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Development and Characterization of Bread with apple and Cinnamon

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Abstract

The aim of this work was to develop a new type of bread, for which several tests were performed with different kinds of ingredients: vegetables (carrots, broccoli, pumpkin), meats (sausages), lupines and salsa, fruit and juices and finally apple with cinnamon. Apart from these ingredients, the product was further tested with a natural substitute for salt and with a preservative.
These assays were all performed using a basic recipe composed of flour, salt, water and yeast. However, in order to increase the nutritional composition of the bread developed so as to increase its value as recognized by a certain targeted population, a new ingredient was added to the bread, which was a natural substitute for salt called "Salt Rite". This aimed at decreasing the sodium content, which is of great importance for people with increased risk of suffering from cardiovascular diseases. To achieve this, 50% of the salt contentwas replaced by "Salt Rite".
In a first phase different products were tested and after an evaluation one product was selected as the best, being this the bread with apple and cinnamon. For this product then were accessed the different characteristics at various levels: physical, chemical and sensorial. The different properties that have been evaluated include the water activity, moisture, total ash, crude fat, carbohydrates, starch, size, colour, density, texture and alveolar characterization.
Regarding the chemical properties, the apple with cinnamon bread showed high contents of moisture, fibre and protein and a low sodium content. As to the physical properties, the product presented a darker colour in the crust when compared to the crumb, which is consistent with data from sensory analysis. It also showed a great elasticity, being dense and with a low alveolar percentage. With respect to sensory analysis, the characteristics analysed were generally perceived in an identical way bay all tasters, thus resulting in a somewhat uniform evaluation.

Key Words: Product development,Bread, Apple, Cinnamon, Physicochemical properties, Sensory analysis.

1. Introduction

The bread became over the centuries one indispensable food for most people in the world and in the eighteenth century the first nutritionists Billón and Patyeu proved that bread is essential for the recovery of carbon, nitrogen and vitamin B. Also the first French chef said that "bread is the basis of all meals" [1].
Bread is part of daily life of many people, being even essential, starting right at breakfast. It is regarded as a basis for the diet and the first source of energy [2].
The "image" of bread was, over the recent years, associated with that of a fattening food, leading to a decreased in the domestic consumption. However, studies reveal that its consumption must be on a daily basis, but moderate and combined with a balanced diet [1].
According to Portuguese Law n.º 75/2009 of 12 August, the " bread " is the product obtained by mixing, fermentation and baking, under appropriate conditions, of wheat, rye , triticale or corn flour, single or in combination, according to the types legally established, water and ferment or yeast. Furthermore, it is possible the use of salt and other ingredients, including additives and processing adjuvants under the conditions established legally.
The flour is assumed as the structural component of the mass, being the most essential ingredient to obtain the bread. Water is indispensablefor the formation of the dough. The salt helps in controlling the fermentation, contributing to the fortification of the flour gluten, being decisive in the hydration of the masses. Besides, it is a flavour enhancer and makes the crumb of the bread whiter [3].The yeast carries out alcoholic fermentation, i.e. converts the

fermentable sugars present in the dough to produce ethanol and carbon dioxide, a gas responsible for the growth of bread (Carla Marques 2012).
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].
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.
It is now generally agreed that the diet decisively influences the health of individuals and populations, playing a crucial role in maintaining and preventing several diseases, such as obesity, osteoporosis, diabetes, certain cancers and cardiovascular diseases [5].
The reduction of salt (sodium chloride) is an important public health problem in many countries, since it was identified as the main cause of various diseases such as heart and kidney diseases, hypertension, stomach cancer, osteoporosis, stroke and obesity [6].
According to Vieita et al [7]because of the risks to human health associated with excessive salt intake, the World Health Organization (WHO) and the Food and Agriculture Organization (FAO) recommend a maximum daily intake of 5 g of salt corresponding to 2 g of sodium for prevention of hypertension. However, several studies, particularly in industrialized countries, including Portugal, found an average daily intake of salt between 9 and 12 g, representing a daily intake of sodium between 3 and 5 g.
The last National Health Survey reveals that hypertension is the most prevalent chronic disease, affecting approximately 20% of the Portuguese population [7].
However, to reduce the sodium content in bread is not easy in view of its roles in the baking process and the flavour it provides, which is very difficult to replace.Other ways have been studied to reduce the sodium content in bread, such as through the use of other organic salts, like potassium chloride and magnesium chloride or the addition of flavour enhancers that amplify salt [8].
The Portuguese Law n.º 75/2009 of 12 August states that the maximum permissible content of salt in bread, after made, is 1.4 g per 100 g of bread or the corresponding 0.55 g of sodium per 100 g of bread.
Given the importance of bread the diet, it was aimed to create an innovative and nutritional bread with addition of new constituents besides the basic wheat flourand which had low salt content, using for that a natural substitute for salt.

