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Characterization of chicken *nuggets* with the addition of flour from peach palm by-product

Caracterização de *nuggets* de frango com adição de farinha de subproduto de palmito pupunha

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ABSTRACT

The aim of this study was to evaluate the potential of using the peach palm by-product (FPP), fiber-rich flour, to promote the nutritional enrichment of chicken nuggets. The formulations were produced by replacing chicken skin by FPP, at levels of 0 (control), 4, 8 and 12%. Texture, physicochemical and sensorial properties were evaluated. The contents of dietary fiber and ashes increased due to the addition of FPP ($p<0.05$), while the protein content was similar among the tested formulations ($p>0.05$). With the addition of FPP to nuggets there was a decrease in fat content and weight loss, while the values of yield and emulsion stability increased. The formulations with FPP addition had higher values of luminosity (L*) and chromacity b* and lower value of a* than the control sample. The texture profile analysis indicated that hardness, gumminess and chewiness increased due to the addition of FPP, not interfering in springiness. Nugget formulations containing 4% and 8% FPP were well accepted by the tasters, with a sensorial acceptance index ≥ 70%. According to principal component analysis the formulation containing 4% of FPP addition in replacement of chicken skin can be considered more viable than the other tested formulations.

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Keywords: *Bactris gasipaes*, Fiber, Texture profile, Sensorial properties, Principal component analysis.

RESUMO
O objetivo deste estudo foi avaliar o potencial do uso do subproduto de palmito pupunha (FPP), farinha rica em fibras, para promover o enriquecimento nutricional de nuggets de frango. As formulações foram produzidas substituindo a pele de frango por FPP, nos níveis 0 (controle), 4, 8 e 12%. Textura, propriedades físico-químicas e sensoriais foram avaliadas. O conteúdo de fibras e cinzas na dieta aumentou devido à adição de FPP (p <0,05), enquanto o teor de proteína foi semelhante entre as formulações testadas (p> 0,05). Com a adição de FPP nos nuggets, houve diminuição no teor de gordura e na perda de peso, enquanto os valores de rendimento e estabilidade da emulsão aumentaram. As formulações com adição de FPP apresentaram maiores valores de luminosidade (L *) e cromacidade b * e menor valor de a * que a amostra controle. A análise do perfil de textura indicou que a dureza, a elasticidade e a mastigabilidade aumentaram devido à adição de FPP, não interferindo na elasticidade. As formulações de nuggets contendo FPP de 4% e 8% foram bem aceitas pelos provadores, com um índice de aceitação sensorial ≥ 70%. De acordo com a análise dos componentes principais, a formulação contendo 4% de adição de FPP em substituição à pele de frango pode ser considerada mais viável do que as outras formulações testadas.

Palavras-chave: *Bactris gasipaes*, fibra, perfil de textura, propriedades sensoriais, análise do componente principal.

1 INTRODUCTION

Nowadays, the search for industrialized food of easy preparation has been steadily increasing; at the same time, the population's concern with the health problems associated with consumption of such foods has been increasing (Oliveira et al., 2014; Oliveira et al., 2013). Breaded products, especially poultry-based ones, have grown in the consumer market due to the practicality of their preparation (Dill; Silva; Luvielmo, 2009) and their mild flavor, which allows for the use of varied condiments, according either to consumer preference or to regional or cultural characteristics (Olivo and Shimokomaki, 2006). The meat industry has been seeking natural sources that provide nutritional benefits to these products, such as the use of fiber and minerals (Selgas; Cárceres; García, 2005). One example is the search for ingredients that can be used as substitutes for animal fat in meat, as saturated fat is related to the occurrence of various chronic diseases (Santos Júnior et al., 2009).

Fiber intake can be associated with prevention of diseases, as fibers cause a number of beneficial effects on the digestive tract. Most of agro-industrial by-products can be considered source of fibers which can be obtained at a low cost (Elleuch et al., 2011). The physiological properties of fibers are associated with their chemical constituents, which increase fecal weight and prevent the onset of diabetes mellitus, cardiovascular diseases, obesity and colon cancer (Tharanathan and Mahadevamma, 2003). Fibers are incorporated into meat products due to their water and fat retention capacities (Choi et al., 2009), ability to prevent the final cooked product to "break" and to stabilize emulsions (Contado et al., 2015). Thus, addition of dietary fibers to meat products can increase yield, reduce the cost of production and improve texture and rheological and sensorial properties (Mendoza et al., 2001).

Brazil is considered to be one of the largest producers and consumers of heart-of-palm in the world (Neves et al., 2007), being the *pupunha* palm (*Bactris gasipaes*) considered a sustainable crop (Yuyama et al., 1991; Yuyama et al., 1996). During the processing of peach palm (locally known as *palmito pupunha*), a large volume of waste is discarded, around 135 tons per month at an industrial scale (Moraes; Paulino; Possenti, 2011). The by-products are formed mainly by the stem portion and foliar sheaths that can be processed into flours and then potentially incorporated into food products. The flours produced have high levels of dietary fiber and antioxidant compounds (Bolanho; Danesi; Beléia, 2014).

