Scientific Papers. Series D. Animal Science. Vol. LXVI, No. 2, 2023
ISSN 2285-5750; ISSN CD-ROM 2285-5769; ISSN Online 2393-2260; ISSN-L 2285-5750

BAKERY PRODUCTS WITH VALUE-ADDED PREMIX BASED ON LUPIN (*LUPINUS ANGUSTIFOLIUS*) SPROUTS

Loredana PLUSTEA (PAVEN)[1], Diana Nicoleta RABA[1], Monica NEGREA[1], Ileana COCAN[1], Christine DRAGOMIR[1], Mariana-Atena POIANA[1], Carmen Daniela PETCU[2], Mirabela CHICA[1], Antoanela COZMA[1], Adina BERBECEA[1], Ersilia ALEXA[1]

[1]University of Life Sciences "King Mihai I" from Timisoara, Calea Aradului 119, 300645, Timisoara Romania
[2]University of Agronomic Sciences and Veterinary Medicine of Bucharest, 105 Splaiul Independenţei, District 5, 050097, Bucharest, Romania

Corresponding author email: diana.raba@usab-tm.ro

Abstract

The paper aims to study the nutritional and sensorial properties of bakery products fortified with lupin sprouts. The lupin seeds were germinated, and the sprouts collected after 14 days of germination were dried and ground. Wheat flour mixed with different percentages of sprout flour (10-30%) was used to obtain bun-type bakery products obtained from leavened dough. The proximate composition (proteins, lipids, mineral substances, carbohydrates), macro and microelements composition and the content of total polyphenols, as well as the antioxidant activity of fortified products was determined. The obtained results showed that the maximum mineral content was recorded in the case of buns with 30% (2.225%). The content of total polyphenols varied between 8.0-28.9 µM GAE/g.d.m.) and antioxidant activity (2.52-9.44 µM Fe^{2+}/g d.m.). Elemental composition highlighted an increase of Cu (0.873-1.382 ppm), Ni (0.647-1.348 ppm), Mn (0.622-283.409 ppm), Fe (2.182-12.197 ppm), Zn (3.440-14.133 ppm), Na (607.973-851.325 ppm), Mg (165.781-389.073 ppm), Ca (451.163-502.318 ppm), K (202.683-420.596 ppm) with the percentage of lupin sprouts addition. Sensorial analysis showed that the addition of 10% lupin sprouts was appreciated by consumers regarding all the sensory parameters analyzed.

Key words: *antioxidant activity, legume sprouts, polyphenols, macro and microelements.*

INTRODUCTION

As a result of consumer demand for healthy and naturally processed foods, interest in germinated products has increased over the past decade. The proof lies in the growing number of products contained germinated cereals launched each year (www.mintel.com).

Sprouts are living foods, very rich in vitamins, minerals, antioxidants and other nutrients obtained by germination. During germination an increased volume of fiber is obtained inside the seed, with real benefits for accelerating digestion, the proper assimilation of nutrients and the elimination of fats. The sprouts contain approximately 20-30 times more nutrients compared to the mature plant having a positive impact on the health of the human body (Galanty et al., 2022). Also, during the germination process, a series of vitamins, minerals, enzymes, flavonoids and volatile oils are developed which are known as vital elements for the growth and development of the respective plant, but also for human health. Germination enhances the content of phytochemicals such as polyphenols and flavonoids (Dueñas et al., 2009). The health benefits of phenolic compounds from legume sprouts include anticarcinogenic, anti-thrombotic, anti-ulcer, anti-allergenic, anti-inflammatory, anti-artherogenic, antioxidant, anti-microbial, cardioprotective and analgesic effects (Singh et al., 2017).

Legumes are one of the most important categories of plant products with the potential for germination and use of sprouts obtained in food safety (Goncearov et al., 2004; Gulewicz et al., 2008). Previous studies highlighted the role of germination to enhances the nutritional value and the macro and microelements content of legumes (Gulewicz et al., 2008; Swieca et al., 2019; Farag et al., 2023).

Lupin (*Lupinus angustifolius*) is an herbaceous plant belonging to the Fabaceae family, which also includes peas, lentil, bean and soy. Lupin is a plant cultivated in the Mediterranean basin as food or as an ornamental flower. Lupin seeds – sometimes called Lupini beans because of their pods – are used in mediterranean diet (Lemus-Conejo et al., 2023).

In addition to protein (40%), lupin seeds contain fiber (32%) and probiotics, which strengthen the immune system and support the health of the digestive tract (Msaddak et al., 2023). They also contain B vitamins, magnesium, manganese, copper and zinc (Petterson, 2016).

Lupin seeds do not contain cholesterol, gluten or gastric irritants, unlike soy, which has a large amount of saponins. The fat content is characterised by high percentage of mono and poly-unsaturated fats, omega-3, 6 and 9 fatty acids (Abreu et al., 2023). They are probiotics, helping the development of good bacteria in the body (van de Noort, 2017).

