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Sensorial and physicochemical qualities of pasta prepared with amaranth

Juliana Lopes dos Santos[1], Jamile Kailer dos Santos[1], Elisvânia Freitas dos Santos[2], Fabiane La Flor Ziegler Sanches[2], Maria Raquel Manhani[3] and Daiana Novello[4*]

*[1]Universidade do Centro-Oeste, Guarapuava, Paraná, Brazil. [2]Departamento de Nutrição, Universidade Federal de Mato Grosso do Sul, Campo Grande, Mato Grosso do Sul, Brazil. [3]Departamento de Farmácia e Nutrição, Universidade São Judas Tadeu, São Paulo, São Paulo, Brazil. [4]Setor de Ciências da Saúde, Departamento de Nutrição, Universidade Estadual do Centro-Oeste, Rua Padre Salvador, 875, Santa Cruz, 85015-430, Guarapuava, Paraná, Brazil. *Author for correspondence. E-mail: nutridai@gmail.com*

ABSTRACT. Current assay analyzed the sensorial acceptability of pasta when amaranth flour (AF) is added at different percentages. The physical and chemical composition and the acceptance similarities of standard formulation and formulation with a greater level of AF addition were assessed. Five formulations of pasta were used: F1 standard (0% AF); F2 (20% AF); F3 (25% AF); F4 (30% AF); F5 (35% AF). Fifty-six untrained tasters, from both genders and aged between 17 and 27 years, participated in the sensorial analysis. The physicochemical analyses determined moisture content, ash, protein, fat, carbohydrates, crude fiber, and calories. F4 with the highest AF content obtained acceptance similar to the standard formulation in all attributes. In addition, F4 provided higher levels of dietary fiber, proteins, ash, calories and lipids than standard formulation. Only carbohydrates levels in F4 were lower. Current study demonstrated that pasta with the addition of up to 30% of AF was the most sensory-accepted among the AF-added pastas. Since it provided sensory acceptance similar to the standard product, good marketing expectations are given.

Keywords: sensory analysis, functional food, cereal.

Qualidade sensorial e físico-química de macarrão elaborado com amaranto

RESUMO. Objetivou-se verificar a aceitabilidade sensorial de macarrão adicionado de farinha de amaranto (FA) em diferentes porcentagens, determinando a composição físico-química da formulação padrão e daquela com maior nível de adição de FA e aceitação semelhante. Foram elaboradas cinco formulações de macarrão sendo: F1 padrão (0% de FA) e as demais contendo 20% (F2), 25% (F3), 30% (F4) e 35% (F5) de FA. Participaram da análise sensorial 56 provadores não treinados, de ambos os gêneros, com idade entre 17 e 27 anos. Nas análises físico-químicas foi determinado o teor de umidade, das cinzas, das proteínas, dos lipídios, dos carboidratos, da fibra bruta e do valor calórico. A amostra F4 foi aquela com o maior teor de FA e com aceitação semelhante à padrão, em todos os atributos avaliados. Os teores de fibra alimentar, de proteínas, de cinzas, de calorias e dos lipídeos foram maiores em F4, obtendo-se maiores quantidades de carboidratos na formulação F1. A elaboração dos produtos permitiu comprovar que o nível de adição de até 30% de FA em macarrão foi o mais aceito pelos provadores, dentre aqueles contendo este ingrediente, obtendo-se aceitação sensorial semelhante ao produto padrão, com boas expectativas de comercialização.

Palavras-chave: análise sensorial, alimento funcional, cereais.

Introduction

Amaranth is a cereal belonging to the class of dicots and the family of Amaranthaceae, with more than 60 genera, and includes approximately 800 species of dicotyledonous and herbaceous plants of annual or perennial growth. There are three species of the genus Amaranthus that produce relatively large inflorescences, with more than 50.000 edible seeds per plant, or rather, A. hypochondriacus from Mexico, A. cruentus from Guatemala and A. caudatus from Peru and other Andean countries. Vegetable amaranths grow well in the hot, humid regions of Africa, Southeastern Asia, Southern China and India. They are represented by various amaranth species such as A. tricolor, A. dubius, A. cruentus, A. edulis, A. retroflexus, A. viridis and A. hybridus (BRESSANI, 2003). Amaranth has nutritionally high protein levels and contains essential amino acids, such as methionine and lysine, which are scarce in most cereals (MENDONÇA et al., 2009). The grain also comprises 60 starch, 8 fat and 13% dietary fiber (CAPRILES et al., 2006).

