Esfiha with added chayote peel flour: physical-chemical characterization and sensory analysis among children

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Abstract

The aim of the study was to evaluate the sensory acceptability of sfiha added to different levels of chayote peel flour (CPF). Also, determine the physical-chemical composition of the standard formulation and that containing the highest CPF content and with acceptance similar to the standard. Five sfiha formulations were developed: F1 (standard, 0% CPF) and the others added 2% (F2), 6% (F3), 9% (F4) and 12% (F5) of CPF. Sixty evaluators aged 7 to 10 years participated in the sensory evaluation. The addition of levels

greater than 2% of CPF reduced sensory acceptability ($p<0.05$) of the sfiha for all attributes and for the overall acceptance and purchase intention, in relation to the standard product. Formulation F2 was the one with the highest CPF content and with acceptance similar to the standard formulation. Higher levels of moisture, ash and dietary fiber and lower levels of carbohydrate and energy were observed for F2 compared to F1. There was no significant difference ($p>0.05$) for protein and lipid content between the two formulations. It is concluded that an addition level of up to 2% of CPF in sfiha is well accepted by schoolchildren. In addition, the CPF improves the nutritional value of the product, especially with the increase in dietary fiber and mineral matter.

Keywords: Byproducts; reuse; food waste.

1. Introduction

Food waste is a prominent issue in several countries. Annually, about 1.3 billion tons of food residues are discarded in environment, causing environmental impacts, mainly in relation to chemical components in food [1], impacts on global warming, eutrophication and soil acidification [2]. Foods such as fruits and vegetables are those with the highest waste rate waste, since, in general, stems, leaves, peels and seeds are not used in food. The waste of these byproducts occurs mainly during harvesting (10%), processing, including storage and transportation (50%), in industries, residential kitchens and restaurants (40%) [3,4]. Despite this, food waste has high nutrients levels, especially vitamins, minerals and fibers. Studies have shown that residues can be used as ingredients in food products such as cookie [5], cake [6], hamburger [7] and bread [8] for nutritional enrichment. However, the high levels addition of byproducts can increase the residual flavor intensity and impair texture [8], in addition to increasing the hardness of cookie [5] and cakes [6].

Chayote (*Sechium edule*) is a cucurbit, a family made up of creeping, rupicolous or terrestrial stem plants, often with support tendrils, including some species of shrubby habit. Its peel can be smooth or with thorns, according to its species. Contains good amounts of potassium (125 mg 100 g^{-1}), calcium (17 mg 100 g^{-1}) and magnesium (12 mg 100 g^{-1}), vitamin C (7.7 mg 100 g^{-1}) and dietary fiber (1.7 mg 100 g^{-1}). In addition, it has a low energy value (19 kcal 100 g^{-1}) [9]. Brazil is the largest vegetable producer [10], around 50 thousand tons in 2016. In the first quarter of 2017, approximately 13 thousand tons of chayote were sold, corresponding to 3.4% of the vegetables consumed in Brazil [11, 12]. The chayote peel has a greener color than the pulp, due to the higher levels of chlorophyll [13], which can have an antioxidant and anti-inflammatory effect in the body [14]. Also, it contains high levels of vitamin C (51.6 mg 100 g^{-1}), fiber (45.2 g 100 g^{-1}), protein (15.5 g 100 g^{-1}), calcium (307 mg 100 g^{-1}) and iron (6.76 mg 100 g^{-1}) [9]. Despite this, chayote peel is generally not consumed, but can be added to a cereal bar [15], and muffins [16], maintaining sensory acceptability and improving nutritional content.

The bakery sector in Brazil in 2018, grew 2.81% with a turnover of R$ 92.63 billion. Aiming at diversifying these products, the industry continually seeks to innovate to satisfy consumer needs [17]. Among these products is the sfiha, which is highly appreciated by different audiences. It can be consumed in open or closed form and is made with wheat flour, sugar, salt, eggs, oil and yeast, having the most diverse

types of fillings, such as, for example, meat, chicken, cheese and vegetables [18]. Generally, sfiha is consumed as a snack, since it has a low acquisition cost. However, it has high levels of fat (8.84 g 100 g^{-1}) and energy (286.63 kcal 100 g^{-1}), in addition to low levels of dietary fiber (1.01 g 100 g^{-1}) and vitamins and minerals [19]. Thus, excessive consumption of this products can increase the chronic non-communicable diseases risk, such as arterial hypertension, diabetes mellitus, obesity and cancer [20,21]. Knowing this, sfiha becomes a potential product for the addition of healthier ingredients, aiming to improve its nutritional content.

