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THE INFLUENCE OF THE EXTRACT FROM THE FLOWERS ON THE *TAGETES PATULA* ON THE CONSUMER PROPERTIES OF THE BUNS PRODUCTS

Introduction. *In recent years, more and more attention has been paid to a healthy lifestyle, which largely depends on the diet. In the daily menu of a modern person, the main sources of energy and nutrients are mainly cereals and bakery products. The degree of glycaemic of flour products is regulated with the help of resistant starch, non-starch poly– and oligosaccharides of chickpea flour. This increases the biological value of bread due to its high protein content. To maintain normal sugar levels in the human body, a variety of plant materials are used: fruits, vegetables, and herbs. The antihyperglycaemic effect of plants is due to the various biologically active substances they contain, in particular, amino acids, polyphenolic compounds, and polysaccharides. Due to the wide range of pharmacological activity, marigolds (Tagetes patula L.) are widely used in the pharmaceutical, perfumery, and cosmetic industries. They are also used in canning, cooking sauces, and as part of spices. In the scientific literature, there is limited information on the use of marigolds (Tagetes patula L.) in food production.*

The aim of the study *was to determine the amino acids content of Tagetes patula L. flower extract and investigate the effect of the marigold extract on the consumer characteristics of bakery products in bakery production.*

Materials and methods of research. *The amino acids composition of Tagetes patula flower extract is determined by GC/MS method on gas chromatograph Agilent 6890N with 5973 inert mass detector (Agilent Technologies, USA). To determine the effect of the marigold (Tagetes patula L.) flower extract on the quality of the bakery product, a test baking was carried out. The dough was prepared from high-grade wheat flour that met the requirements of DSTU (State Standards of Ukraine) 46.004-99. The main quality* *indicators of the raw materials were evaluated according to generally accepted methods and regulated regulatory documents (DSTU ISO 21415-1:2009, GOST 27839-88 DSTU).*

Research results and their discussion. *According to the results of GC/MS analysis, 12 amino acids were identified in the extract from Tagetes patula flowers. The analysis of the content of amino acids in the studied extract from the flowers of the Tagetes patula showed that the raw material contains a significant amount of L-proline, the total content of which was 138.20 mg/g. The content of free L-proline was 57.86 mg/g, bound – 80.34 mg/g. Glycine was also found in the studied extract from free amino acids, the content of which was 11.34 mg/g. In addition to L-proline, significant amounts of L-aspartic (19.64 mg/g) and L-glutamic (21.63 mg/g) acids were found in the extract from the flowers of the Tagetes patula. To determine the effect of the extract on the quality of the bakery product, the optimal dosage was adopted, taking into account the physiological needs of the human body – 0.021 g per 100 g of bun. A sample bun without the additive served as a control. Research results indicate that the introduction of marigold flower extract into the bun production technology does not change the amount of raw gluten. Biologically active substances contained in the supplement do not have a significant effect on gluten. Therefore, correction of technological regimes and the process of preparation of semi-finished flour is not required. Adding marigold extract to the bun dough does not change the acidity of its pulp. Porosity remains developed, and dimensional stability is within the permissible deviation. The selected dosage of marigold extract does not have a significant effect on the organoleptic and physicochemical indicators of the quality of buns. Therefore, it can be used as a recipe component of a butter bun.*

Conclusions. *Thus, the results obtained by us show that the extract from the flowers of the Tagetes patula has a wide spectrum of amino acid composition with a significant content of these compounds, as well as the use of Tagetes patula extract in other fields, for example, the food industry. It has been established that adding the flower extract of the Tagetes patula does not have a noticeable effect on the quality indicators of bakery products. At the same time, it is possible not only to diversify the range of bakery products and improve their quality but also to increase the nutritional and biological value of the product.*

Key words: *Tagetes patula, flowers, extract, amino acids, buns, bakery products.*

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ВПЛИВ ЕКСТРАКТУ З КВІТОК ЧОРНОБРИВЦІВ РОЗЛОГИХ (*TAGETES PATULA* L.) НА СПОЖИВЧІ ВЛАСТИВОСТІ БУЛОЧНИХ ВИРОБІВ

Актуальність. *В останні роки все більше приділяється увага здоровому способу життя, яке значною мірою залежить від раціону харчування. У щоденному меню сучасної людини основними джерелами енергії та поживних речовин переважно є злаки та хлібобулочні вироби. Регулюють ступінь глікемічності борошняних виробів за допомогою резистентного крохмалю, некрохмальних полі– та олігосахаридів борошна з нуту. При цьому підвищується біологічна цінність хліба завдяки високому вмісту білка. Для підтримання в нормі рівня цукру в організмі людини використовують різноманітну рослинну сировину: фрукти, овочі, трави. Антигіперглікемічна дія рослин зумовлена різноманітними біологічно активними речовинами, які містяться в них, зокрема амінокислотами, поліфенольними сполуками та полісахаридами. За рахунок широкого спектру фармакологічної активності чорнобривці розлогі (Tagetes patula L.) знайшли застосування в фармацевтичній, парфумерно-косметичній галузях. Їх також використовують у консервуванні, приготуванні соусів, вони входять до складу спецій. У джерелах наукової літератури дані про використання чорнобривців розлогих у виробництві харчових продуктів обмежені.*

Мета дослідження. *Визначення вмісту амінокислот в екстракті з квіток чорнобривців розлогих (Tagetes patula L.) та дослідження впливу екстракту на споживчі характеристики хлібобулочних виробів у хлібопекарському виробництві.*

