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The influence of lupine seeds flour addition on wheat-rye bread quality

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The aim of this research was to determine the influence of the amount of 10, 15 and 20% of lupine seeds flour on sensory properties, moisture, acidity, specific volume, density, crumb hardness, and the drying process of wheat-rye bread. In order to assess sensory properties, the test of descriptive analysis of sensory properties was applied in accordance with ISO 11036 and ISO 6564. The evaluation of sensory properties demonstrated that the amount of 10% of lupine seeds flour did not adversely affect the colour, taste and texture of wheat-rye bread. The amount of 15 and 20% of lupine seeds flour reduced porosity and elasticity, increased stickiness and bitterness of bread, and the taste of lupine seeds flour was felt. As the amount of lupine seeds flour in bread increased, the specific volume, porosity and elasticity of bread decreased, whereas the crumb density as well as stickiness increased. Storing a bread sample for 1 day, the amount of increasing lupine seeds flour enhanced bread crumb hardness by 1.5–2 times, and after 4 days of storage it increased by 3–4 times compared to that of the control sample. The amount of 10% of lupine seeds flour in bread did not influence the drying process and did not differ from the control sample in the unpacked samples for 4 days. The amount of 20% of lupine seeds flour increased the weight loss of bread drying process by 53% compared to that of the control sample after 4 days of storage.

Keywords: crumb hardness, elasticity, lupine, sensory properties

INTRODUCTION

Rye and wheat bread take the first position in the Lithuanian market and in the people nutrition pyramid as well. In the production of rye and wheat-rye bread, rye flour is blended with wheat flour to give elasticity to the rye dough, to maintain the gas formation in the dough, to increase the volume of the dough and the finished bakery product. Due to the growing interest in healthy nutrition, protein and fibre rich foods, in the production of bread and other bakery, rye and wheat flours are used to blend with non-traditional raw materials: buckwheat, barley, rice, corn flour, amaranth seeds, and lupine seeds flour (Angioloni et al., 2011; Dvorakova et al., 2012; Minarro et al., 2012; Maghaydah et al., 2013; Časlavkova et al., 2015).

Lupine seeds flour (LSF) is a source of protein, fat, minerals and natural antioxidants. Lupine seeds flour has pale yellow colour and slight beany flavour, it is a rich source of nutrients with higher protein (30–40%) and dietary fibre (30%) content, but lower energy value compared to that of the wheat flour (Kefale et al., 2020). Due to its good nutritional and biological value, it can be used to enrich baked goods with essential amino acids, unsaturated fatty acids (oleic, linolenic), tocopherols, carotenoids and minerals (Hamama et al., 2004; Oomah et al.,

2006; Wang et al., 2008; Hruškova et al., 2009; Duodu et al., 2011; Bartkiene et al., 2016). The mineral content of lupine seeds flour can vary from 3.2 to 4.6 g/100 g, whereas in wheat and wholegrain rye flour it is from 0.6 to 1.7 g/100 g (Siger et al., 2012).

Lupine seeds (*Lupinus* L.) and their products (lupine protein concentrates, lupine grain flour) are non-traditional raw materials that can be used in bread, pastry, biscuits and pasta to improve the nutritional value of the product (Jayasena et al., 2010; Codina et al., 2016; Štefániková et al., 2020). In flour confectionery products lupine grain flour can replace up to 25% of egg solids (Rukshan et al., 2020).

Like many other food raw materials, lupine and its products are classified as containing allergenic and intolerant materials (Villarino et al., 2016). The alkaloids present in them give a bitter taste and when their amount exceeds more than 0.03%, lupine products are not safe for use in the food industry (Arnoldi et al., 2011).

