UDC 663.92:633.8

TECHNOLOGICAL FEATURES OF CAROB POWDER OF DIFFERENT DEGREES OF ROASTING

O. Samokhvalova, O. Shydakova-Kameniuka, M. Labazov

It has been established that with an increase in the degree of roasting of the Carob powder, its moisture content decreases, its fat-retaining and water-holding properties deteriorate, the color becomes darker. It is recommended to use carob powder of the maximum degree of roasting – Carob dark in order to replace cocoa powder, which is due to its maximum proximity to natural cocoa powder in terms of color. By the way, this sample has similar moisture content to cocoa powder, which will not require significant adjustments to the recipes for dry matter. It is promising to study the possibility of using carob powder in technologies of fat-containing confectionery due to higher fat-retaining properties of carob powder compared to cocoa.

Keywords: *carob, cocoa powder, chromaticity, confectionery.*

ТЕХНОЛОГІЧНІ ОСОБЛИВОСТІ ПОРОШКУ КЕРОБУ РІЗНОГО СТУПЕНЯ ОБСМАЖЕННЯ

О. Самохвалова, О. Шидакова-Каменюка, М. Лабазов

Однією із сучасних тенденцій розвитку харчової галузі, зокрема кондитерської промисловості, є пошук нових сировинних ресурсів. Останнім часом усе більшої популярності набуває використання в технологіях кондитерських виробів нетрадиційних інгредієнтів рослинного походження. Зокрема, потенційну привабливість для харчової промисловості мають плоди ріжкового дерева – керобу. Через відмінності в хімічному складі й функціональних властивостях м'якоть і насіння керобу мають різні напрями використання. Насіння застосовують для виробництва камеді, що переважно використовується як стабілізатор у різноманітних харчових системах, фармацевтичних препаратах, косметиці тощо. М'якоть (carob pulp), що залишилася після видалення насіння, підлягає тепловій обробці з подальшим подрібненням. Отриманий порошок широко використовується в різних галузях харчової промисловості для заміни какао-порошку та як підсолоджувач.

Нами проведено вивчення технологічних особливостей порошку керобу різного ступеня обсмаження (carob dry, carob light, carob medium, carob dark) порівняно з натуральним порошком какао. Установлено, що з підвищенням ступеня обсмаження порошку керобу зменшується його вологість, *погіршуються жироутримувальні та жироемульгувальні властивості. Порошок какао за значенням водоутримувальної здатності суттєво перевершує всі дослідні зразки керобу, однак характеризується значно меншою здатністю до утримування жирів. Для заміни порошку какао рекомендовано використовувати порошок керобу найбільшого ступеня обсмаження – Carob dark, що зумовлено його максимальною наближеністю до натурального какао-порошку за ознаками кольору. Також цей зразок має близьке до порошку какао значення вологості, завдяки чому не потрібне суттєве корегування рецептур за сухими речовинами. Зважаючи на більш високі жироутримувальні властивості порошку керобу порівняно з какао, перспективним є дослідження можливості його використання в технологіях жировмісних кондитерських виробів.*

Ключові слова: *кероб, какао-порошок, кольоровість, кондитерські вироби.*

Statement of the problem. One of the current trends in the food industry, including the confectionery industry, is the search for new raw materials. The interest of producers is directed towards raw materials with high biological value, the presence of functional and technological properties, low cost, etc. Particular attention is paid to analog raw materials – that is, ones that allow you to replace recipe components with high cost without compromising the quality of the final finished product [1]. Recently, the use of non-traditional ingredients of plant origin in confectionery technologies is becoming increasingly popular. In particular, the carob beans, *Seratonia siliqua*, are of potential attractiveness for the food industry. This tree grows in semi-arid conditions in the Mediterranean region and has an annual global production of around 310 000 tons [2]. Carob beans are dark brown pods (carob), which consist of pulp (90%) and seeds (10%). However, due to differences in chemical composition and functional properties, the pulp and seeds of carob have different uses [3]. The seeds are used for the production of gum (food additive E410), which is mainly used as a stabilizer in various food systems (yogurts, mayonnaise, hard cheeses, candies, etc.), pharmaceuticals, cosmetics, etc. [4].

The flesh (carob pulp) remaining after removal of seeds is subject to heat treatment with the subsequent crushing. Consequently, powder is obtained that is also a promising target for the food industry nowadays.

