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Quality of pasta made of cassava, peach palm and golden linseed flours

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Abstract

The possibility of industrially producing new types of pastas based on other types of flour than wheat has raised interest for enabling the use of widely available materials and providing adequate products to persons with celiac disease. A mixture design was developed with the purpose of preparing a gluten-free dry using cassava starch, peach palm meal, and golden linseed while observing the nutritional value added and its technological properties. The pasta underwent assessments of its physicochemical and rheological characteristics. The drying temperatures studied were 60, 75, and 90 °C and the influence of those temperatures on pasta quality parameters and texture properties assessed. The percentage composition of the flours met the standards mandated by the Brazilian legislation and the pasta was classified as rich in fibers. The texture parameters of the pasta were influenced by the drying process, with the best results obtained at the lowest and highest temperatures studied.

Keywords: pasta; cassava starch; peach palm flour; linseed; gluten-free; celiac.

Practical Application: The pasta produced is a gluten-free product with high nutritional value. The sensory and technological characteristics of the new pasta are similar to those of traditional products. The Peach palm flour is rich in fiber and has viability to produce pasta with the best technological and sensory characteristics.

1 Introduction

The possibility of industrially producing new types of pasta with no wheat flour has raised interest not only for the cost of raw material, but also for allowing widely available materials with better nutritional characteristics to be used (Silva et al., 2009).

Several studies have been conducted to find alternative sources to produce pasta by replacing the wheat (Chillo et al., 2010; Fiorda et al., 2013). Such studies are important as they offer dietary options to gluten-intolerant individuals (Thompson et al., 2005). Flours with gluten must be replaced to allow persons intolerant to that protein to consume a broader range of foods. The production of pasta based on flours with no wheat may provide this consumer group sensorily satisfactory products with adequate nutritional levels (Onyango et al., 2009).

Quality pasta can be obtained by adding highly nutritious raw materials. Such enrichment mainly aims at increasing the nutritional quality of the pastas regarding the contents of proteins, dietary fibers, vitamins, and minerals (Chillo et al., 2010; Marconi & Carcea, 2001).

The fruit of the peach palm tree has fleshy, thick, and fibrous pulp. The fruits are consumed cooked and can be raw material for the extraction of oil or for flour production for various purposes (Clement, 2000). The potential for using peach palm as raw material to produce flour lies in its high nutritional value and composition since it carries all essential amino acids, has a significant dietary fiber content, and its main fatty acids are oleic and palmitic. In addition, it has high concentration of carotenoids, a nutritionally very relevant component (Yuyama et al., 2003).

Cassava starch has physicochemical characteristics of great industrial interest, such as the high peak viscosity and low setback, forms a clear and high transparent paste, has a light flavor, and resistance to retrogradation. It has wide application in several industrial sectors, such as the food industry (Rolland-Sabaté et al., 2013).

Linseed is used to prepare food products for its water holding capacity, total dietary fiber content, and, in particular, as a replacement for fat. Besides its technological role, the use of this fiber as an ingredient favors the development of foods with specific healthful effects (Jenkins et al., 1999; Tarpila et al., 2005; Chen et al., 2006).

In the overall quality assessment of pasta, texture properties are the most important since they are directly related to consumer acceptance. As a whole, desirable pasta has al dente characteristics (moderate firmness and high elasticity), no tacky surface, good integrity, brilliant color, and attractive flavor (Mariotti et al., 2011; Pagani et al., 2007). Those characteristics are directly impacted by drying conditions (Marchylo & Dexter, 2004).

The objective of this study was to verify the viability of using cassava starch, peach palm flour, and golden linseed to produce gluten-free pasta and to evaluate the combined effect of the component blend on technological characteristics.

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2 Materials and methods

2.1 Raw materials

The experiment was developed at the Laboratory of Physical Measurements (LAMEFI) of the Federal University of Pará (UFPA) in the city of Belém, PA, Brazil. The peach palm (*Bactris gasipaes* Kunth) fruits used were purchased at the Ver-o-Peso market in Belém. The cassava starch and golden linseed flour were purchased on the local market.

2.2 Obtaining peach palm flour

In order to produce peach palm flour, the skins and pits were removed and the mesocarp was cut into cubes approximately 2 cm thick, which were dried in a forced circulation oven at 55 °C for approximately 48 h until they reached 12% moisture. After drying, the fruits were ground in a hammer mill and sieved (60 mesh) to homogenize the granulometry.