2. Experimental

2.1. Exploratory Tests for Product Development

In this step several tests were undertaken until reaching a final optimized product. For that was used the basic recipe used in the bread factory (Seia) to produce the wheat bread (137,5 kg of wheat flour T65, 2 kg yeast, 2 kg salt and 85 L water), adapting it to a reduced quantity of flour (2 or 3 kg).
When carrying out these preliminary tests were used different ingredients: vegetables (carrots, squash, and broccoli), sausages, fruits (apple and orange) juice, lupine and spices (cinnamon, parsley).Figure 1depicts the different tests that were carried out.
During the confection of the breadswith broccoli and pumpkin (Figure 2a and 2b), it was found that when adding the puree the dough tends to get wetter and thus stickier. Hence, in the future, when working with purees it would be desirable to add more flour or decrease the amount of water added. After baking the loaves of bread presented themselves flattened. However the bread wassoft and without a tough crust. Regarding flavour and aroma, the bread with broccoli did not taste to broccoli being more like boiled vegetables.The bread with pumpkin does not taste like pumpkin, tasting like the typical wheat bread.
During the confection of the breads with carrot, it was found that by adding the grated carrot, the mass tends also to become wet. Furthermore, large changes in the viscosity of the dough were observed. After cooking, both the grated carrots and carrot cubes breads showed no carrot smell (Figure 2c and 2d). However also in this case the loaves were fluffy and without a hard crust. It was found that the grated carrots show a more intense flavour, since the carrot is dispersed in the mass, whereas the bread with diced carrots does not taste like

carrot and still has a major disadvantage that is when cutting the carrot tends to fall, which is not very favourable.In the bread with the carrot pre-treated with vinegar (Figure 2e), it was found an intense vinegar flavour and aroma.
The tests with legumes in different ways all lead to unsatisfactory results and therefore were excluded.

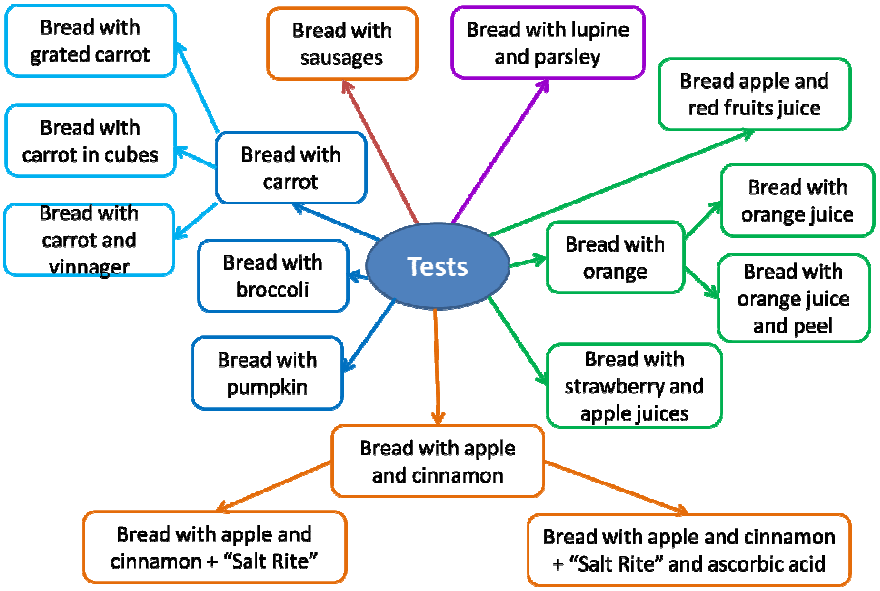

Figure 1 - Schematization of the essays done.

