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Utilization of Soursop (*Annona muricta*) Flour for the Production of Chin-Chin

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Abstract

The present study was aimed at utilizing soursop flour for the production of chin-chin. Soursop (SS) was processed to flour. Chin-chin was prepared from blends of wheat and soursop flours using 90:10, 80:20, 70:30, 60:40, 50:50 of wheat flour to soursop flour (SSF), and 100% wheat flour as control. Proximate and sensory analysis of the chin-chin was determined using standard methods. The samples were also stored for 3 weeks and evaluated at weekly intervals for total bacterial and fungal counts. Proximate composition of the chin-chin revealed a significant ($p<0.05$) increase in ash (0.42-0.96%), fat (33.31-39.29%), crude protein (5.32-7.94% protein), crude fibre (0.95-1.12%), and moisture content (4.85-7.65%) with a decrease in carbohydrate content (55.14–42.94%) as substitution of soursop flour increased. Energy content decreased as substitution of soursop flour increased, but beyond 30%, level, the energy content was observed to increase significantly. Substitution of soursop flour with wheat flour at the level of 10% compared favorably with the control sample suggesting that acceptable chin-chin could be produced at SSF substitution of up to 10%. The samples presented adequate microbiological conditions after storage of 3 weeks with counts ranging from 5.20×10^{3}-7.00×10^{4}cfu/g and 4.00×10^{4}-6.00×10^{4}cfu/g, for total bacterial and fungal counts, respectively. The study therefore showed that soursop can be utilized for the development of chin-chin with improved nutritional value over 100% wheat flour thereby serving as a nutritious household food which will help address the problem of protein-energy malnutrition.

Keywords: Soursop, Chin-Chin, Wheat, Proximate, Household, Utilization.

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Contents

Contribution of this paper to the literature

This study contributes to literature by enhancing the utilization of soursop flour towards the production of chin-chin. The nutritional composition of chin-chin was enhanced by the incorporation of soursop flour. The acceptable level of soursop flour to wheat flour for chin-chin production was also established.

1. Introduction

In Nigeria and other developing countries, the use of wheat flour for the production of baked goods has been on the increase. These products are highly consumed due to their cost, ready-to-eat nature and the availability of wheat flour as wheat flour is being imported consistently into the country [1]. Most cereals are limited in essential vitamins and minerals while nuts and fruits are rich in them. Thus a combination of such food products will improve the nutritional blend that will give it better nutrition value compared to wheat flour constituents alone. Wheat flour which is a product of wheat grain is low in protein, vitamins and minerals. Sengev, et al. [2]reported that wheat flour have a nutritional value inferior to flours produced from composite flours of cereals, fruits, tubers or nut. The fortification of wheat flour with fruits and nuts flour for the production of nutritious snacks would improve the nutritional value of wheat based products.

With the current trend in nutrition, consumers are highly conscious of their health which has resulted to the consumption of foods with health-promoting effects [3]. This has also promoted research by food professionals and industries in the development of baked goods from non-wheat flour blends. This involves incorporation of food materials that are rich in nutrient such as fibre, protein, minerals and vitamins with wheat flour, a process called composite flour technology. Several studies have been carried out on the chemical and physical properties of various flours blended with wheat flour and this showed that composite flours produced from cereals, tubers, fruits, legumes and nuts are preferable and have an advantage of enhancing the overall nutrition and sensorial properties of the finished product than products produced from single wheat flour [4-8]. However, the selection of components to be used in composite blends depends on the availability and nutritional potentials of the raw materials [2].

