https://doi.org/10.31891/2307-5732-2025-349-28
УДК 664:665

KOKOSH MARYNA
Yuriy Fedkovych Chernivtsi National University
e-mail: kokosh.maryna@chnu.edu.ua
OKSANA SEMA
Yuriy Fedkovych Chernivtsi National University
https://orcid.org/0000-0003-0159-2151
e-mail: o.sema@chnu.edu.ua
SACHKO ANASTASIIA
Yuriy Fedkovych Chernivtsi National University
https://orcid.org/0000-0002-3364-4297
e-mail: an.sachko@chnu.edu.ua

COMPOSITE FLOUR MIXTURES IN THE PRODUCTION OF GINGERBREAD PRODUCTS

One of the approaches to improving product quality and enhancing the nutritional structure of the population is the incorporation of novel, unconventional plant-based raw materials into the diet. These materials contain balanced complexes of proteins, lipids, minerals, vitamins, and other essential compounds. An innovative direction in the development of the flour-based confectionery industry is the production of new baked goods utilizing flour blend compositions that include flour from various cereals, legumes, and oilseeds.

This study presents the results of research on the formulation of choux gingerbread using composite flour mixtures to obtain an enriched product with increased levels of essential amino acids, macro- and micronutrients, and other biologically active components. To impart specific properties to the gingerbread products, a partial replacement of wheat flour with chickpea flour was proposed. Due to its amino acid composition and fiber content, legume flour serves as an ideal ingredient for enhancing the nutritional value of confectionery products. Additionally, chickpea flour is a gluten-free product that contains dietary fiber, which contributes to gut health regulation.

The nutritional value of the baked gingerbread was assessed, revealing that the inclusion of chickpea flour in its production led to an increase in nutritional quality, enrichment with proteins, fats, and amino acids, and a reduction in caloric content by 6–9.3% compared to gingerbread made according to the traditional recipe. Structural and mechanical analysis indicated a deterioration in product rise and water absorption capacity, yet an increase in baking loss by 1.5 times was observed. The addition of chickpea flour also resulted in a 35% decrease in alkalinity compared to the control sample, along with a slight reduction in moisture content.

КОКОШ МАРИНА
СЕМА ОКСАНА
САЧКО АНАСТАСІЯ
Чернівецький національний університет імені Юрія Федьковича

КОМПОЗИТНІ СУМІШІ БОРОШНА У ВИРОБНИЦТВІ ПРЯНИЧНИХ ВИРОБІВ

Один із способів підвищення якості харчових продуктів та покращення структури харчування населення – це впровадження до раціону нових нетрадиційних рослинних компонентів, що містять збалансовані комплекси білків, ліпідів, мінералів, вітамінів та інших необхідних сполук. Інноваційним напрямом розвитку борошномельно-кондитерської галузі є виробництво нових борошняних виробів, у складі яких використовуються суміші з борошна різних злакових, бобових та олійних культур. У роботі представлено результати дослідження щодо розробки рецептури заварних пряників із використанням композитних борошняних сумішей для отримання збагаченого продукту з високим вмістом незамінних амінокислот, макро- та мікроелементів, а також інших біологічно активних компонентів.

Ключові слова: заварні пряники, нутове борошно, нетрадиційна сировина.

Problem definition

In modern flour-based product technologies, there is a strong trend towards the development and implementation of confectionery products incorporating plant-based food additives, which play a crucial functional role in human nutrition. The use of such components enhances the nutritional value of products by enriching them with biologically active compounds, increasing the content of dietary fibers, antioxidants, and other beneficial substances. Moreover, the addition of plant-based additives not only expands the assortment of confectionery products but also extends their shelf life, improves organoleptic properties, and ensures compliance with contemporary healthy eating standards.

The results of the analytical review of the literature on this topic indicate that a significant number of methods for enriching confectionery products with beneficial nutrients are based on the use of cereal and legume raw materials, as well as secondary products of oilseed processing, such as press cakes and oil meals. Due to their high content of proteins, dietary fiber, and antioxidants, as well as their good compatibility with the main recipe components of confectionery products, these ingredients can be effectively used to enhance the nutritional value of foods. To compensate for the deficiency of essential nutrients and expand the product range, buckwheat, rye, corn, soybean, rice, pea, and oat flours are widely utilized [1]. These types of flour either do not contain gluten-forming proteins or have only a minimal amount.