The aim of this study was to develop chicken nuggets with the addition of flour from peach palm by-product, evaluating texture and physicochemical, microbiological and sensorial properties.

2 MATERIALS AND METHODS

Materials

Boneless whole chicken and skin were ground with 8 mm and 5 mm thick discs, respectively, in an electric grinder (MB Braesi, Caxias do Sul, Brazil). These and other ingredients, including refined salt, black pepper, garlic powder, powdered onion, textured soy protein, wheat flour, bread crumbs and eggs were purchased in the local market of Umuarama (state of Paraná - Brazil).

The peach palm waste was donated by a local company, Palm Three (Mariluz- Paraná - Brazil). In order to obtain the flour, the by-product –either stem or basal parts - was cut into fillets and dried in an oven with forced air circulation (MA 035, Marconi, Piracicaba, Brazil) at 60ºC for 36 h. Subsequently, the material was ground in a knife mill (SL - 30, Solab, Piracicaba, Brazil), followed by sieving for granulometric separation. The material retained in mesh fractions of 80 (0.18 mm) was used for production of the nuggets.

Nuggets production

The nugget formulations were produced according to manufacturing parameters described in Normative Instruction nº. 6, dated February 15, 2001, of the Ministry of Agriculture, Livestock and Supply - MAPA (MAPA, 2001). The formulations were prepared with addition of FPP at levels of 4% (NF4), 8% (NF8) and 12% (NF12) by replacing chicken skin, following the recommendations of Barros et al. (2018), with adaptations; a fourth formulation not containing FPP was also produced as a control formulation (NC). The proportions of chicken meat, skin and FPP used in the formulations were, respectively: 62g/20g/0g for NC, 62g/16g/4g for NF4, 62g/12g/8g for NF8 and 62g/8g/12g for NF12. The other ingredients – 1.4g of salt, 0.5g of black pepper, 0.2 g of garlic powder, 0.3g of onion powder, 3 g of textured soy protein and 12.5 mL of water – were mixed until a homogeneous mass was obtained. The nuggets were molded to a final mass of approximately 36 g each.

Next breading was carried out, a process which takes three stages. The initial stage is known as pre-dusting, in which wheat flour was rubbed on the nuggets. The second stage is the batter, in which the nuggets were dipped in beaten eggs, forming an outer covering. In the last stage, bread crumb was applied to the moistened nuggets. The nuggets were then pre-fried, which consisted of immersing the products in oil at high temperatures (180-200ºC) for a short period of time (20 to 35 s). Subsequently, the cooking process was carried out at 110-170º C for 9 to 20 min in an industrial oven (FTT 24OE, Tedesco, Caxias do Sul, Brazil), and then packaged and frozen at -18º C for subsequent analyzes.

Physicochemical characterization

The nuggets formulations and the peach palm by-product flour were characterized as composition according to AOAC methods: moisture (method 925.09), ashes (method 923.03), proteins (method 920.87) and lipids (method 920.85) (Horwitz and Latimer, 2005). The pH analysis was carried out using a common pH-electrode (PG 2000, Ind. e Com. Eletro – Eletronica Gehaka Ltda, São Paulo, Brasil) into a sample diluted in distilled water.

In relation to cooking properties, the weight loss was determined according to Polizer et al. (2015), being calculated as percentage using the Equation. 1.

$$\%\,\text{weight loss} = \frac{\text{weight before frying} - \text{weight after frying}}{\text{weight before frying}} \qquad (1)$$

For the analysis of cooking yield, the nuggets were fried in an industrial stove (Metalmaq, Rio de Janeiro, Brazil) for approximately 15 min at 150º C (Barros et al., 2018). This parameter was calculated using the weight of the fried nugget and the weight of the raw nugget (after the cover system, pre-frying and cooking), as described in Equation 2.

$$\%\,\text{cooking yield} = \frac{\text{fried sample weight}}{\text{raw sample weight}} \qquad (2)$$

To determine the emulsion stability, 5 g of sample were weighed in test tubes, which were heated in a water bath (Nova Ética, São Paulo, Brazil) at 80° C for 30 min. The samples were centrifuged for 10 min at 3000 rpm (MTD III PLUS, Metroterm, Porto Alegre, Brazil), after draining the released water, the tube was again weighed. Thus, the emulsion stability was calculated by Equation 3 (Tamsen; Shekarchizadeh; Soltanizadeh, 2018).

$$\text{emulsion stability} = 1 - \frac{(\text{starting weight} - \text{final weight})}{\text{sample weight}} \qquad (3)$$

The percentage of weight gain after breading the nuggets (pick-up) was calculated by the weight difference of the nugget before and after the coverage application, using Equation 4 (Barros et al., 2018).

$$\%\,\text{pick-up} = \frac{(\text{nuggets with coverage} - \text{nuggets without coverage})}{\text{nuggets with coating}} \qquad (4)$$

The shrinkage was obtained by measuring the diameter of the nuggets before and after the final cooking, using Equation 5 (Seabra et al., 2002).

$$\%\,\text{shrinkage} = \frac{(\text{raw sample diameter} - \text{fried sample diameter})}{\text{raw sample diameter}} \qquad (5)$$

The color characteristics of the samples were defined by the parameters of CIE-Lab, L* (lightness), +a* (red) –a* (green), and +b* (yellow) –b* (blue) using the colorimeter Color Reader CR-10 (Konica Minolta, Japan).