Amaranth is one of the few crops that may be used in its entire. Its leaves may be eaten as vegetables and both the whole and milled grains may be used in the food industry for the preparation of porridge, puddings, salads, cakes, pastas and others (MARCÍLIO et al., 2005; CAPRILES et al., 2006; BORNEO; AGUIRRE, 2008). Attention has been focused on amaranth due to its adaptation to Brazilian soil and for its nutritional value. Recent research shows that amaranth grain may lower serum cholesterol and assist in the control of heart disease and atherosclerosis (MENDONÇA et al., 2009).

Functional foods, which maintain and/or improve health by lowering the risk of disease (SILVA et al., 2012), have currently played an important role in the food industry. They are primarily added to baked products due to the easy technology required and to consumers´ concerns on health (STRINGHETA et al., 2007). Meanwhile, the most consumed foods are those that lack many nutritional properties but are easy to prepare, such as pasta, rice and other cereals. Consequently, the formulation of products containing added functional ingredients, such as amaranth, would be an efficient alternative to increase the intake of nutrients that the cereal offers and to improve the sensorial and organoleptic characteristics of new types of food.

Sensorial analysis is a measurement method that verifies the acceptance of these new products by consumers. The method is based on the answers provided by a given population to various sensations that arise from physiological reactions to stimuli, generating an interpretation of the intrinsic properties of the products. Contact and interaction between the parties, individuals and products should be available. The sensations produced may assess the intensity, extent, duration, quality and taste/distaste for the product being evaluated (IAL, 2008).

Current study develops pasta formulations with amaranth flour (AF) to verify their sensory acceptability, their physicochemical composition and similarities of acceptance between the standard product and the ones with AF.

Material and methods

Acquisition of the prime matter

The ingredients were purchased in supermarkets in Guarapuava, Paraná State, Brazil.

Preparation of the formulations

Five formulations of pasta were prepared, namely, F1 standard (0% AF), F2 (20% AF), F3 (25% AF), F4 (30% AF) and F5 (35% AF), as displayed in Table 1. The percentages were defined by preliminary sensory tests with the product.

Table 1. Ingredients of standard pasta formulations with the addition of amaranth flour (AF).

Ingredients	F1	F2	F3	F4	F5
Refined wheat flour (%)	64.45	44.45	39.45	34.45	29.45
Eggs (%)	28.32	28.32	28.32	28.32	28.32
Water (%)	6.25	6.25	6.25	6.25	6.25
Refined salt (%)	0.98	0.98	0.98	0.98	0.98
Amaranth flour (%)	0.00	20.00	25.00	30.00	35.00

The ingredients were weighed on a digital scale (Filizola®, Brazil), 1g precision and maximum capacity 6 kg, at the Laboratory of Dietetic Technique of Unicentro, Guarapuava, Paraná State, Brazil.

The ingredients were placed in a bowl in the following order: wheat flour, amaranth flour (according to percentage additions in Table 1), refined salt, eggs and water. After this stage, the ingredients were manually kneaded for about 5 min. until they formed a homogeneous dough. The pasta was then cut in noodles by a mechanical cylinder (Malta®, Brazil). Each unit of pasta measured about 0.5 wide by 12 cm long. The products were cooked in boiling water (100°C) for 15 min.

Sensory analysis

Fifty-six untrained tasters participated in the research. They comprised male and female undergraduates, aged between 17 and 27 years, at Unicentro Campus Center for Educational Development and Technology of Guarapuava (Cedeteg). The sensorial analysis evaluated appearance, aroma, taste, texture and color, according to methodology by Dutcosky (2011). The samples were analyzed with a 9-score hedonic scale, ranging from 'I disliked it very much' (grade 1) to 'I liked it very much' (grade 9) (DUTCOSKY, 2011). Questions on overall acceptance using a 9-score hedonic scale (DUTCOSKY, 2011) were applied, coupled to questions on purchase intent with a 5-score hedonic scale (1: I disliked it very much, 5: I liked it very much) (MINIM, 2010).