2.3 Peach palm flour characterization

Only the peach palm flour was characterized, whereas the information contained in the packaging was used for the other raw materials. Association of Official Analytical Chemist (1997) methods were used to quantify the contents of moisture (method no. 925.10), ash (method no. 923.03), crude protein (method no. 960.52), total lipids (method no. 920.39C), and total, soluble, and insoluble dietary fiber (enzymatic-gravimetric method no. 985.29). Carbohydrate content was determined by difference. Total carotenoids were determined using the extraction method by Godoy & Rodriguez-Amaya (1994). pH was determined using method no. 981.12 of the AOAC methodology (Association of Official Analytical Chemist, 1997). Water activity (aw) was measured using a water activity meter (Aqualab 4TEv). All analyses were carried out in triplicate.

2.4 Mixture design of experiment

Formulations were prepared to produce pastas with different contents of cassava starch (CS), peach palm flour (PPF), and golden linseed flour (GLF). The concentrations of the components varied according to the experimental mixing scheme using lower and upper limits established after preliminary tests. In order to better visualize the effects of the independent variables (CS, PPF, and GLF) in the studied region, the actual concentrations of the components were transformed into another set of components, expressed in pseudocomponents, assuming values from 0 to 1 are presented in Table 1. The pseudocomponents (Xi) were calculated from the original concentrations (ci) by $Xi = (ci-Li)/(1-L)$, where Li is the lowest level for component i and L is the sum of the lowest levels of all components (Barros et al., 2003).

The data obtained for each response were submitted to analysis of variance. Regression models were used to express the relationship between the pseudocomponents in each experiment and the values obtained for optimal cooking time (OCT), mass gain (MG), and loss of solids in water (LS) for the samples of experimental pastas. The graphical representation of the mixture system of each response variable was constructed using triangular diagrams based on the fitted model. The highest desirability formulation was determined using the software Statistica version 7.0 (StatSoft, 2007) to select the pasta with the best technological quality according to the shortest cooking time, highest mass gain, and lowest loss of solids in water.

2.5 Pasta production

The pastas were produced in four steps: weighing and mixing dry ingredients, adding water, rolling out and cutting the dough, and drying. The dry ingredients were manually mixed for 5 min followed by water addition and then kneading for 15 min to obtain homogeneous dough. The dough was rolled out in a pasta machine (Marcato, Atlas 150, Italy) down to 0.4 cm thickness and then cut in the same machine using the dimensions of traditional tagliarini noodles, i.e., 26 cm long and 0.5 cm wide. The pasta then underwent fixed-bed drying at 60, 75, and 90 °C with air velocity of 1.5 m/s, during which mass loss over time was monitored until the product reached 12% moisture. The data obtained during the drying process at the different temperatures were analyzed using the Page, Midilli, Newton, and Henderson and Pabis models in the software Statistica version 7.0 (StatSoft, 2007). The coefficient of determination (R^2) and the mean standard error (SE) were used to select the best fit to each equation.

2.6 Rheological properties

Pasta texture was analyzed using a TA-XTi texturometer (Stable Micro Systems, Halesmere, England). Firmness and elasticity were determined using AACC method 66-50 (American Association of Cereal Chemists, 2000). Firmness determination used readings of the maximum force required to cut the noodle. The device was operated under the following conditions: force measured in compression, pre-test velocity: 0.50 mm/s, test velocity: 0.17 mm/s, post-test velocity: 10.0 mm/s, distance: 4.5 mm, trigger: base (initial height: 5 mm). Elasticity was determined as the pasta's resistance to break and its extensibility. The test conditions were: force measured in tension, pre-test velocity: 1.0 mm/s, test velocity: 3.0 mm/s, post-test velocity: 10.0 mm/s, distance: 30 mm, trigger: auto -5 g.

Table 1. Mixture design of experiment with actual values and pseudocomponents.

	Proportion of ingredients of the ternary mixture					
	Pseudocomponents			Real concentration		
Assays	CS (X1*)	PPF (X2*)	GLF (X3*)	CS (c1*)	PPF (c2*)	GLF (c3*)
1	1	0	0	0.80	0.10	0.10
2	0	1	0	0.30	0.60	0.10
3	0	0	1	0.30	0.10	0.60
4	1/2	1/2	0	0.55	0.35	0.10
5	1/2	0	1/2	0.55	0.10	0.35
6	0	1/2	1/2	0.30	0.35	0.35
7	1/3	1/3	1/3	0.33	0.33	0.33
8	1/3	1/3	1/3	0.33	0.33	0.33

Cassava starch (CS), peach palm flour (PPF), and golden linseed flour (GLF). $X1 + X2 + X3 = 1$ or 100% in actual components. *Calculated based on the equations: $X1 = (c1 - 0.30)/0.50$; $X2 = (c2 - 0.10)/0.50$; $X3 = (c3 - 0.10)/0.50$.