Soursop (*Annonamuricata*) belongs to the family *Annonaceae* and a native of Tropical North and South America [9]. They are either irregular, ovoid or heart shaped fruits which is 15-30 cm long and a width of 10-30 cm. It has a thick skin which is dark green with sparse curved spines [10]. The fruit mesocarp resembles white cotton and possesses a stingy and sweet-sour taste containing many dark seeds [11]. According to Iombor, et al. [11] the oven dried soursop contains 8.10% moisture, 21.30% protein, 2.30% fat, 16.30% fibre, 11.40% ash, 40.70% carbohydrate and 2871.60kcal of energy. Soursop is often consumed as a dessert fruit or utilized by food industries for the production of beverages, ice cream, wine, candy and syrup [9, 12]. The utilization of soursop flour for the production of bread has also been reported by Zabidi and Yunus [13]. Iombor and Banjo [1] also investigated the effect of soursop flour inclusion to wheat flour for bread production and reported that the flour from soursop has quality attributes which could be utilized for the production of bread and other baked goods thereby diversifying the utilization of soursop and improving the quality of food products produced from it. Zabidi and Yunus [13] also added that soursop flour could be utilized in enhancing the nutritional content (especially dietary fibre, minerals and protein contents) of various food products. Akomolafe and Ajayi [14] also reported that soursop possesses some therapeutic properties such as antioxidant and anticancer. They further added that the soursop fruits can be explored as a viable source of natural antioxidants for the production of functional foods.

Chin-chin is a fried or baked snack which is popular across Nigeria and other parts of West Africa [15]. It is a sweet, doughnut-like product prepared primarily from wheat flour, butter, eggs and milk. This is made into a stiff paste, rolled, cut and shaped into ¼ inches and then fried using vegetable oil or baked until it is golden brown and crispy [16]. Chin-chin is usually consumed by children and adolescents. As a result of the general acceptance of chin-chin, there is a need to enrich it with nutritionally rich ingredients such as soursop flour.

In Nigeria, soursop fruit is highly underutilized. Little industrial value is placed on the fruit due to high post harvest losses arising from poor storage and preservation technologies [13]. This poses a lot of concern for nutrients wasted which are not properly utilized. Current estimates also have it that over 60% of fruits are lost to poor post harvest handling and storage [1]. Soursop is also mainly consumed in the form of fruit juice or taken in its fresh form and no record of soursop flour used for the production of chin-chin has been carried out. In order to increase the demand and reduce wastage of this fruit, it can be incorporated into wheat flour for the production of baked products. The consumption of these products will contribute to ensuring food security at the household levels and also improve the nutritional status of households. The aim of this work therefore was to utilize soursop flour for the production of chin-chin and also to evaluate the proximate composition, sensory and microbiological quality of the product. This was with a view to reduce post harvest losses, encouraging utilization of soursop and also, increase overall nutrient of the products.

2. Materials/Methods

2.1. Sources of Materials

Soursop fruit was obtained locally from Fruit Garden Market at D-Line area Port Harcourt City, Rivers State, Nigeria. Refined wheat flour and other ingredients such as margarine, eggs, brown sugar, salt, milk and vegetable oil were purchased from Mile 3 Market Diobu, Port Harcourt. Chemicals used for all analysis were of analytical grade.

2.2. Processing Of Soursop Flour

Soursop fruits were processed into flour as shown in Figure 1. Matured and ripedsoursop fruits (3 kg) were washed under running water and peeled gently with stainless knife. The peeled fruits were sliced into 5 mm thickness and the core and seeds removed, then the pulp was cut into small pieces and oven dried at 60°C for 48 hr. The dried fruit was milled into flour using a Nutri-Blender (BL487Q model) and was passed through a US70 (180μm diameter) sieve. The flour obtained was stored in an air tight plastic container at room temperature (37°C) to prevent spoilage of sample until used for further analysis.