The bread with sausages (Figure 2f) presented a strong sausage flavour and aroma. There was no large change in the viscosity of the dough, however, the amount of sausage added should be higher and with different sizes so that some would crush in the mass so as to give a final product with more flavour and aroma. This test was rejected because the use of meat is not very feasible to the company.

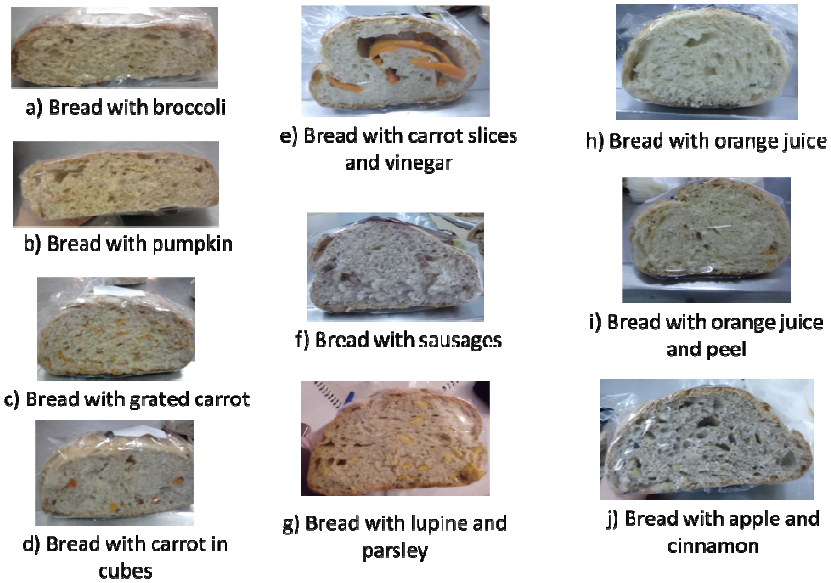

Figure 2 - Different types of bread produced.

The bread with lupine and parsley (Figure 2g), after cooked, showed some aroma to lupine and some slight aromatic herb. The parsley added was dried and therefore its aroma was not very strong. Also the lupine used was not the best because it was too salty and was added in very large size portions. Also this test was rejected.
In the breads with juices (apple and red fruits, orange, apple and strawberry) was found that during the manufacture of bread, there was no great change in bulk viscosity. After baking, the bread with juice (Figure 2h) presented a practically non existing flavour to the juice while the bread that included the orange peel (Figure 2i) showed some colour and some aroma but still no flavour to orange.
In the bread with apple and cinnamon (Figure 2j) was found that the amount of apple should be close to the amount of flour added and that there were no significant changes in the mass. This bread tastes to apple and has a very strong aroma of cinnamon. The bread with apple and cinnamon and with "Salt Rite" resulted in a product very similar to the previous one. However, the addition of the natural substitute for salt gave a distinctive flavour to the product, masking the lack of salty taste with the intense apple and cinnamon flavour. Finally, the addition of preservative (sorbic acid) to the bread did not influence the quality of the final product, only contributing to the antifungal properties.
This product, combination of apple and cinnamon, was selected as the best bread and therefore was further studied.

2.2. Production of Bread with Apple and Cinnamon

For the baking of the Loavesof bread with apple and cinnamon were used the following ingredients: 3 kg wheat flour T65 (Grinding Ceres), 1.9 L water, 44 g yeast (Mauri classic), 22 g salt, 22 g "Salt Rite" (Ingrenor), 2.5 kg peeled apples (Golden),15 g cinnamon (Continent) and 30 g sorbic acid. The equipments used were a mixer Spiral Ferneto AEF035 (Ferneto, Vagos, Portugal), an electric oven model Modulram Classic with built in stove (Ramalhos, Aveiro, Portugal), and a water doser.

2.3. Chemical Analyses

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. Crude protein was evaluated by a Kjeldahl analyser, by means of determination of organic nitrogen. Fat was determined by extraction with ether. Ashes were determined by calcination at 500 ºC. Crude fibre was evaluated by DosiFiber method and carbohydrates were calculated by difference. Also evaluated were the sodium and starch contents and fatty acids [5].

2.4. Physical Analyses

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). There were also determined the colour parameters in cylindrical coordinates: value, tone or hue (h^0) and saturation or chroma (C) according to the following equations [9].

