Advance Journal of Food Science and Technology 15(SPL): 205-209, 2018
DOI:10.19026/ajfst.15.5896
ISSN: 2042-4868; e-ISSN: 2042-4876

Submitted: September 14, 2017 Accepted: December 15, 2017 Published: July 10, 2018

Research Article

Effects of the Use of Cassava Flour in the Physical and Sensory Properties of Bread

Ruiz Luis E., Garcia Emith V. and Serpa José G.
University of Sucre, Cra 28 N° 5-267 Sincelejo-Sucre, Colombia

Abstract: The aim of this study was to evaluate the effect of the use of Cassava Flour (CF) enriched with gluten in the baking process. It was determined: growth, weight loss, specific volume and sensory evaluation of bread. A completely randomized design of experiment with a 3×4 factorial arrangement was performed using three types of Cassava Flour (CF): Commercial (CCF), with peel (PCF) and without peel (WPCF) in four levels of substitution: 12.5; 25, 37.5 and 50%, plus a control 100% wheat flour (WF). Growth and weight loss were assessed by measuring volume and mass before and after the baking process; the specific volume for the relation between volume and mass of baked bread and a test of sensory preference. The results showed significant differences in growth between the control and the treatments of flour with the 50%substitution. Weight loss showed significant differences between the control and all treatments except for the level of 12.5% with (CCF) and (PCF). The specific volume had significant differences with the control in all levels except for 12.5% (PCF). Bread with a substitution level of 12.5% (WPCF) did not show significant differences in acceptability with respect to the control. It is concluded that the use of (WPCF) with a substitution level of 12.5% is a technological alternative for bread making because of present good sensory acceptance and characteristics similar to those of bread elaborated with 100% (WF).

Keywords: Baking process, gluten, physical properties, wheat flour

INTRODUCTION

The cassava is an important source of calories in tropical regions of Africa, Asia and America, where millions of people depend on it. This tuber can satisfy food needs of its producers and at the same time serve in the development of its processing industry, since it can become a basic raw material for the production of diverse products, thus increasing this tuber demand and the economic growth of developing countries (FAO, 2008).

Caused by the dependence of many Latin American countries on the importation of wheat for bakery industry, using other sources of flour in baking, is technically interesting since wheat proteins have the capacity to spread and retain the air produced in the fermentation process (Rodríguez-Sandoval *et al*., 2012). Gluten is a protein that allows wheat flours to form a mass capable of retaining gases in baking products; there is no other flour that has comparable properties (Villanueva, 2014). However, diverse studies with cassava flour in bread products have allowed for the development of bread without significantly affecting the processing and with final quality similar to those produced with wheat flour using levels of substitution between 5 and 10% of cassava flour in the formulation (Galvis *et al*., 2017). According to Tejero (2015), the addition of gluten to flours increases the protein content and improves the baking properties in those with high fiber content, allowing the addition of higher percentages of flour of other cereals or grains with good fiber content and thus obtaining bread with good volume. In the baking process, the bread volume grows because the heat supplied stimulates the CO_2 production in yeast, as well as weight loss by evaporation of water (Badui, 2012).

This study evaluated the effect of partial substitution of wheat flour for cassava flour with gluten in the bread making process, which is expected to produce products with similar physical and organoleptic properties to those made with wheat flour and increase the industrial uses of cassava.

MATERIALS AND METHODS

Materials obtaining: The cassava flour processed in the laboratory was obtained from the variety CM 3311 sweet cassava provided by the University of Puerto Rico. To obtain it, the procedure used was described by Hernández *et al*. (2016).

Commercial cassava flour, wheat flour and gluten were purchased in Mayaguez-Puerto Rico, from the

Corresponding Author: Ruiz Luis E., University of Sucre, Cra 28 N° 5-267 Sincelejo-Sucre, Colombia, Tel.: (57+5)3006007249

Lares brands, in the case of cassava and Goya for wheat products.

Proximal analysis of flour and bread: The flours used and processed breads were evaluated for their proximal composition following AOAC (2000) for humidity, protein, ashes, fat and fiber contents. The carbohydrates were calculated by difference with the other components.

Bread baking process: The loaves of bread made in this research were of the special type and the direct method described by Pacheco and Testa (2005) was used. The formulation used was: 78.12% flour, 9.37% sugar, 6.25% margarine, 4.68% yeast, 1.56% salt and 50-55% water was added according to the flour weight. The baking was done in a conventional oven at 175 °C for 12 min.