Information on the use of lupine seeds flour in the production of wheat bread and flour confectionery (biscuits, muffins) as well as its influence on quality criteria is found in the literature (Hruškova et al., 2009; Paraskevpolou et al., 2010; Jayasena et al., 2011; Bartkiene et al., 2013). This flour can only be used in small quantities because it has a potentially negative effect on the taste, texture, and acceptability of the pastry. Adding more than 10% of lupine seeds flour from the total weight of the flour to the dough has a negative effect on dough mixing, since lupine protein has a low elasticity and a high water absorption capacity, which reduces the elasticity of the dough and bread texture. Incorporation of more than 20% of lupine seeds flour in biscuit and 30% in muffin lowered the flavour acceptance of the products, which was attributed to the taste of lupine seeds flour (Villarino et al., 2016). 9–10% of lupine seeds flour is the optimum amount which does not change the structural properties of the dough and bread sensory properties, and it also has a positive effect on reducing the drying process after 24 h (Paraskevpolou et al., 2010).

The aim of this research was to determine the influence of the amount of 10, 15 and 20% of lupine seeds flour on sensory properties, moisture, acidity, specific volume, density, crumb hardness, and the drying process of wheat-rye bread.

RESEARCH METHODS AND CONDITIONS

Samples of wheat-rye bread with different quantities of lupine seeds flour were prepared under laboratory conditions by preparing wheat-rye dough from the following raw materials: wheat flour 550 D, whole grain rye flour, water, yeast, sugar and salt. A part of the mixture of rye and wheat flour in the dough was replaced by lupine seeds flour in the following quantities (as a percentage of the total flour weight):

wheat flour (550 D) 55%, whole grain rye flour 45%, LSF 0%;

wheat flour (550 D) 50%, whole grain rye flour 40%, LSF 10%;

wheat flour (550 D) 42.5%, whole grain rye flour 42.5%, LSF 15%;

wheat flour (550 D) 40%, whole grain rye flour 40%, LSF 20%.

Whole grain rye flour and wheat 550 D flour (MALSENA, Lithuania), lupine seeds flour (VEGA PROVITA, Czech Republic) were used for bread samples. The nutritional value of the flour used in the bread samples preparation is presented in Table 1.

Table 1. **Nutritional value of whole grain rye flour, wheat flour, and lupine seeds flour per 100 g**

	Wheat flour	Whole grain rye flour	Lupine seeds flour
Energy value, kJ/kcal	1446/341	1370/325	1255/299
Fat, g	1.70	1.10	5.90
of which saturated fat, g	0.36	0.16	1.3
Carbohydrate, g	68.0	62.2	43.7
of which sugars, g	1.4	1.5	6.7
Fibre, g	3.9	16.0	11.0
Protein, g	11.5	8.5	33.3
Salt, g	0.004	0.005	0.12

Stages of bread production

Sourdough preparation

The sourdough for wheat-rye bread was prepared from a mixture of whole grain rye flour and water, spontaneously fermented at 20 ± 2°C for 24 h. The moisture content of the sourdough obtained was 60%. A portion of the sourdough was taken to make the dough, and the rest was added to a mixture of whole-grain rye flour and water. The sourdough was stored in a refrigerator at 8 ± 2°C.

Dough preparation

The prepared sourdough was mixed with the yeast, 28–30°C temperature water, a part of the whole grain rye flour as well as wheat flour mixture and left to ferment for 12 h. The remaining raw materials – sugar, salt, water, and the rest of whole-grain rye flour and wheat flour (the control sample) – were added to the mixture. For the test samples, the rye and wheat flour mixture was supplemented with the amount of 10, 15 and 20% of lupine seeds flour, based on the total amount of flour. The dough had a moisture content of 47 ± 2% and acidity of 8–9 mg KOH/100 g. A semi-finished dough product weighing 620 ± 5 g was placed in a 10 × 20 cm baking form. The semi-finished dough product was fermented in the proving oven at 40 ± 2°C for 1.5 h. It was baked in a convection oven at 200°C for 45 min. The samples of sliced wheat-rye bread with different amounts of lupine seeds flour are presented in Fig. 1. The bread test was carried out for 20 ± 4 h after baking. The quality of the bread was evaluated by their sensory properties, specific volume, density, moisture, acidity, the hardness of the crumb, and the drying process in 1–4 days after baking.

