



# Production and Characterization of Fruit Bars Produced from the Mucilaginous Pulp of *Garcinia kola*



Nuria C. Oganezi<sup>1\*</sup>, Ogan I. Mba<sup>2</sup> and Uchenna Okonkwo<sup>3</sup>

<sup>1</sup>Department of Food Science and Technology, Abia State University, Uturu, Abia State, Nigeria; ORCID: 0000-0002-8378-1775; chinonyeremwog@yahoo.com

<sup>2</sup>Department of Bioresource Engineering, Macdonald Campus, McGill University, 21,111 Lakeshore Road, Sainte-Anne-de-Bellevue H9X 3V9, QC, Canada; ORCID: 0000-0002-8047-7196; ogan.mba@mcgill.ca

<sup>3</sup>Department of Food Science and Technology, Abia State University, Uturu, Abia State, Nigeria.

\*Corresponding author: [chinonyeremwog@yahoo.com](mailto:chinonyeremwog@yahoo.com)

Abstract	Article History
<p>Fruit bars were produced from exotic <i>Garcinia kola</i> fruit pulp puree at different concentrations. The bars were sweetened using 'date fruit paste', aspartame and sucrose. Hydrocolloids such as guar gum, xanthan gum and gelatin were added for stabilization. Analysis of the sensory results showed that the aspartame sweetened bars were preferred for their crispiness, taste color and mouthfeel. Further characterization of the bar samples with overall acceptability score <math>\geq 5.0</math> indicated that while fruit bars sweetened with aspartame and stabilized using gelatin was higher in crude protein content, the sucrose sweetened bars had higher carbohydrate content. The energy values of the bars ranged between 265.59 and 348.15 kcal/100g. Essential minerals were present in appreciable amounts in the fruit bars samples in this order: potassium&gt;calcium&gt;phosphorus&gt;sodium&gt;magnesium&gt;iron&gt;zinc. The results also showed that the <i>G. kola</i> fruit bars were low in antinutrients and contains beneficial antioxidants and bioactive compounds such as vitamin E, flavonoids, carotenoids, tannins, alkaloids and phenols. The pH of the bars (3.0 – 4.0) and the acidity values (0.16 – 0.22%) is an indication of potential shelf stability of the bars.</p> <p><b>Keywords:</b> <i>Garcinia kola</i> pulp, fruit bars, sensory evaluation, nutrients, phytochemicals</p>	<p>Received: 15 Mar 2025 Accepted: 22 Mar 2025 Published: 04 Apr 2025</p>  <p>Scan QR code to view*</p> <p>License: CC BY 4.0*</p>  <p>Open Access article.</p>
<p><b>How to cite this paper:</b> Oganezi, N. C., Mba, O. I., &amp; Okonkwo, U. Production and characterization of fruit bars produced from the mucilaginous pulp of <i>Garcinia kola</i>. <i>IPS Journal of Nutrition and Food Science</i>, 4(2), 372–383. <a href="https://doi.org/10.54117/ijnfs.v4i2.84">https://doi.org/10.54117/ijnfs.v4i2.84</a>.</p>	

## 1. Introduction

Fresh fruits are consumed when in season but lack availability throughout the year; hence it is necessary to preserve them in order to relish their nutrition when out of season (Aslam *et al.*, 2023). Current trends in the food industry necessitate the development of new high-quality convenient fruit products acceptable to the consumer. Food enrichment and fortification are the most cost effective and sustainable plans to address micronutrient malnutrition (Sithika and Narayanan, 2024). In order to prevent post-harvest losses, fruits are further processed into different types of value added products (Bandaru and Bakshi, 2020). Common products made from fruit and vegetables include sliced minimally processed fruits, juices and concentrates, pulps and dehydrated products, jams and jellies, pickles, chutneys and fruit bars (Danalache *et al.*, 2015). Fruit bars are restructured dehydrated fruits made from fresh fruits pulp or a mixture of fruit juice concentrate and other ingredients. They are also known as 'fruits stabs', 'fruit roles' or 'fruit leathers' (Torres *et al.*, 2015). Fruits are recognized as good sources of minerals, vitamins and

phytochemicals. Comparatively, fruit bars are reported to possess greater nutritional value than fresh fruits. The nutrients in fruit bars are condensed and concentrated. Thus, the bars serve as a convenient source of different types of nutrients (Orrego *et al.*, 2014) and flavour (Diamante *et al.*, 2014).

*Garcinia kola* (*G. kola*) fruit belongs to the *Guttifera* family. The fruit is commonly consumed in sub-Saharan Africa especially Nigeria and Cameroun. In a ripened fruit pod, the seeds are embedded in yellow-orange mucilaginous pulp. Conventionally, after seed extraction, the pulp is discarded as a waste. The nutrients and phytochemical composition of the garcinia fruit pulp extracted has been evaluated by Amaechi *et al.* (2017). The pulp is rich in vitamin C, potassium, saponin and carotenoids. Follow up studies showed the presence of high concentrations of sesquiterpenes and triterpenoid phytochemicals mainly lupeol (Amaechi and Okonkwo, 2017). Many fruits have been used to produce fruit bars. The composition of *G. kola* fruit pulp makes it a potential raw material to produce functional foods and other useful products.

♦ This work is published open access under the [Creative Commons Attribution License 4.0](https://creativecommons.org/licenses/by/4.0/), which permits free reuse, remix, redistribution and transformation provided due credit is given.

The usefulness of *G. kola* fruit and its flavorful pulp that has not been fully studied. The objective of this study was to formulate, produce and characterize fruit bars made from the pulp of the *G. kola* fruit. The effect of added sweeteners and stabilizers was also investigated.

subsequently dried in an oven at 70°C for 10 hours. The fruit bars were cut into smaller pieces, packaged and stored at 10°C for the subsequent analyses. The flow chart to produce *Garcinia kola* fruit bar is shown in Figure 1.

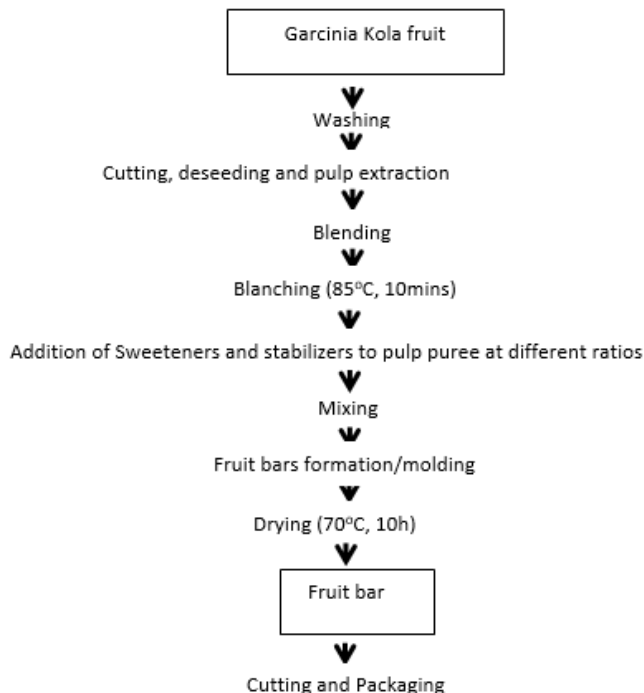
## 2. Materials and Methods

### Materials

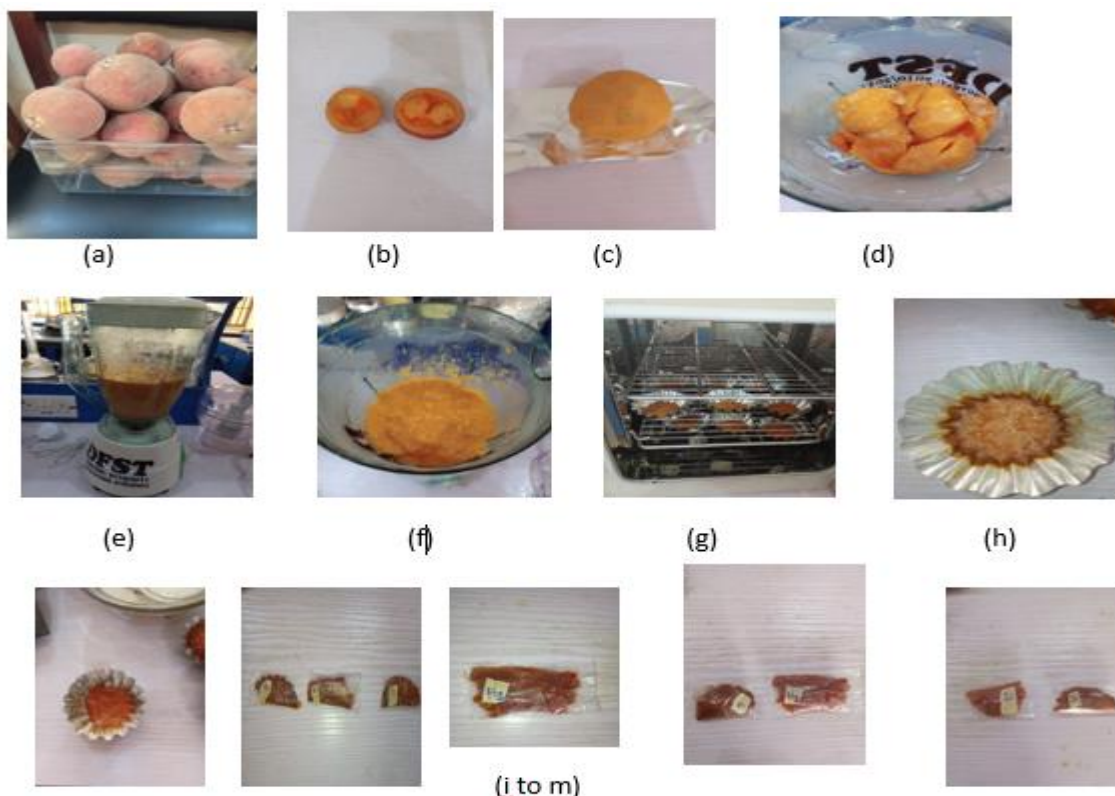
Mature *G. kola* fruits, date fruit, sucrose, and aspartame were purchased from a local market in Uyo, Akwa Ibom State, Nigeria. Glycerol and xanthan gum were purchased from Universal Oil Field Chemical, Gujrat-India, gelatin from Gelita AG, Germany, guar gum from Lobochemie, Mumbai-India. The other reagents made by Sigma-Aldrich, namely, 2,2-bipyrimidine, hydrochloric acid, Folin-Ciocalteu phenol reagent and sodium hydroxide were purchased from Bristol Scientific Company Limited, Lagos. The date paste used as sweetener was freshly prepared in the lab and kept at 10°C just before use.

