International Journal of Biological, Life and Agricultural Sciences
ISSN: 2415-6612
Vol:9, No:10, 2015

Development and Characterization of Wheat Bread with Lupin Flour

Paula M. R. Correia, Marta Gonzaga, Luis M. Batista, Luísa Beirão-Costa, Raquel F. P. Guiné

Abstract**—**The purpose of the present work was to develop an innovative food product with good textural and sensorial characteristics. The product, a new type of bread, was prepared with wheat (90%) and lupin (10%) flours, without the addition of any conservatives. Several experiences were also done to find the most appropriate proportion of lupin flour. The optimized product was characterized considering the rheological, physical-chemical and sensorial properties. The water absorption of wheat flour with 10% of lupin was higher than that of the normal wheat flours, and Wheat Ceres flour presented the lower value, with lower dough development time and high stability time. The breads presented low moisture but a considerable water activity. The density of bread decreased with the introduction of lupin flour. The breads were quite white, and during storage the colour parameters decreased. The lupin flour clearly increased the number of alveolus, but the total area increased significantly just for the Wheat Cerealis bread. The addition of lupin flour increased the hardness and chewiness of breads, but the elasticity did not vary significantly. Lupin bread was sensorially similar to wheat bread produced with WCerealis flour, and the main differences are the crust rugosity, colour and alveolus characteristics.

Keywords**—**Lupin flour, physical-chemical properties, sensorial analysis, wheat flour.

I. Introduction

BREAD has always been one of the most popular and appealing food products due to its superior nutritional, sensorial and textural characteristics, ready to eat convenience as well as cost competitiveness. Bread is essential to the diets of many people worldwide.

Bread is essentially made with cereals, of which the most commonly used for being considered the nobler, is wheat (*Triticum genus*, and more specifically *Triticum sativum*). Wheat flour is an excellent source of fibre, particularly insoluble fibre [1], [2].

As the artisan baking process extended to the industrial scale, the use of flour enhancing agents has been generalized, as a way to improve the process characteristics and shelf life of the products obtained [3]. For decades enzymes have been added to flour in bread production in order to improve the volume, flavour, aroma, structure of the shell and crumb, tenderness and shelf life [4]. Among the various intrinsic properties of bread, volatile flavour compounds play a key role in the perception of fresh bread flavour, which is also determined by the type of bread, ingredients, method of production and shelf life [5], [6].

There are several types of bread, such as for example, wheat bread, rye bread, mixed flour bread, whole bread, bread for diabetics, among others. The latter are examples of products with added nutritional value and unique taste [7].

The ingredients of bread will impart characteristic colors, texture, and nutritional value which may improve the bread quality. Therefore, a proper balance of ingredients needs to be obtained to produce high-quality bread. Concerns about the quality of breads go beyond the ingredients in the loaves themselves. One of the main quality criteria on bread is related with texture, and the development of a desirable volume, related to alveoli formation.

Today's consumer is more informed and more demanding, caring about the characteristics of bread and how it can contribute to the well-being and improvement of health. Used of plant-derived protein is widely accepted as a way of meeting the demand for health requirement in food products. Thus, the main attribute of lupin (*Lupin* spp.) is its high protein and dietary fiber as well as negligible amounts of starch content. It has been proven that bread enriched by lupin flour has the potential to provide health benefits, such as increased saciety and reduce energy intake, decrease blood pressure, and decrease blood glucose level [8].

The development of new products requires that they undergo a series of steps. Sensory analysis and consumer research are the most important tools that enable informed decision making. Sensory evaluation is one of the last steps in product development and aims to characterize and measure sensory attributes of the product and/or to determine differences among products. It may be defined as the examination of the organoleptic characteristics of a product by the sense organs and hence its importance in evaluation of the final product [9].

Thus, the objective of this study was to develop and produce a biological bread with good physical-chemical, textural and sensorial properties.

II. Experimental Procedure

A. Product Preparation and Formulation

The wheat flours were supplied by two factories with the following trademarks: Cerealis and Ceres. A basic recipe was used to produce the wheat breads [5 kg of wheat flour T65

P. M. R. Correia is with the Research Centre CI&DET, Polytechnic Institute of Viseu, Campus Politécnico, Repeses, Portugal (corresponding author to provide phone: +351-232-480700; fax: +351-232-480750; e-mail: paulacorreia@esav.ipv.pt).