Матеріал і методи. *Визначення амінокислотного складу екстракту з квіток чорнобривців розлогих проводили методом ГХ/МС на газовому хроматографі Agilent 6890N, із детектором 5973 (Agilent Technologies, США). Для визначення впливу екстракту з квіток чорнобривців розлогих на якість хлібобулочних виробів було проведено пробну випічку. Тісто готували з борошна пшеничного вищого ґатунку, що відповідало вимогам ДСТУ 46.004-99. Основні показники якості сировини оцінювали за загальноприйнятими методиками та нормативними документами (ДСТУ ISO 21415-1:2009, ГОСТ 27839-88 ДСТУ).*

Результати дослідження. *За результатами ГХ/МС аналізу в екстракті з квіток чорнобривців розлогих (Tagetes patula L.) виявлено 12 амінокислот. Згідно з одержаними результатами, у досліджуваному екстракті з квіток чонобривців розлогих найбільший уміст становив L-пролін, загальний уміст якого був 138,20 мг/г. Уміст вільного L-проліну становив 57,86 мг/г, зв'язаного – 80,34 мг/г. У досліджуваному екстракті з вільних амінокислот виявлено також гліцин, уміст якого становив 11,34 мг/г. Окрім L-проліну, в екстракті з квіток чорнобривців розлогих виявлено значну кількість L-аспарагінової (19,64 мг/г) та L-глутамінової (21,63 мг/г) кислот. Для встановлення впливу екстракту на якість хлібобулочного виробу прийняли оптимальне його дозування з огляду на фізіологічні потреби організму людини – 0,021 г на 100 г булочки. Контролем слугував зразок булочки без додавання екстракту. Результати досліджень свідчать, що введення у технологію виробництва булочок екстракту з квіток чорнобривців не змінює кількість сирої клейковини. Біологічно активні речовини, які містяться в екстракті, суттєвого впливу на клейковину не мають, тому корекції технологічних режимів і процесу приготування борошняного напівфабрикату не потрібно. Додавання екстракту чорнобривців у тісто для булочки не змінює кислотність її м'якушки. Пористість залишається розвиненою, формостійкість – у межах допустимого відхилення. Таким чином, вибране дозування екстракту чорнобривців не має суттєвого впливу на органолептичні й фізико-хімічні показники якості булочок. Тому його можна застосовувати як рецептурний складник булочки здобної.*

Висновок. *Таким чином, одержані нами результати амінокислотного складу екстракту з квіток чорнобривців розлогих (Tagetes patula L.) свідчать про значний уміст цих сполук, що зумовлює можливість використання досліджуваного екстракту в багатьох сферах, наприклад у харчовій промисловості. Установлено, що додавання екстракту з квіток чорнобривців розлогих помітно не впливає на якісні показники хлібобулочних виробів. При цьому можна не лише урізноманітнити асортимент хлібобулочних виробів і підвищити їхню якість, а й підвищити харчову та біологічну цінність продукції.*

Ключові слова: *чорнобривці розлогі (Tagetes patula L.), квітки, екстракт, амінокислоти, булочки, хлібобулочні вироби.*

Introduction. In recent years, more and more attention has been paid to a healthy lifestyle, which largely depends on the diet. In the daily menu of a modern person, the main sources of energy and nutrients are mainly cereals and bakery products. The range of flour products is quite wide: wheat bread, rye bread, and various bakery products. In addition to yeast and salt, baked goods contain significant amounts of sugar and fat. Dairy and egg products may be present. These ingredients increase the energy value of the products.

The main sweetening agent is sugar, with a carbohydrate content of 99.7 g/100 g. In addition, buns are made mainly from high-grade flour that is free of bran particles. Minerals and dietary fibre are removed from the grain hulls during milling. Due to the absence of complex carbohydrates and a significant amount of starch, such flour and products made from it are classified as foods with a high glycaemic index. They are not recommended for diabetics, as one of the causes of hyperglycaemia is an excessive intake of easily digestible carbohydrates.

People with metabolic disorders are advised to reduce the consumption of foods containing easily digestible carbohydrates (Yan-Do, 2016).

It is possible to reduce the glycaemic index of flour products by using dietary fibres, as they contribute to the slow and gradual entry of glucose into the bloodstream and regulate insulin release (Yurchak, 2012). Today, the range of diabetic bakery products is insignificant. Sorbitol and xylitol are mainly used to replace sucrose, and to a lesser extent fructose and lactulose. The use of synthetic sweeteners is a controversial issue, and in some countries, their use in food is prohibited.

The degree of glycaemicity of flour products is regulated with the help of resistant starch, non-starch poly– and oligosaccharides of chickpea flour. This increases the biological value of bread due to its high protein content. To maintain normal sugar levels in the human body, a variety of plant materials are used: fruits, vegetables, and herbs (Tkachenko, 2018; Voloshchuk, 2019).

Today, about 200 plant species are known to have anti-diabetic properties (Marchyshyn, 2021; Marchyshyn, 2023; Vlasenko, 2021).

The antihyperglycaemic effect of plants is due to various biologically active substances they contain, in particular amino acids – arginine, inositol, guanidine, which have an insulin-like effect; polyphenolic compounds, which exhibit antioxidant activity by inhibiting lipid peroxidation and accelerating the utilisation of their toxic products, stabilise the structure of cell membranes, and stimulate regeneration processes in the body; inulin is a polysaccharide that reduces blood glucose levels, has antioxidant and detoxifying effects by removing radionuclides and ketone bodies from the body, improves the state of the cardiovascular system, normalises metabolism, and prevents the occurrence of severe complications of diabetes (retinopathy, angiopathy, etc.) (Marchyshyn, 2021; Vlasenko, 2021).

