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Effect of partial substitution with precooked rice and amaranth flours on the technological and nutritional characteristics of bread

Efecto de sustituir parcialmente con harinas precocidas de arroz, amaranto en las características tecnológicas y nutricionales del pan

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Abstract: Developing innovative products by rescuing ancestral raw materials with high nutritional value is a challenge for researchers, the objective of this research was to develop breads with high nutritional quality by partially substituting wheat flour with precooked amaranth and brown rice flour. To establish the formulations, the Design Expert Ver 8.0 software was used; the substitution levels cover a range from 5% to 30%; the sponge method was used because it offers better crumb quality. Bread quality was analyzed in terms of chemical composition, specific bread volume, width/height ratio of the central slice, crumb structure and firmness, and sensory analysis. Starch thermal properties were studied in terms of starch hydration properties. The incorporation of the flour blend increased protein, lipid, fiber, ash and myoinositol phosphate contents. The best mixture contains 20% amaranth and 10% brown rice, the bread obtained has a soluble/insoluble fiber ratio close to 1:2, which presents the most effective physiological action and has a protein content that could cover the protein requirement in adults.

Keywords: bakery, amaranth, brown rice

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Resumen: Desarrollar productos innovadores rescatando materias primas ancestrales con alto valor nutricional es un reto para los investigadores, el objetivo de esta investigación fue desarrollar panes con alta calidad nutricional mediante la sustitución parcial de harina de trigo por harina precocidas de amaranto y arroz integral. Para establecer las formulaciones se utilizó el software Design Expert Ver 8,0, los niveles sustitución cubren un rango del 5% hasta el 30%, el método esponja se empleó porque ofrece mejor calidad de miga. La calidad del pan se analizó en términos de composición química, volumen específico del pan, relación ancho/alto de la rebanada central, estructura y firmeza de la miga y análisis sensorial. Las propiedades térmicas del almidón se estudiaron en función de las propiedades de hidratación del almidón. La incorporación de la mezcla de harina incrementó los contenidos de proteína, lípidos, fibra, cenizas y fosfato de mioinositol. La mejor mezcla contiene 20% de amaranto y 10% de arroz integral, el pan obtenido presenta una relación de fibra soluble/insoluble cercanas a 1:2, lo que presenta la acción fisiológica más efectiva y presenta un contenido de proteína que podría cubrir el requerimiento proteico en adultos.

Palabras clave: panificación, amaranto, arroz integral

Introduction

Wheat bread is a food widely consumed by the population. Wheat flour is used to make this type of bakery product, but in Ecuador the wheat harvest is not enough to meet the country's needs, so about 98% of wheat is imported. This is used for its gluten content, which gives the dough resistance and elasticity, leaving behind several cereals such as corn, rice, oats, etc., but it has a low level of essential amino acids such as lysine and threonine, as well as low fiber content. Recent studies seek to improve these nutritional characteristics by incorporating other ingredients into the baking process (Salas & Haros, 2016). The nutritional properties of grains such as amaranth, quinoa, brown rice and other grains by being a source of dietary fiber, protein, bioactive compounds, whose lysine concentration is considerably higher than that of wheat flour (Mesas & Alegre, 2002)help prevent diseases associated with metabolic syndrome such as cardiovascular diseases, arteriosclerosis and colon cancer (Marianda, Ponce, & Alegre, 2002). (Marianda, Ponce, & Haros, 2019).

The benefits from the consumption of precooked brown rice (Oryza sativa L.), due to its fiber content is interesting, it has low prolamin content, low sodium content, high content of digestible carbohydrates and high rate of protein, which are composed mostly of albumins, globulins, and has higher lysine content than polished rice because this amino acid is present in the outer layers of the grain, compared to polished and processed white rice. The proportion of essential amino acids with respect to total amino acids is 41%, being the recommended that this ratio is approximately 36%, finding that this cereal exceeds what is established by FAO (Salas & Haros, 2016). From a food security perspective, brown rice has been recognized by FAO as an important part of the human diet.