Children aged 6 to 12 years are classified as school-aged [22]. At this stage, eating habits are influenced by different factors, such as family behavior and income, social norms, school environment and marketing [23]. Children generally have a food intake with high levels of calories, fat, salt and sugar [24] and low levels of vitamins, minerals and fibers. This is because the fruits and vegetables is below 200 g [25] of the daily recommendation, which is 400 g, which is equivalent to 5 servings [26]. Children remain in school for a long time and are directly influenced by friends, colleagues and teachers regarding food consumption. In this regard, school is a strategic environment for health promotion through practical interventions related to healthy eating, in addition to contributing to prevention of nutritional deficiencies and combating excess weight [27].

Sensory analysis is an important phase for the new food products development. This tool is used to obtain responses from consumers regarding the acceptability of the most diverse products [28]. For children, playful hedonic scales are used, with facial expressions, which facilitate the understanding and interpretation of responses [29]. Other analyzes, such as the physical-chemical evaluation, provide essential information to ensure food quality and safety, verifying its adequacy to requirements of the current legislation [30]. In this context, the objective of this research was to evaluate the sensory acceptability of sfiha with the addition of different levels of chayote peel flour (CPF) among children. Also, determine the physical-chemical composition of standard formulation and that containing the highest CPF content and with acceptance similar to the standard.

2. Materials and methods

2.1 Acquisition of raw material

Ingredients were purchased in supermarkets in municipality of Guarapuava city, PR state. Seventy-one kg of chayote (*Sechium edule* Sw.) with better visual appearance, smooth surface, without imperfections and light green color were used. The vegetables were cleaned in running drinking water, sanitized (dipped in sodium hypochlorite solution for 15 minutes) and again cleaned in running water.

2.2 Preparation of chayote peel flour

For peels extraction, a stainless-steel knife was used. Subsequently, they were dried in a dehydrator (Pardal®, Brazil) with air circulation (65 °C) for 48 hours. After drying, they remained at room temperature (22 ºC) until completely cooled. The peels were crushed in a domestic blender (Mondial®, Brazil) and passed through a 32 mesh/Tyler sieve (Bertel®, Brazil) until the CPF was obtained, which obtained a yield of 3.1 kg.

2.3 Preparation of formulations

Five sfihas formulations were added with different levels of CPF: F1 (0%, standard), F2 (3%), F3 (6%), F4 (9%) and F5 (12%). These percentages were defined through preliminary sensory tests performed with the product. In addition to the CPF, the ingredients used in the formulations were: Dough - wheat flour (F1: 60%, F2: 57%, F3: 54%, F4: 51%, F5: 48%), water (19%), egg (10.6%), sugar (4.2%), oil (4.9%), salt (0.3%), biological yeast (1%); Filling - shredded cooked chicken (24.5%), braised tomato (22.1%), braised carrot (20.4%), chopped cooked chayote (16%), braised onion (14.3%), salt (1%), oil (1%) and sautéed garlic (0.6%). For sfiha dough preparation, all the ingredients were mixed until homogenized, considering the percentage of CPF addition. The dough was molded into smaller circular pieces, remaining at rest until it doubled in size (22 ºC), being molded into a sfiha shape. The filling was made by mixing chicken, onion, carrot, tomato, chayote, garlic and salt, which were previously sautéed in the oil. The sfihas were stuffed and baked in an oven (Venâncio®, Brazil), preheated to 200 °C for 20 minutes. After this process, they remained at rest until they reached room temperature (22 ºC). The products were packed in hermetically sealed plastic containers until the time of analysis.

