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Influence of the different addition levels of amaranth flour and rice flour on pasta buckwheat flour

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Abstract

Given the limited availability of specific products that are essential for improving the quality of life of people with celiac disease, this study aimed to develop and evaluate the chemical composition and sensory and technological quality of pasta with partial substitution of buckwheat flour by amaranth flour and rice flour. The chemical composition was determined by analysis of moisture, fat, ash and protein. The quality of the pasta was evaluated through cooking tests (increased volume and weight, cooking time, and loss of solids in the cooking water), color, and sensory analysis by acceptance test. All the pastas showed good protein content (14.9 to 19.73%). The pasta with 100% buckwheat flour showed the best cooking properties and lowest acceptance regarding color, while the pastas with partial substitution of buckwheat by amaranth flour and rice flour were clearer and more acceptable. Overall, the pastas that were developed received low sensory acceptance in all the analyzed attributes.

Introduction

Celiac disease is characterized by the malabsorption of nutrients as a result of damage to epithelial cells by absorption involving the small intestine. This damage occurs in susceptible people when they eat wheat or their derivatives. The only satisfactory treatment for people with celiac disease is the complete removal of gluten (Kasarda, 1978). Wheat is one of the most consumed cereals in Brazil, usually in the form of bread, pasta, cakes and biscuits, and among the different types of cereals it is the one which has the ability to form viscoelastic dough (Tedrus *et al*., 2001). The protein fractions that form gluten are very important from a technological point of view, because they play a key role in the production of pasta and breads.

According to Pagani (1986), unconventional raw materials can produce good quality products. All that is necessary is to employ technologies that exploit the functional properties of the components of the raw material such as starch, or add flour that is rich in proteins, which are able to form a structure similar to gluten. Amaranth is a plant that is easy to grow. It is nutritious, has a pleasant taste and high protein content, and is an excellent alternative for human nutrition for people with celiac disease because it does not contain gluten. The nutritional characteristics of the grains are quite positive, with a protein percentage of 12- 17%, a balanced amino acid profile and a high level of lysine (Costa and Borges, 2005).

Buckwheat *(Fagopyrum esculentum)*, originated in Central Asia and is a pseudo cereal produced in the winter that is mainly available in Brazil in the state of Rio Grande do Sul. It has 10.93% protein, is gluten-free, and is widely used in the preparation of products for people with celiac disease (Ferreira *et al*., 1983).

Rice is one of the few cereals that can be included in the diet of a person with celiac disease. The possibility of mass production based on rice to meet this sector of the market is justified both by the popularity of pasta in Brazilian cuisine and the availability of the raw material (Ormenese *et al*., 2001).

The possibility of industrially producing new formulations of pasta from different grains other than wheat has attracted the attention of researchers worldwide. The literature presents several reasons for the production of unconventional pastas, such as the economic factor, the dietary habits of some nations, and issues related to nutrition and health (Gimenéz *et al*., 2012).The aim of this study was to prepare pasta from buckwheat flour with different levels of amaranth flour and rice flour, and to analyze the chemical composition and sensory and technological quality.

Materials and Methods

The tested flours were coded FAm and FAr corresponding to amaranth flour and rice flour, respectively and were bought locally in Santa Maria, RS.

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Experimental design

A 2^2 factorial design was used with three replications at the center point, totaling 7 trials, as can be seen in Table 1. In addition to planning, a control formulation (C) was prepared with 100% buckwheat flour. The buckwheat flour was replaced by amaranth flour or rice flour at levels of 5, 10 and 15%, corresponding to the percentage of flour in the final formulation of 2.71, 5.42 and 8.13% g/kg, respectively.

Table 1. Formulations tested based on 22 factorial design with central point (F1 to CP) and additional testing

Formulations	Ingredients tested[a]	
	Amaranth Flour (%)	Rice Flour (%)
	5.0	5.0
F1	(-1)	(-1)
	15.0	5.0
F2	(+1)	(-1)
	5.0	15.0
F3	(-1)	(+1)
	15.0	15.0
F4	(+1)	(+1)
	10.0	10.0
CP[b]	(0.0)	(0.0)

[a] Real values and coded values.
[b] Proportion of 10% of amaranth flour and 10% rice flour.
** CP: central point corresponds to formulations F5, F6 and F7.

