

# Proximate composition, sensory properties and microbiological status of granola substituted with soursop flour (*Annona muricata*) for household consumption

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**ABSTRACT:** This study was undertaken to investigate the proximate composition, sensory properties and microbiological status of granola substituted with soursop flour for household consumption. Matured soursop fruits were processed into flour. Granola 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. Samples were subjected to sensory evaluation within 30 minutes of production. Proximate analysis was carried out using standard methods. The samples were also stored for 3 weeks and evaluated at weekly intervals for total bacterial and fungal counts. Proximate analysis revealed an increase in moisture (5.21 to 7.22%), ash (1.25 to 1.79%), protein (9.56 to 12.62%), crude fibre (0.83 to 1.21%) and energy contents (418.64 to 422.22kcal) with decrease in fat (14.13 to 12.09%) and carbohydrate contents (69.02 to 65.07%) as substitution of wheat flour with soursop flour increased. Sensory analysis showed that colour, taste, texture and overall acceptability of the control granola were more preferred. Colour of control granola and sample substituted with 20% SSF were significantly ( $p < 0.05$ ) similar. Similarly, texture and overall acceptability of control granola and samples substituted with 10, 20 and 30% SSF were significantly ( $p < 0.05$ ) similar suggesting that wheat flour can be substituted with soursop flour at levels up to 30% for the preparation of granola. During storage, total bacterial counts (TBCs) and fungal counts (TFCs) were observed to increase for all granola samples. TBCs and TFCs of granola samples after 3 weeks of storage ranged from  $6.00 \times 10^3$  to  $7.00 \times 10^3$  cfu/g and  $5.00 \times 10^4$  to  $5.20 \times 10^4$  cfu/g, respectively. The samples presented adequate microbiological conditions and were within recommended safe limit of microbial guidelines. The findings of this study therefore show that soursop can be utilized in the preparation of granola with improved nutritional value over wheat flour thereby reducing wastage associated with soursop fruits.

**Keywords:** Soursop, granola, proximate, sensory, microbial.

## INTRODUCTION

There is an increasing awareness among consumers regarding diet and health. This has resulted in a significant change in the development of food products that not only provide satiety and nutrients but also prevent nutrition-related diseases (Betoret et al., 2011). Health conscious consumers desire foods that not only provide convenience but also high quality, safety and optimum nutrient balance.

In this connection, there is a continuous search for wholesome foods by food industries due to the poor nutritional quality of some baked products available in the market (Eke-Ejiofor et al., 2016).

Wheat flour is an important raw material obtainable from grain. It is used for the production of confectionary products due to its unique gluten content, responsible for

its strength and elasticity required in the production of baked confectionaries such as bread, chin-chin and cookies of desirable texture and flavour (Akhtar et al., 2008). During milling and refining of wheat grain, the bran and germ are discarded, resulting in the loss of dietary fiber, vitamins, and minerals (Ndife et al., 2014). Enrichment of food products produced from wheat flour is therefore important so as to enhance their nutritional properties (Mounika et al., 2017).

Granola is a dry granulated cereal product composed of ingredients such as oats, wheat, nuts or dried fruits mixed with a binder to form a compressed bar (Ying et al., 2018). The texture and taste of a granola bar is very important as it greatly influences consumer acceptability and preference for the product (Kim et al., 2009). Granola is often eaten as a breakfast cereal and served with yoghurt, honey, fruit and milk. It can also be eaten by those who are hiking or camping because of its lightweight and high calories (Eke-Ejiofor et al., 2016). Wheat and oat are the main raw materials for the production of granola, which are relatively of high cost due to the fact that wheat is not grown in Nigeria. There is therefore need to search for locally available raw materials which can be used in partial substitution with wheat for the production of granola. In an attempt to achieve this and to improve its nutritional content, several studies have been carried out. Eke-Ejiofor et al. (2016) prepared nutritious and acceptable granola from maize and coconut blend while Agbaje et al. (2016) developed granola with puffed glutinous rice and selected dried Sunnah foods. Partial replacement of wheat with puffed rice, chickpea, nuts and oat flakes for the development of high energy granola bar was also studied by Ahmad et al. (2017).

