Use of lupine flour and cavbuz puree in bread technology

Svitlana Bazhay-Zhezherun, Galina Simakhina, Ludmyla Bereza-Kindzerska, Tetiana Romanovska

National University of Food Technologies, Kyiv, Ukraine

Keywords:

Cavbuz
Lupine
Flour
Bread
Health food

Article history:

Received 15.07.2022
Received in revised form 19.11.2022
Accepted 30.12.2022

Corresponding author:

Svitlana Bazhay-Zhezherun
E-mail: LanaNEW_1@ukr.net

DOI: 10.24263/2304-974X-2022-11-4-7

Abstract

Introduction. The influence of vegetable additives: cavbuz (a hybrid of watermelon and pumpkin) puree and flour of non–alkaloid lupine on the nutritional and biological value of wheat bread, its sorption capacity in relation to toxic lead ions was studied.

Materials and methods. Content of following substances was determined: proteint by Bradford method; starch by polarimetric method; fat by exhaustive extraction with chemically pure hexane; vitamins E, P (rutin), β–carotene colorimetrically; vitamin C titrimetrically; B_1, B_2 fluorometrically; fiber by acid hydrolysis; pectin by the calcium–pectate method; te amount of lead absorbed by “wet burning” method.

Results and discussion. Cavbuz puree is a rich source of substances with antioxidant activity: β-carotene, 13.4 mg, P (rutin), 45.4 mg, phenolic compounds, 283.23 mg, as well as natural food sorbents such as fiber 1.7% and pectin, 1.5% per 100 g of product with moisture content 83.1%. According to sensory and physico-chemical characteristics, cavbuz puree may be used as a component in the manufacturing of health products. Lupine flour contains 3.9 times more protein, 40 times more fiber, 10.5 pectin substances compared to wheat flour; a significant amount of tocopherols, 12.8 mg, β-carotene, 0.52 mg, vitamin C, 35.84 mg per 100 g of product with moisture content 9.5%.

The inclusion of 4-7% of lupine flour and 3–5% of cavbus puree in the recipe of wheat bread, makes it possible to obtain bread for health purposes, in which the protein content is 22–32%, fiber content is two to three times higher, tocopherols are 9 times higher than in control, provided that the physico-chemical and organoleptic parameters of the product are acceptable. 100 g of developed bread provides 23% of the minimum rate of pectin consumption, 6% of the daily need for vitamin E; 13.8% in B_1, 14% in β–carotene; 6.6% in flavonoids, which are absent in wheat bread. Enriched bread has a 25–30 times higher sorption capacity for toxic divalent lead ions than wheat bread.

Conclusions. It is recommended to use of cavbuz puree and flour of non–alkaloid lupine varieties for the production of wheat bread with increased nutritional value.

Introduction

Proteins play an extremely important role in human nutrition, as they are the main component of all organs and tissues of the body. It is also important to have a sufficient amount of dietary fiber in the diet, which has sorption properties in relation to toxic compounds, has a positive effect on the intestinal microbiome, and helps to prevent a number of metabolic diseases (Ioniță-Mîndrican et al., 2022). The need to increase the content of full–fledged proteins and natural food sorbents in the diet of the population (Hertzler et al., 2020) determines the feasibility of enriching mass consumption products with these compounds, in particular bread and bakery products.

Lupine, along with soy, has the highest content of full protein among legumes, contains biologically active substances, such as oligosaccharides, phenolic compounds and vitamins, which have a wide range of biological effects: they participate in redox processes, are natural antioxidants, and precursors of coenzymes (Ruiz-Lópezet et al., 2019). Promising for use in the food industry are new varieties of narrow-leaved, alkaloid-free lupine, which contain 36–40% of proteins, 6–6.5% of fat, 26% of carbohydrates, but have a rather insignificant content of alkaloids, 0.0025%, compared to yellow and white lupine varieties (Ratoshniuk et al., 2020). Lupine flour, as well as protein concentrates and lupine isolates, which have a protein solubility of more than 90%, a water absorption capacity of 4.5 g/g of dry weight, are used to increase the protein content of pasta, bread, cookies, and as a gluten-free raw material in production dietary, functional and medical food products (Carvajal-Larenas et al., 2016; Krawęcka et al., 2022; Mazur, et al., 2018). A decrease in the density of bread and insignificant change in its elasticity and sensory indicators were observed in cases when lupine flour was included in the recipes (Guiné et al., 2015). Moreover, the amount of it in the recipe 5–15% contributes to increasing water absorption, improving the amino acid and fat-acid composition, as well as the content of mineral compounds (Hanan, 2013; Maghaydah et al., 2022). However, replacing wheat flour with lupine flour more than 10%, reduces the quality of bread, in particular porosity, elasticity, and increases stickiness (Lazdauskienė et al., 2022; Villarino et al., 2016). Therefore, it is actial to study the combination of the use of high-protein raw materials and food fiber sources for the enrichment of bread.

