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FOOD TECHNOLOGY

Utilizing tamarind residues in the São Francisco valley: food and nutritional potential

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ABSTRACT: *This performed a technical application of tamarind residues (peel and seeds) in a habitually-consumed food product (cookie) and to verify its sensory and market acceptance. We initially proceeded by preparing the peel flour and roasted seeds by conventional drying. Then, the flours were physico-chemically characterized. Next, the products were prepared; cookies were prepared replacing wheat flour with peel flour (PF0, 15 and 30%), and a second kind of cookie was made by replacing wheat flour with roasted seed flour (SF0, 15 and 30%). Affective tests (hedonic scale, attitude and ordering) and purchase intention were subsequently evaluated to verify sensory acceptability. All cookies generated high energy value. The fiber content was higher in the incorporated formulations compared to the standards. The highest sensorial acceptance mediansfor the peel flour cookies were for the standard cookie and the cookiewith 15% peel flour, which were statistically equivalent. Conversely, the cookie with 30% peel flour had lower medians compared to the others. Other tests also revealed better scores for standard formulations and 15%peel flour. There was no difference in the medians by the hedonic tests, attitude and purchase intentionfor cookies prepared with roasted seeds, presenting scores indicating high sensory and market appreciation. It is concluded that it is possible to incorporate tamarind peel flour and roasted seeds in cookies and add nutritional value, especially at a concentration of 15%.*

Key words: *full use of food, peel, seeds, food consumption.*

Aproveitamento dos resíduos do tamarindo no vale do São Francisco: potencial alimentar e nutricional

RESUMO: *O objetivo deste trabalho foi realizar a aplicação técnica dos resíduos do tamarindo (casca e sementes) em um produto alimentar de consumo habitual (cookie) e verificar sua aceitação sensorial e de mercado. Inicialmente, procedeu-se a elaboração da farinha da casca e semente torrefada por meio de secagem convencional. Em seguida foi realizada a caracterização físico-química das farinhas. Posteriormente, procedeu-se a elaboração dos produtos: cookies com substituição da farinha de trigo pela farinha da casca (0, 15 e 30%) e cookies com substituição da farinha de trigo pela farinha da semente torrefada (0, 15 e 30%). Para verificar a aceitabilidade sensorial foram utilizados testes afetivos (escala hedônica, de atitude e ordenação) e de intenção de compra. Todos os cookies apresentaram alto valor energético. O teor de fibra foi maior nas formulações incorporadas em relação aos padrões. Sensorialmente, para os cookies da casca, as maiores medianas de aceitação foram para o padrão e aquele com 15% de farinha da casca, equivalentes estatisticamente. Enquanto o cookie com 30% teve menores medianas em comparação aos demais. Demais testes, também revelaram melhores notas para formulações padrão e com 15% de farinha da casca. Para os cookies com semente torrefada, não houve diferença nas medianas pelos testes hedônicos, atitude e intenção de compra, com notas indicando alto apreço sensorial e de mercado. Conclui-se que é possível incorporar farinha da casca e semente torrefada do tamarindo em cookies e agregar valor nutricional, especialmente na concentração de 15%.*

Palavras-chave: *aproveitamento integral dos alimentos, casca, sementes, consumo alimentar.*

INTRODUCTION

The unconscious and unsustainable production and consumption activities are an important topic of debate and research by researchers and governmental and non-governmental organizations in terms of the environmental impacts they have been causing (TURCHETO et al., 2016).

Thus, a logical first step in building national transformation pathways is to select appropriate indicators which can assess and track progress towards the sustainability of their diets and food systems

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(KANTER et al., 2016). However, there is currently no comprehensive and overall assessment of the sustainability of national food systems which takes into account multiple domains of interest such as nutritional, environmental, economic, social and resilience implications (VANHAM et al., 2013).

In contrast to environmental and food sustainability, the culture of wasting and not reusing food is part of the way of life of Brazilian society; after all, natural resources and even food are wasted daily without any proposal for a return. This fact not only causes irrecoverable losses in the economy, but also contributes to an imbalance in supply, thus reducing the availability of material and resources for society (CAVALCANTI et al., 2010). Notably, there is an accumulated quantity of waste produced by the food industry in the country, with important and enormous potential, even presenting a more beneficial purpose for man and the environment (DO NASCIMENTO FILHO; FRANCO, 2015)

Thus, the reuse of fruit residues is an important step for the food industry and for the population (BERTAGNOLLI et al., 2014), especially due to the enormous potential for use. This is because stalks, leaves, peels and seeds of fruits, vegetables and plants are discarded by the population when they could be used as a way to enrich the diet, as they concentrate large amounts of vitamins, minerals and fibers, in turn promoting health, minimizing costs, reducing the production of organic waste and helping to generate Food and Nutritional Security (BRASIL, 2016). In addition, reusing the processing by-product can increase the yield of the raw material, minimizing the problems caused by disposing large quantities of the industrial by-product and also expand alternative food production (BERTAGNOLLI et al., 2014).

