Effect of amaranth flour (Amaranthus mantegazzianus) on the technological and sensory quality of bread wheat pasta

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Article

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Effect of amaranth flour (*Amaranthus mantegazzianus*) on the technological and sensory quality of bread wheat pasta

Cristina S Martinez[1,5], Pablo D Ribotta[2,3], María Cristina Añón[4] and Alberto E León[1,5]

Abstract

The technological and sensory quality of pasta made from bread wheat flour substituted with wholemeal amaranth flour (*Amaranthus mantegazzianus*) at four levels, 15, 30, 40 and 50% w/w was investigated. The quality of the resulted pasta was compared to that of control pasta made from bread wheat flour. The flours were analyzed for chemical composition and pasting properties. Cooking behavior, color, raw and cooked pasta texture, scanning electron microscopy and sensory evaluation were determined on samples. The pasta obtained from amaranth flour showed some detriment of the technological and sensory quality. So, a maximum substitution level of 30% w/w was defined. This is an equilibrium point between an acceptable pasta quality and the improved nutritional and functional properties from the incorporation of amaranth flour.

Keywords

Amaranthus mantegazzianus, amaranth flour, bread wheat flour, pasta, sensory evaluation

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INTRODUCTION

Dry pasta is a traditional cereal-based food product that is becoming increasingly popular worldwide because of its convenience, palatability and nutritional quality (Hernández-Nava et al., 2009; Petitot et al., 2009). There is an enormous variety of pasta as a result of traditional and regional preferences and the raw materials, and production process (lamination or extrusion) used to make them, which result in products that vary markedly in texture and appearance. In central and north Argentine areas, where durum wheat (*Triticum durum* Desf) is not grown, hard wheat (*Triticum aestivum*) is used in spaghetti and pasta making in local industries. Nevertheless, ideally cooked pasta should be firm and resilient with no surface stickiness and little, if any, cooking losses (Brunnel et al., 2010).

In recent years, grains different from wheat have been used (as partial or total substitutes) in the production of particular kinds of "pasta" with healthy characteristics (Chillo et al., 2007), to enhance their nutritional profile or confer functional properties.

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The genus *Amaranthus* belongs to the family *Amaranthaceae* and includes more than 60 species, of which three viz., *Amaranthus hypochondriacus*, *A. cruentus* and *A. caudatus*, are the essential grain species (Kaur et al., 2010). Some authors identify the *A. mategazzianus* Pass as a fourth cultivated species, but genetic studies do not seem to warrant recognition of this group (Huerta-Ocampo and Barba de la Rosa, 2011), but rather *A. mantegazzianus* is considered as synonymous of *A. caudatus* (Costea et al., 2001; Noelting et al., 2011; USDA (GRIN), 2003 [Online Database]).

Amaranthus grains are cultivated as minor food crops in Central and South America, and in some areas of Asia and Africa. These dicotyledonous plants grow relatively fast and are resistant to moisture stress and low temperature (Konishi et al., 1985), and the grain yields ranged from about 900 to 1800 kg dry matter/ha (Carlsson, 1997). The seeds have been submitted to various treatments such as cooking, popping, toasting or grinding to be consumed as suspensions with water or milk, or to be incorporated in preparations (Dias Capriles et al., 2008). A traditional use of amaranth includes mixing popped grains with honey, jaggery or molasses to produce a candy-type product (Kaur et al., 2010). Additionally, amaranth has great potential in the production of nutrient-rich gluten-free products such as bread, pasta and confectionery products (Alvarez-Jubete et al., 2010).

The amaranth grains nutritional value is based on the high content and high quality of their proteins and lipids. Amaranth has a minimum protein content of 16%, which is generally higher than those found in commercial varieties of common cereals. Amaranth protein has unique characteristics because its amino acid balance is close to the optimal balance required for human nutrition (Drzewiecki, 2001). Furthermore, lysine content is particularly high in relation to common cereals and can therefore complement the amino acids present in other cereals such as wheat (Duranti, 2006).