Review of the latest research and publications. The safety of carob powder for humans has been confirmed by the US Food and Drug Administration (FDA). According to its conclusion, this product belongs to the class GRAS - Generally recognized as safe [5]. The relevance of the use of carob powder in food technology is largely justified by the peculiarities of its chemical composition and taste characteristics. In particular, it contains dietary fiber and vitamins (A, E, D, B_2, B_6, B_{12}, C), macro- and microelements (Ca, P, K, Mg, Na, Fe, Cu, Zn), polyphenolic compounds and other useful nutrients in quantities that are significant for the human body [4; 5]. This determines the prospects for using carob in order to improve dietary intake. In addition, it contains a significant amount of mono- and disaccharides, which give the powder a sweet taste. As a result, the use of this additive in confectionery technology will reduce the recipe sugar content. A distinctive feature of carob powder is its color – depending on the commodity-based form; it is determined by the degree of roasting, its color varies from light brown to dark brown. Nowadays, high degree – roasted carob is widely used to replace cocoa powder. Its advantages over cocoa powder are as follows: lower cost, lower energy value, absence of oxalates, which bind calcium and lead to the formation of kidney stones, and theobromine and caffeine, which can cause allergic reactions [6]. However, the use of carob is not limited to replacing cocoa. Recommendations are given for its use in the manufacture of bread in order to improve the microbiological stability of products during storage [7]. It has been proposed to use carob powder as a sweetener in the technology of fermented milk drinks [8; 9] and curd products [10]. There are proposals for using carob during the production of confectionery products in order to improve its chemical composition (including enrichment with dietary fiber), and to provide original organoleptic properties. In particular, the technology of muffins with a content of carob powder 25% of the total raw materials has been proposed [11]; in biscuit technology, it is recommended to replace up to 50% of wheat flour with the specified additive [12], in the technology of whipped cookies, 10% flour has been replaced by carob [13]. Studies are being conducted on the possibility of using carob powder in the manufacture of marshmallows [14], fillings for confectionery [15], etc.

However, in the presented works, studies are mainly aimed at exploring the properties of finished products with the addition of carob powder. There are no systematic recommendations for the use of carob of different degrees of roast, which would be based on an assessment of its main characteristics.

Taking into consideration mentioned above, we consider that research aimed at studying the technological features of carob powder of various degrees of roasting is relevant in order to provide recommendations for its further use in the manufacture of confectionery.

The objective of the research is to study the technological features (humidity, water and fat-retention capacity, chromaticity) of carob powder of different degrees of roasting.

Presentation of the research material. Carob powder of various degrees of heat treatment has been used in the studies, namely: carob dry (dried), carob light (light roasting), carob medium (medium roasting), and carob dark (strong roasting) (manufacturer TM "Cacaogold", Spain), according to TU U 10.6-2949619066-001:2019. Prior to testing, the samples were stored in vacuum factory packaging. Natural cocoa powder produced by TM "Cacaogold" (Spain) has been used for comparison due to the prevalence of the use of carob to replace cocoa powder.

In the studied samples, the indicators of moisture content, water-holding capacity, fat-retaining ability and chromaticity were assessed. Humidity was measured according to AOAC 925.09 by drying to constant weight. Fat-retaining (FRC) capacity and water-holding (WHA) ability was assessed by the amount of fat or water abstained with the sample after infusion and centrifugation according to the method described in [16].

Chromaticity was assessed using a 45/0 optical geometry spectrophotometer (brand: 3nh; model: YS4560; in conjunction with the SQCX program) according to the method described in [17]. Prior to measurement, the equipment was calibrated using a standard white plate and a black trap. Color parameters were determined by the following characteristics: L* (from 0 – black to 100 – white), a* (from (–50) – green to 50 – red), b* (from (–50) – blue to 50 – yellow).

It has been established that the humidity of carob powder decreases with increasing the degree of roasting (Fig. 1), which is due to the greater removal of physically bound moisture in the case of prolonged thermal exposure.