Analysis of the physical properties of bread: The loaves of bread were evaluated for their physical properties, volume and mass before and after the baking process. Based on this information, the growth (G), Specific Volume (SV) and percentage of Weight Loss (WL) during the baking stage were calculated.

The mass of the loaves of bread was determined using a digital balance with an accuracy of 0.1 g. The volume (Vol) was determined by the displacement method (AACC, 1984), using canola seed as "fluid". The specific volume of the bread was obtained using Eq. (1):

$$SV = \frac{\text{Volume of baked bread}}{\text{Mass of baked bread}} \quad (1)$$

Growth during the baking was evaluated using Eq. (2):

$$G = \text{Vol after baking} - \text{Vol before baking} \quad (2)$$

The percentage of weight loss during the baking was evaluated using Eq. (3):

$$\%WL = \frac{\text{weight before baking} - \text{weight after baking}}{\text{weight before baking}} \quad (3)$$

Sensory evaluation of bread: The breads with better physical properties during the baking were sensory analyzed, where the attribute evaluated was the preference. For this, 80 untrained panelists were used. The test used was the simple ordering of five points, where the rating of 1 (one) corresponded to the best bread and (five) to those of lesser preference.

Experimental design: For the experimental design, a 3×4 factorial model was used, with two variables: 1) Flour ratio of Cassava Flour (CF)/wheat flour (WF), for which they had 4 levels: 12.5/87.5, 25/75, 37,5/62.5, 50/50; 2) Cassava flour origin, using three levels: commercial cassava flour (CCF), cassava flour prepared in the laboratory with peel (PCF) and without peel (WPCF), also a control with wheat flour. For a total of 13 treatments. The results were statistically analyzed using Analysis of Variance (ANOVA) using the Infostat V3.0 program. The means of significant effects ($p<0.05$) were compared with the Tukey's test. The sensorial test was performed using the Friedman method.

RESULTS AND DISCUSSION

Proximal composition of flours: Table 1 shows the proximal composition of the flours used in this research.

The protein content had significant differences ($p \leq 0.05$) between wheat flour and cassava flour with gluten. Studies by De la Vega (2009) confirm that a flour for baking should contain between 10 -12% protein, the cassava flours oscillated between 11.06% and 11.16%, so they are inside the ideal range. Enriching cassava flours with gluten, favors the increase of proteins levels, suggesting the production of bakery products with better quality.

The humidity, carbohydrates and ashes contents presented significant differences ($p \leq 0.05$) among the flours used. In spite of differences, the flours are within the limits established by Codex Alimentarius Commission (1985, 1989), for wheat flour and cassava flour, respectively. Likewise, crude fiber content showed significant differences ($p \leq 0.05$). The fiber of cassava flour was higher than wheat flour. Henao and Aristizabal (2009) found that with substitutions of 5-15% WF, crude fiber increased by 30%, which improved water absorption, time of development of the mass and resistance during the kneading, but decreased capacity to retain CO2 and bread volume. Regarding fat content, the analysis of variance did not detect significant differences ($p \geq 0.05$) between the flours studied.

Proximal composition of bread: The results obtained in the proximal analysis of the breads produced in this research are shown in Table 2.

The protein, carbohydrate and fat contents did not present significant differences ($p \geq 0.05$) among the breads under study. About humidity, significant differences were found between the control and the breads made with CCF in the proportion of 50%, the elaborated WPCF in all treatments and those of PCF 37.5% and 50% of substitution. This result evidences a proportional influence between the amount of cassava flour added and the humidity. There were no significant differences ($p \geq 0.05$) in moisture content between breads made with CF/WF. In fiber, the only treatments that did not present significant differences with the control were those made with CCF 12.5% and WPCF 12.5% and 25%, which was expected due to the high content of this component in the cassava flours. These

Table 1: Proximal composition of the flours*

Source	Protein (%)	Humidity (%)	Fat (%)	Fiber (%)	Ashes (%)	Carbohydrates (%)
WF	12.04^{a}	12.76^{a}	0.55^{a}	0.29^{b}	0.38^{c}	86.74^{a}
CCF	11.16^{b}	8.11^{d}	1.17^{a}	2.02^{a}	1.47^{b}	84.17^{b}
WPCF	11.07^{b}	10.01^{b}	1.11^{a}	1.72^{a}	1.82^{b}	84.29^{b}
PCF	11.06^{b}	9.14^{c}	0.80^{a}	2.08^{a}	2.33^{a}	83.73^{b}