These plants include marigolds (*Tagetes patula* L.), genus *Tagetes* L., family *Asteraceae* – a promising medicinal and ornamental plant with a wide range of pharmacological activity: antibacterial, insecticidal, wound healing, anti-inflammatory, antioxidant, hepatoprotective, hypoglycaemic, analgesic, etc. (Babu, 2007; Slobodianiuk, 2021).

It has been shown that the herb marigold (*Tagetes patula* L.) contains valuable biologically active substances: flavonoids, hydroxycinnamic acids, essential oil, polysaccharides, organic and fatty acids, amino acids (Politi, 2017; López, 2018; Craveiro, 2024).

Due to the wide range of pharmacological activity, marigolds (*Tagetes patula* L.) are widely used in the pharmaceutical, perfumery and cosmetic industries. They are also used in canning, cooking sauces, and as part of spices. In the scientific literature, there is limited information on the use of marigolds (*Tagetes patula* L.) in food production.

Therefore, **the aim of the study** was to determine the amino acids content of *Tagetes patula* L. flower extract and investigate the effect of the marigold extract on the consumer characteristics of bakery products in bakery production.

Materials and methods. Flowers of the *Tagetes patula* L. were collected at the experimental sites of the New Cultures Department of M. M. Hryshko National Botanic Garden of the NAS of Ukraine in Kyiv. The aerial part was harvested during a mass flowering period in 2023. The raw material was authenticated by Prof. Svitlana Marchyshyn. A voucher specimen was deposited in the herbarium at the Department of Pharmacognosy and Medical Botany, TNMU, Ternopil, Ukraine (Slobodianiuk, 2022; Marchyshyn, 2021).

Preparation of extracts. About 500 g of dried raw materials was powdered with the help of a suitable crusher. After that, it was placed in an extractor and extracted using 60 % ethanol as a solvent. The extracts were concentrated under vacuum and dried by rotator evaporator under reduced pressure.

Standards and chemicals. Standards of the amino acids: L-serine, L-glutamic acid, L-leucine, L-valine, L-alanine, L-threonine, L-methionine, L-tryptophan, L-isoleucine, L-cysteine, L-proline, L-phenylalanine, L-asparagine, L-histidine, L-aspartic acid, L-glutamine, L-tyrosine, L-lysine, obtained from Sigma-Aldrich (USA), analytical grade (> 98 % purity).

GC/MS determination of amino acids. The amino acids composition of *Tagetes patula* flower extract is determined by GC/MS method on gas chromatograph Agilent 6890N with 5973 inert mass detector (Agilent Technologies, USA). Samples were analyzed on a capillary column HP-5MS of 30 m in length and an internal diameter of 0.25 mm, a thickness of the stationary phase is 0.25 μm (Budniak, 2022). The vaporizer temperature was 250 °C, and the interface temperature was 280 °C. The first set-up oven temperature was at 50 °C and held for 4 min, then elevated to 300 °C at the rate of 5 °C/min and kept at this point for 5 min. Injections of 1 μl were made in the split mode 1:50. The carrier gas flow pace through the column was 1.0 ml/min.

The pre-column derivatization was conducted with the help of automatic programmable regulations. The dry samples of the extract were solved in 390 μl of 1 M sodium hydroxide, then 333 μl of methanol and 67 μl of pyridine and mixed thoroughly for 5 seconds. To the resulting mixtures, 80 μl of methyl chloroformate was added and stirred thoroughly for 60 seconds.

The amino acid derivatives were extracted with 400 μl of chloroform followed by the addition of 400 μl of 50 mM sodium bicarbonate. The chloroform phase was used for future analysis (Vancompernolle, 2016; Feshchenko, 2021).

The identification of amino acids was executed by comparing the retention times of amino acid standards and the presence of representative molecular and fragment ions (table 1). Quantification was done using the internal standard of nor-valine added to the sample. The content of bound amino acids was determined by subtracting the content of free amino acids from their total content (Chen, 2010).

Table 1

The chromatographic conditions for identification of amino acids

Amino acids	t_R, min	Molecular ion, m/z	Main fragmentary ions, m/z
Glycine	14.77	147	88
L-alanine	14.85	161	102, 88
L-valine	18.56	189	146, 130, 115, 98
L-leucine	19.57	203	144, 115, 102, 88
L-serine	20.77	191	176, 144, 114, 100, 88
L-threonine	21.11	205	147, 115, 100, 88
L-isoleucine	21.31	203	144, 115, 101, 88
L-proline	21.87	187	128, 84
L-asparagine	21.97	262	146, 127, 95
L-aspartic acid	23.90	219	160, 128, 118, 101
L-glutamic acid	24.02	233	201, 174, 142, 114
L-methionine	26.86	221	147, 128, 115
L-cysteine	27.14	192	192, 176, 158, 146, 132
L-phenylalanine	29.18	237	178, 162, 146, 131, 103, 91
L-glutamine	29.74	276	141, 109, 82
L-lysine	31.90	276	244, 212, 142, 88
L-histidine	35.91	285	254, 226, 210, 194, 140, 81
L-tyrosine	37.24	296	252, 236, 220, 192, 165, 146, 121
L-tryptophan	38.91	276	130

To determine the effect of the marigold (*Tagetes patula* L.) flower extract on the quality of the bakery product, a test baking was carried out. The dough was prepared from high-grade wheat flour that met the requirements of DSTU (State Standards of Ukraine) 46.004-99.

The product recipe included the following raw materials:

– pressed classic bakery yeast, TU (Technical Conditions) U 10.8-00383320-001; drinking water, DSanPiN (State Sanitary Rules and Norms) 2.2.4-171-10; table salt, DSTU 3583:2015; crystalline white sugar, DSTU 4623:2006;

– sweet cream butter with a fat content of 72.5 %, DSTU 4399; extract from marigold flowers collected during the flowering period.