Processing of pastas

The standard formulation comprised 54.2% buckwheat flour, 31.8% eggs, 12% water and 2.0% xanthan gum. The opening and cutting of the dough was performed by a manual pasta machine (Anodilar, Caxias do Sul, Brazil). The mass with 4 mm thickness was cut to a size of 15 cm long and 7 mm wide, constituting a noodle-like pasta. Then, the pasta was dried at 90°C for 6 hours for quality analysis, as recommended by Chillo *et al*. (2008) and the remainder was dried in an oven with air circulation at 55°C for 24 hours for further analysis. The other formulations can be seen in Table 1, but they had the same amount of gum, water and eggs. After the pasta was cut and dried it was visually evaluated regarding length, thickness, width, texture and color.

Chemical analyses

Determination of moisture, protein, ash and lipids in the pastas followed the methodology described by the AOAC (1995).

Cooking test

The cooking test used to determine the quality of the pasta comprised four specific evaluations: a) cooking time: was determined according to the methodology described by Paucar-Menacho *et al.* (2008); b) water absorption: was determined by the weight gain that occurred during cooking. 10g of pasta was weighed, placed in 300 ml of boiling water, and cooked for an optimum cooking time (Nabeshima and El-Dash, 2004); c) increase in volume: the volume of distilled water displaced by 10 g of pasta was measured before and after baking in a 250 mL graduated cylinder (Nabeshima and El-Dash, 2004); and d) loss of soluble solids: was determined by the percentage of solids present in the cooking water (Nabeshima and El-Dash, 2004).

Acceptance test

Sensory analysis of the pasta was performed in the laboratory of sensory analysis of the Department of Food Science and Technology at the Federal University of Santa Maria (UFSM). The pasta was placed in boiling water with 6.5 g of salt and 10 mL of oil and was served to the testers soon after cooking. A seven-point hedonic scale was used to assess the acceptability of the pasta in which the upper and lower limits corresponded to, 7 = liked very much, and 1 = disliked very much for the evaluation of the attributes of color, flavor, appearance and texture. The sensory panel consisted of 50 untrained, randomly recruited testers. The pastas were coded with three random digits and 15 g of pasta was offered on disposable plates with a glass of water to wash the taste buds as suggested by Dutcosky (2006).

Color analysis

The color of the pasta was measured with a colorimeter (Minolta Chroma Meter CR-300) and was assessed four days after manufacture. The pasta was crushed raw and dry and then homogenized and distributed in Petri dishes. The results were expressed as L^*, which represents the percentage of light, ranging from black (0%) to white (100%); a^*, where $-a^*$ represents direction to green, and $+a^*$ direction to red; b^*, where $-b^*$ represents direction to blue and $+b^*$ toward yellow; and h^* (hue angle). For each treatment the average value of five readings was obtained at different points on the surface of the pasta.

Statistical analysis

To reduce the number of experiments, which would require much time and would be expensive, a 22 full factorial design with three replicates at the central point was performed. This enables a statistical

Table 2. Chemical composition of pastas prepared with buckwheat flour and different added proportions of amaranth flour and rice flour

Formulation	Moisture (%)	Ash (%)	Protein (%)	Lipids (%)
Control	9.89[a] ± 0.28	1.89[b] ± 0.04	14.90[c] ± 0.07	5.35[bc] ± 0.06
F1	9.41[ab] ± 0.25	2.06[b] ± 0.07	16.6 [b] ± 0.01	5.28[c] ± 0.02
F2	9.37[ab] ± 0.35	1.93[b] ± 0.07	18.51[a] ± 0.04	5.11[c] ± 0.17
F3	10.40[a] ± 0.47	2.01[b] ± 0.03	17.12[b] ± 0.11	5.77[b] ± 0.16
F4	8.98[b] ± 0.50	2.39[a] ± 0.09	19.73[a] ± 0.07	6.32[a] ± 0.04
CP	10.20[a] ± 0.40	1.97[b] ± 0.16	15.95[b] ± 0.07	5.31[c] ± 0.09

