ХАРЧОВІ ТЕХНОЛОГІЇ

DOI https://doi.org/10.32782/2220-8674-2025-15-2-33
UDC 664.68:634.36(477.62)

Iu. A. Goriainova, PhD in Tech. Sci., As. Prof. ORCID: 0000-0003-1228-7793
O. O. Simakova, PhD in Tech. Sci., As. Prof. ORCID: 0000-0002-4432-8337
Kryvyi Rih National University, Mykhailo Tugan-Baranovsky Educational and Scientific Institute of Economics and Trade
e-mail: goryaynova@donnuet.edu.ua

STUDY OF THE INFLUENCE OF WHITE AND BLACK MULBERRY ADDITIVES ON THE STATE OF THE PROTEIN-PROTEINASE COMPLEX OF WHEAT FLOUR

Summary. The work is devoted to the study of the chemical composition of black and white mulberry fruits of the Donetsk region, as well as the study of the influence of fruit powder additives on the state of the protein-proteinase complex of wheat flour. The ash content, moisture content, simple and complex carbohydrates, ascorbic acid, carotene, fiber, and the content of ions of some important metals were determined in these samples. The indicators of the quantity and quality of wheat flour gluten in the presence of additives were established. The properties of gluten were determined by its spreading and the strength of wheat flour by the structural and mechanical properties of the dough in the presence of additives. It was established that black and white mulberry additives in concentrations of 1…1.5 % do not reduce the quality of wheat flour in terms of its technological properties.

Keywords: ash content, moisture, carbohydrates, ascorbic acid, carotene, fiber, gluten, dough spreading.

Statement of the problem. Complex processing of plant raw materials, especially local ones, remains always relevant. It is this raw material that is able to enrich the mineral and vitamin composition of food products, improve their organoleptic properties.

Recently, many products have been created using various food additives that improve their quality, biological, nutritional and consumer value. Powders from plant fruits are of particular importance in this direction – this is a concentrate of fruit pulp containing a large number of biologically active substances. The advantage of powders is their good regenerability when adding water, ease of mixing with other recipe components, low moisture content, which slows down microbiological processes in their mass, powders are easily transported and stored in airtight containers for quite a long time. This makes them very technological for enriching various culinary products with vitamins, organic acids, antioxidants, pectins in order to give them special functional properties.

At the same time, preference is given to substances of natural origin, which are contained, in particular, in plant raw materials and do not cause side effects on the human body. Therefore, the use of wild fruits, which are widely distributed in different regions and have a valuable chemical composition, is quite promising. Also, the introduction of additives obtained from wild raw materials into traditional food formulations allows not only to fully use the valuable chemical composition of plants, but also to obtain cheap, accessible raw materials and, thus, to expand the raw material base for the food technology industry [1; 2].

Analysis of recent research. The most promising direction for expanding the range of flour products is currently considered to be the integrated use of non-traditional raw materials – various products, mainly of plant origin with a complete chemical composition, containing biologically active substances.

The Kharkiv State Biotechnological University is working on the issue of using non-traditional plant raw materials in cracker technology, namely, powder of medicinal plants: licorice, yarrow, and St. John's wort. The concentrations of medicinal plant raw materials for the production of crackers have been scientifically substantiated, quantitative changes in physiological and functional ingredients in crackers with the addition of infusions of these plants have been established, and the feasibility of using this plant raw material to give crackers functional properties has been proven [3].

The Department of Hotel and Restaurant Business of the Kyiv National University of Culture and Arts is studying the possibility of using carrot puree and pumpkin seed oil in the preparation of flour confectionery products [4]. Scientists have developed a technology for the production of such products, studied their nutritional value and developed regulatory documentation for flour confectionery products. It has been established that the introduction of carrot puree and pumpkin seed oil into the technology for the preparation of flour confectionery products improves the nutritional value of the products.