Pseudo cereals are widely used in the diet of the ancient inhabitants of America, for this reason in Ecuador the Andean crops program of INIAP have developed an improved variety INIAP - Alegria (Amaranthus caudatus), which is a white seed very popular among consumers. Amaranth has important nutritional properties in its seed components; about 16% of high quality proteins (such as globulin) are rich in lysine and sulfur amino acids, these are essential for optimal nutrition because of their excellent amino acid balance, as they provide 16.6% lysine, which is a higher percentage than traditional cereals such as wheat, which according to Gil (2010) has a 2.5% (Galarza, I, & Falcón, 2013).Amaranth also contains lipids between 7 to 8%, of which squalene is a potent antioxidant and strengthener of the immune system, also contains unsaturated fatty acids such as linoleic acid, has minerals such as sodium, potassium, calcium, magnesium, copper, manganese, nickel and iron. (Matias, et al., 2018).. In addition, it contains thiamine, riboflavin, niacin and when germinated it contains vitamin A and C (Alvarez, Gallagher, Reguera, & Haros, 2009)For this reason, this seed has achieved a growing interest as a functional ingredient due to its nutritional and technological properties, especially in baking processes, and because it is very versatile for its processing and industrialization (Penella, Wronkows, & Haros, 2009). (Penella, Wronkowska, Smietana, & Haros, 2013).. Because of its characteristic texture (gummy), amaranth as well as quinoa, are more difficult to eat in large quantities, for this reason it is better to use it in the form of precooked flour, combining this flour in the elaboration of cookies, cookies, tortillas, etc. Although sensory acceptance may decrease with substitution.

A widely used practice to improve nutritional quality is the fortification of flour, which is defined by the standard (NTE INEN 616, 2016) as a preventive strategy based on a diet designed to increase the value of

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micronutrients, and which can be included in the framework of other interventions designed to reduce vitamin and mineral deficiencies to prevent or correct one or more nutrient deficiencies demonstrated in the population. Many studies have been conducted to improve the nutritional value of bread by partially replacing wheat flour with other flours; some researchers suggest adding whole wheat grains, wheat bran, grains of other cereals or pseudocereals such as amaranth, quinoa, rice for bakery products up to a maximum of 30% (Pilataxi, 2013)The use of amaranth often contains anti-nutrients such as phytic acid (myoinositol (1,2,3,4,5,6)-hexakisphosphate, InsP6) or its salts, phenolic compounds, and trypsin inhibitors (D'Amico, Schoenig, 2013). (D'Amico, Schoenlechner, Tömösközia, & Langó, 2020).. Phytic acid has negative health effects because it inhibits the availability of minerals (Penella-Sanz, 2013). The phytate content in Amaranthus spp. has been found to range from 4.8 to 21.1 μmol/g (Reguera & Haros, 2017). However, several studies have suggested that this compound has favorable effects, such as antioxidant function, prevention of heart disease and anti-carcinogenic effect, which it performs through its hydrolysis products (Haros, et al., 2009); (Kumar, Sinha, Makkar, & Becker, 2010).. Recent studies show wheat flour substitution up to a level of 25% (Kamoto, Kasapila, Kasapila, et al., 2009). (Kamoto, Kasapila, & Manani, 2018)or in specific breads without fermentation (Banerji, Ananthanarayan, & Lele, 2018).. The purpose of this research is to develop bread with higher nutritional value, with good technological and sensory quality.

Materials and methods

Commercial whole wheat flour brand "La Cordillera", the variety used was hard red spring wheat, precooked amaranth flour brand "Zangur", of the species Amaratus caudatus, precooked brown rice flour brand "Portilla". The variety used was INIAP 17. For flour processing according to the methodology of Altamirano, 2017, the brown rice samples are subjected to a process of soaking in water at 60°C for 45 minutes and precooked at 75°C for 6 minutes, with the same water - rice ratio (1:1) (Altamirano, Ortola, & Castello, 2017).. Then the drying process of the samples is carried out at 60°C, described by. (Santamarìa, 2017) in a "LINDBERG BLUE "GO1390A-1" oven. For the preparation of the samples, we proceeded to the milling of grains in a conventional mill to obtain rice flour. According to the standard (NTE INEN 3050, 2016) the particle size of rice flour must be passed through a 250 µm sieve.

The formula for bread dough expressed based on flour consisted of different formulations of flour (500 g), fresh yeast commercial brand "Levapan", sodium chloride was used salt commercial brand "Cris-Sal", fat commercial brand "Bonella" (Silva, 2016)sugar, "San Carlos" brand sugar, eggs and "Propastel" brand improver. The average weight of the bread is 50g.

To carry out the experimental design of flour substitution mixtures, the Design Expert software version 8.0 was used, choosing the Optimal factorial design (custom) to have a model that adapts to the established conditions, depending on the maximum range to be able to substitute, the dough with 100% wheat flour was used as a control sample and the bread dough was also made using the precooked rice and amaranth flours at 100%.

The sponge method was used, for which the dough was made in two stages according to the methodology described by (Iglesias-Puig, Monedero, & Haros, 2015).. Finally, the samples were baked at 170 °C/20 min. The breads were cooled at room temperature for 2 h for subsequent analysis (Sanz-Penella, Tamayo-Ramos, Sanz, & Haros, 2013)..