Preparation of bread for sensory evaluation

The sensory evaluation included 5 trained panellists that assessed the crumb colour intensity, texture, taste, and the overall impression of the bread. For the assessment of intensity, a 5-point scale was applied (5 is very strong, 4 is strong, 3 is moderate, 2 is weak, and 1 is just recognizable). The overall impression is a general assessment of the product, and it was rated on a 3-point scale (1 is bad, 2 is good, and 3 is very good). The bread samples were cut into 1.5 cm thick slices, placed on three-coded plastic plates and presented to the panellists. Coded bread samples were served to the panellists individually. The panellists were supplied with drinking water for cleansing the palate between the samples.

RESEARCH METHODS

In order to assess sensory properties, the test of descriptive analysis of sensory properties was applied in accordance with ISO 11036 Sensory Analysis. Methodology. Texture Profile and ISO 6564 Sensory Analysis. Methodology. Flavour Profile methods. The bread samples were analysed for acidity (according to the standard LST 1553) and moisture content (according to the standard LST 1492). The moisture content of bread samples was determined by air-oven method, drying 5.00 ± 0.05 g of the sample for 1 h at 110 ± 5°C. Afterwards, the samples were cooled in a desiccator.

The specific volume of a crumb was determined (Villarino et al., 2015; Minarro et al., 2012) by cutting a cube from the centre of the bread after which the volume in cm^3 (length (cm) × width (cm) × height (cm) of the cube) was measured and divided by the weight (g) of the cube. It was calculated as the ratio of the volume and the weight in cm^3/g. The density was calculated as the weight/volume ratio of the cube in g/cm^3.

Hardness of the bread crumb by storing the samples for 1–4 days was determined by using a texture analyser Lamy Rheology TX-700 (Lamy Reology Inc., France). The crumb hardness was analysed as a force (N), required to achieve sample deformation, using a 34 mm plate probe was subjected to compressing a 20 mm thick bread sample with the speed of 1 mm/s and maximum deformation of 40%. The measurement time was 20 s.

The influence of lupine seeds flour on the freshness of bread and the drying process of the baked samples (as a percentage of the initial cooled mass of the unpacked bread) was determined at room temperature for 1–4 days.

All the measurements of the analysed samples were made in triplicate.

The nutritional value of bread was calculated according to the Method for Calculating the Energy and Nutritional Value of Foods, approved in 2014 by Food Institute, Kaunas University of Technology. Statistical analysis was made by subjecting the data to the Analysis of Variance (ANOVA) Statistical Program SPSS, Version 11.0 (SPSS Inc., USA). Differences between the groups were considered significant at $p < 0.05$.

RESULTS AND DISCUSSION

The results demonstrated that the increased amount of lupine seeds flour reduced sensory properties of wheat-rye bread (Table 2). The overall impression of bread with the amount of 15 and 20% of LSF did not reach the evaluation 'good' (2 points). The control and the sample with the amount of 10% of LSF were scored well. The amount of lupine seeds flour did not affect the sweet and sour taste of the bread; however, it increased the bitter taste. The bread containing the amount of 20% of LSF had a taste of lupine seeds flour, with a change in the colour of the flesh from brownish to beige, which had a negative impact on the overall impression of the bread due to an undesirable aftertaste. This effect has already been reported by other researchers (Hall et al., 2006; Nasar-Abbas et al., 2012). The addition of lupin seeds flour influenced the crust colour significantly; however, it did not influence the other properties (Correia et al., 2015).

Fig. 1. Wheat-rye bread with different amounts of lupine seeds flour

Sensory evaluation of the texture properties showed that the amount of 15 and 20% of LSF reduced the porosity and elasticity and increased the stickiness of wheat-rye bread. The evaluation of sensory properties demonstrated that the amount of 10% of LSwF did not adversely affect the colour, taste or the texture of wheat-rye bread.

