



## LEGUMES – THE ALTERNATIVE RAW MATERIALS FOR BREAD PRODUCTION

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### ABSTRACT

Legumes are an important group of cultural plants cultivated for their seeds which are suitable for human nutrition. They are rich in proteins, minerals, vitamins and sugars in seeds guaranteeing a high biological value and a wide use in human nutrition. Experimental loaves prepared from mixtures of wheat flour T 512 and pulverized lentil and chickpea in amount of 10 – 50 % showed with higher addition lower volume, specific loaf volume, volume efficiency and cambering in comparison to control ones. Nevertheless, from nutritive point of view the higher content of proteins with a suitable fraction structure and higher content of minerals with substances indispensable for humans were a significant contribution. From the technological point of view chickpea appeared to be more suitable raw material. Its addition in a portion of 10 % improved technological parameters of pastry. From the nutritive point of view, lentil was an excellent raw material. The best qualitative parameters (objective as well as subjective) were found in bread with addition of 10 % of chickpea.

**Keywords:** lentil, chickpea, bread addition, bread test, sensory evaluation

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## INTRODUCTION

Legumes have a very specific place from the nutritive point of view and play an important role in nourishment of world population. Pursuant to the Alimentary Codex of the Slovak republic (part three, chapter twelve) as legumes are understood ripe eatable seeds of legume plants: pea (*Pisum sativum* L.), lentil (*Lens culinaris* Med.), common bean (*Phaseolus vulgaris* L.), soya bean (*Glycine max* L.), chickpea (*Cicer arietinum* L.), sweet pea (*Lathyrus* L.) and broad beans (*Vicia faba* L.), which are suitable after processing for consumption. Among these, pea is highly consumed in Asian countries, common bean in Latin American and African countries, chickpea in India and lentil in countries of the Middle East (**Costa de Almeida et al., 2004**). The most popular legume in our regions is lentil and lately also chickpea.

In general, legumes are a source of complex carbohydrates, protein and dietary fibre, having significant amounts of vitamins and minerals (**Tharanathan and Mahadevamma, 2003**). Protein content in legume grains range from 17 % to 40 %, contrasting with 7 – 13 % of cereals (**Bojňanská, 2004**), and being equal to the protein contents of meats (18 – 25 %) (**Čuboň et al., 2011**). Addition of legumes to cereal products increases their content of fibre, resistant starch (**Utrilla-Coello et al., 2007**), important minerals (**Dhingra and Jood, 2001; Dalgetty and Baik, 2003; Costa de Almeida et al., 2004**) and vitamins. These products with addition of legumes have in comparison to classical bread prepared from wheat or rye higher nutritive value. Their consumption has positive impact on health conditions of consumers (**Goni and Valentin-Gamazo, 2002; Johnson et al., 2005; Hawkins and Johnson, 2005; Pittaway et al., 2007**). Apart from classical processing, legumes are also used to produce flour with specific granulation to be used in variety of food including pastries, bread, snacks, soups, mashed potatoes, etc. (**Maaroufi et al., 2000**).

Bread is one of the oldest foodstuffs. The purpose of the foodstuffs is not only to satisfy one's appetite and to help to stay alive, it should also support one's health and good form.

Taking into consideration the present health condition of population and prevalence of morbidity and mortality in the Slovak Republic, it is desirable to develop such foodstuffs which are natural source of bioactive substances and have positive impact on health of consumers (functional food). Considering this, the bread enriching plays an important role here as bread is consumed daily and the technology of its enriching is relatively simple.

## MATERIAL AND METHODS

Control bread as well as bread with an addition of lentil (test 1) and chickpea (test 2) in an amount of 10 %, 20 %, 30 %, 40 %, and 50 % were prepared in the rheological and bakery laboratory of the Department of Plant Products Storing and Processing at the Faculty of Biotechnology and Food Science of the Slovak University of Agriculture in Nitra. Control loaves of bread were prepared from 100 % of wheat flour T 512. Experimental bread loaves were made from wheat flour T 512 with the addition of lentil and chickpea in portions of 10 %, 20 %, 30 %, 40 % and 50 % which increased their nutritive quality (amount and structure of proteins and minerals, fibre enrichment, etc.). The raw materials and prepared products were evaluated from the viewpoint of their technological and nutritive value: starch content (according to Ewers), ash content (weight method by burning in muffle kiln), crude protein (by Kjeldahl's method,  $f = 6.25$ ). The analysis of the rheological property changes caused by different portions of lentil and chickpea has been provided by means of the Farinograph-E (Brabender OhG, Duisburg). The selected parameters loaf volume ( $\text{cm}^3$ ), specific loaf volume ( $\text{cm}^3 \cdot 100\text{g}^{-1}$  loaf), volume efficiency ( $\text{cm}^3 \cdot 100\text{g}^{-1}$  flour), crumb acidity (titration method), ash and crude protein content in bread have been evaluated during an experimental baking test.