Moisture was determined by gravimetric method (NTE-INEN 518, 1980-12).Ash content was determined in an incineration muffle at 900 °C (aoac 923.03, 2005). (AOAC 923.03, 2005). v, protein determination was carried out by the Kjeldahl technique (aoac 2001.11, 2005). (AOAC 2001.11, 2001).lipids were determined by extraction under petroleum ether reflux conditions by the Soxhlet technique (aoac 945.16, 2001). (AOAC 945.16, 1990) and the dietary fiber content was measured by (AOAC 2011.25, 2011)..

Concentrations of calcium, iron and zinc were determined in the selected mixtures using for calcium (AOAC 985.35, 2016)for calcium, iron and zinc, which was determined by atomic absorption using Spectra model 220 Fast sequential equipment with zinc lamp (aoac 985.35, 2005). (AOAC 985.35, 2005) and with iron lamp (AOAC , 1999).

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The technological parameters analyzed were the following: specific bread volume (cm3 /g) by volume measurement (cm3) by seed displacement (volume-meter, Chopin, France) and weight (g), width/height ratio of the central cut (cm/cm).

For the crumb, digital image analysis was used to measure the breadcrumb structure. The images were pre-fronted at 240 pixels per cm with a flatbed scanner (Epson ScanJet L375.) and supported by Image J 3.1 Software. A 10 mm × square field of view of two central slices (10 mm thick), thus producing 2 digital images per treatment. The data was processed using Image J Image Analysis Software (version 5.0.0), The crumb grain features chosen were evaluated using the number of cells per cm2 ; and Cell Mean Area, μm2 (Sanz-Penella, Tamayo-Ramos, Sanz, & Haros, 2013).. The texture of the selected formulation was evaluated by sensory tests and the following parameters were evaluated: relative firmness, elasticity, cohesiveness, (Haros, Rosel, & Bebedito, 2002)..

Preliminary sensory analysis of fresh breads was conducted by a panel of 90 untrained tasters who typically consume wheat bread, using about nine hedonic scale points of overall acceptability (Iglesias-Puig, Monedero, & Haros, 2015)..

Fisher's least significant and multiple sample comparison of means The difference test (LSD) was applied to establish statistical differences. All statistical analyses were performed with Desing Expert Plus 8.0 software and differences were considered significant at $p < 0.05$.

3. Result

The incorporations of increasing percentages of amaranth flour in the dough formulations progressively and significantly increased protein, lipid and ash content with respect to the control sample, as well as variation is also found with the increase of brown rice flour (Table 1). The highest percentages of nutrients were recorded when wheat flour was substituted by precooked amaranth flour. These results are consistent with other studies on breads incorporating a different species of amaranth (Sanz-Penella, Tamayo, Tamayo and others). (Sanz-Penella, Tamayo-Ramos, Sanz, & Haros, 2013)these authors found a higher moisture content when they increased the wheat flour substitution. This coincides with the research where only substitution with A. hypochondriacus at 25% and 50% was performed, showed a significant difference in this parameter with respect to the bread control, other studies show that despite the higher water absorption of flour mixtures measured by farinograph, from 55.0% for wheat flour to 57.5%-60.5% for wheat/amaranth combinations, with a higher water holding capacity of the doughs when the flour is integral amaranth flour in the formulation was increased, in general, amaranth did not significantly modify the moisture of fresh bread (Penella, Collar, & Haros, 2008)., (Miranda, Sanz- Ponce, & Haros, 2019).

Table 1. *Composition of raw materials and blends*

Formulations	Proteins (%)	Fats	Humidity	Ashes	InsP6
1	12,2 (0,2)	2,3 (0,02)	9,13 (0,02)	0,75 (0,02)	6,4 (0,08)
	10,1(0.01)	1,6 (0,01)	12,9 (0,05)	0,98 (0,03)	0,08
	11,2(0.09)	1,9 (0,02)	11,54 (0,03)	0,65 (0,02)	1,7 (0.02)
	13,4(0.02)	2,3 (0,03)	11,58 (0,02)	0,68 (0,02)	3,4 (0,2)
5	10(0.1)	1,8 (0,02)	12,78 (0,02)	0,81 (0,02)	0,09
	9,5 (0.03)	2,2 (0,01)	11,47 (0,02)	0,62 (0,02)	0.1
	12,1 (0.05)	2,1 (0,02)	12,57 (0,02)	0,79 (0,03)	1,6 (0,05)
	11,5 (0.1)	1,6 (0,01)	12,8 (0,06)	0,80 (0,03)	1,45 (0,05)
	12,2 (0.1)	2,1 (0,2)	13,04 (0,03)	1,00 (0,05)	1,8 (0.02)
	11,69 (0.5)	1,3 (0,2)	13,82 (0,05)	1,00 (0,03)	**2 (0,03)**
100% wheat control sample	10.50 (0.28 (Nx5.7))	1,1 (0,12)	9,13 (0,02)	0,98 (0,05)	**N.a.**
AMARANTO		8,1	13,92	1, 97	20 (2)
WHOLE RICE	7,9	0,64	11,54	0,90	0,89 (0,2)