Tamarind (*Tamarindus indica* L.) can be mentioned among the fruit species which generate food waste. Even though tamarind is not native to Northeast Brazil, it is considered a typical fruit plant in the region, being an ideal crop for semi-arid regions due to its rusticity and adaptability to different climatic conditions (SOUZA et al., 2010). Tamarind is mainly used for its pulp in manufacturing sweets, ice cream, liqueurs, concentrated juices, jellies/jams, condiments and sauces. By convention, the industries that use tamarind in food processing discard its peels and seeds, which do not have an effective use despite presenting good nutritional values, easy availability, and low cost (RAO et al., 2015).

Consequently, as a socio-environmental emergency in the food context, above all directed to the effective and integral use of fruit and vegetable residues due to its nutraceutical prowess and its computation and participation in organic waste and food waste, it is urgent to find alternative uses for such foods. In this sense, the cultivation of tamarind, which is important for the Northeast region, is not used in its entirety, as the population only uses the pulp of the fruit, which is naturally consolidated as the only food and nutritive part.

Therefore, it is justified to perform a study with the perspective of clarifying the population and the scientific community about the advantages and potential of tamarind peels and seeds for human consumption. In view of the above, this study technically applied these residues in a food product of usual consumption (cookies) and verifying it's sensory and market acceptance.

MATERIALS AND METHODS

Study design

This is an exploratory study conducted at the University of Pernambuco (UPE), Campus Petrolina, between June and August 2019, constituting part of the project: "Use of tamarind (*Tamarindus indica* L.) residues in human nutrition: a sustainable, nutritional and functional proposal", approved by the Ethics and Research Committee for Human Beings of the University of Pernambuco (UPE), under opinion number 2,701,445, in July 2018.

Raw material

The raw materials used were the peels and seeds of the tamarind fruit in full maturation stage, obtained in the Submédio São Francisco region from open markets. The other ingredients included: wheat flour, butter, refined sugar, brown sugar, eggs, raisins, chemical yeast, salt and vanilla essence, all purchased in commercial establishments in the city, intact and with established validity.

Flour formulation and physicochemical characterization

The tamarind fruit pods were manually broken and separated from the pulp with seeds. The peels and seeds were then sanitized (chlorinated solution at 200 ppm/15 minutes), washed with distilled water, and then dried in an air circulation oven (60 ºC for 6 h). The seeds were submitted to thermal processing at 150 ºC for 15 minutes in a conventional oven. The roasted peels and seeds were subsequently and separately crushed and ground into fine flour using a commercial blender. The resulting flour was sieved using a 250µm screen and stored in airtight containers at 18 °C before further use (NATUKUNDA et al., 2016).

Physicochemical analyzes were determined after obtaining the flours, all carried out in triplicate. The pH was electrometrically determined with a calibrated potentiometer (Method 017/IV). Titratable acidity was determined in 0.1 N sodium hydroxide using phenolphthalein as the indicator (Method 016/IV). Humidity was determined in an oven at 105°C until constant mass (Method 012/IV). The ash content was obtained by incineration in a muffle furnace at 550 ºC (Method 018/IV). Nitrogen content was determined by the Kjeldahl method, considering a conversion factor for crude protein of 6.25 (Method 036/IV). The ether extract was obtained through direct extraction with Soxhlet (Method 032/IV) (LUTZ, 2008). The carbohydrate content was estimated by the difference [Carbohydrate (%) = 100% -% (moisture + ash + crude protein + crude fat)]. The water activity was determined by the Standard Method for the Examination of Water and Wastewater (AOAC, 2016). The conversion values of 4 kcal/g for carbohydrates, 4 kcal/g for proteins and 9 kcal/g for lipids were usedto determine the caloric value (SOUSA, et al, 2014).

Cookies' formulations and nutritional composition

The formulations were individually prepared in the Nutrition II laboratory (Dietetic Technique) of the University of Pernambuco (UPE). Three types of cookies were prepared for each type of waste flour: the standard flour cookie (PF0%) – no addition of peel flour; 15% cookie (PF15) – 15% replacement of wheat flour by peel flour; 30% cookie (PF30) – replacement with 30% of the wheat flour by the peel flour; standard roasted seed flour cookie (SF0%) – no added roasted seed flour; 15% cookie (SF15) – replacement with 15% of wheat flour by roasted seed flour; 30% cookie (SF30) – 30% replacement of wheat flour with roasted seed flour. The varieties of cookies, their ingredients and quantities can be seen in table 1.

