

*Full Length Research Paper*

# Development and characterization of cake made with a mixture of cowpea and rice flours

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**This study developed a cake recipe based on a flour mixture of cowpea and rice. Four formulations with different percentages of cowpea flour (CF) and rice flour (RF) (0% CF + 100% RF, 10% CF + 90% RF, 20% CF + 80% RF, 30% CF + 70% RF) were developed. Microbiological, physicochemical and sensory evaluations were performed. Tasters preferred the mix formulation containing 10% of cowpea and 90% of rice ( $p < 0.05$ ), that revealed adequate physicochemical and microbiological characteristics. It is worth noticing the low lipid, high fiber, iron and zinc content, and gluten free characteristic of the developed product. The study also showed 91% of acceptance and 66% of purchase intention by the tasters. We conclude that the use of the flour mixture of cowpea and rice produced an innovative, nutritious product with good acceptance and technological potential that stimulates the production of family farming and, at the same time, increases consumption of rice and beans by the Brazilian population.**

**Key words:** Legumes, family farming, *Vigna unguiculata*, sensory evaluation.

## INTRODUCTION

Legumes are highly regarded both in the international and national scenario due to their nutritional value and socioeconomic importance (IQBAL et al., 2006). Brazil is the third producer of beans, accounting for 12% of the global production, making them an important crop in the country (Brasil CONAB, 2015).

Family farming is the main supplier of foodstuffs for the Brazilian domestic market. Thus, it helps to control the inflation rates by controlling the price of food (Brazil,

2017). According to the agricultural census, family farming is responsible for 83% of the bean consumed in the homes of the state of Bahia (Brasil, 2014).

Cowpea (*Vigna unguiculata* (L.) Walp.), also known as string beans or macassar beans, is one of the main agricultural crops in the Brazilian North and Northeast regions, widely cultivated by family farmers. This legume stood out as an important ingredient of the diet of the population in this region and represents one of the main

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**Table 1.** Formulations of the cakes containing 0, 10, 20 and 30% of cowpea flour (CF) and different percentages of rice flour.

Ingredient	CF (%)			
	0	10	20	30
Cowpea flour(g)	-	29.65	58.48	87.73
Rice flour (g)	292.44	262.80	237.95	204.71
Margarine (g)	87.87	87.87	87.87	87.87
Sugar(g)	150.00	150.00	150.00	150.00
Eggs(g)	110.12	110.12	110.12	110.12
Wholemilk (g)	189.52	189.52	189.52	189.52
Baking powder (g)	5.00	5.00	5.00	5.00
Salt (g)	0.40	0.40	0.40	0.40

sources of employment and income (Freire Filho et al., 2011).

From the nutritional point of view, cowpea is considered a staple food source for carbohydrates (mainly the complexes ones), considerable amounts of fibers, vitamins and minerals (phosphorus, iron, potassium, magnesium, zinc and manganese), bioactive compounds, and essential amino acid, especially lysine (Freire Filho et al., 2011; TACO, 2011). On the other hand, rice (*Oryza sativa L.*) is a very common component of the Brazilian diet, being a source of vitamins, mainly of the B complex, minerals and fibers. The typical Brazilian combination of rice and beans is recommended by health agencies for providing the complementarity of essential amino acids (Brazil, 2014; Mesquita et al., 2007; Monks et al., 2013).

The dietary guidelines for the Brazilian population recommend daily consumption of rice and beans in the proportion of 2: 1 (Brazil, 2014). However, due to changes in the eating habits of Brazilians between 2002 and 2009 there was a reduction of 40.5% in the participation of rice in the household dietary index and 26.4% of beans, while the participation of industrialized ultra-processed food products increased (IBGE, 2011).

The use of a flour mixture of beans and rice in food formulations has been studied as a strategy to add a higher nutritional value and functional properties to gluten-free products without raising their final cost (Chávez-Santoscoy et al., 2016).

In this context, the objective of this study is to develop a cake made with a flour mixture containing cowpea and rice, rescuing the consumption habits of rice and beans and eventually valuing the traditional Brazilian diet.

## MATERIALS AND METHODS

### Sampling and production of cowpea flour

The grains of the cowpea beans (immature seed) were obtained from family farmers in the city of Santo Antônio de Jesus - Bahia. Average temperature variation between seasons is small in the region. The grains were selected, washed and bleached in the Food

Technology Laboratory at UFRB.