2.7 Pasta quality analysis

The quality of the dry pasta was assessed after the cooking assay and sensory analysis. The cooking assay was performed according to AACC method 16-50 (American Association of Cereal Chemists, 2000). The quality analyses were performed in the pastas that had the best results in the rheological analysis.

For the sensory analysis, the research project was submitted to the Research Ethics Committee of the Federal University of Pará (protocol no. 1.030.354/15) and was only carried out after approval. Eighty untrained tasters took part in the research and performed the monadic sequential assessment of appearance, texture, flavor, and odor of the pasta using a 9-point structured hedonic scale. The 25 g samples were served alone and with tomato sauce in individual booths at the Sensory Analysis Laboratory. The attributes were judged under natural light (Sereewat et al., 2015).

2.8 Pasta chemical analysis

The sample selected in the desirability analysis was characterized according to Association of Official Analytical Chemist (1997) techniques regarding moisture (method no. 925.10), ash (method no. 923.03), crude protein (method no. 960.52), total lipids (method no. 920.39C), and total, soluble, and insoluble dietary fiber by enzymatic digestion (according to enzymatic-gravimetric method no. 985.29). Carbohydrates were determined by difference.

2.9 Statistical analysis

The graphical representation of the mixture system of each response variable was made using triangular diagrams. The software Statistica version 7.0 (StatSoft, 2007) was used to create the experimental design, data analysis, and plotting. The data obtained for each response underwent analysis of variance (ANOVA) to assess significance ($p < 0.05$), coefficient of variation, and adjusted coefficient of determination (R^2 adj) of the mathematical models obtained. The pasta with the best technological quality according to the shortest cooking time, greatest mass gain, and lowest loss of solids in water was selected using the software Statistica version 7.0 (StatSoft, 2007).

2.10 Microbiological evaluation

Total and thermotolerant coliforms, molds and yeasts, sulfite-reducing clostridia, and coagulase-positive staphylococcus counts were performed. The techniques described by the American Public Health Association (2001) were followed. The microbiological analyses were performed in accordance with the microbiological standards established by RDC no. 12 of the National Health Surveillance Agency (ANVISA) of the Ministry of Health (Brasil, 2001).

3 Results and discussion

3.1 Chemical characterization of the peach palm flour raw materials

The percentage composition of the raw materials of peach palm flour is presented in Table 2.

The moisture content found for the flours used in this study is below the upper limit of 15% established by the Brazilian legislation (Brasil, 2005). The protein content found was 4.71 and 25.03% for peach palm and linseed flours, respectively. The greatest protein contribution comes from linseed, which adds more nutritional value to the diet. The properties of the protein, particularly its network-forming capacity, are very important for pasta texture (Mariotti et al., 2011).

The total fiber content found in the peach palm flour was 7.65 g. Adding fruits and vegetables to gluten-free extruded products is a possible alternative to provide consumers with celiac disease products enriched with healthy dietary fibers (Stojceska et al., 2007).

3.2 Mixture design of experiment

The regression models adjusted for OCT, MG, LS of the pastas prepared based on the mixture design of experiment and dried at 75 °C are presented in Table 3.

The quadratic regression model adjusted to the OCT, MG, and LS responses was significant at 5% probability with a regression coefficient of 0.999 for OCT and LS and of 0.77 for MG.

The CS, PPF, and GLF contents were significant for at least one of the responses ($p < 0.05$). It can be seen that OCT was

Table 2. Percentage composition of peach palm flour.

Components (g/100 g)*	Peach palm flour	Cassava starch	Linseed
Moisture	9.59 ± 0.17	12.65 ± 0.01	7.7 ± 0.37
Lipids	7.89 ± 0.26	1.56 ± 0.00	21.19 ± 1.09
Proteins	4.71 ± 0.05	0.14 ± 0.01	25.03 ± 0.98
Ash	1.21 ± 0.02	0.12 ± 0.19	3.01 ± 0.11
Carbohydrates	68.91 ± 0.33	85.52 ± 0.18	47.82 ± 0.46
Total fiber	7.65 ± 0. 18	0.61 ± 0.02	39.78 ± 0.05
Insoluble fiber	7.23 ± 0.4	0.41 ± 0.09	32.20 ± 0.15
Soluble fiber	0.42 ± 0.26	0.20 ± 0.07	7.58 ± 0.02
Total Carotenoids (μg/g)	4.26 ± 0.02	-	-
pH	5.92 ± 0.04	6.75 ± 0.05	-
Aw	0.47 ± 0.03	0.52 ± 0.00	-

*Values expressed on dry basis.