An important direction for the enrichment of bread products is also the use of vegetable purees (Ebrahimi et al., 2020). Adding vegetable purees to the recipe composition of bread significantly improves the quality of raw gluten, increases its sensory and nutritional properties (Amoah et al., 2021), increases the content of phenolic compounds and folic acid in finished products (Czarnowska-Kujawska, 2022). There is data on the use of pumpkin puree (Bayramov et al., 2022) and sweet potato puree (Malavi et al., 2022) for the enrichment of bread with bioavailable phenols, β-carotene, and fiber. The use of vegetable purees as sources of dietary fibers, which are sorbents of such heavy metals as lead cations, cadmium (Guo, 2022) in the technology of mass consumption products and, in particular, bread, is an urgent issue, weighing the distribution of these toxicants, particularly lead in the environment (Collin et al., 2022). Complex use of two enrichment agents: wheat germ and vegetable puree (Ebrahimi et al. 2020); sweet corn flours and drum-dried pumpkin (Amoah et al. 2021) in bread technology, improves nutritional value, increases antioxidant and sorption capacity of products.

A promising vegetable raw material is cavbuz, a molecular hybrid of watermelon and pumpkin, which contains a significant amount of pectin, sugars (glucose, fructose); hemicellulose, fiber, β-carotene, vitamins of group B, C, E, P; salts of potassium, calcium, magnesium, iron (Potopalskyi et al., 2019). The given research results prove that lupine flour could be used in bakery for increasing the protein content in products. There is also data on the independent use of vegetable purees and in combination with other non-traditional raw materials to enrich bread with vitamins, phenols, and natural sorbents. However, there are no studies on the possibility of using two natural enrichers: vegetable cavbuz puree and lupine flour for the production of healthy bread.


a **b**

Figure 1. Images of cavbuz (a) and lupine (b)

The aim of the present study is to check the feasibility of using lupine flour and cavbuz puree as a source of antioxidant compounds and natural sorbents to increase the nutritional value of wheat bread and increase its sorption capacity.

Materials and methods

Materials

During experimental studies, non-alkaloid lupine of the «Volodymyr» variety harvest 2021 (Mazur et al., 2018) and cavbuz varieties «Zdoruyaga» (Potopalskyi et al., 2019), samples of bread were used.

Methods

Preparation of puree

Preparation of cavbuz puree included washing of raw material, cleaning, removal of seed, slicing, blanching, wiping, homogenization, pasteurization, and packaging followed by storage at a temperature of 2–4 ° C, 2–3 days, or at a temperature of -18 to -22 ° C for 5–6 months.

The purified cavbus pulp was cut into pieces of 8–12 mm, blanched with hot steam at a temperature of 96–98 °C for 5–8 min. Then the mass was wiped through a sieve with a diameter of 0.7–0.8 mm, homogenization of the puree was carried out with a blender at a speed of 15000 rpm. The product was pasteurized at a temperature of 90 °C for 10 min.

Preparation of bread

The dough was kneaded in a non-evaporating manner (Drobot, 2019) from wheat flour of the first grade with partially replacemtn of flour with equal amount of non-alkaloid lupine, 4–8%, and cavbus puree, 2–6%. Yeast and salt were added in an amount of 1–1.5% of the flour weight. The developed formulations are given in Table 1.

Table 1

Dough preparation

№	Prescription components,%				
	First grade wheat flour	**Lupine flour**	**Cavbuz puree**	**Yeast**	**Salt**
1 (Control)	97	–	–	1.5	1.5
2	92	4.0	2.0	1.0	1.0
3	90	5.0	3.0	1.0	1.0
4	87	6.0	4.0	1.5	1.5
5	85	7.0	5.0	1.5	1.5
6	83	8.0	6.0	1.5	1.5

Titrated acidity. Titrated acidity in semi–finished products (dough) and finished products (bread) was determined by titration (Tyl et al., 2017).

Physical and chemical indicators of bread. The porosity of the bread was determined using the Zhuravlev device. Specific volume was determined by standard method (Drobot, 2019).

Moisture. The moisture content in the test samples was determined by drying to a constant mass at a temperature of 105 °C.

Protein. The protein content in the experimental samples was determined by the Bradford method (Carlsson et al., 2011).

Starch. The amount of starch was determined by the polarimetric method (Subroto et al., 2020).

Fat was determined by exhaustive extraction with chemically pure hexane (Erickson, 2005).

Vitamin E was determined by a method based on the formation of quinones during the oxidation of tocopherol molecules extracted from the test product by chloric iron. Chlorine iron is reduced to chloride, the amount of which is determined by the intensity of color during the addition of orthophenanthroline (Gamna, 2021).

β-carotene was determined by spectrophotometric method (Biehler et al., 2009).

Vitamin P **(rutin)** was determined by spectrophotometric method (Dong et al., 2020).

Phenolic compounds were determined by spectrophotometric method (Waterhouse, 2002).

Vitamin C content was determined by titrometric method, which is based on extraction of vitamin C from the test sample with a solution of acid (hydrochloric, metaphosphoric or a mixture of acetic and metaphosphoric) followed by titration visually or potentiometrically with a solution of 2,6–dichlorophenoline sodium phenolate (Majidi et al., 2016)

Choline was determined by a method based on the formation of a stained choline compound with Reinecke salt (Phillips, 2012)

Thiamine, riboflavin. Vitamin B_1 and B_2 contents were determined fluorometrically (Zajicek et al., 2005).

