Roots, Tubers, Grains and Bananas; Flours and Starches. Utilization in the Development of Foods for Conventional, Celiac and Phenylketonuric Consumers

Elevina E Pérez**, Antonieta Mahfoud², Carmen L Dominguez³ and Romel Guzmán¹

¹Universidad Central de Venezuela, Facultad de Ciencias, Instituto de Ciencia y Tecnología de Alimentos, Calle Suapure, Colinas de Bello Monte Caracas, Venezuela
²Fundación Instituto de Estudios Avanzados (IDEA), Hoyo de la Puerta Caracas, Venezuela

Abstract

Grains, roots, tubers, rhizomes, and unripe bananas are sources of flour and starches, however they are perishable. Consequently converting these crops into flours may be important process to produce new foods. The goals of the research were the production of flours, starches, and low-phenylalanine protein hydrolyzate, from these crops at pilot level and its application in the production of bread, baked good, pastas, mix to prepare drinks and baby foods; all of them to be used for conventional, celiac and phenylketonuric consumers. Each of the foods was prepared following the conventional recipes, with modifications, until they have reached the optimal acceptance by a panel of subjective judges. The ingredients and the food products were analyzed in its proximate composition, sensorial, chemical, physicochemical, and functional properties by using the official methodologies. It was verified the feasibility to produce these new foods using non-traditional sources.

Keywords: Legumes; Roots; Tubers; Bananas; Food development; Special diets

Introduction

Tropical legumes, roots, tubers, and musaceous are plants yielding grains, roots, tubers, rhizomes, and fruit cluster that have been sub utilized. In spite, that all of them are potential sources for flours, and starches that have not yet been exploited; only a few of them are utilized. It is due that they are highly perishable, difficult to store and to handle, and transporting to distant markets. In the tropical areas, where the temperature and humidity are naturally high, losses of all types of these items are prevalent today and have been estimated to vary depending of the type of tuber from 5-40%. It has been estimated an average of 30% loss during storage [1]. In order to minimize its losses, they must to be converted from perishable to non-perishable through food processing operations. Consequently, converting these crops into flours may be important process that would contribute to minimizing its losses, and also to allow commercial food industry to store them throughout the year.

Incidentally, some of them (root, tubers and unripe bananas) have low protein contents. In contrast, the legumes are characterized for to have high contents of good biological quality protein. Therefore they both combined could produce a composite flours highly nutritive that can be applied to develop foods. Despite the high occurrence of these floury crops in the tropical area, the flour and starch production in the world is confined to few crops. Certainly, wheat and rye, non-tropical plants, are the unique sources for bread flours.

Currently it is recognized the close relationship between heath and nutrition; reason why food and products are being developed with modifications in its composition by reduction, elimination or addition of nutrients with the purpose of contributing to avoid deficiencies and prevent excesses injurious to health [2]. Even, it has been defined the expressions food for special diets: as diet produced or specially prepared to meet particular needs feeding, which are determined by physical or physiological conditions, and/or diseases or specific disorders of the individual. The composition of these foods must be fundamentally different from the composition of ordinary foods of a similar nature [2]. Moreover, the relationship between food and health is connected to the concept of food security; since, not only it is referred to its biological utilization, and the stock, but also its accessibility. Alongside with the development of traditional foods, it must be developed foods for special diet, but it is not happening in the tropical undeveloped countries. Consumers with special diet have to acquired your foods from importation, and for hence they are expensive, scarce and nontraditional. Examples of them are celiac disease, phenylketonuric disease; which are diseases, which respond successfully to a modification of the diet. If foods that contain gluten are completely removed from diet in celiac consumers, and the intake of phenylalanine (phe) is restricted in phenylketonuric, in order to prevent the abnormal accumulation of the phe in blood, the body metabolic balance in the individual is re-established. These two pathologies have in common, that its early diagnosis and treatments, prevents important and irreversible sequels. By foregoing, the objectives of the study were to prepare flours and starches from tropical staples foods, supplementing them with low-phe ingredients; such as the low-phe hidrolizate elaborated from legumes, commercial soy protein concentrate or another commercial staple food with high protein content. Then with these ingredients develop products such as; breads, pasta, drinks, baby food and mixes to prepare pancake, cake and pizza. All of these food products must meet the needs of the traditional consumer and those with special regimes.

