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Papaya seed flour (*Carica papaya*) affects the technological and sensory quality of hamburgers

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Abstract

The present study evaluated the effect of the addition of papaya seed flour (*Carica papaya*) on technological and sensory quality of hamburgers. Four treatments were prepared, as follows: control (0% flour), T1 (1% flour), T2 (2% flour), and T3 (3% flour). The flour was characterized by having a high content of protein and fiber. A significant increase in cooking yield and moisture retention, and a reduction in hamburger shrinkage was observed as the level of flour increased. The addition of 1% flour did not change the instrumental color of the hamburgers, and no sensory changes were observed up to 2% addition. It can be concluded that the addition of papaya seed flour is a viable way of improving the technological characteristics without impairing the sensory quality of the hamburgers.

Introduction

Hamburgers are meat products widely consumed worldwide. Their sensory quality, practicality, and convenience can be pointed as the major factors of the high consumption, since consumers are increasingly seeking easy-to-prepare meals that satisfy their sensory expectations. However, from the point of view of a healthy diet, the regular intake of hamburger is not recommended, since this product is high in saturated fat and low in dietary fiber (Muguerza *et al.*, 2001).

With the increasing concern for healthier foods, and with the great demand from the food industry, it becomes increasingly necessary to produce foods to satisfy the consumer's desire, combined with protection against various diseases occurring by nutritional deficiencies (Arihara, 2006). The use of fruit by-products is a promising alternative to enhance meat products such as hamburgers, since these wastes often contain large amounts of dietary fiber (Marfo *et al.*, 1986; Turhan *et al.*, 2005; Choi *et al.*, 2010). Besides the nutritional enrichment, the reuse of food waste for the production of new products is of great importance for the environment, since large volumes of waste from food processing are discarded improperly (Helbig *et al.*, 2008; He *et al.*, 2011).

Brazil is the largest producer of papaya (*Carica papaya*), its annual production is around 1500 tons, and of this total, 99% is destined for domestic consumption (Porte *et al*., 2011). With these numbers, it is easy to imagine the large amount of waste that is generated only by that fruit within the country. Taking into consideration the large number of seeds from a single fruit, one of the solutions to alleviate this problem would be the use of these seeds as a source of nutritional enrichment of meat products such as hamburger, since papaya seeds can bring nutritional and technological benefits to this product.

Papaya seeds have important nutrients for proper functioning of the human organism. The seeds of both Formosa group and Solo group papaya have about 26% fat, 25% protein and 29% fiber, thus evidencing that the papaya seeds can be a good nutritional source. They also have antioxidant activity (Pierson *et al*., 2012), as well as high water holding capacity (Adesuyi and Ipinmoroti, 2011; El-Safy *et al*., 2012). Based on this, this paper aimed to study the production of papaya seed flour and the effect of its addition on the technological and sensory quality of hamburgers.

Material and Methods

Manufacture of papaya seed flour

First, the papaya (*Carica papaya*) seeds were removed and washed in drinking water for removal of the residual pulp. Then, drying of the seeds was performed in an air-circulating drier (60 Pardal P3) at 60°C for about 24 hours. After drying, the seeds were ground with a micro thermostated blade mill (Marcone MA 345 / T) to obtain fine flour. The flour was vacuum packed and stored at 4°C for future analysis.

Physicochemical characterization of papaya seed flour

The pH of papaya seed flour was determined by a

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bench top pH meter (HANNA PH-210). The moisture content was determined by drying at 105ºC ± 2ºC; the nitrogen content was determined by the Kjeldahl method, and the protein content was estimated by multiplying the nitrogen content by 5.75; the fiber content was determined by gravimetric method after digestion in acidic medium; the lipid content was determined by Soxhlet method using petroleum ether; and ash was determined by incineration at 550°C (AOAC, 2005). All analyses were performed in triplicate.