M. Gonzaga is with the Food Engineering Department, Agrarian School of Viseu, Viseu, Portugal (e-mail: sofia_7305@msn.com @gmail.com).

L. M. Batista is with the Fabrica do Pão. Seia, Portugal (e-mail: lbatista@gmail.com)

L. Beirão-Costa is with the Research Center LEAF, Instituto Superior de Agronomia, Lisboa, Portugal (e-mail: lbeirao@isa.utl.pt).

R. P. F. Guiné is with the Research Centre CI&DET, Polytechnic Institute of Viseu, Viseu, Portugal (e-mail: raquelguine@esav.ipv.pt).

Cerealis or Ceres, 100 g yeast (2%), 75 g salt (1.5%) and water (60-63%)]. The equipments used were a mixer Spiral Ferneto AEF035 (Ferneto, Vagos, Portugal) and an electric oven model Modulram Classic with built in stove (Ramalhos, Aveiro, Portugal). The water content used for each formulation was determined by the farinograph results as described in the subsection C, physical analysis of doughs.

Lupin (*Lupinus albus* L.) flour was purchased in the local market. Two tests were undertaken until reaching a final optimized wheat bread with lupin flour. The wheat with lupin flours breads were produced under the same conditions as described previously for wheat breads, with the following proportion of lupin/wheat flours: 1/9 and 1.5/8.5. These breads were produced with a reduced quantity of flour (5 kg), corresponding to 5 final breads.

The codes used to name the samples are: W for wheat and WL for wheat and lupin flour. Each of these is followed by the trade mark corresponding to the wheat flour used.

B. Farinographic Assay

A farinograph measures rheological properties of flours by determining the resistance of the dough against the mixing action of paddles. Farinographic assay was conducted by using a 300 G Brabender Farinograph (Brabender GmbH & Co. KG, Germany) [10]. The parameters obtained from the farinogram were the percentage of water to yield consistency of 500 BU (water absorption), the time to reach 500 UB (development time), the time that dough remained at a consistency of 500 BU (dough stability time).

C. Physic-Chemical Analysis of Breads

Water activity was determined by a hygrometer (Rotronic) and five determinations were made. Moisture content was accessed by mass loss until constant weight in a stove at 100-105ºC, and also five determinations were made [11].

The colour parameters were evaluated using a colorimeter Chroma Meter (Konica Minolta) and the results are expressed in CIELab coordinates system, where L* is the lightness of the sample, and ranges from 0 (black) to 100 (white), a* ranges from -60 (green) to +60 (red) and b* ranges from -60 (blue) to +60 (yellow).

For the analysis of texture properties it was used a texturometer TA-XT2 (Stable Microsystems, UK) which compresses the sample twice to simulate the action of chewing. The compression is usually 80% of the original length of the sample [12]. For the analysis it was necessary to cut the sample into slices (10 mm thick), removing a cube of side 30 mm from the crumb. Fourteen replicates were performed.

The probe used was cylindrical with 75 mm diameter base (being the pressure probe greater than the sample) at a temperature of about 20 ºC. The test parameters were:

- Compression speed: 0.5 mm/s;
- Compression distance: 6 mm (corresponding to a deformation of 40% of the height of the sample);
- Recovery time (pause) between the two compressions: 5 seconds;
- Acquisition rate: 50 readings taken per second.

The textural properties evaluated were hardness, elasticity, cohesiveness and chewiness.

For the density, determination was used the relation between mass and volume. For that pieces of bread were carefully cut in the form of parallelepipeds (3x3x1 cm), which were then weighed on a precision balance. Fourteen replications were done.

For the alveolar characterization, was undertaken the analysis of slices using the program "Image J" developed by Wayne Rasband from the National Institute of Mental Health of the United States of America. Five 10 mm thick slices were scanned, and the slice cut was made in the central zone eliminating the crust (See Fig. 1). With the use this program it was possible to determine the number and size of the alveoli, the total area and the alveolar percentage on that area.

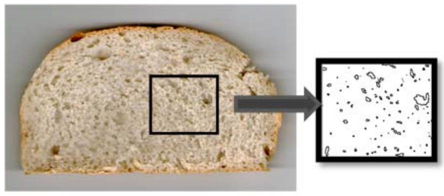

Fig. 1 Methodology for alveolus characterization

The analyzed properties were determined in the same day of bread production and also in the 5 days after.