Regarding the impact on health, lupin seeds have a diuretic, hypoglycemic, cicatrizing, and carminative effect (Devkota et al., 2023). The lupin sprouts shown cytotoxic effects on some breast and prostate cancer cells (Galanty et al., 2022).

The use of germinated legumes in bakery has been a real success in recent years, studying, in addition to the nutritional effects, the influence of germination on the rheological properties of the dough (Atudorei et al., 2022; Atudorei, et al., 2023).

The objective of this paper was to study the nutritional, phytochemical and sensory characteristics of bread obtained with added-value premix based on lupin sprouts.

MATERIALS AND METHODS

Obtaining of lupin sprouts

The lupin seeds (450 g) were immersed in 1000 mL could water for 12 hours. After hydration, the lupin seeds were placed in an even layer in a pan (55x34 cm) with moistened cotton wool in a bright room with constant temperature (20-24^{0}C). The seeds germination begins after two days and after 14 days majority of sprouts was obtained. The constant humidity during germination was maintained by daily sprinkling with water. After 14 days the lupin sprouts were harvested by cutting green shoots and then dried in the incubator (INB, 500 Memmert, Schwabach, Germany) at a temperature of 60^{0}C for 4 days. The sprouts were grinded in the mill (GRINDOMIX RETSCH, GM 200, Haan, Germany) and the obtained flour was used to prepare the composite sprouts flours.

Preparation of composite sprout flours

Wheat flour type 000 purchased from Baneasa Company, Romania, was used as control sample. Three types of added value premix were obtained by adding 10%, 20% and 30% milled lupin sprouts flour in wheat flour.

Obtaining of composite sprout buns

The composite premix was used in different percentage regarding wheat and lupin sprouts flours: 100 g/90 g/80 g/70 g superior white wheat flour 000 from Baneasa, Romania company and 10 g/20 g/30 g flour obtained from lupin sprouts obtaining four samples: C (control), LSB1 (buns with 10% lupin sprouts flour), LSB2 (buns with 20% lupin sprouts flour), LSB3 (Buns with 30% lupin sprouts flour).

The buns were prepared using the indirect bakery method according to (Plustea et al., 2022). The method included following steps: preparing the ingredients and their dosage, kneading the sourdough, fermenting, kneading the dough, fermenting the dough, dividing, shaping, leavening, baking the dough and cooling the final product.

The sourdough was obtained by dissolving 3 g fresh yeast in 10 mL water at 30^{0}C, 1g crystal white sugar and 1/3 from the flour mixture for each sample. After 30 minutes the sourdough was added to the rest of flour mixed initially with 2 g iodized salt.

The dough obtained was kneaded manually until obtaining a non-sticky dough, well bound, with a porous aspect in structure. During kneading, an additional 3 mL of sunflower oil with emulsifying role was added. The obtained dough was divided into 2 equal parts and left to ferment for 30 minutes in the leaven equipment at 35^{0}C.

After leavening the dough was baked in the electric oven at the temperature of 180^{0}C for 20 minutes. The buns obtained are presented in Figure 1.

The proximate composition of lupin sprouts buns

The proximate composition of composite sprout buns and control was analyzed using standardised methods: moisture SR 91/2007 pct.10, protein SR EN ISO 8968-1:2014; total lipid SR 91:2007 pct.14.4; minerals SR ISO 2171/2010, starch 2009R0152-RO-004.001-61. The carbohydrate content (%) was calculated as the difference between 100 and the sum of the following fractions: proteins, lipids, proteins, mineral substances and moisture.

Taking in account the contribution of lipids (1 g lipid = 9 kcal), proteins (1 g protein = 4 kcal) and carbohydrates (1 g carbohydrate = 4 kcal) it was calculated the energy value. All determinations were done in triplicate. Also, it was determined the contribution of intake consumption of 100 g samples calculated by reporting the values obtained to the reference intake established for an average adult according to the Regulation CE 1169/2011, namely: lipids 70 g; proteins 50 g; carbohydrates 260 g and energy value 2000 Kcal (https://eur-lex.europa.eu/legal-content/).

Determination of macro and microelements

The macro and microelements content were determined after calcination of samples at 650^{0}C using a calcination oven (Naberthem GmbH, Lilienthai/Bremen, Germany) until a white color of ash.

The quantification of macro and microelements was performed by atomic absorption spectroscopy (AAS) using the Varian 220 FAA equipment according to the method described by (Plustea et al., 2022).

The determinations were performed in triplicate and the results were expressed in ppm.