Texture profile analysis was carried out using a TA-XT2i texturometer (TA-XT2i, Extralab, São Paulo) equipped with a 70-mm diameter probe moving at 0.3 mm/s (Barros et al., 2018). Force versus time curves provided by the equipment allowed for determination of springiness, hardness, chewiness, gumminess and cohesiveness.

Microbiological and sensorial parameters

The microbiological parameters required by Brazilian legislation (absence of thermotolerant coliforms and coagulase positive Staphiloccocus and *Salmonella* spp.) were assessed in the formulations following the methodology recommended by the American Public Health Association – APHA (APHA, 2001).

In order to evaluate the sensorial acceptance of the nugget formulations, an acceptance test was applied to a panel of untrained testers (n=100) composed of individuals of both sexes and aged 16 to 60 years. The nugget formulations were fried in an industrial stove for approximately 15 min at 150º C using 1 mL of vegetable oil, and kept under heating in an electric oven (Mueller Fogões LTDA, Florianópolis, Brazil) until the sensorial evaluation was carried out. The samples (20 g) were provided in encoded disposable cups to the testers in a randomized manner, following the recommendations of Dutcosky (2001). A structured nine-point hedonic scale was used (9 = like extremely; 8 = like very much; 7 = like moderately; 6 = like slightly; 5 = neither like nor dislike; 4 = dislike slightly; 3 = dislike moderately; 2 = dislike very much; 1 = dislike extremely). For purchase intention, a structured five-point scale was used, ranging from 1, which corresponds to "would not buy", up to 5, which corresponds to "would certainly buy". This analysis was approved by the Ethics Committee - COPEP-UEM/CAAE under protocol number 84073518.3.0000.0104. Based on the scores assigned by the testers, the acceptance index (AI) was calculated by multiplying the ratio between the average score for an individual sample and the maximum score of the hedonic scale (9) by one hundred (Dutcosky, 2001).

All assays were performed in triplicates for each formulation with the exception of analysis of texture, which employed 8 replicates. The results were statistically analyzed using One-Way Analysis of Variance (ANOVA) tests followed by Tukey post-hoc tests at a 5% significance level using the Statistica® 8.0 software. Principal component analysis was also carried out using this software.

3 RESULTS AND DISCUSSION

Physicochemical characterization

The flour produced with peach palm by-product had the following approximate composition: 5.9 g/100 g moisture, 4.94 g/100 g ashes, 8.89 g/100 g protein and 69.6 g/100 g dietary fiber. These results are similar to those found by Bolanho, Danesi and Beléia, (2014).

Regarding the composition of nugget formulations (Table 1) the control formulation (NC) had lower moisture content (38.26 g/100g) than the NF12 formulation, probably due to the water retention capacity of fiber components. Polizer et al. (2015) also found increased moisture content (51.69 g/100g) in nuggets produced with addition of pea fiber partially replacing meat and fat.

Table 1. Composition (g/100g) and pH of chicken nuggets formulations with chicken skin replacement by peach palm flour

Parameters	NC	NF4	NF8	NF12
Moisture	38.26±0.31^{b}	40.05±1.05^{ab}	41.10±0.64^{ab}	42.74±1.91^{a}
Ashes	1.97±0.04^{c}	2.39±0.15^{b}	2.53±0.20^{b}	2.74±0.18^{a}
Proteins	24.03±1.93^{a}	23.20± 0.73^{a}	22.82± 0.53^{a}	22.20±1.78^{a}
Fat	24.56±0.92^{a}	21.17±1.43^{b}	19.27±0.99^{b}	16.21±1.07^{c}
Dietary fiber	0.54±0.05^{d}	2.61±0.12^{c}	5.15±0.41^{b}	7.92±0.27^{a}

NC= nugget formulation without FPP addition. NF4= nugget formulation with 4% of FPP addition. NF8= nugget formulation with 8% of FPP addition. NF12= nugget formulation with 12% of FPP addition. Means followed by same letters (same line) did not differ statistically (p>0.05) by Tukey test.

The addition of FPP to nugget formulations increased the ashes content, especially in formulation NF12 (2.74 g/100g). These results are attributed to the high ashes content of FPP, which contains minerals such as calcium (0.43 g/100g), magnesium (0.39 g/100g), potassium (1.48 g/100g), iron (0.37 mg/100g) and zinc (1.25 mg/100g), according to Bolanho, Danesi and Beléia, (2014). In nuggets produced with addition of soybean meal (3, 4 and 5%) there was also an increase in ashes content, varying from 2.7 to 3.0 g/100g (Kumar et al., 2013).