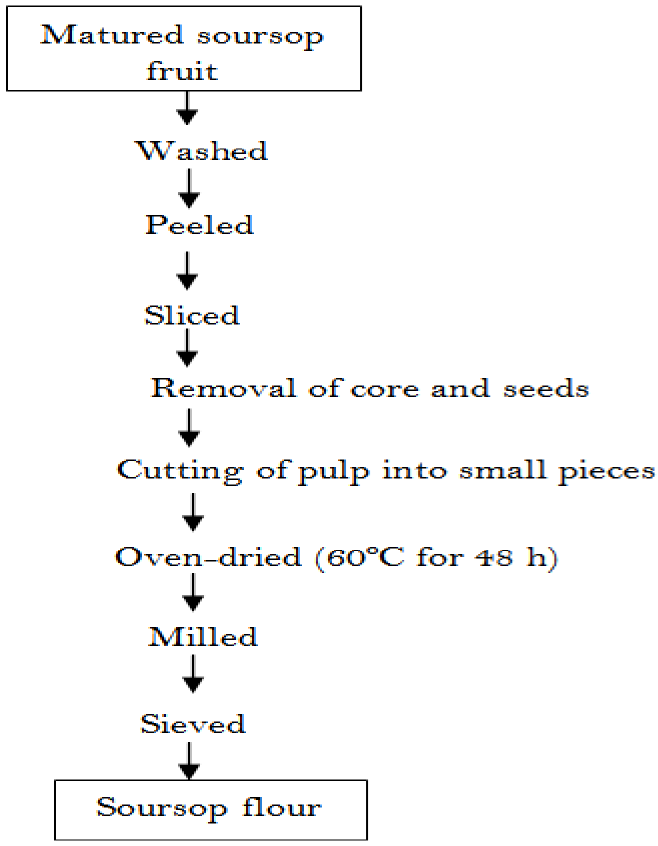

Figure-1. Flow chart for the production of soursop flour.
Source: Zabidi and Yunus [13].

2.3. Preparation of Chin-Chin

Chin-chin was prepared using the method of Akindele, et al. [17]. The ingredients except vegetable oil Table 1 were mixed and rubbed together in a large bowl. The dough was placed on a flour surface and kneaded until smooth and elastic. The kneaded dough was then rolled out to appropriately 2 cm thickness and then cut into ¼ (2 cm by 2 cm) in size. Vegetable oil (400 ml) was poured into a deep fryer MC 1800 model and allowed to be hot enough. Thereafter, the cubes were poured into the hot oil and the chin-chin deep fried for 8 min until golden brown. The fried chin-chin was removed, drained off excess oil and allowed to cool then packaged for analysis.

Table-1. Formulation of wheat and soursop composite flour for the production of chin-chin.

Ingredients	Chin-chin samples					
	A	B	C	D	E	F
Refined Wheat flour (g)	100	90	80	70	60	50
Soursop flour (g)	-	10	20	30	40	50
Sugar (g)	40.00	40.00	40.00	40.00	40.00	40.00
Margarine (g)	25.00	25.00	25.00	25.00	25.00	25.00
Baking powder (g)	2.00	2.00	2.00	2.00	2.00	2.00
Nutmeg (g)	1.00	1.00	1.00	1.00	1.00	1.00
Eggs (Whole)	1	1	1	1	1	1
Milk (g)	15.00	15.00	15.00	15.00	15.00	15.00
Water (ml)	15.00	15.00	15.00	15.00	15.00	15.00
Salt (g)	0.5	0.5	0.5	0.5	0.5	0.5
Vegetable oil (L)	2.00	2.00	2.00	2.00	2.00	2.00

Source: Akindele, et al. [17].

2.4. Proximate Analysis and Energy Determination of Chin-Chin

Proximate analysis (moisture, ash, protein, fat and crude fibre) of the food products was determined using the method of AOAC [18] while total available carbohydrate was calculated by difference using the formula:

100% - (% Moisture + % Ash + % Crude protein + % Fat + % Crude fibre)

The energy content (E) was calculated using Atwater factor method as described by Adegunwa, et al. [15].

E = (9 x Protein) + (4 x Fat) + (4 x Carbohydrate)

2.5. Sensory Evaluation of Chin-Chin

The chin-chin samples were subjected to sensory evaluation 30 minutes after preparation using 9-pont hedonic scale. This was carried out using a 20 panelist made up of students of Department of Home Science/Hospitality Management and Tourism, Michael Okpara University of Agriculture, Umudike, Abia State, Nigeria. The following attributes namely Appearance, crispness, texture, flavour and overall acceptability were assessed. The assessment ranged from 9 (like extremely) to 1 (dislike extremely) as described by Iwe [19]. The criterion for selection of panelist was based on their knowledge of the products to be evaluated. The panelists were asked to sit on the laboratory stools with spaces apart and with coded paper given to each of them according to the samples to be evaluated. The panelists were instructed to rinse their mouth with water before and after tasting the samples.