The contribution of intake consumption of 100g samples calculated by reporting the values obtained to the daily reference intake (DRI) established for an average adult according to the Regulation CE 1169/2011 (potassium: 2000 mg, magnesium: 375 mg, calcium: 800 mg, zinc: 10 g, iron: 14 mg, copper: 1 mg, manganese: 2 mg).

Evaluation of the total phenolic content (TPC)

The TPC was determined using Folin-Ciocâlteu method adapted according to (Obistioiu et al., 2021). The extract was prepared in ethanol 70% at the ratio 1:10 (sample: ethanol). After colour reaction the absorbance of the samples was read at 750 nm using the Specord 205 spectrophotometer (Analytik Jena AG, Jena, Germany). Results were expressed as mg gallic acid equivalent (GAE) per 100 g sample. The calibration curve was performed using GAE solutions in the concentration range between 2.5-250 μg/mL. All the determinations were performed in triplicate.

Evaluation of antioxidant activity (AA)

The AA was determined according FRAP method (Horablaga et al., 2023). The results are expressed as mM Fe^{2+}/100 g sample and the calibration curve ranged between 0.05-0.4 μM/mL. All the determinations were performed in triplicate.

Sensory analysis

The consumer acceptability of lupin sprouts buns was evaluated using sensory analysis performed by 16 untrained consumers, with ages between 19 and 26. The samples were presented in cardboard plates with four-digit characters, once at a time to each panelist. The panelists were asked to evaluate the bun samples in relation to the control sample. Appearance, odor, texture, taste/chewiness, and overall acceptability was evaluated using a 5-point hedonic scale (5 for "like extremely" and 1 for "dislike extremely") (Alomari, 2013). Evaluators were asked to rinse their mouths with still water and eat unsalted crackers between samples evaluation (Molnar et al. 2020). All 16 panellists were trained according to ISO 6658:2017.

Statistical analysis

Al determinations were made in triplicate and the results are reported as mean values ± standard deviation (SD). Differences between means were analyzed by t-test (two-sample assuming equal variances) using Microsoft Excel 365. Differences were considered significant when p-values < 0.05.

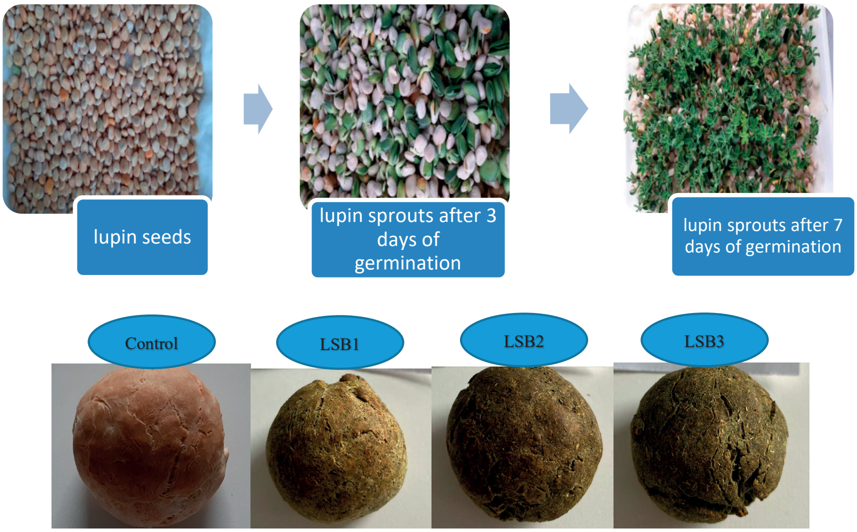

Figure 1. Lupin sprouts buns. Control - wheat bun, LSB1 - Bun with 10% lupin sprouts, LSB2 - Bun with 20% lupin sprouts, LSB3 - Bun with 30% lupin sprouts

RESULTS AND DISCUSSIONS

Proximate composition

The results presented in Table 1 show the nutritional characteristics of buns with lupin added sprouts. The lipid content varied between 1.234% in control sample and 7.836% in the sample with addition of 30% lupin sprouts. The increasing of lipids content is due by the legume matrix and sprouts. Similar results regarding the lipids content in bread supplemented with lupin flour were reported in the literature (Alomari, 2013; Plustea et al., 2022). Protein content was enhanced when different percentage of lupin sprouts was added in the dough composition. The maximum level was recorded in the sample LSB3 (20.97%) that mean a 100.66% increase compared to the control (buns with wheat flour). Sprouting process caused significant increases in moisture, protein, ash, crude fiber, free amino acids, total, reducing and nonreducing sugars (Fouad and Rehab, 2015).

The effect of germination on lentil protein content was reported by Santos S et al. (2020) and highlighted the increase in all lentil varieties with a mean of 29% protein in sprouts. Significant differences were reported between protein levels in seeds and sprouts (Santos et al., 2020). The use of lupin both in the form of flour from un-germinated seeds and from sprouts in the bakery industry represents a viable method of increasing the protein content without increasing the fraction of gluten proteins in the dough.