Polysaccharides. The fiber content was determined by acid hydrolysis (Möller et al., 2008). To determine the mass fraction of pectin substances, a weight calcium–pectate method was used, which is based on the hydrolysis of pectin substances to pectin acids, their precipitation in the form of calcium salts, drying and weighting (Chandel et al., 2022).

Determination of lead ion content. A sample of a water-acid solution of a bread sample containing pectin was prepared. For this purpose, the sample was hydrolyzed with distilled water at a temperature of 45°C for 30 minutes. The obtained extract was filtered. The bread residue was subjected to acid hydrolysis with HCl solution (0.3 mol/dm3) for 30 minutes in a boiling water bath to extract protopectin and pectic acid. The resulting solution was filtered. Filtrates of hydrated pectin and protopectin solutions were combined. The filtrate sample was treated with a standard lead solution (0.035 N) to form a precipitate of lead Pb pectates. The precipitate was boiled for 2 hours in a combustible mixture of concentrated nitric acid and a 30% hydrogen peroxide solution in a ratio of 3:1 to a clear solution. The content of lead ions in the solution was determined by spectrophotometric method (Lang et al., 2008).

Results and discussion

Chemical composition of the cavbuz

Chemical composition of raw materials is a factor influencing the quality of the finished product. The content of important macro- and micronutrients of cavbus in comparison with pumpkin is shown in Table 2.

The obtained results correlate with the data of Potopalskyi et al. (2019) and show that cavbus has a higher nutritional value in comparison with pumpkin, in particular, in the content of vitamins, sugars, pectin substances, and fiber.

Physico-chemical and sensory characteristics of vegetable puree quality

The physico-chemical and sensory characteristics of quality of cavbuz puree, given in comparison with pumpkin puree, were determined (Tables 3, 4).

Table 2

Chemical compositions of cavbus and pumpkin

Indicators	Value	
	Cavbus	Pumpkin
Dry matter content,%	16.9±0.2	8.8±0.2
Protein,%	0.60±0.01	0.51±0.02
Fat,%	0.05±0.12	0.06±0.01
Sugars,%	11.50±0.25	5.2±0.14
Pectin,%	1.63±0.02	0.7±0.12
Fiber ,%	1.85±0.11	1.2±0.15
Organic acids,%	0.1±0.1	0.1±0.1
Vitamins		
Vitamin E, mg/100 g	1.22±0.01	0.60±0.02
β–carotene, mg/100 g	18.53±0.12	10.14±0.43
Vitamin C, mg/100 g	37.52±0.03	10.36±0.02
P (rutin), mg/100 g	67.41±0.26	55.84±0.32
Choline, mg/100 g	84.2±0.34	75.3±0.38
Phenolic compounds, mg/100 g	328.12±0.42	285.24±0.35

Table 3

Sensory characteristics of puree

Parameters	Characteristics	
	Cavbuz puree	Pumpkin puree
Appearance	Grated homogeneous mass, without skin, fibers, seeds, seeds.	
Color	Saturated orange, homogeneous throughout the mass of cavbuz puree.	Yellow, homogeneous throughout the mass of puree
Smell	Peculiar to cavbuz, without foreign odors.	Characteristic of pumpkin, without extraneous odors.
Taste	Pleasant sweet, peculiar to cavbuz.	Sweet, peculiar to pumpkin.
Consistency	Homogeneous, without stratification, juicy without extraneous inclusions.	

Table 4

Physico–chemical characteristics of vegetable puree

Indicators	Cavbuz puree	Pumpkin puree
Dry matter content,%	15.32±0.12	7.23±0.31
Titrated acid content (in terms of malic acid),%	0.09±0.01	0.09±0.01
pH	5.6	5.2

Cavbus puree contains twice as much dry matter as pumpkin puree, both puree contain a small amount of organic acids.

It was noted that due to the presence of a significant amount of pectin substances and fiber, which are characterized by high water absorption capacity (Tan et al., 2017), cavbus puree has a thicker consistency, compared to pumpkin puree. During processing in the finished product, the content of vitamins decreases compared to the initial raw materials (Herrera-Ardila et al., 2022). The vitamin contents of vegetable puree, as well as the content of polysaccharides in them, which are part of the complex of food fibers, were determined (Table 5).

Table 5

Content of vitamins and polysaccharides in puree

Indicators	Content	
	Cavbuz puree	**Pumpkin puree**
Vitamin E, mg/100 g	0.92±0.03	0.34±0.02
β–carotene, mg/100 g	13.42±0.13	6.38±0.04
P (rutin), mg/100 g	45.42±0.22	36.41±0.31
Phenolic compounds, mg/100 g	283.23±0.25	236.81±0.15
Pectin,%	1.50±0.02	0.56±0.04
Fiber ,%	1.72±0.04	0.95±0.12

According to the results, cavbus puree has a higher content of vitamins, phenolic compounds, pectin, and fiber compared to pumpkin puree.

Nutritional value of wheat and non–alkaloid lupine flour

Comparison of the nutritional value of wheat and non-alkaloid lupine flour was done and the results are shown in Table 6.