Teachers of the Kyiv State University of Trade and Economics are conducting scientific research on the use of a mixture of dietary fiber and pumpkin seed meal in the technology of flour confectionery production to expand the range of confectionery products with increased biological value and products with a reduced calorie level [5]. Scientists have proven that adding a mixture of dietary fiber and pumpkin seed meal to the composition of cookies positively affected the chemical composition of the finished product, saturating it with useful and necessary mineral elements, vitamins, and dietary fiber for the human body.

The influence of herbal additives on the quality indicators of gingerbread is the subject of scientific research by the teachers of the Department of Technology and Organization of Restaurant Management of the Kyiv State University of Trade and Economics [6]. They substantiate the feasibility of using cedar meal, sesame flour, and phytopowder from snake gourd in gingerbread technologies. In finished products with additives, moisture, alkalinity, dependence of ultimate shear stress, and dependence of wetting of gingerbread on the content of herbal additives were determined, and a sensory evaluation of the organoleptic indicators of finished products was carried out.

Drobot V. I. and colleagues are studying the effect of flax seed meal on the quality of bread when it is included in the recipe [7]. A group of researchers led by Kalakura M. M. substantiated and developed a technology for using apple powder for the production of fruit biscuits, gingerbread and decorative semi-finished products [8].

At the Mykhailo Tugan-Baranovsky Educational and Scientific Institute of Economics and Trade of Kryvyi Rih National University, the Department of Technologies in Restaurant Management, Hotel and Restaurant Business and Tourism is conducting research on the use of purple amaranth, chokeberry and common mountain ash, and beer grains additives in the technology of flour confectionery products [9; 10; 11]. It has been proven that these additives have a positive effect on the baking properties of wheat flour and the quality of fat in these products, and improve the mineral composition of finished products.

One of the types of plant raw materials, which, in our opinion, can be used for the production of products with specified properties, are mulberry fruits of different varieties and different regions of Ukraine.

Analysis of literary sources shows that mulberry fruits contain vitamins B_1, B_2, C, PP, carotene, flavonoids, organic acids, pectin, coloring, tannins, iron ions, a large number of carbohydrates, including glucose, fructose, sucrose [12].

Formulation of the purpose of the article (task statement). The task of this article is to study the chemical composition of black and white mulberry fruits of the Donetsk region, comparative analysis, and also to identify the influence of powders from dried fruits on the state of the protein-proteinase complex of wheat flour.

Main part. In order to use mulberry as a food additive for the production of products with specified properties, we obtained the corresponding powders from dried black and white mulberry fruits. The ash content, moisture content, simple and complex carbohydrates, ascorbic acid, carotene, and fiber were determined in these samples by standard methods (Table 1).

Table 1

Chemical composition of mulberry fruit powders

Sample	Total moisture, %	Ash content, %	Ascorbic acid, mg/100g	Carotene, mcg/g	Simple carbohydrates %	Complex carbohydrates %	Fiber, %
Black mulberry	13.56 ± 5.42	7.18 ± 0.29	170.33 ± 6.81	0.39 ± 0.02	36.15 ± 1.45	37.53 ± 1.50	9.82 ± 0.39
White mulberry	12.75 ± 0.51	6.28 ± 0.25	80.08 ± 3.20	0.39± 0.02	36.33 ± 1.45	36.68 ± 1.47	8.42 ± 0.34

According to Table 1, black mulberry prevails in terms of mineral content (ash content), ascorbic acid, complex carbohydrates and fiber; the carotene content in white and black mulberry coincides and is equal to 0.39 mcg/g. In addition, in the analyzed samples of black and white mulberry, we determined the content of ions of some important metals by atomic absorption method (Table 2).

Table 2

The content of ions of some metals in the fruits of white and black mulberry

Sample	Content, mg/100 g of dry raw material						
	K	Na	Ca	Mg	Fe	Cu	Zn
Black mulberry	4,045.7 ± 121.4	173.2 ± 5.2	291.3 ± 8.7	395.8 ± 11.9	107.1 ± 3.2	1.2 ± 0.03	2.6 ± 0.1
White mulberry	2179.1 ± 65.4	156.7 ± 4.7	262.5 ± 7.9	356.8 ± 10.7	79.7 ± 2.4	0.9 ± 0.03	2.2 ± 0.01

Comparative analysis of different varieties of mulberry in the Donetsk region shows that black fruits prevail over white ones in terms of the content of all metal ions that have been identified. The rich mineral composition of the research objects allows us to conclude that white and black mulberries can be used as food additives in the production of products with specified properties, namely products for medical and prophylactic purposes.