Soursop (*Annona muricata*) is a plant belonging to the family Annonaceae and widespread in tropical North and South America (Fasakin et al., 2008). The fruits are oval or irregular, 15 to 30 cm long, with sparse soft green curved spines. It has a white pulpy flesh which is sweet-sour containing shiny dark seeds (Akubor and Egbekun, 2007). The fruit is consumed as a dessert and is also used for the production of beverages, ice creams, wine, syrups and bread (Pamplona-Roger, 2004; Lombor and Banjo, 2018). According to Othman et al. (2014), soursop fruit is considered to be a functional food product of immense health benefit because it possesses anti-oxidant properties that can be useful in the reduction of free radicals in the body. Wijewardana et al. (2016) reported that the oven dried soursop fruit contains 8.58% moisture, 1.95% protein, 2.90% ash and 28.21% crude fibre. The high crude fibre and ash contents of soursop can therefore be used to enrich the lost nutrients in wheat flour during refining. Despite the high nutritional value of soursop, it is underutilized in Nigeria and other developing countries due to inadequate processing and preservation methods. It is normally eaten fresh or as juice. Improper storage and processing of soursop during pre and post harvesting causes it to deteriorate rapidly which leads to huge losses.

Hence a better strategy to solve this problem is by processing it to flour and utilizing the flour for the enrichment of existing food products such as granola (Zabidi and Yunus, 2014). Thus, soursop fruit added into more convenient ready-to-eat food such as granola would be an ideal form to eat as part of a meal in households.

The term households are group of people living together in a common residence as consuming units in a physical environment (China et al., 2020). Food security and malnutrition are of critical concern in Nigeria and other developing countries especially among the poor and vulnerable rural farming households. Most households in Nigeria are food insecure with prevalence of stunting, wasting and underweight at 42, 9 and 25%, respectively (Akinyele, 2009). Appropriate food consumption in households is important for the nutritional status of family members (China et al., 2019). To ensure sustainable food consumption in household, there is a need to utilize available food resources. The utilization of soursop for the production of granola will help in ensuring food security at the household levels and also improve the nutritional status of households.

The microbiological status of any food product is very important in order to ensure good shelf-life. Shelf-life of a food product is defined as the period of time between packing of a product and its use, during which the product maintains good sensorial attributes and safe microbial parameters that are acceptable for consumption (Loverday et al., 2009). The shelf-life of food is often influenced by the temperature of storage, relative humidity and water activity (Ebabhamiegbebho et al., 2011). Water activity is a central factor that affects food stability. It also evaluates in qualitative terms how much of the moisture present in food is actually available for microbial growth. The microbiological status of food products depends on the control of water activity and moisture content below the lower limit at which microorganisms are able to multiply and cause spoilage (Noah, 2017). Since soursop is a highly perishable fruit, it becomes necessary to evaluate the microbiological status of products developed from it. This study therefore aims to evaluate the proximate composition, sensory properties and microbiological status of granola substituted with soursop flour.

## MATERIALS/METHODS

### Sources of materials

Matured soursop fruits were obtained locally from Fruit Garden Market at D-Line Area Port Harcourt City, Rivers State, Nigeria. Refined wheat flour and other ingredients such as rolled oats, peanuts, brown sugar, olive oil and vanilla were purchased from Mile 3 Market Diobu, Port Harcourt. All reagents used for all analysis were obtained from Analytical Laboratory, Department of Food Science and Technology, Rivers State University, Port Harcourt and were of analytical grade.

### Processing of soursop flour

Soursop fruits were processed into flour (Figure 1) using the method described by Zabidi and Yunus (2014). Matured and riped soursop 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 hours. The dried fruit was milled into flour using a Nutri-Blender (BL487Q model) and was passed through a US70 (180 µm 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.

### Preparation of granola

Granola was prepared using the method as described by Pamplona-Roger and Malaxetxebarria (2008). All the dry ingredients (Table 1) were weighed into a mixing bowl and mixed together in a Kenwood mixer (Model A 907 D, Kenwood Ltd, England); the liquid ingredients were then added and mixed into dough. It was thereafter cut into tiny balls of ¼ inches using a dough cutter, spread on a six inch vegetable oil greased baking tray and baked in a preheated oven (U Test Malzeme Test Cihazlari) at 130°C for 50 minutes. The baked product was cooled under a sterile atmosphere and stored in an airtight container until required for analysis.