To obtain the flour, the cowpea grains were dried in an oven (Biopar, Porto Alegre, Brazil) at 50°C for 30 h and then ground in a food processor (Philips, São Paulo, Brazil). The flour was sieved with a 21 mm mesh, packed in plastic containers and stored at 25°C.

### Technological functional properties of cowpea flour (CF)

To determine the gelling capacity of cowpea flour (CF), we used the modified method of Coffmann and Garciaj (1977). The water absorption index (WAI) was determined according to Beuchat's methodology (1977) and the water solubility index (WSI), according to the modified method of Okezie and Bello (1988).

### Preparation of cake formulations

Following the results of previous laboratory tests, we developed four formulations with different percentages of cowpea flour (CF) and rice flour (RF) (0% CF+ 100% RF, 10% CF + 90% RF, 20% CF + 80% RF, 30% CF + 70% RF) based on a traditional recipe (Table 1).

All the ingredients were weighed in a semi-analytical balance (Marte, São Paulo, Brazil). Eggs, margarine and sugar were added to the mixer (Arno, São Paulo, Brazil) to prepare the dough. RF and CF were added to the mixture and homogenized for 15 min. Milk, salt and baking powder were added gradually. The prepared dough was placed in an aluminium tray, greased with margarine and sprinkled with RF, and baked in an oven (Metalmaq, Duque de Caxias, Brazil) preheated at 180°C for 1 h.

### Sensory evaluation

This study was approved by the Federal University of Reconcavo da Bahia (UFRB) Ethics Committee (Process n. 31797114 0000056). All subjects signed the Informed Consent Form (ICF). Sensory evaluation was conducted at UFRB.

### Ranked -preference test

The test was carried out inside individual booths with 40 untrained tasters. They were offered four cake samples in disposable dishes coded with a three-digit code in random order. The tasters were asked to taste the four samples from left to right and rate them

**Table 2.** Functional properties of cowpea flour

Parameter	CF
Gelification capacity (%)	10
Water Absorption Index (gel/g)	3.53 ±0.174
Water Solubility Index (%)	13.66 ±0.577

according to their preference.

Results were analyzed with the Friedman's non-parametric test at 5% of significance (Meilgaard et al., 2007).

#### Acceptance test and purchase intent

The acceptance test and purchase intent were carried out with potential consumers of the product based on the most preferred sample, according to the previous test. The test was conducted with 100 untrained tasters (employees, teachers and students at UFRB).

The 9-points hedonic scale was used in the acceptance test, ranging from 1 (dislike extremely) to 9 (like extremely). The same scale was used to evaluate the flavor, color, texture and overall consumer acceptance of the product. For the purchase intention assessment, we adopted a structured 5-points scale, ranging from 1 (certainly would not buy) to 5 (certainly would buy) (MEILGAARD et al., 2007).

#### Physicochemical evaluation

The cake selected into the ranked-preference test was characterized in relation to moisture (AOAC, 1997), water activity (DecágonoLab Master, Novasina®), pH, total titratable acidity, proteins, iron, zinc (IAL 2008), lipids (Bligh and Dyer, 1959), fibers (Goering and Van Soest, 1970; Van Soest et al., 1991). Carbohydrates were determined by difference and total caloric value by the Atwater System (Watt and Merrill, 1963). The color parameters (a \*, b, L \*, C \* and h) were determined by the CIELAB System. All evaluations were performed in triplicates.

#### Microbiological evaluation

The microbiological evaluations were made for total and thermotolerant coliforms at 45°C, and the detection of *Salmonella* species and yeasts and molds with the methodology described by the American Public Health Association-APHA (2001).

The physicochemical and microbiological evaluations were carried out at the Applied Research Laboratory of Biotechnology and Food at SENAI-CIMATEC in the city of Salvador –Bahia.

## RESULTS AND DISCUSSION

Average WAI of cowpea flour was 3.53 ±0.174 g of water g<sup>-1</sup> (Table 2). This result was higher than the one found by Gomes et al. (2012), who found 2.63 g.g<sup>-1</sup> in cowpea tegument-free flour. In the food industry it is known that higher WAI values yields better bakery products. This is due to water retention by the starch granules that confer moisture and softness to the final product (Wang et al., 2006). The WSI was 13.66%, a result lower than the one found by Rios et al. (2016). The authors found values

between 17 and 23% in flours of five commercial cowpea cultivars. Solubility is closely related to proteins type, structural conformation and presence of polar amino acids. Globulins are abundant in beans, especially in the cotyledon. Although they are only partially soluble in water, they are easily denatured, which can influence the solubility index. In addition to that, the higher proportion of amylose in the starch granules of mature beans also contributes to an increase in hydrophilicity (Salgado et al., 2005; Lourenço, 2000). It is worth noticing, however, that our study was based on flours obtained from immature grains with tegument, which may explain our result. It is worth mentioning that the immature form of the grain is massively consumed by the population.