Table 3. Adjusted regression models, regression coefficients (R^2) for optimal cooking time (OCT), mass gain (MG), and loss of solids (LS) of the experimental pastas as a function of variables Cassava starch (CS) (x), peach palm flour (PPF) (y), and golden linseed flour (GLF) (z).

Model	R^2
OCT v= +7.17x + 22.16y + 10.62z -36.87xy + 1.69xz -23.10yz	0.99
MG v= +60.61x + 31.84y + 84.99z + 33.16xy+40.51xz + 10.93yz	0.77
LS v= +1.97x + 21.16y + 12.69z -27.57xy + 4.44xz -18.38yz	0.99

significantly influenced by the three raw materials used, while MG was influenced only by GLF. LF was influenced by PPF and GLF.

Regarding the interactions among the components, OCT was significantly impacted by interactions between CS and PPF and between PPF and GLF. The interaction between CS and PPF was significant for LS, while PPF was the component that most influenced LS. MG, in turn, was not influenced by the interactions among those matrices.

The pasta samples had different OCT values. Figure 1 shows the lowest OCT for assays 1, 3, 4, 5, 6, 7, and 8 with values of 7.20, 10.64, 5.39, 9.26, 10.13, 9.94, and 9.94 min, respectively, which are in the experimental region delimited by points a, b, and c. A similar value was obtained by Baiano & Conte (2006) for pasta with semolina and wheat flour, whose OCT was 8 min.

The MG parameter is related to the water-absorption capacity of the pasta and depends on its shape. According to Hummel (1966), wheat-based pastas should have minimum weight gain of 100 g/100 g. According to the criteria of that author, only the value of assay 4 was beyond the threshold for that quality parameter. The lowest value obtained was 31.08% (assay 2) and the highest, 113.5% (assay 4). The highest MG values are in the region delimited by points a, b, and c.

The LS values found showed that the pastas prepared in assay 1 (1.90%), 4 (4.84%), and 5 (8.62%) are within the quality range according to the criteria by Hummel (1966). That author stated that losses of solids of up to 6 g/100 g are characteristic of high-quality wheat-based pastas. The lowest LS values are in the region delimited by points a, b, and c.

The values optimized for OTC, MG, and LS were observed in assay 4 of this design, whose formulation had the highest peach palm flour content and the best results among the quality parameters. In face of the results obtained, the pasta from assay 4 was chosen for the rheological, quality, microbiological, and sensory tests.

3.3 Chemical composition of the pasta

The moisture content of the dry pasta was 12%, within the range recommended by the current legislation, which sets a maximum limit of 13% moisture (Brasil, 2000). The pasta prepared had 10.33 g of total dietary fiber, with a breakdown of 2.77 g of soluble and 7.59 g of insoluble fibers. That value is higher than the pastas available on the market, thus this product is considered a food rich in dietary fiber (Brasil, 2012). The higher fiber content may have beneficial physiological effects to the organism, which may include reduction in serum cholesterol, glycemia modulation, and laxative properties (Brennan, 2005). After processing, the carotenoid content in the final processing was 1.16 µg/g, which is close to the 1.8 to 2.9 µg/g found by Pereira et al. (1998) in pastas produced with wheat flour and fortified with synthetic β-carotene.