The protein content was similar among all tested formulations (p>0.05), which is interesting since nuggets are considered a product of high protein content (MAPA, 2001). The same effect was observed by Barros et al. (2018) in nuggets where the chicken skin had been replaced with chia flour. These authors reported mean protein values (34-3 7g/100g) higher than those found in the present work (22-24 g/100g), which is due to the different percentages of ingredients used in the formulations.

The increasing amounts of FPP added to the nugget formulations increased the dietary fiber (DF) content. In comparation with the control sample, the increase of DF ranged from 5 to 15 times, approximately. The maximum value of DF (7.9 g/100g). found in NF12 formulation, is higher than the value found by Barros et al. (2018) in formulations containing chia flour added at 20% (5.2 g/100). Fiber intake is important due to abundant evidence on its health benefits, which is related to keep regular bowel movements and environment, to lower body weights and to the prevention of cardiovascular diseases, diabetes mellitus and some types of cancer (Tharanathan and Mahadevamma, 2003; Choi et al., 2009).

Another benefit of using FPP in substitution of chicken nuggets was the percentage of fat reduction. The formulations NF4 and NF8 had similar fat content, 20% lower than the control; to NF12 this reduction reached 35%. The consumption of high fat-food is associated to obesity and there is a tendency of reduced the intake of this kind of product to avoid health problems.

The FPP had a pH value of 5.85, and therefore its addition to the nugget formulations caused a pH decrease in the chicken nuggets produced (Table 1), being the lowest value found for the NF12 formulation (6.23). These values were similar to those found by Florek et al. (2004) and Kumar et al. (2013) in meat products (5.80 a 6.30) and chicken nuggets made with green banana flour (6.00 – 6.10), respectively. Barros et al. (2012) state that some factors such as type and amount of raw material used in formulations and the cooking process may interfere with the pH of food products.

For cooking properties (Table 2), the control formulation had the highest value for weight loss, meaning the addition of FPP prevented weight loss. According to Polizer et al. (2015) this is due to the addition of fibers, which can bind water and maintain fat stable in the product matrix. Addition of any percentage of FPP increased yield in comparison to the control formulation at values from 88.65 to 96.47% ($p<0.05$). These values are similar to those obtained for extended gluten-free chicken nuggets produced with addition of 5 to 10% of sorghum flour - 92.63 to 96.24% (Devatkal et al., 2011), and such increase in yield was attributed to the capacity of this flour to retain water and fat.

Table 2. Cooking properties, color parameters and texture profile of chicken nuggets formulations with chicken skin replacement by peach palm flour

Parameters	NC	NF4	NF8	NF12
pH	6.45 ± 0.02[a]	6.37 ± 0.00[b]	6.36 ± 0.03[b]	6.23 ± 0.02[c]
Weight loss (%)	11.34 ± 2.27[a]	6.19 ± 1.00[b]	3.76 ± 0.64[c]	3.53 ± 0.57[c]
Yield (%)	88.65 ± 2.27[b]	93.81 ± 1.00[a]	96.24 ± 0.64[a]	96.47 ± 0.57[a]
ES (%)	96.12± 0.87[b]	98.63± 0.37[a]	99.15± 0.27[a]	99.67± 0.02[a]
Pick-up (%)	29.64 ± 3.08[a]	30.80 ± 3.08[a]	29.38 ± 1.16[a]	25.99 ± 1.60[a]
Shrinkage (%)	2.47 ± 0.70[a]	2.54 ± 0.74[a]	2.46 ± 0.66[a]	1.94 ± 0.31[a]
L*	60.99 ± 0.15[b]	59.77 ± 1.31[b]	61.52± 0.32[ab]	63.40 ± 0.16[a]
a*	2.08 ± 0.12[a]	1.36 ± 0.30[b]	1.30± 0.11[b]	1.23 ± 0.08[b]
b*	12.42 ± 1.30[b]	14.30 ±0.77[ab]	15.37± 0.66[a]	17.03 ± 0.51[a]
Springiness (mm)	3.4 ± 0.20[a]	3.25 ± 0.36[a]	3.29 ± 0.31[a]	3.14 ± 0.17[a]
Hardness (g)	1.02 ± 0.24[d]	2.83 ± 0.64[c]	4.12 ± 0.73[b]	6.17 ± 0.84[a]
Chewiness (g.mm)	1.89 ± 0.57[d]	5.91 ± 1.47[c]	8.68 ± 1.44[b]	11.20 ± 1.42[a]
Gumminess (g.mm)	0.61 ± 0.16[d]	1.81 ± 0.36[c]	2.67 ± 0.54[b]	3.58 ± 0.47[a]
Cohesiveness	0.60 ± 0.02[b]	0.64 ± 0.03[a]	0.64 ± 0.03[a]	0.58 ± 0.02[b]

ES= emulsion stability. NC= nugget formulation without FPP addition. NF4= nugget formulation with 4% of FPP addition. NF8= nugget formulation with 8% of FPP addition. NF12= nugget formulation with 12% of FPP addition. Means followed by same letters (same line) did not differ statistically ($p>0.05$) by Tukey test.

