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Development and characterization of wheat breads with acorn flour

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Abstract

The use of wheat and acorn flours in the production of breads was studied, in order to develop an innovative food product with good textural and sensorial characteristics. Flours and breads were characterized considering the functional, the physical-chemical and sensorial properties, respectively. The water absorptions were similar (57.5%-60.0%), achieving all the doughs the 500 BU, with a shorter dough development time for doughs whit acorn, and they also presented a high stability time (>30 minutes). The energy, the resistance to extension and the extensibility of doughs increased with the addition of acorn flour and with the proving time. The breads presented low moisture but a considerable water activity (0.93-0.97). The density of bread decreased with the introduction of acorn flour, which was also corroborated by sensorial and alveolar analysis (higher alveolar number and total area, with large alveolus). Acorn breads were darker, dimming along the storage. Acorn flours increased the hardness and decreased the cohesiveness of wheat breads, with no significant variation in elasticity. The global sensorial appreciation of breads had similar scores. The crust and crumb colour were more intense for acorn bread, presenting a low uniformity and little alveolus, and it was scratchier than 100% wheat breads.

Keywords

Wheat, Acorn, Flour, Bread, Rheological properties, Physicochemical properties, Sensory analysis.

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Conference Topic – TS1 – Food Engineering and Properties

1. Introduction

Bread is one of the oldest functional foods which health effects have been investigated in many studies [1], being an important staple food [2] and the most widely consumed bakery product [3].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 [4]. 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 fiber, particularly insoluble fiber [5, 6]. However, the development of bakery products using composite flour (a mixture of flours, starches and other ingredients to replace wheat flour totally or partially) has increased and is attracting much attention [7] for many reasons, such us reduce the importation of wheat flour or encourage the use of locally grown crops as flour with nutrition and health benefits [8, 9]. Moreover, a proper balance of ingredients needs to be obtained to produce high-quality bread. The ingredients of bread will impart characteristic colors, texture, and nutritional value which may improve the bread quality. 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. Thus, acorn flour may be an interesting component of gluten-free bread, which does not need to go through a novel food approval process and would broaden the list of plant ingredients used to improve sensory and nutritional value of such bakery products [10]. These authors mention that, generally, *Quercus* acorns are composed by starch (31-55%), protein (2.8-8.4, with high content of essential amino acids), fat (0.7-9%, with high levels of unsaturated fatty acids), and they are a good source of minerals and biologically active compounds with antioxidant ativity, which allows treating them as functional foods.
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 [11].
The aim of this research was to produce bread from wheat and acorn and compare it with breads produced from 100% wheat flour.

2. Material and Methods

2.1 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 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 2.4, physical analysis of doughs.
Acorns from *Q. rotundifolia* were collected in Idanha-a-Nova region, Portugal. Three sets of 1 kg each of acorns fruits were randomly harvested at the maturity stage. Samples were stored in dark conditions at 4ºC until the experiments began. Before milling, the fruits were prepared as follow: (1) predehydration at 40ºC during 24 h in a FD 115 Binder ventilated drying chamber (with an air flow of 300 m^3/h), (2) peeling and chopping into little pieces, (3) drying in the same equipment at 60ºC, (4) milling in a SK 100 Cross Beater Retsch knife mill to pass a 1 mm sieve. Two tests were undertaken until reaching a final optimized wheat bread with acorn flour. The wheat with acorn flour breads were produced under the same conditions as for wheat breads, with the following proportion of acorn/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 WB for wheat and acorn flour. Each of these is followed by the trade mark corresponding to the wheat flour used.

2.2 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 according to the AACC standard method [12] using a 300 G Brabender Farinograph (Brabender GmbH & Co. KG, Germany). 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).

2.3 Extensographic Assay

An extensograph measures the stretching properties of the dough, in particular the resistance to extension and the extensibility of dough by determining the force required to stretch the dough with a hook until it breaks. In this study, an extensograph – E (Brabender GmbH & Co. KG, Germany) was used. This provides data on the energy value (area under the curve, cm^2, evaluated with a planimeter), the resistance to extention (R, BU, obtained as height of curve in BU at maximum), the dough extensibility (E, total length of curve in cm) and the R/E value at 45, 90, 135 min according to the standard method [12].

2.4 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. 14 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 (Figure 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.

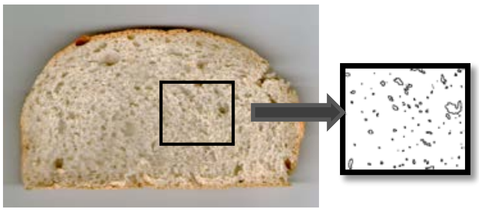

Figure 1 – Methodology for alveolus characterization

Some of the analysed properties were determined in the same day of bread production and also 5 days after. The analysed samples were the wheat breads (Cerealis and Ceres), and wheat with 10% of acorn flours because of the low quantity of acorn flour needs.