[*]Different letters in the same column indicate significant difference between treatments at 5% by Tukey's test. Control: pasta with 100% buckwheat flour; F1: pasta with 5% amaranth flour and 5% rice flour to replace the buckwheat; F2: pasta with 15% amaranth flour and 5% rice flour replacing the buckwheat; F3: pasta with 5% amaranth flour and 15% rice flour to replace the buckwheat; F4; pasta with 15% amaranth flour and 15% rice flour to replace the buckwheat; CP: 10% of amaranth flour and 10% rice flour to replace the buckwheat

inference implementation and approach because it allows the calculation of residue, and therefore the standard errors and interval estimates. Tests at the central point provide useful information about the behavior of responses and highlight the quality of the repeatability of the process (Rodrigues and Iemma, 2009; Barros Neto *et al.*, 2003). The evaluation consisted of: analysis of variance (ANOVA); Tukey's test (significance level of 95%) which calculated the effects; and evaluation of the regression coefficient by F test (Fischer-Snedecor). If the model was appropriate it was considered to be a predictor for the construction of response surfaces, which allowed visualization. Only models that had an appropriate regression coefficient allowing graphical representation (response surface) are presented. Data evaluation was performed using Statistica® 8.0 (StatSoft Inc.) and Microsoft® Excel 2003 (Microsoft Co.) software.

Results and Discussion

All the pasta that was measured in the dry, raw state showed uniformity in terms of length (26 cm), thickness (4 mm) and width (0.5 cm). All pastas were smooth and uniform in color. According to Dexter, Matsuo and Morgan (1981), these quality characteristics are fundamental for the commercial aspect of the product.

Table 2 shows that the pasta had good protein content (from 14.9 to 19.73%). Pasta is usually used as an energy source because of its high carbohydrate content; however it is low in minerals, lipids and proteins (Borneo and Aguirre, 2008). The formulations F2 and F4 (Table 2) differed from due to a higher protein level; this formulation contained more amaranth flour than the others. This flour has a high level and quality protein of with a lysine content of 3 to 3.5 times higher than corn and 2 to 2.5 times higher than wheat (Borneo and Aguirre, 2008).

Ascheri *et al.* (2008) developed snacks made from amaranth flour and rice flour and found levels of protein of 14.0%, lower than those found in this study. Borneo and Aguirre (2008) produced pasta enriched with amaranth flour and spinach protein, and found values of 14.18%. Gimenéz *et al.* (2012) developed pasta from wheat flour with added quinoa, and found protein values in the order of 16.91 to 31.07%, values that were generally lower than those found in the present study.

After drying, the pasta showed low humidity. Lipid content favors nutritional value because buckwheat, amaranth and rice flours are rich in polyunsaturated fatty acids. The F4 formulation differed significantly from the others, with a higher mineral content. It was not possible to construct any model as the R2 in the ANOVA table showed that the F value calculated from the regression and the F value calculated from the residues were not adequate. The effects of the addition of amaranth flour and rice flour on the moisture content and lipids of the pasta can be seen in Table 4. There were individual significant effects for both the flours and no interaction effect between them regarding the moisture of the product. The amaranth flour showed a negative effect of reduced humidity and the rice flour showed increased humidity. As for the content of lipids, it was observed that there was a positive individual effect only for the rice flour, and there was a positive effect for the interaction or mixture of the flours.

The behavior of pasta during and after cooking is one of the quality parameters of greatest importance

Table 3. Technological properties and color of pastas prepared with buckwheat flour and different added proportions of amaranth flour and rice flour

	Control	F_1	F_2	F_3	F_4	CP
Cooking time (min)	$11.33^{d}\pm0.57$	$13.66^{c}\pm0.57$	$13.33^{c}\pm0.57$	$17.66^{a}\pm0.57$	$12.33^{cd}\pm0.57$	$15.66^{b}\pm0.57$
water ab (%)	$344^{a}\pm0.20$	$258^{b}\pm0.11$	$242^{b}\pm0.13$	$250^{b}\pm0.07$	$237^{b}\pm0.43$	$234^{b}\pm0.12$
Increase in volume (%)	$384^{a}\pm0.83$	$247^{b}\pm0.40$	$249^{b}\pm0.30$	$265^{b}\pm0.24$	$235^{b}\pm0.15$	$239^{b}\pm0.18$
Loss of solids (%)	$5.75^{d}\pm0.40$	$14.12^{a}\pm0.42$	$10.12^{c}\pm0.64$	$15.04^{a}\pm0.31$	$6.01^{d}\pm0.40$	$12.85^{b}\pm0.26$
L^*	$55.82^{e}\pm0.08$	$65.67^{d}\pm0.37$	$67.70^{a}\pm0.13$	$66.79^{bc}\pm0.05$	$67.50^{ab}\pm0.22$	$65.99^{cd}\pm0.16$
a^*	$3.87^{ab}\pm0.04$	$3.59^{b}\pm0.30$	$3.89^{ab}\pm0.02$	$4.15^{a}\pm0.04$	$4.16^{a}\pm0.04$	$4.11^{a}\pm0.02$
b^*	$12.89^{c}\pm0.02$	$14.38^{b}\pm0.36$	$15.33^{a}\pm0.09$	$15.59^{a}\pm0.01$	$15.50^{a}\pm0.03$	$15.50^{a}\pm0.02$
h^*	$73.15^{c}\pm0.07$	$7.35^{ab}\pm0.06$	$75.65^{a}\pm0.06$	$74.95^{b}\pm0.07$	$75.00^{b}\pm0.14$	$75.40^{ab}\pm0.28$