The formulation of cookies followed standard commercial recipes, with adaptations. The sugars together with the butter were mixed in a plastic containerand submitted to manual beating until the dough acquired a clear and light color. Then, the eggs were added along with the vanilla essence, proceeding with mixing and beating. Next, the flour, powdered yeast and salt (already mixed and conditioned) were added to the mixture of butter and eggs. The dough was completely homogenized. Finally, raisins were incorporated into the mass, and then taken to refrigeration (20 ºC) to rest for 30 minutes. After resting, the cookies were organized in a commercial oven at a temperature of 180 ºC for 30 minutes. After the oven time, they were removed and placed in a desiccator and later packaged with polypropylene at room temperature for the sensory pathway.

The nutritional composition of cookies was estimated by a proportional calculation using a simple

Table 1 - Ingredients and quantities for the formulations of cookies enriched with tamarind peel and seed flour.

Ingredients	------Cookies with tamarind peel flour-----			---Cookies with roasted tamarind seed flour---		
	PF0	PF15	PF30	SF0	SF15	SF30
Wheat flour (g)	350	297.5	245	350	297.5	245
Tamarind peel flour (g)	-	52.5	105	-	-	-
Roasted tamarindo seed flour (g)	-	-	-	-	52.5	105
Refined sugar (g)	100	100	100	80	80	80
Brown sugar (g)	200	200	200	200	200	200
Butter (g)	150	150	150	130	130	130
Eggs (unit)	2	2	2	2	2	2
Raisins (g)	85	85	85	50	50	50
Baking powder(g)	1.5	1.5	1.5	1.5	1.5	1.5
Salt (g)	0.6	0.6	0.6	0.6	0.6	0.6
Vanilla essence (ml)	15	15	15	15	15	15

PF0:standard cookie without tamarind peel flour; PF15: cookie with 15% replacement of wheat flour by tamarind peel flour; PF30: cookie with 30% replacement of wheat flour by tamarind peel flour; SF0: standard cookie without roasted tamarind seed flour; SF15: cookie with 15% replacement of wheat flour by roasted tamarind seed flour; SF30: cookie with 30% replacement of wheat flour by roasted tamarind seed flour.

rule of three, using the nutrient values described in the Brazilian Table of Food Composition (TACO, 2011), on the ingredient labels and through the data from the peel and roasted seed flours obtained via the physicochemical characterization.

Sensory analysis and market research

Sensory analysis was performed in two moments. Samples of peel flour cookies were analyzed in the first moment and in the second moment at an interval of approximately 15 days with the roasted seed flour cookies. To do so, 51 untrained tasters participated in both periods, being composed of students, professors and employees of the University of Pernambuco, of both genders, over 18 years of age and who agreed to participate in the studyby signing the Informed Consent Form (ICF).

A total of four tests were performed: 1st affective test, acceptance type by hedonic scale, structured with 9 points, in which “1” corresponds to extremely disliked and “9” to extremely liked; 2ndaffectivetest, being an attitude or intention scale structured with 7 points, in which “1” corresponds to would never eat and “7” would always eat; 3rdaffective test of the sorting-preference type, in which a series of samples is ordered according to the judge’s preference, being structured in 3 points in which“1” refers to the least preferred sample, and “3” to the most preferred. Finally, a 4th market study test to evaluate the degree of purchase intention of the products if they existed in the market for consumption structured by 5 points, in which “1” corresponds to something I would certainly buy, and “5” to certainly would not buy (LUTZ, 2008). The formulation samples were randomized and coded with three different numbers and delivered to the tasters in closed booths and with controlled environmental conditions (light, temperature).

The Acceptability Index (AI) was calculated from the expression: AI (%) = A x 100/B, where A represents the average score obtained for the product, and B is the maximum score for the product. Products with AI% equal to or greater than 70% were considered accepted (TEIXEIRA, et al., 1987).

Statistical analysis

Statistical analyzes were performed using the SPSS version 23.0 data package (SPSS Inc., Chicago, IL, USA). Data compilation took place in an electronic spreadsheet (Microsoft Excel 2013). Discrete quantitative variables (physical-chemical and sensory) were tested for normal distribution using the Shapiro Wilk test and homogeneity of variances using the Levene test. As they assumed non-normal distribution, a non-parametric analysis was performed using the Kruskall-Wallis test with multiple comparisons by pairs. A significance level of 5.0% was established to reject the null hypothesis.