*Corresponding author: Elevina Perez, Universidad Central de Venezuela, Facultad de Ciencias, Instituto de Ciencia y Tecnología de Alimentos, Calle Suapure, Colinas de Bello Monte Caracas, Venezuela, Tel: +582129528579; Fax: +582127533881; E-mail: perezee@hotmail.com

Received December 13, 2012; Accepted December 28, 2012; Published January 08, 2013

Citation: Pérez EE, Mahfoud A, Dominguez CL, Guzmán R (2013) Roots, Tubers, Grains and Bananas; Flours and Starches. Utilization in the Development of Foods for Conventional, Celiac and Phenylketonuric Consumers. J Food Process Technol 4: 211. doi:10.4172/2157-7110.1000211

Copyright: © 2013 Pérez EE, et al. This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.
Materials and Methods

Materials

**Raw materials:** Grains as: rice (*Oryza sativa*), lentil (*Lens culinaris*); white beans (*Phaseolus vulgaris*), and isolated soy (*Glycine max*) protein, whey protein powder. All of them obtained from commercial production of the local market. Cassava roots (*Manihot esculenta*), and tubers; as, cocomay (*Xanthosoma sagittifolium*) were acquired from the germoplasm Bank of the Universidad Central de Venezuela, FAGRO/UCV, Maracay estado Aragua, Venezuela.

The sweet potato (*Ipomoea batatas*), peruvian carrot (*Arracacia xanthorrhiza*), tari (*Colocasia esculenta*), soursop (*Annonas muricata*), pineapples (*Ananas comosus*), coconut (*Cocos nucifera*) and beet (*Beta vulgaris*) were acquired from the local market. Unripe bananas (*Harton Comun; Musa AAB*); with a ripe degree [3] equal to 1; with a green color) gathered from the germoplasm banks of the Instituto Nacional Investigaciones Agrícolas, Venezuela INIA-Maracay. Amaranth flour was elaborated from the amaranth panicles (*Amaranthus dubius*, sp) gathered from the Fundación Desarrollo Endógeno Comunal y Agroalimentario-FUNDECA crops; estado Miranda, Venezuela.

Methods

**Flours elaboration, and isolation and purification of the starches:** The flour [4,5] and starches [6] were prepared by following the procedure described in Figure 1.

**Protein and concentrates and low-phe hydrolyzates:** Concentrates [7] and low-phe hydrolyzate [8] were prepared from lentils, white beans, amaranth panicles, and whey power following the methodologies described in Figure 1.

**Food products formulation:** With each one of the ingredient was prepared, at pilot level, several formulations of each product (mixes for preparing; drink [9] (see Figure 3), cake [10,11], pancake [11], and pizzas [12] (Figure 3), baby food (Figure 3), and pastas [13] until the optimal formulation as a function of its functional properties and acceptability characteristics were reached. All these products were developed to meet the demands of conventional consumer and special regimes; specifically in celiac and phenylketonurics consumers.

**Proximate and chemical analysis characteristics of the ingredients (flours, hydrolyzate and starches) and the food products:**

The ingredients and the food products developed were analyzed in its proximate composition, and chemical characteristics. Moisture content, crude protein (Nx6.25), crude fat, and ash were evaluated [14] in both (ingredients and foods). In the flour it was also evaluated dietary fiber [15], total and available carbohydrates [16]. The energy values (calories) were calculated using the general factors of Atwater [16]. The gluten content was quantified by using the Enzyme-Linked ImmunoSorbent Assay (ELISA) [17] and phe content by using the technique of HPLC [18]. It was also evaluated the starch availability in vitro [19], total cyanide content [20], and resistant starch [21].

**Physical, physicochemical and functional properties of the ingredients (flours, hydrolyzate and starches) and the food products:**

Among the physical and physicochemical and functional properties were evaluated: Bulk density [22], granular size [23], color (white and brown indexes; WI and BI respectively) and ΔΕ [24-26], sedimentation, pH, titratable acidity, gelatinization profile [8% (w/w)], and syneresis [14]. Consistency was measured by using the Bostwick consistometer.
and soluble solids with the Abbe refractometer [14]. Water activity ($a_w$) was calculated by using the Decagon’s Aqualab Cx- 2 (Decagon Devices, Pullman, USA).