The next stage of our research was to study the effect of white and black mulberry additives on the properties of wheat flour, which is the main recipe component of flour confectionery products. After all, the effect of new additives on wheat flour affects both the quality of the semi-finished product and the quality of the final product.

It is known that the formation of structural and mechanical properties of dough depends on gluten proteins – gliadin and glutenin. Considering the features of the chemical composition of white and black mulberry powders, which was determined by us earlier, we can assume their influence on the state of the protein-proteinase complex of wheat flour. This influence was judged by the properties of flour gluten, namely its quality and quantity, its ability and the dough ball to spread.

In this series of experiments, wheat flour was used, the gluten of which was characterized as good, of the 1st quality group. We selected a research interval of concentrations of powders from white and black mulberry fruits from 1 to 5 % by weight of wheat flour. The indicators of the quantity and quality of gluten of wheat flour of the same batch without additives were used as controls (Table 3).

 ISSN 2220-8674

The results of experimental studies showed that the introduction of powder from white and black mulberry fruits in an amount of 1…1.5 % does not significantly affect the amount of raw and dry gluten and the ability of gluten to stretch compared to the control sample.

Table 3

Evaluation of the quantity and quality of wheat flour gluten

Sample	Gluten content, %		Gluten quality indicators		
	raw	dry	color	elasticity	extensibility, cm
Control	26.0 ± 1.0	13.6 ± 0.5	light cream	good	12.0 ± 1.0 (average)
1% black mulberry	24.0 ± 1.0	12.0 ± 0.5	gray-blue	good	14.0 ± 1.0 (average)
1% white mulberry	25.4 ± 1.0	11.4 ± 0.5	cream	good	13.5 ± 1.0 (average)
1.5% black mulberry	25.2 ± 1.0	15.4 ± 0.5	dark gray	good	12.5 ± 1.0 (average)
1.5% white mulberry	25.4 ± 1.0	11.9 ± 0.5	dark cream	good	14.0 ± 1.0 (average)

Increasing the concentration of the additive to 3…5 % led to the fact that the dough frame was not formed at all, the gluten in this case could not be washed. Therefore, at this stage of the research it was determined that to preserve the quality of wheat flour gluten, it is advisable to use additives of powders from mulberry fruits in concentrations from 1 to 1.5 %.

Next, the properties of gluten were determined by its spreading using a method based on observing the change in the diameter of two gluten balls weighing 5 g each during 60 min of aging at a temperature of 30 °C. Spreading is characterized either by the value of the ball diameter D_{60}, or by the change in diameter compared to the initial $\Delta D = D_{60} - D_0$. The results of the studies are given in Table 4.

Table 4

Determining gluten properties by its spreading

Sample	Average ball diameter of two gluten samples, mm			
	initial, D_0	in 60 minutes, D_{60}	$\Delta D = D60 - D_0$	Conclusion on gluten quality
Control	24.3 ± 0.9	28.0 ± 1.1	3.7 ± 0.2	Strong
1% black mulberry	24.3 ± 0.9	30.0 ± 1.2	5.7 ± 0.2	Strong
1% white mulberry	23.8 ± 0.9	26.8 ± 1.1	3.0 ± 0.1	Strong
1.5% black mulberry	26.5 ± 1.1	28.8 ± 1.1	3.3 ± 0.1	Strong
1.5% white mulberry	23.5 ± 0.9	29.3 ± 1.2	5.8 ± 0.2	Strong

The experimental data obtained indicate that the sample with 1 % white mulberry addition is characterized by the least spreading of the gluten ball. It should also be noted that the gluten of all the samples studied is characterized as strong.