### Preparation of *Garcinia kola* bar

The fully ripened fruits were cut open using stainless steel knife and the seeds removed. The pulp was scooped into a warring blender and blended into a smooth puree. The puree was blanched at 85°C for 10mins to hinder enzymatic browning, soften the tissues and sanitize it. Twenty-seven different fruit bar preparations were made by mixing the fruit pulp puree with different ratios of the sweeteners and hydrocolloid stabilizers (Table 1). Each pulp-sweetener-stabilizer mixture was thoroughly homogenized and poured into stainless steel molds pre-smearred with glycerol to a thickness of about 3cm. The formed *G. kola* bars were



**Figure 1:** Flow chart for the preparation of fruit bar from *Garcinia kola* fruit pulp.



**Figure 2:** (a) Ripe *Garcinia kola* fruit (b) Fruit cut open for deseeding. (c) Peeled and deseeded fruit (d) Extracted Pulp (e) Blending of Pulp (f) Blended Pulp (g) Fruit bars dried at 70°C (h) Moulded *Garcinia kola* fruit pulp bar (i to m) *Garcinia kola* fruit pulp bar samples.

**Table 1:** Composition of the various *Garcinia kola* fruit pulp puree-sweetener-stabilizer mixtures.

Code	Sample		Sweeteners		Stabilizer gums		
	G. kola pulp (g)	Date paste (g)	Sucrose (g)	Aspartame (g)	Xanthan (g)	Guar(g)	Gelatin (g)
A <sub>1</sub>	20	3	-	-	0.2	-	-
A <sub>2</sub>	20	-	3	-	0.2	-	-
A <sub>3</sub>	20	-	-	0.3	0.2	-	-
B <sub>1</sub>	20	3	-	-	-	0.2	-
B <sub>2</sub>	20	-	3	-	-	0.2	-
B <sub>3</sub>	20	-	-	0.3	-	0.2	-
C <sub>1</sub>	20	3	-	-	-	-	0.2
C <sub>2</sub>	20	-	3	-	-	-	0.2
C <sub>3</sub>	20	-	-	0.3	-	-	0.2
D <sub>1</sub>	15	3	-	-	0.2	-	-
D <sub>2</sub>	15	-	3	-	0.2	-	-
D <sub>3</sub>	15	-	-	0.3	0.2	-	-
E <sub>1</sub>	15	3	-	-	-	0.2	-
E <sub>2</sub>	15	-	3	-	-	0.2	-
E <sub>3</sub>	15	-	-	0.3	-	0.2	-
F <sub>1</sub>	15	3	-	-	-	-	0.2
F <sub>2</sub>	15	-	3	-	-	-	0.2
F <sub>3</sub>	15	-	-	0.3	-	-	0.2
G <sub>1</sub>	10	3	-	-	0.2	-	-
G <sub>2</sub>	10	-	3	-	0.2	-	-
G <sub>3</sub>	10	-	-	0.3	0.2	-	-
H <sub>1</sub>	10	3	-	-	-	0.2	-
H <sub>2</sub>	10	-	3	-	-	0.2	-
H <sub>3</sub>	10	-	-	0.3	-	0.2	-
I <sub>1</sub>	10	3	-	-	-	-	0.2
I <sub>2</sub>	10	-	3	-	-	-	0.2
I <sub>3</sub>	10	-	-	0.3	-	-	0.2

### Sensory Evaluation

The sensory quality attributes of the *G. kola* fruit pulp bar products were evaluated on a 9-point hedonic scale, where 1 = dislike extremely, 5 = neither like nor dislike, and 9 = like extremely (Torres *et al.*, 2015). The coded samples were presented to a panel of 15 semi-trained judges in a well-lit lab. Potable water was provided for mouth rinsing in between samples. The attributes tested were aroma, color, crispness, mouth-feel, softness, taste, texture, and overall acceptability. The means of the responses submitted by the panelists were calculated for each attribute. *G. kola* bar samples that scored 5.0 and above on overall acceptability were selected for further evaluations. Their nutrient composition, phytochemical and physicochemical properties were determined.

### Proximate Composition Analysis

The selected fruit bar products were subjected to proximate composition analysis using established AOAC protocols (AOAC, 2005). Crude protein was determined by the micro Kjeldhal method (AOAC 939.02). The nitrogen content of the sample digest was multiplied by 6.25 and expressed as percentage protein. Ash content was determined gravimetrically after muffle furnace (SX2-2.5-12 England) incineration at 550°C for 6 h. Crude fat was also determined gravimetrically after solvent extraction using hexane. Crude fiber was determined by the Weende method while moisture determination was done by drying the pulverized fruit bars in a convection oven at 105°C for 12h to a constant weight.

Nitrogen free extract (carbohydrate) was calculated by applying the formula:  $100 - [\% \text{Moisture} + \% \text{Ash} + \% \text{Fat} + \% \text{Crude fiber} + \% \text{Crude protein}]$ . Energy values of the respective fruit bars in kcal/100g were obtained by multiplying the percentage of crude protein, fat and carbohydrate by the factor of 4, 9 and 4, respectively and summing them up. All the analyses were performed in triplicates.

### Mineral Analysis

The ash obtained from the ash content experiment was used for the minerals assay (James, 2013). Briefly, each ash sample was transferred to 100 mL glass tubes and 2mL of 2M hydrochloric acid was added. The digest in each tube was made up to mark with deionized water. The diluted digest was used to analyze the different mineral elements. Sodium and potassium were analyzed using Type 128 Flame photometer (Systronics, Gujarat India). Phosphorus and zinc were analyzed by determining the absorbance of color complex formed molybdovanadate and Zincon, respectively. The absorbance read at 400 nm for phosphorus and 615 nm for zinc (Säbel *et al.*, 2010) using UV/Vis SpectroArt 200 spectrophotometer (Wealtec Bioscience, New Taipei City, Taiwan). EDTA titration was used for the determination of calcium and magnesium. Iron was analyzed by Orthophenanthroline red ferrous complex method. The analysis was carried out in triplicates and the mean of each mineral reported in mg/100g edible portion.

### Vitamin analysis

The B vitamins, vitamin A and Vitamin E contents of the *G. kola* pulp bars were estimated spectrophotometrically (UV/Vis SpectroArt 200, Wealtec Bioscience, New Taipei City, Taiwan) using 1 cm path length cuvette, according to the methods described by Okwu and Emenike (2006) with some modifications. Briefly, 5g of each *G. kola* bar sample was homogenized and extracted using a mixture of absolute ethanol and 5% potassium hydroxide (10:1) and boiled for 30mins under reflux before adding petroleum ether. The extract mix was evaporated to dryness on a rotary evaporator. Small amounts of the residue was re-dissolved in appropriate carrier solvents for each vitamin. Vitamin standards were prepared in the carrier solvents at different concentrations. Their absorbance was read and used to create the calibration curves used to calculate the concentration of the vitamin on a dry weight basis. The absorbances of the vitamins were monitored as follows: thiamin (vitamin B1) at 360 nm, riboflavin (vitamin B2) at 510 nm, niacin (vitamin B3) at 470 nm, vitamin A at 450 nm and vitamin E at 295 nm.

Vitamin C was determined titrimetrically after homogenizing each sample in 50mL 5.6 mM EDTA solution. The homogenized samples were filtered using Whatman no.1 filter paper. Approximately 10mL of 30% potassium iodide was added to 20mL of filtrate and mixed thoroughly. The mixture was titrated against 0.1M CuSO<sub>4</sub> to a dark end point using 1% starch solution as the indicator (Okwu and Emenike, 2006).

### Phytochemical Analysis

The phytochemicals in each *G. kola* fruit bar samples were investigated. Total polyphenols were determined by the Folin–Ciocalteu assay (Waterhouse, 2001), while oxalate was determined by titrimetry as described by Gupta *et al.* (2005). Total tannins, cyanides and phytic acid contents were determined by Folin-Dennis assay, alkaline picrate assay, and 2,2-bipyrimidine solution assay, respectively, as described by Yasmin *et al.* (2008). Gravimetric estimations of total alkaloids, total saponins and total flavonoids were carried out following the protocols described by Harborne (1998). Phytosterol was determined spectrophotometrically after precipitation (Kasal *et al.*, 2010). Similarly total carotenoids was determined spectrophotometrically after extraction as reported by (Mba *et al.*, 2017).

### Physicochemical Analysis

The pH of each fruit bar sample, homogenized in 10 mL boiled deionized water, was measured using a digital pH meter (PHS-3C, England) after calibration with pH 4.0 and 7.0 buffers. The total titratable acidity (TTA) was determined by AOAC Method 920.124 (AOAC, 2005). Three drops phenolphthalein indicator was added to aliquots of each sample homogenate titrated against 0.01N sodium hydroxide. Percentage TTA was calculated using equation 1.

$$TTA(\%) = \frac{V \times N \times 0.0064}{\text{Volume of sample analyzed}} \quad (1)$$

Where V = Titer value obtained and N = Normality of NaOH. The viscosity of the respective fruit bar formulations was determined using a Brookfield dial viscometer (AOAC, 2005). Briefly, 100mL of each sample was stirred in a beaker using

spindle number 2 at a speed of 30rpm. Dial reading was noted and viscosity in centipoises was calculated using equation 2.

$$\text{Viscosity} = \text{Dial reading} \times 10 \dots \dots \dots (2)$$

Total soluble solids (TSS) of each fruit bar was determined before drying using pre-calibrated OP refractometer (Bellingham and Stanley, Tunb ridge Wells, UK). The percentage of TSS was obtained from direct reading of the refractometer.