Manufacture of hamburgers

Three independent replicates of each treatment were made. Ground beef and pork back fat (fat source) was used to prepare the hamburgers. Beef and pork back fat were ground separately in a conventional meat grinder with a 3-mm disk, and then were mixed to obtain the desired fat percentage (10%). The following ingredients were added in relation to the meat mixture: garlic powder (0.2%), onion powder (0.2%), and sodium chloride (2%). The meat mixture was divided into four equal parts, resulting in the following treatments: Control (without addition of papaya seed flour), T1 (1% addition of papaya seed flour), T2 (2% addition of papaya seed flour) and T3 (3% addition of papaya seed flour). From the meat mixture, hamburgers weighing approximately 80 grams were shaped using a machine for making hamburger patties (Hollymatic Super). The hamburgers were immediately frozen and stored at -18°C until the time of analysis.

Physicochemical characterization of hamburgers

The moisture content was determined by drying at 105ºC ± 2ºC and the lipid content by Soxhlet method using petroleum ether according to AOAC (2005), both in triplicates. Color determination was performed in the cooked hamburgers, using the Minolta CR-400 colorimeter (Konica Minolta Sensing Inc., Japan) according to CIE L^* a^* b^* system, using spectral reflectance included as calibration mode, illuminant D65, and observation angle of 10°. L^* (lightness), a^* (red intensity) and b^* (yellow intensity) values were determined. Five burgers per treatment were used for color determination, and the color parameters were evaluated at four different points for each hamburger.

Cooking tests

Soon after thawing under refrigeration for 12 hours, the burgers were fried on a hot griddle until they reach 72ºC in the geometric center. The griddle had heating mechanism in the lower and upper parts, thus it was not necessary to turn the hamburgers. The determination was performed in triplicate.

Both cooking yield and fat retention were measured according to Murphy *et al.* (1975):

$$\%\text{ cooking yield} = \frac{\text{Weight of cooked sample}}{\text{Weight of raw sample}} \times 100$$

$$\%\text{ fat retention} = \frac{(\text{Weight of cooked sample}) \times (\%\text{ fat in cooked sample})}{(\text{Weight of raw sample}) \times (\%\text{ fat in raw sample})} \times 100$$

The moisture retention was measured according to the equation described by El – Magoli *et al.* (1996):

$$\%\text{ moisture retention} = \frac{\%\text{ cooking yield} \times \%\text{ moisture content of cooked sample}}{100}$$

The hamburger shrinkage was measured according to the equation described by Berry (1992):

$$\%\text{ shrinkage} = \frac{(\text{Diameter of raw sample} - \text{Diameter of cooked sample})}{\text{Diameter of raw sample}} \times 100$$

Consumer study

A sensory acceptance test was performed using a nine point hedonic scale, with extremes ranging from dislike extremely (1) to like extremely (9). The attributes color, aroma, flavor, texture and overall acceptance were evaluated. Sensory analyses were performed by 100 untrained consumers, but with habit of consuming hamburgers. Consumers aged between 18 and 60 years were recruited among students and staff of the Federal Institute of Triangulo Mineiro (Meilgaard *et al.*, 1999). The samples were cooked in a hot griddle until internal temperature of 72ºC, and then served to consumers in monadic form, following a balanced design as described by Macfie and Bratchell (1989). The sensory acceptability index was calculated by dividing the mean score for overall acceptance by the maximum score of hedonic scale (9.0), and multiplying the result by 100.

Statistical Analysis

The results were analyzed by analysis of variance (ANOVA), and the means were compared by Tukey's test at 5% significance level ($p \leq 0.05$), using the SPSS statistical package (SPSS, Chicago, IL, USA).