The strength of wheat flour was also determined by the structural and mechanical properties of the dough in the presence of black and white mulberry powders using a method based on observing the change in the diameter of a dough ball D_{180} weighing 100 g during its aging at a temperature of 30 °C for 180 min. The results obtained are presented in Table 5.

It was found that the dough balls with white mulberry powder additives changed their diameter almost as much as the control sample within 180 min, while the dough balls with black mulberry additives changed their diameter by approximately 13.8–20.8 % more than the control. All samples with additives according to the strength of wheat flour are considered strong.

Conclusions. The results of the conducted studies to determine the influence of white and black mulberry fruit powders on the state of the protein-proteinase complex of wheat flour indicate that additives in concentrations of 1…1.5 % do not reduce the quality of wheat flour in terms of its

Table 5

Determining the strength of wheat flour by spreading a ball of dough

Sample	Average ball diameter of two dough samples, mm					
	initial, D_0	in 60 minutes, D_{60}	in 120 minutes, D_{120}	in 180 minutes, D_{180}	$\Delta D = D_{180} - D_0$	Conclusion on gluten quality
Control	59.5 ± 2.4	63.4 ± 2.5	69.5 ± 2.8	74.0 ± 3.0	14.5 ± 0.6	Strong
1 % black mulberry	55.8 ± 2.2	63.5 ± 2.5	69.3 ± 2.8	73.3 ± 2.9	17.5 ± 0.7	Strong
1 % white mulberry	58.3 ± 2.3	63.8 ± 2.5	68.8 ± 2.7	73.3 ± 2.9	15.0 ± 0.6	Strong
1.5 % black mulberry	56.0 ± 2.3	65.5 ± 2.6	68.8 ± 2.7	72.5 ± 2.9	16.5 ± 0.7	Strong
1.5 % white mulberry	59.3 ± 2.4	68.3 ± 2.7	69.8 ± 2.8	73.8 ± 2.9	14.5 ± 0.6	Strong

technological properties. This gives grounds to use them in the technologies of confectionery flour products in order to increase the biological value of the latter.

Prospects for further research in this direction are to study the influence of additives of black and white mulberry powders of the Donetsk region on the state of the carbohydrate-amylase complex of wheat flour, as well as on the state of fat – the second recipe component of flour confectionery products.

Bibliography

1. Лозова Т. М., Сирохман І. В. Наукове обґрунтування поліпшення споживних властивостей борошняних кондитерських виробів з використанням природної нетрадиційної сировини : монографія. Львів : ЛТЕУ, 2017. 328 с.

2. Lozova T. Modern approaches improve consumer properties and quality of confectionery products with consideration of their security / Lozova T., Syrohman I., Reshetylo L. Sciences of Europe (Praha, Czech Republic). *Technical sciences*. 2020. No. 47. Vol. 1. P. 50–56.

3. Черевична Н. І., Скирда О. Є., Симоненко В. І. Розробка нових видів крекерів з нетрадиційною рослинною сировиною. *Молодий вчений*. 2017. № 2 (42). С. 220–224.

4. Завадинська О. Ю. Технологія борошняних кондитерських виробів оздоровчого призначення. Траєкторія науки www.pathofscience.org. *Міжнародний електронний науковий журнал*. 2016. № 4 (9). Розділ «Виробництво та технології». С. 3.1–3.5. ISSN 2413-9009.

5. Бачинська Я. Використання нетрадиційної сировини при виробництві борошняних кондитерських виробів як прогресивний напрямок створення продуктів підвищеної біологічної цінності. Traektoriâ Nauki. www.pathofscience.org. *International Electronic Scientific Journal*. 2017. Т. 3, № 2. Section "Technics". С. 7.1–7.10. DOI: 10.22178/pos.19-11

6. Кравченко М. Ф., Ярошенко Н. Ю. Дослідження впливу вмісту рослинних добавок на показники якості пряників. *Східно-Європейський журнал передових технологій*. 2017. № 5/11 (89). С. 45–54. DOI: 10.15587/1729-4061.2017.110168

7. Дробот В., Іжевська О., Бондаренко Ю. Шрот насіння льону в технології хлібобулочних виробів. *Харчова наука і технологія*. 2016. № 10 (3). С. 76–81. doi.org/10.15673/fst.v10i3.183

