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Physical-Chemical and Sensory Quality of Cassava Extruded Snack Added with *Hibiscus Sabdariffa L.*

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The hibiscus plant has a well-known rich phytochemical profile responsible for beneficial health effects while cereal extruded products have dense energy content but are nutritionally poor. This work aimed to assess the addition of Hibiscus sabdariffa L in extruded products represented by a snack made of cassava. Blends of cassava and hibiscus flower powder were processed in a single-screw extruder. Formulations showed significant differences between expansion ratio and hardness suggesting that hibiscus powder was capable to retain the moisture during process. The white color of FC (formulation control) (L= 81.65 a = 1.97 b = 2.86) changed drastically to a light red in F1 (formulation 1) (L= 71.68 a = 16.55 b = 5.85) intensified in F2 (formulation 2) (L= 58.6 a = 25.86 b = 6.72) turning to an intense red. Antioxidant activity, phenolic compound and anthocyanin content increased drastically from control. The formulations F1 and F2 showed a significant increase on antioxidant activity average of six and ten times higher than in FC. A positive consumer acceptability of the tested formulations (between 6-7 points out 9) was important to understand and show that hibiscus powder is a potential ingredient for enhancing food formulations in low amounts phytochemicals like snacks.

1. Introduction

The rise of information accessibility, the recent studies about food functionality and modern life style oriented by quick meals, increased the demand for health food and prompted the industry to develop products that combine convenience and nutrition.

Extrusion is a thermo-mechanical processing wherein a crude feed is subject to combinations of high temperatures, high pressures and high shear leading to various chemical reactions and functional changes in the extruded material producing different types and products shapes (Brennan, 2006).

Examples of a widely consumed product made from extrusion processing are snacks and breakfast cereals. Because they are basically made up of starch, these products have dense energy content but are nutritionally poor, so manufactures must add functional amounts of nutrients (Dehghan-Shoar et al., 2010) and minerals in order to improve their nutrition capacity.

Tapioca is classified as a starch product derived from cassava root being sub classified according to their granules format and quality of the product (Brasil, 2005). The extrusion resulting from cassava starch produces a close structure to other breakfast cereals or snacks, a smooth surface, a neutral taste, clear color (Chang et al., 1998) and a high degree of expansion (Yu, 1991).

The hibiscus plant has a rich phytochemical profile responsible for beneficial health effects. The biological potential of Hibiscus sabdariffa L. is evidenced, according to Patel (2014), in antioxidant actions, lowering cholesterol, control obesity, hypotensive, antidiabetic, immune modulatory, anticancer, hepatic protective, antimicrobial, renal protective and diuretic. The red hibiscus cultivar shows significant differences in the concentration of phenolic compounds and antioxidant activity compared to other cultivars (Subrata de, 2012).

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This work aims to investigate the physical-chemical properties of the extruded manufactured from tapioca, the starch source, and dried hibiscus flower as the bioactive source. The enrichment of extruded products is common but there is no report of any flower source as raw material. Three formulations were extruded and analyzed regarding color, expansion, density, hardness, phenolic compounds, total antioxidant activity and total anthocyanin content. The consumer acceptability was assessed through sensory analysis.

2. Materials and methods

2.1 Raw materials

Tapioca and dried Hibiscus sabdariffa L flower were obtained from the local market and sent to Cereals Technology laboratory. A particle size distribution was carried out on tapioca flour for homogenization and sent to the extrusion processing. The dried hibiscus flower was reduced to powder using rotating knives Mill ACS Labor sieve opening 100 mesh. The milled hibiscus was stored in polyethylene bag under normal conditions of brightness and room temperature until the analysis and extrusion processing.

2.2 Particle size distribution

Particle size distribution: The test with tapioca flour was evaluated according to Mikalouski et al. (2014), using a Berter magnetic agitator equipped with 14, 16, 28, 60, 100, 270 meshes sieves. The speed test was set at “5” for 30 minutes.

2.3 Extrusion cooking

The snack was manufactured in laboratory scale and the proportions are:
FC or Formulation Control: Manufactured with tapioca flour;
F1: Produced by adding to the starting mixture, 2% of hibiscus powder;
F2: Produced by adding to the starting mixture, 5% of hibiscus powder.
F1 and F2 were dosed and mixed manually in such quantities as to obtain a mixture of 2kg.
All the treatments were submitted to moistening standardization. The standardization was performed by adding 5% water on total weight of tapioca flour.
The mixture was extruded in single-screw extruder, model IMBRA RX equipped with die plate 50 and output diameter of 3.1 mm. The screw speed (120 rpm) and feeding speed (15g/s) were maintained constant during the extrusion.
The snacks were packed in 100 g polyethylene bags. Initially, 75% of the extruded products were stored in normal conditions of lightness and room temperature. The treatments were analyzed though the physical properties (expansion, hardness, density and color) and consumer acceptance. The left percentage (25%) were stored at low temperature (-18oC) under no light incidence and the samples were chemically analyzed by phenolic compounds, total antioxidant activity and total anthocyanin content.