Gel formation was observed at the concentration of 10% of CF. Medeiros (2013) found similar results (8 - 10% of CF), while Pereira (2013) found gelling ability at 14% of CF. Gel formation is associated with starch gelatinization, dependent mainly on the amylose content, and on the ability of proteins to form three-dimensional networks capable of holding water (Singh et al., 2003).

Table 3 shows that sample CF10 is similar to the standard sample and differs from CF20 and CF30 (p <0.05). Based on these results, we chose sample CF10 (the most preferred sample) to proceed with the acceptance test, and physicochemical and microbiological assessments.

Participants of the acceptance test were mostly females (74%), and their age range was distributed as: 51% (21-29 years); 16% (30-39 years); 7% (40-49 years); 2% (50-59 years). Regarding their cake consumption habits, most participants consume the product monthly (32%), followed by fortnightly (27%), 2 to 3 times a week (11%), once a week (28%), and daily (1%). This shows that the consumption of cakes by this population is not usual. However, cake consumption is high among children and adolescents. Bezerra et al. (2013) observed that adolescents are the main consumers of cakes, among the studied age groups. Corroborating this result, Souza et al. (2017) reported frequent cake consumption by elementary school children.

According to the acceptance test, the CF10 cake recipe was approved by tasters with 91% of positive acceptance (ratings 6 to 9 in the acceptance scale) (Figure 1A). Similarly, Frota et al. (2010) obtained 84.4% of acceptance for sweet biscuits with 10% of CF. This recipe also obtained 66% of positive purchase intent (probably would buy or certainly would buy). The negative purchase intention

**Table 3.** Statistical analysis of the cake formulations based on cowpea flour in the ranked –preference test.

Sample	Scores*
RF	92 <sup>ab</sup>
CF10	78 <sup>a</sup>
CF20	115 <sup>b</sup>
CF30	115 <sup>b</sup>

RF=Rice flour cake used as control; CF10=cake recipe with 10% of cowpea flour; CF 20=cake recipe with 20% of cowpea flour; CF30=Cake recipe with 30% of cowpea flour. Scores followed by the same letter did not differ from each other at the 5% of significance. \*Total taste score attributed by tasters.

(certainly or probably would not buy) reached 4%, while 30% of tasters were not sure (Figure 1B).

The sensorial attributes of flavor, color, texture and overall acceptance obtained averages of 6.73, 7.52, 6.07 and 7.08, respectively, ranging from "like slightly" to "like moderately". Lower values were found by Farias et al. (2016) when evaluating cookies made with CF, obtaining averages of 5.46, 6.49, 5.65, and 5.93 for the attributes of color, flavor, texture and general evaluation, respectively.

The product's sensorial aspects were acceptable, demonstrating the viability of the use of RF and CF in cake recipes. The product incorporates ingredients cropped by family farmers, meets the demand for gluten-free foods and can be included in school meals, as recommended by the Brazilian School Feeding Program (PNAE) (Brasil, 2009).

The developed recipe can also help to rescue the habit of consumption of rice and bean recommended by the food guide (Brazil, 2014). The annual consumption of beans per capita in Brazil dropped from 12.4 kg/inhabitant/year in 2002-2003 to 9.1 kg/inhabitant/year in 2008-2009. In the same period, the annual consumption of rice per capita decreased 16.1%, from 24.5 to 14.6 kg/inhabitant/year (IBGE, 2011).

The results of the centesimal analysis of the CF10 formulation are shown in Table 4. pH found for the product was 7.53 and acidity 0.27%. Guimaraes et al. (2010) found post-cooking pH between 7.45 and 6.66, and acidity of 1.0 and 4.56% in cakes produced with 7 and 10% of watermelon rind, respectively.

The moisture content of the product was 34.20%, which is higher than that found by Carvalho et al. (2011) in a cake containing 50% of white bean flour in combination with wheat flour (32.83%). Water activity was 0.950, higher than that found by Gutkoski et al. (2009) in samples of English-type cakes (0.850 to 0.890).

Ash content was 5.62%. Carvalho et al. (2011) found 2.97% of ashes. Frota et al. (2010) found 2.83% of ashes in Brazilian rolls and 2.98% in biscuits with partial substitution of wheat flour for 10% of cowpea flour.