### Proximate analysis and energy content of granola

Proximate analysis (moisture, ash, protein, fat and crude fibre) of the granola was determined using the method of Association of Official Analytical Chemist (AOAC, 2006) while total available carbohydrate was calculated by difference using the formula:

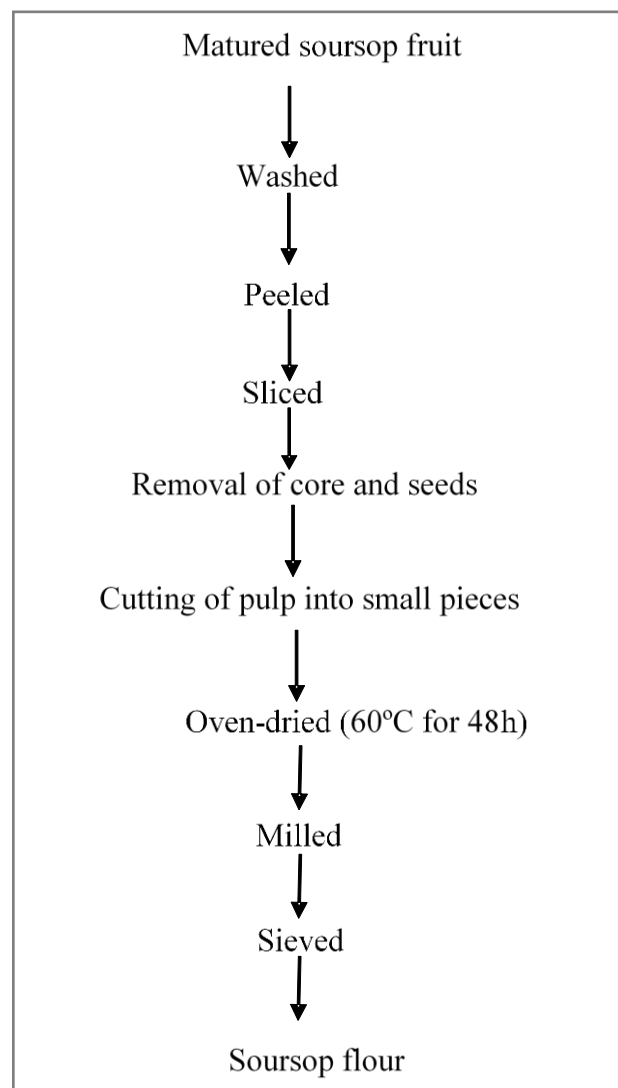
$$100\% - (\% \text{ Moisture} + \% \text{ Ash} + \% \text{ Crude protein} + \% \text{ Fat} + \% \text{ Crude fibre})$$

The energy content (E) was calculated using Atwater factor method as described by Adegunwa et al. (2014):

$$E = (9 \times \text{Protein}) + (4 \times \text{Fat}) + (4 \times \text{Carbohydrate})$$

### Sensory evaluation of granola

The samples were subjected to sensory evaluation 30 minutes after preparation using 9-point hedonic scale. This was carried out using a 20 panellist 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, aroma, taste, texture and overall



**Figure 1.** Flow chart for the production of sour-sop flour (Source: Zabidi and Yunus, 2014).

acceptability were assessed. The assessment ranged from 9 (like extremely) to 1 (dislike extremely) as described by Iwe (2007). The criterion for selection of panellist was based on their knowledge of the products to be evaluated. The panellists 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 panellists were instructed to rinse their mouth with water before and after tasting the samples.

### Storage studies

Granola was crushed separately with the aid of a sterile ceramic mortar and pestle. The crushed sample was packaged in an airtight container, stored at room temperature (37°C) and analyzed for microbial analysis at weekly intervals for 3 weeks.