D. Sensorial Analysis

Sensory analysis was performed in a laboratory prepared for that purpose, on the day of delivery of the samples by a panel of 73 untrained tasters, aged between 18 and 64 years, who were asked to rate the following attributes: crumb color and rugosity, crust color, alveolus characteristics (little/big and uniformity), aroma (bread and fermentation), taste (bread, sweet, salt and fermentation), elasticity, density, and finally the overall appreciation. In this test the taster expressed the intensity of each attribute through a scale where verbal Hedonic expressions are translated into numeric values in order to allow statistical analysis. The scale of values varied from 0 (less intense) to 10 (more intense).

III. Results and Discussion

A. Farinographic Characteristics of Flours

Characterizing dough rheological properties can be effective for predicting processing behavior and for controlling the quality of food products. The farinograph, extensograph, and mixograph are the most common instruments used for characterizing dough rheology. The specific farinograph characteristic values of dough samples are presented in Table I, and their farinograms in Fig. 2. The water absorption of wheat flour with 10% of lupin is higher than that of the normal wheat flours, and wheat Ceres flour presented the lower value. These could be due to the flour components, like starch (the main component) and also due to his structure (amorphous areas absorbed large amounts of water [13]. The WLCerealis flour with 10% of lupin did not achieve the 500 BU, and this result was also observed for the wheat Cerealis and Ceres flours with 15% of lupin (data not shown). The dough development time was shorter for WCeres flour and for this flour with 10% lupin, an advantage for improving the time for bread making was observed. The stability time is an indication of the strength of flour, higher value means stronger dough. Also, WCeres presented the greater value. Furthermore, this flour shows the lower degree of softening (30.0 Bu) at 12 min, suggesting that gluten was stronger, making the dough easier to mold during processing and it will not collapse easily in the final products.

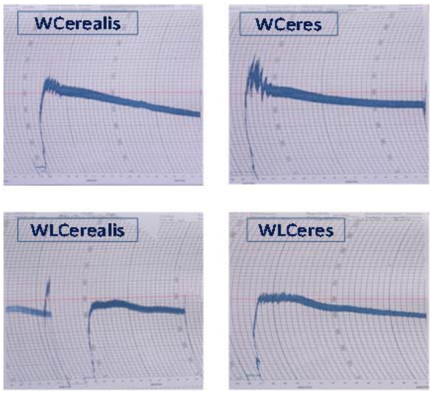

Fig. 2 Farinogram curves of wheat (W) and wheat with 10 % of lupin flours (WL) dough

TABLE I
FARINOGRAPHIC CHARACTERISTICS DATA OF WHEAT AND WHEAT WITH 10% LUPIN FLOUR DOUGH

Characteristics	WCerealis	WCeres	WLCerealis	WLCeres
Water absorption (%)	60.0	55,7	67.0	67.0
Dough development time (min)	4.0	2.0	-	2.5
Dough stability (min)	6.5	8.5	-	6,5
Degree of softening at 12 min (BU)	60.0	30.0	-	60.0

Note: W-Wheat flour; WL- wheat with 10% lupin flour

The addition of lupin flour to wheat bread can lower the bread quality [14], mainly due to the low elasticity of lupin protein and the high capacity of lupin dietary fiber to bind water [15], which weak the gluten matrix and consequently the bread presented poor loaf texture and volume [16]. Publishing reports indicate that above 10% substitution of refined wheat flour with lupin flour significantly decreases dough and bread quality [14]. These conclusions are in accordance with our results (see also the other encountered results).

B. Physic-Chemical Properties of Breads

The moisture and water activity (a_w) are important factors for food storage. The results shown that moisture content is low, but the a_w is quite high (more than 0.94) (Fig. 3), meaning that the water present is available to react with other components of bread matrix and also exists the possibility of fungi development. The moisture content is stable during the 5 days of storage, but there is a slight decreasing for a_w.

Fig. 4 presented the results of density evaluation. It seems that the wheat flour type influenced greatly the bread density, probably due to the gluten characteristics. The wheat Ceres flour showed the less density value, and this decreased when the flour contain lupin flour.