2.4 Expansion ratio

Expansion ratio was calculated according to Mercier et al. (1998). Diameters of 15 extruded products were measured using a universal caliper Jomarca (155 mm) carbon steel. The ratio was determined by dividing the average of the products diameters (mm) by the diameter (mm) of the output die plate and the result was multiplied by 100.

2.5 Hardness

The hardness of 15 extruded samples was measured according to Dischsen et al. (2013) using Texture meter (Stable Micro Systems Texture Analyzer TAXT2, Texture Technologies Corp., England) employed with a Warner Bratzler probe 12 x 7cm (HDP/BS) with maximum load of 5kg. The probe was set to move at a pre-test speed of 1.5 m/s, speed test of 2.0 m/s, speed post-test of 10 m/s, force of 0,5N, counting cycle of 5 s, machine sensitive of 5g, with measurement of precision. Measurements are expressed as Newton (N).

2.6 Density

The product density was determined by the millet seed displacement method according to the 72-10 methodology from AACC (2012) applied to extruded products. The determination was performed by displacing a known volume of millet seeds in a suitable container. The density (mL/g or cm3/g) was obtained by dividing the volume (mL) by the final weight (g) of the extruded.

2.7 Color evaluation

The colors were taken according to Dehghan-Shoar et al. (2010) using a portable colorimeter CR400 Minolta®. The system used was the L* a* b* coordinates.

2.8 Antioxidant activity

The snack was ground with a pestle and mortar. The extraction was performed in solvent 90% methanol and 10% water for 2 hours followed by centrifugation in Centrifuge TDL 802B for 5 min. The total antioxidant content

(AA%) was determined by the capture of free radical DPPH (1,1-diphenyl-2-picrylhydrazyl) (Sigma Lot Alorich STBC 1252v) according Rufino et al. (2007) with some modifications such as using volume of 3.5 ml in environment reaction (extract + DPPH solution + methanol). The absorbance reading was performed in a spectrophotometer Varian Cary 50 UV Dell PC SMS at wavelength of 517nm. All the chemical analyses were evaluated on both extruded cereal as the hibiscus powder.

2.9 Phenolic compounds

The analysis was performed according to the method used by Bucic'- Kojic' et al. (2007). The extraction was performed in 50mL methanol 50% (methanol:water 1:1 (v/v)) by homogenizing 2g with the methanol followed by a centrifugation. An aliquot of 0.2 ml of each extract were homogenized with 1.8 ml of distilled water and 10 ml of Folin Ciocalteu 10%. Between 30 seconds to 8 minutes was added 8 ml of Sodium Carbonate 7.5%. (stored 2 hours in the dark). The absorbance wavelength was 765 nm. A standard curve of gallic acid was used to obtain the results expressed in gallic acid equivalents (mg GAE / ml).

2.10 Total Anthocyanin Content

The quantification was performed by Francis (1982). The sample (1 g) was extracted with a 95% ethanol/1.5 N HCl solution (85:15), vortexed for 2 min and then brought to 50 mL with the extracting solution. Protected from the light, the mixture was refrigerated at 4°C for 12 h and then filtered. The absorbance of the filtrate was measured at 535 nm for the total anthocyanin content using an absorption coefficient of 98.2 and the results were expressed as mg/100 g.

2.11 Consumer acceptance

The samples FC, F1 and F2 were coated in steel pan steel for 15 minutes with hibiscus sauce (hibiscus powder, sugar and water) and dried in an oven at 105oC for 15 min. This step aimed to reduce the color discrepancy between the formulation control (white) and the other samples F1 and F2 (light red). The difference could immediately indicate to panelists that one of the samples had no hibiscus addition. The consumer acceptation was performed according to Monteiro & Cestari (2013) by 95 untrained panellists. A 9-point hedonic scale (9 as “like extremely” and 1 as “dislike extremely”) was used to evaluate the attributes of texture, color, odor, flavor and overall acceptability. The purchase intention test was with 3-point scale (1 = certainly would buy to 3 = certainly not buy). The tests were performed at the Laboratory for Sensory Analysis with individual booths and white lighting. The samples were placed in white containers where they received three digit random codes. After tasting each sample, the volunteers had to rinse their mouths with water. Sensory tests were approved by the Ethics Committee in Research of the State University of Maringa (CAAE18718013.3.0000.0104).