The amount of 15 and 20% of LSF reduced the specific volume of bread, which indicated a dense, compacted air crumb with small particles. The bread volume decreased with the increase of lupin seeds flour addition at levels higher than 10% (Codina et al., 2016).

Table 2. **Values of sensory properties in wheat-rye bread with different amount of lupine seeds flour**

Sensory properties	Lupine seeds flour, %			
	0 Control	10	15	20
Crumb colour intensity (from brown to yellowish brown)	4.0 ± 0.70d	3.8 ± 0.83c	3.4 ± 1.34b	2.6 ± 0.89a
Taste parameters				
Sweet	2.2 ± 1.64b	2.4 ± 0.89c	2.2 ± 0.83b	1.8 ± 0.44a
Sour	2.0 ± 0.70a	2.0 ± 1.22a	2.2 ± 1.09b	2.0 ± 1.22a
Bitter	1.8 ± 0.83a	2.0 ± 0.70b	2.4 ± 0.89c	2.6 ± 0.89d
Lupine seeds flour	1.2 ± 0.44a	1.6 ± 0.89b	1.6 ± 0.54b	2.2 ± 0.83c
Texture parameters				
Porosity	4.6 ± 0,89d	4.2 ± 0.83c	2.8 ± 1.09b	2.6 ± 0.89a
Stickiness	1.2 ± 0.44a	1.4 ± 0.54b	1.6 ± 0.89c	1.8 ± 0.83d
Fragility	2.4 ± 1.14a	2.8 ± 1.41c	2.6 ± 1.67b	2.8 ± 0.44c
Elasticity	4.4 ± 0.89d	4.2 ± 0.83c	2.4 ± 1.14b	2.0 ± 1.22a
Overall impression	2.4 ± 0.54d	2.0 ± 0.70c	1.6 ± 0.89b	1.2 ± 0.44a

Data expressed as means ($n = 5$) ± SD (standard deviation). Values within each group in the same superscript letter are not different at $P \leq 0.05$.

Table 3. **Changes in the moisture, specific volume, density and acidity of wheat-rye bread with different amounts of lupine seeds flour**

Sample	Bread moisture content, %	Specific volume, cm^3/g	Density, g/cm^3	Acidity, mg KOH/100 g
0% LSF (control)	42.23 ± 3.48 a	1.96 ± 0.06 d	0.51 ± 0.04 a	9.00 ± 1.45 c
10% LSF	43.03 ± 1.85 b	1.95 ± 0.19 d	0.53 ± 0.03 a	8.60 ± 0.82 b
15% LSF	44.53 ± 1.32 c	1.56 ± 0.23 b	0.59 ± 0.05 b	8.60 ± 0.96 b
20% LSF	46.44 ± 1.80 d	1.45 ± 0.14 a	0.67 ± 0.02 c	8.30 ± 1.44 a

Data expressed as means ($n = 5$) ± SD (standard deviation). Values within each group in the same superscript letter are not different at $P \leq 0.05$.

The bread control sample and the sample with a low crumb density of the amount of 10% of LSF showed a porous, airier crumb. The moisture content of the crumb indicated that with the increasing lupine seeds flour content in the sample, the moisture content of the crumb was slightly enhanced. That was influenced by lupine seed flour proteins, which do not have an elastic network in the dough and pastry, as well as by the high water absorption capacity of these material fibres (Kohajdova et al., 2011; Villarino et al., 2016; Piasecka-Jóźwiak et al., 2018). The results showed that the increasing LSF content in the sample reduced the specific volume of bread, increased the crumb density and slightly decreased the acidity of bread (Table 3).

Sensory texture properties detected by panellists were associated with the mechanical texture properties, e. g. bread crumb hardness. The results of the texture analyser showed that for 1 day storage of wheat-rye bread, the increasing amount of lupine seed flour increased crumb hardness by 1.5–2 times and after 4 days of storage it increased by 3–4 times compared to the control sample (Fig. 2).