(1) $Value = \frac{L^*}{10}$

(2) $H^\circ = \tan^{-1}\left(\frac{b^*}{a^*}\right)$; if a*>0 and b*>0

(3) $C = \sqrt{a^{*2} + b^{*2}}$

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 [10]. For the analysis it was

necessary to cut the sample into slices (10 mm thick), removing a cube of side 30mm so much from the crumb than the crust. 14 replicates were performed.
The probe used was cylindrical with 75mm 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 (hardness, elasticity, cohesiveness and chewiness) can be calculated by the following equations, from the TPAs obtained (Texture Profile Analysis) (See Figure 3):

(4) Hardness (N) = F_1

(5) Elasticity (%) = $(t_2/t_1) \times 100$

(6) Cohesiveness (dimensionless) = A_2/A_1

(7) Chewiness (N) = $(F_1) \times (t_2/t_1) \times (A_2/A_1)$

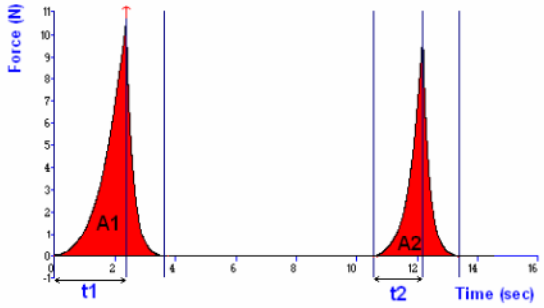

Figure 3 – Example of a TPA[11].

For the analysis of the volume and dimensions of the bread were measured the thickness, width and length, using a scale measurer. For the determination of the volume the bread was approximated to an ellipsoid and the volume was calculated by the following equation being taken the average of 6 tests.

(8) $V = \frac{4}{3}\pi\, abc$

For the determination of density 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. The number of replicates was 14.
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. 5 10mm thick slices were scanned, and the slice cut was made in the central zone eliminating the crust (See Figure 4). 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.

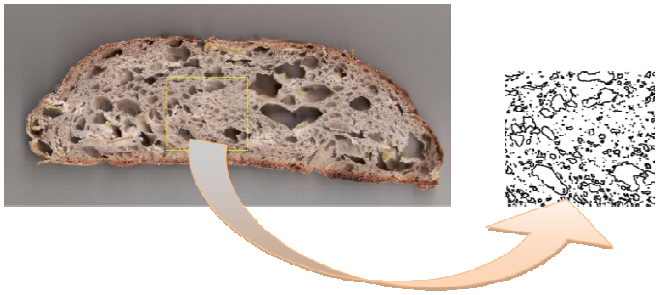

Figure 4 – Methodology for alveolar characterization.

2.4. Sensorial Analysis

In this study was used the preference test in hedonic scale. It is a subjective test that measures the acceptance and preference of consumers. In hedonic scale the tester expresses the product acceptance, following a previously established scale which varies gradually, based on the attribute data expressing the intensity. The scale points are distinguished orally so that they can be assigned to numeric values, allowing statistical analysis.
The panel consisted 50 untrained tasters, aged between 18 and 60 years and mostly females. The panellists were asked to rate the following attributes: ▫ Colour of crust and crumb; ▫ Amount of mass; ▫ Aroma of bread, firewood, fermented, cinnamon and mass; ▫ Flavour of bread, firewood, fermented, cinnamon, mass, salt and sweet; ▫ Elasticity; ▫ Density; ▫ Overall assessment.

3. Results and Discussion

3.1. Chemical composition

Table 1 shows the analytical results of the analyses performed for the bread with apple and cinnamon, together with other breads for comparison purposes, namely another bread also produced and commercialized by the bread factory and data from the literature regarding regional bread.
The bread developed presented a moisture content of 47.2 g/100 g. This may be due to the relatively high fibre content, since the greater the presence of fibres, the greater the amount of water absorbed by the mass [12]. Compared with the other breads, the bread with apple and cinnamon presented the higher moisture content, for which should possibly contribute the addition of apple, which has a very high percentage of water. The water activity was found to be 0.952. According to Neto et al. [13] most of the microorganisms grow in medium and high values of a_w, in the range 0.90 to 0.99, and hence the bread may besusceptible to the growth of microorganisms. However this value is very close to that reported for the regional bread.
The bread developed presented a crude protein content of 6.23 g/100g. However, compared to wheat bread and regional bread, this value is lower. Proteins are extremely important in the nutrition since they provide essential amino acids to the body.