The addition of lupin sprouts leads to an increase in the content of mineral substances in the bakery products obtained. The maximum increasing percentage was observed in the case of LSB3 sample (69.33%).

Germination involves biochemical and physiological processes in the plant that favour the accumulation of active principles and mineral substances. Similar results regarding the mineral substances in lupin flour processed by several methods were reported by (Devkota et al., 2023).

However, the starch and carbohydrates content decreases with the addition of sprouts in bakery products. The maximum starch content was observed in the control sample (61.30%) and decreased until 32.84% when 30% lupin sprouts were added in the buns composition. In the same manner the carbohydrates were reduced at 43.11% in the sample LSB3 with 28.8% compared with the white wheat sample.

Significant differences ($p<0.05$) were recorded according to t-test, between samples in term of protein content, mineral substances and starch.

Other study highlighted the decreasing of carbohydrates from 67.2% in control bread to

36.85% when 20% lupin seeds flour was added (Alomari, 2013).

Previous studies reported the antidiabetic role of legumes germinated seeds and explained the mechanisms that mediated the delaying of gastric process and inhibition of carbohydrate digestive enzymes (Tefera, 2020) and (Farag et al., 2023).

As a major bioactive component responsible for the hypoglycemic action in legume sprouts was detected the trigonelline (Farag et al., 2023). The use of legumes and especially their sprouts as lupin represents a possibility to replace the floury matrix in bakery products and to obtain hypoglycemic foods intended for people with diabetes.

Regarding the contribution of 100 g bakery product with lupin sprout to the daily reference intake (DRI) according CE Regulation 1169/2011, it can be observed that 30% sprouts added in the buns dough provided 41.94% from the daily protein requirement of an adult, 11.19% lipids, 16.58% carbohydrates and 16.34% from energy value.

Macro and microelements

Tables 2-3 show the macro and micronutrient content of the buns with lupin sprouts. It was observed the increasing of macro and microelements content with the percentage addition of lupin sprouts, the maximum values for all analysed parameters being recorded in the LSB3 sample. The most abundant macroelement was sodium (Na) with concentrations between 607.941-851.312 ppm higher in the case of lupin sprouts addition.

In the LSB1 sample, calcium (Ca) and potassium (K) recorded a lower level as in control, but the concentration increased with the sprouts percentage added. The higher concentration of Ca was 502.319 ppm, respectively 420.602 ppm the level of K recorded in LSB3 sample.

The supplementation of bakery products with lupin sprouts lead to increasing of microelements content. Statistically significant differences ($p<0.05$) between all samples were recorded in terms of all microelements content, but also in Ca and Na content.

The influence of lentil germination on macro and micronutrients content was previously reported by (Santos et al., 2020). This study highlighted that Mg and Ca were not affected by germination, while K concentration has been identified as a possible marker for germination capacity. In terms of K concentrations, other study reported that soybean seed sprouts present a concentration five-times higher when compared to the seeds (Plaza et al., 2003).

The highest increase was observed in the case of Mn where the content varied from 0.645 ppm in the sample obtained from wheat flour to 283.418 ppm in the sample with 30% lupin sprouts. Lupin seeds from Romania are characterised by a high content of manganese. Previous study reported 136.74 ppm Mn in lupin seeds (Plustea et al., 2022). Taking in account the improvement of Mn level during germination process as a phenomenon noted by other authors (Santos et al. 2020), the consumption of lupin sprouts is an important dietary source for people with Mn deficiency.

Cu content increased with 64.07% in the LSB3 sample compared with the control when 30% lupin sprouts was added. Similar pattern was observed in the case of Ni, Zn and Fe. Ni values varied between 0.638 ppm in the control and 1.322 ppm in the sample with highest content of lupin sprouts.

Regarding microelements composition, of the 12 varieties analysed by Santos et al. (2020), only five did not register a significant increase in Zn concentration after sprouting.

The content of Fe and Mn increased by germination in most of the lentil varieties analysed. Legume germination induces the reduction of phytate content, bonded with minerals in seeds and forming insoluble complexes (Santos et al., 2020).

