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Infant dairy-cereal mixture for the preparation of a gluten free cream using enzymatically modified rice flour

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ABSTRACT

The hydrolysis of rice flour produces a sweet-tasting product with an agreeable aroma, which could be well accepted by infants. The objective of the present study was to determine the feasibility of developing an infant food in the form of a powdered pre-mix for making a cereal cream, based on sugar, powdered milk and rice flour modified by α-amylase and amyloglucosidase. The effect of the ingredients on the properties of the dry mix and of the cereal cream after preparation, were evaluated using a Simplex design. The formulation with 5 g 100 g^{-1} refined sugar (sucrose), 40 g 100 g^{-1} milk powder and 55 g 100 g^{-1} modified rice flour was selected, considering the highest values for solubility in water (49.8 g 100 g^{-1}) and in milk (46.4 g 100 g^{-1}), the luminosity (88.8) of the dry mix, and the firmness (0.19 N) of the prepared formulation. The infant food obtained a mean score of 8.0 for sensory acceptance, and had characteristics similar to commercial products. We concluded that it was feasible to produce an infant food with the enzymatically modified rice flour. The dry mix had advantages when compared with commercial products with respect to economic and ecological factors (rice flour from broken kernels).

1. Introduction

Among other functions, starch can serve to alter the texture, act as a thickener, provide suspended solids or facilitate food processing. Rice starch is used as an ingredient in various foods and industrial products such as desserts, bakery products, breakfast cereals, hypoallergenic products, infant formulas and fat substitutes (Zavareze et al., 2009).

Broken grains are produced during rice dehulling and polishing. This by-product has been used in the production of modified starches, with the advantages of low cost and great availability, being feasible for industrial utilization (Limberger, Silva, Emanuelli, Comarela, & Patias, 2008). The use of modified starches has been an alternative to improve the characteristics of foods that the native starches, due to the limitations of their pastes and gels, are unable to confer (Kaur, Ariflin, Bhat, & Karim, 2012). Modified rice flour is present in the products used to coat foods prepared for frying, to decreasing fat absorption, and as a thickener in yogurts, soups, infant foods and diet cereal shakes (Augusto-Ruiz, Bonato, Arrieche & Alves, 2003).

Enzymatic hydrolysis stands out among the industrial techniques used to produce modified starches. The rate of hydrolysis of starch depends on the botanical origin, the size of the granules and on the enzyme system used, among other factors. The α-amylases are endoenzymes that catalyze the hydrolysis of the α-1,4glycosidic bonds in the starch polymers in a random manner, liberating products of medium molecular weight. Amyloglucosidase is a hydrolytic enzyme that acts on the α-1,4glycosidic bonds from the non-reducing end of the amylose or amylopectin, and at a reduced rate hydrolyzes α-1,6 bonds liberating β-D-glucose (Damodaran, Parkin, & Fenemma, 2010).

Starch gives a typical flavor upon cooking, a bland taste, but some of its hydrolysis products, such as maltose and glucose, have a sweetish taste. After hydrolysis, during drying of the hydrolyzed solution, the Maillard reaction can occur between the sugars and amino acids if high temperatures are used. At the end of drying,

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when the moisture content is low, sugar caramelization can occur. Both these reactions can produce different aromas, according to the combination of free amino acids and sugars present in each food in particular, and the temperature used (Fellows, 2008; Purlis, 2012).

The production of glucose from rice flour starch could produce new ingredients for incorporation into various types of product such as bakery products, ice-creams, sweets and other confections (Severo, Moraes, & Ruiz, 2010). However, to date, broken kernel rice flour modified by the enzymes α-amylase and amyloglucosidase has not been used in dry mixtures for the preparation of cereal creams that normally use malted wheat flours. This technology is not feasible to be applied to broken rice grain (by-product), once broken rice grains do not germinate, and therefore cannot be malted.

In various countries wheat flour is the main ingredient of bakery products, other confections and some fried foods, causing problems to those suffering from celiac disease (Castillo, Lescano, & Armada, 2009). Enzymatically modified broken rice flour dried at high temperatures could originate a product with a sweet taste and agreeable aroma, which could be used to formulate products destined for the infant population, and which could also be used for individuals allergic to gluten.

Celiac disease is characterized by intolerance to the gliadin fraction present in wheat and to the prolamins present in rye, triticale and oats, and has been recognized as one of the chronic diseases in infancy throughout the world, with an estimated 1% of children suffering from it in the west of the United States (Kurppa et al., 2010). The objective of the present study was to determine the feasibility of developing an infant food in the form of a powdered mix to make a gluten-free cereal cream based on enzymatically modified broken rice flour, milk powder and sugar. The selected formula was evaluated by sensory analysis and compared to three similar wheat-based products available on the market.