The amount of lipids in amaranth – between 7 and 8% – is also higher than in cereals. Within the unsaponifiable matter, squalene is the main component (about 8% of seed oil). Certain functional properties have been attributed to this highly unsaturated open-chain triterpene, such as chemopreventive effects on colon cancer (Rao et al., 1998), hypocholesterolemic action (He et al., 2002; Mendonça et al., 2009), and beneficial effects on hypertension (Pogojeva et al., 2006). In addition, amaranth presents high concentrations of calcium, phosphorous, iron, potassium, zinc and a dietary fiber range from 9 to 16% (Tosi et al., 2001). However, it should be taken into account that amaranth grain also contains phytic acid which has adverse effects on mineral bioavailability (Sanz-Penella et al, 2013).

In order to fully exploit the functionality of the amaranth grains in cereal-based products, it was necessary to evaluate the physicochemical characteristics of amaranth flour, since the amount of this alternative crop that can be added to wheat flour represents a compromise between nutritional improvement and achievement of satisfactory sensory and functional properties of products such as pasta, where the network forming ability of gluten is absolutely necessary.

Although there are numerous studies on the incorporation of amaranth in cereal-based foods, and even more on pasta products, there is little information available on the use of wholemeal amaranth flour (WAF) in pasta made from bread wheat flour (BWF).

The objectives of the present study were to evaluate (1) the composition and pasting properties of WAF and BWF, (2) the effect of the addition of amaranth flour on the quality of the pasta, in terms of cooking behavior, color, texture, ultrastructure and sensory evaluation.

MATERIALS AND METHODS

Materials

Wholemeal amaranth flour (*Amaranthus mantegazzianus*) (WAF) was obtained by milling cleaned grains using a hammer mill Fritsch Pulverisette 16 (Idar-Oberstein, Germany) and sieved through a U.S. No. 30 (590 μm) with a Zony Test MR (Buenos Aires, Argentina) sifter. Commercial bread wheat flour (BWF), without additives, was provided by Molino Campodónico (La Plata, Argentina), with dry gluten content (%) of 9.8 ± 0.1.

Samples

In this work, samples were referred to as "pasta", although they were made from BWF by a process of sheeting and cutting.

Pasta sample preparation was based on BWF combined with different amounts of WAF: 15, 30, 40 and 50 g/100 g (A15, A30, A40 and A50, respectively).

A sample prepared with BWF only served as control sample (Co). Flour blends (50 g) were mixed, with optimum amount of distilled water and salt (1 g/100 g of flour), with a hand mixer (Philips, 190 W, Buenos Aires, Argentina) at maximum speed for 3 min and the dough was sheeted after a 13-min resting time, using a pasta maker (Pastalinda®, Buenos Aires, Argentina). Optimum absorption was determined by the handling and sheeting characteristics of pasta dough. Pasta strips of 2 mm wide and 2 mm thick were dried by means of a pre-drying step at 30 °C, 40% relative humidity (RH), for 30 min, followed by a drying step at 30 °C, 65% RH, for 17 h. Each formulation was prepared in three replicate batches and processed on different days. Pasta was cooked in boiling distilled water in minimum pasta: water ratio (1 : 10).

Analytical methods

Chemical analysis. Moisture, protein (N × 5.7), gluten, ash, crude fiber, dietary fiber and fat contents of flours were determined according to Approved Methods 44–19, 38–10, 46–13, 08–01, 32–10, 32–05 and 30–25 (AACC, 2000), respectively, at least in duplicate.

Amylose determination. The amylose content was analyzed at least in duplicate using an Amylose/Amylopectin Assay Kit K-AMYL 04/06 (Megazyme, Bray, Ireland). Amylopectin value was also estimated from the difference between total starch and amylose content.