The control formulation had the lowest value of emulsion stability ($p<0.05$). Regardless of the amount used, addition of FPP to the nuggets increased emulsion stability, which, according to Kumar et al. (2013) is due to the increased viscosity caused by the fibers present in the flours. These authors found values between 93.4 and 95.4% in chicken nuggets formulated with green banana and soybean meal.

The formulations had no significant difference ($p>0.05$) regarding their pick-up values, which was expected, since the alterations described for the formulations were carried out in the mass of the product, and not during the coating process. The values obtained in the present study are similar to those of chicken nuggets made with the addition of chia flour, ranging from 30.94 to 34.04% (Barros et al., 2018).

The formulations had similar values for shrinkages ($p>0.05$). Although no shrinkage analyses values were found in the literature for nuggets, for beef patties produced with the addition of gilded flax meal, shrinkage decreased due to addition of fibers (Oliveira et al., 2014). According to Kumar et al. (2013) the addition of fibers may reduce shrinkage of the product during cooking.

For color parameters (Table 2), formulations NF8 and NF12 had the highest values for luminosity, which indicates that the nuggets became brighter with the addition of FPP at higher levels. The values of a* and b* were similar between the formulations containing FPP ($p>0.05$). The control formulation had the highest a* value, thus having a reddish color. The NF8 and NF12 formulations had higher b* values in comparison to the control and the NF4 ($p<0.05$), and thus had a more intense yellow color. Such alterations in color properties are associated with the color characteristics of FPP (b* -23.6) (Bolanho; Danesi; Beléia, 2014). Barros et al. (2018) found b* values between 14.86 and 20.35 in chicken nuggets produced with chia flour addition, being these values similar to those obtained in the present work.

The texture profile analysis (TPA) showed that springiness did not differ ($p>0.05$) among the different formulations (Table 2). However, the control formulation was a less firm product ($p<0.05$) when compared to the other formulations. The addition of increasing amounts of FPP increased hardness, which can be due to the higher fiber contents of the nuggets produced with FPP addition. This effect was also observed by Barros et al. (2018) in nuggets formulated with chia flour instead of fat.

The values for chewiness and gumminess increased with the addition of FPP ($p<0.05$). In gluten-free chicken nuggets produced with addition of 5-10% sorghum flour (Devatkal et al., 2011), there was also an increase in the values for these parameters. According to the authors, the increase of chewiness and gumminess may be due to sorghum flour having properties that increase water and fat absorption, properties also already reported for FPP (Bolanho et al., 2015), which can also explain the increase seen in the present study.

Cohesiveness for the NF4 and NF8 formulations was higher ($p<0.05$) than for the other formulations. Kumar et al. (2013) obtained similar values for this parameter (0.47 - 0.49) in chicken nuggets formulated with addition of green banana flour. The authors reported that as the product becomes harder, consequently it becomes more cohesive, and this relationship is also found in the present study.

The results for microbiological analysis showed that all tested formulations were in accordance with the limits preconized by Brazilian legislation (ANVISA, 2012) for thermotolerant coliforms, coagulase positive Staphiloccocus and *Salmonella* spp. Adequate hygienic-sanitary conditions of the raw materials used in the formulations and further processing steps made the nuggets safe for consumption, being the results in accordance with sanitary parameters is important in order to protect the health of potential consumers (Baugreet et al., 2016).

Regarding sensorial parameters (Table 3), the nuggets had average scores varying from 5.06 to 7.62 for the different parameters analyzed, which fall within grade intervals 5 to 8 which correspond, respectively, to "neither liked nor disliked" and "liked much". The nuggets containing 4% and 8% of FPP had no significant difference ($p>0.05$) in comparison to the control formulation (NC) regarding overall appearance and aroma attributes. On the other hand, the NF12 formulation had the lowest scores for both parameters. For flavor and texture attributes, the NC formulation had the highest scores (7.62 and 7.54, respectively) when compared to the other formulations ($p<0.05$). There was no difference between the grades for flavor for the NF4 and NF8 formulations ($p>0.05$); the NF12 formulation, however, had the lowest grade for flavor (5.06). As for texture, the NF8 and NF12 formulations were not significantly different between them ($p<0.05$), having the lowest grades. Although addition of FPP reduced the scores attributed to taste and texture parameters, especially for the formulations containing the highest FPP levels (NF8 and NF12), the calculated acceptability index (AI) was higher than 70% for the NF4 and NF8 formulations. According to Dutcosky, (2001), for a product to be considered "well accepted", it must have an AI $\geq$ 70%. Polizer et al. (2015) reported that pea fiber added to nuggets caused no impact on consumer acceptance, obtaining grades between 7.20 and 7.48.