Gingerbread is a popular confectionery product that enjoys high consumer demand. It belongs to the category of baked goods with a long shelf life and is characterized by high energy value but relatively low content

of proteins, vitamins, dietary fiber, and minerals. The incorporation of plant-based raw materials into the gingerbread formulation allows for an improvement in its nutritional and biological value by enriching the product with essential macro- and micronutrients.

Modern recipes differ slightly from traditional ones, but certain key ingredients remain fundamental to every production process. These include wheat flour, honey, baking soda, egg products and various spices such as cloves, cinnamon, cardamom, anise, coriander and nutmeg. Throughout its history, the gingerbread recipe has been constantly improved and changed, which has allowed us to develop products that meet modern food requirements and consumer preferences.

Analysis of Research and Publications

The modern confectionery market in Ukraine is characterized by intense competition and continues to grow. As a result, each manufacturer strives to develop and introduce new, original products that, in addition to high organoleptic properties, offer a unique composition and health benefits.

The creation of low-calorie, high-nutrient confectionery products that are appealing to consumers requires the improvement of technologies and the additional use of raw materials containing higher levels of essential amino acids, macro- and microelements, and other bioactive substances [2].

To enhance the nutritional value of gingerbread products, sesame flour and flaxseed meal were introduced into the recipe [3]. The addition of these ingredients (sesame flour up to 15% and flaxseed meal up to 8%) improved the sensory characteristics – color, taste, and texture – while also increasing the nutritional value of the products.

To enrich gingerbread with calcium compounds, chicken eggshells were used, addressing both the issue of eggshell waste processing and the reduction of osteoporosis risk in consumers [4]. An innovative functional food was developed based on gingerbread enriched with a combination of antioxidants from green tea and calcium compounds from eggshells. The addition of eggshell powder at 3% (w/w of wheat flour) improved the ash and calcium content in the gingerbread without significantly altering the appearance, aroma, texture, taste, or hedonic evaluation compared to gingerbread without this additive.

To improve the technology of gluten-free gingerbread products by fully or partially replacing wheat flour [5] with composite mixtures, a study was conducted on the impact of gluten-free flours, namely corn and buckwheat, on the quality indicators of dough and finished products. The resulting gingerbread products can be targeted at individuals with celiac disease, as the gluten content in them does not exceed 20 mg/kg.

Composite blends of gluten-free flours are essential ingredients in the production of gluten-free products, as they help achieve the necessary texture and structure typically provided by gluten. These blends often include various types of flours, such as rice, corn, potato, or quinoa flour, which enhance the nutritional value and improve the flavor of the final products. Among industry experts, there is a strong and sustained interest in expanding the range of bakery confectionery products by incorporating such blends and other plant-based ingredients [6-9]. This approach aims to enrich the final product with proteins, polyunsaturated fatty acids, vitamins, and minerals, as well as to reduce its caloric content.

In terms of biological value, chickpeas (Cicer arietinum) are the leader among legume crops, being grown in most countries worldwide. Chickpea flour is a gluten-free product made from chickpea seeds. It contains dietary fibers that help normalize bowel function, as well as both saturated and unsaturated fatty acids, which are beneficial for the body. Additionally, it contains calcium, phosphorus, and magnesium, essential for the overall development of the human body. Unlike wheat flour, chickpea flour has a low content of vitamin A but is rich in vitamins E and C [10]. Therefore, chickpea flour was chosen for the partial replacement of wheat flour in gingerbread cookies.

Objectives of the Study

The aim of the presented work was to develop a recipe composition for gingerbread cookies using composite flour blends of chickpea and wheat flour to create an enriched product. The main objective was to select the optimal ratio of chickpea and wheat flour to produce gingerbread cookies with optimal sensory and structural-mechanical properties.