Table 6

Chemical composition of flour

Indicator	Lupine flour	First grade wheat flour
Moisture,%	9.5±0.2	11.5±0.3
Proteins,%	41.87±0.12	10.82±0.24
Fats,%	11.03±0.14	1.28±0.05
Starch,%	4.51±0.06	72.04±0.12
Fiber,%	12.51±0.05	0.30±0.03
Pectin,%	10.52±0.36	–
Total ash content,%	2.42±0.15	0.70±0.03
Vitamins		
E, mg/100 g	12.82±0.03	0.21±0.1
β–carotene mg/100 g	0.52±0.02	0.11±0.01
C, mg/100 g	35.84±0.13	2.60±0.05
B_1, mg/100 g	0.22±0.01	0.18±0.01
B_2 , mg/100 g	0.11±0.01	0.15±0.01
P, mg/100 g	0.31±0.01	3.52±0.02

It is found that lupine flour contains four times more protein and more than ten times more fiber and pectin substances, and much more lipids compared to wheat flour. The amount of vitamins, in particular, tocopherols, β–carotene, B_1, is also much higher in lupine flour (Table 6). The results are similar with the data of scientists (Guiné et al., 2015; Prusinski et al., 2019).

Physico–chemical characteristics of dough and bread

Physico-chemical quality indicators of dough and wheat bread, as well as bread enriched with lupine flour and puree cavbus are given in Table 7.

Table 7

Physico–chemical characteristics of dough and bread

Indicators	Recipe number					
	1	2	3	4	5	6
Dough						
Mass fraction of moisture,%	44.0±0.3	43.9±0.1	43.5±0.2	43.2±0.2	42.9±0.1	42.8±0.3
Titrated acidity, degrees						
initial	2.2±0.2	2.5±0.1	2.7±0.1	3.0±0.2	3.1±0.1	3.2±0.3
final	2.5±0.1	2.8±0.2	3.1±0.1	3.3±0.1	3.5±0.1	3.6±0.2
Bread						
Mass fraction of moisture,%	43.5±0.4	42.9±0.1	42.8±0.2	42.6±0.1	42.4±0.3	42.1±0.2
Acidity, degrees	2.7±0.2	3.0±0.1	3.0±0.1	3.1±0.2	3.2±0.1	3.3±0.3
Specific volume, cm^3/g	2.93±0.05	2.90±0.01	2.86±0.03	2.82±0.01	2.80±0.02	2.76±0.05
Porosity,%	71.0±0.2	71.5±0.3	70.2±0.1	69.5±0.4	68.6±0.2	66.2±0.4

The acidity of the dough and, accordingly, of ready–made products with the addition of lupine flour and cavbuz puree varied within 0.5–1.0 deg. When adding of plant enriches to the wheat bread recipe, the specific volume of products is slightly reduced by 1.1–4.5%, depending on the amount of additives. A decrease in specific volume by 5% and porosity of products by 4% was noted when lupin flour was added to the bread recipe in an amount of 10% (Villarino et al., 2016). Increasing the mass fraction of lupine flour to 8% and cavbuz puree to 6% prolongs the time of dough formation, worsens the form resistance of semi–finished products, the finished bread has a lower volume, the porosity structure is fine; since the high water–binding capacity of lupine dietary fibers weakens the gluten matrix, which affects the volume of bread (Guiné et al., 2015).

Effect of vegetable additives on the nutritional value and sensory properties of wheat bread

Characteristics of wheat bread prepared according to recipes shown in Table 1 are given in Table 8.

Table 8

Characteristics of wheat bread with vegetable additives

Recipe number	Content,%					Sensory indicators of bread
	Proteins	Fats	Starch	Fiber	Pectin	
1	7.92 ±0.50	1.21 ±0.23	47.52 ±0.24	0.30 ±0.12	–	The shape is correct, the surface is smooth without cracks, the pulp is well developed, the average porosity, the color is yellow, the taste and smell are inherent in wheat bread.
2	9.63 ±0.21	1.80 ±0.13	45.33 ±0.19	0.62 ±0.08	0.29 ±0.05	The shape is correct, the surface of the smooth pulp is well developed, the average porosity, the color is yellow, the taste and smell are inherent in wheat bread.
3	9.82 ±0.11	1.92 ±0.11	43.50 ±0.31	0.71 ±0.20	0.38 ±0.01	The shape is correct, the surface of the smooth pulp is well developed, the average porosity, the color is rich yellow, the taste and smell are pleasant, with a slight nutty tint.
4	10.20 ±0.22	2.00 ±0.24	41.24 ±0.12	0.80 ±0.14	0.46 ±0.04	The shape is correct, the surface is smooth, the pulp is well developed, the average porosity, the color is golden, the taste and smell are pleasant, with a nutty tint.
5	10.51 ±0.13	2.13 ±0.21	40.91 ±0.17	0.89 ±0.05	0.55 ±0.03	The shape is correct, the surface is smooth, the average porosity, the color is golden, the taste and smell are pleasant, with a walnut–vegetable tint.
6	10.85 ±0.32	2.22 ±0.30	38.17 ±0.26	0.96 ±0.26	0.64 ±0.04	The shape is correct, the surface with minor cracks, the pulp is well developed, small porosity, the color of the product is yellow, the taste of the vegetable additive is too pronounced.