Results and Discussion

Physicochemical characterization of papaya seed flour

The pH values were satisfactory for the use of papaya seed flour in hamburgers. The average pH was 5.4 (± 0.01), which is close to the beef pH ranging from 5.5 to 6.0 (Van der Wal *et al.*, 1988). This result evidenced that the addition of papaya seed flour did not lead to denaturation of meat proteins. As can be

Table 1. Physicochemical characterization of papaya seed flour

Components	Content (%)
Moisture	9.83±0.4
Protein	25.36±1.4
Lipids	20.97±0.41
Ash	6.43±0.24
Dietary Fiber	24.31±1.56

Mean values ± standard deviation of triplicate determinations. Papaya seeds dried and grounded.

Table 2. Fat and moisture contents of raw and cooked hamburgers containing papaya seed flour

	Control	T1	T2	T3
Moisture (%)				
Raw	60,37±2,03[a]	61,41±0,87[a]	60,96±0,98[a]	61,42±1,9[a]
Cooked	51,64±0,54[b]	51,40 ±0,6[b]	51,82±1,87[b]	53,32±2,0[a]
Lipids (%)				
Raw	7,72±0,3[b]	7,8±1,4[b]	7,91±1,4[b]	8,41±0,6[a]
Cooked	11,62±0,76[a]	10,61±1,76[a]	10,21±1,09[a]	9,38±0,7[b]

* Values represent the mean (± standard deviation). Averages followed by the same letter in the same row are not significantly different ($p > 0.05$) by Tukey's test. Control (without flour), T1 (1% papaya seed flour), T2 (2% papaya seed flour) and T3 (3% papaya seed flour).

Table 3. L*, a*, and b* values of the hamburgers containing papaya seed flour

Treatments	L*	a*	b*
Control	41,12±3,4[a]	6,9±1,95[a]	10,95±2,98[a]
T1	40,68±2,53[a]	5,98±2,3[a]	10,58±2.55[a]
T2	37,35±3,73[b]	4,81±2,54[b]	10,13±2,5[ab]
T3	34,13±3,44[c]	4,23±1,89[c]	9,43±1,67[b]

* Values represent the mean (± standard deviation). Averages followed by the same letter in the same column are not significantly different ($p > 0.05$) by Tukey's test. Control (without flour), T1 (1% papaya seed flour), T2 (2% papaya seed flour) and T3 (3% papaya seed flour).

Table 4. Percentage yield, fat retention, moisture retention and shrinkage of the hamburgers formulated with different levels of papaya seed flour

Treatments	Yield (%)	Moisture retention (%)	Fat retention (%)	Shrinkage (%)
Control	62,91±2,3[c]	32,28±0,98[d]	94,09±1,92[a]	25,89±1,3[a]
T1	65,52±1,2[b]	33,67±0,7[c]	89,13±0,88[b]	24,06±0,8[b]
T2	67,35±1,21[b]	34,90±0,7[b]	87,67±0,9[b]	22,12±1,56[c]
T3	71,25±1,3[a]	37,99±1,68[a]	79,47±2,1[c]	20,72±1,5[d]

* Values represent the mean (± standard deviation). Averages followed by the same letter in the same column are not significantly different ($p > 0.05$) by Tukey's test. Control (without flour), T1 (1% papaya seed flour), T2 (2% papaya seed flour) and T3 (3% papaya seed flour).

Table 5. Consumer acceptability of the color, aroma, flavor texture and overall acceptance of hamburgers containing papaya flour seeds

	Control	T1	T2	T3
Color	7.71±1.16[a]	7.87±1.02[a]	7.53±1.01[a]	5.71±1.24[b]
Aroma	7.5±1.21[a]	7.78±1.01[a]	7.5±1.15[a]	7.08±1.17[a]
Flavor	7.75±1.19[a]	8.2±0.99[a]	7.53±1.19[a]	5.68±1.32[b]
Texture	8.0±0.98[a]	8.25±1.01[a]	7.81±1.01[a]	4.95±1.41[b]
Overall Acceptance	7.8±1.01[a]	8.18±1.03[a]	7.53±1.10[a]	5.12±1.28[b]