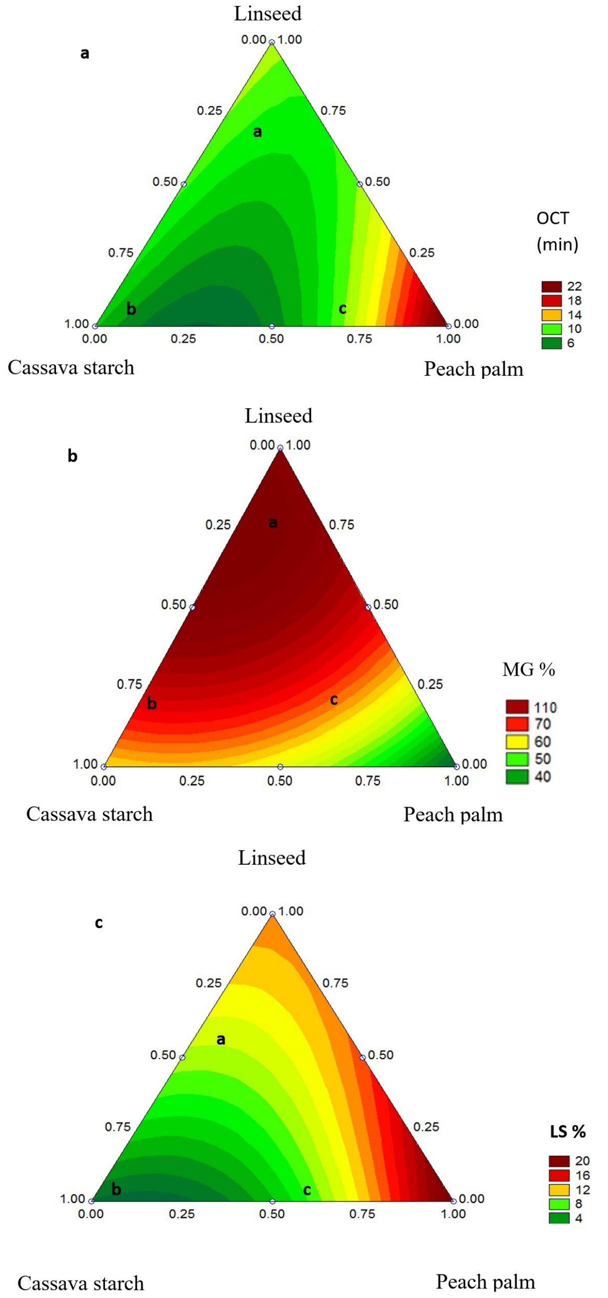

Figure 1. Level curves obtained by the experimental model (in terms of pseudocomponents): (a) optimal cooking time (OCT); (b) mass gain (MG); (c) loss of solids (LS). The area delimited among the experimental points demonstrates the region that can be analyzed.

3.4 Rheological analysis

The technological quality of pasta during and after cooking is the most important quality parameter for consumers of this product, besides taste and aroma. The experimental results of the texture characteristics of the pasta dried at different temperatures obtained in assay 4 of this experimental design are presented in Table 4.

In the statistical analysis, the drying parameters significantly impacted pasta texture (firmness and elasticity). No difference in firmness was found between the samples dried at the lowest temperature (60 °C; 223 gf) and the intermediate temperature (75 °C; 205 gf), which had the best results for this parameter. This behavior was also observed by D'Amico et al. (2015) when assessing the effect of drying (60, 80, and 100 °C) on two types of gluten-free pasta, which justifies that the drying process at high temperatures may change the physicochemical properties of starch and of the protein present in the pasta.

Pasta elasticity significantly differed for the three temperatures studied, yielding values of 47.72, 34.26, and 43.44 gf, respectively. The drying effects at the temperatures studied were less pronounced in the pasta and elasticity was not significantly extended. Gluten-free pasta has lower elasticity (Huang et al., 2001). Aravind et al. (2012) observed a significant reduction in pasta viscosity by adding soluble fibers, which is consistent with a competition between dietary fibers and starch for the available water, inhibiting starch pasting and retrogradation and/or disruption of the starch/protein matrix. In this case, the food fibers probably interfere with the pregelatinized starch and pasta viscosity is directly influenced by the amount of this available starch to structure the pasta, which also decreases the firmness of the starch (Hsieh et al., 1991).

Although high-temperature drying appears to be promising for improving pasta elasticity, it should be stated that the values achieved require further improvement.

3.5 Quality characteristics

In order to analyze pasta quality parameters, the positive results obtained in the rheological analysis of the pasta dried at 60 and 75 °C were considered and no significant difference in firmness was found.

The cooking time of the dry pasta was 8 min. For the shortest OCT values (<9.5 min), the pastas with maximum CS (55-80%) and minimum amounts of PPF (10-35%) and GLF (10-35%) can be found in the area delimited by points a, b, and c (Figure 1a). The same cooking time was obtained by Sereewat et al. (2015) for pastas based on rice flour and defatted soybean. A trend was observed for the pastas with lower CS and higher PPF and GLF contents to result in longer OCT (<10 min). This may occur because fibers and proteins in the PPF and GLF absorbed more water during cooking, thus reducing the amount of available water for starch gelling and requiring longer cooking times.

Table 4. Firmness and elasticity of the pasta from assay 4 dried at different temperatures.

Texture attribute	65 °C	75 °C	90 °C
Firmness (gf)	223^{a} ± 0.01	205^{a} ± 0.00	161^{b} ± 0.01
Elasticity (gf)	47.72^{a} ± 0.01	34.26^{c} ± 0.02	43.44^{b} ± 0.01

Average of five readings, standard deviations. Means followed by the same letter on the same row do not differ statistically according to Tukey's test at 5% probability.