The sensory characteristics of the baked loaves have been evaluated with scoring points using an intensive scale (1-5) for the crust colour, crumb colour and crumb porosity and a hedonic scale (1-9) for the surface appearance, crumb appearance, taste, flavour and the complex evaluation (overall acceptability). The breads with a high scale were preferred.

## RESULTS AND DISCUSSION

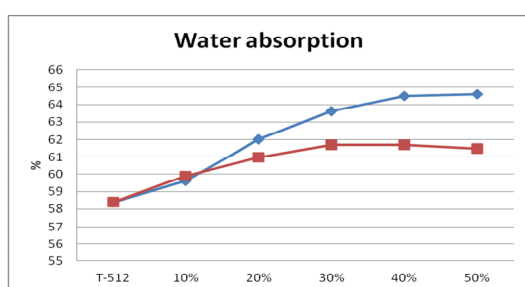
Based on raw materials used for bread production, the content of important substances varied significantly (Tab 1). The content differences resulted in different characteristics of experimental bread loaves. All additives used in bread loaves increased the content of minerals. Lentil as well as chickpea has from the nutritive point of view very interesting qualitative and quantitative structure of minerals. Lentil is an excellent source of such minerals as zinc (approx  $38 \text{ mg} \cdot \text{kg}^{-1}$ ), iron (approx  $64 \text{ mg} \cdot \text{kg}^{-1}$ ) and manganese (approx  $53 \text{ mg} \cdot \text{kg}^{-1}$ ). In chickpea there is an important amount of phosphorus (approx  $38.7 \text{ mg} \cdot \text{kg}^{-1}$ ), magnesium (approx  $16.8 \text{ mg} \cdot \text{kg}^{-1}$ ) and calcium ( $11.4 \text{ mg} \cdot \text{kg}^{-1}$ ) (Sotelo and Adsule, 1996; Vojtaššáková et al., 1999; Dalgetty and Baik, 2003; Dostálová and Prugar, 2008).

Regarding N-substances, their content in lentil and chickpea was considerably higher than in used wheat flour. With the increased portion of lentil and chickpea, the content of N-substances increased to max 16.28 % of crude protein in bread with addition of 50 % of lentil.

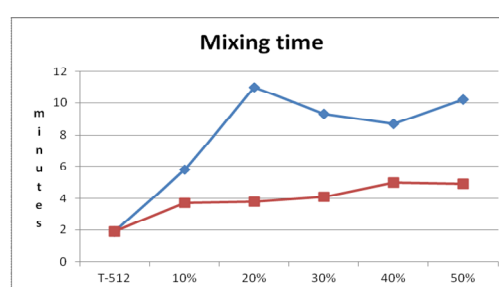
**Table 1** Qualitative parameters of raw materials

Parameter	Wheat flour	Lentil	Chickpea
Starch, %	71.9	48.9±0.22	44.3±0.96
Crude protein, %	13.0	24.37±0.15	20.98±0.21
Ash content, %	0.57	2.39±0.04	2.30±0.20

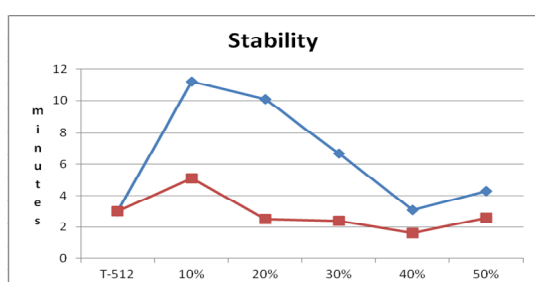
Addition of different amount of chickpea and lentil in a mixture with wheat flour was reflected also in changes of physical properties of dough during its production (Fig 1-4). The influence of non bakery crops added to composite flours on properties evaluated by farinograph was significant.