Formulations: 1 (70% wheat, 30% amaranth), 2 (85% wheat, 15% brown rice), 3 (85% wheat, 15% amaranth), 4 (70% wheat, 20% amaranth, 10% brown rice), 5 (80% wheat, 20% brown rice) , 6 (70% wheat, 30% brown rice), 7 (80% wheat, 10% amaranth, 10% brown rice), 8 (70% wheat, 10 amaranth, 20 brown rice), 9 (70% wheat, 15% amaranth, 15% brown rice), 10 (90% wheat, 5% amaranth, 5% brown

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rice), 11 (100% wheat), 12 (100% amaranth), 13 (100% brown rice).

The behavior of starch in the blends can be seen in Table 2. From a technological point of view, according to (Salas & Haros, 2016) y (Rivera, 2014) suggests that a higher value of IAA and lower ISA, is suitable for use in products of a high viscosity, the conditions established in n the formulas that meet it are: 4(70% wheat, 20% amaranth, 10% brown rice), 7(80% wheat, 10% amaranth, 10% brown rice), 8(70% wheat, 10 amaranth, 20 brown rice) which would be optimal in the baking process.

Table 2. *Effect of the inclusion of precooked amaranth and brown rice flours on the behavior of starches.*

Formulation	IAA	ISA	CLA	CAA	CRA
1	8,030± 0,052	9,037± 0,639	1,180± 0,016	1,106± 0,365	3,018± 0,649
	7,078± 0,612	6 ,921± 0,269	1,085± 0,121	1,032± 0,137	2,030± 0,136
	6,856± 0,375	8,831± 0,147	1,144± 0,012	1,118± 0,014	2,317± 0,037
	9,847± 0,247	8,567± 0,002	1,130± 0,013	0,987± 0,063	2,573± 0,019
5	7,129± 0,297	6,966± 0,098	1,286± 0,015	1,090± 0,015	2,309± 0,305
	8,128± 0,307	6,435± 0,462	1,228± 0,006	0,840± 0,025	2,111± 0,135
	7,033± 0,422	4,605± 0,211	1,705± 0,009	0,889± 0,113	2,757± 0,281
	7,964± 0,345	5.780± 0,345	1,070± 0,050	1,144± 0,043	2,158± 0,098
	7,023± 0,237	7,178± 0,756	1,059± 0,045	0,956± 0,040	2,341± 0,691
	7,029± 0,254	7,833± 0,750	1,045± 0,054	0,907± 0,294	2,241± 0,834
Control	7,870± 0,146	4,553± 0,347	1,038± 0,012	0,911± 0,031	1,366± 0,957
H. amaranth	7,485± 2,460	4,,397± 0,594	1,001± 0,001	0,933± 0,170	2,981± 0,949
H. brown rice	11,958±0,815	18,409± 7,755	5,663± 0,295	1,174± 0,165	5,069± 0,285

IAA: Water absorption index (g /g), ISA: Water solubility index (g/100g) , CAA: Oil absorption capacity(g/g), CRA: Water retention capacity(g/g), CLA: Water binding capacity(g/g). Formulations: 1 (70% wheat, 30% amaranth), 2 (85% wheat, 15% brown rice), 3 (85%

wheat, 15% amaranth), 4 (70% wheat, 20% amaranth, 10% brown rice), 5 (80% wheat, 20% brown rice) , 6 (70% wheat, 30% brown rice), 7 (80% wheat, 10% amaranth, 10% brown rice), 8 (70% wheat, 10 amaranth, 20 brown rice), 9 (70% wheat, 15% amaranth, 15% brown rice), 10 (90% wheat, 5% amaranth, 5% brown rice), 11 (100% wheat), 12(100% amaranth), 13 (100% brown rice)

