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The Acceptability, Antioxidative, Linoleic inhibition and FTIR characterization of *Chinchin* and Peanut Burger Snacks Enriched with Cardaba Banana Flour

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Abstract:

The dependency of all classes of human beings on snacks coupled with the adverse health challenges associated with the frequent consumption of snacks had called for its improvement via enrichment with functional materials. Cardaba banana is an underutilized, non-seasonal, widely available, relatively cheap phytonutrients which can be preserved by processing into flour for use as functional material. This work focused on the production of composite flour from wheat and cardaba banana to produce *chinchin* and peanut burger snacks (100:0, 70:30, 60:40, and 0:100 of refined wheat flour: cardaba banana flour). The proximate composition, antioxidant activities, inhibition of linoleic acid, fourier transform infrared spectroscopy (FTIR), and sensory acceptability of the samples were determined. The result showed that the values obtained for the *chinchin* and peanuts varied, even though these products were made using the same flour formulations. The snacks are well accepted with scores higher than 6.0 on a nine-point hedonic scale, also the linoleic acid inhibition showed the functional capability of the snacks in delaying oxidation. The moisture, fibre, ash, and protein contents of *chinchin* samples decrease with the incorporation of cardaba banana while the fat and carbohydrate contents, likewise the energy value increased. Peanut burgers exhibited an increase in moisture, carbohydrate and energy value but a decrease in fat, fibre, ash, and protein contents. Blends that contained 60 % cardaba banana flour had higher total phenolic contents and DPPH radical scavenging activity values, both in the *chinchin* and peanuts. Also, the presence of cardaba banana flour in the formulation enhanced the presence of alkene group in the *chinchin* while increasing the concentration of amides group in the peanut burgers. The study concluded that formulating blends of wheat flour and cardaba flour would enhance the functionality of the resulting flour blends while enhancing the nutritional status of the products.

Keywords: Snacks, FTIR, Linoleic-acid Inhibition, Cardaba banana, Antioxidant, Diseases

INTRODUCTION

From times immemorial, snacks referred to the meals consumed in between regular meals mostly for satiety or aesthetic purposes but today they are becoming an indispensable quota of human nutrition owing to the ever-increasing consumption pattern globally (Bongjo *et al.*, 2023). Snacks, energy-dense but nutrient-poor meals (Hess *et al*., 2016) comprised of the processed, convenient, mostly packed, energy-supplying, readily available foods on the shelves, streets, schools, parks, etc. (Ugwuanyi *et al.*, 2020). They are the delight of all human races, male, female, young, and old, since time immemorial, these include *chinchin and* peanut burgers.

The outburst of rural-urban migration in both the developed and the developing countries contributed immensely to the high demand and the level of dependence on snacks (Ugwuanyi *et al.*, 2020). The high demand for the importation of wheat, been the basis of most snack food had negatively affected the economy of most non-wheat producing countries like Nigeria. This had consequentially contributed to a nutrition shift in the populace and it had been linked with the occurrence of most cardiovascular diseases. To boost the country's economy and simultaneously improve the health of consumers, food processors have been challenged to produce functional materials to be used in compositing wheat-based snacks (Abioye *et al*., 2020).

Cardaba banana (*Musa acuminate* X *balbisiana*), is a cross-breed, dwarf specie of the cooking banana, it is rich in antioxidative properties like Total Phenolic Content (TPC), Ferric Reducing Antioxidant Power (FRAP), Metal Chelating Assay and 1,1-diphenylpicrylhydrazine (DPPH)

(Babalola and Taiwo, 2019). Antioxidants are naturally occurring phytochemicals capable of delaying the on-set or preventing the initiation of free radicals within the body (Rahaman *et al.*, 2023), their antioxidative power on inhibition of linoleic acid in fried snacks had been established (Babalola *et al.*, 2021).

Proximate composition constitutes the percentage variations of protein, moisture, ash, lipid, fibre, and carbohydrate contents of any biomaterial. It serves as a guide in food processing for navigating different material compositions in product development or quality control or regulation processes (Parimelazhagan and Thangaraj (2016). Onwuka *et al.* (2015) and Iliyasu and Ayo-Omogie (2019) reported favourable moisture, protein, and carbohydrate contents for cardaba banana flour sample. The low moisture content required for shelf stability has been attributed to it in addition to the low fat, high ash, and crude fiber. The high carbohydrate content indicates the high energy value that will be supplied by consuming any food enriched with cardaba banana.

Linoleic acid is an essential fatty acid that is beneficial to human health when consumed in the appropriate proportion, excessive accumulation of linoleic acid in the body system is a precursor of the formation of oxidized linoleic acid metabolites, confirmed to be responsible for the prevalence of chronic diseases like cancer, Alzheimer and cardiovascular diseases (Mercola and D'Adamo, 2023). Since it is impossible to quantify linoleic acid intake to ascertain the quantity consumed, it is crucial to devise means of inhibiting excessive linoleic acid consumption as a preventive measure for oxidized linoleic acid metabolites.