The total sucrose content of each fruit bar mixture was determined by the modified anthrone method, while the reducing sucroses were determined by the dinitrosalicylic acid method (James, 2013). The non-reducing sucrose content was calculated using equation 3.

$$\% \text{Non-reducing sugar} = \% \text{total sugar} - \% \text{reducing sugar} \dots \dots \dots (3)$$

### Statistical Analysis

Each analysis was carried out in triplicates. The data were analyzed using one-way ANOVA on SPSS version 20 for windows. Significant differences between means were separated using Duncan's Multiple Range Test (DMRT) at 95% confidence interval. Results are reported as means  $\pm$  standard deviation.

## 3. Results and Discussion

### Sensory Evaluation

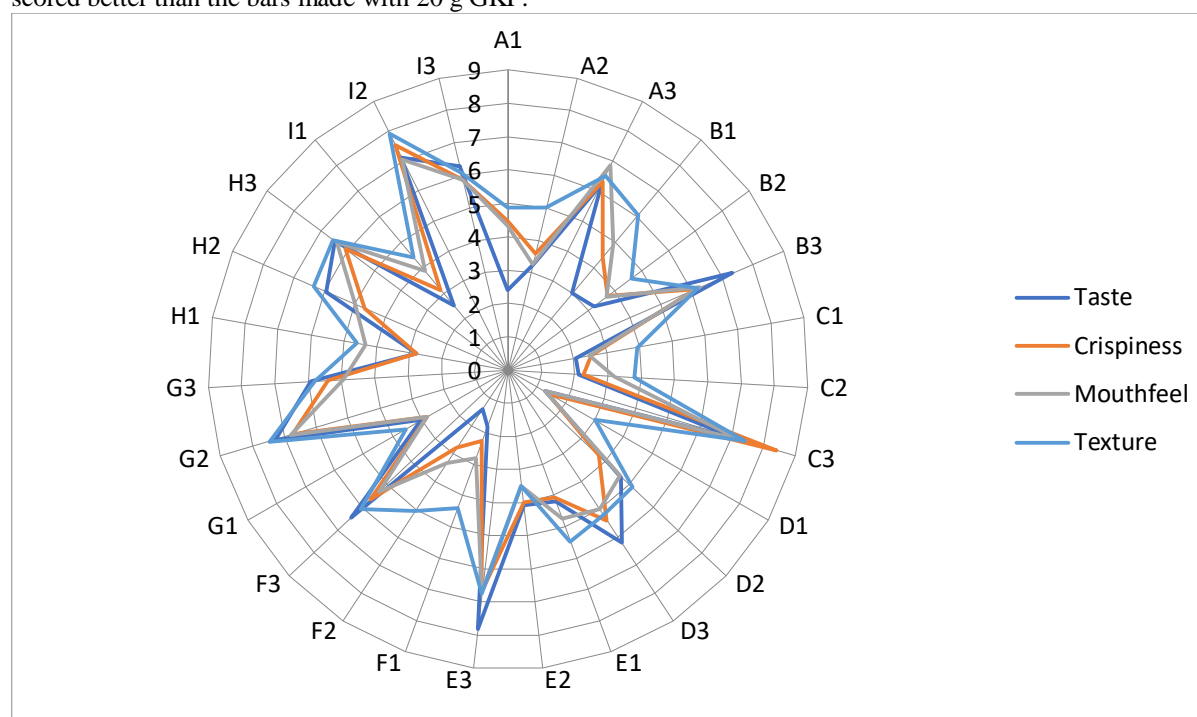
The results of the sensory evaluation tests are presented in Figures 2 and 3. Taste is a primary sensory attribute that influences the acceptability of a food product and willingness to purchase the product (Orrego *et al.*, 2014). The taste scores of the GKP fruit bars sweetened with date paste (DP), sucrose (Suc) and aspartame (Asp) ranged from 1.27 – 4.20, 1.40 – 7.22 and 5.40 – 7.82, respectively (Figure 1). The taste results indicated that the type of sweetener had a significant ( $p < 0.05$ ) influence on the taste scores of the GKP bars. The mean taste scores suggested that the taste of this newly developed GKP fruit bars sweetened with aspartame and sucrose were generally liked by the panelists. The taste of the bars sweetened with date paste were not much liked. Increasing the proportions of the GKP puree in the formulations did not affect the taste rating of the fruit bars. In terms of crispiness, sample D<sub>1</sub> (GKP: DP: XG, 15: 3: 0.2) had the least mean score of 1.40, while sample C<sub>3</sub> (GKP: Asp: Gln, 20: 0.3: 0.2) had the highest score of 8.40. The interaction of stabilizer type and the amount of GKP puree in the formulation had significant ( $p < 0.05$ ) effect on the crispiness scores of the fruit bars. The gelatin (Gel) appear to have the most significant influence on the crispiness of the fruits bars while guar gum (GG) was most suitable for bars with 15 g GKP puree and xanthan gum (XG) performed well on the crispness of bars with 20g and 10g GKP puree inclusion. It has been reported that there is a negative correlation between the hardness and crispiness of processed foods. Snack foods with low moisture content and well distributed fine pore structure tend to be crispier (Sanahuja *et al.*, 2018).

The mouth-feel scores of the fruit bar samples varied significantly ( $P < 0.05$ ). It is possible that panelists had different definitions and interpretations mechanical interactions between the fruit bars and their mouth. Fruit bar sample I<sub>2</sub> (GKP: Suc: Gln, 10: 3: 0.2) had the highest mouthfeel mean score of 7.93. The panelists showed the least mouthfeel and texture preference for the fruit bars formulated with DP. The bars made with 20 g and 15 g GKP puree and sweetened with aspartame also had high mouthfeel and texture ratings irrespective of the stabilizer used.

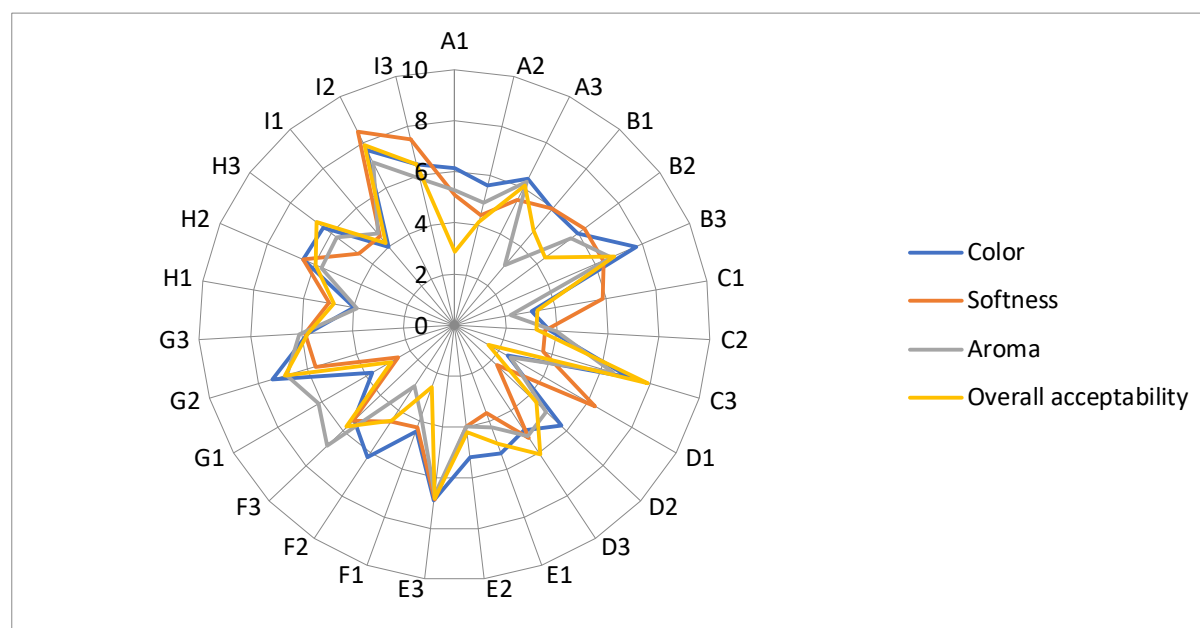
As shown in Figure 3, the fruit bars differed significantly ( $p < 0.05$ ) in their color scores. This reinforces the importance of the visual appearance of food product in predicting consumer acceptability and level of satisfaction. Among the DP sweetened bars, sample A<sub>1</sub> had the highest mean score of 6.13. Sample I<sub>2</sub> with color score of 7.67 was the highest for the sucrose sweetened samples, while B<sub>3</sub> with a score of 7.73 was the highest among the aspartame sweetened samples. On the average, the sucrose sweetened bars had the most preferred color followed by the aspartame and date paste sweetened samples. Possibly the ability of free sugars to participate in non-enzymatic browning may have favored the color of the bars containing sucrose. It was also observed that in most cases, the color of the bars with 10 g and 15 g GKP levels scored better than the bars made with 20 g GKP.

In terms of the sensory parameter of softness (Figure 3), the panelists liked the softness sucrose sweetened bars more than the aspartame and date paste sweetened fruit bars. Sample D<sub>2</sub> bars (GKP: Suc: XG, 15: 3: 0.2) had softness value of 2.27, while bar sample I<sub>2</sub> (GKP: Suc: Gln, 10: 3: 0.2) scored 8.47. Conversely the aroma properties of the aspartame sweetened products were the most preferred irrespective of GKP concentration or stabilizer used. The results of the overall acceptability score ranged from a high of 7.87 for sample C<sub>3</sub> bars (GKP: Asp: Gln, 20: 3: 0.2) and sample I<sub>2</sub> (GKP: Suc: Gln, 10: 3: 0.2), to a low of 1.53 for the bar sample D<sub>1</sub> (GKP: DP: XG, 15: 3: 0.2). The overall acceptability showed that the order of preference was aspartame sweetened bars > sucrose sweetened bars > date paste sweetened bars.