8. Калакура М. М., Ратушенко А. Т., Бублик Г. А. Оптимізація якості кондитерських виробів із використанням яблучного порошку. *Технологічний аудит та резерви виробництва*. 2016. № 3/3 (29). С. 12–17. DOI: 10.15587/2312–8372.2016.70976

9. Simakova O., Korenets Yu., Yudina T., Nazarenko I., Goriainova Iu. Examining a possibility of using purple amaranth in the technology for products made of yeast dough. *Eastern-European Journal of Enterprise Technologies*. 2018. Vol. 2. Issue 11 (92). P. 57–64. DOI: 10.15587/1729-4061.2018.127173

10. Korenets Y., Goriainova I., Nykyforov R., Nazarenko I., Simakova O. Substantiation of feasibility of using black chokeberry in the technology of products from shortcake dough. *Eastern-European Journal of Enterprise Technologies*. 2017. Vol. 2. Issue 10 (86). P. 25–31. DOI: 10.15587/1729-4061.2017.98409

11. Назаренко І. А., Горяйнова Ю. А., Боднарук О. А., Світлична О. О. Дослідження якості бубликів ванільних із використанням борошна з пивної дробини. *Праці ТДТАУ*. 2020. Вип. 20. Т. 2. С. 175–185. DOI: 10.31388/2078-0877-20-2-175-185

12. Олексійченко Н. О. Генофонд шовковиці в Україні та перспективи його використання : монографія / Н. О. Олексійченко, О. В. Галанова. Київ : ННЦ «Ін-т аграр. Економіки», 2008. 140 с.

Стаття надійшла до редакції 2.10.2025
Стаття прийнята 10.11.2025
Статтю опубліковано 22.12.2025

Ю. Горяйнова, О. Сімакова
Криворізький національний університет
ННІ економіки і торгівлі імені Михайла Туган-Барановського

ВИВЧЕННЯ ВПЛИВУ ДОБАВОК БІЛОЇ ТА ЧОРНОЇ ШОВКОВИЦІ НА СТАН БІЛКОВО-ПРОТЕЇНАЗНОГО КОМПЛЕКСУ ПШЕНИЧНОГО БОРОШНА

Анотація

Роботу присвячено дослідженню хімічного складу плодів чорної та білої шовковиці Донецького регіону, його порівняльному аналізу, а також вивченню впливу добавок порошку з плодів на стан білково-протеїназного комплексу пшеничного борошна. Було встановлено в цих зразках зольність, вміст вологи, простих і складних вуглеводів, аскорбінової кислоти, каротину, клітковини стандартними методиками. Атомно-абсорбційним методом визначено вміст іонів деяких важливих металів у зразках білої та чорної шовковиці. Встановлені показники кількості (вміст сухої та сирої клейковини) та якості (колір, еластичність, розтяжність) клейковини пшеничного борошна в присутності добавок. Визначено властивості клейковини за її розпливанням та силу пшеничного борошна за структурно-механічними властивостями тіста в присутності порошків із висушених плодів білої та чорної шовковиці. Результати досліджень свідчать, що добавки чорної та білої шовковиці у концентраціях 1…1,5 % не знижують якіості пшеничного борошна щодо його технологічних властивостей. Збільшення концентрації добавок білої та чорної шовковиці до 3…5 % призводить до того, що зовсім не формується каркас тіста, клейковину в цьому випадку неможливо було відмити. Встановлено, що найменшим розпливанням кульки клейковини характеризується зразок з 1 % добавки білої шовковиці. Кульки тіста з добавками порошку білої шовковиці протягом 180 хв змінили діаметр, практично як і контрольний зразок, тоді як кульки тіста з добавками чорної шовковиці – приблизно на 13,8–20,8 % більше за контрольний. Клейковина всіх зразків, що досліджувалися, характеризується як сильна.

Ключові слова: зольність, вологість, вуглеводи, аскорбінова кислота, каротин, клітковина, клейковина, розпливання тіста.