2.5 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 colour 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).

3. Results and Discussion

3.1 Farinographic and Extensiographic Characteristics of Flours

The specific farinograph characteristic values of dough samples are presented in Table I, and their farinograms in Figure 2. The water absorption of wheat flour with 10% of acorn is higher for Ceres wheat flour, with wheat Ceres flour presenting the lower value, meaning that they required less volume of water to reach the 500 B.U., line at the point of optimum development [13]. These could be due to the flour components, like starch (the main component) and also due to its structure (amorphous areas absorbed large amounts of water [14]. All the doughs achieved the 500 BU, and this result was also observed for the wheat Cerealis and Ceres flours with 15% of acorn (data not shown). The dough development time was shorter for both WBCerealis and WBCeres doughs, meaning an advantage for improving the time for bread making. The stability time is an indication of the strength of flour, the flour's tolerance to mixing. Thus, higher value means stronger dough, as it is the case of the doughs with acorn flour (> 30 minutes).

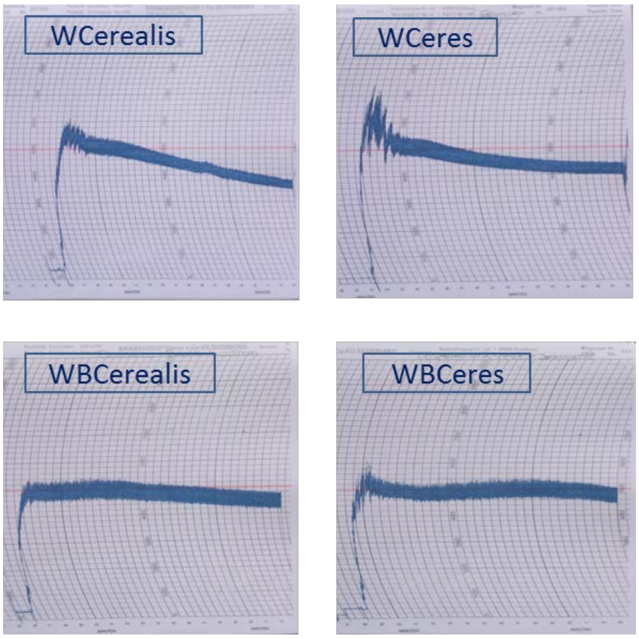

Figure 2 – Farinogram curves of wheat (W) and wheat with 10 % of acorn flours (WB) dough

Table 1- Farinographic characteristics data of wheat and wheat with 10% acorn flour dough

Characteristics	WCerealis	WCeres	WBCerealis	WBCeres
Water absorption (%)	60.0	55,7	57.5	59.3
Dough development time (min)	4.0	2.0	2.0	2.5
Dough stability (min)	6.5	8.5	> 30	> 30

Note: W-Wheat flour; WB- wheat with 10% acorn flour

The extensograph is used to measure the extensibility of dough and its resistance to extension. Table 2 shows the results of this test for all samples. The energy, the resistance to extension and the extensibility of doughs increased with the addition of acorn flour and with the proving time. Because resistance to extension is a measure of dough strength and of dough´s capacity to retain gas, a high resistance means that more force is required to stretch the dough. The extensibility indicates the amount of elasticity in the dough and its ability to stretch without breaking [13].

Table 2- Extensographic characteristics data of wheat and wheat with 10% and 15% of acorn flour dough

Extensograghic characteristic	WBCerealis 10%			WBCerealis 15%		
	Fermentation time (minutes)			Fermentation time (minutes)		
	45	90	135	45	90	135
Energy (cm^2)	16.5	20.2	23.6	34.1	81.5	121.4
Resistance (BU)	310	360	380	290	403	540
Extensibility (cm)	4.9	5.2	5.5	13.0	11.1	8.9
Resistance/Extensibility (BU/ cm)	63.3	69.2	69.1	22.3	36.3	60.7

3.2 Physic-chemical Properties of Breads

The moisture and water activity (a_w) are important factors for food storage. The results show that moisture content is low, and the a_w is quite high (range from 0.93 to 0.97) (Figure 3), meaning that the water present is available to react with other components of bread matrix and also exists the possibility of fungi development. Generally, the parameters remained stable during the 5 days of storage.

Figure 4 presented the results of density evaluation. The wheat Ceres flour showed the less density value, even with addition of acorn four. Generally, the density decreased during the storage time.

