking water increases by 0.5 %. Obviously, due to saccharides that solve in cooking water.

Totally, macaroni products with whortleberry powder had higher quality on 3 balls by complex index comparing to the products without additional raw materials.

At the further step the dosage of 10 and 15 % of whortleberry powder to the mass of flour has been investigated with the aim of maximum fortification of macaroni products with valuable bioactive substances. It was important to save the acceptable quality of macaroni products.

Table 1. Effect of whortleberry powder on the quality of macaroni products

Quality indexes	<i>Characteristics of products with the addition of whortleberry powder</i>	
	control (without whortleberry powder)	whortleberry powder, 5 % to the weight of flour
<i>Organoleptic characteristics</i>		
Colour	white	light violet
Surface	smooth, small number of cracks	
Micro-cracks	absent	
Fracture	glassy	
<i>Physical and chemical characteristics</i>		
Moisture, %	13±0.5	12±0.5
Acidity, degree	2.2±0.2	2.5±0.2
Strength, H	5.5±0.2	5.2±0.2
<i>Cooking properties</i>		

Cooking time, min.	18±1	18±1
Mass increase index, M_i	1.4±0.1	1.5±0.2
Volume increase index, V_i	1.5±0.2	1.6±0.1
The amount of dry matter passed in cooking water, %	7.0±0.2	7.5±0.3
Stickiness, shape	Retain their shape, stick in some way	Retain their shape, do not stick
Taste and odour	typical for the kind of the product	light whortleberry, free of foreign
Complex quality index	89±1	92±1

It has been installed (*table 2*), that products with 10, 15 % of whortleberry powder get strong violet colour and whortleberry taste, that do not worst the taste properties of products. However, micro-cracks appear in the structure of products and strength decreases to the 30 %. This indicates that whortleberry powder does not ensure the formation of structure products.

Table 2. Effect of whortleberry powder dosage on the quality of macaroni products

Quality indexes	<i>Characteristics of products with the addition of whortleberry powder, to the weight of flour</i>		
	Control sample	10 %	15 %
<i>Organoleptic characteristics</i>			
Colour	white	intense violet	
Surface	smooth	small number of cracks	
Micro-crack	absent		
Fracture	glassy		
<i>Physical and chemical characteristics</i>			
Moisture, %	12±0,2	12±0,5	13±0,5
Acidity, degree	2.2±0,2	4.8±0,2	6.5±0,2
Strength, H	5.4±0,3	4.2±0,2	3.9±0,3
<i>Cooking properties</i>			
Cooking time, min.	17±1	13±1	10±1
Mass increase index, M_i	1.4±0,2	1.3±0,1	1.1±0,1
Volume increase index, V_i	1.5±0,2	1.4±0,2	1.2±0,2
The amount of dry matter passed in cooking water, %	7.0±0,1	7.7±0,1	8.0±0,2
Stickiness, shape	Some stick together, form is not lost		
Taste and odour	typical for the kind of the product	light whortleberry, free of foreign	
Complex quality index	89±1	88±1	85±1

The increasing of acidity of products has been installed, in case of dosage whortleberry powder 15 % this index increases triply.

Cooking properties of products get worst, namely, products have less volume after cooking, the amount of dry matter passed in cooking water increases. As a result, complex quality index of macaroni products decreases.

However, acceptable quality of macaroni products is characterized in case of dosage 5 % of whortleberry powder. Further increasing of dosage has a negative effect to the quality of macaroni products – acidity increases; cooking properties are getting worst, strength decreases.

The quality of gluten, structural and mechanical processes, friability of macaroni dough and parameters of pressing have been researched to prove the mechanism of influence of additional raw materials to the processes of dough and products forming, structure of dough.

The gluten research was implemented with dosage of whortleberry powder 5 and 10 % to the weight of flour (*table 3*). It was found that whortleberry powder provides a reduction of gluten and its dehydration ability. This gluten reveals more elastic properties in terms of extensibility and compression device DDG-1. Obviously, whortleberry powder and flour proteins compete for water absorption in the dough. As a result of more coarse dispersiveness fiber whortleberry powder prevents swelling protein wheat flour for gluten formation.