In the production of bread with the introduction of lupine flour in the amount of 4–7% and puree cavbuz in the amounts of 2–5% to replace the equal amounts of the wheat flour, there are improvements in the structural and mechanical properties of the dough due to an increase in its water absorption capacity (Ratoshniuk et al., 2020). The process of dough formation is accelerated, and its blurring is reduced. Sensory characteristics of the finished product are acceptable: the shape of the bread is correct, the surface is smooth without cracks, the softness is well developed, the average porosity, the color of the product is golden, the taste and smell are pleasant, inherent in wheat bread. In the bread obtained according to the recipe 6, too pronounced taste of the vegetable additive in the finished product is noted, which is not appropriate.

Natural dyes found in vegetable additives, carotenoids and flavonoids (Ruiz–López et al., 2019; Saccotelli et al., 2018), contribute to the improvement of the sensory properties of the product, in particular, to intensify the color of bread.

The presence of increased amounts of protein substances in bread enriched with lupine flour and cavbuz puree, and gamma–conglutin, specific protein fraction of lupine, as well as dietary fibers, makes it possible to predict the positive physiological effects of this product in the human body. Foods enriched with fiber and protein play a significant role in the nutrition of individuals suffering from chronic cardiovascular diseases and excess weight (Belski et al., 2012).

The presence of lupine flour in this type of bread has important effects, since this raw material contains valuable biologically active compounds, namely, essential amino acids, vitamins, phenols (Prusinski et al., 2017) and, dietary fibers (Krawęcka et al., 2022). Using whole lupine and its processing products as part of food products, has more sustainable beneficial effects for saturation, glycemic control and blood pressure than extracted lupine protein or lupine fiber (Bryant et al., 2022).

The nutritional value of wheat bread and wheat bread, enriched with cavbuz puree and lupine flour was determined by the presence of essential food components. In addition, an important indicator characterizing nutritional value is the degree of provision of the human body in a certain nutrient, according to the recommended daily norm of consumption. The nutritional value of the developed bread (recipe 4) and control sample (recipe 1), as well as the results of calculating the degree of ensuring a person's daily need for important physiological and functional ingredients due to consumption of 100 g, are given in Table 9. For the calculation, the category of the population of the 1st intensity group aged 40–59 years (women) was selected.

Table 9

Food and energy value of bread enriched with lupine flour and cavbuz puree

Indicator	**Daily norms consumption**	**Nutrient content in 100 g of wheat bread**		**Provision daily norm,%,**	
		Control	Bread enriched with cavbuz puree and lupine flour	Control	Bread enriched with cavbuz puree and lupine flour
Proteins, g	58.0	7.9	10.2	13.6	17.6
Fats, g	58.0	1.2	2.0	2.1	3.4
Carbohydrates, g	240.0	47.5	41.2	19.8	17.2
Alimentary fiber, g	20.0	0.3	1.26	1.5	6.3
B_1, mg	1.3	0.16	0.18	12.3	13.8
B_2, mg	1.6	0.06	0.06	3.8	3.8
E, mg	15.0	0.1	0.90	0.7	6.0
β–carotene, mg	5.0	-	0.71	-	14.0
Flavonoids, mg	250.0	-	16.4	-	6.6
Energy value, kcal	1800	233.5	228.6	13.0	12.7

The enrichment of wheat bread with lupin flour and cavbuz puree increases the protein content in the new bread by 29.1%, dietary fiber by 4.2 times, compared to the control sample; 100 g of enriched bread makes it possible to provide the daily demand of a person for protein by 17.6%, in dietary fiber by 6.3% against 13.6% and 1.5%, respectively, in the control sample. The presence of significant amounts of dietary fiber in bread is a positive factor, as these natural sorbents reduce blood cholesterol and the risk of upper digestive and respiratory tract tumors, and regulate microbiocenosis in the gut (Tappy, 2005). Bread enriched with lupine flour has higher protein efficiency and improved amino acid composition (Hanan, 2013).

A new type of bread is characterized by an improved biological value, namely, an increased content of vitamins, pectin substances, and flavonoids. The enrichment of bread contributes to an increase in the content of vitamin E by 9 times, B_1 by 12.5%, which allows us to provide a daily need for them, respectively, by 6.0 and 13.8% due to the consumption of 100 g of bread. An important advantage of bread enriched with lupine flour and cavbuz puree is providing the human body with β–carotene (14%) and flavonoids (6.6%), which are absent in traditional bread. This type of bread is a health product (Birch et al., 2019), which is able to provide the body daily with vitamins of antioxidants and phenolic compounds, which is important for the antioxidant protection of the body (Ebrahimi et al., 2021; Vollmannova et al., 2021). Considering that the minimum preventive rate of pectin consumption in environmentally friendly areas is 2 g per day (Pornsak, 2001), 100 g of developed bread allows to provide 23% of the norm.

Pectin substances are natural sorbents that are able to form gel structures in the intestine, which contributes to the binding of water–soluble toxic compounds, heavy metals and the subsequent removal of their body (Chandel al., 2022; Jandosov et al., 2022), therefore, the sorption ability of enriched bread, which contains natural pectin, to divalent lead ions was determined (Table 10).