RESULTS AND DISCUSSION

Physicochemical composition of flours

The physicochemical composition of the tamarind peel and roasted seed flours can be seen in table 2. Both flours have low humidity and water activity within the regulations for flours (moisture up to 15%) (BRASIL, 2005), and a low pH in the case of the peel flour, which favors and furthers its possible use in the food context.

In addition, a high protein volume for the roasted seed flourstands out. Flours are considered to be high-content fiber foods due to the fiber content found (>6g of fiber per 100g of food), as regulated by the National Food Surveillance Agency (BRASIL, 2012).

Therefore, the possibility of incorporating bark flour as a substitute or complementary food is acceptable, mainly due to its high fiber content and predictable commercial and chemical stability, due to its low humidity and considerable acidity.

When comparing the peel and roasted seed flour with wheat, corn and cassava flour, it can be seen that they exceed the fiber content of these traditionally consumed flours by more than 50%, according to data observed in the Brazilian Table of Food Composition.

Nutritional composition of the cookies

The results of the nutritional composition of the prepared cookies can be seen in table 3. As can be seen, a high energy value of the products predominates even when replacing wheat flour and enriching it with tamarind peel or roasted seed flour, a characteristic which is expected for this type of food. Even so, there is a relationship of a reduction in carbohydrate content and energy value, and an increase in fiber content as the peel flour and seed flour are incorporated.

Essentially, the value of added fiber surpasses the standard and places the peel flour cookies (PF15 and PF30) in the category of food fiber sources, as it presents in 100g of the product a minimum of 3g of the nutrient, according to the directory of the National Sanitary Surveillance Agency (*ANVISA*) (BRASIL, 2012). Only the SF30 cookie of the roasted seed formulations presented a fiber content above 3g/100g of product, and it also presented the lowest energy value.

Table 2 - Physicochemical characterization of tamarind peel and roasted seed flour.

Parameters	---Flour---	
	---Tamarind peel	Roasted tamarind seed---
	Mean ± SD	Mean ± SD
pH	2.9±0.35	5.8±0.09
Titratable acidity	3.8±0.12	1.3±0.17
Wateractivity (A_w)	0.43±0.0	0.47±0.0
Moisture (g.100g^{-1})	6.7±0.32	6.6±0.24
Protein (g.100g^{-1})	3.63±0.01	14.6±0.09
Total fats (g.100g^{-1})	0.6±0.01	4.3±0.16
Total dietary fiber (g.100g^{-1})	24.6±0.08	15.3±0.03
Glucose fraction (g.100g^{-1})*	59.45±0.41	56.6±0.3
Ash (g.100g–1)	5.0±0.02	2.3±0.08
Total caloric value	237±1.65	326±1.52

Data presented for 100g of product on a dry basis; *: Obtained by difference; SD: Standard deviation.

Sensorialanalysis –tamarind peel flour cookies

The sensory evaluation for the formulations with tamarind peel can be seen in table 4. Using the hedonic scale test and the computation of grades, it is noted that the PF15 sample had the highest median of acceptance (median = 8), surpassing the standard (median = 7), although without significant differences ($P > 0.05$). Conversely, the Kruskal-Wallis test revealed a reduction in the effect of the 30% peel flour concentration (PF30) on the acceptance levels (median = 6.0), significantly differing from PF15 ($P < 0.05$); however, there was no significant difference in relation to the standard. Thus, this implies that adding 15% of peel flour did not promote a negative sensory acceptance, while adding 30% causes a lower acceptancelevel, but still within the consumption scale of the standard formulation. This fact can be attributed to changes in sensory characteristics, such as flavor, texture, aroma and color.

Several studies have incorporated fruit and vegetable residues in cookies in order to improve their quality (sensory and nutritional physics). A study analyzing the addition of orange peel powder on the nutritional, physicochemical and sensory

Table 3 - Nutritional composition of tamarind peel and roasted tamarind seed cookies.