Generally, it was observed that most of the products sweetened with date paste and some sweetened with sucrose irrespective of GKP level or stabilizer used had acceptability score  $\leq 5.0$ . On the other hand, most of the fruit bars containing 10g GKP had an overall acceptability  $\geq 5.0$ . While the date paste sweetened bars were the least accepted, the aspartame sweetened fruit bars were the most accepted.



**Figure 2:** Spider diagram of mean ratings of the sensory attributes of GKP fruit bar samples: taste, crispiness, mouthfeel and texture. ; GKP: DP: XG – A<sub>1</sub> (20: 3: 0.2), D<sub>1</sub> (15: 3: 0.2), G<sub>1</sub> (10: 3: 0.2); GKP: DP: GG – B<sub>1</sub> (20: 3: 0.2), E<sub>1</sub> (15: 3: 0.2), H<sub>1</sub> (10: 3: 0.2); GKP: DP: Gln – C<sub>1</sub> (20: 3: 0.2), F<sub>1</sub> (15: 3: 0.2), I<sub>1</sub> (10: 3: 0.2). GKP: Suc: XG – A<sub>2</sub> (20: 3: 0.2), D<sub>2</sub> (15: 3: 0.2), G<sub>2</sub> (10: 3: 0.2); GKP: Suc: GG – B<sub>2</sub> (20: 3: 0.2), E<sub>2</sub> (15: 3: 0.2), H<sub>2</sub> (10: 3: 0.2); GKP: Suc: Gln – C<sub>2</sub> (20: 3: 0.2), F<sub>2</sub> (15: 3: 0.2), I<sub>2</sub> (10: 3: 0.2)., GKP: Asp: XG – A<sub>3</sub> (20: 3: 0.2), D<sub>3</sub> (15: 3: 0.2), G<sub>3</sub> (10: 3: 0.2); GKP: Asp: GG – B<sub>3</sub> (20: 3: 0.2), E<sub>3</sub> (15: 3: 0.2), H<sub>3</sub> (10: 3: 0.2); GKP: Asp: Gln – C<sub>3</sub> (20: 3: 0.2), F<sub>3</sub> (15: 3: 0.2), I<sub>3</sub> (10: 3: 0.2); *Garcinia kola* fruit pulp, Asp: Aspartame, XG: Xanthan gum, GG: Guar gum, Gln: Gelatin, Suc: Sucrose, DP: Date paste.



**Figure 3:** Spider diagram of mean ratings of the sensory attributes of GKP fruit bar samples: color, softness, aroma and overall acceptability. GKP: DP: XG – A<sub>1</sub> (20: 3: 0.2), D<sub>1</sub> (15: 3: 0.2), G<sub>1</sub> (10: 3: 0.2); GKP: DP: GG – B<sub>1</sub> (20: 3: 0.2), E<sub>1</sub> (15: 3: 0.2), H<sub>1</sub> (10: 3: 0.2); GKP: DP: Gln – C<sub>1</sub> (20: 3: 0.2), F<sub>1</sub> (15: 3: 0.2), I<sub>1</sub> (10: 3: 0.2). GKP: Suc: XG – A<sub>2</sub> (20: 3: 0.2), D<sub>2</sub> (15: 3: 0.2), G<sub>2</sub> (10: 3: 0.2); GKP: Suc: GG – B<sub>2</sub> (20: 3: 0.2), E<sub>2</sub> (15: 3: 0.2), H<sub>2</sub> (10: 3: 0.2); GKP: Suc: Gln – C<sub>2</sub> (20: 3: 0.2), F<sub>2</sub> (15: 3: 0.2), I<sub>2</sub> (10: 3: 0.2). GKP: Asp: XG – A<sub>3</sub> (20: 3: 0.2), D<sub>3</sub> (15: 3: 0.2), G<sub>3</sub> (10: 3: 0.2); GKP: Asp: GG – B<sub>3</sub> (20: 3: 0.2), E<sub>3</sub> (15: 3: 0.2), H<sub>3</sub> (10: 3: 0.2); GKP: Asp: Gln – C<sub>3</sub> (20: 3: 0.2), F<sub>3</sub> (15: 3: 0.2), I<sub>3</sub> (10: 3: 0.2). *Garcinia kola* fruit pulp, Asp: Aspartame, XG: Xanthan gum, GG: Guar gum, Gln: Gelatin, Suc: Sucrose, DP: Date paste.

### Proximate Composition:

The proximate composition results of the GKP bars samples that had sensory score  $\geq 5.0$  on overall are shown in Table 2. The data showed significant variations ( $p < 0.05$ ) in the moisture content of the GKP fruit bars. The bar sample I<sub>2</sub>(GKP: Suc: Gln, 10: 3: 0.2), had the least moisture value of 11.68%, bar sample E<sub>3</sub>(GKP: Asp: GG, 15: 0.3: 0.2) had the highest moisture content value 32.68%. The range of moisture content of the GKP bars was higher than the moisture content range of 2.56 – 11.85% reported for fruit bars made from a blend of the pulps of African bush mango and Sour sop (Mbaeyi-Nwaoha and Ezeigwe, 2016), and 14.11 – 15.05% for fresh papaya-guava fruit bars (Bhalerao *et al.*, 2017). Table 2 also shows that fruit bar samples containing 10% GKP and sweetened with sucrose, such as G<sub>2</sub> and I<sub>2</sub> had significantly lower moisture content than the bars containing 10% GKP but sweetened with aspartame. Sucrose humectant activity possibly contributed to this lower moisture content. Generally, the more the level of inclusion of GKP in the formulation (15 and 20%) the higher the moisture contents.

The ash content results showed a range of 0.95 to 1.75%. The fruit bar sample E<sub>3</sub>(GKP: Asp: GG, 15: 0.3: 0.2) and fruit bar I<sub>2</sub>(GKP: Suc: Gln, 10: 3: 0.2) had the minimum and maximum ash content values, respectively. However, these values were not significantly different ( $p > 0.05$ ). The ash content results further showed that most of the GKP bar samples sweetened with sucrose had more ash content than samples sweetened with aspartame. Similarly, the crude fiber content of the GKP bars ranged from 0.85% to a maximum of 1.60% in fruit bar sample I<sub>2</sub>. These values were lower than the 5.48 to 13.63% fiber content reported for fruit bars made from blends of African-bush mango and Sour sop (Mbaeyi-Nwaoha and Ezeigwe, 2016). However, the values correlated with the low crude fiber values of the raw *Garcinia kola* pulp reported in the previous characterization studies (Amaechi *et al.*, 2017).

The fat content of the GKP bar products ranged between 0.90% in sample E<sub>3</sub>(GKP: Asp: GG, 15: 0.3: 0.2) and 1.65% in sample I<sub>2</sub>(GKP: Suc: Gln, 10: 3: 0.2). The fat content of some of the fruit bar products were significantly different ( $p < 0.05$ ). Compared to the fat content of the African bush mango/Soursop fruit bars (Mbaeyi-Nwaoha and Ezeigwe, 2016), most of the GKP bars were higher in crude fat content. Generally, Table 2 shows that the fat content of all the GKP fruit bar samples were expectedly low since fruits are poor sources of fat. This result is consistent with literature reports as the major component of fruit bar products are fruits which are generally low in fat (Orrego *et al.*, 2014). The very low-fat content of the dry bar products contributes to their low energy value and helps to increase their shelf life during storage. Low fat contents in food products decreases the chances of oxidative rancidity.

The crude protein content of the GKP bars ranged from 4.40% in sample I<sub>2</sub>(GKP: Suc: Gln, 10: 3: 0.2) to 9.00% for sample F<sub>3</sub>(GKP: Asp: Gln, 15: 0.3: 0.2). Table 2 shows that GKP bars containing either aspartame, an amino acid sweetener and gelatin, a fibrous protein had significantly ( $p < 0.05$ ) higher protein content. Thus, the protein contents of C<sub>3</sub>, F<sub>3</sub> and I<sub>3</sub> were 8.75%, 9.00% and 7.83%, respectively. The aspartame and the gelatin may have contributed to a synergistic increase in crude protein. The crude protein content of the GKP fruit bars were higher than the crude protein content of African bush mango/Soursop fruit bars (Mbaeyi-Nwaoha and Ezeigwe, 2016) and unfortified/fortified Sapota/Papaya fruit bars (Take *et al.*, 2012). The GKP fruit bars had carbohydrate content that ranged from 58.77% in sample E<sub>3</sub> to 78.18% in I<sub>2</sub> (Table 2). There was a significant difference ( $p < 0.05$ ) in the carbohydrate content of the various fruit bar products. The carbohydrate content is within the range reported in literature for other fruit bars (Mbaeyi-Nwaoha and Ezeigwe, 2016; Take *et al.*, 2012). In this study, the GKP bar

samples sweetened with sucrose (I<sub>2</sub>, G<sub>2</sub> and H<sub>2</sub>) had the highest carbohydrate contents which in each product was above 70%.

The energy values of the bar samples ranged between 265.59 to 348.15kcal/100g. Sample E<sub>3</sub> had the least value while sample I<sub>2</sub> had the highest value (Table 2). Fruit bar samples which were sweetened with sucrose had higher energy values than fruit bars

sweetened with aspartame. There was no significant difference ( $p > 0.05$ ) in energy values of samples G<sub>3</sub> and H<sub>2</sub>. The energy values of fruit bar G<sub>2</sub> (343.93kcal/100g) and I<sub>2</sub> (348.15kcal/100g) compared well with the energy values reported for unfortified and fortified Sapota/Papaya fruit bars which ranged between 342.96kcal/100g to 346.06kcal/100g (Take *et al.*, 2012).