2.6. Microbial Evaluation of Chin-Chin during Storage

Chin-chin from different blends of soursop and wheat flour was crushed separately with the aid of a sterile ceramic mortar and pestle. The samples were packaged in an airtight container, stored at room temperature (37°C) and analyzed for their total bacterial and fungal populations at weekly intervals for 3 weeks. One gram (1.0 g) of each crushed sample was transferred into a 10ml sterile normal saline, separately. The mixtures were shaken vigorously, and then 0.1ml each mixture was inoculated on nutrient agar (NA) plate and sabouraud dextrose agar (SDA) plate in duplicates using the spread plate method [20]. The inoculated NA plates were incubated 37⁰C for 24 h while the inoculated SDA plates were incubated at ambient temperature for 5 days. After incubation, counts of the colonies on the NA and SDA plates were used to calculate the bacterial and fungal population respectively, with the aid of the equation below.

$$\text{Population (cfu/g)} = \frac{\text{Colonyx 10ml}}{\text{0.1ml x 1g}}$$

2.7. Statistical Analysis

Results were analyzed statistically using analysis of variance (ANOVA). Significant differences in mean values was calculated by least significant difference (LSD) test and Duncan's Multiple Range Test (DMRT) using the Statistical Package for the Social Sciences (SPSS) version 23.0 at the level of $p<0.05$.

3. Results and Discussion

3.1. Proximate Composition of Chin-Chin Produced From Wheat and Soursop Flour Blends

Table 2 shows the proximate composition of chin-chin produced from wheat and soursop flour (SSF) blends**.** The range of moisture content for all the chin-chin samples was between 4.85% and 7.65% with control sample as least and sample with 50% SSF substitution as highest. There was a significant increase ($p<0.05$) in the moisture content as the substitution with soursop flour increased. Samples substituted with 20, 30 and 40% SSF were significantly ($p<0.05$) similar. The increase could be attributed the increase to the hygroscopic nature of soursop flour due to the presence of reducing sugars. The trend is in concordance with the study of Deedam and Mbah [21] for granola produced from wheat and soursop flour blends. They reported the increase in moisture content of granola on substitution with soursop flour to be due to the high crude fibre content of soursop of 28.21% [22] The moisture values from the present study is in line with the findings of Akindele, et al. [17] who reported values between 4.17-6.80% for chin-chin enriched with pumpkin and Indian spinach vegetables. It was also comparable to the moisture content of chin-chin made from Trifolate yam flour enriched with pumpkin seeds (5.38-7.30%) as reported by Adelakan, et al. [23]. The range of moisture obtained from this study is at the minimum limit of moisture for baked goods [24]. The low moisture content of the chin-chin samples shows that the product will store better, ensuring high shelf stability [25].

The ash content of the chin-chin samples ranged between 0.42- 0.96% with sample substituted with 50% SSF as highest and control sample as least. An increase in the ash content of chin-chin samples was observed as substitution with soursop flour increased. The control sample was significantly ($p<0.05$) different from others while samples substituted with SSF at all levels were significantly similar ($p<0.05$). The increase in ash content is attributed to the high ash content of 11.4% soursop flour [11]. This study agrees with the statement of Wijewardana, et al. [22] that high ash content of soursop flour can be used to enrich the lost nutrients in wheat flour during refining. Ibidapo, et al. [26], equally reported an increase in ash value of cookies enriched with carrot powder with values between 1.47-1.82%. Ash content from this study is comparable with the findings of Adebayo-Oyetoro, et al. [27] with values between 0.47- 0.75%. It was also similar to the study of Eke-Ejiofor and Beleya [28] who reported ash content of 0.40-1.09% for chin-chin produced from high quality cassava flour and tiger nut residue flour blends. The result therefore indicates that the chin-chin samples would contribute mineral elements to the body.

The substitution of wheat flour with soursop flour resulted to an increase in the fat content of chin-chin samples from 33.31-39.29%. Chin-chin from 50% soursop flour substitution recorded the highest value while the control sample recorded the least. This increase in fat content did not differ significantly ($p>0.05$) among samples substituted with 30, 40 and 50% SSF while control sample was significantly ($p<0.05$) different from others. This increase in fat content of chin-chin from composite flours as compared to chin-chin from wheat flour could be due to substitution effect, as a result of higher fat content of soursop flour. This confirms the earlier reports of Fasakin, et al. [9] that soursop fruit has high fat content of 22.57%. This trend was also observed by Akindele, et al. [17]and Sengev, et al. [2] for vegetable enriched chin-chin (11.67-17.34%) and wheat/sweet potato/mango mesocarp flour blends chin-chin (11.00-24.00%), respectively. Fat content from the study was higher than the findings of Adegunwa, et al. [15] and Eke-Ejiofor and Beleya [28] for millet-wheat composite chin-chin and high quality cassava flour/tiger nut residue chin-chin, respectively. The high fat content of the chin-chin from this study is attributable to the fat from the frying oil and difference in recipes.