Table 3. Effect of whortleberry powder to the quality indexes of gluten

Indexes	<i>Dosage of whortleberry powder</i>		
	Control sample	5%	10%
Content of raw gluten,% to the weight of flour	25.4±0,2	24.6±0,2	21.2±0,2
Content of dry gluten, %	8.4±0,1	8.6±0,2	7.9±0,1
Humidity of gluten, %	67.0±0,5	64.8±0,5	62.6±0,5
Hydrating ability of gluten,% the weight of dry gluten	203±2	184±2	167±2
Colour	Light	dark, violet	dark, violet
Extensibility, cm	19±1	17±1	16±1
Elasticity	Extensible	extensible	extensible
Elasticity of gluten, unit of device DDK	73,6±0,2	64,7±0,3	45,8±0,2

The study of structural and mechanical properties of the dough carried on with whortleberry powder in dry form in an amount of 5 and 10% by weight of flour.

Results of farynohrams (*Fig. 1, Table. 4*) show that the addition of whortleberry powder practically has no influence on the water absorbing ability of dough.

The duration of formation dough, in other words, time during which the value of consistency investigated dough reaches its maximum, increases with the addition of whortleberry powder.

Sustainability (stability) of dough, which characterizes the duration of preservation macaroni the maximum level of consistency in the mixing, not typical for all samples. However, the degree of dilution of dough, which is characterized by the difference between the maximum reached during mixing texture and consistency in the final mixing time, increases with increasing dosage of whortleberry powder. Evaluation based on farinogram reduced. This indicates that the components of whortleberry powder detect dehydrating effect in the macaroni products dough and prevent biopolymers wheat flour to form a dough.

Table 4. Farinogram indexes of dough with whortleberry powder

Indexes	Without additional raw materials	with 5% whortleberry powder	with 10% whortleberry powder
Watersorbing capacity, $\text{sm}^3/100 \text{ g}$	59.6-56.4	59.8-56.6	59.4-56.2
Time of dough forming, min.	2.5	3	5
Stability, min.	0	1	0
Rarefaction for mixing, unit of device	35	165	180
Evaluation based on farinogram, units of device	52	42	48

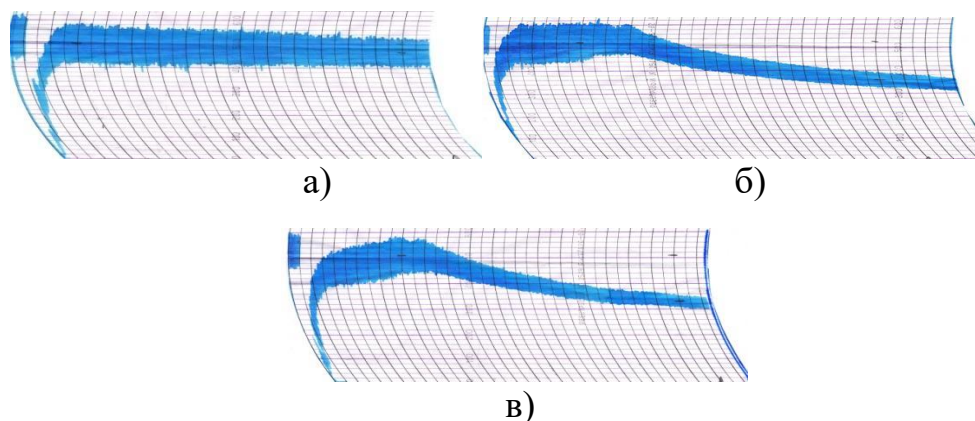


Fig. 1. Farinograms of macaroni products dough: a) no additional material (control); b) adding of a 5% whortleberry powder; c) adding of 10% whortleberry powder

Results of studying of friability of macaroni products dough established (Fig. 2), that whortleberry powder provides formation more small friability dough: increasing mass fractions of crumbs with size of 3-5 mm and greater than 1 mm, and weight decreased of largest fraction in case of increasing the dosage of whortleberry powder.