Table 3. Sensorial acceptance, acceptability index (AI) and purchase intention of chicken nuggets formulations with chicken skin replacement by peach palm flour

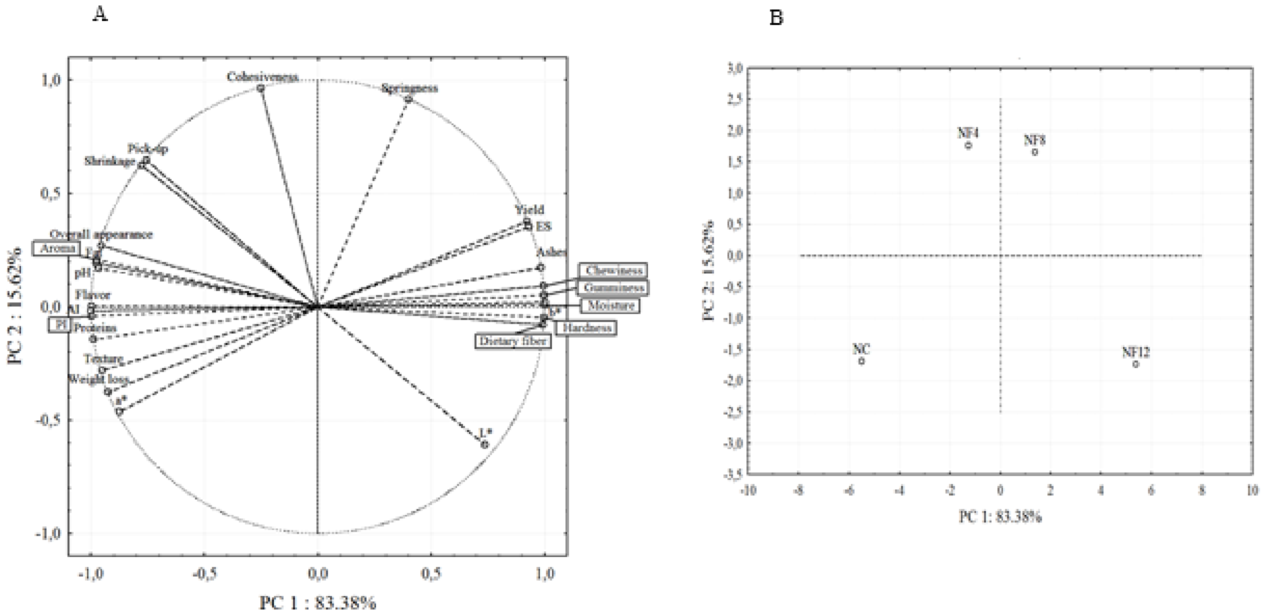
Parameters	NC	NF4	NF8	NF12
Overall appearance	7.28 ± 1.20[a]	7.02 ± 1.26[a]	6.90 ± 1.39[a]	6.25 ± 1.59[b]
Aroma	7.49 ± 1.20[a]	7.20 ± 1.19[a]	7.02 ± 1.39[a]	6.43 ± 1.70[b]
Flavor	7.62 ± 1.38[a]	6.53 ± 1.83[b]	6.11 ± 2.03[b]	5.06 ± 1.97[c]
Texture	7.54 ± 1.23[a]	6.42 ± 1.89[b]	5.66 ± 1.93[c]	5.50 ± 1.94[c]
AI (%)	83.11	75.44	71.33	64.55
Purchase intention	4.15 ± 1.01[a]	3.50 ± 1.17[b]	3.02 ± 1.24[c]	2.51 ± 1.17[d]

NC= nugget formulation without FPP addition. NF4= nugget formulation with 4% of FPP addition. NF8= nugget formulation with 8% of FPP addition. NF12= nugget formulation with 12% of FPP addition. Means followed by same letters (same line) did not differ statistically (p>0.05) by Tukey test.

Purchase intention analysis evidenced that for the NF4 formulation, 29 and 23% of the tasters would "possibly buy" and "would certainly buy", respectively (grades 4 and 5). Thus, NF4 samples were more widely accepted after the control (NC) formulation, being its average grade lower ($p<0.05$) than the value found for the NC formulation (Table 1), but higher than those obtained for the NF8 and NF12 formulations.

The correlation of the results for physicochemical, sensorial and texture properties of the nugget formulations can be seen in Figure 1. The principal component analysis (PCA) shows the evaluated parameters (Figure 1A) and the tested formulations (Figure 2B) on factorial planes (PC1xPC2), being the two principal components (PC) responsible for 99% of the total variance. According to Montanuci, Garcia and Prudencio, (2010), values of PC above 70% indicate appropriate explanation of the variance.

Figure 1. Principal component analysis: parameters evaluated (A) and nuggets formulations (B). AI – acceptability index, PI – purchase intention, ES – emulsion stability



The parameters for instrumental texture – hardness, chewiness and gumminess – had a positive correlation (>0.994) with the moisture and dietary fiber contents (Figure 1A), indicating that these components contribute directly to a firmer texture of the nuggets. These parameters of texture and composition, including the color parameter b*, negatively affected sensorial attributes (flavor, acceptability index, purchase intention and texture), because they are approximately at an 180^{o} angle from each other, being the correlations between -0.939 to -0.999. On the other hand, the higher fat content of nuggets with lowers levels of FPP had a positive impact on aroma (0.990), flavor (0.971) and overall appearance (0.979). It was observed that addition of FPP increased yield and emulsion stability, and these cooking properties negatively correlated to weight loss (>-0.984) and positively correlated to instrumental texture parameters, specially chewiness and gumminess (>0.944).