The data demonstrated that the amount of 10% LSF in bread did not influence the drying process and did not differ from the control sample in the unpacked samples for 4 days. The amount of 20% of lupine seeds flour increased the weight loss of bread drying process by 53% compared to the control sample after 4 days of storage (Fig. 3).

Bread nutrition value calculations showed that using the amount of 10–15% of LSF in wheat-rye bread production, the protein content can be increased from 1.4 to 1.9 g per 100 g and the fibre content can be increased from 0.1 to 0.15 g per 100 g without effecting the sensory properties of bread (Table 4).

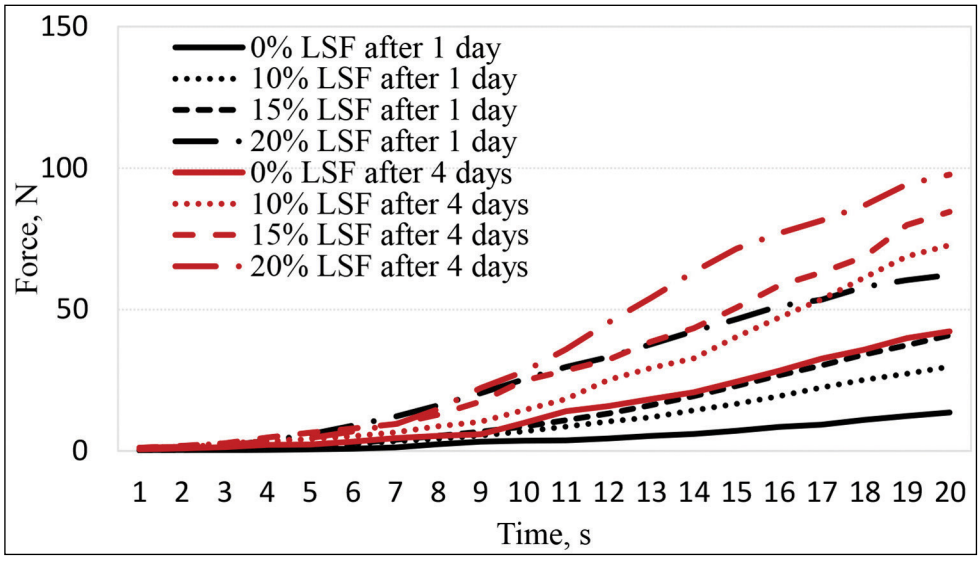

Fig. 2. Changes in the hardness of bread crumb with different amount of lupine seeds flour

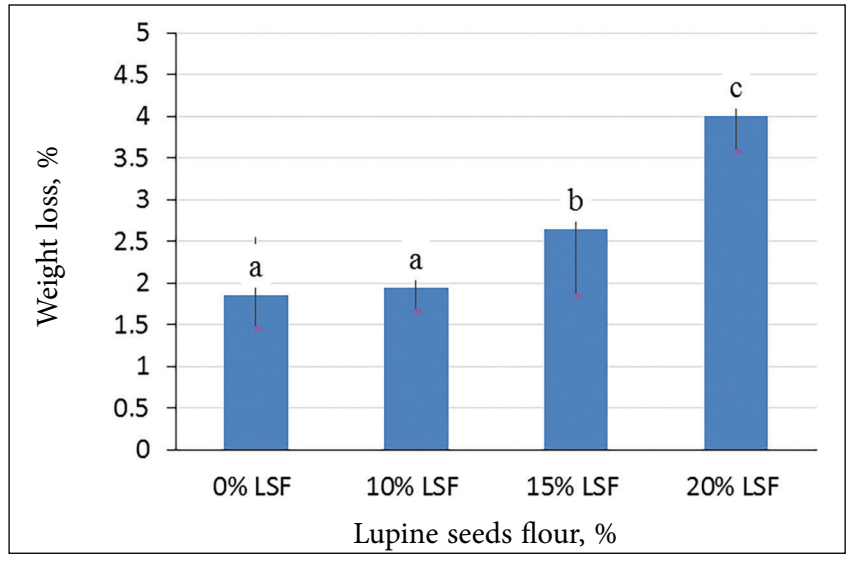

Fig. 3. Influence of lupine seeds flour on bread drying process

Table 4. **Nutritional value of wheat-rye bread with different amounts of lupine seeds flour**