Components	---Formulations (cookies)---					
	PF0	PF15	PF30	SF0	SF15	SF30
Carbohydrates (g.100g^{-1})	94.0	92.4	90.6	95.5	94.0	79
Protein (g.100g^{-1})	8.3	7.8	7.2	10.3	10.7	11.2
Lipids (g.100g^{-1})	23.7	23.7	23.6	21.1	21.3	21.6
Fiber (g.100g^{-}1)	1.4	3.38	5.13	1.72	2.8	4
Energeticvalue (Kcal)	622.5	627.7	614.7	613.1	609.7	555.2

PF0: standard cookie without tamarind peel flour; PF15: cookie with 15% replacement of wheat flour by tamarind peel flour; PF30: cookie with 30% replacement of wheat flour by tamarind peel flour; SF0: standard cookie without roasted tamarind seed flour; SF15: cookie with 15% replacement of wheat flour by roasted tamarind seed flour; SF30: cookie with 30% replacement of wheat flour by roasted tamarind seed flour.Kcal: kilocalories.

Table 4 - Sensory evaluation of cookies made with tamarind peel flour.

----------------------------------Tests------------------------------------	---------------------Formulations (cookies)-------------------------		
	PF0	PF15	PF30
	Median (IQ)	Median (IQ)	Median (IQ)
Overall acceptance	7(4-8)[a]	8(5-9)[ab]	6(4-8)[ac]
Consumption intent	4(4-6)[a]	5(4-6)[a]	4(2-4)[b]
Purchase intention	2(1-3)[a]	2(1-3)[a]	3(2-4)[b]
Preference	2(1-3)[a]	2(2-3)[ab]	2(1-2)[ac]

PF0: standard cookie without tamarind peel flour; PF15: cookie with 15% replacement of wheat flour by tamarind peel flour; PF30: cookie with 30% replacement of wheat flour by tamarind peel flour. Different lowercase letters in the lines show a significant difference (P<0.005) by the Kruskal-Wallis test. IQ: interquartile range.

properties of cookies obtained overall means of 8.09, 8.22, 7.10 and 6.68 for the incorporation scale of 5, 10, 15 and 20% of the powder, respectively (ZAKER et al., 2016). These findings are similar to the results of the present study which presented medians greater than 6. Similarly, the addition of values above 20% was not testedin the aforementioned study, possibly due to the probable degree of rejection, as observed in this study.

In the same way, another trial working with the addition of pomegranate peels to cookiescorroborates our findings, in which the authors found overall acceptance values higher than 7, and becoming higher as the addition of pomegranate peel decreases (PAUL; BHATTACHARYYA., 2015). Yet another study testing the replacement of wheat flour by pitaya peel flour in the biscuit formulation found values (5.23-5.50) in the average scores for replacement scales of 5.10 and 15% of pitaya flour (HO et al., 2016). There were no significant differencesinthe aforementioned study. Similarly, overall acceptance values higher than 5 were found in the present study for both formulations, however significantly higher ($P < 0.05$) for the PF15 sample.

Regarding the consumption attitude scores towards tamarind peel cookie formulations, it is observed that there was no significant difference ($P > 0.05$) between the standard and the PF15 formulations. The overall median of PF15 assumed a value of 5, which indicates that the product would be frequently consumed by the population. However, the PF30 sample had a lower average value of “4” representing the occasional consumption of these products, significantly differing from the PF0 and PF15 formulations ($P < 0.05$). Thus, the best acceptance of the standard and PF15 products is establishedtogether with the overall assessment, either in sensory terms or in terms of consumption attitude (Table 4).

It is possible to notice that all formulations presented median values between “2” and “3” for the purchase intention (Table 4), which oscillates in the structured scale between “I would probably buy it” and “I have doubts if I would buy it”. However, there were no differences in the medians obtained from the standard and PF15 formulations; however, significantly lower values were observed for PF30 ($P < 0.05$). Once again, the results converge to preferring the formulation with 15% of peel flour.

Regarding the last test performed (Table 4) for ordering preference, it is observed that the PF15 formulation had the best values (>2). It is noteworthy that the number “1” in the structured scale represents the least preferred sample, and the number “3” the most preferred sample. Thus, the participants preferred the standard samples and PC15, while PF30 had values less than 2 and one more rejection point.

Sensorial analysis – roaste dtamarind seed flour cookies

The results regarding the sensory evaluation of cookies made with roasted tamarind seed flour can be seen in table 5. It is verified that the overall acceptance medians regarding the hedonic scale test were high, for which the SF0 and SF15 obtained the highest values (median=8), while the SF30 formulation had a median of 7. However, they did not differ significantly.

Thus, it is clear that the addition of roasted seed flour was positive, as it did not promote a negative effect on the acceptability of the product. It should be noted that “8” represents moderately liked and “7” regularly likedin the structured scale of “9” points, indicating a high sensory appreciation.

Table 5 - Sensory evaluation of cookies made with roasted tamarind seed flour.