2.12 Statistical analysis

All analysis was determined in triplicate. Data were evaluated using analysis of variance (ANOVA) and means were compared with Tukey test ($p < 0.05$) using the software Statistica 8.0/2008 (Stat Soft, Inc., Tulsa, USA).

3. Results and Discussions

3.1 Physical characteristics

There was significant difference in the expansion ratio between the formulations. Significant reductions were observed in Dehghan-Shoar et al. (2010) work where tomato pulp and skin powder were extruded using corn, rice and wheat as raw material and the same occurred in Potter et al. (2013) who evaluated the addition of apple, banana, strawberry and tangerine powder to one control with different raw materials (wheat, corn, potatoes and milk powder) formulations. The significant increase of this parameter could be explained by the hibiscus ability to retain water due it fiber content. In addition, Hill & Sriburi (2000) indicated that the presence of ascorbic acid levels increase the degree of expansion in extrusion of cassava starch. The acid ascorbic content in *Hibiscus sabdariffa L* dried calyces was reported by Cissé et al. (2009) as minimum 6.7mg/100g, medium 72.0mg/100g and maximum 141.1mg/100g. Abou-Arab et al. (2011) reported the ascorbic acid content being 140.13mg/100g.

According to Dehghan-Shoar et al. (2010), variation of the product density is dependent on the products proportion voids fraction and is correlated with hardness and general consumer acceptability**Table 1**: Physical parameters identified in different formulations enriched with *Hibiscus sabdariffa L.*

The addition of hibiscus powder decrease the hardness and increase the density compared to the control. However, statistically, the density is not affected by the hibiscus powder concentrations showing no big changes in void fraction of the products. In the other hand, hardness decreases significantly with the increase of hibiscus concentrations and, observing the raise of expansion ratio, we suggest that the addition of hibiscus flower was able to retain the moisture during the machine processing. Hashimoto & Grossmann (2003), based in previous works (Badrie & Mellowes, 1991), suggests that moisture has a significant effect on cohesiveness and chewiness of cassava extruded products and these changes the texture profiles.

Table 1: Physical parameters identified in different formulations enriched with Hibiscus sabdariffa L.

Formulation	Expansion Ratio (%)	Hardness (N)	Density mL/g	L* Value	a* Value	b* Value
FC	357.85[c]	15.26[a]	0.10[a]	81.65[a]	1.97[c]	2.86[c]
F1	403.44[b]	12.89[a]	0.08[b]	71.68[b]	16.55[b]	5.85[b]
F2	435.48[a]	9.64[b]	0.08[b]	58.61[c]	26.86[a]	6.72[a]

Values within columns followed by different letters are significantly difference (Tukey test, $p< 0.05$). FC: Control Formulation; F1: 2% of hibiscus powder; F2: 5% of hibiscus powder.

As for the color attribute, all formulations showed significant differences compared to the control due the rich presence of anthocyanin in Hibiscus sabdariffa L. The white color of the snacks FC (L= 81.65 a = 1.97 b = 2.86) changed drastically to a light red in F1 (L= 71.68 a = 16.55 b = 5.85) intensified in F2 (L= 58.6 a = 25.86 b = 6.72) turning to an intense red. The same result was reported in Dehghan-Shoar et al. (2010) when the lycopene content influenced the red color of the extruded snack. Part of the pigments presented in the raw material can be transferred to the final product since the extrusion is high temperature process but performed in short times.

3.2 Chemical characteristics

The analysis of antioxidant activity, total phenolics and anthocyanins carried out on hibiscus flower powder, had respectively the following values: 83.43%; 1551.36 mg GAE / mL to 536.80 mg / 100g. These values indicate that this powder is a potential ingredient for enhancing food formulations in low amounts phytochemicals.

As can be seen in Table 2, formulations with 2 and 5% of hibiscus powder (F1 and F2) added to tapioca flour snacks showed significant increase in all studied parameters.

The observed values of AA% on average doubled and tripled, respectively, for replacements of 2 and 5% of tapioca flour by hibiscus flower powder. The formulations F1 and F2 showed a significant increase on average of six and ten times higher than in FC. In addition, the contents of total anthocyanins, not present in tapioca flour (as expected), were added with the application of hibiscus powder in F1 and F2. This fact has an interesting point of view because in recent years the population search for foods that offer to them health and wellness and, according to Kuskoski et al. (2005), anthocyanins are phytochemicals that can act to prevent and combat chronic diseases.