Table 1. Proximate composition of buns with lupin added sprouts

Samples	Lipids %	% from DRI*	Proteins (%)	% from DRI*	Mineral substances %	Humidity (%)	Starch (%)	Carbo-hydrates (%)	% from DRI*	Energy value [kcal/ 100 g]	% from DRI*
Control	1.234±0.119 [a]	1.76	10.45±0.254 [a]	20.90	1.314±0.084 [a]	26.402±0.503 [a]	61.30±1.64 [a]	60.60	23.31	295.30	14.76
LSB1	5.320±0.147 [b]	7.60	13.87±0.266 [b]	27.74	1.555±0.095 [b]	22.425±0.470 [b]	54.73±1.36 [b]	56.83	21.86	330.68	16.53
LSB2	5.826±0.154 [b]	8.32	17.64±0.305 [c]	35.28	1.872±0.117 [c]	24.668±0.399 [c]	43.79±1.25 [c]	49.99	19.23	322.97	16.15
LSB3	7.836±0.155 [c]	11.19	20.97±0.384 [d]	41.94	2.225±0.112 [d]	25.855±0.476 [a]	32.84±0.88 [d]	43.11	16.58	326.86	16.34

*[a–d] data within the same column sharing different superscripts are significantly different ($p < 0.05$) according to t-test; *DRI (daily reference intake according CE Regulation 1169/2011*

Table 2. Macroelements content of buns with lupin added sprouts

	K (ppm)	% from DRI*	Ca (ppm)	% from DRI*	Mg (ppm)	% from DRI*	Na (ppm)
Control	202.649±0.182 [a]	1.01	451.176±0.175 [a]	5.64	165.761±0.206 [a]	4.42	607.941±0.195 [a]
LSB1	68.929±0.196 [b]	0.34	257.631±0.189 [b]	3.22	214.181±0.209 [b]	5.71	762.839±0.180 [b]
LSB2	256.188±0.206 [a]	1.28	357.845±0.191 [c]	4.47	229.152±0.19 [b]	6.11	893.093±0.194 [c]
LSB3	420.602±0.212 [c]	2.10	502.319±0.197 [d]	6.28	389.122±0.193 [c]	10.38	851.312±0.201 [c]

[a–d]data within the same column sharing different superscripts are significantly different ($p < 0.05$) according to t-test; *DRI (daily reference intake according CE Regulation 1169/2011

Table 3. Microelements content of content of buns with lupin added sprouts

	Cu (ppm)	% from DRI*	Ni (ppm)	Zn (ppm)	% from DRI*	Fe (ppm)	% from DRI*	Mn (ppm)	% from DRI*
Control	0.835±0.181[a]	8.35	0.638±0.172[a]	3.447±0.208[a]	3.44	2.196±0.182[a]	1.57	0.645±0.172[a]	3.22
LSB1	1.268±0.158[b]	12.68	1.046±0.179[b]	9.187±0.204[b]	9.18	7.110±0.181[b]	5.08	66.874±0.169[b]	334.37
LSB2	1.370±0.178[c]	13.70	1.233±0.168[c]	10.523±0.20[c]	10.52	8.844±0.175[c]	6.32	162.136±0.185[c]	810.68
LSB3	1.480±0.159[d]	14.80	1.322±0.198[d]	14.183±0.20[d]	14.18	12.202±0.19[d]	8.72	283.418±0.199[d]	1417.09

[a–d]data within the same column sharing different superscripts are significantly different ($p < 0.05$) according to t-test, *DRI (daily reference intake according

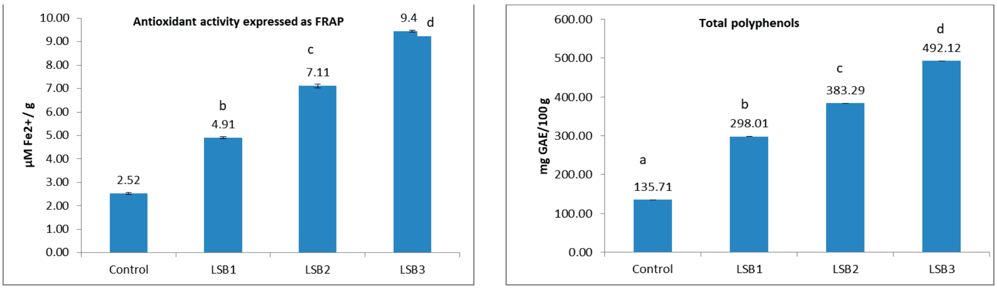

Figure 2. AA and TPC of buns with lupin added sprouts
Control - wheat bun, LSB1 - bun with 10% lupin sprouts, LSB2 - bun with 20% lupin sprouts, LSB3 - bun with 30% lupin sprouts

A significant increasing of iron content was recorded with addition of lupin sprouts in buns. The iron content was 2.196 ppm in control and increased until 12.202 ppm in the case of LSB3, representing an iron supplementation of 455.64%. The natural supplementation of iron in bakery products represents a special issue that comes to meet the increased requirements of recent years regarding the fortification of bakery products with iron in Romania. Currently, in Romania there is no obligation to fortify wheat flour with iron, even if the incidence of anemia among the population is high, almost 60% of children aged between one and two years having iron deficiency anemia. In the USA, since 1998, bread and other cereal products have been fortified with folic acid, by order of the Food and Drug Administration. All US cereals, rice and corn are fortified with 140 µg folic acid/100 g grain, providing consumers with 100 µg/day of this vitamin (Hagiu, 2021). In addition, fortification with folic acid causes a reduced bioavailability of iron, which is facilitated when iron is found naturally in food. As a result, the use of sprouts of lupin in bakery products can solve problems related to the high level of anemia among the Romanian population.