Table 10

Sorption capacity of bread enriched with flour of non-alkaloid lupine and cavbuz puree to toxic ions of bivalent lead

Amount by weight of wheat flour,%		Sorption capacity of bread, мг Pb^{2+}/g
Lupine flour	Cavbuz puree	
5	3	2.64±0.14
6	4	2.81±0.11
7	5	3.03±0.08
0	0	0.16±0.12

As the results show, the sorption capacity of bread enriched with non–alkaloid lupine flour and cavbuz puree to toxic divalent lead ions is 25–30 times higher than for control. This is explained by a significant amount of pectin substances – 0.38–0.55 g in 100 g of enriched products. Pectins contain carboxyl groups of galacturonic acid, which gives them sorption–chemical properties to bind metals and form insoluble complexes, this contributes to the elimination of harmful substances from the human body (Wang et al., 2021). In addition, pectins have radioprotective effects (Chandel et al., 2022).

Conclusions

1. Puree cavbuz and lupine flour are the source of a complex of vitamins, protein, and dietary fiber. The use of these vegetable additives to partially replace wheat flour in the recipe of bread will increase the nutritional value of the product.

2. The acidity of the dough and, accordingly, ready-made products with the addition of lupine flour and cavbuz puree, varied within 0.5–1.0 deg. The specific volume of products decreased by 1.1–4.5% compared to control, depending on the addition of enrichment agents, since the high water–binding capacity of dietary fibers of vegetable raw materials weakens the gluten matrix, which affects the volume of bread.
3. Adding to the recipe of wheat bread flour of non–alkaloid varieties of lupine in an amount of 4–7% and cavbuz puree in an amount of 3–5% contributes to an increase in the protein content in the finished product on 20–32%, dietary fibers in 2–3 times, as well as the enrichment of bread with pectin substances, natural enterosorbents, which are absent in the traditional product.
4. The enrichment of wheat bread with plant additives contributes to the improvement of the biological value of the product, in particular, an increase in the content of vitamin E by 9 times, B_1 by 12.5%, which provides a daily human need for them, by 6.0 and 13.8%, respectively, when consumed 100 g of bread. Non-alkaloid lupine flour and cavbuz puree are a source of carotenoids and phenolic compounds that are not present in wheat flour. These ingredients made it possible to enrich the product with β–carotene and flavonoids – their content in a new type of bread is, respectively, 0.71 mg (14% of daily requirement) and 16.4 mg (6.6%) per 100 g of product.
5. Enriched bread has a 25–30 times higher sorption capacity for toxic divalent lead ions than wheat bread.
6. Wheat bread, enriched with flour of non–alkaloid varieties of lupine and cavbuz puree, is a product of a wellness trend.

References

Amoah I., Cairncross C., Elaine Rush E. (2021), Swallowing and liking of vegetable-enriched bread compared with commercial breads as evaluated by older adults, *Nutrition and Food Science Technology*, 7, 599737, DOI: 10.3389/fnut.2020.599737.

Atudorei D., Ropciuc S., Codină G. (2022), Possibilities to use germinated lupine flour as an ingredient in breadmaking to improve the final product quality, *Agronomy*, 12, 667, DOI: 10.3390/agronomy12030667.

Al Omari D.Z., Abdul-Hussain S.S. Ajo R.Y. (2016), Germinated lupin (*Lupinus albus*) flour improves arabic flat bread properties, *Quality Assurance and Safety of Crops & Foods*, 8(1), pp. 57–63, DOI: 10.3920/QAS2014.0441.

Bayramov E., Aliyev S., Gasimova A., Gurbanova S. (2022), Increasing the biological value of bread through the application of pumpkin puree, *Eastern-European Journal of Enterprise Technologies,* pp. 58-68, DOI: 10.15587/1729-4061.2022.254090.

Biehler E., ′Ericmayer F., Hoffmann L., Krause E., Bohn T. (2009), Comparison of 3 spectrophotometric methods for carotenoid determination in frequently consumed fruits and vegetables, *Journal of Food Science,* 75(1), pp. 55–61, DOI: 10.1111/j.1750–3841.2009.01417.x.

Bryant L., Rangan A., Grafenauer S. (2022), Lupins and health outcomes: a literature review, *Nutrients*, 14, pp. 327–339, DOI: 10.3390/nu14020327.

Birch C. S., Bonwick G.A. (2019), Ensuring the future of functional foods, *International Journal of Food Science & Technology*, 54(5), pp. 1467–1485, DOI: 10.1111/ijfs.14060.

Belski R. (2012), Fiber, protein, and lupin–enriched foods: role for improving cardiovascular health, *Advances in Food and Nutrition Research*, 66, pp. 147–215, DOI: 10.1016/B978-0-12-394597-6.00004-5.

Carvajal–Larenas F. E., Linnemann A. R., Nout M. J. R., Koziol M. (2016), Lupinus mutabilis: composition, uses, toxicology, and debittering, *Food Science and Nutrition,*56 (9), pp. 1454–1487, DOI: 10.1080/10408398.2013.772089.

Carlsson N., Borde A., Wölfel S., Åkerman B., Larsson A. (2011), Quantification of protein concentration by the Bradford method in the presence of pharmaceutical polymers, *Analytical Biochemistry,* 411(1), pp. 116–121.

Collin M. S., Venkatraman S. K., Vijayakumar N., Kanimozhi V., Arbaaz S.M. , Sibiya Stacey R.G , Anusha J. , Choudhary R. , Lvov V., Tovar G. I. , Senatov F., Koppala S., Swamiappan S. (2022), Bioaccumulation of lead (Pb) and its effects on human: A review, *Journal of Hazardous Materials Advances*, 7, 100094, DOI: 10.1016/j.hazadv.2022.100094.