Each participant received five samples of pasta (approximately 20 g) in white plastic plates, randomly coded with three digit numbers. A glass of water was also offered during gap between samples. The formulations were offered to the participants in a sequential monadic way.

Acceptability index (AI)

The Acceptability Index of the five formulations was calculated according to Monteiro (1984), by the formula: AI (%) = A x 100/B (A: mean of grade obtained for the product and B: maximum grade given to the product).

Physicochemical analyses

The physicochemical analyses of the products were performed at the Laboratory of Food Analysis of the Department of Food Engineering of Unicentro, Guarapuava, Paraná State, Brazil. The following determinations were performed in triplicate for standard formulation and for F4, which had the highest AF content and obtained similar sensorial acceptance as the standard formulation: *Moisture:* moisture rate was determined by drying at 105°C until constant weight, following the Association of Official Analytical Chemists (AOAC, 2010); *Ash:* ash rate was determined in oven at 550°C, following methodology by AOAC (2010); *Protein:* total nitrogen was evaluated by Kjeldahl method (AOAC, 2010); the conversion factor used for protein nitrogen was 6.25; *Lipids:* samples passed through the cold extraction method, following method by Bligh and Dyer (1959); *Carbohydrate:* analysis comprised theoretical calculations (by difference) on the results, including crude fiber, according to the formula: % Carbohydrates = 100 - (% moisture + % proteins + % lipids + % ash); *Crude fiber*: assay was performed according to methodology by Adolfo Lutz Institute - IAL (2008); *Total caloric value (*kcal*):* kcal was calculated for 100 g of sample, using Atwater rates (or combustion heat) to lipids (9 kcal g^{-1}), to proteins (4.02 kcal g^{-1}) and to carbohydrates (3.87 kcal g^{-1}) (MERRILL; WATT, 1973).

Determination of the reference Daily Value (DV)

The DV was calculated with rates recommended for adults between 17- and 27-years-old (DRI, 2005). The nutrients were evaluated by calculating average tasters, or rather, 2019.32 kcal day^{-1}, 260.18 carbohydrates, 72.16 proteins and 73.30 g lipids.

Statistical analysis

Data were analyzed with Statgraphics Plus® 5.1, by analysis of variance (ANOVA). The mean comparison was performed by Tukey's and Student's tests at 5% level of significance.

Ethical issues

All participants signed an informed consent and the rules of Resolution n. 196/96 of the National Health Council were complied with. Current research was approved by the Ethics Committee and Research of Unicentro (Comep/Unicentro) by Protocol n. 49549/2012.

Results and discussion

Sensorial analysis

Table 2 shows sensorial acceptability, AI and purchase intention of standard pasta formulation and of pasta with the addition of AF.

There were no statistical differences ($p > 0.05$) between the formulations for appearance, aroma, texture and color, corroborating study by Borneo and Aguirre (2008) in which pasta was made with amaranth flour leaves (0 and 17.48%).

It should be underscored that during the preparation of pasta, the higher the levels of AF added, the more consistent and darker the dough became. However, as previously mentioned, these changes were not detected by tasters. The presence of a darker coloration was due to the amaranth´s typical cream color after being crushed to make flour - as explained by Capriles et al. (2006) - which modifies the dough´s original aspect.

With regard to taste attributes, the standard formulation obtained higher scores ($p < 0.05$) than F5, but no difference between the other formulations was detected. The lower acceptance of products with higher levels of AF is mainly due to the presence of residual taste of amaranth in the products, as explained by Marcílio et al. (2005).

Table 2. Means test sensory affective, acceptability index (AI) and purchase intention performed to pasta formulations, standard and with the addition of 20, 25, 30 and 35% amaranth flour (AF).