**Table 2:** Results on Proximate Composition of *Garcinia kola* fruit pulp bars

Sample	Moisture (%)	Ash (%)	Fiber (%)	Fat (%)	Protein (%)	Carbohydrate (%)	Energy Value (kcal/100 g)
A <sub>3</sub>	18.21 <sup>b</sup> ±0.17	1.58 <sup>c</sup> ±0.00	1.40 <sup>b</sup> ±0.00	1.25 <sup>c</sup> ±0.07	6.65 <sup>c</sup> ±0.00	70.97 <sup>c</sup> ±1.0	321.81 <sup>d</sup> ±1.03
B <sub>3</sub>	20.67 <sup>f</sup> ±0.00	1.30 <sup>d</sup> ±0.00	1.30 <sup>bcd</sup> ±0.00	1.20 <sup>c</sup> ±0.00	6.10 <sup>c</sup> ±0.21	69.43 <sup>f</sup> ±0.2	312.92 <sup>f</sup> ±0.00
C <sub>3</sub>	21.33 <sup>c</sup> ±0.00	1.25 <sup>de</sup> ±0.07	1.20 <sup>de</sup> ±0.00	1.05 <sup>d</sup> ±0.07	8.75 <sup>b</sup> ±0.00	66.42 <sup>i</sup> ±0.00	310.33 <sup>g</sup> ±0.92
D <sub>3</sub>	23.13 <sup>d</sup> ±0.06	1.20 <sup>e</sup> ±0.00	1.27 <sup>c</sup> ±0.07	0.95 <sup>de</sup> ±0.07	5.75 <sup>f</sup> ±0.00	67.25 <sup>h</sup> ±0.09	300.53 <sup>h</sup> ±1.00
E <sub>3</sub>	32.68 <sup>a</sup> ±0.01	0.95 <sup>f</sup> ±0.07	1.10 <sup>e</sup> ±0.00	0.90 <sup>e</sup> ±0.00	5.60 <sup>g</sup> ±0.00	58.77 <sup>j</sup> ±0.06	265.59 <sup>k</sup> ±0.23
F <sub>3</sub>	26.00 <sup>c</sup> ±0.00	1.00 <sup>f</sup> ±0.00	0.85 <sup>f</sup> ±0.07	0.95 <sup>de</sup> ±0.07	9.00 <sup>a</sup> ±0.07	62.20 <sup>k</sup> ±0.07	293.35 <sup>i</sup> ±0.64
G <sub>2</sub>	12.65 <sup>j</sup> ±0.07	1.70 <sup>a</sup> ±0.00	1.55 <sup>ab</sup> ±0.07	1.50 <sup>b</sup> ±0.00	5.25 <sup>h</sup> ±0.00	77.36 <sup>b</sup> ±0.11	343.93 <sup>b</sup> ±0.43
G <sub>3</sub>	16.67 <sup>i</sup> ±0.00	1.60 <sup>b</sup> ±0.00	1.35 <sup>bc</sup> ±0.07	1.40 <sup>b</sup> ±0.00	7.00 <sup>d</sup> ±0.00	71.98 <sup>d</sup> ±0.07	328.52 <sup>e</sup> ±0.28
H <sub>2</sub>	16.63 <sup>i</sup> ±0.06	1.60 <sup>b</sup> ±0.00	1.35 <sup>bc</sup> ±0.07	1.40 <sup>b</sup> ±0.00	6.65 <sup>c</sup> ±0.00	72.57 <sup>c</sup> ±0.13	328.69 <sup>c</sup> ±0.50
H <sub>3</sub>	26.60 <sup>b</sup> ±0.11	1.00 <sup>f</sup> ±0.00	0.90 <sup>f</sup> ±0.14	1.00 <sup>de</sup> ±0.00	7.70 <sup>i</sup> ±0.00	62.8 <sup>l</sup> ±0.25	291.03 <sup>j</sup> ±1.00
I <sub>2</sub>	11.68 <sup>k</sup> ±0.02	1.75 <sup>a</sup> ±0.07	1.60 <sup>a</sup> ±0.00	1.65 <sup>a</sup> ±0.07	4.40 <sup>j</sup> ±0.21	78.18 <sup>a</sup> ±0.02	348.15 <sup>a</sup> ±0.16
I <sub>3</sub>	20.33 <sup>e</sup> ±0.00	1.30 <sup>d</sup> ±0.00	1.30 <sup>bcd</sup> ±0.00	1.25 <sup>c</sup> ±0.07	7.83 <sup>b</sup> ±0.11	68.00 <sup>g</sup> ±0.18	314.53 <sup>e</sup> ±0.35

Values are means ± standard deviation. Samples with different superscripts in the same column are significantly different ( $p < 0.05$ ). GKP: Asp: XG – A<sub>3</sub> (20: 3: 0.2), D<sub>3</sub> (15: 3: 0.2), G<sub>3</sub> (10: 3: 0.2); GKP: Asp: GG – B<sub>3</sub> (20: 3: 0.2), E<sub>3</sub> (15: 3: 0.2), H<sub>3</sub> (10: 3: 0.2); GKP: Asp: Gln – C<sub>3</sub> (20: 3: 0.2), F<sub>3</sub> (15: 3: 0.2), I<sub>3</sub> (10: 3: 0.2). GKP: Suc: XG – G<sub>2</sub> (10: 3: 0.2); GKP: Suc: GG – H<sub>2</sub> (10: 3: 0.2); GKP: Suc: Gln – I<sub>2</sub> (10: 3: 0.2); GKP: *Garcinia kola* fruit pulp, Asp: Aspartame, XG: Xanthan gum, GG: Guar gum, Gln: Gelatin, Suc: Sucrose

### Minerals Content

The minerals content of the GKP fruit bar samples are presented in Table 3. The results showed that the quantity of *Garcinia kola* fruit pulp puree used in making the GKP bars influenced the minerals composition of the bar samples. As the concentration of the puree decreased, the mineral content of the bar decreased correspondingly. Although there were some variations in the individual mineral content, they were not statistically significant ( $p > 0.05$ ). Sample A<sub>3</sub> (GKP: Asp: XG, 20: 0.3: 0.2) had the highest magnesium, potassium, calcium and sodium composition with values of 28.65, 102.45, 76.59 and 42.11mg/100g, respectively. The iron content ranged from 3.40 to 7.50mg/100g. According to FNB/IM/NA (2001), the recommended dietary allowance (RDA) for healthy individuals and adequate intake of iron at different stages of life and gender groups is 0.27– 27mg/day. The iron

content of the GKP bar samples would provide about 30– 68% of the RDA for adults and adequately satisfy the requirements for children. The value for Zinc was between 1.50 and 2.70 mg/100g. The GKP bar samples G<sub>2</sub> and G<sub>3</sub> had the lowest values while sample B<sub>3</sub> had the highest value. The RDA and adequate intakes of zinc (mg/day) for healthy individuals are 3 – 5 for children, 9 for adult females and 11 for adult males (FNB/IM/NA, 2001). The zinc content of the GKP bars shows that it can provide 30 to 55% of the RDA for children as well as 17% and 14% for adult females and males, respectively. Zinc and iron are vital trace minerals. They are required for the repairs of biological tissues and as enzyme cofactors in metabolic processes (Gharibzahedi and Jafari, 2017).

**Table 3:** Results on mineral content of *Garcinia kola* fruit bars

Sample	Magnesium (mg/100g)	Potassium (mg/100g)	Calcium (mg/100g)	Sodium (mg/100g)	Phosphorus (mg/100g)	Iron (mg/100g)	Zinc (mg/100g)
A <sub>3</sub>	28.65 <sup>a</sup> ±0.21	102.45 <sup>a</sup> ±0.00	76.59 <sup>a</sup> ±0.11	42.11 <sup>a</sup> ±0.00	36.31 <sup>d</sup> ±0.08	4.00 <sup>g</sup> ±0.00	2.40 <sup>e</sup> ±0.00
B <sub>3</sub>	24.70 <sup>c</sup> ±0.00	94.13 <sup>b</sup> ±0.13	69.41 <sup>b</sup> ±0.00	40.50 <sup>b</sup> ±0.00	42.14 <sup>b</sup> ±0.08	3.85 <sup>b</sup> ±0.07	2.70 <sup>a</sup> ±0.00
C <sub>3</sub>	22.20 <sup>d</sup> ±0.00	89.63 <sup>d</sup> ±0.90	64.13 <sup>c</sup> ±0.00	37.59 <sup>c</sup> ±0.35	46.91 <sup>a</sup> ±0.27	5.60 <sup>c</sup> ±0.00	2.60 <sup>b</sup> ±0.00
D <sub>3</sub>	28.20 <sup>b</sup> ±0.14	92.67 <sup>c</sup> ±0.00	62.46 <sup>d</sup> ±0.13	29.50 <sup>d</sup> ±0.11	32.07 <sup>i</sup> ±0.25	4.51 <sup>e</sup> ±0.00	2.51 <sup>e</sup> ±0.00
E <sub>3</sub>	20.90 <sup>e</sup> ±0.00	84.30 <sup>f</sup> ±0.00	59.72 <sup>de</sup> ±0.00	27.21 <sup>ce</sup> ±0.23	36.46 <sup>f</sup> ±0.06	7.50 <sup>a</sup> ±0.00	2.30 <sup>c</sup> ±0.00
F <sub>3</sub>	22.80 <sup>d</sup> ±0.00	86.20 <sup>e</sup> ±0.80	61.28 <sup>c</sup> ±0.00	26.22 <sup>ef</sup> ±0.23	41.15 <sup>c</sup> ±0.00	3.40 <sup>j</sup> ±0.14	1.65 <sup>gh</sup> ±0.07
G <sub>2</sub>	17.10 <sup>f</sup> ±0.00	82.89 <sup>g</sup> ±0.00	56.41 <sup>b</sup> ±0.02	24.19 <sup>gh</sup> ±0.00	41.86 <sup>b</sup> ±0.28	4.00 <sup>b</sup> ±0.00	1.50 <sup>d</sup> ±0.00
G <sub>3</sub>	18.88 <sup>f</sup> ±0.18	78.71 <sup>i</sup> ±0.36	57.22 <sup>g</sup> ±0.00	25.15 <sup>f</sup> ±2.12	35.43 <sup>g</sup> ±0.04	5.30 <sup>d</sup> ±0.00	1.50 <sup>ef</sup> ±0.00
H <sub>2</sub>	16.18 <sup>g</sup> ±0.32	79.37 <sup>h</sup> ±0.02	54.55 <sup>d</sup> ±0.20	23.07 <sup>hi</sup> ±0.07	36.92 <sup>c</sup> ±0.00	5.30 <sup>d</sup> ±0.00	1.80 <sup>ef</sup> ±0.00
H <sub>3</sub>	15.20 <sup>h</sup> ±0.00	76.40 <sup>j</sup> ±0.13	54.17 <sup>i</sup> ±0.00	22.49 <sup>ij</sup> ±0.00	38.22 <sup>d</sup> ±0.10	5.25 <sup>d</sup> ±0.21	1.70 <sup>f</sup> ±0.00
I <sub>2</sub>	14.27 <sup>i</sup> ±0.12	76.14 <sup>i</sup> ±0.00	53.16 <sup>j</sup> ±0.29	21.25 <sup>j</sup> ±0.30	32.86 <sup>e</sup> ±0.34	4.90 <sup>e</sup> ±0.00	1.75 <sup>ef</sup> ±0.07
I <sub>3</sub>	15.20 <sup>h</sup> ±0.00	74.62 <sup>k</sup> ±0.00	54.28 <sup>j</sup> ±0.00	21.18 <sup>j</sup> ±0.00	34.30 <sup>b</sup> ±0.00	5.90 <sup>b</sup> ±0.14	1.55 <sup>b</sup> ±0.07