2. Material & methods

2.1. Material

Mixed broken grains from the cultivars Puitá and Irga 417, produced in Rio Grande do Sul, Brazil in 2011, were donated by Cristal Alimentos S/A (Aparecida de Goiânia, Goiás, Brazil) and used to produce the modified rice flour. The enzymes were amyloglucosidase (EC 3.2.1.3.) from *Aspergillus niger* (*Spring Ag*) and α-amylase (EC 3.2.1.1.) from *Aspergillus oryzae* (*Spring Alfa 125000*), both freeze dried and donated by Granotec do Brazil S/A, Curitiba, Paraná, Brazil. The ingredients used and the commercial cereal–milk mixes were acquired from supermarkets Londrina, Paraná, Brazil in the period between September and November, 2011. The following ingredients were included in the formulation of the dry gluten-free cereal cream: modified rice flour, whole instant milk powder (Nestle, Brazil) and refined sugar (União, Brazil). For the sensory evaluation whole UHT milk (Tyrol) and artificial vanilla aroma (Fleischman) were used to prepare the cereal creams. Commercial cereal–milk mixes (Nutrimental, Nestle and Carrefour) were used for comparison to the selected formulation.

2.2. Production of modified rice flour

The broken rice grains were ground in a hammer mill (Marconi, MA-090/CF, Piracicaba, Brazil), passed through the sieve with 0.250 mm and retained on the 0.150 mm sieve. For the enzymatic hydrolysis, the rice flour was used in a proportion of 20 g 100 mL^{-1}(Beninca, 2008). Two EU of α-amylase per gram of flour was used in sodium acetate buffer, pH 5.0 and at 40 °C. The suspension was maintained in high density polyethylene containers in a Dubnoff-type water bath with agitation (Tecnal TE-053, Ourinhos, Brazil) for 2 h. Subsequently, amyloglucosidase 3.5 EU per gram of flour, diluted in the same solution, was added to the partially hydrolyzed material, reducing the concentration of the material to 16 g mL^{-1} (Silva, Asquieri, & Fernandes, 2005), and returned to the water bath for a further 3 h. The enzymatic hydrolysis was carried out in 60 g batches of rice flour with 300 mL of α-amylase solution and 75 mL of amyloglucosidase solution. After the enzymatic hydrolysis the hydrolyzed material was dried in a sterilization oven at 100 °C for 8 h to final moisture content between 3.0 and 4.5 g 100 g^{-1}. The dried product was ground in a mill (IKA, A11, Diadema, Brazil) and standardized in 32 mesh sieves.

2.3. Production of the mixes for preparation of the cereal creams

The effects of the ingredients of the ternary formulation on the physical and functional properties of the dry mixes and the cereal creams were investigated, varying the concentrations of the modified rice flour (59–75 g100 g^{-1}), instant milk powder (20–40 g100 g^{-1}) and refined sugar (5–15 g100 g^{-1}). A simplex design was used according to Table 1. The mixtures were homogenized for 2 min in a planetary cake mixer (Arno, BPA, São Paulo, Brazil) and dried to final moisture content between 3.0 and 4.5 g100 g^{-1}.

2.4. Preparation of the cereal creams

The cereal creams were prepared in the proportion of (0.08:1) (g:mL) as defined in preliminary tests. Thus 80 g of the experimental modified rice flour, milk powder and sugar mix plus 2 mL of artificial vanilla aroma were added to 1 L whole milk. The suspension was heated in a stainless steel pan with constant stirring, maintaining the temperature at 90–93 °C for 8 min, obtaining the consistency of a cream. In parallel the commercial cereal with milk mixes were prepared according to the manufacturer's labels instructions.

2.5. Physical and functional properties of the dry mixes and the cereal creams

The water absorption index (WAI), milk absorption index (MAI), water solubility index (WSI) and milk solubility index (MSI) were determined in the experimental mixes and in the three commercial brands of cereal–milk mixes according to the methodology of Anderson, Conway, Pfeifer, and Griffin Junior (1969), as well as instrumental color parameters (Colorquest colorimeter, Color Quest, XE, Reston, USA) according to the CIELab system. The observation angle was fixed at 10° and the standard illuminant as D65 corresponding to natural daylight. The results were expressed in L^*, a^*, b^*, C^* and h^* units, where L^* (luminosity) varied from black

Table 1
Experimental design for powdered pre-mixes of the infant food product (represented by real and pseudo-component concentrations).

Experiment[b]	Sugar (c_1)	Milk powder (c_2)	Modified rice flour (c_3)	X_1[a]	X_2	X_3
1	0.05	0.20	0.75	0	0	1
2	0.15	0.35	0.50	0.4	0.6	0
3	0.15	0.20	0.65	0.4	0	0.6
4	0.05	0.40	0.55	0	0.8	0.2
5	0.10	0.40	0.50	0.2	0.8	0
6	0.10	0.31	0.59	0.2	0.44	0.36
7	0.10	0.31	0.59	0.2	0.44	0.36

[a] $X_1 + X_2 + X_3 = 1$ or 100%.
[b] Source: STATSOFT (2007).