Flour pasting properties. The pasting properties of each flour and the flour blends were measured with a Rapid Visco Analyser (RVA, Newport Scientific, Narrabeen, Australia). Flour (3.0 g, dry basis) was added to 25 mL of distilled water in an RVA canister and heated from 50 °C to 95 °C in 282 s, holding the temperature at 95 °C for 150 s, and lowering the temperature to 50 °C. Peak viscosity, peak time, final viscosity, breakdown and setback were measured from the pasting curve and recorded in Pa.s units.

Cooking behavior. Pasta (5 g) was cut into pieces of 5 cm length and cooked in 200 mL of boiling distilled water. Optimum cooking time (OCT) and cooking loss were determined by Approved Method 66–50 (AACC, 2000). The OCT for each sample was established after repeating the test at least three times. Water uptake was measured at least in duplicate according to Bustos et al. (2011).

Color of cooked pasta. L*, a* and b* values of cooked pasta were measured using a Minolta 508d spectrophotometer (Ramsey, NJ, USA) according to Martinez et al. (2012), totaling 27 measurements for each substitution level.

Raw pasta fracturability. Raw pasta fracturability was measured using a texture analyzer with a HDP/3PB probe (TA-XT2, Stable Micro System, Surrey, UK). One raw pasta strand 5 cm long was compressed and fracturability (N) was determined as the maximum peak force until the pasta strand was fractured. The test was repeated on six samples of each batch prepared for every formulation.

Cooked pasta texture analysis. Texture profile analysis (TPA) was conducted using a texture analyzer with a stainless steel rectangular probe (HDP/PFS) (TA-XT2, Stable Micro System, Surrey, UK). Pasta strands of 5 cm length were cooked and when OCT was reached, the sample was transferred to an ice water bath to minimize any change on pasta structure until the measurement was made within the following 10 min. Three pieces of cooked pasta, to which the excess of water on their surface was gently wiped off with a filter paper, were placed perpendicularly to the probe, side by side, so that they touched each other along their entire length. The sample was compressed twice at a rate of 0.50 mm/s and at a ratio of 70%. TPA values for firmness (N), stickiness (measures as negative force, N), cohesiveness, springiness and chewiness (N) were obtained. The test was repeated on five samples of each batch prepared for every formulation (15 measurements for each substitution level).

Scanning electron microscopy. The ultrastructure of raw and cooked pasta was observed on the surface and on a transversal fracture of a pasta strand using scanning electron microscopy (SEM) techniques. Freeze dried samples were sputter-coated with gold, and their ultrastructures were imaged in a Joel 35 CF (Tokyo, Japan) under high-vacuum conditions at an accelerating voltage of 6 kV.

Sensory evaluation. Eight semi-trained panelist, but with previous experience in sensory analysis of pasta, evaluated samples of cooked pasta by comparison with a reference standard, according to Po-Hsien et al. (2012). The panel members were recruited from the staff of the Research Unit in Cereal Science and Technology (Universidad Nacional de Córdoba, Argentina).

The following textural parameters were evaluated: firmness, the force required to compress one pasta strand between the molar teeth when biting down evenly during the first bite; chewiness, amount of chewing (number of chews) required to masticate the sample at a constant rate, to reduce it to a consistency ready for swallowing; stickiness, amount of product adhering on/in the teeth after mastication (Kovacs et al., 1997) and springiness, the degree to which one strand of pasta returns to its original shape after partial extent (without failure) with the fingers (Tang et al., 1999).

For the multi-sample comparison test, the reference sample was anchored in the middle of a continuous 15-point scale and considered as zero point (Bourne, 2002); remained 7 positive points to the right and 7 negative points to the left, to quantify the major and the minor difference, respectively. Thus, positive values were used in case the sample was more than control

(+7: the most), while negative values were used in case the sample was less than control (–7: the lowest).

Sensory analysis of the 2 sets of pasta samples were evaluated on separate days. For each session, in randomized order, six cooked pasta samples were offered at a time to each judge: the reference sample and five test samples (four samples made with amaranth flour, plus other reference sample as blind control).

Samples were presented in a plastic cup identified with 3-digit random numbers, served within 30 min after cooking at room temperature. Panelists rinsed their mouths with mineral water between samples, and in order to avoid subjectivity associated with sample color, they were asked to wear red crystal glasses.