Besides the facts, studies revealed (Camire et al., 2007; Dehghan-Shoar et al., 2010; Özer et al., 2006) that those components are heat-label and losses were expected after extrusion. Thus the incorporation of those components on the snacks, despite losses, is indicative that hibiscus has a potential profile being a bioactive source to products enrichments.

Table 2: Chemical characteristics identified in different formulations enriched with Hibiscus sabdariffa L.

Formulation	Antioxidant Activity (%)	Phenolics Compound mg GAE/ mL	Anthocyanins Content mg/100g
FC	18.87[c]	13.57[c]	NP
F1	45.17[b]	86.19[b]	3.21[b]
F2	65.09[a]	143.76[a]	6.69[a]

Values within columns followed by different letters are significantly different (Tukey test, $p< 0.05$). NP – not present. FC: Control Formulation; F1: 2% of hibiscus powder; F2: 5% of hibiscus powder.

Phenolic concentration is correlated with the antioxidant compounds according to Chitarra & Chitarra (2005) and it had been studied as a component to stabilize extruded products retarding the hexanal formation during snacks storage (Viscidi et. al. 2004).

Despite the losses, the amount recovered from samples is indicative that Hibiscus sabdariffa L is a potential source of antioxidant in extruded products. In Camire et al. (2007) work, the highest recoveries were total phenolic (138,5±16 ppm) and anthocyanin (0.46±12 mg/100g) of blueberry and the antioxidant activity of control

(28µm Trolox equivalents/g) manufactured with cornmeal cereal and 1% of respective fruit powder. Oliveira et al. (2013) analyzed the addition of grape seeds and peel in corn gritz extruded and the phenolic content reported were 47.51mg/100g and 60.95mg/100g for 10% and 15% flour adding. In addition, Ahmed & Abozed (2004) described Hibiscus sabdariffa L reside (HSR) as a potential functional food ingredient that may be used in food application since this product increased the phenolic compounds in crackers from 5.99 to 17.57mg Gallic acid equivalents/g (5% HSR).

3.3 Consumer Acceptance

Whilst the nutritional qualities of extruded were improved with the hibiscus addition, the snacks also needs to be acceptable to consumers. Ninety-five untrained panellists indicated their preferences by given 9 points scales to the parameters in table 3.

Table 3: Sensorial preferences of the panellists

Formulation	Texture	Color	Odor	Flavor	Overall Acceptability
FC	5.47 b[#]	6.29 b	6,75 a	6.42 a	6.10 b
F1	7.06 a	7.24 a	7.01 a	6.88 a	6.99 a
F2	6.81 a	6.91 ab	6.85 a	6.40 a	6.58 ab

Values within columns followed by different letters are significantly different (Tukey test, $p< 0.05$). FC: Control Formulation; F1: 2% of hibiscus powder; F2: 5% of hibiscus powder.

The average of the sensorial parameters analyzed emerge between 5 (don't like and don't dislike) to 7 (like regularly). Snacks enriched with hibiscus showed no statistical difference with regard to all parameters. Beyond that, the formulation control revealed lower scores in texture, color and overall acceptability. These conditions are due to the fact (see table 1) that hibiscus enrichment increased the extruded expansion, diminished the density and hardness rates and an increase in the red color being more attractive to consumers. The consumer acceptability according to Dehghan-Shoar et al. (2010) depends mainly on the physical and organoleptic properties measured as expansion ratio, density, texture, appearance and their flavor. The flavor and odor of FC has no significant difference from other formulation. The standard sauce could have influenced those parameters. During the sensorial test, a decrease in crispness was observed in some samples showing that the hibiscus sauce formulation, adhered to an extruded surface, should be reviewed in order to improve the final product.

4. Conclusions

This study corroborates the technological potential of hibiscus flower in food goods since the nutritional improvement and consumer acceptability were achieved. On the physical fact, the hibiscus behaved different from previous extruded addition works as the expansion ratio increased instead of decrease. Tapioca flour proved to be a good starch source for cassava snacks and could incorporate the literature well-known bioactive compounds like anthocyanin. In the technological point of view, the red color resulted from this enrichment is an advantage by not making use of artificial dyes thus contributing to natural colored products availability. Future research may evaluate the sauce influence on bioactive quantity and verify the viability of this addition.

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