The protein content of all the chin-chin samples ranged from 5.32% in control sample to 7.94% in sample substituted with 50% soursop flour. Protein content of control sample and samples substituted with 10, 20 and 30% SSF were significantly ($p<0.05$) similar. A significant ($p<0.05$) increase in protein content was observed at 40 and 50% SSF substitution. This result shows that there was an increase in the protein content with corresponding increase in the substitution of soursop flour. This increase is attributed to the high protein content of soursop fruit (15.62%) as reported by Emelike and Akusu [29]; Prescott, et al. [20]. Similar result was also reported by Deedam and Mbah [21] for granola substituted with soursop flour. The protein content of wheat-soursop chin-chin samples were lower than those reported for wheat-tiger nut flour chin-chin (7.66-11.58%) and millet-wheat chin-chin (12.63-19.50%) as reported by Adebayo-Oyetoro, et al. [27] and Adegunwa, et al. [15] respectively. These differences could be attributed to the differences in recipe and also the use of soursop.

Crude fibre content of the chin-chin ranged from 0.95-01.12% with sample substituted with 50 SSF having the highest and sample with 10% SSF as lowest. There was an increase in the crude fibre of the chin-chin samples as substitution with soursop flour increased; however, this increase was not significant ($p<0.05$) between control sample and samples substituted with 10, 20, 30 and 40% SSF. The significant ($p<0.05$) increase in crude fibre content at 50% SSF substitution is due to the high crude fibre content of sourso (16.30%) as reported by Iombor, et al. [11]. Similar increase was also reported by Deedam and Mbah [21] for granola substituted with soursop flour. Crude fibre of chin-chin from this study was lower when compared with millet-wheat composite chin-chin (4.84-

5.23%) and high quality cassava flour/tiger nut residue chin-chin (11.08-12.95%) as reported by Adegunwa, et al. [15] and Eke-Ejiofor and Beleya [28] respectively. The crude fibre value was however, comparable with wheat and tiger nut flour chin-chin (0.28-0.66%) as reported by Adebayo-Oyetoro, et al. [27]. These differences could be due to the recipe used in the formulation process and the levels of fibre contained in the flour being used.

A significant ($p<0.05$) decrease was observed in the carbohydrate content, which ranged from 55.14% to 42.94% with the highest value in control sample and the lowest in sample substituted with 50% soursop flour. The increase in proportion of soursop flour brought about a decrease in the carbohydrate content of the granola samples. This result is in concordance with the findings of Adebayo-Oyetoro, et al. [27] who reported a decrease in carbohydrate content (62.76-52.95%) of wheat/tiger nut flour chin-chin as substitution of tiger nut increased. The carbohydrate values from this study are higher than 4.44-32.79% for high quality cassava flour/tiger nut residue flour chin-chin [28].

Energy content of the chin-chin samples ranged from 393.34-401.68kcal. Control sample had the highest value while sample substituted with 30% SSF was lowest. The control sample and samples substituted with 40% and 50% SSF were significantly ($p<0.05$) similar. This indicated that energy content of the chin-chin samples decreased with increasing level of SSF substitution, but beyond 30% level, the energy content was observed to increase significantly ($p<0.05$). This could be attributed to the protein, fat and carbohydrate contents of the blend constituents which contributed to the energy value of the chin-chin samples. The result from this study implies that the substitution of soursop flour above 40% level could help to boost the calories level of chin-chin. Ibidapo, et al. [26] reported energy value of biscuits enriched with carrot flour (448.25-461.02kcal) which is higher that obtained from this study.

Table-2. Proximate composition of chin-chin produced from wheat and soursop flour blends.