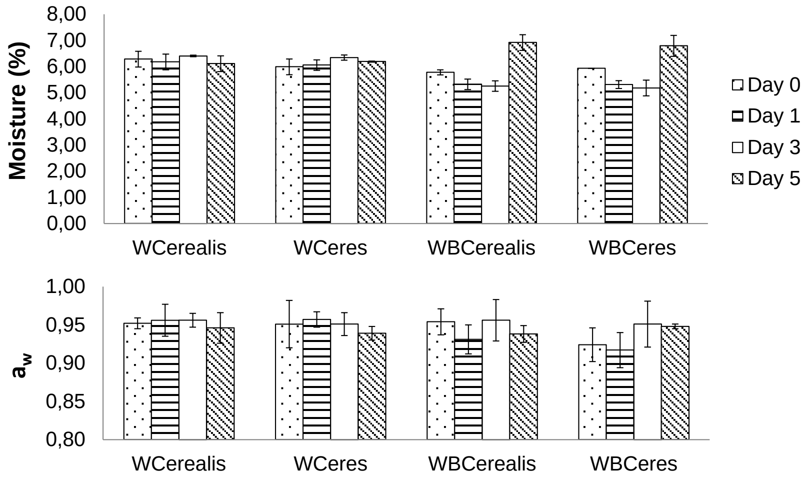

Figure 3 – Moisture and aw of wheat (W) and wheat with 10 % and 15% of acorn flours (WB) breads

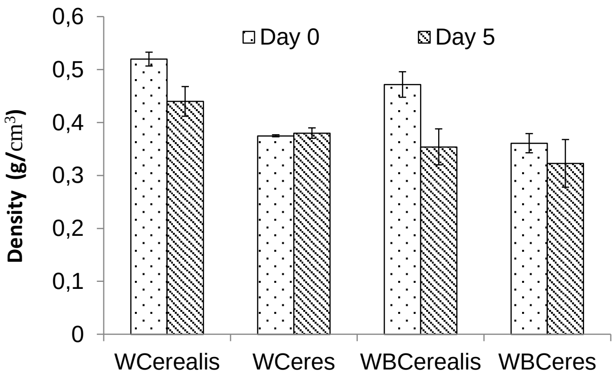

Figure 4 – Density of wheat (W) and wheat with 10 % of acorn flours (WB) breads

Acorn breads were less white, and the WBCerealis was the darkest one (Figure 5), being darker along the storage. The b* parameter was similar for all breads, presenting a predominant yellow colour. The a* values were different, the breads produced with wheat Cerealis flour, even with acorn flour, presented the higher values. This means that those breads are more read, and during the storage tine this parameter increased.

Considering the alveolar characteristics, it was possible to observe that the alveolar percentage and the mean size were strongly correlated. The addition of acorn flour clearly increased the alveolar parameters (Figure 6), producing breads with high alveolar number, and total area, with large alveolus, meaning that bread is fluffier and less dense, which is corroborated by the results obtained for bread density.

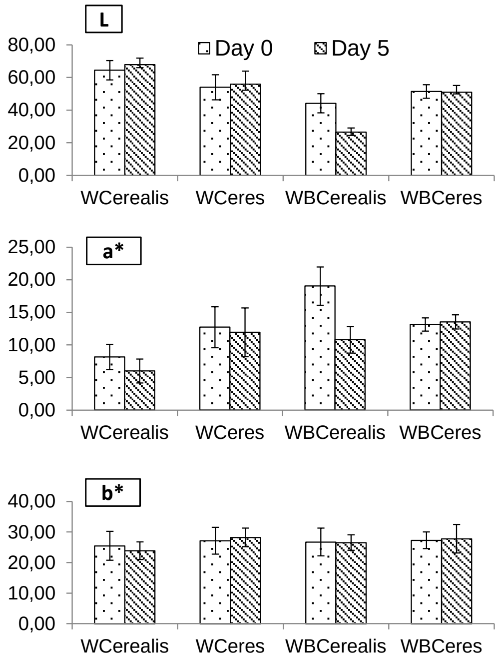

Figure 5 – Colour parameters of wheat (W) and wheat with 10 % of acorn flours (WB) breads