The contribution of 100 g product consumption to daily reference intakes (DRI) for minerals (adults) according to the Regulation CE 1169/2011 (Tables 2-3) highlighted that 100 g products LSB1-LSB3 provides a daily intake of macro-elements corresponding to: 0.34-2.1% K, 3.22-6.28% Ca, 5.71-10.38% Mg from DRI for an adult person.

In term of micronutrients, 100 g products provide a daily intake corresponding to: 12.68-14.8% Cu, 9.18-14.18% Zn, 5.08-8.72% Fe, 334.37-1417.09% Mn from DRI for an adult person. The important increase of Mn content through lupin seeds germination, as well as the high content of Mn in lupin seeds from Romania, recommends these products to people with a deficiency of this microelement.

Phytochemical proprieties

The Figure 2 shows the total polyphenol content and antioxidant activity of bakery product with lupin sprouts addition. The results shown a significant increasing of TPC with the percentage of lupin sprouts added in the dough. The highest value was recorded in the LSB3 sample (492.12 mg GAE/100 g), comparatively with the control obtained from wheat flour (135.71 mg GAE/100 g). The increasing of TPC was 119.59% by addition of 10% lupin sprouts, 182.43% by addition of 20% lupin sprouts, respectively 262.62% for the highest level of substitution. Taking in account the importance of TPC on the development of metabolic processes and maintaining the health of the body, the consumption of bread supplemented with lupin sprouts has a positive impact on the quality of life.

The addition of lupin sprouts is positively reflected also in the antioxidant activity values. The values increased with the addition of lupin sprouts; the maximum level was recorded in the LSB3 sample (9.4 μM Fe^{2+}/g). Similar pattern was observed when lupin seeds flour was added to wheat flour in order to obtain bread (Plustea et al., 2022). The reported increasing of TPC was between 5.58-58.99%, and between 32.88-55.47% for AA, respectively. The values recorded in our study, when lupin sprouts are used in the bread composition, are higher and highlights the importance of germination in order to enhance the phytochemical profile of foods. Values between 46.4-63.9 ppm for TPC were reported in legume sprouts, the level being significantly reduced with increase of sprout age (Chon, 2013). Phenolics content increased from 1341.13 mg/100 g in raw lentil seeds to 1630.20 mg/100g, the maximum value being recorded after 5 days of germination (Fouad & Rehab, 2015).

Sensory analysis

Sensory evaluation of the buns with lupin sprout flour was carried out in order to assess the consumer acceptance and preferences.

Figure 3 indicates the mean scores for the sensory attributes (appearance, odor, texture/porosity, taste/chewiness and overall acceptability) of the studied buns with lupin sprout flour in different proportions (10%, 20% and 30%). The highest scores were recorded in LSB1 samples (buns with 10% lupin sprouts flour) concerning the attributes: appearance (4.813), texture/porosity (4.688), taste/chewiness (4.813) and overall acceptability (4.75). In terms of taste/chewiness attribute, the scores increased in the following order LSB1> Control > LSB2 > LSB3 and in terms of appearance the panellists ranked the bun samples as follows: LSB1> C > LSB2 > LSB3. Regarding the overall acceptability attribute, the score of the studied samples increased in the following order LSB1 >Control>LSB2> LSB3 (Figure 3).

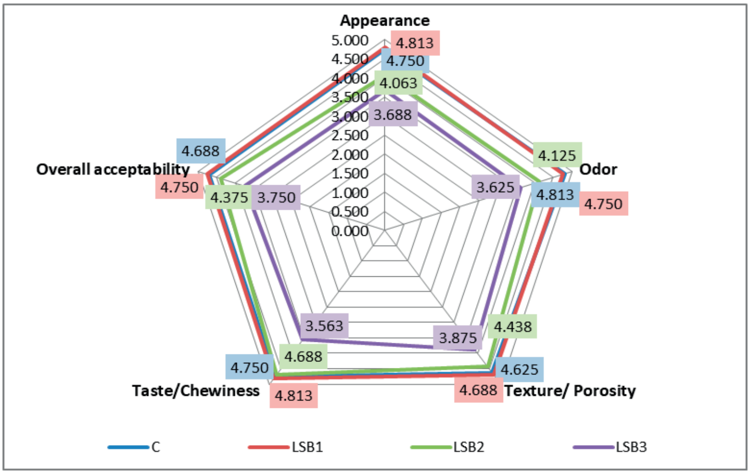

Figure 3. Global values of the sensory evaluation (consumer acceptance) of bread with Moringa (MWB1, MWB2, MWB3 and MWB4; WB (control bread) by using 5-point hedonic scale (n = 36)

Following the sensory evaluation, which highlights the consumers' acceptance, can be pointed out that the addition of lupin sprouts flour in buns significantly influenced the appearance, taste, texture and overall acceptability being highly appreciated by panelists.