Samples	Moisture (%)	Ash (%)	Fat (%)	Protein (%)	Crude fibre (%)	CHO (%)	Energy (kcal)
SCA	4.85 ± 0.01^{d}	0.42 ± 0.03^{b}	33.31 ± 1.49^{c}	5.32 ± 0.00^{b}	0.96 ± 0.00^{b}	55.14 ± 0.20^{a}	401.68 ± 1.91^{a}
SCB	5.70 ± 0.16^{c}	0.84 ± 0.08^{a}	35.31 ± 0.13^{b}	5.36 ± 0.05^{b}	0.95 ± 0.00^{b}	51.76 ± 1.26^{b}	396.84 ± 0.93^{b}
SCC	6.81 ± 0.12^{b}	0.88 ± 0.01^{a}	36.88 ± 0.30^{ab}	5.68 ± 0.00^{b}	0.99 ± 0.01^{b}	48.77 ± 0.01^{bc}	393.72 ± 1.10^{c}
SCD	7.02 ± 0.11^{b}	0.88 ± 0.01^{a}	38.35 ± 0.27^{a}	5.75 ± 0.04^{b}	0.98 ± 0.01^{b}	46.98 ± 0.45^{c}	393.34 ± 0.91^{c}
SCE	7.21 ± 0.00^{b}	0.89 ± 0.01^{a}	38.42 ± 1.13^{a}	7.21 ± 0.00^{a}	0.99 ± 0.01^{b}	45.28 ± 1.37^{c}	399.69 ± 0.96^{a}
SCF	7.65 ± 0.11^{a}	0.96 ± 0.04^{a}	39.29 ± 1.73^{a}	7.94 ± 0.00^{a}	1.12 ± 0.00^{a}	42.94 ± 1.84^{d}	400.38 ± 0.42^{a}

Note: Mean values bearing different superscript in the same column differ significantly ($p<0.05$).
Key: SGA= wheat flour (100%), SGB=wheat/soursop flour (90:10), SGC=wheat/soursop flour (80:20), SGD=wheat/soursop flour (70:30), SGE=wheat/soursop flour (60:40), SGF=wheat/soursop flour (50:50).

3.2. Sensory Properties of Chin-Chin produced from wheat and soursop flour blends

The sensory scores of the chin-chin samples produced from wheat and soursop flour blends are presented in Table 3. Appearance ranged from 5.65-7.45 with control sample as most preferred and sample with 40% soursop flour (SSF) substitution as the least. Chin-chin substituted with soursop flour at different levels were significantly ($p<0.05$) similar while control sample was significantly ($p<0.05$) different. The scores for appearance suggest that the higher percentage of soursop flour, the lower the mean appearance score of the chin-chin. This might be attributed to the addition of soursop flour which resulted to colour darkening of the chin-chin. The low mean scores for appearance of chin-chin substituted with soursop flour could also be due to the known popularity of the panellists with chin-chin prepared from wheat flour. Similar findings were also reported by Wordu and Akusu [30] for wheat and fluted pumpkin flour blend chin-chin. The scores suggest that chin-chin substituted with up to 30% SSF have some level of acceptable appearance as the scores are above 6.00.

Scores for taste of the chin-chin samples ranged from 5.50-7.50 with control sample as most preferred and sample substituted with 50% SSF as the least. The control sample was significantly ($p<0.05$) different from all samples but not from chin-chin with 10% SSF substitution. The decrease in mean scores of taste observed as soursop flour substitution increase may also be as a result of the sweet-sour taste of soursop which may have altered the original taste of the chin-chin. Similar finding was also reported by Zabidi and Yunus [13].

The mean sensory scores for crispness and texture of the chin-chin samples ranged from 5.30-7.20 and 5.75-7.50 with control sample as most preferred and sample substituted with 40% SSF as the least. Control samples was significantly ($p>0.05$) different from all other samples. Crispness and texture of the chin-chin samples decreased with increase in percentage of soursop flour. The low preference for crispness in chin-chin substituted with soursop flour as compared to 100% wheat flour chin-chin may be due to moisture uptake by soursop flour. It has been reported that moisture uptake leads to loss of crispness of food products [2]. Similar finding was also reported by Adebayo-Oyetoro, et al. [27] for chin-chin made from wheat and tiger nut flour. The decrease in texture on substitution with soursop flour may be attributed to the high crude fibre content, which makes the texture less tender [2]. This was also reported by Kehinde, et al. [16] for chin-chin produced from wheat-tiger nut pomace. The mean scores of crispness and texture of samples substituted with 10-30% soursop flour was above 6 suggesting that these samples may be acceptable.