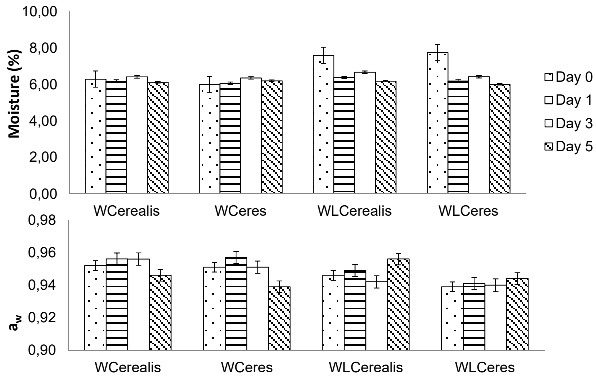

Fig. 3 Moisture and a_w of wheat (W) and wheat with 10 % of lupin flours (WL) breads

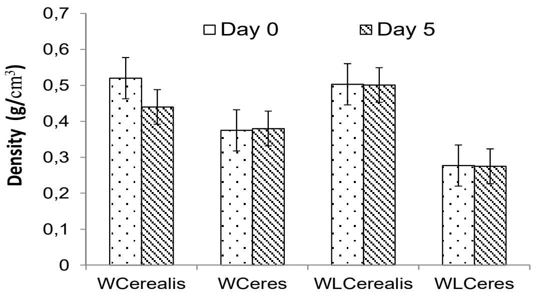

Fig. 4 Density of wheat (W) and wheat with 10 % of lupin flours (WL) breads

Generally the breads were white, and the WCerealais was the whitest one (Fig. 5), with no influence of storage time. The b* parameter was similar for all breads, but there is an increase of this parameter with the addition of lupin flours, becoming more yellow, probably due to the yellow color of original lupin flour. The a* values were different for all breads and increased with the addition of the lupin flour, becoming more read. Generally, the a* and b* parameters decreased with the increasing of the storage time, being the breads less yellow and less red.

Considering the alveolar characteristics, it was possible to observe that the alveolar percentage and the mean size were strongly correlated with the total area and alveolar number, respectively. The lupin flour clearly increased the alveolus number, but the total area just increased significantly for the Cerealis wheat flour bread (Fig. 6). The WCeres presented the low mean size of alveolus, influencing the density parameter presented before.

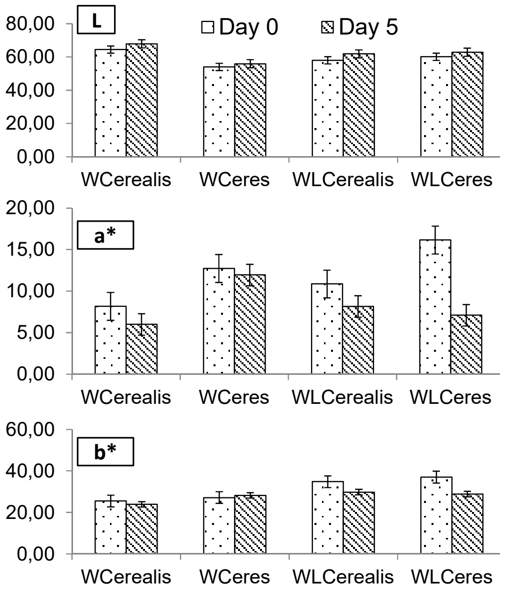

Fig. 5 Color parameters of wheat (W) and wheat with 10 % of lupin flours (WL) breads

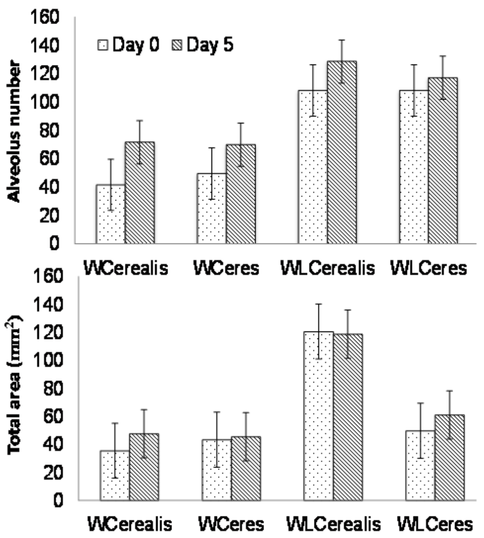

Fig. 6 Alveolar characteristics of wheat (W) and wheat with 10 % of lupin flours (WL) breads

When it was add lupin flour the hardness and chewiness increased, and decrease the cohesiveness of wheat breads (Table II). The elasticity of breads did not vary significantly with the addition of lupin flour, and with the storage time. During bread aging the hardness increase significantly, as expected, and also the chewiness increased slightly, in opposition to the cohesiveness parameter, meaning the ability of the product to stay as one [17].