Values with different letters in the same column indicate significant differences ($p \leq 0.05$); WT: Wheat Flour; CCF: Commercial Cassava Flour; WPCF: Cassava Flour without peel; PCF: Cassava Flour with peel; *Determined on dry basis

Table 2: Proximal composition of breads*

Treatment							
Source	% Cassava	Protein (%)	Humidity (%)	Fat (%)	Fiber (%)	Ashes (%)	Carbohydrates (%)
WF	0.0	9.73^{a}	27.28^{b}	2.05^{a}	0.35^{e}	1.48^{cd}	86.39^{a}
CCF	12.5	9.46^{a}	29.85^{ab}	2.06^{a}	0.64^{de}	1.55^{bcd}	86.29^{a}
CCF	25.0	9.63^{a}	29.11^{ab}	1.98^{a}	1.43^{abcd}	1.41^{d}	85.56^{a}
CCF	37.5	9.39^{a}	29.09^{ab}	1.39^{a}	1.56^{ab}	1.72^{abcd}	85.94^{a}
CCF	50.0	9.37^{a}	32.32^{a}	1.16^{a}	1.51^{abc}	1.98^{ab}	85.98^{a}
WPCF	12.5	9.70^{a}	31.15^{ab}	1.04^{a}	0.72^{cde}	0.93^{e}	87.62^{a}
WPCF	25.0	9.54^{a}	30.84^{ab}	1.02^{a}	0.78^{bcde}	1.60^{bcd}	87.06^{a}
WPCF	37.5	9.38^{a}	29.14^{ab}	1.91^{a}	1.51^{abc}	1.74^{abcd}	85.45^{a}
WPCF	50.0	9.33^{a}	31.82^{a}	1.35^{a}	1.58^{ab}	1.90^{abc}	85.86^{a}
PCF	12.5	9.54^{a}	31.20^{ab}	1.41^{a}	1.28^{abcd}	1.72^{abcd}	86.06^{a}
PCF	25.0	9.51^{a}	30.79^{ab}	1.64^{a}	1.45^{abcd}	2.01^{ab}	85.39^{a}
PCF	37.5	9.40^{a}	32.46^{a}	1.59^{a}	1.68^{a}	1.87^{abcd}	85.46^{a}
PCF	50.0	9.34^{a}	30.93^{a}	1.58^{a}	1.70^{a}	2.13^{a}	85.24^{a}

Values with different letters in the same column indicate significant differences ($p \leq 0.05$); *Determined on dry basis

Table 3: Growth, specific volume, and weight loss of breads in baking

Treatment				
Source	% Cassava	Growth (mL)	Specific volume (mL/g)	Weight loss (%)
WF	0.0	15.73^{a}	2.90^{a}	10.01^{a}
CCF	12.5	12.40^{ab}	2.55^{b}	9.61^{ab}
CCF	25.0	13.13^{ab}	2.44^{bcd}	8.10^{c}
CCF	37.5	11.13^{ab}	2.20^{def}	8.26^{c}
CCF	50.0	10.87^{b}	2.08^{ef}	8.27^{c}
WPCF	12.5	13.47^{ab}	2.57^{bc}	8.51^{bc}
WPCF	25.0	13.60^{ab}	2.31^{cde}	8.32^{bc}
WPCF	37.5	13.40^{ab}	2.10^{ef}	7.61^{c}
WPCF	50.0	10.60^{b}	1.97^{f}	7.53^{c}
PCF	12.5	14.47^{ab}	2.64^{ab}	8.75^{abc}
PCF	25.0	11.67^{ab}	2.44^{bcd}	8.37^{bc}
PCF	37.5	11.27^{ab}	2.03^{ef}	7.97^{c}
PCF	50.0	9.93^{b}	1.95^{f}	8.01^{c}

Values with different letters in the same column indicate significant differences ($p \leq 0.05$)

results coincide with those performed by Ballat (2014), which developed a bread making product with wheat flour, cassava and soybean.

Analysis of the physical properties of the breads: The physical properties evaluated during the baking of the breads are shown in Table 3.

The results show that there were only significant differences in growth between the control and treatments with CF/WF for the 50% substitution level. No significant differences ($p \geq 0.05$) were found when comparing the three sources of cassava flour. This shows that the enrichment of the cassava flour with gluten increases the retention of the gas during the baking and the volume of the bread; in this way, better results were obtained than those reported by Henao and Aristizabal (2009).