Flavour is an important attribute that influences the acceptance of finished food products even before they are tasted. Flavour of the chin-chin samples ranged from 5.65-7.25 with control sample as most preferred and sample with 50% SSF substitution as the least. Substitution of wheat flour with soursop flour significantly ($p<0.05$) decreased the flavour of the chin-chin samples. The scores also suggest that chin-chin samples substituted with up to 40% soursop flour have some level of acceptable flavour as the scores were above 6.00.

Overall acceptability of chin-chin ranged from 5.58-7.38 with 100% wheat flour chin-chin as most preferred. This was followed closely by chin-chin substituted with 10% SSF. Sample substituted with 50% SSF was least preferred. The control sample was significantly ($p<0.05$) different from others while samples substituted with 20, 30, 40 and 50% SSF were significantly ($p<0.05$) similar. This study is in line with the findings of Anozie, et al. [31] and China and Ezema [32] who reported that control snack made from 100% wheat flour was most preferred. The overall acceptability of the chin-chin was observed to decrease with increase in the level of soursop flour substitution. This result is in agreement with the findings of Ajani, et al. [33] who reported that increased levels of breadfruit flour in chin-chin resulted in significant decrease in overall acceptability. On the basis of this observation, substitution of soursop flour with wheat flour at the level of 10% could be considered the best from sensory point of view.

Table-3. Mean sensory scores from taste panel of chin-chin from wheat and soursop flour blends.

Samples	Appearance	Taste	Crispness	Texture	Flavour	Overall Acceptance
SCA	7.45^{a}	7.50^{a}	7.20^{a}	7.50^{a}	7.25^{a}	7.38^{a}
SCB	6.70^{b}	6.90^{a}	6.40^{ab}	6.45^{ab}	6.60^{ab}	6.75^{ab}
SCC	6.15^{b}	5.95^{b}	6.45^{ab}	6.30^{b}	6.40^{b}	6.18^{b}
SCD	6.25^{b}	5.70^{b}	6.15^{b}	6.00^{b}	6.35^{b}	6.03^{b}
SCE	5.65^{b}	5.75^{b}	5.30^{c}	5.75^{b}	6.00^{b}	5.88^{b}
SCF	5.95^{b}	5.50^{b}	5.35^{c}	5.90^{b}	5.65^{b}	5.58^{b}

Note: Mean values bearing different superscript in the same column differ significantly ($p<0.05$), n=20
Key: SCA = wheat flour 100%, SCB = Wheat/soursop flour (90:10%), SCC = wheat/soursop flour (80:20%), SCD=wheat/soursop flour (70:30%), SCE=wheat flour/soursop flour (60:40%), SCF = wheat flour/soursop flour (50:50%).

3.3. Microbiological Status of Chin-Chin Produced From Wheat and Soursop Flour Blends

3.3.1. Total Bacterial Counts

Results of the total bacterial counts (TBCs) of chin-chin samples are shown in Table 4. TBCs on week 0 ranged from no growth in control sample to 1.00×10^{2}cfu/g in sample substituted with 20% soursop flour. As storage period progressed, an increase in bacterial counts was noted. At the end of three weeks of storage, TBCs were observed to range from 5.20×10^{3}-7.00×10^{4}cfu/g. Samples substituted with soursop flour were observed to have higher TBCs than the control sample. This could be due to the high nutritional value of soursop fruit and its relation with its rapid deterioration [34]. Similar trend was also observed by Omachi and Yusufu [35] who repored increased in the level of microbial contamination due to increased level of proteins and fats. The finding of this study also supports the statement of Adams and Moss [36] that spoilage organisms grow faster in medium that is highly nutritious. TBCs of chin-chin from this study after storage for 3 weeks were within acceptable limits of 10^{2}-10^{4}cfu/g established by International Commission of Microbiological Specification of Food Microorganisms [37] for ready to eat food products.

Table-4. Total bacterial counts (cfu/g) of chin-chin produced from wheat and soursop flour blends during storage.