The main quality indicators of the raw materials were evaluated according to generally accepted methods and regulated regulatory documents (DSTU ISO 21415-1:2009, GOST 27839-88 DSTU).

The dough was prepared in a no-steam method using traditional technology (Drobot, 2024).

The finished bun weighing 100 g had a round shape. The organoleptic and physicochemical quality parameters of the finished buns were determined (DSTU 9188:2022; DSTU 7045:2009).

The research presented in this article is aimed at improving the nutritional value of a bun with marigold flower extract and determining its consumer characteristics.

Therefore, our research was to analyze the effect of marigold flower extract on the quality of buns and to investigate the technological aspects of the resulting products.

Research results and discussion. According to the results of GC/MS analysis, 12 amino acids were identified in the extract from *Tagetes patula* flowers. The results of determining the qualitative composition and quantitative content of amino acids in the extract from the flowers of *Tagetes patula* are shown in table 2 and fig. 1, 2.

Table 2

The content of the amino acids composition in the extract from the flowers of the *Tagetes patula* L.

Amino acid name	RT, Min	Amino acids content, mg/g	
		Free	Bound
Glycine	14.34	11.34±0.02	17.81±0.03
L-valine	18.12	n/d	5.74±0.02
Nor-valine	19.1	Internal standard	
L-leucine	20.34	n/d	6.18±0.02
L-serine	20.66	n/d	4.01±0.01
L-threonine	20.908	n/d	n/d
L-isoleucine	21.15	n/d	0.77±0.01
L-proline	21.52	57.86±0.04	80.34±0.07
L-asparagine	21.76	n/d	n/d
L-aspartic acid	23.47	n/d	19.64±0.02
L-glutamic acid	26.41	n/d	21.63±0.04
L-methionine	26.68	n/d	n/d
L-cysteine	28.77	n/d	n/d
L-phenylalanine	29.26	n/d	11.04±0.03
L-glutamine	31.49	n/d	n/d
L-lysine	35.43	n/d	8.11±0.02
L-histidine	36.54	n/d	n/d
L-tyrosine	38.43	n/d	4.85±0.03
L-tryptophan	40.41	n/d	2.22±0.01

Note: n/d – not detected

The analysis of the content of amino acids in the studied extract from the flowers of the *Tagetes patula* showed that the raw material contains a significant amount of L-proline, the total content of which was 138.20 mg/g. The content of free L-proline was 57.86 mg/g, bound – 80.34 mg/g (Tabl. 2). The proline is a regulator of many physiological and biochemical processes in cells, such as contributes to the synthesis of polyamines, and arginine, and activates mTOR cell signal-ling for protein synthesis, specifically collagen (Wu, 2011).

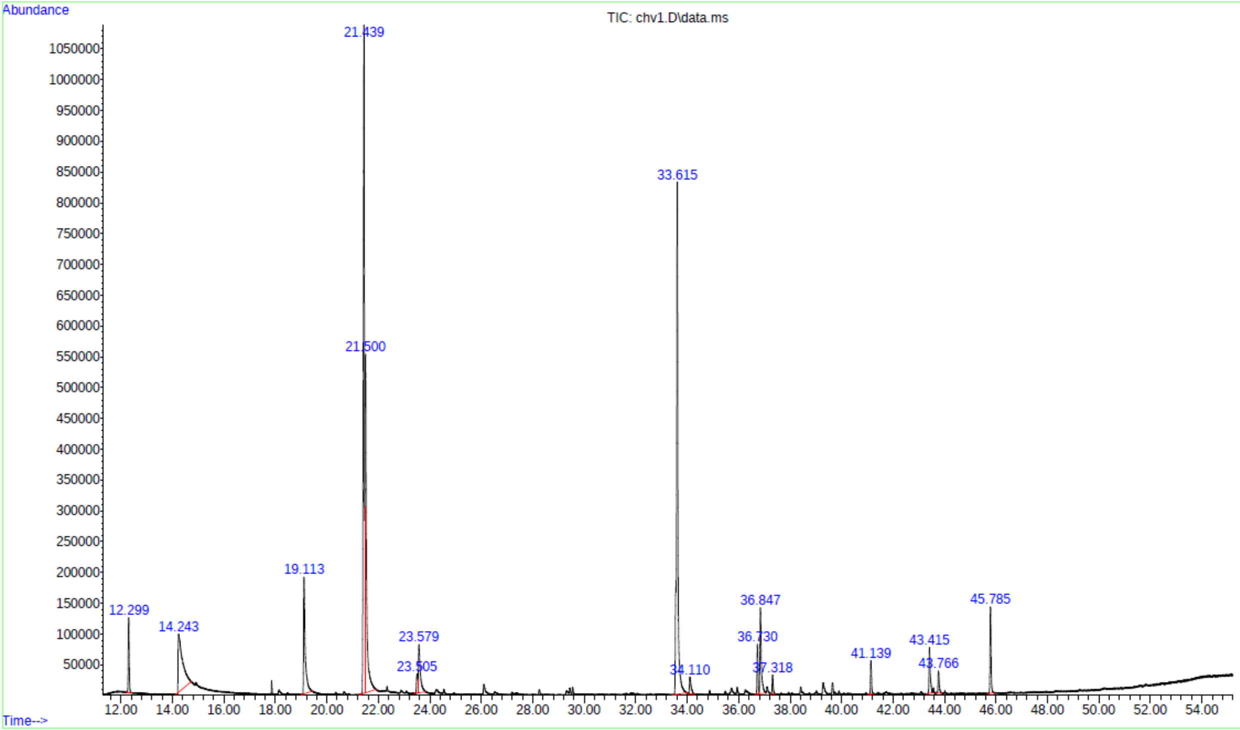

Fig. 1. GC/MS chromatogram of free amino acids in the extract from the flowers of the *Tagetes patula* L.