Similar studies were carried out by Alomari & Abdul-Hussain in 2013 who pointed out that by substituting wheat flour with lupin flour up to 20% level it is possible to produce healthy and nutritionally bread, rich in proteins, mineral substances, lipids and fiber, without affecting sensory propertie.

The extensive study performed by Abreu et al. (2023), regarding the consumer perception and acceptability of lupin-derived products, indicated as optimal percentage 15% of lupin addition in novel food products, but some studies suggest less than 10% of lupin addition (Yaver & Bilgiçli, 2021; Atudorei et al., 2022). Higher as 20% lupin addition resulted in some sensory losses on breads (Abreu et al., 2023).

CONCLUSIONS

The results obtained in this study highlight the nutritional role of sprouted lupin and the added value obtained for bakery products.

The use of lupin sprouts in a proportion of 10-30% increases the supply of proteins, lipids, macro and microelements in bakery products.

Important improvement regarding the compounds with the biologically active value reflected by the antioxidant activity and polyphenolic compounds is also observed.

However, the sensory analysis points to the fact that the addition of more than 10% lupin sprouts in bakery products is reflected in a worsening of the sensory properties in term of: appearance, texture/porosity, taste/chewiness and overall acceptability.

ACKNOWLEDGEMENTS

This study was performed during the doctoral studies of the PhD Loredana Plustea (Paven), University of Life Sciences "King Mihai I" from Timisoara, PhD coordinator: Prof. Ersilia Alexa.

REFERENCES

Abreu, B., João L., & Ada R. (2023). Consumer Perception and Acceptability of Lupin-Derived Products: A Systematic Review, *Foods, 12*, 1241.

Alomari, D.Z., & Abdul-Hussain, S. (2013). Effect of Lupin Flour Supplementation on Chemical, Physical and Sensory Properties of Mediterranean Flat Bread, International *Journal of Food Science and Nutrition Engineering, 3*.

Atudorei, D., Atudorei, O., & Codină, G.G. (2022). The Impact of Germinated Chickpea Flour Addition on Dough Rheology and Bread Quality, *Plants, 11*, 1225.

Atudorei, D., Mironeasa, S., & Codină, G.G. (2022). Effects of Germinated Lentil Flour on Dough Rheological Behavior and Bread Quality, *Foods, 11*, 2982

Atudorei, D., Ropciuc, S., & Codină, G.G. (2022). Possibilities to Use Germinated Lupine Flour as an Ingredient in Breadmaking to Improve the Final Product Quality. *Agronomy, 12*, 667.

Chon, S. U., (2013). Total polyphenols and bioactivity of seeds and sprouts in several legumes. *Curr. Pharm. Des., 19*, 6112-24.

Devkota, L., Kyriakopoulou, K., Bergia, R., & Dhital, S. (2023). Structural and Thermal Characterization of Protein Isolates from Australian Lupin Varieties as Affected by Processing Conditions. *Foods, 12*, 908.

Dueñas, M., Hernández, T., Estrella, I., & Fernández, D. (2009). Germination as a process to increase the polyphenol content and antioxidant activity of lupin seeds (*Lupinus angustifolius* L.). *Food chemistry, 117,* 599-607.

Farag, M. A., Asmaa, F. A. N., Zayed, A., &Sharaf El-Dine, M.G. (2023). Comparative Insights into Four Major Legume Sprouts Efficacies for Diabetes Management and Its Complications: Untargeted versus Targeted NMR Biochemometrics Approach. *Metabolites, 13*, 63.

Fouad, A. A., & Rehab, F. M. (2015). Effect of germination time on proximate analysis, bioactive compounds and antioxidant activity of lentil (*Lens culinaris* Medik.) sprouts. *Acta Sci Pol Technol Aliment, 14*, 233-46.

Galanty, A., Zagrodzki, P., Miret, M., & Paśko, P. (2022). Chickpea and Lupin Sprouts, Stimulated by Different LED Lights, As Novel Examples of Isoflavones-Rich Functional Food, and Their Impact on Breast and Prostate Cells. *Molecules, 27*, 9030.

Goncearov, M., Petcu, C., & Antoniu, S. (2004). Hazard analysis critical control points - a modern concept regarding food quality and safety. *Scientific Papers: Veterinary Medicine, 37*, 868-872.