**Table 1.** Formulation of wheat and sour-sop composite flour for the production of granola

Ingredients	Granola samples					
	A	B	C	D	E	F
Refined wheat flour (g)	100	90	80	70	60	50
Sour-sop flour (g)	-	10	20	30	40	50
Rolled oats (g)	100	100	100	100	100	100
Ground peanut (g)	80	80	80	80	80	80
Water (ml)	70	70	70	70	70	70
Vanilla (tsp)	2	2	2	2	2	2
Olive oil (tsp)	5	5	5	5	5	5
Brown sugar (g)	80	80	80	80	80	80

Source: Pamplona-Roger and Malaxetxebarria (2008).

### Determination of the microbial count

One gram (1.0 g) of each crushed sample was transferred into a 10 ml sterile normal saline, separately. The mixtures were shaken vigorously, and then 0.1 ml each mixture was inoculated on nutrient agar (NA) plate and sabouraud dextrose agar (SDA) plate in duplicates using the spread plate method (Prescott et al., 1999). The inoculated NA plates were incubated 37°C for 24 hours 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.

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

### Statistical analysis

The results were subjected to Analysis of Variance (ANOVA) and significant differences between mean values were calculated by Duncan Multiple Range Test (DMRT) at 5% level of probability using the Statistical Product for Service Solution (SPSS) version 23.0.

## RESULTS AND DISCUSSION

### Proximate composition of granola produced from wheat and sour-sop flour blends

Proximate composition of granola produced from wheat and soursop flour blends is shown in Table 2. Moisture content of the granola samples ranged from 5.21 to 7.22% with control sample having the least while granola substituted with 50% soursop flour (SSF) as highest. A significant increase ( $p < 0.05$ ) in the moisture content of the granola samples was observed as substitution with soursop flour increased. This increase could be due to the high fibre content of soursop flour: 28.21% in soursop flour (Wijewardana et al., 2016). Higher the fibre content has

been related with lower water retaining capacity of the flour (Usman et al., 2015). Similar increase was reported by Agbaje et al. (2016) who reported moisture content 11.35 to 16.41% for granola formulated with puffed glutinous rice and selected dried Sunnah foods. They attributed this increase to be due to the amounts of fruit content in the samples. The moisture content in the present study is comparable with values of 5.65 to 6.75% for granola made from maize and coconut (Eke-Ejiofor et al., 2016). The low moisture content of the granola samples indicates that it will elongate the shelf life and storability of the product as product with less than 12% moisture content have shown to store over long periods without deteriorating (Eke-Ejiofor and Okoye, 2018).

The ash content of the granola samples ranged from 1.25 to 1.79% with control sample recording the lowest and sample substituted with 50% SSF as highest. There was an increase in the ash content of the granola as substitution with SSF increased. The control sample was significantly ( $p < 0.05$ ) different from other samples while samples substituted with 30, 40 and 50% SSF were significantly ( $p < 0.05$ ) similar in ash content. The increase in ash content on substitution with SSF could be due to the high ash of 2.90% soursop flour. This study supports the findings of Wijewardana et al. (2016) that high ash content of soursop flour can be used to enrich the lost nutrients in wheat flour during refining. The increase in ash content obtained from this study shows that the granola substituted with soursop flour had presence of minerals needed to speed up metabolic processes and improve growth and development. Ash values from this study was comparable with range of values of 0.79 to 1.48% and 0.97 to 1.88% for granola produced from different cereal grains (Eke-Ejiofor and Beleya, 2016) and granola formulated with puffed glutinous rice and selected dried Sunnah foods (Agbaje et al., 2016).

Fat content ranged between 12.09 to 14.13% with sample containing 50% SSF having the lowest and control sample as highest. There was a decrease in the fat content of the granola samples as substitution of SSF increased. Fat content of the control sample was significantly ( $p < 0.05$ )