Presentation of the Main Material

The gingerbread cookies were baked according to a technology consisting of the following stages: preparation of raw materials – sifting the flour; preparation of sugar syrup; cooking a portion of the flour with the sugar syrup; cooling the mixture and kneading the dough; shaping and baking the dough blanks; cooling the finished products (Fig. 1).

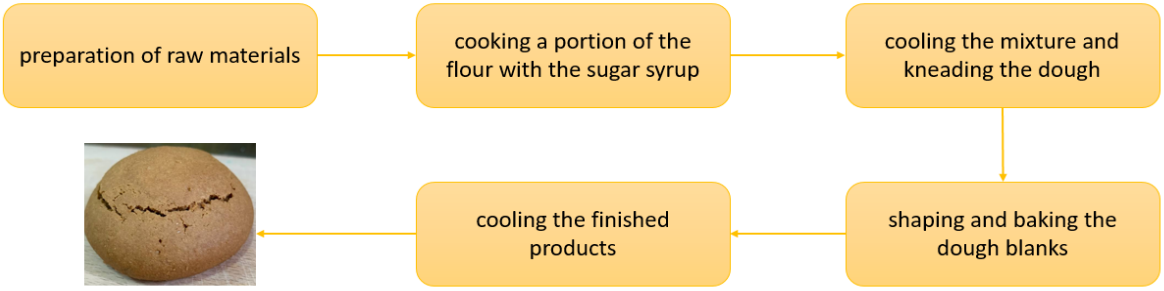

Figure 1. The gingerbread cookies technology

The control sample was gingerbread cookies baked with premium wheat flour without the addition of chickpea flour. The experimental gingerbread samples were made following the same procedure as the control sample, with wheat flour being replaced by chickpea flour in amounts of 10, 20, 30, and 40%. Both types of flour had the same moisture content of 15% (Swiss Made EM 120 – HR moisture analyzer). The baking temperature and duration for all samples were 180 °C and 13 minutes, respectively. The finished products were well-baked, visually increased in size, and had good sensory properties (Table 1).

The gingerbread cookies are characterized by a pleasant, well-balanced taste with a slight sweetness and aromatic spice notes. The texture is tender yet firm, providing a satisfying crunch. The cookies have an appealing brown color, and their surface is smooth with small cracks. The aroma is rich, with a warm, inviting fragrance typical of freshly baked gingerbread. Overall, the sensory properties are highly favorable, making the product enjoyable in terms of both taste and appearance.

Experimental studies have shown that the optimal sensory, structural-mechanical, and physicochemical quality indicators of gingerbread cookies were achieved in samples with 20% chickpea flour incorporation. With an increased percentage of chickpea flour, the porosity improved, and the crust and crumb exhibited a more pronounced lighter brown color, along with a characteristic flavor and a pleasant nutty aroma. It was determined that the inclusion of chickpea flour positively affected the color and aroma of the final products. According to sensory analysis results, a decline in structural properties was noted, with gingerbread containing 40% chickpea flour being denser and harder in texture.

Important characteristics of the finished product are baking, moisture absorption, and rise, as they directly affect the texture, flavor, and appearance of the gingerbread cookies (Table 2). Compared to the control sample, with an increase in the chickpea flour content, there is a rise in the baking index, a slight decrease in the moisture absorption of the gingerbread, and a reduction in rise when the chickpea flour content exceeds 20%.

Table 1

Baked Gingerbread Samples and Their Characteristics

Sample	Appearance	Cross-section	Sensory Evaluation
Classic formulation (without chickpea flour)			The gingerbread cookies are convex in shape, well-baked, pleasant in taste, aromatic, and have a brown color.
10% chickpea flour			Convex in shape, well-baked, aromatic, pleasant in taste, with a brown color.
20% chickpea flour			Convex in shape, well-baked, pleasant in taste, with a slight nutty flavor, light brown color.
30% chickpea flour			Convex in shape, well-baked, pleasant in taste, with a nutty flavor, light brown color.
40% chickpea flour			The shape is not convex, slightly deformed, well-baked, pleasant in taste, light brown color.