The fibre content found (3.3 g/100g) is a relatively high value, comparable to that of the wheat bread, and much higher than that of the regional bread.
Regarding the ash content, the value obtained was 0.73 g/100g. This value is however surprising for being very low, since it would be expected a higher value similar to the wheat bread or even higher, having in mind that the cinnamon is very rich in minerals such as K, Na, Ca and Mg, among others [14]. Minerals are important in nutritional terms, therefore, the higher the value the greater the foods nutritional value. In relation to the sodium content of 0.097 g/100g, this is a low value compared with wheat bread, which was expected since it was used a natural substitute for salt based on potassium chloride containing small traces of sodium. In this way, it can be claimed that the product has a low sodium content, because the product contains no more than 0.12 g/100g Sodium (Regulation (EC) No 1924/2006).

Table 1 – Chemical composition of the bread developed and data relative to other breads.

Parameter	Bread with apple and cinnamon	Weat bread from the bread factory	Regional bread [4]
Moisture (g/100g)	47.2	38.2	39.14
Water activity, a_w	0.95	-	0.94
Crude protein (g/100g)	6.23	7.84	11.84
Crude fibre (g/100g)	3.3	3.5	0.34
Total ash (g/100g)	0.73	1.48	3.78
Sodium (g/100g)	0.097	0.324	0.096
Total sugars (g/100g)	5.7	2.6	-
Starch (g/100g)	35.7	44.9	-
Carbohydrates (g/100g)	41.6	47.7	83.84
Fat (g/100g)	0.90	1.24	0.50
PUFA[1] (g/100g)	0.4	0.6	-
MUFA[2](g/100g)	0.1	0.2	-
SFA[3](g/100g)	0.4	0.4	-
Eneregetic value (Kcal/100g)	206.2	240.5	-

[1]PUFA: polyunsaturated fatty acids; [2]MUFA: monounsaturated fatty acids; [3]SFA: saturated fatty acids.

The amount of sugars was found to be 5.7 g/100g, a much larger amount when compared with the wheat bread.The amount of starch was 35.7 g/100g, being lower when compared with wheat bread. Quantification of starch is very important for companies producing flour since it allows to establish the extraction yield and the quality of the product being marketed.The carbohydratescorrespond to 41.6 g/100 g. It is a satisfactory value, since they must represent the main source of energy in our food. However, compared with the other breads, the bread regional shows a content of carbohydrates much higher.
The fat was found to be 0.90 g/100 g, which is a low value, meaning that the ingredients added do not affect the fat content of bread. This values lies in between the fat contents of the other two breads listed.The determination of fatty acids allowed obtaining for polyunsaturated fatty acids (PUFA) a content of 0.4 g/100 g, for the monounsaturated fatty acids (MUFA) a contentof 0.1 g/100 g and for saturated fatty acids (SFA) the value of 0.4 g/100 g. The values of monounsaturated and polyunsaturated fatty acids are lower than for the wheat bread but for saturated fatty acids, the value is the same.
Regarding the energetic value this was found as 206.2 kcal/100g, relatively lower than for the wheat bread.

3.2. Physical properties

Table 2 shows the results of the determinations of the colour parameters for the bread with apple and cinnamon in the crust and in the crumb, and it can be observed that the crumb and crust are not substantially different in terms of colour.

Table 2 – Colour parameters of the bread with apple and cinnamon.

Parameter	Crumb	Crust
L*	58.76(±3.48)	55.45(±5.99)
a*	2.48(±0.67)	8.67(±2.28)
b*	13.89(±1.69)	20.99(±3.56)
Hue	1.39(±1.19)	1.18(±1.00)
Chroma	14.11(±1.82)	22.71(±4.22)
Value	5.88(±0.35)	5.55(±0.60)

The crust is darker, with lower L*. With respect to parameter a* it is also greater in the crust than in the crumb, which means that the red colour is stronger on the surface. b* also shows a higher value in the crust, indicative of a stronger yellow colour. These results indicate that the crust is browner than the core, which is a result of the browning occurring in the surface of the bread upon cooking due to Maillard reactions.