Values are means ± standard deviation. Samples with different superscripts in the same column are significantly different ( $p < 0.05$ ). GKP: Asp: XG – A<sub>3</sub> (20: 3: 0.2), D<sub>3</sub> (15: 3: 0.2), G<sub>3</sub> (10: 3: 0.2); GKP: Asp: GG – B<sub>3</sub> (20: 3: 0.2), E<sub>3</sub> (15: 3: 0.2), H<sub>3</sub> (10: 3: 0.2); GKP: Asp: Gln – C<sub>3</sub> (20: 3: 0.2), F<sub>3</sub> (15: 3: 0.2), I<sub>3</sub> (10: 3: 0.2). GKP: Suc: XG – G<sub>2</sub> (10: 3: 0.2); GKP: Suc: GG – H<sub>2</sub> (10: 3: 0.2); GKP: Suc: Gln – I<sub>2</sub> (10: 3: 0.2); GKP: *Garcinia kola* fruit pulp, Asp: Aspartame, XG: Xanthan gum, GG: Guar gum, Gln: Gelatin, Suc: Sucrose.

### Vitamin content

In Table 4, the vitamin content data of the GKP fruit bars are presented. The results showed the presence of the fat-soluble vitamins A and E and the water-soluble vitamins B<sub>1</sub>, B<sub>2</sub>, B<sub>3</sub> and C. Their levels of occurrence in the bar samples were significantly different ( $p < 0.05$ ). The range of concentrations of the vitamins in the GKP bar samples were as follows: vitamin A, 5.55 – 7.24 mg/100 g; vitamin C, 7.11 – 9.38 mg/100 g; and vitamin E, 4.75 – 5.90 mg/100 g. While the vitamin C concentration is insufficient to meet the RDA, the vitamin A content has the potential to meet the RDA healthy dose of 400 to 1300 µg/day (FNB/IM/NA, 2000, 2001). Similarly, the vitamin E content of the GKP fruit bars is enough to meet adequate intake and the vitamin E RDA of 4 to 7 mg/day for infants and children. Adults will have to supplement from other food sources in order to meet their vitamin E RDA of 11.9 mg/day (FNB/IM/NA, 2000). Vitamin E is a strong biological antioxidant with beneficial cardiovascular health benefits and fights certain types of cancer (Gironés-Vilaplana

et al., 2017). Vitamin C concentration in the fruit bars were significantly lower than the vitamin C values reported for fresh *G. kola* fruit pulp by Amaechi et al. (2017). This reduction can be attributed to processing and thermal losses during fruit bar production. It has been reported that the loss of ascorbic acid increases with time and temperature of processing (Paul and Ghosh, 2012; Silva et al., 2018).

The thiamine (B<sub>1</sub>), riboflavin (B<sub>2</sub>) and niacin (B<sub>3</sub>) concentration in the fruit bars ranged between 0.86 to 1.45, 0.65 to 0.97 and 0.83 to 1.23 mg/100g, respectively. Vitamin B<sub>1</sub> content of the fruit bars has the potential to meet the RDA and adequate intake of 0.2- 1.4mg/d for different life stages and gender groups of healthy individuals. The vitamin B<sub>2</sub> content of the fruit bar samples is enough to meet the RDA and adequate intake of 0.3-0.6mg/100g for healthy infants and children (FNB/IM/NA, 1998). Adult males and females must supplement their vitamins B<sub>2</sub> and B<sub>3</sub> needs from other dietary sources.

**Table 4:** Results of vitamin content of *Garcinia kola* fruit pulp bars

Sample	Vitamin A (mg/100g)	Vitamin B <sub>1</sub> (mg/100g)	Vitamin B <sub>2</sub> (mg/100g)	Vitamin B <sub>3</sub> (mg/100g)	Vitamin C (mg/100g)	Vitamin E (mg/100g)
A <sub>3</sub>	7.24 <sup>a</sup> ±0.00	1.26 <sup>bc</sup> ±0.00	0.97 <sup>a</sup> ±0.01	1.23 <sup>a</sup> ±0.00	9.38 <sup>a</sup> ±0.06	5.90 <sup>a</sup> ±0.08
B <sub>3</sub>	7.25 <sup>a</sup> ±0.00	1.32 <sup>b</sup> ±0.07	0.92 <sup>b</sup> ±0.00	1.19 <sup>abc</sup> ±0.00	8.68 <sup>b</sup> ±0.11	5.79 <sup>ab</sup> ±0.00
C <sub>3</sub>	6.90 <sup>b</sup> ±0.00	1.12 <sup>d</sup> ±0.06	0.94 <sup>ab</sup> ±0.00	1.21 <sup>ab</sup> ±0.01	8.40 <sup>c</sup> ±0.00	5.64 <sup>b</sup> ±0.00
D <sub>3</sub>	6.80 <sup>b</sup> ±0.13	1.45 <sup>a</sup> ±0.06	0.84 <sup>c</sup> ±0.01	1.15 <sup>cd</sup> ±0.00	8.28 <sup>d</sup> ±0.09	5.45 <sup>c</sup> ±0.10
E <sub>3</sub>	7.00 <sup>ab</sup> ±0.14	1.22 <sup>c</sup> ±0.06	0.80 <sup>d</sup> ±0.00	1.13 <sup>d</sup> ±0.01	7.98 <sup>e</sup> ±0.11	5.38 <sup>cd</sup> ±0.00
F <sub>3</sub>	6.34 <sup>c</sup> ±0.16	1.03 <sup>e</sup> ±0.01	0.82 <sup>cd</sup> ±0.00	1.16 <sup>bcd</sup> ±0.00	7.82 <sup>f</sup> ±0.00	5.24 <sup>de</sup> ±0.00
H <sub>2</sub>	6.05 <sup>c</sup> ±0.16	0.92 <sup>ef</sup> ±0.00	0.71 <sup>e</sup> ±0.05	0.99 <sup>e</sup> ±0.04	7.40 <sup>h</sup> ±0.00	5.05 <sup>f</sup> ±0.21
G <sub>2</sub>	5.55 <sup>d</sup> ±0.53	0.86 <sup>f</sup> ±0.03	0.69 <sup>f</sup> ±0.01	0.87 <sup>fg</sup> ±0.00	7.29 <sup>i</sup> ±0.00	5.07 <sup>f</sup> ±0.00
G <sub>3</sub>	6.13 <sup>c</sup> ±0.11	1.12 <sup>d</sup> ±0.00	0.65 <sup>gh</sup> ±0.00	0.86 <sup>fg</sup> ±0.00	7.38 <sup>i</sup> ±0.00	5.08 <sup>gef</sup> ±0.00
I <sub>2</sub>	5.70 <sup>d</sup> ±0.00	1.09 <sup>e</sup> ±0.00	0.69 <sup>fg</sup> ±0.01	0.86 <sup>fg</sup> ±0.00	7.21 <sup>jk</sup> ±0.02	4.83 <sup>g</sup> ±0.01
I <sub>3</sub>	6.05 <sup>c</sup> ±0.00	1.08 <sup>de</sup> ±0.06	0.64 <sup>b</sup> ±0.00	0.83 <sup>g</sup> ±0.04	7.11 <sup>k</sup> ±0.08	4.75 <sup>g</sup> ±0.07

Values are means ± standard deviation. Samples with different superscripts in the same column are significantly different ( $p < 0.05$ ). GKP: Asp: XG – A<sub>3</sub> (20: 3: 0.2), D<sub>3</sub> (15: 3: 0.2), G<sub>3</sub> (10: 3: 0.2); GKP: Asp: GG – B<sub>3</sub> (20: 3: 0.2), E<sub>3</sub> (15: 3: 0.2), H<sub>3</sub> (10: 3: 0.2); GKP: Asp: Gln – C<sub>3</sub> (20: 3: 0.2), F<sub>3</sub> (15: 3: 0.2), I<sub>3</sub> (10: 3: 0.2). GKP: Suc: XG – G<sub>2</sub> (10: 3: 0.2); GKP: Suc: GG – H<sub>2</sub> (10: 3: 0.2); GKP: Suc: Gln – I<sub>2</sub> (10: 3: 0.2); GKP: *Garcinia kola* fruit pulp, Asp: Aspartame, XG: Xanthan gum, GG: Guar gum, Gln: Gelatin, Suc: Sucrose.