Fourier Transform Infrared (FTIR) spectroscopy application delves into the study of surface chemistry in diver's forms of membranes. FTIR identifies the unique functional groups responsible for membrane surface behavior adulterations, and it aids in clarification and explanation of the different physicochemical properties involved in the membrane change. It has also been employed for monitoring the stability and resilience of membranes (Mohamed *et al.*, 2017), extensively utilized in identifying food adulterations of honey (Damto *et al.*, 2023), edible oils (Bunaciu *et al.*, 2023) and milk (Ceniti *et al.*, 2023).

Adubofuor *et al.* (2016) produced and evaluated composite bread from ripe and unripe cardaba bananas, Ayo-Omogie and Odekunle (2017) worked on compositing cardaba banana and refined wheat flour in the production of doughnuts and cookies, high nutritional and functional values were recorded for doughnut and cookies from the composite values. The compositing effect of cardaba banana flour and refined wheat flour has not been studied, hence this work. This work parses into understanding the antioxidative effect of cardaba banana flour as composite flour in the production of *chinchin* and peanut burgers to determine the inhibitory activities of the cardaba banana flour on linoleic acid metabolites.

MATERIALS AND METHODS

Materials

Cardaba banana fruits were purchased from a local farm market in Ilesha, Osun State, other processing materials (wheat flour, groundnut, vegetable oil, salt, sugar, eggs) used were purchased from retail outlets in Osogbo, Osun State. The chemicals used were of analytical grade.

Production of cardaba banana flour

Cardaba banana fruits were processed into flour following the method of Babalola and Taiwo (2019) with slight modifications. The fruits were removed from the bunch, cleaned, peeled, sliced (manually with knife horizontally into ± 5mm thickness), blanched (at 60 ^{o}C for 10 min), drained, dried (using cabinet dryer), milled (with attrition mill), sieved and packaged.

Peanut burger preparation

The peanut burger was prepared following the reported method of Babalola *et al.* (2021), the peanuts were carefully sorted, cleaned, blanched (at 100 ^{o}C for 15 min), and the blanched peanuts were drained and air dried at room temperature (of 27 ^{o}C ± 2^{o}C for 24 h). The whisked egg and sugar solution was constantly sprinkled simultaneously with the flour mix and salt, this was iteratively done till the peanuts were evenly coated. Coated peanuts were deep fried (in a deep fryer at 180 ^{o}C for 5 mins), cooled, and packaged.

Chinchin production

The method of Bongjo *et al.* (2023) was employed for the *chinchin* preparation, measured composite flour, sugar, salt, and baking powder were dry-mixed together, and a mixed solution of whisked eggs and milk was added followed by margarine. The mixture was thoroughly mixed for tough dough consistency, the dough was kneaded, rolled, cut into sizes, and then fried (in a deep fryer at 180 ^{o}C for 15 mins till golden-brown crust was observed), cooled, and packaged.
The formulation compositions are presented in Table 1, equal composite flour compositions were employed for both *chinchin* and peanut burgers. The recipes for both *chinchin* and peanut burger snacks are presented in Tables 2 and 3 respectively.

Table 1: Refined wheat flour and cardaba banana flour formulations

***Chinchin* Samples**	**Refinery wheat flour (%)**	**Cardaba banana flour (%)**	**Peanut Burger Samples**
A	100	0	**E**
B	70	30	**F**
C	60	40	**G**
D	0	100	**H**

Table 2: Production recipe for *chinchin*

Ingredient	**Quantity**
Flour	100.0
Sugar	20.0
Salt	0.25
Baking powder	1.0
Margarine	12.5
Water	7.5 ml
Powdered milk	7.5
Egg	10.0
Cardaba banana flour	To ratio

Table 3: Production recipe for peanut burger

Ingredient	**Quantity (g)**
Peanut	100.0
Flour mix	50.0
Sugar	20.0
Eggs	30.0
Salt	2.0

Methods of Analysis

The samples were each ground into powder form using mortar and pestle for easiness and even distribution of the samples' compositions for analyses.

Proximate composition

Determination of the proximate composition was by the official methods of AOAC (Igbabul *et al.*, 2015), protein, fat, moisture, fiber, and ash were analyzed while carbohydrate was determined by method of difference.
Carbohydrate = 100 – (protein + fat + moisture + fiber + ash)
Attwater factor was used in calculating the energy value of the snacks;

Energy = (9 X fat content) + (4 X protein content) + (4 X carbohydrate content)

Antioxidant Determination

The modified method described by Girgih *et al*. (2011) was used in determining the 1.1-diphenylpicrylhrazine (DPPH). 10 mg/ml sample concentration was dissolved in 0.1 M sodium phosphate buffer, pH 7.0 containing 1% (v/v) Triton-X to DPPH diluted in 95% methanol to a final concentration of 100 µM. Each sample aliquot (100 µL) was mixed with 100 µL of the DPPH radical solution inside a 96-well plate and incubated at room temperature for 30 min in the dark. For the blank, buffer was used and Glutathione (GSH) was used as the control, the absorbance of all samples, blank, and control was measured at 517 nm using a spectrophotometer. The percentage DPPH radical scavenging activity was determined following the equation below;

$$\% \text{ DPPH} = \frac{(\text{absorbance of blank}) - (\text{absorbance of sample})}{\text{absorbance of blank}} \text{ X } 100$$