---Tests---	---Formulations (cookies)---		
	SF0	SF15	SF30
	Median (IQ)	Median (IQ)	Median (IQ)
Overall acceptance	8(7-9)[a]	8(6-9)[a]	7(7-9)[a]
Consumption intent	5(4-7)[a]	5(4-6)[a]	4(4-6)[a]
Purchase intention	2(1-3)[a]	2(1-3)[a]	2(2-3)[a]
Preference	3(2-3)[a]	2(1-2)[b]	2(1-3)[b]

SF0: standard cookie without roasted tamarind seed flour; SF15: cookie with 15% replacement of wheat flour by roasted tamarind seed flour; SF30: cookie with 30% replacement of wheat flour by roasted tamarind seed flour. Different lowercase letters in the lines show a significant difference ($P < 0.005$) by the Kruskal-Wallis test. IQ: interquartile range.

Corroborating these findings, there is a study which aimed to enrich cookies with tamarind seed flour which found overall acceptability values of 6.6 to 7.8, indicating a favorable degree of acceptability, as in this study (NATUKUNDA et al., 2016). Yet another study with the same proposal found values from 5.2 to 8.7 for overall acceptance (EL-GINDY et al., 2015), which differs in terms of the results of this research, as no scores below six were obtained. Differences in the dietary matrix may explain this inversion, especially in the treatment and preparation of seed flour, which can cause a reduction in acceptabilitydue to the significant presence of tannins because of the astringency caused.

It appears that there were no significant differences between the formulations regarding the consumption intention, or the overall acceptance. In computing the scores, the SF30 formulation had a median of 4, while the SF0 and SF15 both had medians of 5. In this case, consumption would be occasional and frequent considering the structured scales. However, due to the absence of a statistical difference, it is possible to attribute the same degree of interest in the consumption frequency of the products.

No significant differences were observed in the purchase intention analysis of the roasted seedformulations. The score "2" on the structured scale represents "would probably buy", indicating that the samples could be part of the consumption and commodification by the community once on the market. It is noted that there were no differences between the incorporated formulations for the preference of the samples; however, it was observed thatthe standard (SF0) obtained a median of "3", being the most preferred.

All of the formulations presented percentages above 70% for the acceptance index (AI) (Table 6), classifying them as accepted products, while only the PF30 formulation was lower (TEIXEIRA et al., 1987). The calculations show that the addition of peel and roasted seed floursensured an acceptance rate that surpasses or matches the standard formulations, in which the 15% incorporation degree of both residues was better than 30%. Thus, it is possible to add materials from processing highly nutritious fruitsinto the matrices of traditional recipes, instead of discarding themand contributing to organic waste.

Notably, research involving the technological use of plant residues has shown considerable AI. A study working with vegetable leaves, stalks, peels and seeds observed that the vast majority of food formulations made with these residues had high acceptability levels (STORCK et al., 2013).

Furthermore, a study using orange peels in cookies at three concentrations (10, 20 and 30%) and sensory testing obtained acceptance rates ranging from 70.1 to 89.5% (ROSOLEN et al., 2018). In the latter study, the best rates were for cookies of 10 to 20% and the lowest for cookies of 30%. Likewise, another study; however working with guava seed flour in the preparation of cookies, obtained general acceptability rates above 70% (SILVEIRA et al., 2016). Although, differently from this study, an acceptable sensorial appreciation is observed in such studies for formulations with vegetable residues, including tamarind residues.

The importance of these residues is highlighted, as they present a compatible nutritional composition with the nutritional recommendations of individuals and populations, which are often not supplied by the noble parts of foods. For example, in this study, aggregated fiber, protein and energy values would respond as ingredients in food consumption.

Table 6 - Acceptance index for cookie formulations enriched with peel flour and roasted tamarind seed flour.

Formulations	Acceptability Index (%)	Formulations	Acceptability Index (%)
PF0	70.1	SF0	85.3
PF15	77.5	SF15	82.4
PF30	62.4	SF30	78.7

PF0: standard cookie without tamarind peel flour; PF15: cookie with 15% replacement of wheat flour by tamarind peel flour; PF30: cookie with 30% replacement of wheat flour by tamarind peel flour; SF0: standard cookie without roasted tamarind seed flour; SF15: cookie with 15% replacement of wheat flour by roasted tamarind seed flour; SF30: cookie with 30% replacement of wheat flour by roasted tamarind seed flour.

Thus, due to all that was found herein, the mixture of flours from unconventional products with wheat flour can be considered assertive, because parameters such as nutritional quality and palatability were improved, ensuring acceptance by consumers. Notably, the astringent characteristics of tamarind did not cause rejection of the products, possibly due to its elimination or reduction in the thermal processing step.