2.4 Sensory analysis

Sixty untrained judges participated in sensory analysis, being children duly enrolled in a Municipal School of Guarapuava, PR, of both sexes, aged between 7 and 10 years. Products were submitted to sensory analysis in a school room and the judge was instructed by the researchers to fill out the answers. The attributes of appearance, aroma, flavor, texture and color were evaluated using a mixed structured hedonic facial scale of 7 points ranging from 1 (super bad) to 7 (super good). Also, questions of global acceptance and purchase intention were analyzed and analyzed using a mixed 5-point structured scale (1 - I disliked a lot/I would not buy; to 5 - I liked a lot/I would buy for sure) [31]. The judges received a portion of each sample (approximately 15 g), on white disposable plates encoded with three-digit numbers, in a randomized and balanced way, accompanied by a glass of water for cleaning the palate. The formulations were offered in a sequential monadic manner. Acceptability index (IA) calculation was performed according to the formula: AI (%) = A x 100/B (A = average grade obtained for the product and B = maximum grade given to the product) [32].

2.5 Physical-chemical composition

Following physical-chemical analyzes were performed in triplicate at CPF, in the standard formulation and in the one with the highest level of CPF addition and with sensory acceptance similar to the standard product: Moisture: determined in an oven at 105 °C until constant weight; Ash: analyzed in a muffle furnace (550 °C) [33]; Lipid: the cold extraction method was used [34]; Protein: assessed through the total nitrogen content of the sample, using the Kjeldahl method, determined at the semi-micro level [33]. The nitrogen to protein conversion factor of 6.25 was used; Total and insoluble dietary fiber: determined by enzymatic method [33]. The soluble dietary fiber content was calculated by the difference in the results of total and insoluble dietary fiber; Carbohydrate: evaluated by theoretical calculation (by difference) in the triplicates results, according to the formula: % Carbohydrate = 100 - (% moisture + % protein + % lipid + % ash + % fiber); Total caloric value (kcal): calculated using the following values: lipid

(8.37 kcal g^{-1}), protein (3.87 kcal g^{-1}) and carbohydrate (4.11 kcal g^{-1}) [35]. The Daily Reference Value (DV) was calculated in relation to 100 g of sfiha, based on the average daily values recommended for children (7 to 10 years) [36], resulting in: 1,933.5 kcal day^{-1}, 130 g day^{-1} of carbohydrate, 26.5 g day^{-1} of protein and 26.75 g day^{-1} of dietary fiber.

2.6 Statistical analysis

The data were analyzed with software R version 3.6.1, through analysis of variance (ANOVA). The means comparisons were performed using the Tukey and Student's t tests, assessed at a 5% level of significance.

2.7 Ethical issues

This work was approved by the Research Ethics Committee of UNICENTRO, opinion number 2,451,570/2017. The exclusion criteria were: having an allergy to any ingredient used in the preparation of the sfiha or not delivering the Informed Consent Form (ICF) signed by the legal guardian and the Consent Form signed by the child.

3. Results and discussion

3.1 Sensory analysis

The sensory analysis results of the sfiha added with different levels of CPF are shown in Table 1.

Table 1 - Sensory scores (mean ± standard error) obtained for esfiha with addition of different levels chayote peel flour (CPF)

Parameter	F1 (0%)	F2 (2%)	F3 (6%)	F4 (9%)	F5 (12%)
Appearance	6.2±0.86^{a}	5.7±0.85^{ab}	5.3±1.13^{bc}	5.1±1.16^{c}	4.9±1.24^{c}
AI (%)	89.4	81.9	75.3	72.9	70.0
Aroma	6.1±0.74^{a}	5.4±1.02^{ab}	5.2±1.40^{b}	5.1±1.55^{b}	5.0±1.33^{b}
AI (%)	86.9	77.6	74.6	72.9	72.1
Flavor	6.0±0.85^{a}	5.4±0.97^{ab}	5.0±1.35^{b}	5.2±1.28^{b}	5.1±1.32^{b}
AI (%)	85.7	77.9	71.4	73.7	73.6
Texture	5.9±1.06^{a}	5.4±1.21^{ab}	5.3±1.40^{b}	5.0±1.31^{b}	5.1±1.30^{b}
AI (%)	85.0	77.4	75.4	71.9	72.4
Color	6.1±0.90^{a}	5.4±1.21^{a}	4.6±1.48^{b}	4.4±1.77^{b}	4.3±1.73^{b}
AI (%)	87.4	77.9	66.1	63.6	61.4
Overall Acceptance	4.7±0.55^{a}	4.2±0.71^{a}	3.5±0.89^{b}	3.1±1.04^{bc}	2.8±1.18^{c}
AI (%)	93.2	83.2	70.0	61.4	55.4
Purchase Intention	4.2±1.02^{a}	3.7±1.25^{ab}	3.4±1.28^{bc}	3.1±1.29^{bc}	3.0±1.25^{c}