**Table 2.** Proximate composition of granola produced from wheat and soursop flour blends.

Samples	Moisture (%)	Ash (%)	Fat (%)	Protein (%)	Crude Fibre (%)	CHO (%)	Energy (kcal)
SGA	5.21±0.08 <sup>d</sup>	1.25±0.14 <sup>d</sup>	14.13±0.16 <sup>a</sup>	9.56±0.00 <sup>d</sup>	0.83±0.23 <sup>b</sup>	69.02±0.41 <sup>a</sup>	418.64±0.10 <sup>c</sup>
SGB	5.54±0.29 <sup>cd</sup>	1.43±0.09 <sup>c</sup>	14.06±0.71 <sup>a</sup>	10.37±0.00 <sup>c</sup>	0.87±0.01 <sup>b</sup>	67.73±0.19 <sup>b</sup>	420.49±0.85 <sup>b</sup>
SGC	6.09±0.10 <sup>bc</sup>	1.50±0.01 <sup>c</sup>	13.89±0.91 <sup>a</sup>	10.94±0.62 <sup>bc</sup>	0.90±0.01 <sup>b</sup>	66.68±0.03 <sup>c</sup>	420.74±0.25 <sup>b</sup>
SGD	6.50±0.49 <sup>b</sup>	1.70±0.18 <sup>bc</sup>	12.71±0.30 <sup>b</sup>	11.56±0.62 <sup>b</sup>	0.98±0.01 <sup>ab</sup>	66.55±1.03 <sup>cd</sup>	421.08±0.52 <sup>ab</sup>
SGE	7.21±0.15 <sup>a</sup>	1.73±0.06 <sup>a</sup>	12.35±0.43 <sup>bc</sup>	12.41±0.00 <sup>a</sup>	1.08±0.04 <sup>ab</sup>	65.22±0.42 <sup>d</sup>	421.97±0.54 <sup>a</sup>
SGF	7.22±0.01 <sup>a</sup>	1.79±0.01 <sup>a</sup>	12.09±0.16 <sup>c</sup>	12.62±0.62 <sup>a</sup>	1.21±0.01 <sup>a</sup>	65.07±0.06 <sup>e</sup>	422.22±0.51 <sup>a</sup>

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

similar with samples substituted with 10 and 20% SSF. The decrease in fat content observed from this study is due to the substitution of soursop flour. Fruits generally are not good sources of fat except avocado pear (Iombor et al., 2014). This study agreed with the work of Iombor and Banjo (2018) who observed a decrease in the fat content of bread substituted with soursop flour from 8.50 to 4.00% as substitution of soursop flour increased. Fat plays significant role in the shelf life of food product as fat have the ability of promoting rancidity in foods leading to development of unpleasant and odorous compounds (Barber et al., 2016). From this research, it is evident that granola substituted with 40 and 50% soursop flour significantly ( $p < 0.05$ ) lowered the fat of the granola showing its ability of been stored for a longer period than those produced from 100% wheat flour.

Protein content ranged from 9.56% in control sample to 12.62% in sample substituted with 50% SSF. Increase in substitution of SSF resulted to a significant ( $p < 0.05$ ) increase in protein content of the granola samples. Samples substituted with 40 and 50% SSF were significantly ( $p < 0.05$ ) similar. This increase is due to the substitution of wheat flour with soursop flour. This confirms earlier reports by Emelike and Akusu (2019) that soursop has a high protein content of 15.62% as compared to other fruits. Zabidi and Yunus (2014) also added that soursop flour could be utilized in enhancing the protein content of various food products. The protein content of the granola samples were higher than 3.38 to 4.04% for granolas formulated with puffed glutinous rice and selected dried Sunnah foods (Agbaje et al., 2016). The values are also within the range of 9.65 to 16.36% for granola produced from different cereals and processing methods (Eke-Ejiofor et al., 2017). It can be concluded from this study that soursop flour could be used to formulate granola of appreciable protein content.

Crude fibre content of the granola samples ranged from 0.83 to 1.21% with control sample having the least and sample substituted with 50% SSF as highest. Similarly, increase in SSF substitution led to an increase in crude fibre content of the granola samples. Samples substituted with 10 and 20% SSF and control sample were

significantly ( $p < 0.05$ ) similar. The increase in crude fibre of the granola is due to the substitution with soursop flour. According to Wijewardana et al. (2016), oven dried soursop flour contains 28.21% crude fibre which can be used to enrich lost nutrients in wheat flour during refining. This study is in concordance with that of Agbaje et al. (2016) who reported increase in fibre content (1.94 to 9.39%) of granola formulated with puffed glutinous rice and selected dried Sunnah foods. Iombor and Banjo (2018) also reported increase in crude fibre content of bread (2.45 to 2.85%) on substitution with soursop flour. The increase in the crude fibre of the granola on substitution with soursop flour implies that soursop is a rich source of fibre and its utilization for the production of granola will be of health benefits such as reduced constipation and ease in colon digestion.