CONCLUSION

The purpose of this study was to analyze whether tamarind residues (peels and seeds) could be used for human consumption.It is noted that there was no rejection of the elaborated product through the incorporation of flour from these residues, as verified by sensory tests. In addition, there was also an improvement in terms of added nutritional value in the fiber content for products enriched with peel flour and an increase in the protein and fiber content for products with seed flour, in addition to an energy reduction in the higher incorporation level.

These results implied strategies to strengthen the consumption of waste by industries and communities, given the nutritional potential present and its likely impact on human nutrition due to the nutrients found. Furthermore, gains in the socio-environmental sustainability scenario can be attained through a reduction of organic waste and the full use of waste.

DECLARATION OF CONFLICT OF INTEREST

The authors declare no conflict of interest. The founding sponsors had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, and in the decision to publish the results.

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AUTHORS' CONTRIBUTIONS

All authors contributed equally for the conception and writing of the manuscript. All authors critically revised the manuscript and approved of the final version..

REFERENCES

AOAC. Official methods of analysis of association of official analytical chemists international. 20 ed. **Association of Official Analytical Chemists International**, 2016.

BERTAGNOLLI, S. M. M et al. Bioactive compounds and acceptance of cookies made with Guava peel flour. **Food Science Technology**, v.34, n.2, p.303-308, 2014. Available from: <https://www.scielo.br/j/cta/a/Dw7JgPJcPZLgwrSTVvGfTnJ/abstract/?lang=en>. Accessed: Feb. 20, 2020. doi: 10.1590/fst.2014.0046.

BRASIL. **Agência Nacional de Vigilância Alimentar – ANVISA**. Resolução da Diretoria Colegiada – RDC nº 263, de 22 de setembro de 2005.

BRASIL. **Agência Nacional de Vigilância Alimentar – ANVISA**. Resolução da Diretoria Colegiada – RDC nº 54, de 12 de novembro de 2012.

BRASIL. **Ministério da Saúde**. Na cozinha com as frutas, legumes e verduras. Brasília, DF, p.112, 2016.

CAVALCANTI, M. A et al. Pesquisa e desenvolvimento de produtos usando resíduos de frutas regionais: inovação e integração no mercado competitivo. **XXX Encontro Nacional de Engenharia de Produção: maturidade e desafios da Engenharia de Produção: competitividade das empresas, condições de trabalho, meio ambiente**. São Paulo, 2010.

DO NASCIMENTO FILHO, W. B; FRANCO, C. R. Avaliação do potencial dos resíduos produzidos através do processamento agroindustrial no Brasil. **Revista Virtual de Química**, v.7, n.6, p.1968-1987, 2015. Available from: <http://static.sites.sbq.org.br/rvq.sbq.org.br/pdf/v7n6a06.pdf>. Accessed: Feb. 20, 2020. doi: 10.5935/1984-6835.20150116.

EL-GINDY, A. A; YOUSSIF, M. E; YOUSSIF, M. R. G.Chemical studies and utilization of Tamarindus indica and its seeds in some technological application. **Egypt. J. of Nutrition and Health**, v.10, n.1, p.93-107, 2015. Available from: <https://www.researchgate.net/signup.SignUp.html>. Accessed: Feb. 20, 2020. doi: 10.21608/ejnh.2015.4825.

HO, L. H. Nutritional composition, physical properties, and sensory evaluation of cookies prepared from wheat flour and pitaya (Hylocereus undatus) peel flour blends. **Journal Cogent Food e Agriculture**, v.2, n.1, 1-10, 2016. Available from: <https://www.tandfonline.com/doi/full/10.1080/23311932.2015.1136369>. Accessed: Feb. 20, 2020. doi: 10.1080/23311932.2015.1136369.

KANTER, D. R et al. Translating the sustainable development goals into action: a participatory backcasting approach for developing national agricultural transformation pathways. **Global Food Security**, v.10, p.71-79, 2016. Available from: <https://www.sciencedirect.com/science/article/abs/pii/S2211912416300049>. Accessed: Jan. 20, 2020. doi: 10.1016/j.gfs.2016.08.002.

LUTZ, I. A. **Métodos físico-químicos para análise de alimentos**. São Paulo: Instituto Adolfo Lutz, p.1020, 2008.

NATUKUNDA, S. et al. Effect of tamarind (Tamarindus indica L.) seed on antioxidant activity, phytocompounds, physicochemical characteristics, and sensory acceptability of enriched cookies and mango juice. **Food Science e Nutrition**, v.4, n.4, p.494-507, 2016. Available from: <https://pubmed.ncbi.nlm.nih.gov/27386100/>. Accessed: Feb. 20, 2020. doi: 10.1002/fsn3.311.