The IAA (water absorption index) is an indicator that shows the ability of flours to absorb water until they reach a desirable consistency to improve yield and shape the feed (Rivera, 2014). (Rivera, 2014)In the case of amaranth, formulations 1 (70% wheat, 30% amaranth), 6 (70% wheat, 30% rice) and 8 (70% wheat, 10 amaranth and 20 brown rice) are the most similar to the behavior of wheat, and when comparing the values obtained with the IAA and ISA of amaranth, it can be observed that the starch of this pseudocereal absorbs more water. The ISA indicates the amount of dissolved solids in a fixed amount of water, i.e., it quantifies the level of polymer destruction when the starch is modified. (Bustos & Guerrero, 2015)When comparing the behavior of this parameter with wheat flour, it can be observed that sample 7 (80% wheat, 10% amaranth, 10% brown rice) and 8 (70% wheat, 10 amaranth, 20 brown rice) show the best results. The water binding capacity (CLA) expresses strong between amylose and amylopectin, therefore that this characteristic highlights the state of the starch granule, the content of dietary fiber and protein present in addition to producing a fresh bread with firmness and adequate volume. (Rivera, 2014). Formulations 2 (85% wheat, 15% brown rice), 4 (70% wheat, 10% brown rice, 20% amaranth) ,8 (70% wheat, 10% amaranth, 20% brown rice), 9 (70% wheat, 15% amaranth, 15% rice), 10 (90% wheat, 5% amaranth and 5% brown rice) present values close to the 100% wheat sample. For the AAC (oil absorption capacity), the formulations: 2 (85% wheat, 15% rice), 4 (70% wheat, 20% amaranth, 10% rice), 7 (80% wheat, 10% amaranth, 10% rice), 9 (70% wheat, 15% amaranth, 15% rice), have the behavior close to that shown by the 100% wheat mixture, and wheat tends to have a behavior similar to brown rice, this is due to the variety chosen, INIAP 17, which shows a good hydration of its granules, this characteristic allows it to be recommended (Cedeño & Galleza, 2005). (Cedeño & Galarza, 2013)in the preparation of bread. The CRA gives us the possibility of obtaining a quality product, the closest values to wheat are those of sample 2 (80% wheat, 15% rice), 6

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(70% wheat, 30% rice), 8 (70% wheat, 10% amaranth, 20% rice).

The statistical analysis with a $p < 0.05$ determined that there is no significant difference in relation to the protein percentage of the flour mixes that include the three raw materials, but there were significant differences in the ISA, CLA and CAA, for this reason the author chose the formulations with the highest protein values and the best behavior of the starches.

Table 3. *Effect of inclusion of amaranth and rice precooked flours on bread quality.*

Formulations	Proteins (%)	Specific volume ml/g	Firmness N	Cohesiveness	N. alveoli N/cm2	Average size Cm2
	13,4(0.02)	3,80 (0,5)	0,95	0,85		0,042
	12,1 (0.05)	3,70 (0,9)	0,87	0,83		0,035
	12,2 (0.1)	3,60 (0.7)	0,90	0,84	145	0,037
100% wheat control sample	10,50 (0.28 (Nx5.7))	4,80 (0,9)	0,74	0,89		0,046
AMARANTO		1,50 (0,6)	3,01	-	-	-
WHOLE RICE	7,9	1,80 (0,5)	2,80	-	-	-

Formulations: 4 (70% wheat, 20% amaranth, 10% brown rice), 7 (80% wheat, 10% amaranth, 10% brown rice), 9 (70% wheat, 15% amaranth, 15% brown rice), Control (100% wheat), (100% amaranth), (100% brown rice).

The amount of phytates in amaranth was 20 mol / g dry matter, respectively. Similar values in A. cruentus were reported by Sanz-Penella et al. (2013) and to those reported by Miranda,K et al. (2019) in contrast to other investigations, which reported values between 4.8 and 9.4 mol / g in A. cruentus, A. hypochondriacus, and A. hybridus (Lorenz & Wright, 1984). The inclusion of amaranth flour in bread increased the phytic acid content to negligible values as shown in Table 1. The decrease of phytate in the bread is probably due to the longer fermentation time used in this research, since the sponge method was used (Sanz-Penella, Tamara, & Tamara, 1984). (Sanz-Penella, Tamayo-Ramos, Sanz, & Haros, 2013).. Phytate can be hydrolyzed as a result of the action of endogenous phytase enzymes during the cereal/pseudocereal fermentation stage, this was achieved with the sponge method because the fermentation time increases and the phytic content decreases (Siwatch, Yadav, & Yadav, 2019) .

Effect of bread formulation on minerals and mineral reference dietary fiber.

The contribution of mineral intake increased the Dietary Reference Intake (DRI) for an average daily intake of 250 g of bread if mineral absorption inhibitors are absent, according to the Board of Directors of the Institute of Medicine, National Food and Nutrition Academy of Sciences (2005). Consumption of control 100% wheat bread would provide only 27% or less of the daily requirement in adults, whereas processed bread could provide almost 50% of the daily requirement for women. The fiber content of 100% wheat bread is 2.8%, with an increase in fiber noted in bread formulations containing precooked amaranth and brown rice flour by 3.6% to 6%. The iron and zinc content in the 100% wheat bread is 1.5 (mg/kg) and 1.1 (mg/kg) respectively, while in the bread where wheat has been partially substituted with the proposed mixes it reaches values for iron and zinc of 4.52 (mg/kg) and 1.60 (mg/kg) respectively.