There was a decrease in the carbohydrate content of the granola samples as substitution with SSF increased with values ranging from 69.06% in control sample to 65.07% in sample substituted with 50% SSF. The increase in proportion of soursop flour brought about a decrease in the carbohydrate content of the granola samples. The carbohydrate values of this study were comparable with those reported for granola produced from different cereals (63.59 to 69.16%) for granola produced from different cereals by Eke-Ejiofor and Beleya (2016) and granola from millet, guinea corn, white maize and yellow maize (54.97 to 62.48%) by Eke-Ejiofor et al. (2017).

Energy content ranged from 418.64 kcal in control sample to 422.22 kcal in sample substituted with 50% SSF. An increase in the energy value of the granola samples was observed as substitution with soursop flour increased. Samples substituted with 40 and 50% SSF were significantly ( $p < 0.05$ ) similar. The protein, fat and carbohydrate contents of the blend constituents contributed to the energy value of the granola samples. This value is comparable with energy values of granola developed from puffed rice, corn flakes, chickpea and oat flakes (402.01 to 421.88 kcal) by Ahmad et al. (2017). Granola is an energy-giving food consumed as a breakfast cereal. The result from this study implies that the substitution of soursop flour could help to boost the level

**Table 3.** Mean sensory scores from taste panel of granola from wheat and sour-sop flour blends.

Samples	Appearance	Aroma	Taste	Texture	Overall acceptability
SGA	7.05 <sup>a</sup>	7.05 <sup>a</sup>	6.85 <sup>a</sup>	6.55 <sup>a</sup>	7.35 <sup>a</sup>
SGB	6.45 <sup>ab</sup>	6.30 <sup>ab</sup>	6.70 <sup>a</sup>	6.35 <sup>a</sup>	7.10 <sup>a</sup>
SGC	6.80 <sup>a</sup>	6.30 <sup>ab</sup>	6.85 <sup>a</sup>	6.70 <sup>a</sup>	7.15 <sup>a</sup>
SGF	6.35 <sup>ab</sup>	6.55 <sup>ab</sup>	6.20 <sup>ab</sup>	6.55 <sup>a</sup>	7.20 <sup>a</sup>
SGD	5.60 <sup>ab</sup>	5.55 <sup>b</sup>	6.55 <sup>ab</sup>	5.60 <sup>ab</sup>	6.30 <sup>ab</sup>
SGE	5.45 <sup>b</sup>	5.65 <sup>b</sup>	5.50 <sup>b</sup>	5.15 <sup>b</sup>	5.75 <sup>b</sup>

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

of calories of granola.

### Sensory properties of granola produced from wheat and soursop flour blends

Mean sensory scores of the granola samples produced from wheat and soursop flour blends are presented in Table 3. Appearance of the control sample was most preferred with mean score of 7.05 while sample substituted with 50% soursop flour (SSF) was the least (5.45). Appearance of the control sample was significantly ( $p < 0.05$ ) different from all others but not from sample substituted with 20% SSF. The high value observed from 100% wheat flour may be as a result of changes in appearance of granola due to substitution with soursop flour which had effect on the appearance as compared to whitish colour usually obtained for all-purpose wheat flour. Similar findings were also reported by Zabidi and Yunus (2014) for bread substituted with different levels of matured soursop flour.

Aroma of control sample was most preferred with mean score of 7.05 while sample substituted with 40% SSF was least preferred with mean score of 5.55. Aroma of samples substituted with 10, 20 and 30% SSF were significantly ( $p < 0.05$ ) similar. Increased substitution with soursop flour led to a significant ( $p < 0.05$ ) decrease in mean aroma scores of the granola. This decrease is also attributed to the substitution of wheat flour with soursop flour. Similar finding was also reported by Lombor and Banjo (2018) for wheat bread substituted with soursop flour.