Statistical analysis

Data were statistically analyzed using InfoStat Statistical Software to record Fisher's least significant difference (LSD), Di Rienzo, Guzman, Casanoves (DGC) of multiple comparisons, Pearson's correlation coefficients and analysis of variance (ANOVA).

RESULTS AND DISCUSSION

Characterization of raw materials

Properties of flours. WAF presented higher protein, ash and fat than BWF. Further, fat content was almost an order of magnitude greater than BWF. As expected, WAF crude fiber was higher than BWF value, since amaranth flour is wholemeal type, compared to refined BWF (Table 1). Except for fat content, the other values of WAF were slightly higher than those reported by Kaur et al. (2010) for *Amaranthus caudatus* (which, in accordance with some authors (Costea et al., 2001; USDA (GRIN), 2003 [Online Database]; Noelting et al., 2011), is considered synonymous with *Amaranthus mantegazzianus*) due to the larger aperture size of the sieve used to obtain the flour.

BWF presented total starch, amylose and amylopectin values higher than WAF (Table 1). Amaranth flour showed 14.8 g of amylose/100 g flour. However, amylose and amylopectin values, expressed as g/100 g starch, were smaller and larger, than those measured in BWF, respectively. According to Wu and Corke (1999), who evaluated 243 genotypes of 26 species of amaranth, the average of amylose content was 19.2%, ranging from 7.8 to 34.3%. In addition, Inouchi et al. (1999) identified three types of amaranth starches based on its amylose content: normal (19.4 to 27.8%), low amylose (6.6 to 12.6%) and waxy or glutinous (0 to 1%); thereby, the WAF used in this work presented a normal amylose content.

Table 1. Protein, ash, fat, crude fiber, total starch, amylose and amylopectin of flours

	Flours	
Components	BWF	WAF
Protein (g/100 g flour, db)	12.2 ± 0.1 a	17.5 ± 0.1 b
Ash (g/100 g flour, db)	0.76 ± 0.03 a	3.33 ± 0.05 b
Fat (g/100 g flour, db)	0.9 ± 0.2 a	7.8 ± 0.1 b
Crude fiber (g/100 g flour, db)	0.3 ± 0.0 a	3.3 ± 0.1 b
Total starch (g/100 g flour, db)	76.0 ± 0.4 b	60.5 ± 0.8 a
Amylose (g/100 g flour, db)	24.2 ± 0.6 b	14.8 ± 0.2 a
Amylopectin (g/100 g flour, db)	51.8 ± 0.9 b	45.7 ± 0.6 a
Amylose (g/100 g starch, db)	31.8 b	24.5 a
Amylopectin (g/100 g starch, db)	68.2 a	75.5 b

BWF: bread wheat flour; WAF: wholemeal amaranth flour; db: dry basis.
Values followed by different letters in the same column are significantly different ($p \leq 0.05$) according to Fisher test.

Pasting of flours in an RVA. WAF showed lower values of pasting temperature, peak viscosity, breakdown, setback and final viscosity than BWF: 83.3 vs. 87.3 °C; 1.48 vs. 2.53; 0.11 vs. 1.02; 0.18 vs. 1.41; 1.55 vs. 2.92 Pa.s, respectively. Consequently, increasing amounts of amaranth flour in pasta formulations decreased RVA viscosity profile (Figure 1).

The low starch and amylose contents of WAF with respect to BWF, and therefore the low starch granule swelling and amylose leaching, could have contributed to a flatter RVA viscosity profile as amaranth flour substitution level was higher in pasta formulation. Moreover, since amaranth flour showed a very low breakdown value, a higher proportion of this flour in the flour mixture resulted in a lower breakdown value. In addition, according to Gunaratne and Corke (2007), who suggested that in the presence of two starches from different sources, the amylose release rate from one component inhibits the granular breakdown from the other, the amylose leaching rate from WAF could be lower than BWF.