**Sensory analysis of the food products:** Sensory analyses were conducted by 30 panelists, According to the hedonic scale [27] of

| Bread                        | Cupcake | Cake mix | Pancake mix | Pizza mix | “Casabe” |
|------------------------------|---------|----------|-------------|-----------|----------|
| **Moisture (%)**             | 30.9 ± 0.2 | 24.6 ± 1.3 | 5.1 ± 0.1 | 5.7 ± 0.2 | 4.7 ± 0.1 | 11.5 ± 0.0 |
| **Crude Protein (%)**        | 12.7 ± 0.0 | 9.4 ± 0.4 | 4.6 ± 0.0 | 3.9 ± 0.0 | 27.6 ± 0.1 | 11.0 ± 0.8 |
| **Crude Fat (%)**            | 2.6 ± 0.2 | 21.6 ± 0.0 | 0.5 ± 0.0 | 0.4 ± 0.0 | 2.5 ± 0.1 | 0.8 ± 0.0 |
| **Ash (%)**                  | 1.7 ± 0.1 | 2.7 ± 0.1 | 3.0 ± 0.1 | 2.6 ± 0.1 | 1.7 ± 0.1 | 1.8 ± 0.1 |
| **Dietary Fiber (%)**        | 7.7 ± 0.0 | 7.5 ± 0.2 | 1.6 ± 0.1 | 1.6 ± 0.1 | 2.0 ± 0.1 | 13.8 ± 0.1 |
| **Total Carbohydrates (%)**  | 83.1 ± 0.0 | 41.9 ± 1.6 | 88.8 ± 0.0 | 87.4 ± 0.1 | 63.6 ± 0.4 | 74.4 ± 0.0 |
| **Available Carbohydrates (%)** | 75.5 ± 0.0 | 34.3 ± 0.0 | 87.2 ± 0.0 | 85.2 ± 0.0 | 61.6 ± 0.0 | 60.9 ± 0.4 |
| **Calories**                 | 376 ± 0.0 | 368 ± 0.0 | 372 ± 0.0 | 360 ± 0.0 | 379 ± 0.7 | 295 ± 0.0 |
| **Gluten**                   | >5ppm    | >5ppm    | <5ppm       | <5ppm     | <5ppm    | <5ppm    |
| **Phe (mg/100gms)**          | Not determined | Not determined | 3.2 ± 0.0 | 3.6 ± 0.0 | 387.0 ± 0.7 | Not determined |
| **Digestibility (%)**        | Not determined | Not determined | 87.4 ± 0.7 | 88.1 ± 0.4 | 86.1 ± 0.6 | 51.0 ± 0.2 |
| **Total Cyanide (mg/kg)**    | Not apply  | 6.5 ± 0.5 | 6.5 ± 0.5 | 6.5 ± 0.5 | Not apply  | 6.5 ± 0.5 |
| **Resistant Starch (%)**     | Not determined | Not determined | Not determined | Not determined | Not determined | 6.5 ± 0.7 |

Table 1: Nutritional parameters of the breads and baked goods made with non-conventional flours.