Technological quality of fresh bread

Due to the lack of gluten in the precooked amaranth flour, the specific volume the decreased from 4 to 2 ml/g as a result of the addition of amaranth and rice flour at different levels Table 3. A similar trend was observed by. (Sanz-Penella, Tamayo-Ramos, Sanz, & Haros, 2013) y (Almeida, Chang, & Steel, 2013) in bread with wheat flour substituted by A. cruentus and A. caudatus, respectively. This behavior was observed in other studies as a result of the inclusion of ingredients such as fiber in bread formulations, due to a gluten dilution effect (Puig, Monedero, & Haros, 2015)..

The inclusion of precooked amaranth and rice flours produced a significant change in crumb firmness ranging from 0.90 to 0.87 for 30 % substitution including amaranth and brown rice. The same effect was observed in bread supplemented with other pseudocereals (Iglesias-Puig, Monedero, & Haros, 2015). (Penella, Wronkowska, Smietana, &

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Haros, 2013).. Pseudocereal whole-grain flours are rich in dietary fiber and do not contribute gluten, but their proteins, such as albumin, have the ability to interact with the wheat glutenin protein through disulfide bonds, which does not weaken the gluten network too much (Osvald, Tamás, Raskszeg, Tomoskozi, & Bekes, 2009).. The high polar lipid content in amaranth may have functionality as a gas stabilizing agent during bread making, which probably improves bread elasticity (D'Amico et al., 2017). In fact, (Meullenet & Carpenter, 1998) found a direct relationship between crumb elasticity from a sensory point of view and the measurement of bread firmness and cohesiveness. The cellular area of the crumb did not show much difference due to the technological process that involved using the sponge method (see Annex 1). The specific volume of the control bread was greater than that of the proposed formulations, but this difference is not significant Table 3. Again, this effect could be due to the low amount of gluten and the consequent decrease in the elasticity of the dough in the formulations with greater substitution of precooked amaranth flour. A preliminary sensory analysis was carried out with a hedonic scale, the products elaborated with precooked amaranth and brown rice flours 70% wheat, 20% amaranth, 10% brown rice, showed 20% more acceptability than the other formulations, presented bread development characteristics, color, shape, crumb color, very similar to 100% wheat bread, the smell and flavor did present differences but had an acceptance of 8 which constitutes to I like it very much, characteristics such as elasticity, gumminess and chewiness were very similar to the control. Some of the comments of the tasters who described the taste of the bread indicate that these components give a new flavor that they had not tasted could be due to the presence of saponins, although amaranth grains have a lower amount of saponins than quinoa grains (Reguera & Haros, 2017). (Reguera & Haros, 2017). Thus, the lowest scores were due not only to taste but also to appearance and pleasant texture and flavor see appendix 1.

4. Conclusions

As expected, the incorporation of whole amaranth flours in the formulation progressively and significantly increased total dietary fiber (Table 2). In general, previous studies have shown that pseudocereals are a good source of dietary fiber (Alvarez, Gallagher, Reguera, & Haros, 2009) (Ramos, Ponce, & Haros, 2019)(Alvarez-Jubete et al., 2009; (Iglesias- Puig, Monedero, & Haros, 2015) Reguera & Haros, 2017). In the present investigation, the amount of insoluble dietary fiber increased significantly with the inclusion of amaranth flours, from 3.9 to 7.9 g/100 g with respect to the bread control. These values are higher than the results obtained in bread with whole grain quinoa flour at 25 and 50%, in which the amount of insoluble fiber was 3.7 and 4.4 g/100 g, respectively. (Iglesias-Puig, Monedero, & Haros, 2015).. That should be noted that a similar trend was observed in bread formulations with up to 40% substitution by flour of A. cruentus (Sanz-Penella, Tamayo-Ramos, Sanz, & Haros, 2013).. In general, cereals and pseudocereals have more insoluble fiber, composed mainly of lignin and cellulose. However, in amaranth there is more total dietary fiber than in common cereals, and a higher concentration of soluble fiber (Repo, Carrasco, & Valdez, 2017)..

Dietary fiber exhibits the most effective physiological action at a soluble/insoluble ratio of 1:2 (Jaime, Molla, Fernandez, & Martin-Cabrejas, 2001)(Jaime et al., 2001), (Salas, Bulló, Pérez-Heras, & Ros, 2006).. In the current research, an increase in the content of precooked whole grain rice flour resulted in breads with soluble/insoluble fiber ratios closer to 1:2. The fiber content of the selected mix is 3.6 % suggesting a good potential to exert a favorable effect by regulating intestinal transit, and reducing the risk of diabetes, hypertension, coronary heart disease, cardiovascular disease and colon cancer. (Salas, Bulló, Pérez-Heras, & Ros, 2006)..