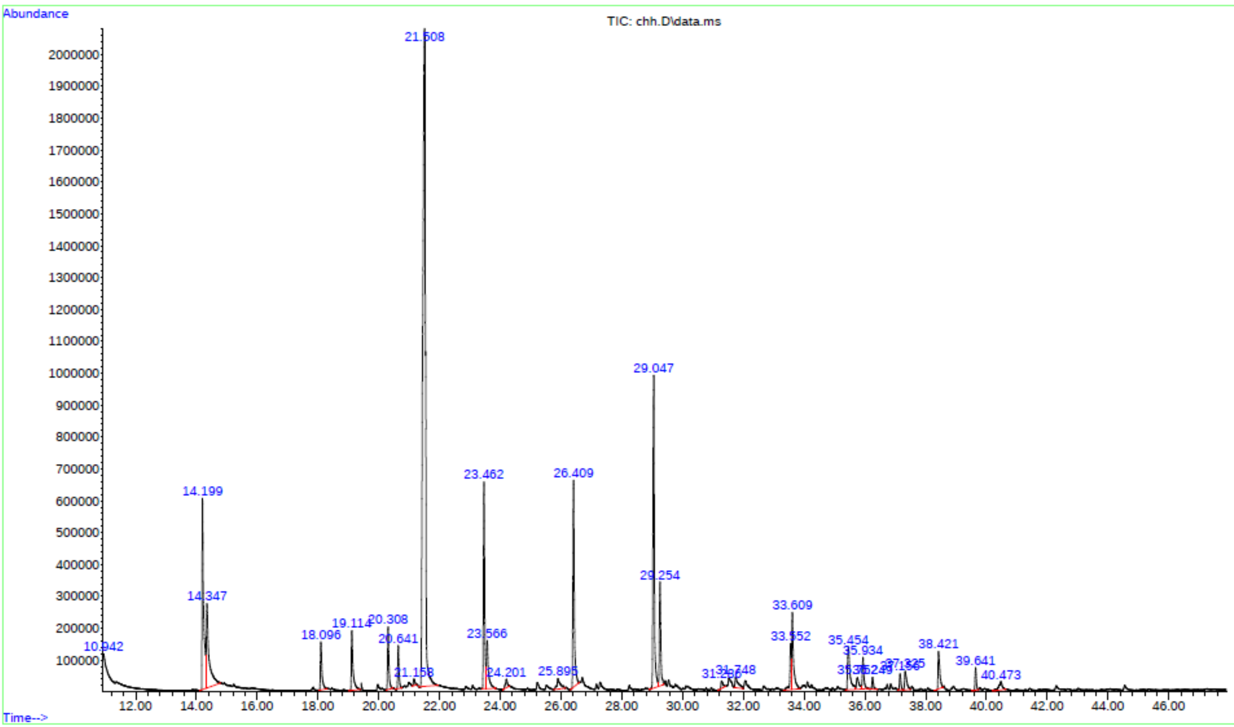

Fig. 2. GC/MS chromatogram of amino acids after hydrolysis in the extract from the flowers of the *Tagetes patula* L.

Glycine was also found in the studied extract from free amino acids, the content of which was 11.34 mg/g. Glycine plays a role in diabetes. It is a secretagogue of glucagon-like peptide-1 (GLP-1), insulin, and glucagon because it has been shown that the effect of ingested glycine on the postprandial glucose concentration facilitates the secretion of insulin by other amino acids (Gameiro, 2005).

Decreased glycine receptor (GlyR) expression in cells from people with type 2 diabetes mellitus (T2DM) is associated with a disruption of glycine-induced insulin secretion (Yan-Do, 2016). Clinical studies have shown that higher circulating glycine concentrations help lower the risk of developing T2DM (Gao, 2017).

In addition to L-proline, significant amounts of L-aspartic (19.64 mg/g) and L-glutamic (21.63 mg/g) acids were found in the extract from the flowers of the *Tagetes patula*.

L-threonine, L-asparagine, L-methionine, L-cysteine, L-glutamine, and L-histidine were not detected in the studied extract.

Plants are capable of synthesizing almost all amino acids, and the human body – only a part, of irreplaceable amino acids must come with food products since each of them performs a certain physiological function. Comparing the obtained results regarding the quantitative content of essential amino acids in the extract of the *Tagetes patula* and the recommended daily requirements for individual essential amino acids, it can be stated that the inclusion of this plant or products based on it in the diet will satisfy a significant percentage of the daily requirement for most essential amino acids.

Therefore, according to the obtained results we have been able to elevate the marigold flower extracts with a high content of amino acids. Prepared extracts were applied in the formulation of the functional products, namely the buns.

To determine the effect of the extract on the quality of the bakery product, the optimal dosage was adopted, taking into account the physiological needs of the human body – 0.021 g per 100 g of bun. Before being added to the dough, the extract was dissolved in water at 35 ^{0}C. A sample bun without the additive served as a control.

It is known that proteins, starch, enzymes, and microorganisms are involved in the formation of the rheological properties of dough. Proteins are an important component of flour, as they absorb a significant amount of water in the dough and form a hydrated substance that is elastic, stretchy and resilient. It is gluten that will provide the internal structure of the fermented dough, porosity and shape stability of the finished products (Drobot, 2024). The main indicators of its quality are shown in table 3.