Growth of pressing parameters of macaroni dough with whortleberry powder has been established (Fig. 3). Thus, adding of whortleberry powder in an amount of 5

- 10% by weight of flour increases the speed and productivity of extrusion press due to the formation dough with crumbs to the size that best fill the screw turns. This is positive as it allows to get more production per unit of time.

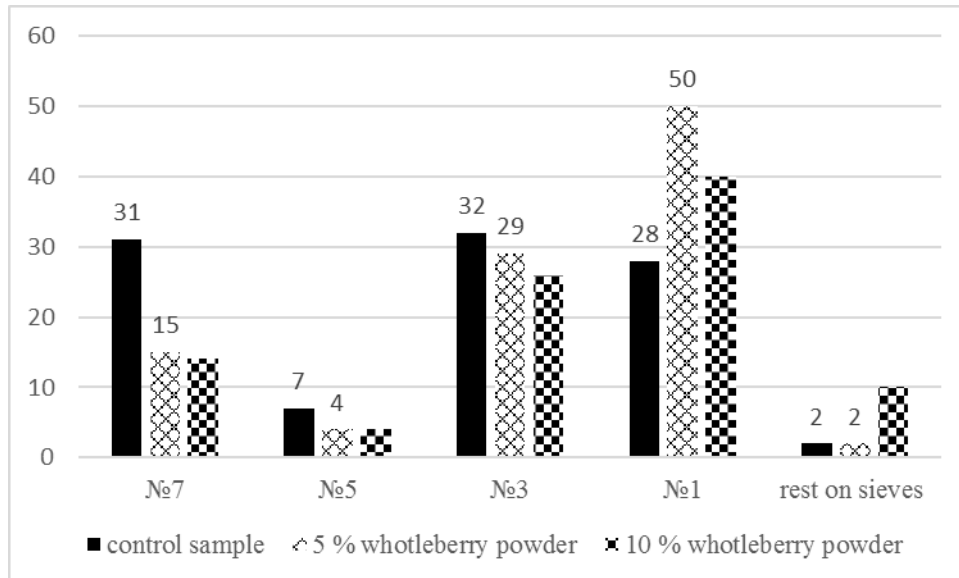


Fig. 2. Effect of whortleberry powder to the macaroni products dough friability

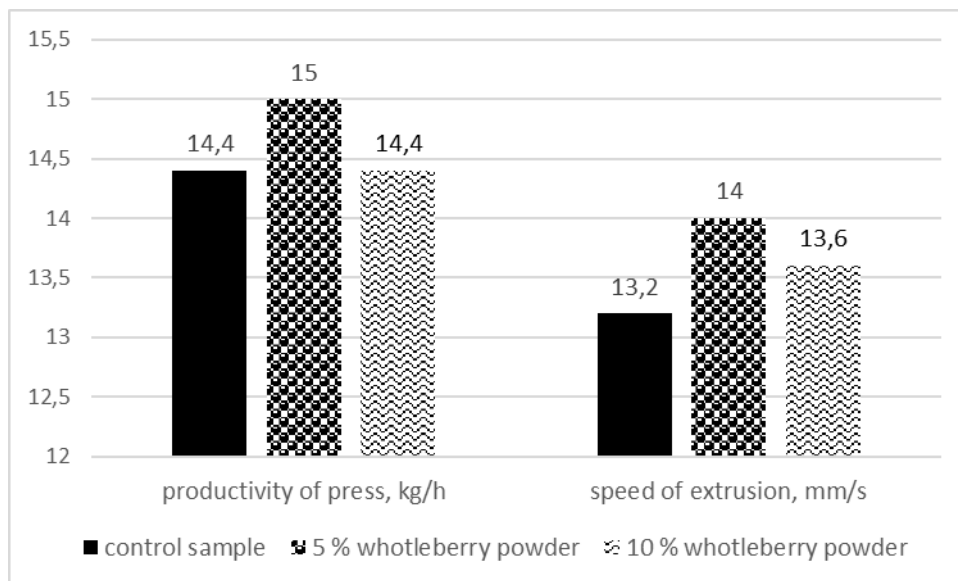


Fig. 3. Effect of whortleberry powder extrusion parameters macaroni products

The full factorial experiment FFE 2² has been implemented for studying the compatible influence of technological factors on the quality of semi-finished and finished products and determining of optimal process parameters of macaroni dough producing.