Formulations	F1	F2	F3	F4	F5
Attributes	Average±SD	Average±SD	Average±SD	Average±SD	Average±SD
Appearance	6.36±1.85a	6.05±1.97a	5.98±1.64a	5.73±1.87a	5.70±1.96a
AI (%)	70.66	6.22	66.40	63.67	63.33
Aroma	5.84±1.85a	5.59±1.97a	5.86±1.56a	5.37±2.04a	5.45±1.76a
AI (%)	64.89	62.11	65.11	59.67	60.56
Taste	6.20±2.19a	5.96±1.96ab	5.48±1.86ab	5.25±1.90ab	5.07±1.96b
AI (%)	68.89	66.22	60.89	58.33	56.33
Texture	6.21±1.87a	5.84±1.80a	5.78±2.08a	5.78±1.77a	5.39±1.82a
AI (%)	69.00	64.89	64.22	64.22	59.89
Color	6.39±1.90a	6.34±1.75a	6.39±1.82a	6.02±1.90a	6.09±1.87a
AI (%)	71.00	70.44	71.00	66.89	67.67
Overall acceptance	6.37±1.81a	6.02±1.96a	5.48±1.83ab	5.57±1.50ab	4.77±1.63b
AI (%)	70.78	66.89	60.89	69.62	53.00
Purchase intent	3.70±1.02a	3.28±1.23ab	3.07±1.11b	2.91±0.98b	2.73±1.03b
AI (%)	74.00	65.60	61.40	58.20	54.60

Different letters on the line indicate significant difference by Tukey's test ($p < 0.05$); SD: Standard deviation; F1: standard; F2: 20 AF; F3: 25 AF; F4: 30 AF and F5: 35% AF.

Table 2 also shows that the scores for overall acceptability of samples F1 and F2 were higher than F5. Thus, the higher AF addition rates, the higher was the rejection rate of the products by the tasters.

Since increased purchase intent referred to the standard formulation ($p < 0.05$), with lower scores for F3, F4, and F5, this fact demonstrated again that higher AF percentages reduced the acceptance of the products. This fact may be explained by the amaranth´s distinctive taste and by the fact that it is a frequently consumed food; so the untrained tasters who simulated the attitude of the consumer towards the product had little knowledge of its distinctive taste. Although overall scores awarded by the tasters to the pasta formulations have been relatively low, this may be due to the absence of a side dish (sauces and other condiments) that changes and improves the taste of the product (ORMENESE et al., 2004). In current research, no condiment or sauce accompanying the product was offered when the food was served so that interference in taste displayed by the samples would be avoided.

According to Teixeira et al. (1987), the product may be sensorially well accepted when AI is above 70%. As Table 2 shows, the formulations showed an AI below this rate. It should be underscored that F1 and F2 were the ones that presented the closest index to that recommended by the authors.

Figure 1 shows the distribution of tasters by hedonic values for each sensory attribute. Figure 1 shows that most scores conferred by the tasters lie between 6 ('I somewhat liked it') and 7 ('I liked it moderately'). It may be observed too that, as the addition of amaranth flour in products increases, the frequency of the highest grades reported by the tasters decreases.

According to Alamanou et al. (1996), attributes such as aroma and taste are probably the most important characteristics that affect the sensory properties of food products with different ingredients added. Consequently, sample F4 (30%) was selected for comparison purposes, together with the standard formulation F1 (0%), for being the one with the highest AF level that obtained an acceptance similar to the standard formulation.