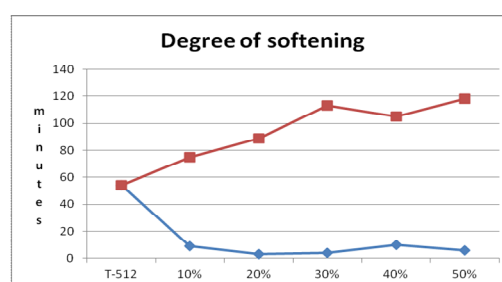
**Figure 1** Farinographic water absorption



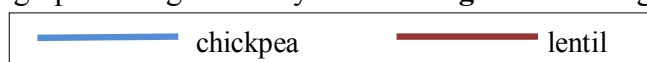
**Figure 2** Farinographic mixing time



**Figure 3** Farinographic dough stability



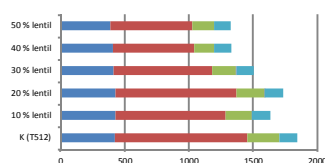
**Figure 4** Farinographic degree of softening



Addition of chickpea and lentil caused the increase of farinographic water absorption of dough in comparison to the one from wheat flour. It was more significant with addition of chickpea. The increase of water absorption was most probably caused by higher portion of

non starch polysaccharids (Collar *et al.*, 2007), or by decrease of portion of non soluble protein fractions (Anton *et al.*, 2008). Higher water absorption causes higher dough weight and higher volume efficiency of pastries. Increase of farinographic water absorption is from the economic point of view desirable since it decreases the amount of flour needed to produce bread of the same weight.

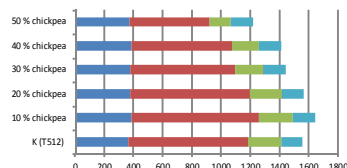
Mixing time (dough development time) is time interval in minutes from the first addition of water until the curve reaches its maximum height. In case of both additives was the mixing time, as well as dough stability higher (more significantly with chickpea addition) compare to wheat flour. Degree of softening is the distance between the centre of the mixing curve and the 500 line after 15 min mixing and it is connected with the destruction of dough caused by shortening of gluten fibres. Dough with chickpea addition was very strong with long developing time, thus increasing amount of chickpea in a mixture increases energy demands to produce dough of optimal consistency and for the industrial processing the regime of kneading must be adjusted (Bojňanská *et al.*, 2010).



**Figure 5**

Technology quality of bread with lentil

[loaf weight (g) + loaf volume (cm<sup>3</sup>) + specific loaf volume (cm<sup>3</sup> · 100g<sup>-1</sup> loaf) + cambering]



**Figure 6**

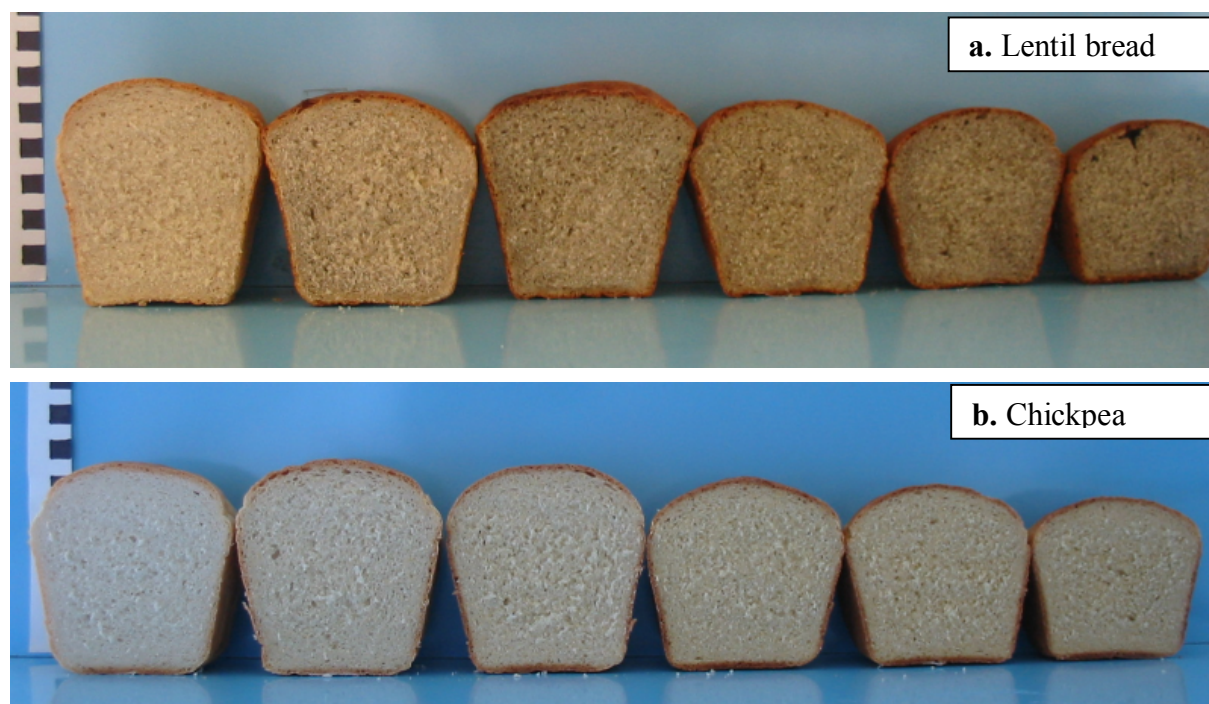
Technology quality of bread with chickpea