*Different letters in the same line indicate significant difference between treatments at 5% by Tukey's test. Control: pasta with 100% buckwheat flour; F1: pasta with 5% amaranth flour and 5% rice flour to replace the buckwheat; F2: pasta with 15% amaranth flour and 5% rice flour replacing the buckwheat; F3: pasta with 5% amaranth flour and 15% rice flour to replace the buckwheat; F4; pasta with 15% amaranth flour and 15% rice flour to replace the buckwheat; CP: 10% of amaranth flour and 10% rice flour to replace the buckwheat

to consumers of such products. The results of the cooking test showed differences between the pastas (Table 3). The cooking time varied, depending on the composition of the pasta, with less time for the pasta made from 100% buckwheat, but all the pastas lost firmness as they reached the optimum cooking time. Moreover, the xanthan gum added to the pasta was not enough to provide elasticity and firmness before and after cooking, a fact confirmed by Teague *et al.* (1983) when preparing breads and pasta.

The weight increase of pasta is related to its water absorption capacity and its format. For Kruger *et al.* (1996), wheat-based pasta had an increase in weight of 160-180%. According to Donnely (1979), the weight increase should be in the range of 200 to 250%, while Hummel (1966) cites minimum values of 100%. The pastas obtained in the present study were within the parameters established by the cited authors; the weight gain ranged from 234-344%, with the greatest weight gain (344%) for the pasta made from 100% buckwheat flour.

It is normally expected that the increase in volume of pasta containing non-conventional flour will be lower because this factor, as well as depending on the cooking time and the shape of the pasta, also depends on the content and quality of the gluten proteins, which, at the moment of mixing the pasta, hydrate, absorb water and participate in the swelling of the pasta (Ormenese *et al.*, 2001). Although the pasta with 100% buckwheat flour did present gluten, it showed higher water absorption, and consequently greater volume, because buckwheat flour has good protein content, which is an advantage because it is capable of forming a structure similar to gluten (Meneglassi and Leonel, 2006). The other pastas showed lower weight gain because they contained different proportions of other flours. In terms of increase in volume, values of around 300% were expected (Casagrandi *et al.*, 1999). Studying this variable (Table 3), it appears that only the pasta with 100% buckwheat flour reached this value; the others were around 250%. Ormenese *et al.* (2001) evaluated pasta made from rice and eggs and observed volume increases in the range of 119-142%, less than the values found in the present study. Ormenese and Chang (2002) evaluated pastas made from rice and wheat and they observed an increase in volume of 175% for both types of pasta.

According to Hummel's (1966) criteria, the loss of soluble solids up to a figure of 6% are typical of very good quality pasta, up to 8% signifies medium quality, and equal to or greater than 10% represents low quality. The pasta with 100% buckwheat flour and the F4 formulation were considered to be of very good quality (the others were low quality), the granulometry should be coarse and there should be high protein content so that the starch gelatinizes during cooking and is retained in the protein network, without leaking into the cooking water. Casagrandi

Table 4. Calculation of the effects of the studied variables on moisture and lipids (%) and loss of soluble solids (%).

	Moisture (%)			Lipidis (%)			Loss Solids(%)		
	Effects	S.D	*p*	Effects	S.D	*P*	Effects	S.D	*P*
Average/Interaction	9.339	0.059	<0.001*	5.561	0.041	<0.001*	11.018	0.118	<0.001*
(1) Amaranth flour	-0.543	0.066	<0.001*	0.188	0.091	0.064	-6.063	0.264	<0.001*
(2) Rice flour	0.390	0.066	<0.001*	0.848	0.091	<0.001*	-1.007	0.264	<0.003*
1X2	-0.103	0.066	0.151	0.358	0.091	<0.001*	-2.088	0.264	<0.001*

* Significance of 95%. Where: 1X2 corresponds to the interaction of the rice flour and amaranth flour