A viscosity increase at the end of the pasting curve is related to pasta cooling, retrograde phenomenon and, therefore, amylose content (Alvis et al., 2008); thus, a low amylose content implies less susceptibility to the retrograde phenomenon (Gunaratne and Corke, 2007; Zuleta and Araya, 2009). Therefore, the low amount of amylose presented by WAF resulted in a low tendency to retrogradation, thus explaining the low values of final viscosity observed in pasting profile from blends with higher amaranth flour percentage.

Characterization of pasta

Cooking behavior. The data related to cooking behavior in terms of OCT, cooking loss and water absorption

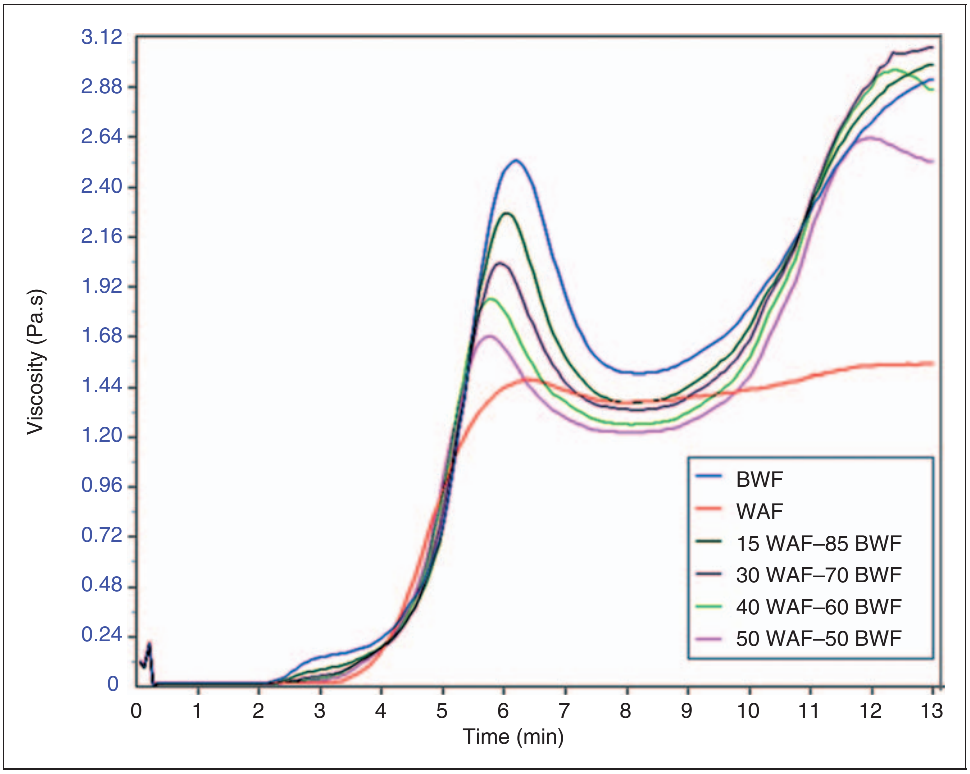

Figure 1. Pasting properties of flours and the flour blends in the same ratio of pasta samples. BWF: bread wheat flour; WAF: wholemeal amaranth flour.

Table 2. Optimum cooking time (OCT), cooking loss and water absorption of pasta

Sample	OCT (min)	Cooking loss (g/100 g dry pasta)	Water absorption (g/100 g dry pasta)
Co	8.0 ± 0.0 d	6.1 ± 0.1 a	160 ± 5 c
A15	7.0 ± 0.0 c	6.6 ± 0.1 b	144 ± 5 b
A30	5.0 ± 0.0 b	6.7 ± 0.1 b	133 ± 3 a
A40	5.0 ± 0.0 b	7.3 ± 0.2 c	149 ± 4 b
A50	4.0 ± 0.0 a	7.9 ± 0.1 d	151 ± 1 b

A15, A30, A40 and A50: pasta made with 15, 30, 40, and 50% (w/w) of amaranth flour, respectively; Co: control sample. Values followed by different letters in the same column are significantly different ($p \leq 0.05$) according to Fisher test.

for the samples analyzed are shown in Table 2. OCT was shorter for pasta samples that contained amaranth flour, compared to Co. OCT decreased 12.5% for A15, 37.5% for A30 and A40 and 50% for A50 with respect to Co. In addition, cooking loss values of pasta made with amaranth flour were higher than Co. However, all cooking loss values were less than 8%, which agreed with the limit value proposed by Dick and Youngs (1988) for spaghetti prepared from semolina.