Gulewicz, P., Martínez-Villaluenga, C., Frias, J., Ciesiołka, D., Gulewicz, K., & Vidal-Valverde, C. (2008). Effect of germination on the protein fraction composition of different lupin seeds. *Food chemistry, 107*, 830-44.

Hagiu, D., Mihai, O., & Mititelu, M. (2021). Fortified foods and the impact on consumer health, *Editorial Group: medichub media*.

Horablaga, N. M., Cozma, A., Alexa, E., Obistioiu, D., Cocan, I., Poiana, M. A., Lalescu, D., Pop, G., Imbrea, I. M., & Buzna, C. (2023). Influence of Sample Preparation/Extraction Method on the Phytochemical Profile and Antimicrobial Activities of 12 Commonly Consumed Medicinal Plants in Romania. *Applied Sciences, 13*, 2530.

Lemus-Conejo, A., Rivero-Pino, F., Montserrat-de la Paz, S., & Millan-Linares, M. C. (2023). Nutritional composition and biological activity of narrow-leafed lupins (*Lupinus angustifolius* L.) hydrolysates and seeds. *Food chemistry, 136104.*

Molnar, D., Novotni, D., Krisch, J., Bosiljkov, T., & Ščetar, M. (2020). The optimisation of biscuit formulation with grape and aronia pomace powders as cocoa substitutes, *Hrvatski časopis za prehrambenu tehnologiju, biotehnologiju i nutricionizam*.

Msaddak, A., Mars, M., Quiñones, M. A., Lucas, M. M., & Pueyo, J. J. (2023). Lupin, a Unique Legume That Is Nodulated by Multiple Microsymbionts: The Role of Horizontal Gene Transfer. *International Journal of Molecular Sciences, 24,* 6496.

Obistioiu, D., Cocan, I., Tîrziu, E., Herman, V., Negrea, M., Cucerzan, A., Neacsu, A.G., Cozma, A.L., Nichita, I., Hulea, A., Radulov, I., & Alexa, E. (2021). Phytochemical Profile and Microbiological Activity of Some Plants Belonging to the Fabaceae Family. *Antibiotics, 10*, 662.

Petterson, D. S., (2016). Lupin: Overview. In: Colin Wrigley, Harold Corke, Koushik Seetharaman and Jon Faubion (eds.), *Encyclopedia of Food Grains* (Second Edition), Oxford, USA: Academic Press Publishing House.

Plaza, L., de Ancos, B., & Cano, P.M. (2003). Nutritional and health-related compounds in sprouts and seeds of soybean (*Glycine max*), wheat (*Triticum aestivum* L.) and alfalfa (*Medicago sativa*) treated by a new drying method. *European Food Research and Technology, 216*, 138-144.

Plustea, L., Negrea, M., Cocan, I., Radulov, I., Tulcan, C., Berbecea, A., Popescu, I., Obistioiu, D., Hotea, I., Suster, G., Boeriu, A.E., & Alexa, E. (2022). Lupin (Lupinus spp.)-Fortified Bread: A Sustainable, Nutritionally, Functionally, and Technologically Valuable Solution for Bakery. *Foods, 11*, 2067.

Santos, S., Silva, C.B., Valente, L.M.P., Gruber, S., & Vasconcelos, M.W. (2020). The Effect of Sprouting in Lentil (Lens culinaris) Nutritional and Microbiological Profile. *Foods, 9*, 400.

Singh, B., Singh, J. P., Kaur, A., & Singh, N. (2017). Phenolic composition and antioxidant potential of grain legume seeds: A review. *Food Res. Int., 101*, 1-16.

Swieca, M., Gawlik-Dziki, U., Jakubczyk, A., Bochnak, J., Sikora, M., & Suliburska, J. (2019). Nutritional quality of fresh and stored legumes sprouts – Effect of Lactobacillus plantarum 299v enrichment. *Food chemistry, 288*, 325-32.

Tefera, M.M., Altaye, B.M., Yimer, E.M., Berhe, D.F., & Tadesse Bekele, S. (2020). Antidiabetic Effect of Germinated Lens culinaris Medik Seed Extract in Streptozotocin-Induced Diabetic Mice. *J. Exp. Pharmacol*., 12, 39-45.

Van de Noort, M. (2017). Chapter 10 - *Lupin: An Important Protein and Nutrient Source in Sudarshan.* In: R. Nadathur, Janitha P. D. Wanasundara and Laurie Scanlin (eds.), Sustainable Protein Sources. San Diego, USA: Academic Press Publishing House.

www.mintel.com.

Yaver, E., & Bilgiçli, N. (2021). Effect of ultrasonicated lupin flour and resistant starch (type 4) on the physical and chemical properties of pasta. *Food chemistry, 357.* 129758.

https://eur-lex.europa.eu/legal-content/.

https://ziare.com/viata-sanatoasa.