Table 3

Gluten quality indicators of the studied bakery product

Indicators	Samples	
	control	**with extract**
Crude gluten content, %:	24.2±0.5	24.2±0.5
Extensibility, cm	14.5±1	16.5±1
Springiness, unit of springiness IDK	71±5	74±5
Hydration capacity, %	160±2	163±2
Elasticity	good	
Color	Light	light brown

Research results indicate that the introduction of marigold flower extract into the bun production technology does not change the amount of raw gluten. Biologically active substances contained in the supplement do not have a significant effect on gluten. Therefore, correction of technological regimes and the process of preparation of semi-finished flour is not required.

Establishing the quality of products is important in this matter. It was established that both samples had an even rounded shape, without cracks. The color of the crust is golden brown. The porosity of the pulp did not differ, it was small and thin-walled, well developed, which will contribute to the maximum access of digestive enzymes and, accordingly, digestibility. The pulp is well baked, not sticky. A change in its color from white in the control to cream in the bun with the extract was observed. The taste is pleasant, the smell of flowers was not felt. For visualization, a photo of the buns is shown in fig. 3.

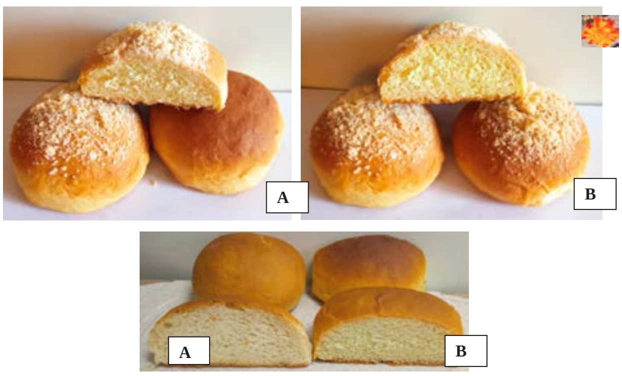

Fig. 3. Photo of experimental buns (A – buns – control; B – buns with marigold flower extract)

The obtained results of research on physical and chemical indicators of bun quality are shown in table 4.

As can be seen from the table, adding marigold extract to the bun dough does not change the acidity of its pulp. Porosity remains developed, and dimensional stability is within the permissible deviation.

Table 4

Physico-chemical indicators of the quality of bun samples

Indicators	Samples	
	Control	with extract
Acidity, degrees	2.3±0.5	2.4±0.5
Porosity, %	70.0±1	70.0±1
Form stability, h/d	0.49	0.48

The selected dosage of marigold extract does not have a significant effect on the organoleptic and physicochemical indicators of the quality of buns. Therefore, it can be used as a recipe component of a butter bun.

Conclusions

Thus, the results obtained by us show that the extract from the flowers of the *Tagetes patula* has a wide spectrum of amino acid composition with a significant content of these compounds, which confirms the perspective of further research, as well as the use of *Tagetes patula* extract in other fields, for example, the food industry.

It has been established that adding the flower extract of the *Tagetes patula* does not have a noticeable effect on the quality indicators of bakery products. At the same time, it is possible not only to diversify the range of bakery products and improve their quality but also to increase the nutritional and biological value of the product.

BIBLIOGRAPHY

Babu K.G., Kaul V. Variations in quantitative and qualitative characteristics of wild marigold (*Tagetes minuta* L.) oils distilled under vacuum and at NPT. *Industrial Crops and Products*. 2007. № 26. P. 241–251.

Budniak L., Slobodianiuk L., Marchyshyn S., Potishnyi I. Determination of amino acids of plants from *Angelica* L. genus by HPLC method. *Pharmacia*. 2022. № 69(2). P. 437–446.

Chen W.P., Yang X.Y., Hegeman A.D., Gray W.M., Cohen J.D. Microscale analysis of amino acids using gas chromatography–mass spectrometry after methyl chloroformate derivatization. *Journal of Chromatography B*. 2010. № 878(24). P. 2199–2208.

Craveiro C.C., Matos F.J.A., Machado M.I.L., Alencar J.W. Essential oil of Tagetes minuta from Brazil. *Perfum. Flavor*. 1988. № 13. P. 35–36.

Дробот В.І. Технологія хлібопекарського виробництва. ПрофКнига. 2024. 516 с.

ДСТУ 7045:2009 Вироби хлібобулочні. Методи визначання фізико-хімічних показників. Київ : Держспоживстандарт України, 2009.

ДСТУ 9188:2022 Вироби хлібобулочні. Органолептичне оцінювання показників якості. Київ : Держспоживстандарт України, 2022.

Feshchenko H., Oleshchuk O., Slobodianiuk L., Milian I. Study of Epilobium angustifolium L. amino acids content by HPLC method. ScienceRise: *Pharmaceutical Science.* 2021. № 6(34). P. 85–90.

Gameiro A., Reimann F., Habib A.M., O'malley D., Williams L., Simpson A.K., Gribble F.M. The neurotransmitters glycine and GABA stimulate glucagon-like peptide-1 release from the GLUTag cell line. *The Journal of Physiology*. 2005. № 569. P. 761–772.

Gao X., Wang Y., Sun G. High dietary choline and betaine intake is associated with low insulin resistance in the Newfoundland population. *Nutrition*. 2017. № 33. P. 28–34.

López E.L., Ortega M.G.P., Bery M.T., León C., Cedillo F.D., Serrato Cruz M.Á. Fungistasis of essential oil extracted from a *Tagetes lucida* population of Hidalgo, México. *Revista Mexicana de Ciencias Agrícolas*. 2018. № 9(2). P. 329–341.