Samples	Storage period (Weeks)			
	0	1	2	3
SCA	NG	1.00×10^{2}	2.00×10^{3}	5.20×10^{3}
SCB	1.00×10	1.00×10^{2}	3.00×10^{3}	4.50×10^{4}
SCC	1.00×10^{2}	1.40×10^{2}	3.00×10^{3}	4.00×10^{4}
SCD	1.00×10	1.10×10^{2}	3.80×10^{3}	4.00×10^{4}
SCE	NG	1.90×10^{2}	3.50×10^{3}	6.00×10^{4}
SCF	NG	1.95×10^{2}	3.00×10^{3}	7.00×10^{4}

Key: Cfu/g= colony forming units per gram; NG= no growth; SCA= wheat flour 100%, SCB=wheat/soursop flour (90:10%), SCC=wheat/soursop flour (80:20%), SCD=wheat/soursop flour (70:30%), SCE=wheat/soursop flour (60:40%) SCF=wheat/soursop flour (50:50%).

3.3.2. Total Fungal Counts

Results of the total fungal counts (TFCs) of chin-chin samples are presented in Table 5. No visible fungal growth was observed on all the chin-chin samples at week 0. However as storage weeks progressed, TFCs were observed to increase to range of 4.00×10^{4}-6.00×10^{4}cfu/g with control sample having the lowest counts and sample substituted with 30 and 50% soursop flour as highest. The increase in TFCs as substitution of soursop increased could be due to the fact that high moisture content in soursop flour (18.33-24.53%) encourages the microbial action [38]. Though there was an increase in the microbial count of the chin-chin, these counts were within the recommended safe limit of microbial guidelines for ready to eat foods such as chin-chin adopted by the International Commission of Microbiological Specification of Food which states that the microbial safe limit for ready to eat food should fall between the range of 10^{2}-10^{4}cfu/ml [35]. Fungal growth on foods could lead to deposit of mycotoxins on foods which are a public health concern.

Table-5. Total Fungal counts (cfu/g) of chin-chin produced from wheat and soursop flour blends during storage.

Samples	Storage period (Weeks)			
	0	1	2	3
SCA	NG	1.00×10^{2}	2.00×10^{3}	4.00×10^{4}
SCB	NG	1.00×10^{2}	3.00×10^{3}	5.00×10^{4}
SCC	NG	1.00×10^{2}	4.00×10^{3}	5.00×10^{4}
SCD	NG	1.00×10^{2}	4.00×10^{3}	6.00×10^{4}
SCE	NG	2.00×10^{2}	4.50×10^{3}	5.50×10^{4}
SCF	NG	2.50×10^{2}	4.00×10^{3}	6.00×10^{4}

Key: Cfu/g= colony forming units per gram; NG= no growth; SCA= Wheat flour 100%, SCB=wheat/soursop flour (90:10%), SCD=wheat/soursop (80:20%), SCD=wheat/soursop flour (70:30%), SCE=wheat/soursop flour (60:40%) SCF=wheat/soursopflour (50:50%).

4. Conclusion

The present study showed the potentials of utilizing soursop flour for the production of highly nutritious chin-chin. The substitution of wheat flour with soursop flour for the production of chin-chin significantly improved the nutritional composition in terms of protein, ash, fat and crude fibre contents while carbohydrate content was observed to decrease. Energy content of the chin-chin decreased as substitution of soursop flour increased, but beyond 30%, level, the energy content was observed to increase significantly. The higher ash, protein, crude fibre and low carbohydrate contents of chin-chin prepared from wheat and soursop flour blends has nutritional advantage over 100% wheat flour chin-chin especially for individuals with health problems requiring protein, fibre and mineral rich foods and low in carbohydrate. Sensory results showed that sensory attributes of the control chin-chin was more preferred and this was followed closely by chin-chin substituted with 10% SSF. Substitution of soursop flour with wheat flour at the level of 10% compared favorably with the control sample suggesting that acceptable chin-chin could be produced at SSF substitution of up to 10%. Total bacterial and fungal counts of chin-chin increased during storage and upon increased substitution with sour-sop flour. However, all the products presented adequate microbiological conditions and were within recommended safe limit of microbial guidelines. This result therefore indicates that the use of soursop flour for the production of chin-chin would greatly enhance the utilization of this fruit in Nigeria, and other developed countries where the fruit has not been optimally utilized, thereby reducing wastage of the fruit and contributing to household food security.

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