| Bread                        | Cupcake | Cake mix | Pancake mix | Pizza mix | “Casabe” |
|------------------------------|---------|----------|-------------|-----------|----------|
| **pH**                       | 5.3 ± 0.2 | 6.9 ± 0.0 | 6.92 ± 0.0 | 6.8 ± 0.0 | 6.4 ± 0.0 | 5-6 |
| **Titratable Acidity**       | 0.2 ± 0.0 | 0.01 ± 0.0 | 0.24 ± 0.0 | 0.2 ± 0.0 | 0.4 ± 0.0 | 0.02 ± 0.0 |
| **ΔΕ²⁰⁰⁰⁰⁰ Crust**             | Not determined | 12.8 ± 0.0 | 7.38 ± 0.0 | Not apply | 11.0 ± 0.1 (Pizza) | 5.10 ± 0.1 (Casabe) |
| **ΔΕ²⁰⁰⁰⁰⁰ Crumb**            | 9.3 ± 0.0 | 5.6 ± 0.0 | 21.3 ± 0.0 | Not apply | Not determined | Not determined |
| **White Index**              | 80.3 ± 0.0 | Not determined | Not apply | Not apply | 84.5 ± 0.1 | 71.8 ± 0.1 |
| **Brown Index (crust)**      | Not determined | 63.9 ± 0.0 | Not apply | Not apply | Not apply | Not apply |
| **Density Apparent (g/ml)**  | 0.57 ± 0.9 | Not apply | Not apply | Not apply | 0.44 ± 0.0 | Not determined |
| **Specific Volume (cm³/g)**  | Not apply | Not apply | 2.7 ± 0.1 | 1.4 ± 0.0 | Not determined | Not apply |
| **Water Activity (A_w)**     | 0.4 ± 0.00 | 0.6 ± 0.2 | 0.4 ± 0.0 | 0.4 ± 0.0 | 0.4 ± 0.0 | 0.4 ± 0.0 |
| **Global Acceptation**       | 7/9      | 6/7      | 6/7         | 6/7        | 7/9       | 5/7       |
| **Granular size**            | Not apply | Not apply | 95%>60µm   | 95%>60µm   | 95%>120µm | Not apply |
| **WSI (%)**                  | Not apply | Not apply | Not apply | Not apply | 9.3 ± 0.7 | Not apply |
| **WAI (g, gel/g,)**          | Not apply | Not apply | Not apply | Not apply | 6.8 ± 1.9 | Not apply |

Table 2: Physical, physicochemical and functional parameters of the breads and baked goods made with non-conventional flours.

| Pasta unripe plantain flour | Pasta Rice/amaranths hydrolyzed low-phe | Pasta wheat semolina/ cassava flour/ beet juice |
|-----------------------------|----------------------------------------|-----------------------------------------------|
| **Moisture (%)**            | 8.3 ± 0.1                              | 11.3 ± 0.1                                   | 12.6 ± 0.0                                   |
| **Crude Protein (%) (N x 6.25)** | 3.5 ± 0.0                              | 9.5 ± 0.1                                   | 12.4 ± 0.0                                   |
| **Crude Fat (%)**           | 0.3 ± 0.0                              | 0.2 ± 0.0                                   | 1.6 ± 0.0                                    |
| **Ash (%)**                 | 2.6 ± 0.0                              | 2.0 ± 0.0                                   | 1.0 ± 0.0                                    |
| **Dietary Fiber (%)**       | 6.5 ± 0.0                              | Not determined                             | 2.0 ± 0.0                                    |
| **Total Carbohydrates (%)** | 85.4 ± 0.0                             | 77.0 ± 0.0                                  | 76.7 ± 0.0                                   |
| **Available Carbohydrates (%)** | 79.0 ± 0.5                             | 77.0 ± 0.0                                  | 74.7 ± 0.0                                   |
| **Calories**                | 335                                    | 346                                         | 350                                          |
| **Gluten**                  | <5ppm                                   | <5ppm                                        | >5ppm                                        |
| **Phe (mg/100g ds)**        | Not determined                          | 43.5                                         | Not determined                              |

Table 3: Nutritional parameters of the pastas made with non-conventional flours.

| Pasta unripe plantain flour | Pasta Rice/amaranths hydrolyzed low-phe | Pasta wheat semolina/ cassava flour/ beet juice |
|-----------------------------|----------------------------------------|-----------------------------------------------|
| **pH**                      | 6.2 ± 0.0                              | 6.2 ± 0.0                                   | 6.4 ± 0.0                                    |
| **Titratable Acidity (%) as H₂SO₄** | 0.03 ± 0.0                              | 0.05 ± 0.0                                  | 0.06 ± 0.0                                   |
| **ΔΕ (Color changes)**      | 2.3 ± 0.11                             | Not determined                             | 26.2 ± 0.0                                   |
| **White Index**             | 58.2 ± 0.2                             | Not apply                                  | Not determined                              |
| **Water Activity (Aw)**     | 0.4 ± 0.0                              | Not determined                             | 0.3 ± 0.0                                    |
| **Global Acceptation**      | 7/9                                    | 7/9                                         | 7/7                                          |
| **Cooking Time (minutes)**  | 4.0 ± 1.0                              | 10.0 ± 1.0                                  | 10.5 ± 1.0                                   |
| **Weight Gain (g)**         | 5.5 ± 0.0                              | 8.8 ± 0.1                                  | ND                                           |
| **Losses of Solids (g)**    | 1.6 ± 0.0                              | 0.5 ± 0.1                                  | 1.6 ± 0.0                                    |