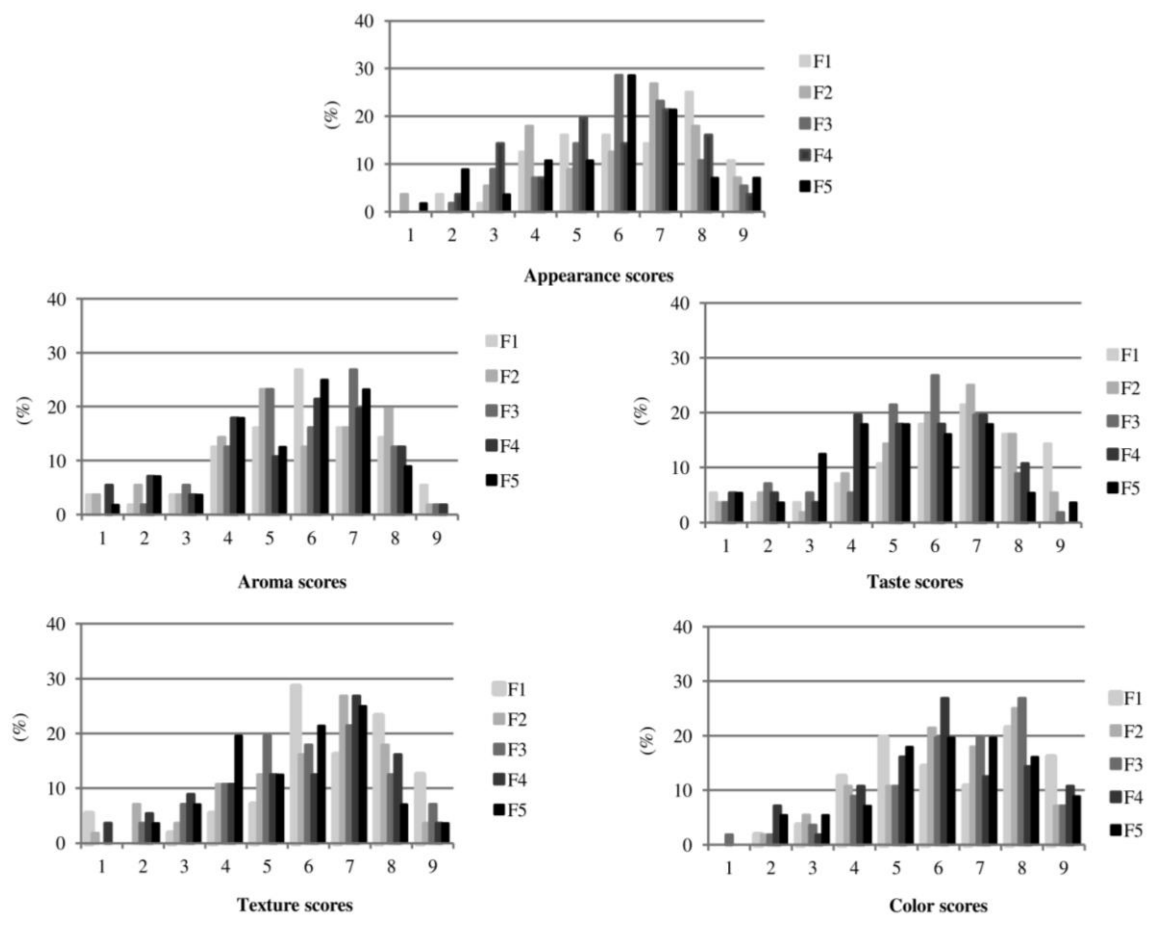

Figure 1. Distribution of tasters by hedonic rates obtained in the evaluation of the attributes appearance, aroma, taste, texture and color to formulations standard pasta and pasta with 20 (F2), 25 (F3), 30 (F4) and 35% (F5) of amaranth flour (AF).

Physicochemical analyzes

Table 3 shows the physicochemical composition and the DV for standard pasta and pasta with 30% AF, compared to a reference product.

No significant differences ($p > 0.05$) between the moisture contents of F1 and F4 were found. According to the recommendation of RDC n. 263 by the National Agency of Sanitary Surveillance (Anvisa), published on the 22nd September 2005 (BRASIL, 2005), the maximum moisture in pasta or pasta is 15%. Both formulations therefore are above that recommended. It is possible to verify that the samples showed moisture rates above the reference product (TACO, 2011).

The ash content was higher ($p < 0.05$) in sample F4 than in F1, but both had higher ash contents than the reference product (TACO, 2011).

The greater protein content in F4 ($p < 0.05$) may be explained by the fact that AF contain 15-16% protein in its composition (MENDONÇA et al., 2009) when compared to wheat flour with only 9.8% (TACO, 2011). Nevertheless, both samples showed higher amounts of protein than the reference product (TACO, 2011), probably due to the different ingredients used in the formulations.