The dosage of whortleberry powder, which has found in one factor experiment, requires clarification of the interaction of other technological factors. Therefore, quantity of whortleberry powder and water temperature for dough kneading were selected as the factors for optimization of products. Quantity of whortleberry powder changed in the range of 4 - 12%, water temperature – from 33 till 55 °C based on

obtained preliminary results. Complex quality of macaroni products index has chosen as an optimality criterion.

Processing of experimental data using correlation regression analysis allowed getting the regression equation in a coded expression (1), which describes the dependence of the original function of the studied variables.

$$Y = 89,25 - 1,8 \cdot X_1 + (-2,37 \cdot X_2) \quad (1)$$

when X_1 – adding of whortleberry powder; X_2 – temperature water mixture.

The analysis of mathematical dependences for complex quality in coded form allows to conclude that the effect of the studied variables on the original function and to quantify this impact. Reduction of whortleberry powder dosage and temperature of water increases the complex quality.

Processing of experimental data has been performed using FFE 2ⁿ, which was created in programming environment Borland Delphi v 6.0. Materiality regression coefficients have been estimated by Student's test, the adequacy of the resulting mathematical model has evaluated by Fisher criterion, the estimated value of which was 5.9.

The optimal values of technological parameters: whortleberry powder dosing - 4%, the water temperature for kneading - 37 ° C, providing maximum value complex quality - 94.5 points have been installed as a result of building the program "steep climb" and the implementing of experiment. These parameters were the basis for developing of technological instructions and recipes for making of macaroni products with whortleberry powder.

According to calculations, the nutritional value of macaroni products found that growth of macronutrients content compared to products without additional materials is negligible increases in fiber and carbohydrates. However, carbohydrates of whortleberry are presented by mono- and disaccharide that is digestible carbohydrates. As a result, the energy value of macaroni products is falling.

Analyzing mineral composition of macaroni products found that they increased with potassium, calcium, phosphorus and iron. Iron contained in whortleberries, is better absorbed due to content of ascorbic acid in whortleberries [12].

Taking to the attention fact that macaroni products without additional raw does not content vitamin C, products with 4% whortleberry powder fortified with this nutrient in 2,3mh / 100 g, which the consumption of 100 grams of macaroni products daily requirement for vitamin C is ensured by 2.56%.

Conclusion

The feasibility of using whortleberry powder in producing of macaroni products has been installed based on experimental data.

Adding of powdered whortleberries has positive effect on the quality of macaroni products in particular 5% whortleberry powder become violet, cooking properties improve, such as the weight and volume increases, except of it, products with whortleberry powder with higher integral index for mineral and vitamins.

The increasing of dosage of whortleberry powder - 10 and 15% by weight of flour has been investigated. Deterioration of quality of macaroni products with 15% whortleberry powder for organoleptic and cooking properties has been established.

The effect of additional raw materials to the quality of gluten and structural and mechanical properties of dough found that whortleberry powder components detect dehydrating effect on the structure of the macaroni products dough and prevent biopolymers flour to form a dough.

Whortleberry powder promotes formation of small friability of dough that encourages growth of pressing parameters of macaroni products.

Optimal parameters of macaroni making with whortleberry powder, namely the amount of powder - 4% by weight of flour, water temperature for the dough – 37 °C have been set on experimental and statistical modeling. The resulting figures have been included to technical and technological documentation for macaroni products with whortleberry powder.

As the whortleberry powder gives the product purple colour, so it should be used for production of flour with enhanced ability to darkening.