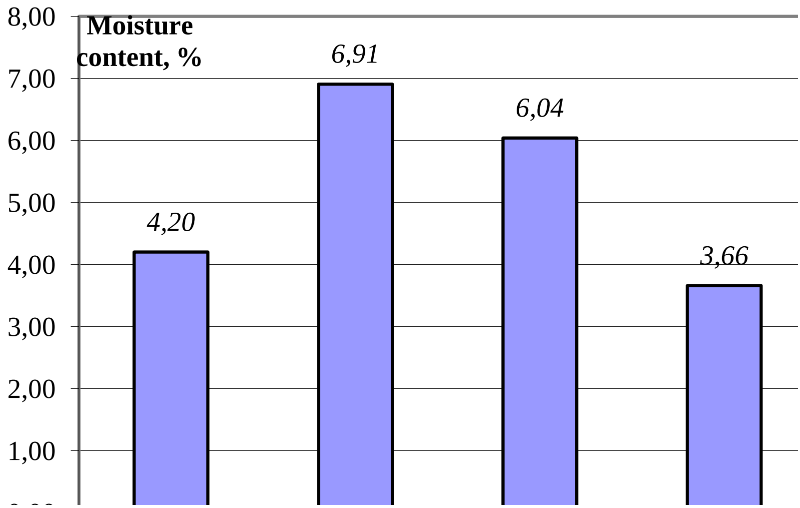

Fig. 1. Comparison of moisture content of carob powder of different roasting degrees with cocoa powder

In particular, the sample *Carob light* compared to dried carob (*Carob dry*) is 12,6 percent less than the value of the moisture content. Concerning the degree of roasting increases – samples *Carob medium* and *Carob dark* should be mentioned, forasmuch as the value of this indicator decreases by 47,0 and 52,5 relative percent, respectively. It should be noted that the value of the moisture content of these samples is as close as possible to natural cocoa powder.

It has been established that in the case of using new types of raw materials in traditional food technologies, it is important to take into account their functional and technological properties, given the possible impact on the formation of qualitative characteristics of the finished product. According to information sources [4; 5] carob powder contains high molecular weight compounds (in particular, up to 8% protein and up to 30% dietary fiber), which to some extent have the following properties. In view of the above, it is considered expedient to evaluate the fat-retaining and water-holding properties of the samples under study.

It has been established (Fig. 2) that with increasing the degree of roasting, the ability of carob powder to retain fat and moisture is slightly reduced.

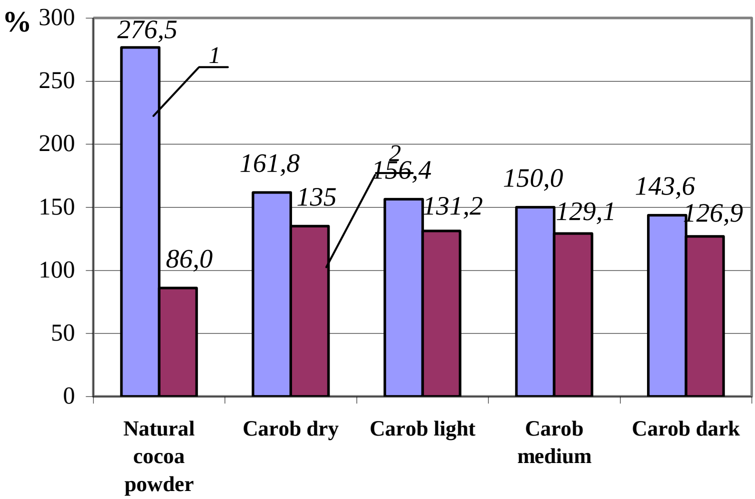

Fig. 2. Comparison of functional and technological properties of carob powder of different degrees of roasting with cocoa powder: 1 – water holding capacity; 2 – fat retention capacity

This can be explained by the thermal denaturation of the protein substances of the additive, as a result of which they lose their native properties, including the ability to bind fat and water.

The overall decrease in the indicator of water-nutritional ability in the sample of the maximum degree of roasting in comparison with dried carob is 11,2 relative percent, and the decrease in the indicator of fat-nutritional ability is only 6%. Cocoa powder significantly exceeds all tested samples of carob by the value of the WHA – by 41,5–48,1 relative percent.

At the same time, compared to carob, cocoa powder has a lower ability to retain fat – the rate of FRC for cocoa is 86,0%, while for carob powder – 126,9–135,0% depending on the degree of roasting. The obtained results can be explained by the peculiarities of the chemical composition of carob and cocoa. Cocoa is characterized by a higher content of protein (about 15%) and dietary fiber (up to 45%), which are largely responsible for its hydrophilicity. The better ability of carob powder to retain fat can probably be explained by the more porous structure of its particles, which makes it possible to retain fat physically. However, the outlined assumption needs further experimental confirmation.

Evaluation of the chromaticity of the studied samples has revealed the following outcomes (Table 1).