According to Fardet et al. (1998), during pasta cooking, the protein network limits the diffusion of water and the swelling of the starch granules in the central zone of the pasta, thus the lack of a continuous protein network causes high hydration of the starch material (Zardetto and Rosa, 2009). The OCT and cooking loss values suggest that as gluten from wheat flour was diluted by the addition of amaranth flour, the pasta protein network became weaker, facilitating water diffusion into the pasta. This led to lower OCT values and higher cooking residues values obtained during the study.

Besides, amaranth pasta presented lower water absorption values than Co. Given that water absorption strongly depends on cooking time (Zweifel et al., 2003), water absorption values measured in these samples can be attributed to the fact that OCT of amaranth pasta were shorter than Co. Nevertheless, A40 and A50 showed higher values of water absorption than A15 and A30, even with equal or shorter OCT. Since amaranth flour is wholemeal flour, the higher fiber content of A40 and A50 could promote greater water absorption.

Color of cooked pasta. As expected from the darker appearance of WAF compared to BWF, the reflectance values measured on the cooked pasta showed that the addition of amaranth flour decreased L* values

Table 3. Cooked pasta texture analysis

Sample	Firmness (N)	Stickiness (x-1, N)	Cohesiveness	Springiness	Chewiness (N)	Resilience
Co	46.6 ± 2.2 b	3.1 ± 0.2 a	0.86 ± 0.02 b	0.95 ± 0.01 b	38.0 ± 1.1 d	0.12 ± 0.01 a
A15	44.4 ± 0.3 b	3.3 ± 0.1 a	0.83 ± 0.02 ab	0.95 ± 0.01 b	34.8 ± 0.9 c	0.12 ± 0.00 a
A30	43.9 ± 3.0 b	4.1 ± 0.4 b	0.81 ± 0.01 a	0.93 ± 0.01 ab	33.1 ± 2.3 bc	0.12 ± 0.01 a
A40	40.1 ± 1.7 a	4.1 ± 0.2 b	0.84 ± 0.03 ab	0.95 ± 0.05 b	31.9 ± 1.3 b	0.12 ± 0.00 a
A50	37.0 ± 2.1 a	4.2 ± 0.2 b	0.84 ± 0.01 ab	0.90 ± 0.01 a	27.9 ± 1.8 a	0.12 ± 0.03 a

A15, A30, A40 and A50: pasta prepared with 15, 30, 40 and 50% (w/w) of amaranth flour, respectively, Co: control sample.
Values followed by a different letter are significantly different ($p \leq 0.05$), according to Fisher test.

(70.0 for Co; 66.3 for A15 to 62.7 for A50) and increased a* values (–0.2 for Co, 2.0 for A15 to 5.3 for A50) and b* values (12.9 for Co, 17.0 for A15 to 20.5 for A50), ($p \leq 0.05$).

Raw pasta fracturability. The breakage susceptibility of dry pasta was evaluated in terms of fracturability, understood as resistance to pasta fracture, for example during a packaging and transport operation.

Pasta prepared with amaranth flour showed a clear tendency to become weaker at higher substitution levels. Fracturability values significantly decreased from 2.75 N for Co, 1.84 N for A15, 1.07 N for A30 to 0.47 N for A50. This weakening of pasta structure was also observed in the texture analysis of cooked pasta substituted with amaranth flour.