This correlates very well with the results of the sensory evaluation. The decrease in dough rise during

baking will lead to a reduction in its porosity, resulting in a perception of hardness. This was precisely noted by the tasters for the samples with 40% chickpea flour content. The decrease in moisture absorption in the gingerbread samples with the addition of chickpea flour can be explained by the ability of chickpeas to actively absorb moisture due to the specific features of their chemical composition. This can affect their consistency during consumption or storage. The reduction in moisture absorption makes the product harder and more brittle. Therefore, to achieve the desired shape and structure of the gingerbread, it is advisable to add chickpea flour in the amount of 10 to 20%.

Table 2

Structural-mechanical properties of gingerbread products

Indicator	Control sample	Gingerbread with the addition of chickpea flour			
		10%	20%	30%	40%
Baking, %	8,88	9,30	9,54	9,90	10,4
Moisture absorption, %	116	116	114	112	111
Rise, sm	1,5	1,5	1,4	1,2	1,1

Overall, an increase in the baking index may indicate an improvement in porosity, structure, and the formation of a smooth, even crust. However, an excessive amount of chickpea flour can make the dough denser, as chickpeas contain more protein and fiber than wheat flour, which may lead to a decrease in porosity and texture of the gingerbread. At the same time, this may suggest insufficient effectiveness of the leavening agents for this particular sample composition.

The addition of leavening agents can significantly affect not only the texture and porosity of the finished products but also their taste. An excess of leavening agents may be noticeable due to a characteristic aftertaste. In general, gingerbread products have an alkaline, rather than acidic, pH. The inclusion of chickpeas in the gingerbread formula lowers the alkalinity compared to the control (Table 3). This can be explained by the presence of amino acids in chickpeas, which can weaken the alkaline nature of the leavening agent through a neutralization reaction, thereby improving the sensory properties.

Table 3

Alkalinity and moisture content of gingerbread products

Indicator	Control sample	Gingerbread with the addition of chickpea flour			
		10%	20%	30%	40%
Alkalinity, ⁰	1,70	1,60	1,51	1,46	1,11
Moisture content, %	17	16	15	15	14

During storage, the gingerbread loses its aroma, and the crumb becomes hard. Staling of gingerbread is accompanied by two processes: moisture loss or drying, and consequently staling, which involves physicochemical changes in the substances that make up the crumb. Therefore, it is important to know the moisture content of the finished products (Table 3). The decrease in moisture content of gingerbread with the addition of chickpea flour may be related to the specific composition of chickpeas. The dietary fibers in the addition are mainly cellulose, which has a developed system of fine capillaries that allows it to physically bind and retain moisture. During baking, the temperature increases, causing the bound moisture to be easily removed, which results in a decrease in the moisture content of the finished products. The values of alkalinity and moisture content for all the tested samples were within the requirements of GOST 4187:2003 "Gingerbread Confectionery Products" [11].

Based on the comprehensive analysis of the obtained results, it can be concluded that the optimal sample, according to consumer evaluation and structural-mechanical properties, is the one with 20% chickpea flour content (Fig. 2).

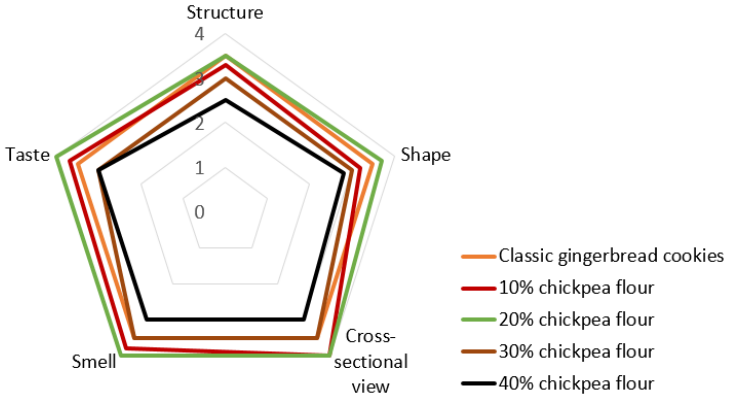

Fig.2. Profilogram of the assessment of the properties of gingerbread with the addition of chickpea flour compared to the control sample.