Chandel V., Biswas D., Roy S., Vaidya D., Verma A., Gupta A. (2022), Current advancements in pectin: extraction, properties and multifunctional, *Applications Food*, 11(17), 2683, DOI: 10.3390/foods11172683.

Czarnowska-Kujawska M., Starowicz M., Barišic V., Kujawski W. (2022) Health-promoting nutrients and potential bioaccessibility of breads enriched with fresh kale and spinach, *Foods*, 11(21), 3414, DOI: 10.3390/foods11213414.

Dong R., Yu B., Yan S. , Qiu Z., Lei J., Chen C., Li Y., Cao B. (2020), Analysis of vitamin P content and inheritance models in eggplant, *Horticultural Plant Journal, 6(4),* pp. 240-246

Drobot V.I. (2019), *Dovidnyk z Tekhnolohii Khlibopekarskoho Vyrobnytstva*, ProfKnyha, Kyiv.

Erickson M. (2005), *Deep Frying. Chemistry, Nutrition, and Practical Applications*, Urbana, Illinois.

Ebrahimi M., Sadeghi A., Sarani A, Purabdolah H. (2021), Enhancement of technological functionality of white wheat bread using wheat germ sourdough along with dehydrated spinach puree, *Journal of Agricultural Science and Technology*, 23(4), pp. 839–851.

Gamna F., Spriano S. (2021), Vitamin E: a review of its application and methods of detection when combined with implant biomaterials, *Materials (Basel)*, 14(13), 3691.

Guiné R., Correia P., Gonzaga M., Batista L., Beirão-da-Costa M. (2015). Development and characterization of wheat bread with lupin flour, *Journal of Biological, Biomolecular, Agricultural, Food and Biotechnological Engineering*, 9, pp. 923–927.

Guo J., Knol L., Yang X., Kong L. (2022) Dietary fiber intake is inversely related to serum heavy metal concentrations among US adults consuming recommended amounts of seafood: NHANES 2013–2014, *Food Frontier*, 3(1), pp. 142–149. DOI: 10.1002/fft2.114

Hanan A.F. (2013), Effect of fortification pan bread with lupine flour on the chemical, rheological and nutritional properties, *Journal Food and Dairy Science,* 4(3), pp. 65–75.

Hertzler S. R., Lieblein–Boff J. C., Weiler M., Allgeier C. (2020), Plant proteins: assessing their nutritional quality and effects on health and physical function, *Nutrients,* 12(12), 3704, DOI: 10.3390/nu12123704.

Herrera-Ardila Y.M., Orrego D., Bejarano-López A.F., Klotz-Ceberio B. (2022), Effect of heat treatment on vitamin content during the manufacture of food products at industrial scale, *Dyna,* 89, 223, DOI: 10.15446/dyna.v89n223.99775.

Ioniță-Mîndrican C.-B., Ziani K., Mititelu M, Oprea E., Neacșu S. M. , Moroșan E., Dumitrescu D.-E., Roșca A.C., Drăgănescu D., Negrei C. (2022), Therapeutic benefits and dietary restrictions of fiber intake: a state of the art review, *Nutrients,* 14(13), 2641, DOI: 10.3390/nu14132641.

Jandosov J., Alavijeh M., Sultakhan S., Baimenov A., Bernardo M., Sakipova Z., Azat S., Lyubchyk S., Zhylybayeva N., Naurzbayeva G., Mansurov Z., Mikhalovsky S., Berillo D. (2022), Activated carbon/pectin composite enterosorbent for human protection from intoxication with xenobiotics Pb(II) and sodium diclofenac, *Molecules*, 27, 2296, DOI: 10.3390/molecules27072296.

Krawęcka A., Sobota A., Zarzycki P. (2022), The effect of the addition of low-alkaloid lupine flour on the glycemic index in vivo and the physicochemical properties and cooking quality of durum wheat pasta, *Foods,* 11(20), 3216, DOI: 10.3390/foods11203216.

Lazdauskienė J., Kepalienė I., Liepienė N., Vaičiulytė-Funk L. (2022), The influence of lupine seeds flour addition on wheat-rye bread quality, *Žemės Ūkio Mokslai*, 29(1), pp. 28–35.

Lang L., Chiu K., Lang Q. (2008), Spectrophotometric determination of lead, *Pharmaceutical Technology*, 32 (4), 3412.

Mazur V. A., Pantsyreva H. V., Didur I. M., Prokopchuk V. M. (2018), *Liupyn Bilyi: Henetychnyi Potentsial ta Yoho Realizatsiia u Silskohospodarske Vyrobnytstvo,* Tvory,Vinnytsia.

Maghaydah S., Alkahlout A., Abughoush M., Nazieh I. Al Khalaileh, Amin N. Olaimat, Murad A. Al-Holy, Ajo R., Choudhury I., Hayajneh W. (2022), Novel gluten–free rolls by substituting wheat flour with resistant starch, lupine and flaxseed flour, *Foods*, 11, 1022, DOI: 10.3390/foods11071022.