References

NTE INEN 3050. (2016). *Rice flour, requirements.* Quito: Instituto Ecuatoriano de Normalización.

NTE INEN 616. (June 11, 2016). *Determination of cadmium, lead and ochratoxin in flour from the husks of two varieties of cocoa in Ecuador.* Quito: Instituto Ecuatoriano de Normalización.

Almeida, E., Chang, Y., & Steel, C. (2013). Effect of resistant starch on physicochemical properties of wheat dough and bread. *Food Science and Technology, 50*, 545-553.

Altamirano, M., Ortola, M., & Castello, M. (2017). *Study of the hydration kinetics of white and brown " Senia" type rice .* Valencia: Polytechnic University of Valencia.

entrosur e-ISSN:2706-6800

INSTITUTO TECNOLÓGICO CORPORATIVO EDWARDS DEMING

Alvarez, L., Gallagher, E., Reguera, L., & Haros, M. (September 2009). Nutritional value and chemical composition of pseudocereals as gluten-free ingredients. 240-257.

AOAC (1999). *AOAC 999.11.* Washington, Rockville, Maryland: Association of Official Analytical Chemists.

AOAC 2001.11. (2001). *Cereal nitrogen method.* Rockville, Maryland: Association of Official Analytical Chemystri.

AOAC 2011.25. (2011). *Fiber methods the quantifies.* Rockville, Maryland : Association of Official Analysisi Chemicals.

AOAC 923.03. (2005). *Official method for determining ash.* Virginia: Association of Official Analysis Chemicals.

AOAC 945.16. (1990). *Oil in Cereal* . Rockville, Maryland : Association of Official Analytical Chemists.

AOAC 985.35. (2005). *Official method for the determination of sodium.* Rockville, Maryland : Association of Official Analysis Chemicals.

AOAC 985.35. (2016). *Method AOAC for calcium recovery.* Arlington Virginia: Association of Official Analytical Chemists.

Banerji, A., Ananthanarayan, L., & Lele, S. (May 24, 2018). Rheological and nutritional studies of amaranth-enriched wheat chapatti (Indian flatbread). *Food Science Technology Institute*.

Bustos, D., & Guerrero, T. (2015). *Study of the partial substitution of wheat flour by raw and cooked amaranth flour in bread making.* Quito: Repositorio Universidad Tecnológica Equinoccial.

Cedeño, M., & Galarza, E. (2013). *The guarantee trust as a financing mechanism for MSMEs engaged in dairy production in the city of Cayambe*. Retrieved from Salesiana: https://dspace.ups.edu.ec/handle/123456789/5823

D'Amico, S., Schoenlechner, R., Tömösközia, & Langó, B. (2020). Investigation of the effect of pentosan addition and enzymatic treatment on the rheological properties of millet flour-based model dough systems. *ELSEVIER, 91*, January.

Galarza, I, & Falcón, S. (2013). Amaranth, nutritional alternative. *Revista de docencia* , 16-21.

Haros, M., Carlsson, N., Almgrem, A., Alminger, L., Sandberg, S., & A. (September 30, 2009). Phytate degradation in human intestinal Bifidobacterium pseudocatenulatum ATCC27919 isolates and their probiotic potential. *ELSEVIER, 135*, 7-14.

Haros, Rosel, & Bebedito (2002). Effect of different carbohydrates on fresh bread texture and bread hardening. *SpringerLink*, 425-430.

Iglesias- Puig, E., Monedero, V., & Haros, M. (2015). Bread whith whole quinoa flour and Bifidobacterial phytase increases dietary mineal intake and bioavaibility. *LWT-Food Science and Technology, 60*, 71-77.

Iglesias-Puig, Monedero, & Haros (January 2015). Bread with whole grain quinoa flour and bifidobacterial phytases increases dietary mineral intake and bioavailability. *60*.

Jaime, L., Molla, E., Fernandez, A., & Martin-Cabrejas, M. L.-A. (2001). Structural carbohydrate differences and potential source of dietary fiber of onion tissues. *Journal of Agricultural and Food Chemystry, 50*, 122-128.

Kamoto, J., Kasapila, W., & Manani, T. (September 28, 2018). Use of fungal alpha amylase and ascorbic acid in the optimization of bread blended with wheat flour and grain amaranth. *PubMed Central*.

Kumar, V., Sinha, A., Makkar, H., & Becker, K. (June 15, 2010). Dietary roles of phytate and phytase in human nutrition: A review. *ELSEVIER, 120*, 949-959.