Table 4: Physical, physicochemical and functional parameters of the pastas made with non-conventional flours.
Citation: Pérez EE, Mahfoud A, Domínguez CL, Guzmán R (2013) Roots, Tubers, Grains and Bananas: Flours and Starches. Utilization in the Development of Foods for Conventional, Celiac and Phenylketonuric Consumers. J Food Process Technol 4: 211. doi:10.4172/2157-7110.1000211

Results and Discussions

Table 1 and 2 summarize the quality parameters of the bread and baked goods (Figure 4), where stands out the partial substitution of the wheat by nonconventional flours; to produce bread and cupcake, and the total substitution to produce mixes to elaborate cake, pancake and pizza. Both the bread (25% cocoyam flour and 75% of wheat flour) and the cupcakes (50% wheat flour and 30% cassava flour) enriched with 20% rice bran have shown high content of dietary fiber. Additionally the cupcakes (50% wheat flour and 30% cassava flour) enriched with hydrolizate soy protein, and the “casabes” are only for celiac and phenylketonuric consumers (Table 1).

The pizzas cooked using the pizza-mix (100% extruded rice flour) enriched with hydrolizate soy protein, and the “casabes” are only for celiac consumption (Figure 4), and they also can be consumed for the conventional consumers. In both cases, it can be emphasized, its high protein content, and good digestibility. The “casabes” are showing low concentration of cyanide, and high content of resistant starch (Table 1).

Statistical analysis: To compare means was used the statistical software Statgraphics plus version 4.0, applying ANOVA and Duncan’s Multiple Range Test, when there were observed statistically significant differences, among variables.

Results and Discussions

Table 1 and 2 summarize the quality parameters of the bread and baked goods (Figure 4), where stands out the partial substitution of the wheat by nonconventional flours; to produce bread and cupcake, and the total substitution to produce mixes to elaborate cake, pancake and pizza. Both the bread (25% cocoyam flour and 75% of wheat flour) and the cupcakes (50% wheat flour and 30% cassava flour) enriched with 20% rice bran have shown high content of dietary fiber. Additionally the cupcakes have high fat contents (Table 1).

Cakes, and pancakes, elaborated with the mixes (100% cassava flour plus other functional ingredients) are gluten-free, and also they are low-phe products. Therefore, they can be consumed by celiac and phenylketonuric consumers (Table 1).

The pizzas cooked using the pizza-mix (100% extruded rice flour) enriched with hydrolizate soy protein, and the “casabes” are only for celiac consumption (Figure 4), and they also can be consumed for the conventional consumers. In both cases, it can be emphasized, its high protein content, and good digestibility. The “casabes” are showing low concentration of cyanide, and high content of resistant starch (Table 1).

It can be observed in Tables 3 and 4, the quality parameters, and acceptance of the products made with flours from cassava, banana and rice/amaranth combination. In regarding to the pastas elaborated using 100% banana flour, and (90:10) rice/amaranth composite-flour, it is obvious that additionally to be used by conventional consumers; these pastas can be consumed by celiac, due they are gluten-free. Highlighting on these products that: 1) Banana paste have presented a quick cooking (3 min) (Table 4), and 2), that the rice/amaranth pasta, due that it is low-phe, they can additionally be consumed by phenylketonuric patients.

In the formulation using cassava and beet juice in a proportion of 50 ml/100g flour: semolina to produce pasta, the wheat semolina was partially substituted for cassava flour in 20%; it is an important fact in countries, where wheat is imported (Table 2).