Majidi M., Y–ALQubury H. (2016), Determination of Vitamin C(ascorbic acid) Contents in various fruit and vegetable by UV–spectrophotometry and titration methods, *Journal of Chemical and Pharmaceutical Sciences,* 9 (4), pp. 2972–2974.

Malavi D., Mbogo D., Moyo M., Mwaura L., Low J., Muzhingi T. (2022). Effect of orange-fleshed sweet potato purée and wheat flour blends on β-carotene, selected physicochemical and microbiological properties of bread, *Foods*, 11(7), 1051, DOI: 10.3390/foods11071051.

Möller J. (2008) Animal feeding stuff – global standard for the determination of acid detergent fibre (ADF) and lignin, *In Focus*, 32(2), pp. 22–24.

Phillips M. M., (2012), Analytical approaches to determination of total choline in foods and dietary supplements, *Analytical Bioanalytical* Chem*ical,* 403, pp. 2103–2112, DOI: 10.1007/s00216–011–5652–5.

Pollard N. J., Stoddard F. L., Popineau Y., Wrigley C.W.(2002), Lupin flours as additives: dough mixing, breadmaking, emulsifying, and foaming, *Cereal Chemistry* 79, pp. 662–669, DOI:10.1094/CCHEM.2002.79.5.662.

Prusinski J. (2017), White lupin (*Lupinus albus L.*) – nutritional and health values in human nutrition – a review, *Czech Journal of Food Science,* 35, (2), pp.95–105, DOI.org/10.1155/2021/5512236.

Potopalskyi A.I. Drozda V.F., Katsan V.A. (2019), *Kavbuz Zdoroviaha — skarbnytsia zdorovia, krasy i dovholittia,* Prostir, Kyiv.

Pornsak S. (2001), Pectin: The role in health, *Journal of Silpakorn University,* 21, pp. 60–77.

Ratoshniuk V.I., Havryliuk M.M. (2020), Liupyn vuzkolystyi – kultura universalnoho vykorystannia u zoni Polissia Ukrainy, *Visnyk Ahrarnoi Nauky*, 8(809), pp. 26–37.

Ruiz-López M. A., Barrientos-Ramírez L., García-López P. M., Valdés-MiramontesE. H., Zamora-Natera J.F., Rodríguez-Macias R., Salcedo-Pérez E. (2019), Nutritional and bioactive compounds in mexican lupin beans species: a mini–review, *Nutrients*, 11(8), pp.1785–1796, DOI: 10.3390/nu11081785.

Saccotelli M.A., Spinelli S., Conte A., Del Nobile M. A. (2018), Gluten-Free bread enriched with vegetable flours, *Food and Nutrition Sciences,* 9(4), 30384, DOI: 10.4236/fns.2018.94028.

Subroto E., Jeanette G., Meiyanasari Y., Luwinsky I., Baraddiaz S. (2020), Review on the analysis methods of starch, amylose, amylopectin in food and agricultural products, *International Journal of Emerging Trends in Engineering Research,* 8 (7), pp. 3519–3524, DOI: 10.30534/ijeter/2020/103872020.

Tan C., Wei H., Zhao X., Xu C., Peng J. (2017), Effects of dietary fibers with high water-binding capacity and swelling capacity on gastrointestinal functions, food intake and body weight in male rats, *Food & Nutrition Research*, 61(1), 1308118, DOI: 10.1080/16546628.2017.1308118.

Tyl C., Sadler G. D. (2017), pH and titratable acidity, In: Nielsen S.S. (eds.), *Food Analysis*, Food Science Text Series, Springer, Cham, pp. 389–406, DOI: 10.1007/978-3-319-45776-5 22.

Tappy L. (2006), Effects of break fast cereals containing various amounts of beta–glucan fibres on plasma glucose and insulin responses in NIDDM subjects, *Diabetes Care,* 19, pp. 831–834.

Vollmannova A., Lidikova J., Musilova J., Snirc M., Bojnanska T., Urminska D., Tirdilova I., Zetochova E. (2021), White lupin as a promising source of antioxidant phenolics for functional food production, *Journal of Food Quality,* 202, pp. 102–113, DOI:10.1155/2021/5512236

Villarino C. B. J., Jayasena V., Coorey R., Chakrabarti–Bell S., Johnson S. K. (2016), Nutritional, health and technological functionality of lupin flour addition to bread and other baked products: benefits and challenges, critical reviews in food, *Science and Nutrition*, 56(5), pp. 835–857, DOI: 10.1080/10408398.2013.814044.

Waterhouse A. L. (2002), Determination of total phenolics, *Current Protocols in Food Analytical Chemistry,* 6(1), pp. I1.1.1–I1.1.8, DOI: 10.1002/0471142913.fai0101s06.

Wang R., Li Y., Shuai X., Liang R., Chen J., Liu C. (2021), Pectin/Activated carbon–based porous microsphere for Pb^{2+} adsorption: Characterization and adsorption behaviour, *Polymers*, 13(15), 2453, DOI: 10.3390/polym13152453.

Zajicek J.L., Tillitt D.E., Brown S.B., Brown L.R., Honeyfield D.C., Fitzsimons J.D. (2005), A rapid solid–phase extraction fluorometric method for thiamine and riboflavin in salmonid eggs, *Journal of Aquatic Animal Health*, 17, pp. 95–105, DOI: 10.1577/H03–079.1.