According to Hummel (1966), high-quality pastas must have minimum increase values of 100%. According to this criterion, the pasta prepared in this study (assay 4) had a satisfactory value (113.5%) for this quality parameter. A trend was found for greater MG with small PPF and GLF amounts and higher amounts of CS in the experimental formulations (Figure 1b). However, since it is desirable that the pasta doubles in size (100% increase), this trend occurred close to experimental points 3, 5, and 6, i.e., when the contents of GLF were between 10% and 35%, CS contents were between 30% and 55%, and PPF contents were between 10% and 35% (region delimited by points a, b, and c). That value is close to the one reported by Bastos et al. (2016), who found MG of 111.5% for pastas prepared with amaranth flour and potato pulp.

Based on the criteria by Hummel (1966), classifies pasta according to the analysis of loss of solids. High-quality wheat-based pastas are those whose LS is up to 6%. Based on that classification, the pasta prepared in the present study can be considered good given its LS of 5.6% (assay 4). A trend was also observed for lower LS values (≤8%) near experimental points 1, 4, and 5 (Figure 1c), a region delimited by points a, b, and c, representing formulations with intermediate amounts of GLS (10-33%) and PPF (10-33%) and maximum amounts of CS (55-80%). It can also be seen that CS influenced this index as the highest LS values (>10%) were found in the regions with the lowest CS amount.

3.6 Microbiological analysis

The microorganism counts of the dry pasta were within the legal limits over 5 months of storage, confirming its good hygienic and sanitary quality according to the current legislation (Brasil, 2001).

3.7 Sensory analysis

The dry pasta was approved by 96, 90, 89, and 88% of the tasters regarding appearance, aroma, texture, and flavor, respectively, with a mean score of 7.7 for all attributes assessed. That value is higher than the one reported by Mirhosseini et al. (2015), who obtained an average score (<7) for pasta produced with corn flour and pumpkin meal. The intent of purchase survey showed that 47.5% of tasters "would certainly buy" and 33% "would possibly buy" the dry pasta made with cassava starch and peach palm and golden linseed flours.

4 Conclusion

Adding cassava starch and flours from peach palm and golden linseed enabled the production of well-structured dry pastas. All formulations or mixtures studied produced firm pastas, which were consistent with different cooking characteristics.

The combination of 55% cassava starch, 35% peach palm flour, and 10% golden linseed flour resulted in pasta with the best cooking and nutritional characteristics. Adding peach palm and linseed flours to that pasta improved its nutritional properties, particularly concerning fiber content, thus it can be characterized as a food rich in fibers.

The drying temperatures of 60 and 75 °C positively impacted pasta firmness. The optimal cooking time, mass gain, and loss of solids of the pasta were within the quality thresholds of this type of food product. The pasta prepared complies with the microbiological standards of the current sanitary legislation. Furthermore, the pasta had a good acceptance index and intent of purchase by tasters.

The results showed that the mixture of cassava starch, peach palm flour, and golden linseed flour has potential for commercialization and pasta preparation. That mixture widens the possibilities of using peach palm flour for consumption in finished products. The possibility of developing gluten-free products with peach palm flour may expand the supply of food products to individuals with celiac disease and will contribute to a more diversified diet for this population group.

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References

American Association of Cereal Chemists – AACC. (2000). *Approved methods of the American Association of Cereal Chemists*. St. Paul: AACC.

American Public Health Association – APHA. (2001). *Compendium of methods for the microbiological examination of foods* (4th ed.). Washington: APHA.

Aravind, N., Sissons, M., & Fellows, C. M. (2012). Effect of soluble fibre (guar gum and carboxymethylcellulose) addition on technological, sensory and structural properties of durum wheat spaghetti. *Food Chemistry*, 131(3), 893-900. http://dx.doi.org/10.1016/j.foodchem.2011.09.073. PMid:22953802.

Association of Official Analytical Chemist – AOAC. (1997). *Official methods of analysis of the Association of Official Analytical Chemist* (16th ed.). Washington: AOAC.

Baiano, A., & Conte, M. D. N. (2006). Drying temperature influence on quality cooking spaghetti. *Journal of Food Engineering*, 76(3), 341-347.

Barros, B. No., Scarminio, I. S., & Bruns, R. E. (2003). *Planejamento e otimização de experimentos* (2. ed., pp. 60-13). Campinas: Editora UNICAMP.

Bastos, G. M., Soares, M. S. Jr., Caliari, M., Pereira, A. L. A., Morais, C. C., & Hidalgo, M. R. C. (2016). Physical and sensory quality of gluten-free pasta processed amaranth and potato pulp flour base. *Lebensmittel-Wissenschaft + Technologie*, 65(2), 128-136. http://dx.doi.org/10.1016/j.lwt.2015.07.067.