The specific volume is related to the gas retention capacity of the bread during the baking and depends on gluten (Henao and Aristizabal, 2009). The analysis of variance showed significant differences ($p \leq 0.05$) between the control, with a value of 2.9 g/mL and all treatments except that of PCF 12.5%. In breads elaborated with composite flours, the specific volume oscillated between 1.95 and 2.64 g/mL, which is equivalent to a 31% reduction. The level of substitution did not affect this property in the proportions evaluated because no significant differences were found, however, the results indicate that the addition of cassava flour is a determining factor for this property, since as the wheat flour was replaced the specific volume became smaller. These results coincide with those of Hernández and Franco (2016), with mixtures of wheat flour and cassava starch using transglutaminase enzyme, in proportions of 0.01 to 0.02%, as enhancer. They found that the maximum substitution without significantly affecting the specific volume was with a 20% substitution of wheat flour.

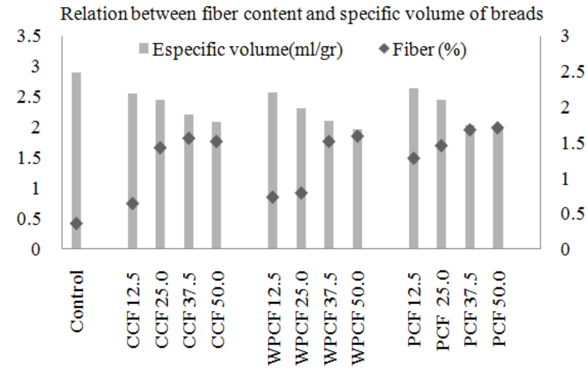

Fig. 1: Relation between fiber content and specific volume of breads

Although the protein in CF/WF composite flours enriched with gluten is acceptable (11-12%) (Table 1), the specific volume decreased. Figure 1 shows the relationship between specific volume and fiber content in breads. It is observed that the greater substitution of (CF), the fiber percentage increases and the specific volume decreases. In studies carried out by Henao and Aristizabal (2009), they found similar behaviors in breads made with cassava flour in substitutions of 5 to 15% of (HT). Alvis *et al*. (2011) used mixtures of brown rice flour and wheat flour and showed that the higher fiber content generates a resistance to the expansion of the bread during the fermentation process and the baking.

In the baking process the breads' weight decreases due to evaporation of water. The analysis of variance showed significant differences ($p \leq 0.05$) with the control, except for breads made with CCF and PCF at 12.5%. When comparing processed breads with a substitution level of 12.5%, it is observed that there are no significant differences, the same trend occurred in the proportions of 25%, 37.5% and 50%. The substitution levels by source showed that only CCF 12.5% presented significant differences with the rest of composite flours. The WPCF and PCF did not present significant differences between them. From this result, it can be inferred that the breads made with cassava-wheat flour have a greater capacity to retain moisture than those produced with only wheat flour. In all treatments, there were decreases in weight loss that ranged from 4% to 25% with respect to the control. Which coincides with the higher moisture content of the breads made with composite flours (Table 1). The humidity values were found within the range reported by Hernández and Franco (2016) in their study with the substitution of wheat flour for cassava starch, in which the moisture of the breads oscillated between 30% and 34%. According to Jorge (2015), breads with the substitution of wheat flour for fish meal at levels of 5 to 10% presented reductions in bread weight loss during the baking.

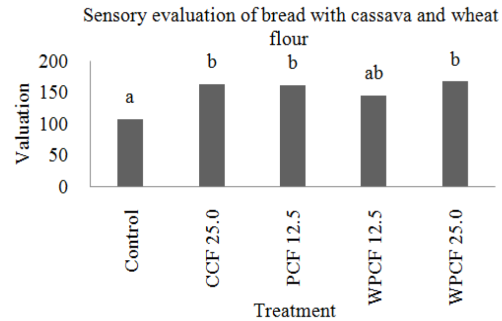

Fig. 2: Sensory evaluation of bread made with cassava and wheat flours

Sensory analysis of breads: Figure 2 also shows the results of the sensorial evaluation of the breads with better physical properties during the baking. Considering the scale used in the sensory analysis, the products with the lowest valuation are those of greater preference by the panelists.