Similarly, lipids contents were higher in F4 ($p < 0.05$) and also higher than in the reference pasta (TACO, 2011). This is mainly due to the chemical composition of amaranth with 8% lipids (CAPRILES et al., 2006), of which 50% are polyunsaturated, 25% monounsaturated and 25% saturated. It must be underscored that this food is rich in linoleic fatty acid (48%) which is necessary for human nutrition (MARTIROSYAN et al., 2007).

The carbohydrate composition of standard pasta was higher than that in F4 ($p < 0.05$), but both were lower than the rate reported in the literature (TACO, 2011). As the wheat flour was substituted by the amaranth, a reduction in the bread´s carbohydrate contents was observed. In current study, this occurred mainly because F4 was formulated with a reduced amount of wheat flour (Table 1), which contains higher carbohydrate content (75.10 g 100 g^{-1}) (TACO, 2011).

Although F4 had a greater amount of total calorie when compared to standard formulation, both showed rates below those of the reference product (TACO, 2011). Marcílio et al. (2004) reported that AF has 13% more energy (kcal) than whole wheat flour, which shows the high potential nutritional characteristics of amaranth.

The main result of current research is the fiber content in F4 (8.39±0.01 g 100 g^{-1}), or rather, a significant increase of 21.95% when compared to that of F1. This is mainly due to the high content of soluble and insoluble fibers (0.98 and 8.90 g 100 g^{-1}, respectively) in whole AF (CAPRILES et al., 2006). Results register that the product is an excellent option for patients with such diseases as diabetes mellitus since fibers delay the absorption of carbohydrates and thus decrease blood glucose (CARVALHO et al., 2012).

According to Brazilian legislation (BRASIL, 1998), a product is considered a source of fiber when it presents a minimum of 3% of fiber alimentary; it is considered a product with high fiber contents if it has at least 6% of alimentary fiber. Since the determination method for crude fiber crude in current assay underestimates the alimentary fiber rate in the products (HERNÁNDEZ et al., 1995), the two formulations may be considered as high fiber content products.

Table 3. Physicochemical composition of standard pasta (F1) and pasta with 30% amaranth flour (F4), compared with the % Reference Daily Value – DV* (average portion of 100 g of crude product) and reference product**.

Evaluation	F1		F4		Reference**
	Average±SD	% DV*	Average±SD	% DV*	
Moisture (%)	29.54±0.30a	ND	30.06±0.09a	ND	10.60
Ash (g 100 g^{-1})***	1.29±0.00b	ND	1.76±0.03a	ND	0.50
Proteins (g 100 g^{-1})***	8.86±0.19b	12.27	11.06±0.21a	15.33	10.30
Lipids (g 100 g^{-1})***	2.44±0.22b	3.34	4.50±0.02a	6.14	2.00
Carbohydrates (g 100 g^{-1})***	57.87±0.72a	22.24	52.61±0.35b	20.22	76.60
Calorie rates (kcal 100 g^{-1})***	281.56±0.04b	13.94	288.61±0.34a	14.29	371.00
Crude fiber (g 100 g^{-1})***	6.88±0.05b	ND	8.39±0.01a	ND	ND

Different letters in the line indicate significant difference by Student's test ($p < 0.05$); *DV: nutrients evaluated by the average of DRI (2005), based on a diet of 2019.32 kcal day^{-1}; **Values compared with 'raw pasta of wheat and eggs' (TACO, 2011); ***Results expressed on humid base; SD: Standard deviation; ND: not available.

Conclusion

The elaboration of the products demonstrated that an addition of up to 30% AF in pasta was the most accepted among all formulations, obtaining sensorial acceptance similar to the standard product. The addition 30% AF increased nutrient content, except for carbohydrates. AF may be thus considered a potential ingredient with functional properties that may be added to pastas and similar products with good market acceptance.

Considering the increase in production and consumption of amaranth in Brazil, mainly due to its nutritional benefits, major investments are necessary so that the product may be marketed at low cost to the consumers.

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