PAUL, P.; BHATTACHARYYA, S. Antioxidant profile and sensory evaluation of cookies fortified with juice and peel powder of fresh Pomegranate (Punica granatum). **International Journal of Agricultural and Food Science**, v.5, n.3, p.85-91, 2015.

RAO, A. S et al. Tamarindus seed processing and by-products. **Agricultural Engineering International: CIGR Journal**, v.17, n.2, p.200-204, 2015. Available from: <https://cigrjournal.org/index.php/Ejounral/article/view/3125/2135>. Accessed: Feb. 20, 2020.

ROSOLEN, M. D et al. Biscoitos tipo cookies desenvolvidos a partir de farinha de casca de laranja. **Revistas Destaques Acadêmicos**, v.10, v.4, p.8-17, 2018. Available from: <http://www.univates.br/revistas/index.php/destaques/article/view/1711>. Accessed: Feb. 20, 2020. doi: 10.22410/issn.2176-3070.v10i4a2018.1711.

SILVEIRA, M. L. P et al. Aproveitamento tecnológico das sementes de goiaba (psidiumguajava l.). Como farinha na elaboração de biscoitos. **Boletim do Centro de Pesquisa de Processamento de Alimentos**, v.34, n.1, p.1-20, 2016. Available from: <https://revistas.ufpr.br/alimentos/article/view/53178>. Accessed: Feb. 20, 2020. doi: 10.5380/cep.v34i2.53178.

SOUSA, E. C et al. Chemical composition and bioactive compounds of grape pomace (Vitis vinifera L.), Benitaka variety, grown in the semiarid region of Northeast Brazil. **Food Science Technology**, v.34, n.1, p.35–142, 2014. Available from: <https://www.scielo.br/j/cta/a/m3tqHHNxYTGXhCN6xzQrxwM/?lang=en>. Accessed: Feb. 20, 2020. doi: 10.1590/S0101-20612014000100020.

SOUZA, D. M. M et al. Caracterização morfológica de frutos e sementes e desenvolvimento pós-seminal de Tamarindus indica L. – Leguminoseae: Caesalpinioideae. **Revista Arvore**, v.34, n.6, p.1009-1015, 2010. Available from: <https://www.scielo.br/j/rarv/a/D5X4PsZZpDhvPSDTVJcsyrk/?lang=pt>. Accessed: Feb. 20, 2020. doi: 10.1590/S0101-20612014000100020.

STORCK, C. R., et al. Folhas, talos, cascas e sementes de vegetais: composição nutricional, aproveitamento na alimentação e análise sensorial de preparações. **Ciência Rural**, v.43, n.3, p.537-543, 2013. Available from: <https://www.scielo.br/j/cr/a/MbK4GTbwHtDHFP3bkBK86kF/abstract/?lang=pt>. Accessed: Feb. 20, 2020.

TABELA BRASILEIRA DE COMPOSIÇÃO DE ALIMENTOS – TACO. **Universidade estadual de campinas – UNICAMP**. 4. Ed. Ver. E ampl. Campinas: UNICAMP/NEPA, 161p, 2011.

TEIXEIRA, E et al. **Análise sensorial dos alimentos**. Florianópolis: UFSC, 180p, 1987.

TURCHETO, Q et al. Destino sustentável de resíduos sólidos orgânicos em restaurante escola: uma proposta de implementação. **Revista do Centro de Ciências Naturais e Exatas**, v.1, n.1, p.220-227, 2016. Available from: <https://periodicos.ufsm.br/remoa/article/view/20036/pdf>. Accessed: Jan. 20, 2020. doi: 10.5902/22361308.

VANHAM, D. et al. Potential water saving through changes in Europeandiets. **EnvironmentInternational**, v.61, n.3, p.45-56, 2013. Available from: <https://www.sciencedirect.com/science/article/pii/S0160412013002055>. Accessed: Jan. 20, 2020. doi: 10.1016/j.envint.2013.09.011.

ZAKER, M. A et al. Studies on effect of orange peel powder incorporation on physical, nutritional and sensorial quality of Cookies**. International Journal of Engineering Research & Technology**, v.5, n.9, p.78-82, 2016. Available from: <https://www.ijert.org/studies-on-effect-of-orange-peel-powder-incorporation-on-physical-nutritional-and-sensorial-quality-of-cookies>. Accessed: Feb. 20, 2020. doi: 10.17577/IJERTV5IS090125.

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Erratum

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