The calorific value of the control sample and gingerbread with chickpea flour was calculated based on widely accessible reference tables. The results indicate that the caloric content of the gingerbread decreases with

an increase in the proportion of chickpea flour: from 400 kcal/100 g for the control sample to 363 kcal/100 g for the sample with 40% chickpea flour content.

The reduction in caloric content is a positive aspect as it can benefit individuals who are looking to decrease their calorie intake, such as those monitoring their weight or following specific dietary restrictions. Lowering the caloric content of gingerbread with the addition of chickpea flour can make it a healthier option without significant loss of taste. Furthermore, chickpea flour is rich in protein, fiber, and micronutrients, which makes the product not only lower in calories but also more nutritious, supporting overall health.

Conclusions from this research

The addition of 20% chickpea flour to the gingerbread dough resulted in the most favorable sensory, structural-mechanical, and physicochemical properties, as it enhanced the porosity, crust, and color, while maintaining a balanced flavor and pleasant aroma. However, a higher percentage of chickpea flour (40%) resulted in a denser, harder texture due to reduced rise during baking.

The incorporation of chickpea flour reduced the moisture absorption capacity of the gingerbread, which can lead to a firmer and more brittle texture. This decrease in moisture retention is due to the specific chemical properties of chickpeas, which actively bind moisture, affecting the consistency of the final product during storage.

The increase in baking index with the addition of chickpea flour indicates an improvement in porosity and the formation of a smooth, even crust. However, beyond a certain threshold (20% chickpea flour), the dough becomes denser due to the higher protein and fiber content in chickpeas, which can decrease porosity and negatively affect the texture.

The inclusion of chickpea flour in the gingerbread recipe results in a reduction of caloric content, from 400 kcal/100 g for the control sample to 366 kcal/100 g for the sample with 20% chickpea flour. This reduction in calories makes the product a healthier alternative without compromising on taste, while also providing additional nutritional benefits from chickpeas, including higher protein, fiber, and micronutrient content.

Acknowledgments

This work was supported by a grant from the Simons Foundation (international project ‘Advanced functional materials for food and energy applications’, Simons Foundation, Award Number: 1290597)

Література

1. Лебединець, В. Т., Лебединець, А. І., Мороз, М. М. Використання різних видів борошна для збагачення борошняних кондитерських виробів // Підприємництво, торгівля: теоретичні підходи та практичні аспекти розвитку : матеріали II Міжнародної науково-практичної конференції (м. Старобільськ, 26–27 листопада 2020 р.). Харків, 2020. С. 108–112.
2. Ковбаса, В., Оболкіна, В., Ємельянова, Н., Пантелеєнко, О. Солодове борошно у кондитерських виробах. Національний університет харчових технологій, 2010. С. 28–30.
3. Кобець, А. С. Технологія пряничних виробів підвищеної харчової цінності // Збірник наукових праць молодих учених, аспірантів та студентів. Одеса, 2021. С. 12.
4. Arnold, M., Rajagukguk, V., Sidor, A. Innovative Application of Chicken Eggshell Calcium to Improve the Functional Value of Gingerbread // International Journal of Environmental Research and Public Health. 2022. Vol. 19, No 7. P. 4195.
5. Феньків, А. В., Мацук, Ю. А. Удосконалення технології виробів із пряничного тіста // Актуальні питання розвитку економіки, харчових технологій та товарознавства : тези доповідей XXXIX наукової студентської конференції за підсумками науково-дослідних робіт студентів (м. Полтава, 19–20 квітня 2016 р.). Полтава : ПУЕТ, 2016. С. 233–236.
6. Марцин, Т. О. Використання борошна кіноа у технології безглютенового хлібу // Туристичний, готельний і ресторанний бізнес: інновації та тренди : матеріали міжнародної науково-практичної конференції (Київ, 2016). С. 264–266.
7. Лінчевський, А. А. Ячмінь – джерело здорового способу життя сучасної людини // Вісник аграрної науки. 2017. Т. 95, № 12. С. 14–21.
8. Хомич, Г. П., Наконечна, Ю. Г., Галушинський, Є. М. Використання борошна чуфи в технології виготовлення мафінів // Наукові праці НУХТ. 2021. Т. 27, № 3. С. 181–191.
9. Тітова, А. Є. Джерела донори господарсько-цінних ознак нуту за комплексом чинників // Proceedings of the International Scientific and Practical Conference «Topical issues of science and education» (2017, Warsaw, Poland). 2017. № 7. С. 19–21.
10. Мороз, В. О. Перспектива використання нутового борошна для приготування хліба // Національний університет економіки і торгівлі ім. Михайла Туган-Барановського. Київ, 2022. С. 42.
11. ДСТУ 4187:2003. Вироби кондитерські пряникові. – [Чинний від 2003-07-01]. Вид. офіц. Київ : Держспоживстандарт України, 2004. 16 с.