In Table 3 are shown the results for the textural attributes and they reveal that the crust is much harder, as expected, and therefore with a higher chewiness. Hardness corresponds to the maximum force recorded during the first cycle of compression, and represents the force required between themolars for chewing a food, being in most cases related to the tensile strength of the sample.Chewiness represents the energy required to disintegrate a solid material in order to swallow it [15].

Table 3 – Texture parameters of the bread with apple and cinnamon.

Parameter	Crumb	Crust
Hardness (N)	6.91(±1.26)	33.88(±16.11)
Chewiness (N)	3.11(±0.58)	16.99(±6.42)
Cohesiveness	0.49(±0.03)	0.62(±0.09)
Elasticity (%)	91.6(±4.33)	85.93(±4.46)

Cohesiveness represents the ratio between the work done in the second compression and the work done in the first compression, and reflects the ability of the product to stay as one [15]. In the present case the crust shows higher cohesiveness than the crumb, because the core of the bread in fact is disintegrated with less effort.
Elasticity is the ratio between the times in the two deformations, and represents the ability to regain shape when the deforming stress is removed or reduced, i.e., expresses the percentage of recovery of the sample [15]. As it would be expected this parameter is higher in the crumb, being this explained because the core of the bread is more fluffy.

Table 4 presents the alveolar characterization as well as the volume and density of the bread. From the analysis of the results, it was found that the bread with apple and cinnamon had a large total area of the alveoli, a relatively high alveolar percentage, although the alveoli are of small size. This means that the sample has a very high number of small holes, thus originating a high porosity and therefore a low density. Regarding the size of the bread, it was found to be high volume, but the standard deviation is also high, which means that the breads produced were not uniform in size.

Table 4 – Alveolar characterization, density and volume.

Total area - slice (pixel^2)	Nº alveoli - slice	% alveoli - slice	Medium size - slice (pixel^2)	Specific mass (g/cm^3)	Volume (cm^3)
106993(±62810)	252.6(±150.8)	33.1(±6.12)	0.48(±0.2)	0.43(±0.06)	1805.4(±387.94)

3.3. Sensorial analysis

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 results indicate that the panellists were not able to clearly identify the aromas to wood or fermented, while distinguishing the aromas to bread or apple, but particularly cinnamon. Also cinnamon was the taste more clearly stated by the panellists, followed by the sweet and apple. Regarding the salty taste, it was not very much perceived, which was expected since it was used a reduced concentration of salt. The bread was described essentially as having a moderate elasticity and a moderate density.The overall assessment obtained was very positive, with about 7 points.
In some of the determinations was, however, observed a very large standard deviation, which may result from the different perceptions of the panellists, given that they were not trained.

Table 5 – Results of the sensorial analysis.

Parameter	Value(±sd)
Appearance	
Colour of the crust	6.48(±1.88)
Colour of the crumb	6.64(±2.16)
Quantity of apple	5.12(±1.67)
Aroma	
of bread	4.25(±2.65)
of wood	2.46(±2.49)
of fermented	2.73(±2.40)
of cinnamon	6.56(±2.16)
of apple	4.43(±2.21)
Taste	
of bread	4.14(±2.50)
of wood	1.94(±1.13)
of fermented	2.89(±2.64)
of cinnamon	6.73(±1.85)
of apple	5.00(±2.15)
of salt	2.49(±1.86)
of sweet	4.48(±2.24)
Texture	
Elasticity	5.03(±2.01)
Density	4.74(±2.20)
Global appreciation	7.08(±2.39)

4. Conclusions

The results of the chemical properties of the apple and cinnamon bread, it can be concluded that it has a relatively high fibre content and a low fat and carbohydrates content, which associated with its low salt content makes this product somewhat balanced from the nutritional point of view.
The results of the physical determinations indicate that the crust is browner than the crumb and also harder. The core of the bread is clearer, softer, more elastic but less cohesive, and with a high porosity and consequently a low density.
In sensory terms, the ingredient cinnamon was highlighted as very perceptible by the panellists, either in terms of aroma or in taste. Other tastes also sensed were apple and sweet. The reduction of the salt content was detected by the panellists; however, this did not affect the overall assessment of the product, which was considered very pleasant, given the high sores of about 7 in a scale up to 10.

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