Distinct letters in the same line indicate significant difference according to Tukey's test ($p<0.05$); AI: Acceptability Index.

The addition of up to 2% CPF did not alter the sfiha sensory acceptability for all attributes and for the overall acceptance and purchase intention, in relation to the standard product. Formulations F4 and F5 were the least accepted by children, especially for appearance and for global acceptance and purchase intention. The CPF greenish color may explain the lower grades obtained for the sfiha with added contents ≥ 6% of the ingredient. This effect is caused by the chlorophyll presence in the chayote peel, which is responsible for pigmentation in several vegetables [13]. The high phenolic compounds content present in chayote peel (0.45 mg gPF^{-1}) [37] is the main responsible for reducing the formulations acceptability F3, F4 and F5. The main phenolic compounds are flavonoids, anthocyanins and tannins that can alter aroma, oxidative stability and color. In addition, they can promote a sensation of astringency and cause a bitter and residual taste in the product [37]. Similar results to the present research were observed in other studies with the addition of CPF in cereal bars [15] and in cookie [38].

During the sfiha preparation, there was a reduction in the dough volume and softness, making it more brittle, as verified by Luz et al. [38]. This is due to the CPF having a higher fiber content compared to wheat flour. The fiber is highly hygroscopic, which increases water absorption and influences the product final volume [39]. Due to the lack of gluten, the CPF can change the technological composition of the dough. Gluten is a protein formed by gliadin and glutenin, which aid in dough viscoelasticity in presence of water [40,41]. During this process, a gluten network is formed that retains carbon dioxide from fermentation, which helps to increase the volume of mass, growth and elasticity [42,41]. Also, it is commonly used as an additive in foods to improve texture, moisture retention and flavor [40]. Acceptability index of less than 70% were verified only for formulations F3, F4 and F5 for color and F4 and F5 for global acceptance. Other formulations can be considered as having good acceptability, since the AI's were ≥ 70% [43]. Similar effects have been reported by Cristo et al. [15], in cereal bars production with the CPF addition (0% to 27%). Figure 1 shows sfiha formulations containing different CPF levels. Judges' distribution by the hedonic values obtained in the sensory test is shown in Figure 2.

F1 F2 F3 F4 F5

Figure 1 - Sfihas formulations added with different levels of chayote peel flour (CPF): F1 (0%), F2 (2%), F3 (6%), F4 (9%) and F5 (12%).