* Values represent the mean (± standard deviation). Averages followed by the same letter in the same row are not significantly different ($p > 0.05$) by Tukey's test. Control (without flour), T1 (1% papaya seed flour), T2 (2% papaya seed flour) and T3 (3% papaya seed flour).

seen in Table 1, the chemical composition of papaya seed flour evidences that it has a high nutritional value, once its lipid content is relatively high, being close to the values found by Marfo *et al.* (1986) for *Carica papaya* seed. In addition, the protein content was higher than 22% found for fresh meat (Vega-Warner *et al*., 1999). The flour also stood out with a high fiber content, which is an extremely important nutrient, because its consumption is associated with a reduced risk of cardiovascular disease, obesity, diabetes and some cancers (Jenkins *et al*., 2004; Olagunju *et al*., 2009). These results have demonstrated that papaya seed flour can be considered an excellent means of increasing the nutritional value of the product.

Physicochemical characterization of hamburgers

The moisture and fat contents of raw and cooked burgers are presented in Table 2. There was no significant difference in moisture content between treatments for the raw burgers. Moreover, the lipid content was significantly higher for the treatment containing 3% flour. This fact can be due to the lipid content of the flour, as presented in Table 1. In the cooked burgers, the treatment containing 3% flour had significantly higher moisture content, which is very positive with regard to the yield of meat products. Concerning the lipid content, the treatment T3 had a significantly lower fat content as compared to the other treatments.

The instrumental color results are presented in Table 3. The addition of 1% papaya seed flour did not change significantly L*, a*, and b* values when compared to the control sample. Both T2 and T3 showed a significant decrease of L* and a* values as compared to control, and T3 showed a b* value significantly lower than the control. These results showed that from 2% addition of papaya seed flour, the hamburgers were darker and less red. Furthermore, the samples containing 3% flour presented a less intense yellow color.

Cooking tests

The results of the cooking tests are shown in Table 4. The cooking yield increased with increasing the level of papaya seed flour, which is correlated to the significant increase in moisture retention found for all treatments. The higher moisture retention was probably due to the fiber content of papaya seed flour (Table 1), because according to Anderson and Berry (2001), the fibers may interact with meat proteins forming a network that prevents water migration from the product to the surface.

All treatments containing papaya seed flour showed a fat retention significantly lower than the control sample. This fact may be attributed to the dilution of the chemical components caused by the higher moisture retention of the treatments containing papaya seed flour. Regarding the hamburger shrinkage, all treatments had significantly less shrinkage than the control, and this effect was proportional to the level of papaya seed flour in the formulations.

Consumer study

The results of the consumer study are shown in Table 5. No significant difference was observed for T1 and T2 for all attributes as compared to the control, which demonstrates that the addition of up to 2% papaya seed flour did not depreciate the sensory acceptance of the hamburgers. In contrast, T3 presented significantly lower scores for the attributes color, flavor, texture, and overall acceptance as compared to the other treatments.

The treatment T2 presented an acceptability index close to 84%, very similar to the control, which showed acceptability values of about 87%. With respect to T1, it presented an even more satisfactory result, reaching an acceptability index close to 91%. These results are very positive if we take into account that a product with good acceptability must have index values higher than 70%. The treatment containing 3% papaya seed flour showed an acceptability index close to 57%, being rejected by consumers.

Conclusions

Due to its high fiber and protein contents, papaya seed flour can be considered an excellent source to nutritionally enhance the products in which it is added. The papaya seed flour enabled the improvement of technological quality of the hamburgers of the present study, once it increased both the cooking yield and the moisture retention, and reduced the hamburger shrinkage. Furthermore, the sensory quality of the burgers was not depreciated until the level of 2% addition of papaya seed flour. The addition of papaya seed flour in the hamburger formulation not only allows the improvement of the nutritional and technological quality of this widely consumed product, but can also be effective to reduce the environmental impact caused by the improper disposal of industrial waste. Therefore, the production and use of papaya seed flour brings benefits to food industries, environment and consumers.

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