	0% LSF	10% LSF	15% LSF	20% LSF
Energy value, kJ/kcal	718.9/169.3	729.4/171.9	733.1/172.8	740.4/174.5
Fat, g	0.69	0.95	1.06	1.22
of which saturated fat, g	0.11	0.16	0.19	0.23
Carbohydrate, g	45.6	44.3	43.7	43.0
of which sugars, g	0.81	1.13	1.25	1.44
Fibre, g	7.2	7.30	7.35	7.39
Protein, g	5.19	6.54	7.12	7.90
Salt, g	1.18	1.18	1.18	1.18

CONCLUSIONS

In bakery, lupine seeds flour can be used as a good source of protein, fibre, minerals and natural antioxidants. The addition of lupine seeds flour can bring a series of changes to the quality of bread. Specific volume values of bread can decrease, and density values can increase by increasing the percentage of lupine seeds flour addition. The textural properties can also be influenced: porosity and elasticity decrease slightly, whereas stickiness and fragility increase slightly by increasing the amounts of lupine seeds flour addition as compared to the control sample. The view of all the parameters demonstrates that products with the amount of 10% of lupine seeds flour addition are the closest ones to the quality of the control samples. The samples with the amount of 15–20% of lupine seeds flour addition had a slight bitter taste, the samples with the amount of 20% of lupine seeds flour addition had a negative impact on the overall impression of the bread due to an undesirable aftertaste and did not reach the evaluation 'good' (2 points). Lupine seeds flour had some influence on bread crumb colour intensity leading to a more yellowish-brown crumb. Using the amount of 10–15% of LSF in wheat-rye bread production, the protein content can be increased from 1.4 to 1.9 g per 100 g and the fibre content can be increased from 0.1 to 0.15 g per 100 g.

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LUBINŲ SĖKLŲ MILTŲ ĮTAKA KVIETINĖS-RUGINĖS DUONOS KOKYBEI

S a n t r a u k a

Šio darbo tikslas – nustatyti lubinų sėklų miltų 10, 15, 20 % kiekio įtaką kvietinės-ruginės duonos jusliniams rodikliams, drėgnio, rūgštingumo, akytumo, savitojo tūrio, tankio, minkštimo kietumo ir nudžiūvimo kitimui. Mėginių juslinėms savybėms įvertinti taikytas juslinių savybių aprašomosios analizės testas pagal LST ISO 11036 ir LST ISO 6564. 10 % lubinų sėklų miltų kiekis neturėjo neigiamos įtakos duonos spalvos, skonio, tekstūros savybėms. 15 ir 20 % lubinų sėklų miltų kiekis sumažino duonos poringumą, elastingumą ir padidino lipnumą, buvo jaučiamas kartus ir lubinų sėklų miltų skonis. Didinant lubinų sėklų miltų kiekį kepinyje, mažėja duonos savitasis tūris, akytumas, elastingumas, o minkštimo tankis, lipnumas padidėja. Palaikius duonos mėginius vieną parą, dėl didėjančio lubinų sėklų miltų kiekio minkštimo kietumas padidėjo 1,5–2 kartus, o palaikius keturias paras – 3–4 kartus, palyginti su kontroliniu mėginiu.

10 % lubinų sėklų miltų kiekis duonoje neturėjo įtakos nudžiūvimo procesui ir nesiskyrė nuo kontrolinio mėginio, palaikius neįpakuotus mėginius keturias paras. 20 % lubinų sėklų miltų kiekis duonoje 53 % padidino duonos nudžiūvimo nuostolius lyginant su kontroliniu mėginiu po 4 parų laikymo.

Raktažodžiai: minkštimo kietumas, elastingumas, lubinai, juslinės savybės