Using the flours elaborated from the edible portion of the cocoyam, Peruvian carrot, taro, and sweet potato were formulated different types of baby food (soup and dessert), flakes, and mixes to prepare drink points of 1-7 or 1-9 were evaluated as global acceptance. The scores of the panelists were averaged.

**Statistical analysis:** To compare means was used the statistical software Statgraphics plus version 4.0, applying ANOVA and Duncan’s Multiple Range Test, when there were observed statistically significant differences, among variables.

**Results and Discussions**

Table 1 and 2 summarize the quality parameters of the bread and baked goods (Figure 4), where stands out the partial substitution of the wheat by nonconventional flours; to produce bread and cupcake, and the total substitution to produce mixes to elaborate cake, pancake and pizza. Both the bread (25% cocoyam flour and 75% of wheat flour) and the cupcakes (50% wheat flour and 30% cassava flour) enriched with 20% rice bran have shown high content of dietary fiber. Additionally the cupcakes have high fat contents (Table 1).

Cakes, and pancakes, elaborated with the mixes (100% cassava flour plus other functional ingredients) are gluten-free, and also they are low-phe products. Therefore, they can be consumed by celiac and phenylketonuric consumers (Table 1).

The pizzas cooked using the pizza-mix (100% extruded rice flour) enriched with hydrolizate soy protein, and the “casabes” are only for celiac consumption (Figure 4), and they also can be consumed for the conventional consumers. In both cases, it can be emphasized, its high protein content, and good digestibility. The “casabes” are showing low concentration of cyanide, and high content of resistant starch (Table 1).

It can be observed in Tables 3 and 4, the quality parameters, and acceptance of the products made with flours from cassava, banana and rice/amaranth combination. In regarding to the pastas elaborated using 100% banana flour, and (90:10) rice/amaranth composite-flour, it is obvious that additionally to be used by conventional consumers; these pastas can be consumed by celiac, due they are gluten-free. Highlighting on these products that: 1) Banana paste have presented a quick cooking (3 min) (Table 4), and 2), that the rice/amaranth pasta, due that it is low-phe, they can additionally be consumed by phenylketonuric patients.

In the formulation using cassava and beet juice in a proportion of 50 ml/100g flour: semolina to produce pasta, the wheat semolina was partially substituted for cassava flour in 20%; it is an important fact in countries, where wheat is imported (Table 2).

Using the flours elaborated from the edible portion of the cocoyam, Peruvian carrot, taro, and sweet potato were formulated different types of baby food (soup and dessert), flakes, and mixes to prepare drink

![Flow charts of the elaboration at pilot level of (A) pizza, (B) baby food and (C) mix for drink.](image)

**Figure 3:** Flow charts of the elaboration at pilot level of (A) pizza, (B) baby food and (C) mix for drink.

![Grup 1: Bread and Baked Goods](image)

**Figure 4:** Examples of the foods elaborated using the different types of non-conventional flours classified by groups.
### Table 5: Nutritional parameters of the baby food and drink mixes made with non-conventional flours.

| Table 6: Physical, physicochemical and functional parameters of the baby food and drink mixes made with non-conventional flours. |
|---|

**Conclusions**

It was verified at laboratory level, the feasibility of using non-traditional sources of local production in the manufacture of food products with good acceptance by consumers, nutritious and succedaneum of those conventional.

**Acknowledgment**

The authors would like to thank to the FONACIT, Mision Ciencia in Venezuela and FRANCE for the financial support for this study, through the projects N°(s): 2007002000 (PCP), G-2000200495 (FAGRO-UCV) and 200701146 (IDEA-ICTA).

**References**

1. Perez E (2000) Determination of the Correlation between Amylose and Phosphorous Content and Gelatinization Profile of Starches and Flours Obtained from Edible Tropical Tubers using Differential Scanning Calorimetry and Atomic Absorption Spectroscopy. UW-Stout.

2. Pérez E (2010) Tecnología de alimentos en la medicina? Perspectivas en Venezuela en la elaboración de productos de regímenes especiales. Tribuna del Investigador 11: 6-10.

3. Von Loeveeh NV (1950) Bananas (2ª ed.). New York: Interscience.

4. Pérez EE, Gutiérrez ME, De Delahaye EP, Tovar J, Lares M (2007) Production and characterization of Xanthosoma sagittifolium and Colocasia esculenta flours. J Food Sci 72:S367-S372.