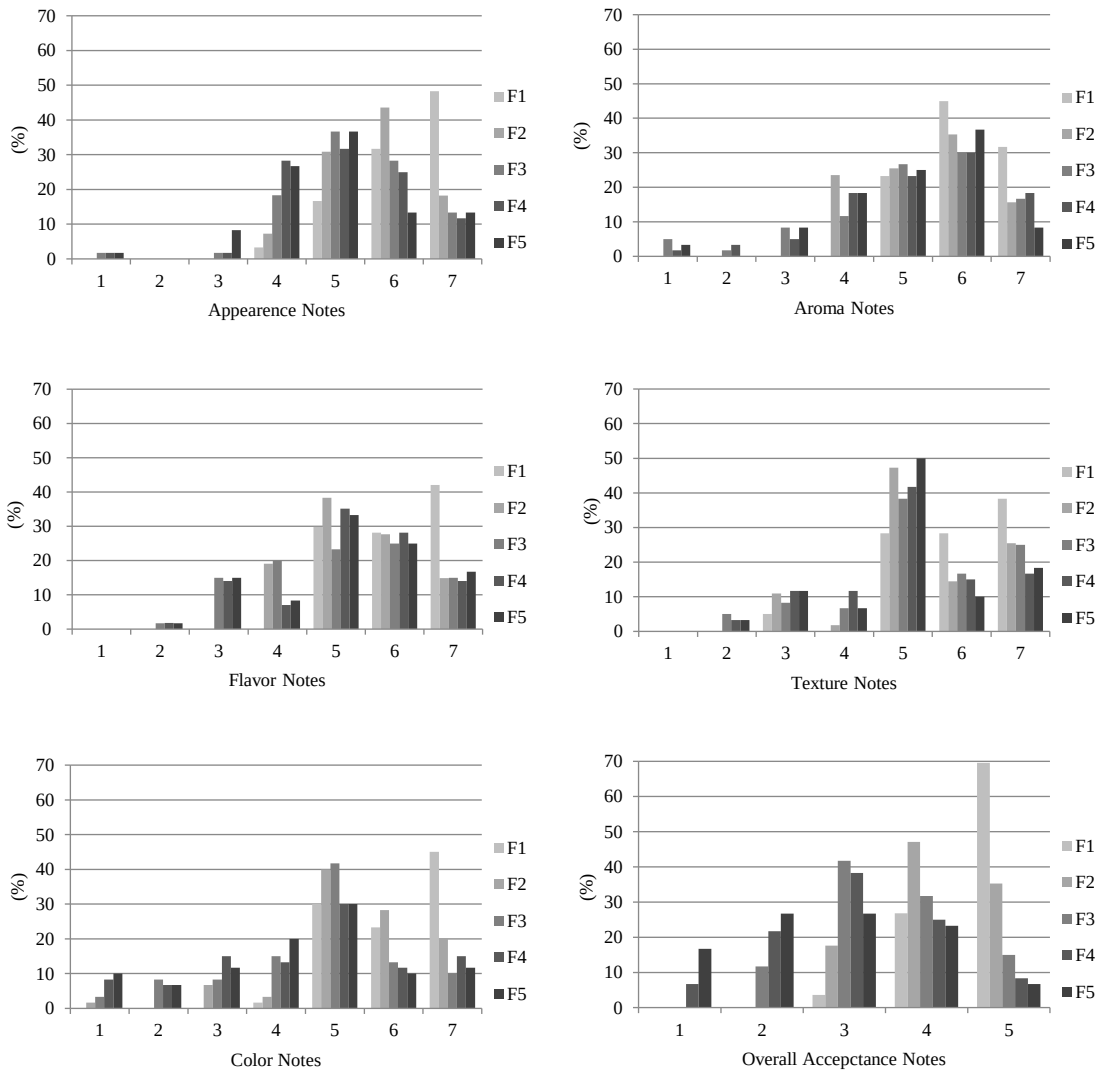

Figure 2 – Judges' distribution by the hedonic values obtained in the evaluation of sfihas with different levels of chayote peel flour (CPF): F1: 0%; F2: 2%; F3: 6%; F4: 9%; F5: 12%.

In general, the judges' distribution scores remained ≥ 5 ("good") for the attributes and ≥ 3 ("liked") for global acceptance. Similar results were verified in cereal bars with the CPF addition (0%, 6.75%, 13.5%, 20.25% and 27%) [15]. In this way, the viability of using vegetable flour as an ingredient in sfihas and similar products is demonstrated, which helps in the full use of food. Furthermore, the vegetables consumption in diet is essential because they are important sources of fiber, vitamins, and minerals, helping to prevent cardiovascular diseases, hypertension and diabetes [44]. The F2 sample was the one with the highest CPF content and acceptance similar to standard (F1) in all sensory tests evaluated (Table 1). Therefore, both were considered for purposes of physical-chemical comparison in the present research.

3.2 Physical-chemical composition

Physical-chemical characterization of the standard sfiha and that with the addition of 2% chayote peel flour (F2) is described in Table 2.