Marchyshyn S., Budniak L., Slobodianiuk L., Panasenko N., Gudz N. Study of hypoglycemic activity of extract of yacon (*Polymnia sonchifolia* POEPP. & ENDL.) root tubers. *Pharmacologyonline*. 2021. №3. P. 1048–1057.

Марчишин С., Пасєчко Н., Слободянюк Л., Будняк Л., Козир Г., Хоміцька А. Дослідження цукрознижувальної активності сухого екстракту з листків стевії медоносної. *Фітотерапія. Часопис*. 2023. № 4. С. 48–56.

Marchyshyn S., Slobodianiuk L., Budniak L., Ivasiuk I. Hypoglycemic effect of *Cyperus esculentus* L. tubers extract. *Pharmacologyonline*. 2021. № 2. P. 1383–1392.

Politi F.A.S., Souza A.A.J., Fantatto R.R., Pietro R., Barioni W.J., Rabelo M.D., Bizzo H.R., de Souza Chagas A.C., Furlan M. Chemical composition and in vitro anthelmintic activity of extracts of *Tagetes patula* against a multidrug-resistant isolate of *Haemonchus contortus*. *Chemistry & Biodiversity*. 2017. № 15. P. e1700507.

Slobodianiuk L., Budniak L., Marchyshyn S., Kostyshyn L., Ezhned M. Determination of amino acids content of the *Tagetes lucida* Cav. by GC/MS. *Pharmacia*. 2021. № 68(4). P. 859–867.

Slobodianiuk L., Budniak L., Feshchenko H., Sverstiuk A., Palaniza Y. Quantitative analysis of fatty acids and monosaccharides composition in *Chamerion angustifolium* L. by GC/MS method. *Pharmacia*. 2022. № 69(1). P. 167–174.

Ткаченко Ю.Д., Буяльська Н.П., Денисова Н.М. Використання продуктів переробки цикорію коренеплідного у виробництві борошняних кондитерських виробів. *Технічні науки та технології*. 2018. № 2 (12). С. 196–203.

Vancompernolle B., Croes K., Angenon G. Optimization of a gas chromatography-mass spectrometry method with methyl chloroformate derivatization for quantification of amino acids in plant tissue. *Journal of chromatography B, Analytical Technologies in the Biomedical and Life*. 2016. № 1017. P. 241–249.

Власенко І.О., Давтян Л.Л. Аудит фасованої продукції лікарських рослин, які застосовуються при цукровому діабеті, на фармацевтичному ринку України. *Фітотерапія. Часопис*. 2021. № 3. С. 53–61.

Волощук Г.І., Ярковий А.О., Полуцька Б.М., Пашова Н. . Дослідження впливу порошку топінамбура на вміст цукрів у хлібі житньому заварному. *Наукові праці Національного університету харчових технологій*. 2019. Т. 25. № 3. С. 253–263.

Wu G., Bazer F.W., Burghardt R.C., Johnson G.A., Kim S.W., KnabeDA Li. P., Li X., Mcknight J.R., Satterfield M.C. Proline and hydroxyproline metabolism: implications for animal and human nutrition. *Amino Acids*. 2011. № 40(4). P. 1053–1063.

Yan-Do R., Duong E., Fox J.E.M., Dai X., Suzuki K., Khan S., Bautista A., Ferdaoussi M., Lyon J., Wu X. A glycine-insulin autocrine feedback loop enhances insulin secretion from human β-cells and is impaired in type 2 diabetes. Diabetes. 2016. № 65. P. 2311–2321.

Юрчак В.Г. Дослідження макаронних властивостей цільнозернового пшеничного борошна. *Наукові праці Національного університету харчових технологій.* 2012. № 47. С. 123–128.

REFERENCES

Babu, K. G., & Kaul, V. (2007) Variations in quantitative and qualitative characteristics of wild marigold (*Tagetes minuta* L.) oils distilled under vacuum and at NPT. Industrial Crops and Products, 26, 241–251.

Budniak, L., Slobodianiuk, L., Marchyshyn, S., & Potishnyi, I. (2022). Determination of amino acids of plants from *Angelica* L. genus by HPLC method. Pharmacia, 69(2), 437–446.

Chen, W.P., Yang, X.Y., Hegeman, A.D., Gray, W.M., & Cohen, J.D. (2010). Microscale analysis of amino acids using gas chromatography–mass spectrometry after methyl chloroformate derivatization. Journal of Chromatography B, 878(24), 2199–2208.

Craveiro, C.C., Matos, F.J.A., Machado, M.I.L., & Alencar, J.W. (1988). Essential oil of *Tagetes minuta* from Brazil. Perfum. Flavor, 13, 35–36.

Drobot, V. I. (2024). Tekhnolohiia khlibopekarskoho vyrobnytstva [Technology of bakery production]. ProfKnyha, 516 [in Ukrainian].

DSTU 7045:2009 Vyroby khlibobulochni. Metody vyznachannia fizyko-khimichnykh pokaznykiv [Bakery products. Methods of determining physical and chemical parameters]. Kyiv: Derzhspozhyvstandart Ukrainy, 2009 [in Ukrainian].

DSTU 9188:2022 Vyroby khlibobulochni. Orhanoleptychne otsiniuvannia pokaznykiv yakosti [Bakery products. Organoleptic assessment of quality indicators]. Kyiv: Derzhspozhyvstandart Ukrainy, 2022 [in Ukrainian].

Feshchenko, H., Oleshchuk, O., Slobodianiuk, L., & Milian, I. (2021). Study of Epilobium angustifolium L. amino acids content by HPLC method. ScienceRise: Pharmaceutical Science, 6(34). 85–90.