[loaf weight (g) + loaf volume (cm<sup>3</sup>) + specific loaf volume (cm<sup>3</sup> · 100g<sup>-1</sup> loaf) + cambering]

Based on results of baking experiments we can conclude that the higher addition of lentil and chickpea worsened the qualitative parameters of baked bread loaves, mainly their volume and volume efficiency (Fig 5 and 6). The reason of decreased volume was mainly the decreasing of gluten amount caused by the addition of materials from which it is not possible to isolate gluten as the fraction of non soluble proteins forming 3D structure. By lowering the amount of gluten, the ability to keep ferment gas during rising of dough also lowered and consequently it influenced lower volume and lower porosity of pastries. The same tendency was observed in loaves cambering, which is the ratio between the height and the width and its

higher value points to a loaf with more arching, more desirable form. Gluten removal from the recipes in bread production leads to significant technological problems. Gluten proteins play a key role in guaranteeing the bakery quality of wheat and influence water absorption, cohesion, viscosity, extensibility, elasticity, resistance to deformation, tolerance to kneading, ability to gas retention and dough strengthening properties (Lazaridou *et al.*, 2007; Wieser, 2007). Also non bakery crops content elements (mainly of saccharid complex), can either positively or negatively influence the rheological properties of dough prepared with addition of these crops.)

However, the addition up to of 20 % of chickpea improved the qualitative parameters of experimental bread compare to the control one which resulted in the higher bread volume (Fig 7a, b). The similar effect was not observed with addition of lentil. Generally, we can conclude that the addition of both legumes up to 30 % in case of lentil, and up to 40 % in case of chickpea is considered as technologically suitable, although in some cases the evaluated parameters have been slightly worsened (Fernandez and Berry, 1989; Singh *et al.*, 1992; Utrilla-Coello *et al.*, 2007). Similar baking experiments with addition of other (non legumes) raw materials e.g. buckwheat and oat did not show this improving effect (Bojňanská, 2008; Bojňanská *et al.*, 2009), what is most probably related to the amount and structure of their proteins. (Sanchez-Vioque *et al.*, 1999; Yanez-Farias *et al.*, 1999; Sabanis *et al.*, 2006).