Table 5. Calculation of the effects of the studied variables on L*, and b*

	L*			b*		
	Effects	S.D	*p*	Effects	S.D	*P*
Average/Interaction	66.504	0.016	<0.001*	15.070	0.030	<0.001*
(1) Amaranth Flour	-0.350	0.036	<0.001*	0.206	0.068	<0.013*
(2) Rice Flour	1.523	0.036	<0.001*	1.088	0.068	<0.001*
1X2	-0.500	0.036	<0.001*	0.091	0.068	0.212

* Significance of 95%. Where: 1X2 corresponds to the interaction of the rice flour and amaranth flour

et al. (1999) analyzed pasta made from a mixture of wheat flour and pigeon pea flour and they observed 9.2% loss of soluble solids in the pasta with 100% wheat, and 15.6% in the pasta with 15% pigeon pea flour, similar to the values observed for the pastas (F1 and F3) in the present study. The pastas from 100% buckwheat and the F4 formulation showed less loss of solids. According to Bordin and Roque–Specht (2012), when fibers are aggregated to pasta they provide less loss of solids into the cooking water. However, due to a higher percentage of amaranth and rice, the F4 formulation had a low loss of solids; in this case, because the amaranth flour was whole wheat it may have reduced the loss of solids to the water.

With regard to the intrinsic characteristics of the raw materials, it seems that the lack of gluten in the flours may have influenced these results, but the pasta with 100% buckwheat flour possessed suitable technological properties, as described by Dexter and Matsuo (1979), such as cohesiveness and hydration, which contributed to an increase in yield, a reduction in soluble solids content, and firmness in hot water.

The effects of the addition of amaranth flour and rice flour on the loss of solids of the pastas can be seen in Table 4. There were significant individual and interaction effects for both flours; these were negative effects, indicating less loss of solids in the cooking water. Pasta is expected to have low loss of solids into the cooking water, since the loss of solids is related to the amount of damaged starch, which after cooking and draining of the water makes it sticky.

The pastas with added rice flour and amaranth flour had a clearer appearance than the pasta made from 100% buckwheat (Table 3), but lower than the L^* values (in the rage of 80-83) obtained for all the mixed pastas found by Hernández-Nava *et al.* (2009) who analyzed semolina spaghetti with 20% added banana starch.

Regarding a^* values, the F3, F4 and PC formulations showed higher values that differed statistically from F1, but similar to the standard pasta and F2. The formulations F2, F3, F4 and PC differed statistically from the standard and F2, with a higher intensity of yellow color (b^* value), thus favoring its acceptability. It was expected that the added flours (rice and amaranth) would favor the whitening of the pastas. In contrast, Chillo *et al.* (2008) developed pastas from durum wheat bran and buckwheat flour, and observed that as the addition of buckwheat increased there was a reduction in L^* and b^* values. In the present study the hue angle was also higher for the F2 pasta, which did not differ from F1 and PC, and it was lower for the standard pasta made from 100% buckwheat.

The effects of the addition of amaranth flour and rice flour on the color parameters (L^*, a^* and b^*) of the pastas can be seen in Table 5. In terms of the brightness

Table 6. Average scores for sensory acceptance test for pastas prepared with buckwheat flour and different added proportions of amaranth flour and rice flour

Formulation	Color	Smell	Taste	Texture
Control	$2.72^b \pm 1.41$	$3.86^a \pm 1.09$	$3.55^a \pm 1.05$	$3.24^a \pm 1.47$
F1	$4.03^a \pm 1.15$	$4.43^a \pm 0.90$	$3.93^a \pm 1.25$	$3.70^a \pm 1.26$
F2	$3.99^a \pm 1.19$	$4.33^a \pm 1.02$	$3.80^a \pm 1.24$	$4.03^a \pm 1.36$
F3	$3.93^a \pm 1.45$	$4.22^a \pm 1.05$	$4.16^a \pm 0.93$	$3.83^a \pm 1.15$
F4	$3.90^a \pm 1.32$	$4.50^a \pm 1.22$	$4.14^a \pm 1.13$	$4.30^a \pm 1.36$
CP	$3.73^a \pm 1.22$	$4.23^a \pm 1.04$	$4.20^a \pm 1.12$	$4.35^a \pm 1.45$