So increasing of nutritional value of macaroni products using whortleberry powder has a social effect. These products are made from domestic raw materials, indicating the stability of raw materials. This will help diversify domestic macaroni products, especially dessert group, and enhance their competitiveness. Such products can be offered in the diet, vegetarian, children's menu at the restaurant establishments.

References

1. Dinkci Nayil (2016). Alternative source for dietary fibre and phenolic compounds // 8th Central European Congress on Food 2016 — *Food Science for Well-being (CEFood 2016): Book of Abstracts*. — 23-26 May 2016. — K.: NUFT, 2016. - p. 76.
2. Nuno B. Alvarenga, Elsa Borralho, Hugo Escola, Samuel André, Teresa Carola, Carlos M. Ribeiro, Joyo M. Dias, Magda S. Taipina, Leda C.A. Lamardo, Simone C. Balian, J.S.B. Canada (2011). Sensory Properties of Macaroni with and without Green Banana Pulp and the Application of 60 Cobalt Ionizing Radiation // *Procedia Food Science*, Vol. 1, P. 1987-1991.
3. C.M. Ajila, M. Aalami, K. Leelavathi, U.J.S. Prasada Rao (2010). Mango peel powder: A potential source of antioxidant and dietary fiber in macaroni preparations // *Innovative Food Science & Emerging Technologies*, Vol. 11, Issue 1, p. 219-224.
4. Emine Nur Herken, Şenol İbanoğlu, Mehmet D. Öner, Nermin Bilgiçli, Salih Güzel (2007). Effect of storage on the phytic acid content, total antioxidant capacity and organoleptic properties of macaroni enriched with cowpea flour // *Journal of Food Engineering*, Vol. 78, Issue 1, p. 366-372.
5. İlkay Pınarlı, Şenol İbanoğlu, Mehmet D. Öner (2004). Effect of storage on the selected properties of macaroni enriched with wheat germ // *Journal of Food Engineering*, Volume 64, Issue 2, p. 249-256.

6. Базарнова Ю. Дикорастущие ягоды в кондитерском производстве // Хлібопекарська і кондитерська промисловість України. – 2012. – №11. – С.17-19.
7. Katarzyna Skupien (2006). Evaluation of chemical composition of fresh and frozen whortleberry fruit (*Vaccinium corymbosum* L.) // *Acta Sci. Pol., Hortorum Cultis*, 5 (1), p. 19 – 25.
8. Dubravka J. Jambrec, Mladenka V. Pestorić, Đorđe B. Psodorov, Marijana B. Sakač, Nataša M., Nedeljković, Anamarija I. Mandić, Ivana J. Sedej (2011). Instrumental and sensory properties of buckwheat flour macaroni products // *Food and Feed Research*, Vol. 38, p. 45 – 50.
9. Євсеєнко Т.П., Юрчак В.Г. (2006). Проаналізуємо енергетичну, харчову й біологічну цінність макаронних виробів // *Хлібопекарська і кондитерська промисловість України*, № 5. – С. 13–15.
10. Demiz Aksten (2007). Application of Box-Wilson experimental design method for the solar photocatalytic degradation of textile dyestuff, 16 p.
11. Alice Chen, Penelope Gilbert, Santosh Khokhar (2009). Estimating the nutrient composition of South Asian foods using a recipe calculation method // *Food Chemistry*, Vol. 113, Issue 3, p. 825 – 831.
12. Хомич Г.П., Капрельянц Л.В. (2010). Вплив попередньої обробки ягід чорниці на вміст флаваноїдів у соку // *Наукові праці ОНАХТ*. – Випуск 28, том 2. – Одеса, с. 4 - 7.

Авторська довідка

Тетяна Петрівна Голікова

Доцент кафедри технології харчування та ресторанного бізнесу, к.т.н.

Національний університет харчових технологій

ел. адреса: tanyayev@ukr.net

тел. 067 316 44 36

Оксана Вікторівна Бабіч

Асистент кафедри технології хлібопекарських і кондитерських виробів, к.т.н.

Національний університет харчових технологій

ел. Адреса: yeliseyeva2008@ukr.net

тел. 068 350 31 45