Table 1

The results of the study of the chromaticity of the studied samples

Test samples	Color options		
	L*	a*	b*
Carob dry	59,60	9,16	25,43
Carob light	54,30	12,14	27,72
Carob medium	45,07	12,32	24,26
Carob dark	32,37	8,94	17,56
Natural cocoa powder	35,14	7,67	13,44

The indicator L* characterizes the luminosity of the sample – from 0 (black) to 100 (white). It has been noted that when degree of roasting samples increases, carob powder acquires a darker color, accompanied by a decrease in the value of L* from 59,6 units in the sample *Carob dry* to 32,7 units in the sample with the maximum degree of roasting. This is due to the intensification of melanoidin formation. It should be noted that in terms of the value of this indicator, it is *Carob dark* that is as close as possible to natural cocoa powder.

It has been established that in terms of the indicator a*, which characterizes the color changes from green to red, samples *Carob dry* and *Carob dark* are insignificantly different from cocoa powder. For *Carob light* and *Carob medium*, red shades are more pronounced (a* is about 12 units), which is probably due to the oxidation of polyphenolic compounds under the influence of temperatures. The decrease in the value of a* for *Carob dark* can be explained by the destruction of polyphenols due to increased temperature exposure.

A decrease in the b* value with an increase in the degree of roasting of carob also indicates the darkening of the product, which may be the result of thermal oxidation of polyphenols and the formation of products of the Maillard reaction.

That is, in terms of chromaticity, the *Carob dark* sample is the closest to natural cocoa powder.

Conclusion. It has been established that with an increase in the degree of roasting of the carob powder, its moisture content decreases, its fat-nutritive and water-holding properties deteriorate; the color becomes darker.

It is recommended to use carob powder of the maximum degree of roasting – *Carob dark* to replace cocoa powder, which is due to its maximum proximity to natural cocoa powder by color. Furthermore, this sample has similar moisture content to cocoa powder, which will not require significant adjustments to the recipes for dry matter. Taking into account the higher fat-nutritive properties of carob powder in comparison with cocoa, studies of its possibility of use in technologies of fat-containing confectionery are promising.

References

1. Гринько Т. В. Проблеми та перспективи розвитку підприємств кондитерської промисловості України / Т. В. Гринько, І. Г. Лесів // Вчені записки ТНУ імені В. І. Вернадського: Економіка і управління. – 2020. – Т. 31 (70), № 2. – С. 171–177. DOI: https://doi.org/10.32838/2523-4803/70-2-28.

Grynko, T., Lesiv, I. (2020), "Problems and aspects of development confectionery industry enterprises in Ukraine", *Scientific notes of TNU V.I. Vernadsky. Series: Economics and Management* ["Problemy ta perspektyvy rozvytku pidpryyemstv kondyterskoyi promyslovosti Ukrayiny"], Vol. 31(70), No. 2, pp. 171-177. DOI: https://doi.org/10.32838/2523-4803/70-2-28

2. Baumel, A., Mirleau, P., Viruel, J., Bou Dagher Kharrat, M., La Malfa, S., Ouahmane, L., Diadema, K., Moakhar, M., Sanguin, H., Médail, F. (2018), "Assessment of plant species diversity associated with the carob tree (Ceratonia siliqua, Fabaceae) at the Mediterranean scale", *Plant Ecology and Evolution*, Vol. 151(2), pp. 185-193. DOI: https://doi.org/10.5091/plecevo.2018.1423.

3. Mekhoukhe, A., Kicher H., Ladjouzi, A., Medouni-Haroune, L., Brahmi, F., Medouni-Adrar, S., Madani, K. (2018), "Antioxidant activity of carob seeds and chemical composition of their bean gum by-products", *J. Complement. Integr. Med.*, No. 16(1). DOI: https://doi.org/10.1515/jcim-2017-0158.

4. Papaefstathiou, E., Agapiou, A., Giannopoulos, S., Kokkinofta, R. (2018), "Nutritional characterization of carobs and traditional carob products", *Food Sci. Nutr.*, No. 6(8), pp. 2151-2161. DOI: https://doi.org/10.1002/fsn3.776.

5. Yousif, A.K., Alghzawi, H.M. (2000), "Processing and Characterization of Carob Powder", *Food Chemistry*, Vol. 69, pp. 283-287. DOI: http://dx.doi.org/10.1016/S0308-8146(99)00265-4.

6. Свинина А. А. Кэроб функциональный пищевой ингредиент / А. А. Свинина, Л. А. Кокорева // Потребительский рынок Евразии: современное состояние, теория и практика в условиях Евразийского экономического союза и ВТО : сб. статей III Междунар. науч.-практ. конф. – 2015. – С. 137–140.