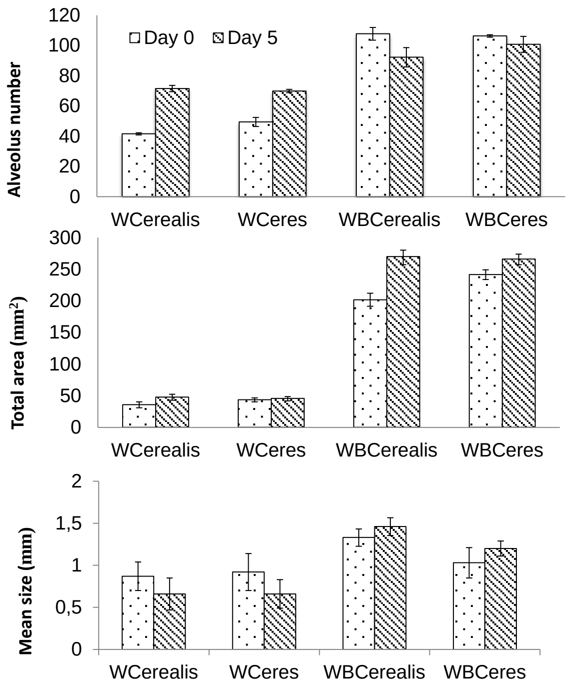

Figure 6 – Alveolar characteristics of wheat (W) and wheat with 10 % of acorn flours (WB) breads

When it was add acorn flour the hardness and chewiness increased, and decreased the cohesiveness of wheat breads (Table II). The elasticity of breads did not vary significantly with the addition of acorn flour, nor with the storage time. During bread aging the hardness increased 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 [15].

Table 3- Textural properties of wheat (w) and wheat with 10 % of acorn flour (WB) breads considering storage time

Properties	Day	WCerealis	WCeres	WBCerealis	WBCeres
Hardness (N)	0	1.34±0.26	1.12±0.53	2.11±0.38	1.32±0.16
	5	5.25±0.18	3.51±0.42	8.09±1.08	5.72±0.69
Cohesiveness	0	0.74±0.03	0.74±0.02	0.63±0.02	0.65±0.05
	5	0.59±0.05	0.51±0.01	0.34±0.04	0.37±0.07
Elasticity (%)	0	92.4±4.3	93.10±5.7	92.84±3.1	93.14±2.78
	5	87.10±3.4	87.45±3.8	88.9±1.43	85.47±3.68
Chewiness (N)	0	0.91±0.58	0.56±0.30	1.21±0.24	0.79±0.13
	5	0.94±0.41	1.09±0	1.44±0.66	2.02±0.36

3.2 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. As mentioned before, the wheat breads are the reference. For this analysis it was considered just the WBCerealis bread because the sensorial results for this bread presented high scores (Figure 7). 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 acorn flour influenced significantly the crust and crumb colour, being more intense for bread with acorn flour, being scratchier, with small alveolus and of low uniformity. The panellists classifyed the WBCeralis bread as less dense, with a low fermented aroma and high elasticity, when compared with the WCerealis bread. The global appreciation of acorn bread had similar score as the whole wheat breads. These results are quite optimists since with the addition of the acorn flour the nutritional value of the wheat bread increased, with all the related health and economic benefits.

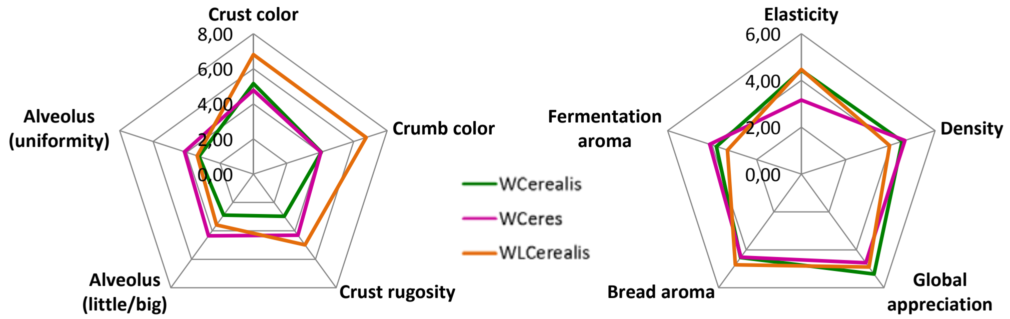

Figure 7 – Sensorial profile of wheat (W) and wheat with 10 % of acorn flours (WB) breads

4. Conclusion

This work allowed concluding that the addition of 10% of acorn 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, colour parameters, alveolar characteristics and texture properties, but the sensorial evaluation showed that the bread produced with 10 % of acorn flours added to wheat Cerealis flour presented similar scores for the consumer, meaning that the majority of the encountered differences were not perceptible for them. These results are quite optimists since with the addition of the acorn flour the nutritional value of the wheat bread increased, with all the related health benefits. Moreover, the addition of acorn flours possible will bring also economic benefits in terms of saving of hard currency, promotion of high-yielding native plant species, and a better overall use of family agriculture production.

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