The lipid content (6.0%) was lower than the one reported by Carvalho et al. (2011) who identified 10.0%

of lipids in cake formulation containing 50% of white bean flour. Frota et al. (2010) also identified higher lipid content (11.96 and 11.98%) in biscuits and Brazilian rolls with 10% CF, respectively. The reduced lipids content found in our recipe follows the global demand for healthy diets.

Protein content reached 8.17%, higher than the one found by Guimaraes et al. (2010), who reported 6.47% of protein in a cake recipe with wheat flour. The partial substitution of rice flour for beans flour not only increases the protein content of the recipe but also improves its amino acid profile (Brasil, 2014).

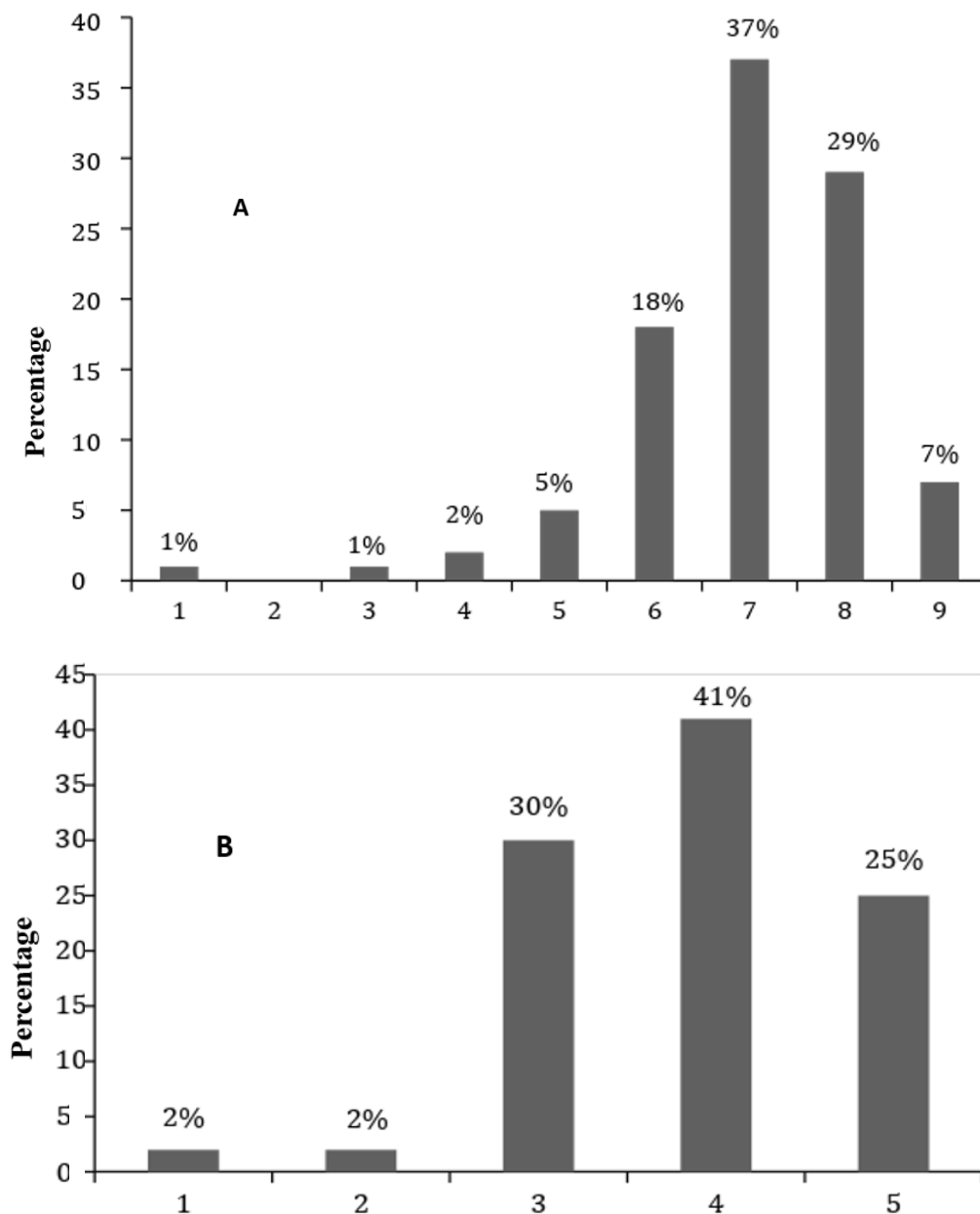
Carbohydrate content of the product was 36.62%. Cavalcante et al. (2016) and Carvalho et al. (2011) found between 51.5 and 74.91% in cassava cheese bread enriched with 5.6% of CF and cake containing 50% of white bean flour, respectively.