C. Sensorial Evaluation

In sensory analysis were evaluated attributes related to appearance, aroma, taste, texture and finally the global appreciation, translated into a scale of 10 points. The wheat breads are the reference. For this analysis was just produced the WLCerealis bread because the results for sensorial results for the WCerealis bread presented high scores (Fig. 7). There were some considerable differences considering the two wheat breads analyzed.

The results showed that the taste (bread, fermentation, salt and sweet) for all breads was very similar between them, and the higher score was obtained for the bread taste in a range of 4.4 to 4.7. The addition of lupin flour influenced significantly the crust color, but it did not influence the other properties when compared with wheat bread produced with Cerealis flour.

TABLE II
TEXTURAL PROPERTIES OF WHEAT (W) AND WHEAT WITH 10 % OF LUPIN FLOUR (WL) BREADS CONSIDERING STORAGE TIME

Properties	Day	WCerealis	WCeres	WLCerealis	WLCeres
Hardness(N)	0	1.34±1.26	1.12±0.53	2.68±0.88	1.48±0.71
	5	5.25±0.18	3.51±0.42	6.53±0.32	6.60±0.95
Cohesiveness	0	0.74±0.03	0.74±0.02	0.60±0.03	0.62±0.01
	5	0.59±0.05	0.51±0.01	0.33±0.02	0.53±0.02
Elasticity (%)	0	92.4±4.3	93.1±5.7	91.7±3.1	78.87±4.8
	5	87.10±3.4	87.45±3.8	80.35±4.6	91.04±2.7
Chewiness (N)	0	0.91±0.58	0.56±0.30	1.14±0.67	0.71±0.12
	5	0.94±0.41	1.09±0	1.71±0.52	1.01±0.44

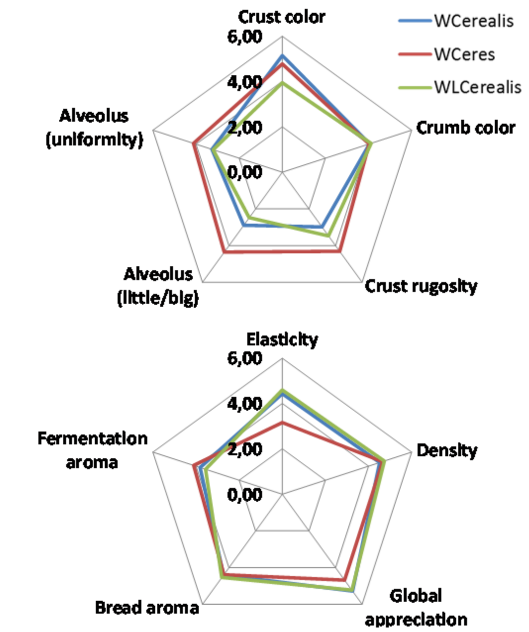

Fig. 7 Sensorial profile of wheat (W) and wheat with 10 % of lupin flours (WL) breads

IV. CONCLUSION

This work allowed concluding that the addition of 10% of lupin flour to wheat flours to produce bread caused the emerging of different physical-chemical and sensorial properties. Some of the evaluated properties were quite different; mainly the rheological characteristics of doughs, the density values, color parameters, alveolar characteristics and texture properties, but the sensorial evaluation showed that the bread produced with 10% of lupin flours added to wheat Cerealis flour presented similar scores for the consumer, meaning that the measured differences were not perceptible for them. These results are quite optimists since with the addition of the lupin flour the nutritional value of the wheat bread increased, with all the related health benefits.

Acknowledgment

The authors thank CI&DETS Research Centre and Polytechnic Institute of Viseu for financial support.