*Different letters in the same column indicate significant difference between treatments at 5% by Tukey's test. Control: pasta with 100% buckwheat flour; F1: pasta with 5% amaranth flour and 5% rice flour to replace the buckwheat; F2: pasta with 15% amaranth flour and 5% rice flour replacing the buckwheat; F3: pasta with 5% amaranth flour and 15% rice flour to replace the buckwheat; F4: pasta with 15% amaranth flour and 15% rice flour to replace the buckwheat; CP: 10% amaranth flour and 10% rice flour to replace the buckwheat

of the product (L^*) there was significant individual effects for both flours and negative interaction effect. The amaranth flour showed a negative effect of reducing L^* (darker) and the rice flour showed a positive effect of increase of L^* (lighter). As for the b^* coordinate, there was only a significant positive individual effect for both the flours, indicating a higher b^* value (product with a tendency to yellow color).

Lighter colored pastas usually have a better acceptance in relation to whole wheat pastas because consumers are accustomed to consume pasta made with wheat flour. Observing the color parameters together, it follows that the addition of rice flour increased luminosity, making the product whiter (> L^* and < a^* values), whereas the addition of amaranth flour made the product a darker color and with a tendency to yellow (<L^* value, a^* value above one, and > b^* value). When the two flours were mixed, the characteristics of the amaranth flour predominated (especially the L^* parameter, the tendency to yellow). Consequently, the result of the interaction of amaranth flour and rice flour meant that the pastas were yellower in color. According to Chang and Flores (2004), higher intensity of yellow color is a highly desirable feature in a product because this is one of the most influential factors in terms of mass consumer acceptance.

Sensory acceptance test of the pastas

The marks awarded for the sensory acceptance test are presented in Table 6. The acceptance of the pastas was low, there was no statistical difference between the formulations and attributes that were analyzed and only the pasta from 100% buckwheat flour differed in color. The tasters gave marks between 3 and 4, commenting "dislike moderately" and "indifferent" with respect to the attributes; this fact can be attributed to lack of habit of consuming whole wheat foods and also due to the color and texture of the product. Another factor that explains the low acceptance of the pastas was the very high ash content; according to Chang and Flores (2004), levels above 0.90% of ash in flour signify that there is unwanted material in the flour, such as bran, which may be reflected in lower texture quality and the sensory characteristics of the final product.

The average for the color of the pasta made with buckwheat differed significantly from the others, with a mark of 2, relating to "dislike very much", which was due to the very dark color of the buckwheat. However, Chillo *et al.* (2008) developed buckwheat flour spaghetti with durum wheat bran and the spaghetti showed sensory properties very similar to those made only with durum wheat semolina, particularly for overall quality, with a mark of 7 for the attribute "liked" in a nine-point hedonic scale.

According to Ormenese and Chang (2002), pastas made from unconventional flours with good quality require the addition of protein substances capable of forming a network during cooking. Gluten-free pasta has poor quality protein with a discontinuous protein matrix that can release exudate from the starch gelatinization during cooking, resulting in sticky pasta (Chillo *et al*., 2008). This possibly may have occurred in the present study, contributing to low acceptance of the pastas.

One of the problems of gluten-free pasta is its texture, which produces unacceptable sensory characteristics due to its disintegration during cooking. Wang *et al.* (1999) developed gluten-free pasta from pea flour that was rich in protein, especially the amino acid lysine; however, the products were considered to be of poor quality, with poor sensory characteristics, similar to the products obtained in the present study with low sensory acceptability.

Conclusion

The combined use of buckwheat flour, rice flour and amaranth flour, at the studied levels, allowed the development of formulations of pasta with greater protein and lipid content than pasta simply prepared with buckwheat flour. The best quality attributes were observed in the pasta made from 100% buckwheat flour, followed by the pasta with 15% amaranth flour and 15% rice flour in place of buckwheat flour (F4), which had higher water absorption, higher weight gain, shorter cooking time and less loss of solids.

The pasta made from 100% buckwheat flour was less accepted in terms of the color attribute; the pastas with partial substitution of buckwheat by amaranth flour and rice flour were clearer and had better acceptance. This study showed that the partial substitution of buckwheat flour by amaranth flour and rice flour did not negatively affect the chemical and sensory composition of the pastas, demonstrating that it is possible to develop gluten-free pasta of reasonable quality and high protein content for people with celiac disease.

Ethical aspects

This study was approved by the Human Ethics Committee (CEP - CONEP) of the Federal University of Santa Maria (UFSM) in accordance with Resolution CNS 196/96 under Protocol. 182.590.

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