Svynina, A., Kokoreva, L. (2015) "Carob functional food ingredient", *Consumer market of Eurasia: current state, theory and practice in the conditions of the Eurasian Economic Union and the WTO: Collection of articles of the III International scientific-practical conference* ["Kerob funkcionalnyj harchovyj ingrediyent"], pp. 137-140.

7. Dragana M. Šoronja-Simović, Sonja Smole-Možina, Peter Raspor, Nikola R. Maravić, Jana J. Zahorec, Lucia Luskar, Zita I. Šereš (2016), "Carob flour and sugar beet fiber as functional additives in bread", *APTEFF*, Vol. 47, pp. 83-93. DOI: https://doi.org/10.2298/APT1647083S.

8. Лунева О. Н. Использование биологически активных веществ природного происхождения для расширения ассортимента и обогащения кисломолочных продуктов функционального назначения / О. Н. Лунева, Е. В. Заугольникова, С. Г. Ушакова // Новые концептуальные подходы к решению глобальной проблемы обеспечения продовольственной безопасности в современных условиях : сб. науч. статей 8-й Междунар. науч.-практ. конф., – 13 ноября 2020 / Юго-Западный гос. ун-т. – Курск, 2020. – С. 247–250.

Luneva, O., Zaugolnikova, E., Ushakova, S. (2020), "The use of biologically active substances of natural origin to expand the range and enrichment of fermented milk products for functional purposes", *Collection of scientific articles of the 8th International scientific-practical conference "New conceptual approaches to solving the global problem of food security in modern conditions"* ["Ispolzovanie biologicheski aktivnyh veshhestv prirodnogo proishozhdenija dlja rasshirenija assortimenta i obogashhenija kislomolochnyh produktov funkcionalnogo naznachenija"], Southwestern State University, Kursk, pp. 247-250.

9. Соболева О. М. Йогурт с плодами рожкового дерева и ягодным наполнителем, обработанным в электромагнитном поле / М. О. Соболева, К. А. Шилова // Вестник Алтайского государственного аграрного университета. – 2018. – № 1 (159). – С. 187–192.

Soboleva, O., Shilova, K. (2018), "Yogurt with carob fruit and berry filler processed in an electromagnetic field", *Bulletin of the Altai State Agrarian*

University [“Jogurt s plodami rozhkovogo dereva i jagodnym napolnitelem, obrabotannym v jelektromagnitnom pole”], No. 1(159), pp. 187-192.

10. Разработка технологии обогащенного творожного продукта для потребителей с повышенной физической нагрузкой / В. В. Крючкова, С. Н. Белик, Н. И. Мосолова, В. Э. Никитчук, Т. Ю. Кокина, А. А. Веровский, Е. Ю. Злобина // Известия Нижневолжского агроуниверситетского комплекса: наука и высшее профессиональное образование. – 2016. – № 1 (41). – С. 254–262.

Kruchkova, V., Belik, S., Mosolova, N., Nikitchuk, V., Kokina, T., Verovskiy, A., Zlobin, E. (2016), “Development of technology of the enriched curd product for consumers with the increased physical activity”, *News of the Lower Volga agro-university complex: science and higher professional education* [“Razrabotka tehnologii obogashhennogo tvorozhnogo produkta dlja potrebitelej s povyshennoj fizicheskoj nagruzkoj”], No. 1(41), pp. 254-262.

11. Сычёва О. В. Мучное кондитерское изделие с заменителем какао / О. В. Сычёва, Е. А. Скорбина, Э. Д. Алтунян // Кондитерская индустрия. – 2019. – № 4. – С. 38–40.

Sycheva, O., Scorbina, E., Altunjan, E. (2019), “Flour confectionery with cocoa substitute”, *Confectionery industry* [“Muchnoe konditerskoe izdelie s zamenitelem kakao”], No. 4, pp. 38-40.

12. Fidan, H., Petkova, N., Sapundzhieva, T., Baeva, M., Goranova, Z., Slavov, A., Krastev, L. (2020), “Carob syrup and carob flour (Ceratonia siliquaL.) as functional ingredients in sponge cakes”, *Carpathian J. Food Sci. Technol.,* Vol. 12, pp. 58-68. DOI: http://doi.org/10.34302/CRPJFST/2020.12.2.6.