**Figure 7a, b** Bread with addition lentil/chickpea (control, 10 %, 20 %, 30 %, 40 %, 50 %)



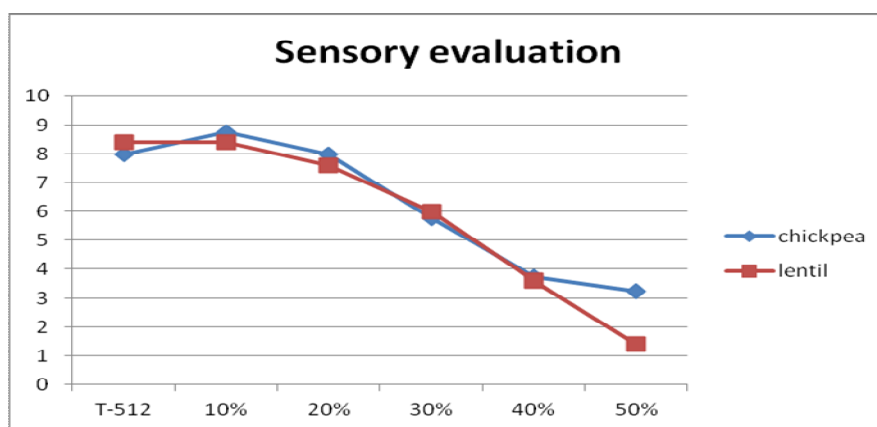
With addition of lentil and chickpea the sensory and nutritive qualities of bread loaves varied considerably. With the addition of legumes the content of important substances (protein, ash) in bread increased, thus increased its nutritive value in comparison to pure wheat bread. (Tab 2) – from this point of view lentil has been evaluated as a better raw material. When cereals and legumes are combined, the quality score of the combined proteins may be much higher than each of the individual values (Hegarty, 1995). Crumb acidity is the indicator of the content of acid substances – acids present in the raw material as well as forming during the processing. Too low value of titration acids is not desirable as such pastries are tasteless. On the other side too high value of titration acids can signal that used flour was not fresh and due to long-termed or incorrect storing was already damaged. During the baking experiment crumb acidity increased with addition of lentil and chickpea, thus the bread became more tasty and richer. In none of the cases the acidity reached too high undesirable values. The highest increase of acidity was found in bread loaves with addition of lentil what is related most probably to the high input of minerals coming from this raw material. Heat treatment applied to legumes improves their texture, palatability and nutritive value by gelatinization of starch, denaturation of proteins, increased nutrient availability and inactivation of heat labile toxic compounds and other enzyme inhibitors.

**Table 2** Nutritive quality bread with chickpea and lentil

	Crumb acidity, mmol.kg <sup>-1</sup>	Crude protein, %	Ash content, %
<b>Control bread</b>	45	12.57	0.8
<b>Chickpea 10 %</b>	50	12.33	0.9
<b>Chickpea 20%</b>	56	12.99	1.1
<b>Chickpea 30 %</b>	59	13.79	1.1
<b>Chickpea 40 %</b>	61	14.7	1.3
<b>Chickpea 50 %</b>	63	15.73	1.6
<b>Control bread</b>	30	10.53	1.11
<b>Lentil 10 %</b>	33	12.5	1.38
<b>Lentil 20 %</b>	40	13.13	1.44
<b>Lentil 30 %</b>	50	14.43	1.75
<b>Lentil 40 %</b>	60	15.49	1.82
<b>Lentil 50 %</b>	76	16.28	2.13

During a sensory evaluation it has been found out that the addition of lentil and chickpea influenced considerably colour, texture, flavour as well as taste of crumb depending on the amount used. The total acceptability of bread with addition of chickpea up to 20 % was considered as better or equally good as wheat bread. Bread with addition of 10 % of lentil was

evaluated as equally good as wheat bread (Fig 8). The bread produced with addition of both raw materials in portion of 40 % and 50 % was from sensory point of view unacceptable (< 4). Out of all evaluated bread loaves bread with addition of 10 % chickpea was evaluated as the best.



**Figure 8** Sensory evaluation added bread

## CONCLUSION

Obtained results with regard to possibilities of using legumes in mixtures with wheat flour at bread production confirmed the current tendency of enriching traditional products by additives interesting from nutritive viewpoint. Experimental bread loaves prepared from the mixture of wheat flour T 512 and 10 – 50 % of pulverized lentil and chickpea showed in comparison to control loaves lower volume, special loaf volume, volume efficiency and cambering, especially with higher portions of additions. However, from the nutritive point of view the higher content of proteins with a suitable fraction structure as well as higher amount of minerals indispensable for human organism was of a significant improvement. Nutritive value of such products is given by higher portion of vitamins, fibre and further biologically active substances. From technological point of view chickpea appeared to be more suitable material. Its addition in portion of 10 % improved technological parameters of pastry. From nutritive point of view lentil was extremely suitable material.

From consumer point of view sensory acceptance of product is of main importance, therefore at the end, the success of product in the market is decided by organoleptic evaluation. Acceptable values were found in loaves with addition of 10 %, 20 %, and 30 % of lentil and chickpea. Based on the results these additions can be recommended as suitable. The best



qualitative parameters (objective and subjective) were found in bread with addition of 10 % of chickpea.

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