References

[1] M. Bonnand-Ducasse, G. D. Valle, J. Lefebvre, e L. Saulnier, «Effect of wheat dietary fibres on bread dough development and rheological propertities», *Journal of Cereal Science*, vol. 52, pp. 200-206, 2010.

[2] A. E. Léon, e C. M. Rosell, *De tales harina, tales pan*. Argentina: Eds. Baés Ediciones, 2007.

[3] E. Gallagher, T. R. Gormley, e E. K. Arendt, «Crust and crumb characteristics of gluten free breads», *Journal of Food Engineering, vol. 56, pp. 153-161*, 2003.

[4] A. G. Nunes, A. P. S. Faria, F. R. Steinmacher, e J. T. C. Vieira, Processos enzimáticos e biológicos na panificação. Trabalho de curso de Engenharia Bioquímica. Florianópolis, Brasil: Universidade Federal de Santa Catarina, 2008.

[5] A. Giménez, P. Varela, A. Salvador, G. Ares, S. Fiszman, e L. Garitta, «Shelf life estimation of brown pan: a consumer approach», *Food Quality and Preference*, vol. 18, pp. 196-204, 2007.

[6] S. Jensen, L. H. Oestdal, E. Larsen, e A. K. Thybo, «Chemical changes in wheat panbread during storage and how it effects the sensorial perception ofaroma, flavor, and taste», *Journal of Cereal Science,* vol. 53, pp. 259-268, 2011.

[7] Portaria 254/2003. «Normas técnicas realtivas à definição, caracterização, composição, acondicionamento, rotulagem, métodos de análise, tolerâncias analiticas e comercialização de farinhas», DR, vol. 66,pp. 1861-1865, Marc. 2003.

[8] S. Islam, W. Ma, G. Yan, L. Gao, e R. Applels, «Differential recovery of lupin proteins from the gluten matrix in lupin-wheat bread as revealed by mass spectrometry and two-dimention electrophoresis», *Journal of Agriculture and Food Chemistry*, vol. 59, pp. 6696-6704, 2011.

[9] M. W. J. Noort, J. H. F. Bult, M. Stieger, e R. J. Hamer, «Saltines enhancement in bread by inhomogeneous spatial distribuition of sodium chloride», *Journal of Cereal Science*, vol. 52, pp. 378-386, 2010.

[10] Americam Association of Cereal Chemistry. *Approved methods of the AACC*, 10th ed. Washington: American Association of Cereal Chemistry, 2000.

[11] C. A. A. Marques, L. M. Batista, R.l P. F. Guiné, e P. M. R. Correia. Development and characterization of bread with apple and cinnamon, Proceeding book of ICEUBI 2013, International Conference on Engineering. Covilhã, Portugal, 2013.

[12] S. Sahin, e S. G. Sumnu. Physical properties of foods. New York, USA: Springer, 2006.

[13] H. Zhang, W. Zhang, C. Xu, eX. Zhou, «Studies on the rheological and gelatinization characteristics of waxy wheat flour», International Journal of Biological Macromolecules, vol. 64, pp. 123-129, 2014.

[14] C. B. Villarino, V. Jayasena, R. Coorey, S. Chakrabarti-Bell, e S. Johnson, «The effects of bread-making process factors on Australian sweet lupin-wheat bread quality characteristics», *International Journal of Food Science & Technology*, vol. 49, pp. 2373–2381, 2014.

[15] C. M. Turnbull, A. L. Baxter, e S. K. Johnson, «Water dbinding capacity and viscosity of Australian sweet lupin kernels fibre under in vitro condituons simulating the human upper gastrointestinal tract», *International Journal of Food Science and Nutrition*, vol. 56, pp. 87–94, 2005.

[16] N. Guemes-Vera, R. J. Pena-Bautista, C. Jimenez-Martinez, G. Davila-Ortiz, e G. Calderon-Dominguez, «Effective detoxification and decoloration of *Lupinus mutabilis* seed derivatives, and effect of these derivatives on bread quality and acceptance », *Journal of the Science of Food and Agriculture*, vol. 88, pp. 1135–1143, 2008.

[17] R. P. F. Guiné e B. L. Marques, « Evaluation of Texture of Packhams Pears », *World Academy of Science, Engineering and Technology*, vol. 79, pp. 406–410, 2013.