Cooked pasta texture analysis. Higher levels of amaranth flour on pasta formulation decreased firmness and chewiness and increased stickiness (Table 3). Nevertheless, firmness values were significantly lower only after reaching the substitution level of 40% (w/w), whereas significant differences for stickiness values were found from A30 onwards. Cohesiveness, resilience and springiness values did not show any trend for the different percentages of substitution (Table 3).

The textural properties of cooked composite-flour pasta showed a clear detriment of their technological quality due to amaranth flour substitution.

Though the pasting properties of amaranth starch might help to strengthen pasta structure (Limroongreungrata and Huang, 2007), a decrease in the technological quality of pasta was observed. Such negative effect can be attributed to the dilution of the existing gluten from wheat flour through the incorporation of flour lacking in gluten. In addition, the bran particles should be considered as points of discontinuity on protein network, which is responsible for pasta structure.

SEM of cooked pasta. SEM was used to observe how the incorporation of amaranth flour affected pasta ultrastructure. According to Mariotti et al. (2009), small amaranth starch granules (Ø: 0.5 to 2 μm) usually form agglomerates of up to 80 μm and they can act together with proteins as a network filler favoring pasta structure. However, the presence of many wide plates of teguments (which could get almost to 600 microns according to the sieve used to obtain the flour) from WAF produced a marked discontinuity in the protein network, negatively affecting pasta quality (Figure 2).

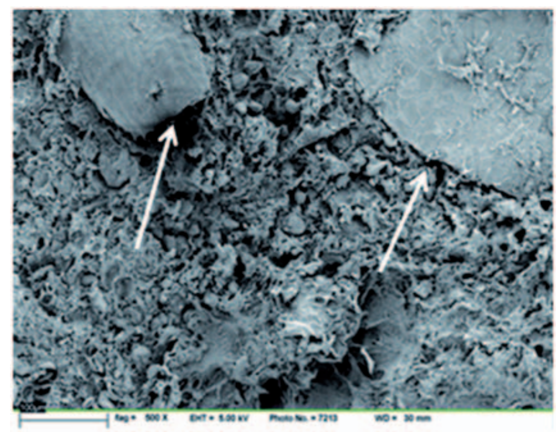

Figure 2. Surface of cooked pasta made with 50% (w/w) of wholemeal amaranth flour.
Arrows indicate amaranth tegument plaques.

These results are consistent with the results observed in cooking behavior and texture measurements.

Figure 3 shows how cooked pasta surface gradually lost continuity due to the addition of amaranth flour, producing increasingly larger pores that significantly facilitated water diffusion into the pasta being cooked. Therefore, starch gelatinization was favored and cooking times were reduced, as shown in the results above.

A weakened and quite heterogeneous pasta structure was also observed from the transversal fracture of cooked pasta, where proteins were probably just added in no particular order and interrupted by large tegument plaques.