The analysis of variance shown in Fig. 2 revealed that there were significant differences between all treatments and control except those elaborated with WPCF 12.5%. It is also reflected that tasters at the sensory level still prefer the breads made with wheat flour as these had the best rating. There were no significant differences between the different breads made with CF/WF composite flours. In the study by Ballat (2014), with a substitution level of 30% of cassava flour, the breads did not have a good preference because they considered that their color was very pale. Jensen *et al*. (2015) recommends the standardization of the processing variables of bread with the substitution of cassava flour to obtain better quality products.

CONCLUSION

The physical properties of the bread made with wheat-cassava flour differed with the control, the growth was very similar except for the substitution of 50%; by contrast the specific volume was reduced to levels above 12.5%, because of the higher fiber content of the CF/WF mixture; while the weight loss during the baking improved proportionally with the substitution level of cassava flour.

At the sensory level, bread made with wheat flour was preferred by the tasters followed by those with 12.5% cassava flour without peel, which also had physical properties similar to the control. Making it feasible to manufacture bread with gluten-enriched cassava flour using this level of substitution, although it is necessary to investigate processing alternatives in search of improving the adverse effect presented in the specific volume.

CONFLICT OF INTEREST

There is no "Conflict of interest" of the authors, with the results of the investigation.

REFERENCES

AACC, 1984. Official Methods of Analysis. Approve method. 8th Edn., American Association of Cereal Chemists Approve Methods, Washington, D.C.

Alvis, A., L. Perez and G. Arrazola, 2011. Elaborated breads with aggregate of brown rice and modeling of their sensory attributes through surface response methodology. J. Inform. Technol., 22(5): 29-38.

AOAC, 2000. Official Methods of Analysis. Association of Official Analytical Chemists, Washington, D.C.

Badui, S., 2012. The Science of Food in Practice. Pearson. Naucalpan de Juarez, Mexico, pp: 180.

Ballat, F., 2014. Development of a baking product using flour composed of wheat, cassava and soy. Work Master in Technology and Quality in the Processes Food Industries. Public University of Navarra. Spain, pp: 65-72.

Codex Alimentarius Commission, 1985. International Food Standards. Standard for Wheat Flour. Codex Stan 152-1985 (Rev. 1-1995).

Codex Alimentarius Commission, 1989. International Food Standards. Standard for Edible Cassava Flour. Codex Stan 176-1989 (Rev. 1-1995).

De la Vega, H., 2009. Proteins of wheat flour: Classification and functional properties. Sci. Technol. Topics, 13(38): 27-32.

FAO, 2008. Why Cassava? FAO: Agriculture: Cassava. Food and Agriculture Organization of the United Nations. Rome, Italy.

Galvis, J.A.A., J.A.G. Agredo and B.O. Patiño, 2017. Refined cassava flour in bread making: A review. Ing. Invest., 37(1): 25-33.

Henao, S. and J. Aristizabal, 2009. Influence of the cassava variety and the level of substitution of composite flours on rheological behavior in baking. Eng. Res. J., 29(1): 39-46.

Hernández, E., L. Ruiz and F. Mendoza, 2016. Addition of cassava flour in baking dough. J. Vitae, 23(Suppl. 1): 702-707.

Hernández, O. and I. Franco, 2016. Effect of rheological and bread making properties of the enzyme transglutaminase on cassava starches. Acad. J. Technol. Univ., Panama, 12(2): 56-67.

Jensen, S., L.H. Skibsted, U. Kidmose and A.K. Thybo, 2015. Addition of cassava flours in bread-making: Sensory and textural evaluation. LWT-Food Sci. Technol., 60: 292-299.

Jorge, J., 2015. Wheat substitutes in bread making. M.S. Thesis, Polytechnic University of Valencia. Valencia, Spain.

Pacheco, E. and G. Testa, 2005. Nutritional, physical and sensory evaluation of green banana breads. INCI, 30(5): 300-304.

Rodríguez-Sandoval, E., A. Lascano and G. Sandoval, 2012. Influence of the partial substitution of wheat flour for quinoa and potato flour in the thermomechanical and baking properties of masses. J. U.D.C.A., News Sci. Outreach, 15(1): 199-207.

Tejero, F., 2015. Gluten in the Bakery. Technical Assistance in Baking. Technical Articles. Flours. Madrid. Spain. Retrieved from: http://www.franciscotejero.com/tecnicas/el-gluten-en-la-panaderia/.

Villanueva, R., 2014. Wheat gluten and its role in the banking industry. Ind. Eng. Magaz., 32: 231-246.