Table 2 - Average physical-chemical composition (± standard deviation) of chayote peel flour (CPF), sfiha with 0% CPF and that with 2% CPF

Parameter	CPF	0%	DV (%)*	2%	DV (%)*
Moisture (g 100 g^{-1})	5.0±0.08	36.7±0.05^{b}	ND	40.6±0.03^{a}	ND
Ash (g 100 g^{-1})	6.2±0.05	0.8±0.07^{b}	ND	1.8±0.04^{a}	ND
Protein (g 100 g^{-1})	11.1±0.09	11.7±0.09^{a}	44.1	11.8±0.08^{a}	44.6
Lipid (g 100 g^{-1})	1.3±0.08	1.7±0.04^{a}	ND	1.7±0.08^{a}	ND
Carbohydrate (g 100 g^{-1})**	76.4±0.21	49.1±0.21^{a}	37.8	44.1±0.32^{b}	33.9
Energy value (kcal 100 g^{-1})	367.6±0.75	261.3±0.74^{a}	13.5	240.8±0.75^{b}	12.4
Soluble fiber (g 100 g^{-1})***	0.5±0.09	0.5±0.10^{a}	ND	0.5±0.11^{a}	ND
Insoluble fiber (g 100 g^{-1})***	22.8±0.14	2.2±0.15^{b}	ND	2.8±0.13^{a}	ND
Total fiber (g 100 g^{-1})***	23.3±0.11	2.6±0.17^{b}	9.9	3.3±0.14^{a}	12.2

Distinct letters in the same line differ significantly by Student's t test ($p<0.05$); *Daily Reference Value (DV): nutrients evaluated by the DRI average (2005), based on a diet of 1,933.5 kcal day^{-1} and an average portion of 100 g of sfiha (1 unit); *Values calculated in dry basis; **Include dietary fiber; ***Dietary fiber; ND: not detected.

Luz et al. [38] evaluating the CPF, observed lower values for calories (316.1%) and similar values for moisture (5.3%), ash (6.2%), protein (11%), lipid (1.3%) and carbohydrate (76.2%). Variations in the nutritional contents of the CPF can occur due to the climate of vegetable production, environmental conditions, type of cultivar, form of cultivation, harvest, exposure to light [45] and type of thermal processing [46], among other factors. The CPF complies with Brazilian law, which establishes a maximum moisture content of 15% for flours [47]. The CPF ash content confirms the expressive minerals amount in product (dry weight), such as calcium (307 mg 100 g^{-1}) and phosphorus (196 mg 100 g^{-1}) [9]. Furthermore, the high content of dietary fiber in the CPF helps to improve intestinal microbiota and reduce serum levels of blood lipids and glucose [48], also plays an important role in controlling body weight, preventing cancer and in chronic diseases [49].

The standard formulation F1 showed a lower moisture content than F2 ($p<0.05$), since the CPF has a high fiber content. The fibers have hygroscopic characteristics, which increase water absorption [39]. Higher ash content was also observed for F2, since the CPF contains greater minerals, amount compared to wheat flour (0.47 g 100 g^{-1}) [50]. There was no significant difference between protein and lipid levels in samples F1 and F2 ($p>0.05$), while carbohydrate and energy levels were lower for F2. Similar results in relation to protein, lipid and carbohydrate were observed after the addition of CPF in a cereal bar [15] and for carbohydrate and calories when the CPF was added in a cookie [38].

There was no significant difference in the soluble fiber levels between F1 and F2. However, higher contents of insoluble fiber and total fiber were observed for F2, which is due to the greater fibers amount present in the CPF compared to wheat flour (2.70 g 100 g^{-1}) [50]. Thus, the consumption of 1 portion of chayote sfiha (100 g) reaches 12.2% of the daily recommendation of total dietary fiber for children. In this context, formulation F2 can be classified as a product source of dietary fiber, as it has a minimum of 3% fiber in its composition [51].

4. Conclusion

An addition level of up to 2% of chayote flour in sfiha is well accepted by children, obtaining sensory acceptance similar to the standard product. The addition of 2% CPF provided reduction in carbohydrate and energy levels and an increase in moisture, ash and dietary fiber contents, improving the nutritional profile of the product. Thus, chayote peel flour can be considered as a potential ingredient for addition to sfiha and other bakery products, with the possibility of being offered to children with high expectations of acceptance in the market.

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