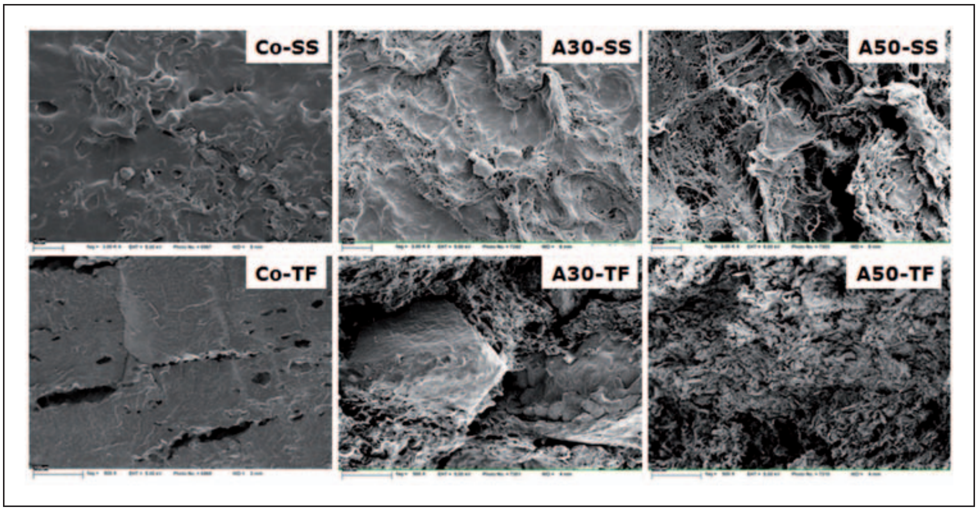

Figure 3. Scanning electron micrographs of surface section (SS) and transversal fracture section (TF) of cooked pasta strand.
Co: Control sample. A30 and A50: pasta made with 30 and 50% (w/w) of wholemeal amaranth flour.

Table 4. Sensory evaluation of cooked pasta prepared with amaranth flour

Sample	Firmness	Stickiness	Chewiness	Springiness
Co	0 b	0 a	0 b	0 c
A15	−0.2 ± 1.5 b	0.7 ± 1.7 a	−0.4 ± 1.7 b	−3.4 ± 2.2 b
A30	−0.7 ± 1.8 b	0.6 ± 1.4 a	−0.5 ± 1.2 b	−3.2 ± 1.7 b
A40	−1.8 ± 2.1 a	1.1 ± 2.2 a	−1.9 ± 1.1 a	−4.4 ± 1.3 a
A50	−2.8 ± 2.0 a	1.5 ± 2.4 a	−2.3 ± 1.3 a	−5.0 ± 1.6 a

A15, A30, A40 and A50: pasta prepared with 15, 30, 40 and 50% (w/w) of amaranth flour, respectively, Co: control sample.
Values followed by a different letter are significantly different ($p \leq 0.05$), according to Di Rienzo, Guzman, Casanoves (DGC) test.

Sensory evaluation. Sensory evaluation data was analyzed by a randomized complete block design, where the panel evaluators were treated as a block and the samples (Co, A15, A30, A40 and A50) were considered treatments (data not shown).

From the ANOVA performed on firmness, chewiness and springiness, the block effect (evaluators) as well as the treatment effect (substitution levels) were found to be significant. So, total variability was based on three sources: panel members, different levels of amaranth flour substitution and unexplained variability by the two previous sources, which were considered as experimental error. Multiple comparisons Di Rienzo, Guzman, Casanoves (DGC) test (Table 4) indicated that A40 and A50 showed lower firmness, chewiness and springiness than the other samples.

In the case of stickiness, only the block effect (evaluators) was significant as a source of total variability, beyond that explained by experimental error. Notably, all panel members expressed considerable difficulty in assessing this property. In fact, the variability generated by the evaluators sidestepped any differences in stickiness among the substitution levels (Table 4). When measuring this property on a texturometer (Table 3), A30, A40 and A50 resulted significantly stickier than Co.

CONCLUSIONS

The WAF used in this work showed higher values of protein, fat, ash and fiber than BWF, according to composition analysis. Furthermore, as a result of the lower amylose content measured in amaranth flour regarding BWF, flatter pasting profiles were found as amaranth flour substitution levels increased.

Beyond the functional properties and nutritional benefits that amaranth flour can provide to pasta, it was essential to bear in mind that amaranth flour has no gluten, which is a key component of pasta structure, so that the detriment of the pasta quality obtained could be quite predictable. Indeed, the assessment of physical and chemical properties of pasta made with different substitution levels of WAF showed an adverse effect on pasta quality. Therefore, it was necessary to define a right balance between the incorporation of this alternative flour and the technological and sensory quality of the pasta.

Within the substitution levels tested, the sample with 30% amaranth flour showed a cooking loss value below the limit proposed for spaghetti made from semolina, a firmness value similar to the Co. In addition, it was the major level of substitution for which significant differences were not observed with the Co in the sensory evaluation. Thus, it was proposed that the maximum substitution level was 30% w/w in order to obtain pasta with acceptable technological and sensory quality, with the consequent improvement of nutritional and functional properties given by amaranth flour.

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