Texture and taste of the granola samples ranged from 5.15 to 6.70 and 5.50 to 6.85 with control sample and sample substituted with 30% SSF as most preferred for texture while control sample and sample substituted with 20% SSF were most preferred for taste. Texture of control sample was significantly ( $p < 0.05$ ) different from samples substituted with 40 and 50% SSF but not from samples substituted with 10, 20 and 30% SSF. Similarly, taste of control sample and samples substituted with 10 and 20% SSF were significantly ( $p < 0.05$ ) similar. A decrease in the texture and taste of the granola was observed on substitution with SSF. The decrease in mean taste scores

may be as a result of sweet-sour taste of soursop fruit which may have resulted to changes in the taste of the granola on substitution (Akubor and Egbekun, 2007). The decrease in texture might be attributed to the high moisture content of soursop flour (18.33 to 24.53%) as reported by Minh (2018) which may have led to loss of texture of the granola as substitution increased. Similar finding was also reported by Zabidi and Yunus (2014) for bread substituted with different levels of matured soursop flour.

Overall acceptability of the granola ranged from 5.75 to 7.35 with control sample as most preferred and sample substituted with 50% SSF as the least. Overall acceptability of the control granola and samples substituted with 10, 20 and 30% SSF were significantly ( $p < 0.05$ ) similar. The appearance, taste, texture and aroma of the blend constituents contributed to the overall acceptability of the granola samples. The mean sensory scores from this study therefore suggest that acceptable granola product can be formulated with soursop flour at levels up to 30%.

### Microbiological status of granola produced from wheat and soursop flour blends

#### Total bacterial counts

Results of the total bacterial counts (TBCs) of granola samples are shown in Table 4. No visible bacterial growth was observed on all the samples on the initial week of production. This indicates adequate ingredient quality and that good hygiene and food handling practices were followed during the preparation of the product. The high temperature involved in the baking process may also have accounted for this. After storage period of 3 weeks, TBCs were observed to increase to a range of  $6.00 \times 10^3$  cfu/g in control sample to  $7.00 \times 10^3$  cfu/g in samples substituted with 40 and 50% soursop flour. The high TBCs in samples substituted with soursop flour may be due to the fact that increases in moisture and protein of the samples incorporated with soursop flour encourages the microbial action (Minh, 2018). Omachi and Yusufu (2017) reported increased in the level of microbial contamination to be due to increased level of proteins and fats. Adams and Moss

**Table 4.** Total bacterial counts (cfu/g) in granola produced from wheat and soursop flour blends during storage.

Samples	Storage period (Weeks)			
	0	1	2	3
SGA	NG	2.00×10 <sup>2</sup>	2.70×10 <sup>2</sup>	6.00×10 <sup>3</sup>
SGB	NG	2.00×10 <sup>2</sup>	3.00×10 <sup>2</sup>	6.00×10 <sup>3</sup>
SGC	NG	2.40×10 <sup>2</sup>	4.50×10 <sup>2</sup>	6.00×10 <sup>3</sup>
SGD	NG	3.00×10 <sup>2</sup>	3.40×10 <sup>2</sup>	6.20×10 <sup>3</sup>
SGE	NG	3.20×10 <sup>2</sup>	4.00×10 <sup>2</sup>	7.00×10 <sup>3</sup>
SGF	NG	3.70×10 <sup>2</sup>	5.00×10 <sup>2</sup>	7.00×10 <sup>3</sup>

**Key:** Cfug= colony forming units per gram; NG = no growth, SGA = wheat flour 100%; SGB = wheat/sour-sop flour (90:10%); SGC = wheat/sour-sop (80:20%); SGD = wheat/sour-sop flour (70:30%); SGE = wheat/sour-sop flour (60:40%); SGF = wheat/sour-sop flour (50:50%).