### Phytochemical Content

The concentration of different phytochemicals found in the GKP fruit bars are shown in Table 5. The results indicated significant variations ( $p < 0.05$ ) in the phytochemical composition of GKP bar samples. The range of phytates found in the bars was 7.27 to 9.17 mg/100g. Fruit bar sample G<sub>2</sub> had the least value, while sample C<sub>3</sub> had the highest value. Dietary phytates have been reported to reduce the bioavailability of minerals by forming insoluble phytate-mineral complex that are not readily absorbed by the human gastrointestinal tract (Kumar et al., 2010). The concentration present in the GKP bars was much lower than the phytic acid levels (255.60 to 823.6 mg/100 g) reported in literature report for some lesser known plant-based foods (Abreroumand, 2012). The GKP bars had very low hydrogen cyanide content. Flavonoids concentration were in the range of 5.50 – 6.70 mg/100g while the saponins were 7.77 – 8.60 mg/100g. As the level of the GKP inclusion decreased, there was a corresponding decrease in the concentrations of flavonoids and saponins in the fruit bar samples. The presence of flavonoids in foods has been reported to contribute to the dietary intake of antioxidants. They also have free radical scavenging capacity, anti-cancer activity and help in preventing coronary heart disease (Yao et

al., 2004). Recent research has also attributed hepatoprotective, anti-inflammatory and potential anti-viral activities to flavonoids (Kumar and Pandey, 2013). Saponins can be beneficial or deleterious depending on the type, concentration administered and route of administration. Some studies have reported that saponins affect the immune system in ways that help to protect the body against cancers; lower cholesterol levels, blood lipids, and blood glucose response; and inhibit dental caries and platelets aggregation (Shi et al., 2004).

The fruit bar samples had alkaloid concentration levels of 6.90 – 7.80 mg/100g while the total phenolic content ranged from 3.69 to 4.27 mg/100g. Alkaloid content of the fruit bars were higher than the alkaloids in aqueous and chloroform extracts of some wild edible fruits such as *Carissa carandas* and *Carissa spinarum* (Subramaniam et al., 2017). Alkaloids have been reported to have emetic, anti-chlorogenic, antitumor, diuretic, sympathomimetic, antiviral, antihypertensive, antidepressant, myorelaxant, antitussive, antimicrobial and anti-inflammatory properties (Abreroumand, 2012). The total phenolic concentration in the fruit bars were close to the total phenolic composition reported for wild edible fruits such as

*Coccinia indica*, *Ficus benghalensis* and *Ficus religiosa* (Subramaniam *et al.*, 2017).

Table 5 also show that significant differences ( $p < 0.05$ ) existed in the tannin composition of the GKP fruit bars. The water-soluble tannins have been reported to exhibit anti-nutritive properties such as inhibition of digestive enzymes, which affect protein digestibility and energy conversion. Other studies have indicated that tannins reduce the mutagenic activity of several mutagens and has anticarcinogenic potentials which may be related to their antioxidative property (Serrano *et al.*, 2009). Abdel-Moemin (2014) reported that foods with less than 10mg oxalate concentration are classified as low oxalate foods. The results showed that the GKP fruit bars with oxalate concentrations range of 6.41 – 8.13 mg/100g can be classified as low oxalate foods. The total carotenoids content of fresh *G. kola* fruit pulp was earlier reported to be 4.13 mg/100 g (Amaechi *et al.*, 2017). The total carotenoids in the GKP bars ranged between 0.74 - 1.19 mg/100 g. This loss could be due to the degradation of carotenoids during GKP fruit bars production. This observation agrees with the reported thermal degradation of  $\beta$ -Carotene and lycopene in cherry tomatoes during processing (D'Evoli *et al.*, 2013). The authors also reported that the rate of degradation is faster in  $\beta$ -carotene than in lycopene. The concentration of both the oxalates and total carotenoids in the GKP bars decreased as amount of *G.kola* fruit pulp decreased in the fruit bar sample formulations.

#### Physicochemical properties:

The results of the physicochemical properties of the fruit bar samples are presented in Table 6. Statistical difference was observed ( $p < 0.05$ ) in all the parameters evaluated. The fruit bars had a pH range of 3.0 – 4.0 which is similar to the pH of fresh papaya/guava fruit bar (pH 3.59 – 3.96) (Kumar *et al.*, 2017). However, Kourany *et al.* (2017) reported slightly higher acidity for protein fortified mango fruit bar (pH 4.86) and protein fortified guava fruit bar (pH 4.75). The acidic pH of the GKP fruit bar samples implies enhanced resistance to many spoilage microorganisms. The fruit bars also have potential for longer shelf stability. Total titratable acidity (TTA) of the GKP bars was 0.16 – 0.22%. These TTA values were lower than the TTA of 1.67 – 1.76% reported for freshly produced mango/papaya fruit bars (Bhalerao *et al.*, 2017). TTA is a better predictor of the impact of acidity on flavors than pH (Sadler and Murphy, 2010). Acids present in foods improve its palatability and influence the flavor, color brightness, consistency, stability and keeping quality of the food product (Adedeji *et al.*, 2008). The observed range of total sugars, reducing sugars and non-reducing sugars in the GKP bar samples was 12.45 – 20.10%, 8.33 – 15.81% and 3.75 – 5.31%, respectively. The fruit bar samples that were sweetened with sucrose, namely, G<sub>2</sub>, H<sub>2</sub> and I<sub>2</sub>, had higher concentrations of total and reducing sugars, as well as total soluble solids than the aspartame sweetened fruit bar samples.

The viscosity of the fruit bar samples reduced as the concentration of GKP gradually decreased in the formulation. The viscosity values also correlated to the amount of dispersed soluble solids in the aqueous medium. It has been reported that aspartame addition did not cause any important change in the

viscoelastic characteristics of food systems containing various hydrocolloids. In contrast, sucrose can increase or decrease the viscoelasticity of hydrocolloids (Bayarri *et al.*, 2004). The hydroxyl groups of the sucrose molecules confer them with the ability to effect changes in the viscoelasticity of the hydrocolloids used in stabilizing the fruit bars.

#### 4. Conclusion

Fruit bars of different formulations were produced using the pulp of the exotic fruit *Garcinia kola*. Descriptive sensory analysis showed that GKP bars sweetened with aspartame were most acceptable, followed by GKP bars sweetened sucrose. The date paste sweetened bars were not scored highly by the panelists. The amount of *G. kola* fruit pulp, sweetener and stabilizer used in the bar preparation significantly influenced the nutrient composition, phytochemical and physicochemical characteristics of the fruit bar products. Essential minerals were present in the GKP bars in the following order of magnitude: potassium>calcium>phosphorus>sodium>magnesium>iron>zinc. Appreciable amounts of vitamin E was also found in the fruit bars. The antinutrients were generally low to elicit any significant negative physiological actions. On the other hand, beneficial bioactive compounds such as flavonoids, carotenoids, tannins, alkaloids and phenols were found to be present. The sucrose sweetened fruit bars had higher total sugars, reducing sugars, total soluble solids and viscosities than aspartame sweetened bars. The abundant nutrients and phytochemicals in GKP fruit bars can be exploited in meeting satiety, the nutrient needs and RDA of vulnerable groups such as children.

**Author Contributions:** This research was carried out in collaboration of three authors. Author NCO designed the study, monitored sample collection and identification, literature search and initial draft of the interpretation. Author OIM scrutinized the literature search and interpreted the data. Author UO produced the fruit bars, monitored sensory evaluation and gathered the analytical data.

**Funding:** This research received no external funding.

**Acknowledgement:** The authors appreciate the students and staff of the Department of Food Science and Technology, Faculty of Agriculture Abia State University, Uturu. Abia State, Nigeria.