References

1. Lebedynets, V. T., Lebedynets, A. I., Moroz, M. M. Vykorystannia riznykh vydiv boroshna dlia zbahachennia boroshnianykh kondyterskykh vyrobiv // Pidpryiemnytstvo, torhivlia: teoretychni pidkhody ta praktychni aspekty rozvytku : materialy II Mizhnarodnoi naukovo-praktychnoi konferentsii (m. Starobilsk, 26–27 lystopada 2020 r.). Kharkiv, 2020. S. 108–112.
2. Kovbasa, V., Obolkina, V., Yemelianova, N., Panteleienko, O. Solodove boroshno u kondyterskykh vyrobakh. Natsionalnyi universytet kharchovykh tekhnolohii, 2010. S. 28–30.
3. Kobets, A. S. Tekhnolohiia prianychnykh vyrobiv pidvyshchenoi kharchovoi tsinnosti // Zbirnyk naukovykh prats molodykh uchenykh, aspirantiv ta studentiv. Odesa, 2021. S. 12.
4. Arnold, M., Rajagukguk, V., Sidor, A. Innovative Application of Chicken Eggshell Calcium to Improve the Functional Value of Gingerbread // International Journal of Environmental Research and Public Health. 2022. Vol. 19, No 7. P. 4195.
5. Fenkiv, A. V., Matsuk, Yu. A. Udoskonalennia tekhnolohii vyrobiv iz prianychnoho tista // Aktualni pytannia rozvytku ekonomiky, kharchovykh tekhnolohii ta tovaroznavstva : tezy dopovidei XXXIKh naukovoi studentskoi konferentsii za pidsumkamy naukovo-doslidnykh robit studentiv (m. Poltava, 19–20 kvitnia 2016 r.). Poltava : PUET, 2016. S. 233–236.
6. Martsyn, T. O. Vykorystannia boroshna kinoa u tekhnolohii bezghliutenovoho khlibu // Turystychnyi, hotelnyi i restorannyi biznes: innovatsii ta trendy : materialy mizhnarodnoi naukovo-praktychnoi konferentsii (Kyiv, 2016). S. 264–266.
7. Linchevskyi, A. A. Yachmin – dzherelo zdorovoho sposobu zhyttia suchasnoi liudyny // Herald ahrarnoi nauky. 2017. T. 95, № 12. S. 14–21.
8. Khomych, H. P., Nakonechna, Yu. H., Halushynskyi, Ye. M. Vykorystannia boroshna chufy v tekhnolohii vyhotovlennia mafiniv // Naukovi pratsi NUKhT. 2021. T. 27, № 3. S. 181–191.
9. Titova, A. Ye. Dzherela donory hospodarsko-tsinnykh oznak nutu za kompleksom chynnykiv // Proceedings of the International Scientific and Practical Conference «Topical issues of science and education» (2017, Warsaw, Poland). 2017. № 7. S. 19–21.
10. Moroz, V. O. Perspektyva vykorystannia nutovoho boroshna dlia pryhotuvannia khliba // Natsionalnyi universytet ekonomiky i torhivli im. Mykhaila Tuhan-Baranovskoho. Kyiv, 2022. S. 42.
11. DSTU 4187:2003. Vyroby kondyterski prianykovi. – [Chynnyi vid 2003-07-01]. Vyd. ofits. Kyiv : Derzhspozhyvstandart Ukrainy, 2004. 16 s.