The formulations containing higher amounts of FPP (NF8 and NF12) are located at the right side of the graph (Figure 2B), which allows for association with higher contents of dietary fiber, moisture, ashes and a firmer texture (Figure 1A). The control and NF4 formulations, on the other hand, are located at the left side of the graph (Figure 1B), so it can be inferred that these formulations have better sensorial attributes. Thus, among the formulations containing FPP, the overall "best" formulation was NF4 due to its sensorial characteristics associated with higher fiber content (5 times higher than the control formulation) and lower weight loss (half than the value of the control formulation).

4 CONCLUSIONS

The use of flour from peach palm by-product to chicken skin replacement into nuggets improved their nutritional value, increasing content of ashes and dietary fibers. Yield, emulsion stability, hardness, chewiness and gumminess increased, and weight loss was reduced due to addition of FPP. The principal component analysis showed the correlation among the evaluated parameters and it demonstrated that the formulation containing 4% of FPP was the most similar to the control formulation, also having the best sensorial analysis scores. This study contributes to provide an alternative of nutritional enrichment, especially in dietary fibers, to chicken nuggets, using a low-cost ingredient.

REFERENCES

Agência Nacional de Vigilância Sanitária – ANVISA. RDC n°54, de 12 de Novembro de 2012. Regulamento Técnico sobre Informação Nutricional Complementar. Brasil: Diário Oficial da União, 2012.

American Public Health Association – APHA, Committee on Microbiological for Foods. Compendium of methods for the microbiological examination of foods. 4th edition. Washington, 2001.

Barros, J. C.; Munekata, P. E. S.; Pires, M. A.; Rodrigues, I.; Andaloussi, O. S.; Rodrigues, C. E. C.; Trindade, M. A. Omega-3- and fibre-enriched chicken nuggets by replacement of chicken skin with chia (Salvia hispanica L.) flour. LWT, v. 90, p. 283-289, 2018.

Barros, N. V. S.; Costa, N. Q.; Porto, R. G. L.; Morgano, M. A.; Araújo, M. A. M.; Reis, R. S. Elaboração de hambúrguer enriquecido com fibras de caju (Anacardium occidentale L.). CEPPA, v. 30, p. 315-325, 2012.

Baugreet, S.; Kerry, J. P.; Botinestean, C.; Allen, P.; Hamill, R. M. Development of novel fortified beef patties with added functional protein ingredients for the elderly. Meat Science, v. 122, p. 40–47, 2016.

Bolanho, B. C.; Danesi, E. D. G.; Beléia, A. P. Characterization of flours made from peach palm (Bactris gasipaes Kunth) by-products as a new food ingredient. Journal of Food and Nutrition Research, v. 53, n. 1, p. 51-59, 2014.

Bolanho, B. C.; Egea, M. B.; Guido, E. S.; Danesi, E. D. G. Produção de farinha com subproduto do processamento de palmito pupunha (Bactris gasipaes Kunth.) para aplicação em biscoitos. Revista Brasileira de Produtos Agroindustriais, v. 17, n. 2, p. 149-158, 2015.

Choi, Y. S.; Choi, J. H.; Han, D. J.; Kim, H. Y.; Lee, M. A.; Kim, H. W.; Jeong, J. Y.; Kim, C. J. Characteristics of low-fat meat emulsion systems with pork fat replaced by vegetable oils and rice bran fiber. Meat Science, v. 82, n. 2, p. 266-271, 2009.

Contado, E. W. N. F.; Rocha, D. A.; Queiroz, E. R.; Abreu, C. M. P.; Ramos, E. M. Use of yacon flour and fructan extract in the formulation of luncheon meats. Brazilian Journal of Food Technology, v. 18, n. 1, p. 49-56, 2015.

Devatkal, S. K.; Kadam, D. M.; Naik, P. K.; Sahoo, J. Quality characteristics of gluten-free chicken nuggets extended with sorghum flour. Journal of Food Quality, v. 34, n. 2, p. 88-92, 2011.

Dill, D. D.; Silva, A. P.; Luvielmo, M. M. Processamento de empanados: sistemas de cobertura. Estudos Tecnológicos, v. 5, n. 1, p. 33-49, 2009.

Dutcosky, S. D. Análise Sensorial de Alimentos. 1ª edição. Pucpress, São Paulo, 2001.

Elleuch, M.; Bedigian, D.; Roiseux, O.; Besbes, S.; Blecker, C.; Attia, H. Dietary fibre and fibre-rich by-products of food processing: Characterization, technological functionality and commercial applications: a review. Food Chemistry, v. 124, n. 2, p. 411-421, 2011.