Lorenz, B., & Wright, B. (1984). Phytate and tannin content of amaranth. *ELSEVIER, 14*, 27-34.

Marianda, C., Ponce, S., & Haros, M. (November 2019). Evaluation of the technological and nutritional quality of bread enriched with amaranth flour. *ELSEVIER, 114*.

Matias, G., Hernández, B., Caballero, V., Torres, N., Espinoza, V., & Ramirez, L. (2018). Current and potential uses of Amaranth. *Journal of Negative and non-positive results*, 423-435.

Mesas, J., & Alegre, T. (July 15, 2002). BREAD AND ITS ELABORATION PROCESS. *3*, 307-313.

Meullenet, J., & Carpenter, J. (1998). *Relationship between sensory and instruments texture profile attributes.* Fayetteville: Dept. of Food Science University of Arkansas.

Miranda, K., Sanz- Ponce, N., & Haros, M. (2019). Evaluation of technological and nutritional quality of bread enriched with. *Food Science and Technology* , 1-8.

NTE-INEN 518. (1980-12). *Determination of moisture in cereal flours.* Quito: Instituto Ecuatoriano de Normalización.

Osvald, M., Tamás, C., Raskszeg, M., Tomoskozi, S., & Bekes, F. (2009). Effect of incorporated amaranth albumins on the. *Journal of Food and Nutrition Research, 6*, 335-340.

Penella, S., Collar, C., & Haros, M. (2008). *ELSEVIER, 48*, 751-721.

entrosur e-ISSN:2706-6800
INSTITUTO TECNOLÓGICO CORPORATIVO EDWARDS DEMING

Penella, S., Wronkowska, M., Smietana, S., & Haros, M. (March 2013). Effect of whole amaranth flour on the properties and nutritional value of bread. *ELSEVIER, 50*, 679-685.

Penella-Sanz, J. (March 2013). Effect of whole amaranth flour on the properties and nutritional value of bread. *ELSEVIER, 50*, 679-685.

Pilataxi, M. (2013). *Elaboration and nutritional evaluation of bread with amaranth flour* . Riobamba: University of Guayaquil.

Puig, I., Monedero, V., & Haros, M. (2015). Bread with whole-grain quinoa flour and bifidobacterial phytases increases dietary mineral intake and bioavailability. *ELSEVIER, 60*, 71-77.

Ramos, K., Ponce, S., & Haros, M. (November 2019). Evaluation of the technological and nutritional quality of bread enriched with amaranth flour. *ELSEVIER, 114*, 1-27.

Reguera, M., & Haros, C. (2017). structure and composition of kernels. *Pseudocereals: Chemestry and Technology*, 28-48.

Repo, R., Carrasco, V., & Valdez, J. (2017). Carbohydrates of kernels. In M. Haros, & R. Schoenlechiner, *Pseudocereals: Chemistry and Technology* (pp. 49-61). Oxford, UK,: John Wiley and Sons, Ltd.

Rivera, V. (2014). *Effect of maturity stage of Cavendish banana on flour and gel hydration.* Guayaquil: Escuela Superior Politecnica del litoral.

Salas, M., & Haros (September 2016). Evaluation of the technological, nutritional and sensory quality of bakery products by substitution of wheat flour with rice wholemeal flour. *DIGITAL.CSI*.

Salas, M., & Haros, M. (2016). Evaluation of technological, nutritional and sensory quality of bakery products by substitution of wheat flour for whole rice flour. *Brazilian Journal Food Technology*, 1-9.

Salas, M., & Haros, M. (2016). Evaluation of the technological of bakery products produced whit. *Brazilian Journal of Food Technology, 19*, 1-9.

Salas, -S. J., Bulló, M., Pérez-Heras, A., & Ros, E. (2006). Dietary fibre, nuts and cardiovasscular diseases. *Brithish Journal of Nutrions*, 45-51.

Santamarìa, J. (2017). *Study of the drying and cooking stages to obtain fast cooking "senia" rice.* Valencia: Universidad Politecnica de Valencia.

Sanz-Penella, Tamayo-Ramos, Sanz, & Haros (2013). Effect of whole amaranth flour on the properties and nutritional value of bread. *ELSEVIER*, 679-685.

Silva. (2016). High performance factors and practices influencing work climate: a case analysis. *SciELO, 26*.

Siwatch, M., Yadav, R., & Yadav, B. (2019). Chemical, physicochemical, bonding and microstructural properties of amaranth (Amaranthus hypochondriacus) flour as affected by different processing treatments. *Wagningen Academic*, 3-13.

entrosur e-ISSN:2706-6800
INSTITUTO TECNOLÓGICO CORPORATIVO EDWARDS DEMING