Gameiro, A., Reimann, F., Habib, A.M., O'malley, D., Williams, L., Simpson, A.K., & Gribble, F.M. (2005). The neurotransmitters glycine and GABA stimulate glucagon-like peptide-1 release from the GLUTag cell line. The Journal of Physiology. 2005, 569, 761–772.

Gao, X., Wang, Y., & Sun, G. (2017). High dietary choline and betaine intake is associated with low insulin resistance in the Newfoundland population. Nutrition, 33, 28–34.

López, E.L., Ortega, M.G.P., Bery, M.T., León, C., Cedillo, F.D., & Serrato Cruz, M.Á. (2018). Fungistasis of essential oil extracted from a *Tagetes lucida* population of Hidalgo, México. Revista Mexicana de Ciencias Agrícolas, 9(2), 329–341.

Marchyshyn, S., Budniak, L., Slobodianiuk, L., Panasenko, N., & Gudz, N. (2021). Study of hypoglycemic activity of extract of yacon (*Polymnia sonchifolia* POEPP. & ENDL.) root tubers. Pharmacologyonline, 3, 1048–1057.

Marchyshyn, S., Pasyechko, N., Slobodianiuk, L., Budniak, L., Kozyr, G., & Khomitska, A. (2023). Doslidzhennia tsukroznyzhuvalnoi aktyvnosti sukhoho ekstraktu z lystkiv stevii medonosnoi [Study of sugar-lowering activity of dry extract from stevia leaves]. *Fitoterapiia. Chasopys – Phytotherapy. Journal*, 4, 48–56 [in Ukrainian].

Marchyshyn, S., Slobodianiuk, L., Budniak, L., & Ivasiuk, I. (2021). Hypoglycemic effect of *Cyperus esculentus* L. tubers extract. Pharmacologyonline, 2, 1383–1392.

Politi, F.A.S., Souza, A.A.J., Fantatto, R.R., Pietro, R., Barioni, W.J., Rabelo, M.D., Bizzo, H.R., de Souza Chagas, A.C., & Furlan, M. (2017). Chemical composition and in vitro anthelmintic activity of extracts of *Tagetes patula* against a multidrug-resistant isolate of *Haemonchus contortus*. Chemistry & Biodiversity, 15, e1700507.

Slobodianiuk, L., Budniak, L., Marchyshyn, S., Kostyshyn, L., & Ezhned, M. (2021). Determination of amino acids content of the *Tagetes lucida* Cav. by GC/MS. Pharmacia, 68(4), 859–867.

Slobodianiuk, L., Budniak, L., Feshchenko, H., Sverstiuk, A., & Palaniza, Y. (2022). Quantitative analysis of fatty acids and monosaccharides composition in *Chamerion angustifolium* L. by GC/MS method. Pharmacia, 69(1), 167–174.

Tkachenko, Yu.D., Buialska, N.P., & Denysova, N.M. (2018). Vykorystannia produktiv pererobky tsykoriiu koreneplidnoho u vyrobnytstvi boroshnianykh kondyterskykh vyrobiv [Use of chicory root processing products in the production of flour confectionery products]. *Tekhnichni nauky ta tekhnolohii*, 2 (12), 196–203 [in Ukrainian].

Vancompernolle, B., Croes, K., & Angenon, G. (2016). Optimization of a gas chromatography-mass spectrometry method with methyl chloroformate derivatization for quantification of amino acids in plant tissue. Journal of chromatography B, Analytical Technologies in the Biomedical and Life, 1017. 241–249.

Vlasenko, I.O., & Davtian, L.L. (2021). Audyt fasovanoi produktsii likarskykh roslyn, yaki zastosovuiutsia pry tsukrovomu diabeti, na farmatsevtychnomu rynku [Audit of prepackaged products of medicinal plants used for diabetes on the pharmaceutical market of Ukraine]. *Ukrainy Fitoterapiia. Chasopys*, 3, 53–61 [in Ukrainian].

Voloshchuk, H.I., Yarkovyi, A.O, Polutska, B.M., & Pashova, N.V. (2019). Doslidzhennia vplyvu poroshku topinambura na vmist tsukriv u khlibi zhytnomu zavarnomu [Study of the effect of Jerusalem artichoke powder on the sugar content of rye custard bread]. *Naukovi pratsi Natsionalnoho universytetu kharchovykh tekhnolohii,* 25, 3, 253–263 [in Ukrainian].

Wu, G., Bazer, F.W., Burghardt, R.C., Johnson, G.A., Kim, S.W., KnabeDA, Li. P., Li, X., Mcknight, J.R., & Satterfield, M.C. (2011). Proline and hydroxyproline metabolism: implications for ani-mal and human nutrition. Amino Acids, 40(4), 1053–1063.

Yan-Do, R., Duong, E., Fox, J.E.M., Dai, X., Suzuki, K., Khan, S., Bautista, A., Ferdaoussi, M., Lyon, J., & Wu, X., (2016). A glycine-insulin autocrine feedback loop enhances insulin secretion from human β-cells and is impaired in type 2 diabetes. Diabetes, 65, 2311–2321.

Yurchak, V.G. (2012). Doslidzhennia makaronnykh vlastyvostei tsilnozernovoho pshenychnoho boroshna [Study of pasta properties of whole wheat flour]. *Naukovi pratsi Natsionalnoho universytetu kharchovykh tekhnolohii*. Kyiv: NUKhT, 47, 123–128 [in Ukrainian].

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Karpyk H. – collection and analysis of literature, conclusions, participation in writing the article;
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Marchyshyn S. – idea, research design, experiment, article correction;
Slobodianiuk L. – collection and analysis of literature, conclusions, participation in writing the article;
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