Florek, M.; Litwinczuk, A.; Skatecki, P.; Topyta, B. Influence of pH of fatteners musculus longissimus lumborum on the changes of its quality. Polish Journal of Food and Nutrition Science, v. 13, n. 2, p. 195-198, 2004.

Horwitz, W.; Latimer, G. W. Official Methods of Analysis of AOAC International. 18th edition. Association of Official Analytical Chemistry International, Maryland, 2005.

Kumar, V.; Biswas, K. A.; Sahoo, J.; Chatli, K. M.; Sivakumar, S. Quality and storability of chicken nuggets formulated with green banana and soybean hulls flours. Journal of Food Science and Technology, v. 50, n. 6, p. 1058-1068, 2013.

Mendoza, E.; García, M. L.; Casas, C.; Selgas, M. D. Inulin as fat substitute in low fat, dry fermented sausages. Meat Science, v. 57, n. 4, p. 387-393, 2001.

Ministério da Agricultura, Pecuária e Abastecimento – MAPA (Brasil). Instrução Normativa nº 6, de 15 de Fevereiro de 2001. Regulamento Técnico de Identidade e Qualidade de Empanados - Anexo III. Brasil: Diário Oficial da União, 2001.

Montanuci, F. D.; Garcia, S.; Prudencio, S. H. Sensory characterization and acceptance of sweetened full fat and low fat Kefir with inulin. Brazilian Journal of Food Technology, v. 14, p. 79-90, 2010.

Moraes, J. E.; Paulino, V. T.; Possenti, R. A. Nutrientes e formas de utilização do resíduo agroindustrial do palmito de pupunha para alimentação animal no vale do ribeira. Pesquisa & Tecnologia, v. 8, n. 2, 2011.

Neves, E. J. M.; Santos, A. F.; Rodigheri, H. R.; Júnior, C. C.; Bellettini, S.; Tessmann, D. J. Cultivo da Pupunheira para Palmito nas Regiões Sudeste e Sul do Brasil. Circular Técnica, v. 143, p. 1-9, 2007.

Oliveira, D. F.; Coelho, A. R.; Burgardt, V. C. F.; Hashimoto, E. H.; Lunkes, A. M.; Marchi, J. F.; Tonial, I. B. Alternatives for a healthier meat product: A review. Brazilian Journal of Food Technology, v. 16, n. 3, p. 163-174, 2013.

Oliveira, D. F.; Mileski, J. P. F.; Carli, C. G.; Marchi, J. F.; Silva, D. C.; Coelho, A. R.; Tonial, I. B. Golden flaxseed flour as a substitute for animal fat in reduced-sodium beef hamburgers. Brazilian Journal of Food Technology, v. 17, n. 4, p. 273-282, 2014.

Olivo, R.; Shimokomaki, M. Meat extension technology: the latest in meat science and technology. 1th edition. Varela, São Paulo, 2006.

Polizer, Y. J.; Pompeu, D.; Hirano, M. H.; Freire, M. T. A.; Trindade, M. A. Development and evaluation of chicken nuggets with partial replacement of meat and fat by pea fibre. Brazilian Journal of Food Technology, v. 18, n. 1, p. 62-69, 2015.

Santos Júnior, L. C. O.; Rizzatti, R.; Brungera, A.; Schiavini, T. J.; Campos, E. F. M.; Neto, J. F. S; Rodrigues, L. B.; Dickel, E. L.; Santos, L. R. Desenvolvimento de hambúrguer de carne de ovinos de descarte enriquecido com farinha de aveia. Ciência Animal Brasileira, v. 10, n. 4, p. 1128-1134, 2009.

Seabra, L. M. J.; Zapata, J. F. F.; Nogueira, C. M.; Dantas, M. A.; Almeida, R. B. Fécula de mandioca e farinha de aveia como substitutos de gordura na formulação de hambúrguer de carne ovina. Ciência e Tecnologia de Alimentos, v. 22, n. 3, p. 244-248, 2002.

Selgas, M. D.; Cárceres, E.; García, M. L. Long-chain soluble dietary fiber as functional ingrediente in cooked meat sausages. Food Science and Technology International, v. 11, n. 1, p. 41-47, 2005.

Tamsen, M.; Shekarchizadeh, H.; Soltanizadeh, N. Evaluation of wheat flour substitution with amaranth flour on chicken nugget properties. LWT, v. 91, p. 580-587, 2018.

Tharanathan, R. N.; Mahadevamma, S. Grain legumes - a boon to human nutrition. Trends in Food Science & Technology, v. 14, n. 12, p. 507-518, 2003.

Yuyama, L. K. O.; Cozzolino, S. M. F. Efeito da suplementação com pupunha como fonte de vitamina A em dieta: estudo em ratos. Revista Saúde Pública, v. 30, n. 1, p. 61-6, 1996.

Yuyama, L. K. O.; Favaro, M. M. D.; Yuyama, K.; Vannucchi, H. Bioavailability of vitamin a from peach palm (Bactris gasipaes H.B.K) and from Mango (Mangifera indica L.) in rats. Nutrition Research, v. 11, n. 10, p. 1167-1175, 1991.