13. Применение нетрадиционного сырья в производстве бисквитно-сбивного печенья / С. И. Лукина, Е. И. Пономарева, И. П. Пешкина, Х. Ю. Боташова // Хранение и переработка сельхозсырья. – 2018. – № 1 – 2018. – С. 56–59.

Lukina, S., Ponomareva, E., Peshkina, I., Botashova, H. (2018), “The use of non-traditional raw materials in the production of biscuit-whipped cookies”, *Storage and processing of agricultural raw materials* [“Primenenie netradicionnogo syrja v proizvodstve biskvitno-sbivnogo pechenja”], No. 1, pp. 56-59.

14. Ситникова О. В. Разработка технологии зефира для диабетического питания / О. В. Ситникова, О. Н. Клюкина // Здоровьесберегающие технологии в вузе: состояние и перспективы : материалы Всерос. науч.-практ. конф., Орел, 14–15 июня 2018 г. – Орел: Орловский гос. ун-т экономики и торговли, 2018. – С. 155–158.

Sitnikova, O., Kljukina, O. (2018), “Development of marshmallow technology for diabetic nutrition”, *Health-saving technologies in high school: state and prospects: Proceedings of the All-Russian scientific-practical conference* [“Razrabotka tehnologii zefira dlja diabeticheskogo pitanija”], pp. 155-158.

15. Maja Benković, Tomislav Bosiljkov, Amela Semić, Damir Ježek, Siniša Srečec (2019), “Influence of Carob Flour and Carob Bean Gum on Rheological Properties of Cocoa and Carob Pastry Fillings”, *Foods*, Vol. 8, pp. 66. DOI: http://doi.org/10.3390/foods8020066.

16. Ianchyk, M., Niemirich, O., Gavrysh, A. (2016), “Study of functional and technological properties of plant powders for use in confectionery industry”, *Food Science and Technology*, Vol. 10(4), pp. 31-36. DOI: https://doi.org/10.15673/fst.v10i4.251.

17. Afoakwa, E., Budu, A., Mensah-Brown, H., Felix Takrama, J., Ofosu-Ansah, E. (2014), “Effect of Roasting Conditions on the Browning Index and Appearance Properties of Pulp Pre-Conditioned and Fermented Cocoa (Theobroma Cacao) Beans”, *J. Nutrition Health Food Sci.*, Vol. 1(1), p. 5. DOI: http://doi.org/10.15226/jnhfs.2014.00110.

Samokhvalova Olga, PhD in Tech. Sciences, Prof., Department of Bakery, Confectionary, Pasta and Food Concentrates Technology, Kharkiv State University of Food Technology and Trade. Address: Klochkivska str., 333, Kharkiv, Ukraine, 61051. Tel.: (057)349-45-39; e-mail: sam55ov@gmail.com.

Самохвалова Ольга Володимирівна, канд. техн. наук, проф., зав. кафедри технології хліба, кондитерських, макаронних виробів і харчоконцентратів, Харківський державний університет харчування та торгівлі. Адреса: вул. Клочківська, 333, м. Харків, Україна, 61051. Тел.: (057)349-45-39; e-mail: sam55ov@gmail.com.

Shydakova-Kameniuka Olena, PhD in Tech. Sciences, Assoc. Prof. of Department of Bakery, Confectionary, Pasta and Food Concentrates Technology, Kharkiv State University of Food Technology and Trade. Address: Klochkivska str., 333, Kharkiv, Ukraine, 61051. Tel.: (057)349-45-39; e-mail: shidakovae@gmail.com.

Шидакова-Каменюка Олена Гайдарівна, канд. техн. наук, доц., кафедра технології хліба, кондитерських, макаронних виробів і харчоконцентратів, Харківський державний університет харчування та торгівлі. Адреса: вул. Клочківська, 333, м. Харків, Україна, 61051. Тел.: (057)349-45-39; e-mail: shidakovae@gmail.com.

Labazov Maksym, PhD student, Department of Bakery, Confectionary, Pasta and Food Concentrates Technology, Kharkiv State University of Food Technology and Trade. Address: Klochkivska str., 333, Kharkiv, Ukraine, 61051. Tel.: (057)349-45-39; e-mail: maksla28@gmail.com.

Лабазов Максим Ігорович, асп., кафедра технології хліба, кондитерських, макаронних виробів і харчоконцентратів, Харківський державний університет харчування та торгівлі. Адреса: вул. Клочківська, 333, м. Харків, Україна, 61051. Тел.: (057)349-45-39; e-mail: maksla28@gmail.com.

DOI: 10.5281/zenodo.5043560