**Conflict of Interests:** The authors declare no conflict of interests.

**Table 5:** Phytochemicals concentration in fruit bars made from *Garcinia kola* pulp.

Sample	Phytate (mg/100g)	Hydrogen Cyanide (mg/100g)	Flavonoids (mg/100g)	Saponins (mg/100g)	Alkaloid (mg/100g)	Phenol (mg/100g)	Tannin (mg/100g)	Oxalate (mg/100g)	Carotenoid (mg/100g)	Sterol (mg/100g)
A <sub>3</sub>	8.41 <sup>c</sup> ±0.10	0.24 <sup>b</sup> ±0.00	6.45 <sup>b</sup> ±0.07	8.36 <sup>abc</sup> ±0.06	7.70 <sup>ab</sup> ±0.14	4.06 <sup>abcd</sup> ±0.00	5.26 <sup>ab</sup> ±0.06	8.13 <sup>a</sup> ±0.13	1.19 <sup>a</sup> ±0.00	0.05 <sup>bcd</sup> ±0.07
B <sub>3</sub>	8.69 <sup>v</sup> ±0.13	0.27 <sup>a</sup> ±0.00	6.40 <sup>b</sup> ±0.00	8.57 <sup>ab</sup> ±0.02	7.60±0.00	4.18 <sup>ab</sup> ±0.08	5.06 <sup>ab</sup> ±0.03	7.62 <sup>b</sup> ±0.03	1.13 <sup>a</sup> ±0.00	0.06 <sup>abc</sup> ±0.00
C <sub>3</sub>	9.17 <sup>a</sup> ±0.00	0.29 <sup>a</sup> ±0.01	6.70 <sup>a</sup> ±0.00	8.60 <sup>a</sup> ±0.00	7.80 <sup>a</sup> ±0.00	4.27 <sup>a</sup> ±0.00	5.32 <sup>ab</sup> ±0.00	7.65 <sup>b</sup> ±0.07	1.13 <sup>a</sup> ±0.06	0.08 <sup>a</sup> ±0.01
D <sub>3</sub>	7.36 <sup>hi</sup> ±0.06	0.19 <sup>de</sup> ±0.00	5.80 <sup>cd</sup> ±0.00	8.56 <sup>a</sup> ±0.49	7.25 <sup>cd</sup> ±0.00	3.88 <sup>cde</sup> ±0.18	5.19 <sup>ab</sup> ±0.00	7.62 <sup>b</sup> ±0.00	1.01 <sup>bc</sup> ±0.06	0.04 <sup>cde</sup> ±0.01
E <sub>3</sub>	7.59 <sup>efg</sup> ±0.00	0.22 <sup>c</sup> ±0.00	5.55 <sup>f</sup> ±0.07	8.16 <sup>bcd</sup> ±0.00	7.13 <sup>df</sup> ±0.04	4.00 <sup>bcd</sup> ±0.0	4.96 <sup>ab</sup> ±0.06	7.19 <sup>c</sup> ±0.00	0.92 <sup>de</sup> ±0.00	0.04 <sup>cde</sup> ±0.01
F <sub>3</sub>	8.18 <sup>d</sup> ±0.06	0.25 <sup>b</sup> ±0.00	5.93 <sup>c</sup> ±0.04	8.25 <sup>abcd</sup> ±0.00	7.33 <sup>c</sup> ±0.04	4.10 <sup>abcd</sup> ±0.03	6.03 <sup>a</sup> ±0.15	7.22 <sup>c</sup> ±0.00	0.95 <sup>cde</sup> ±0.00	0.7 <sup>ab</sup> ±0.01
G <sub>2</sub>	7.27 <sup>i</sup> ±0.17	0.14 <sup>g</sup> ±0.11	5.75 <sup>de</sup> ±0.07	7.78 <sup>e</sup> ±0.04	7.05 <sup>efg</sup> ±0.07	3.88 <sup>de</sup> ±0.21	5.92 <sup>ab</sup> ±0.19	6.80 <sup>d</sup> ±0.00	0.89 <sup>e</sup> ±0.04	0.03 <sup>def</sup> ±0.00
G <sub>3</sub>	7.52 <sup>fgh</sup> ±0.08	0.17 <sup>f</sup> ±0.02	5.80 <sup>cd</sup> ±0.00	7.90 <sup>de</sup> ±0.00	7.05 <sup>efg</sup> ±0.14	3.69 <sup>e</sup> ±0.00	5.14 <sup>ab</sup> ±0.00	6.59 <sup>de</sup> ±0.00	0.82 <sup>f</sup> ±0.00	0.03 <sup>def</sup> ±0.00
H <sub>2</sub>	7.60 <sup>e</sup> ±0.00	0.19 <sup>de</sup> ±0.00	5.65 <sup>ef</sup> ±0.07	7.92 <sup>de</sup> ±0.10	7.00 <sup>fg</sup> ±0.00	4.12 <sup>abc</sup> ±0.00	4.40 <sup>ab</sup> ±0.00	6.43 <sup>e</sup> ±0.06	0.79 <sup>fg</sup> ±0.01	0.04 <sup>cde</sup> ±0.01
H <sub>3</sub>	7.43 <sup>ghi</sup> ±0.08	0.21 <sup>cd</sup> ±0.00	5.50 <sup>g</sup> ±0.14	7.70 <sup>ef</sup> ±0.07	6.90 <sup>g</sup> ±0.14	3.89 <sup>cde</sup> ±0.00	5.02 <sup>ab</sup> ±0.03	6.58 <sup>de</sup> ±0.00	0.74 <sup>g</sup> ±0.00	0.02 <sup>f</sup> ±0.01
I <sub>2</sub>	7.74 <sup>e</sup> ±0.00	0.22 <sup>c</sup> ±0.01	5.90 <sup>c</sup> ±0.00	8.05 <sup>cde</sup> ±0.00	7.20 <sup>cde</sup> ±0.00	4.17 <sup>ab</sup> ±0.00	5.17 <sup>ab</sup> ±0.00	6.54 <sup>de</sup> ±0.00	0.96 <sup>cd</sup> ±0.00	0.05 <sup>bcd</sup> ±0.00
I <sub>3</sub>	7.43 <sup>ghi</sup> ±0.08	0.17 <sup>ef</sup> ±0.01	5.70 <sup>de</sup> ±0.00	7.77 <sup>e</sup> ±0.11	6.90 <sup>g</sup> ±0.00	3.85 <sup>de</sup> ±0.00	4.80 <sup>ab</sup> ±0.00	6.41 <sup>e</sup> ±0.13	0.76 <sup>fg</sup> ±0.06	0.03 <sup>def</sup> ±0.01

Values are means ± standard deviation. Samples with different superscripts in the same column are significantly different ( $p < 0.05$ ); GKP: Asp: XG – A<sub>3</sub> (20: 3: 0.2), D<sub>3</sub> (15: 3: 0.2), G<sub>3</sub> (10: 3: 0.2); GKP: Asp: GG – B<sub>3</sub> (20: 3: 0.2), E<sub>3</sub> (15: 3: 0.2), H<sub>3</sub> (10: 3: 0.2); GKP: Asp: Gln – C<sub>3</sub> (20: 3: 0.2), F<sub>3</sub> (15: 3: 0.2), I<sub>3</sub> (10: 3: 0.2); GKP: Suc: XG – G<sub>2</sub> (10: 3: 0.2); GKP: Suc: GG – H<sub>2</sub> (10: 3: 0.2); GKP: Suc: Gln – I<sub>2</sub> (10: 3: 0.2). GKP: *Garcinia kola* fruit pulp, Asp: Aspartame, XG: Xanthan gum, GG: Guar gum, Gln: Gelatin, Suc: Sucrose.

**Table 6:** Results on Physicochemical Properties, total sugar, reducing and non-reducing sugar composition of *Garcinia kola* pulp fruit bars.

Sample	pH	TTA (%)	Total Sugar (%)	Reducing Sugar (%)	Non-reducing Sugar (%)	TSS	Viscosity (°Brix)
A <sub>3</sub>	3.70 <sup>c</sup> ±0.00	0.166 <sup>g</sup> ±0.00	14.25 <sup>f</sup> ±0.00	9.08 <sup>e</sup> ±0.00	5.20 <sup>a</sup> ±0.00	9.00 <sup>e</sup> ±0.00	1.21 <sup>a</sup> ±0.01
B <sub>3</sub>	3.50 <sup>e</sup> ±0.00	0.179 <sup>e</sup> ±0.00	15.19 <sup>e</sup> ±0.00	10.35 <sup>d</sup> ±0.08	4.85 <sup>b</sup> ±0.00	6.00 <sup>i</sup> ±0.00	1.09 <sup>c</sup> ±0.01
C <sub>3</sub>	3.60 <sup>d</sup> ±0.00	0.173 <sup>f</sup> ±0.00	15.71 <sup>d</sup> ±0.02	10.40 <sup>d</sup> ±0.00	5.31 <sup>a</sup> ±0.12	7.00 <sup>h</sup> ±0.00	0.97 <sup>e</sup> ±0.01
D <sub>3</sub>	3.80 <sup>b</sup> ±0.00	0.160 <sup>h</sup> ±0.00	12.65 <sup>l</sup> ±0.10	8.65 <sup>g</sup> ±0.00	4.00 <sup>f</sup> ±0.10	7.50 <sup>gh</sup> ±0.71	0.98 <sup>d</sup> ±0.00
E <sub>3</sub>	3.65 <sup>cd</sup> ±0.07	0.175 <sup>ef</sup> ±0.00	12.88 <sup>h</sup> ±0.11	8.72 <sup>g</sup> ±0.00	4.16 <sup>d</sup> ±0.11	8.00 <sup>fg</sup> ±0.00	0.82 <sup>f</sup> ±0.00
F <sub>3</sub>	3.70 <sup>c</sup> ±0.00	0.168 <sup>g</sup> ±0.002	13.45 <sup>g</sup> ±0.00	8.97 <sup>f</sup> ±0.06	4.49 <sup>c</sup> ±0.06	8.50 <sup>ef</sup> ±0.71	1.13 <sup>b</sup> ±0.01
G <sub>2</sub>	3.70 <sup>c</sup> ±0.02	0.171 <sup>fg</sup> ±0.002	19.34 <sup>c</sup> ±0.08	15.61 <sup>b</sup> ±0.06	3.74 <sup>h</sup> ±0.02	25.00 <sup>b</sup> ±0.00	0.80 <sup>g</sup> ±0.00
G <sub>3</sub>	4.00 <sup>a</sup> ±0.00	0.157 <sup>h</sup> ±0.003	12.48 <sup>j</sup> ±0.00	8.50 <sup>h</sup> ±0.00	3.98 <sup>g</sup> ±0.00	7.00 <sup>h</sup> ±0.00	0.82 <sup>f</sup> ±0.01
H <sub>2</sub>	3.00 <sup>h</sup> ±0.00	0.222 <sup>a</sup> ±0.004	19.70 <sup>b</sup> ±0.00	14.39 <sup>c</sup> ±0.00	5.31 <sup>a</sup> ±0.00	25.50 <sup>b</sup> ±0.71	0.76 <sup>h</sup> ±0.00
H <sub>3</sub>	3.15 <sup>g</sup> ±0.07	0.210 <sup>b</sup> ±0.003	12.62 <sup>ii</sup> ±0.04	8.35 <sup>i</sup> ±0.11	4.28 <sup>de</sup> ±0.15	10.00 <sup>d</sup> ±0.00	0.74 <sup>i</sup> ±0.00
I <sub>2</sub>	3.20 <sup>g</sup> ±0.00	0.198 <sup>c</sup> ±0.03	20.10 <sup>a</sup> ±0.03	15.81 <sup>a</sup> ±0.04	4.29 <sup>d</sup> ±0.07	27.00 <sup>c</sup> ±0.00	0.72 <sup>j</sup> ±0.01
I <sub>3</sub>	3.30 <sup>f</sup> ±0.00	0.192 <sup>d</sup> ±0.00	12.45 <sup>ij</sup> ±0.00	8.33 <sup>i</sup> ±0.00	4.12 <sup>efg</sup> ±0.00	12.00 <sup>c</sup> ±0.00	0.70 <sup>k</sup> ±0.00

Values are means ± standard deviation. Samples with different superscripts in the same column are significantly different ( $p < 0.05$ ); GKP: Asp: XG – A<sub>3</sub> (20: 3: 0.2), D<sub>3</sub> (15: 3: 0.2), G<sub>3</sub> (10: 3: 0.2); GKP: Asp: GG – B<sub>3</sub> (20: 3: 0.2), E<sub>3</sub> (15: 3: 0.2), H<sub>3</sub> (10: 3: 0.2); GKP: Asp: Gln – C<sub>3</sub> (20: 3: 0.2), F<sub>3</sub> (15: 3: 0.2), I<sub>3</sub> (10: 3: 0.2); GKP: Suc: XG – G<sub>2</sub> (10: 3: 0.2); GKP: Suc: GG – H<sub>2</sub> (10: 3: 0.2); GKP: Suc: Gln – I<sub>2</sub> (10: 3: 0.2); TTA = Total titratable acidity and TSS = Total soluble solids; GKP: *Garcinia kola* fruit pulp, Asp: Aspartame, XG: Xanthan gum, GG: Guar gum, Gln: Gelatin, Suc: Sucrose.