Brasil, Ministério da Saúde. (2000, November 1). Dispõe sobre o regulamento técnico para fixação de identidade e qualidade de massa alimentícia (Resolução RDC nº 93, de 31 de outubro de 2000). *Diário Oficial [da] República Federativa do Brasil*. Retrieved from http://www.abima.com.br/dload/13_45_resol_93_00_leg_alim_nac.pdf

Brasil, Agência Nacional de Vigilância Sanitária. (2001, January 10). Regulamento técnico sobre padrões microbiológicos para alimentos (Resolução RDC nº 12, de 2 de janeiro de 2001). *Diário Oficial [da] República Federativa do Brasil*. Retrieved from http://www.e-legis.bvs.br

Brasil, Ministério da Saúde. (2005, September 23). Regulamento técnico para produtos de cereais, amidos, farinhas e farelos (Resolução RDC nº 263, de 22 de setembro de 2005). *Diário Oficial [da] República Federativa do Brasil*. Retrieved from http://www.abima.com.br/dload /13_46_resol _263_05_leg_alim_nac.pdf

Brasil, Agência Nacional de Vigilância Sanitária. (2012, November 13). Dispõe sobre o Regulamento Técnico sobre Informação Nutricional Complementar (Resolução da Diretoria Colegiada - RDC nº 54, de 12 de novembro de 2012). *Diário Oficial [da] República Federativa do Brasil*. Retrieved from http://portal.anvisa.gov.br/documents/%2033880/2568070/rdc0054_12_11_2012.pdf/c5ac23fd-974e-4f2c-9fbc-48f7e0a31864

Brennan, C. S. (2005). Dietary fiber, glycemic response, and diabetes. *Molecular Nutrition & Food Research*, 49(6), 560-570. http://dx.doi.org/10.1002/mnfr.200500025. PMid:15926145.

Chen, H.-H., Xu, S.-Y., & Wang, Z. (2006). Gelation properties of flexseed gum. *Journal of Food Engineering*, 77(2), 295-303. http://dx.doi.org/10.1016/j.jfoodeng.2005.06.033.

Chillo, S., Civica, V., Iannetti, M., Mastromatteo, M., Suriano, N., & Del Nobile, M. A. (2010). Influence of repeated extrusions on some properties of non-conventional spaghetti. *Journal of Food Engineering*, 100(2), 329-335. http://dx.doi.org/10.1016/j.jfoodeng.2010.04.018.

Clement, C. R. (2000). *Pupunha (Bactris gasipaes Kunth, Palmae)* (Série Frutas Nativas, No. 8). Jaboticabal: Fundep.

D'Amico, S., Maschle, J., Jekle, M., Tomoskozi, S., Lango, B., & Schoenlechner, R. (2015). Effect of high temperature drying on gluten-free pasta properties. *Food Science & Technology*, 63(1), 391-399. http://dx.doi.org/10.1016/j.lwt.2015.03.080.

Fiorda, F. A., Soares, M. S. Jr., Silva, F. A., Grosmann, M. V. E., & Souto, L. R. F. (2013). Microestructure, texture and colour of gluten-free pasta made with amaranth flour, cassava starch and cassava bagasse. *Lebensmittel-Wissenschaft + Technologie*, 54(1), 132-138. http://dx.doi.org/10.1016/j.lwt.2013.04.020.

Godoy, H. T., & Rodriguez-Amaya, D. B. (1994). Occurrence of cis-Isomers of provitamin A in brazilian fruits. *Journal of Agricultural and Food Chemistry*, 42(6), 1306-1313. http://dx.doi.org/10.1021/jf00042a011.

Hsieh, F., Huff, H. E., Lue, S., & Stringer, L. (1991). Twinscrew extrusion of sugar beet fiber and corn meal. *Lebensmittel-Wissenschaft + Technologie*, 24, 495-500.

Huang, J., Knight, S., & Goad, C. (2001). Model prediction for sensory attributes of non-gluten pasta. *Journal of Food Quality*, 24(6), 495-511. http://dx.doi.org/10.1111/j.1745-4557.2001.tb00626.x.

Hummel, C. (1966). *Macaroni products: manufacture processing and packing* (2nd ed.). London: Food Trade.

Jenkins, D. J., Kendall, C. W., Vidgen, E., Agarwal, S., Rao, A. V., Rosenberg, R. S., Diamandis, E. P., Novokmet, R., Mehling, C. C., Perera, T., Griffin, L. C., & Cunnane, S. C. (1999). Health aspects of partially defatted flaxseed, including effects on serum lipids, oxidative measures, and *ex vivo* androgen and progestin activity: a controlled crossover trial. *The American Journal of Clinical Nutrition*, 69(3), 395-402. http://dx.doi.org/10.1093/ajcn/69.3.395. PMid:10075322.