In the present study, we quantified two important micronutrients, iron and zinc, and compared them with a few existing studies. We found 2.04 mg of iron/100 g of product, which is higher than the results found by Awasthi (2014) in cake made with refined wheat flour (0.14 mg/100 g). The content of zinc was 2.48 mg/100 g. Frota et al. (2010) found 0.70 mg and 0.42 mg/100 g in biscuits and Brazilian rolls with 10% of CF, respectively.

Addition of CF can, thus, improve iron and zinc intake. This makes it especially suited for school meals, since children are the most affected by micronutrient deficiency (Pedraza and Rocha, 2016). The amount of iron and zinc found are within the recommended Dietary Reference Intakes (DRI) for children between 4 and 8 years old (20.4 and 40.8% of the DRI, respectively). For children between 9 and 13 years old, the product meets 25.5% of the DRI for iron and 22.54% for zinc (IOM, 2002).

The product contains 9.388% of fibers. Carvalho et al. (2011) found 5.18% of fibers in a cake containing 50% of white bean flour. Awasthi (2014) reported 1.12% of fibers in a cake is made with refined wheat flour.

The energy content of the cake was 233.16 Kcal/100 g. In cakes made with rice flour and cassava peel in different percentages, energy content varied from 184.76 to 281.7 Kcal.g<sup>-1</sup> for recipes with 100% cassava peel flour and 100% rice flour, respectively (Souza et al., 2013).



**Figure 1.** Distribution of acceptance rates of the cake recipe with 10% of cowpea flour. (A) Frequency distribution of acceptability scores: 1= Dislike Extremely; 2= Dislike a Lot; 3= Dislike Moderately; 4= Dislike Slightly; 5= Neither Like/Nor Dislike; 6= Like Slightly; 7= Like Moderately; 8= Like a Lot; 9= Like Extremely; (B) purchase intention: 1= Certainly Would Not Buy; 2= Probably Would Not Buy; 3= Maybe Would Buy / Maybe Would Not Buy; 4= Probably Would buy; 5=Certainly Would Buy.

The parameters of chromaticity were  $a^* = 2.77 \pm 0.170$  and  $b^* = 18.65 \pm 0.421$ . The parameter of luminosity was  $L^* = 53.223 \pm 0.456$ .  $C^*$  and  $h$  indicated that the product showed low saturation and yellowish hue with values of  $18.860 \pm 0.407$  and  $51.547 \pm 0.633$ , respectively. These results indicate that the addition of CF reduced  $L^*$  and increased  $b^*$ , moving towards a yellow core. Similar results were found by La Hera et al. (2012) for cakes

made with lentil flours. Camili et al. (2016) found  $L^* = 29.06$ ,  $C^* = 17.10$  and  $h = 42.74$  for the kernel of cakes made with wheat flour.

The microbiological evaluation showed that the product met the microbiological standards required by the Brazilian legislation (Brasil, 2001): negative for *Salmonella* species, contamination by molds and yeasts  $<1 \log \text{CFU/cm}^2$ , total coliforms  $<3 \text{ NMP/g}$ , and coliforms

**Table 4.** Mean and standard deviation of the centesimal composition of the recipe with 10% of cowpea flour.

Parameter	Average±SD
pH	7.53±0.081
Acidity	0.27±0.050
Water activity	0.950±0.008
Moisture (%)	34.20±1.191
Ashes (%)	5.62±1.31
Lipids (%)	6.0±0.339
Proteins (%)	8.17±0.053
Carbohydrates (%)	36.62±0.246
Energy value (Kcal/100 g)	233.16±4.300
Fibers (%)	9.38±1.585
Iron (mg/100 g)	2.04±0.003
Zinc (mg/100 g)	2.48±0.068

at 45°C <3 NMP/g.

## Conclusions

It can be concluded that the incorporation of CF in RF resulted in a product with adequate sensorial, microbiological and physicochemical characteristics. The product use rice and cowpea in optimized gluten-free food formulations with low lipid, high fiber, iron and zinc content. Additionally, it stimulates the production of family farming and values the traditional Brazilian diet.

## CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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