5. Pacheco-Delahaye E, Maldonado R, Pérez E, Schroeder M (2008) Production and characterization of unripe plantain (Musa paradisiaca L. f.) flours. Interciencia 33: 290-296.

6. Pérez E (1997) Characterization of starch isolated from plantain (Musa paradisiaca normalis). Starch-Stärke 49: 45-49.

7. Avanza MV, Puppo MC, Añón MC (2005) Rheological characterization of amaranth protein gels. Food Hydrocolloid. 19: 889-898.

8. Ari S, Maeda A, Matsumura M, Hirao N, Watanabe M (1986) Enlarged-scale production of a low-phenylalanine peptide substances as a foodstuff for patients with phenylketonuria. Agr Biol Chem 50: 2929-2931.

9. Rodríguez P, Pérez E, Guzmán R, Dufour D (2011) Characterization of the proteins fractions extracted from leaves of Amananthus dubius (Amaranthus spp.). African Journal of Food Science 5: 417-424.

10. Cueto D, Pérez E (2010) Proximate composition and rheological properties of a cake mix elaborated using composite flour wheat:cassava. International Journal of Food Engineering 6(3).

11. Cueto D, Pérez E, Ribotta P, Borno R (2011) Efecto de la adición de harina de yuca (Manihot esculenta Crantz) sobre las características sensoriales, reológicas y físicas de tortas y panquecas. Rev Fac Agron (UCV) 37: 64-74.

12. De Delahaye EP, Jiménez P, Pérez E (2005) Effect of enrichment with high content dietary fiber stabilized rice bran flour on chemical and functional properties of storage frozen pizzas. J Food Eng 68: 1-7.

13. Pérez E, Pérez L (2009) Effect of the addition of cassava flour and beetroot juice on the quality of fettuccine. African Journal of Food Science 3: 352-360.
14. AACC (2003) Cereal Laboratory Approved Methods St Paul, MN, USA.
15. AOAC (2000) Official Methods of Analysis (17th Ed) Arlington, Virginia USA.
16. Instituto Nacional de Nutrición (2001) Tabla de composición de los alimentos para uso práctico, Ministerio de Salud y Desarrollo Social, Pub. N° 54, Serie de Cuadernos Azules, Caracas, Venezuela, 97p.
17. Skerritt JH, Hill AS (1990) Monoclonal antibody sandwich enzyme immunoassays for determination of gluten in foods. J Agric Food Chem 38: 1771-1778.
18. Nielsen S (2003) Food Analysis (3rd Ed) Kuwer Academic-Plenum Publishers, Nueva York, pp 257.
19. Holm J, Björck I, Asp NG, Sjöberg LB, Lundquist I (1985) Starch availability in vitro and in vivo after flaking, steam-cooking and popping of wheat. J Cereal Sci 3: 193-206.
20. Cooke RD (1978) An enzymatic assay for the total cyanide content of cassava (Manihot esculenta Crantz). J Sci Food Agric 29: 345-352.
21. Golli I, García LD, Mañas E, Saura FC (1996) Analysis of resistant starch: a method for foods and food products. Food Chem 56: 445-449.
22. Subramanian S, Viswanathan R (2007) Bulk density and friction coefficients of selected millet grains and flours. J Food Eng 8: 118-126.
23. Bedolla S, Rooney LW (1984) Characteristics of U.S. and Mexican instant maize flours for tortilla and snack preparation. Cereal Food World 29: 732-735.
24. Aksisse N, Hounhouigan J, Mistres C, Nago M (2003) How blanching and drying affect the colour and functional characteristics of yam (Dioscorea cayenensis-rotundata) flour. Food Chem 82: 257-264.
25. Hsu C-L, Wenlung C, Ming W-Y, Tsenga C-Y (2003) Chemical composition, physical properties and antioxidant activities of yam flours as affected by different drying methods. Food Chem 83: 85-92.
26. Hunter Lab Manual (2001) Hunter Associates Laboratory Universal software version 3, 8 ISO 9001 certified.