Marchylo, B. A., & Dexter, J. E. (2004). Improving the texture of pasta. In D. Kilcast (Ed.), *Texture in food: solid foods* (Vol. 2, pp. 475-500). Cambridge: Woodhead Publishing. http://dx.doi.org/10.1533/978185538362.3.475.

Marconi, E., & Carcea, M. (2001). Pasta from non traditional materials. *Cereal Foods World*, 46, 522-530.

Mariotti, M., Iametti, S., Cappa, C., Rasmussen, P., & Lucisano, M. (2011). Characterization of gluten-free pasta through conventional and innovative methods: evaluation of uncooked products. *Journal of Cereal Science*, 53(3), 319-327. http://dx.doi.org/10.1016/j.jcs.2011.02.001.

Mirhosseini, H., Abdul Rashid, N. F., Tabatabaee Amid, B., Cheong, K. W., Kazemi, M., & Zulkurnain, M. (2015). Effect of partial replacement of corn flour with durian seed flour and pumpkin on cooking yield, texture properties, and sensory attributes of gluten free pasta. *Lebensmittel-Wissenschaft + Technologie*, 63(1), 184-190. http://dx.doi.org/10.1016/j.lwt.2015.03.078.

Onyango, C., Unbehend, G., & Lindhauer, M. G. (2009). Effect of cellulose derivatives and emulsifiers on creep-recovery and crumb properties of gluten-free bread prepared from sorghum and gelatinised cassava starch. *Food Research International*, 4(11), 1-7. http://dx.doi.org/10.1016/j.foodres.2009.04.011.

Pagani, M. A., Lucisano, M., & Mariotti, M. (2007). Traditional Italian products from wheat and other starchy flours. In Y. H. Hui (Ed.), *Handbook of food products manufacturing*. New York: John Wiley-Interscience. http://dx.doi.org/10.1002/9780470113554.ch17.

Pereira, M. R., Amaya-Farfan, J., & Rodriguez-Amaya, D. B. (1998). Evaluation of the analytical methodology for the determination of b-carotene in fortified pasta. *Food Science and Technology*, 18, 1.

Rolland-Sabaté, A., Sanchez, T., Buléon, A., Colonna, P., Ceballos, H., Zhao, S., Zhang, P., & Dufour, D. (2013). Molecular and supramolecular structure of waxy starches developed from cassava (*Manihot esculenta* Crantz). *Carbohydrate Polymers*, 92(2), 1451-1462. http://dx.doi.org/10.1016/j.carbpol.2012.10.048. PMid:23399176.

Sereewat, P., Suthipinittham, C., Sumathaluk, S., Puttanlek, C., Uttapap, D., & Rungsardtong, V. (2015). Cooking properties and sensory acceptability Spaghetti made from rice flour and defatted soybean. *Food Science and Technology*, 60(2), 1061-1067. http://dx.doi.org/10.1016/j.lwt.2014.10.001.

Silva, R. F., Ascheri, J. L. R., Pereira, R. G. F. A., & Modesta, R. C. D. (2009). Acceptability of extruded rice and coffee biscuits and cakes. *Food Science and Technology*, 29(4), 815-819. http://dx.doi.org/10.1590/S0101-20612009000400018.

StatSoft. (2007). *Statistica 7.0 for Windows: computer program manual*. Tulsa: StatSoft. CD-ROOM.

Stojceska, V., Butler, F., Gallagher, E., & Keehan, D. (2007). A comparison rheological measurement of wheat dough to predict baking behaviour. *Journal of the Food Engineering*, 83(4), 475-482. http://dx.doi.org/10.1016/j.jfoodeng.2007.02.043.

Tarpila, A., Wennberg, T., & Tarpila, S. (2005). Flaxseed as a functional food. *Current Topics in Nutraceutical Research*, 3, 167-188.

Thompson, T., Dennis, M., Higgins, L. A., Lee, A. R., & Sharrett, M. K. (2005). Gluten-free diet survey: are Americans with celiac disease consuming recommended amounts of fibre, iron, calcium and grain foods. *Journal of Human Nutrition and Dietetics*, 18(3), 163-169. http://dx.doi.org/10.1111/j.1365-277X.2005.00607.x. PMid:15882378.

Yuyama, L. K., Aguiar, J. P., Yuyama, K., Clement, C. R., Macedo, S. H., Favaro, D. I., Afonso, C., Vasconcellos, M. B., Pimentel, S. A., Badolato, E. S., & Vannucchi, H. (2003). Chemical composition of the fruit mesocarp of three peach palm (*Bactris gasipaes*) populations grown in central Amazonia, Brazil. *International Journal of Food Sciences and Nutrition*, 54(1), 49-56. PMid:12701237.