**Table 5.** Total fungal counts (cfu/g) of granola produced from wheat and soursop flour blends during storage.

Samples	Storage period (Weeks)			
	0	1	2	3
SGA	NG	1.00×10 <sup>2</sup>	2.00×10 <sup>3</sup>	5.00×10 <sup>4</sup>
SGB	1.00×10	1.00×10 <sup>2</sup>	2.00×10 <sup>3</sup>	5.00×10 <sup>4</sup>
SGC	1.00×10 <sup>2</sup>	1.00×10 <sup>2</sup>	2.00×10 <sup>3</sup>	5.00×10 <sup>4</sup>
SGD	1.00×10	1.00×10 <sup>2</sup>	3.00×10 <sup>3</sup>	5.20×10 <sup>4</sup>
SGE	NG	1.00×10 <sup>2</sup>	2.50×10 <sup>3</sup>	5.00×10 <sup>4</sup>
SGF	NG	1.00×10 <sup>2</sup>	3.00×10 <sup>3</sup>	5.00×10 <sup>4</sup>

**Key:** Cfug = colony forming units per gram; NG = no growth; SGA = wheat flour 100%; SGB = wheat/sour-sop flour (90:10%); SGC = wheat/sour-sop flour (80:20%); WG4 = wheat/sour-sop flour (70:30%); WG5 = wheat/sour-sop flour (60:40%); WG6 = wheat/sour-sop flour (50:50%).

(1999) also stated that spoilage organisms grow faster in medium that is highly nutritious. TBCs of the granola samples after 3 weeks of storage were within acceptable statutory limits of 10<sup>4</sup> to less than 10<sup>6</sup> cfu/g of ready to eat food products (ICMSF, 2002) suggesting that the granola prepared at all levels of soursop flour has a good shelf-life up to 3 weeks of storage. Total bacterial counts indicate the microbiological quality of any food product and the presence of a high number of TBCs is an indication of low expected shelf life of the product (Noah, 2017).

### Total fungal counts

Results of the total fungal counts (TFCs) of granola samples are presented in Table 5. Fungal counts at initial week of production were 1.0×10 cfu/g, 1.0×10<sup>2</sup> cfu/g and 1.0×10 cfu/g for samples substituted with 10, 20 and 30% sour-sop flour (SSF), respectively. The control sample and samples substituted with 40 and 50% SSF recorded no growth. At the end of three weeks storage period, an increase in fungal counts was observed. The control sample and samples substituted with 10, 20, 30 and 50% SSF had TFCs of 5.00×10<sup>4</sup> cfu/g each while sample

substituted with 40% SSF recorded TFCs of 5.20×10<sup>4</sup> cfu/g. The increase in fungal counts during storage could arise from the uptake of moisture from the food products thereby encouraging microbial growth during storage. TFCs of the granola samples after 3 weeks of storage were within 10<sup>2</sup> to 10<sup>4</sup>cfu/g for fungal counts (ICMSF, 2002). This study therefore demonstrates that the granola prepared from soursop and wheat flour at all levels has a good shelf-life up to 3 weeks of storage but could pose health risk after three weeks of storage. Souza and Silva (2015) reported that microbial conditions of granola prepared from blends of dried cashew fruits and almonds at different levels were all adequate, similar to the findings of this study.

### Conclusion

This study showed that wheat flour can be substituted with sour-sop flour for the production of nutritious and acceptable granola. Substitution of wheat flour with soursop flour resulted to a significant ( $p < 0.05$ ) increase in moisture, ash, protein, crude fibre and energy contents with a decrease in fat and carbohydrate contents. The

results also showed that colour, taste, texture and overall acceptability of the control granola were more preferred. Appearance of control granola sample was not significantly ( $p < 0.05$ ) different from sample substituted with 20% SSF. Taste and aroma of the granola samples were accepted at SSF substitution levels of 20 and 30%, respectively. Texture and overall acceptability of the control granola and samples substituted with 10, 20 and 30% SSF were significantly ( $p < 0.05$ ) similar suggesting that acceptable granola can be produced at SSF substitution of up to 30%. Total bacterial and fungal counts of all the products increased during storage and upon increased substitution with soursop flour. All the products presented adequate microbiological conditions and were within recommended safe limit of microbial guidelines. The findings of this study therefore suggest that wheat flour can be substituted with soursop flour at levels up to 30% for the preparation of granola. This would contribute to the utilization and consumption of soursop fruits and meet the growing demand for consumption of healthier, and natural foods.

## CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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