Famuwagun and Gbadamosi (2021) method was modified in determining the phenolic content (TPC), it was based on the Folin-Ciocalteu method. The standard calibration curve was prepared by using 25 – 350 mgmL gallic acid concentration in 50 % (v/v) methanol, the samples were equally diluted with the 50 % (v/v) methanol to a concentration before being centrifuged. To each sample was an aliquot of Folin-Ciocalteu reagent (0.25 mL) and gallic acid solution (0.25 mL) added and mixed, left to incubate in the dark at room temperature for 5 min. 0.5 mL of 20 % sodium carbonate solution was then added followed by 4 mL of double distilled water, the contents were thoroughly mixed and incubated in the dark at room temperature for 1 h. A UV-visible spectrophotometer was used to measure the intensity of the green color at 725 nm, TPC was expressed as milligrams gallic acid equivalents (GAE) per gram of sample (mg GAE/g).

Inhibition of linoleic acid oxidation

The method reported by Babalola *et al.* (2021) on the determination of the linoleic acid oxidation was used, 1.0 g of each sample was dissolved in 1.5 mL of 0.1 M sodium buffer (pH 7.0). The mixture was added to 1.0 mL of 50 mM linoleic acid dissolved in 99.5 % ethanol, the control assay was distinguished by the addition of 1.5 mL of buffer to the ethanolic linoleic acid solution. The mixtures were incubated in the dark at 60 ^{o}C for 7 days, on a 24-h basis, 100 µL of the assay solution was mixed with 4.7 mL of 75 % aqueous ethanol, 0.1 mL of ammonia thiocyanate (30 % w/v) and 0.1 mL of 0.02 M ferrous chloride dissolved in 1 M HCl. At 500 nm, the degree of color development of the samples was measured after incubating for 3 min at room temperature. An increase in the absorbance measured implied an increase in the level of linoleic acid oxidation.

Fourier transform infrared spectroscopy

FTIR spectrometer (SHIMADZU FTIR-8400S) coupled with the IR solution (32-bit high-performance FTIR software) was used to analyze the samples.

Sensory analysis

A nine-point hedonic scale sensorial evaluation was employed in accordance with the reported method of Akindele *et al.* (2017).

Statistical analysis

All data obtained from this work were subjected to analysis of variance (ANOVA), means were separated using the Duncan multiple range test, and significant differences were selected at $P < 0.05$.

RESULTS AND DISCUSSION

Proximate composition of the cardaba banana enriched *chinchin* and peanut burger snacks

Table 4 shows the proximate composition of the cardaba banana flour-enriched *chinchin* and peanut burger snacks. Moisture content for all samples falls within the shelf-stable products of less than 13 %, the values are significantly ($p < 0.05$) different, snacks from 100 % cardaba banana had the least moisture content and inclusion of cardaba banana flour into the snacks flour composition reduced the moisture content. Low moisture content is required for the shelf stability of products, compositing with cardaba banana might be a means of reducing products' moisture content. The values of moisture content obtained for *chinchin* (7.95 – 8.65 %) samples of this work are lower than those of wheat-cassava *chinchin* samples (8.29 – 10.40 %) reported by Okwunodulu *et al*. (2022) but higher than those of millet-wheat *chinchin* samples (3.98 – 5.04 %) reported by Adegunwa *et al.* (2014). The moisture content recorded for the peanut burger samples of this work is however higher (8.61 – 9.10 %) than those reported by Babalola *et al.* (2021) for veggie peanut burgers (1.01 – 7.58 %).

The fiber content of the *chinchin* samples was not significantly ($p > 0.05$) different i.e. the same value of fiber content was obtained for all the samples regardless of their different percentage compositions. However, the fiber content values of the peanut burger snacks were significantly ($p < 0.05$) different. The fat, ash, protein, and carbohydrate contents were significantly different from each other for both (*chinchin* and peanut burger) snacks.

The fat, fiber, ash, and protein contents of snacks from 100 % cardaba banana flour samples were the lowest values for all samples, it was noteworthy that the incorporation of cardaba banana flour into the flour mix lowered the fat, fiber, ash, and protein contents. A similar trend has been reported by Okwunodulu *et al*. (2022) for wheat-cassava *chinchin* , this was due to the high fat, fiber, ash, and protein content of wheat compared with cardaba banana flour. Compositing at a much higher percentage of 70 % wheat flour and 30 % cardaba flour will thereby be encouraged to avert compromising the health benefits of the fat, fiber, ash, and protein contents. Fat contributes a nine-multiple of the energy requirements of the body more than the four-multiples supplied by protein and carbohydrates. Fibre is required in the body for the prevention of various cardiovascular diseases, obesity, hemorrhoids, and constipation (Nzelu *et al.*, 2012).

The carbohydrate content however increases with the inclusion of cardaba banana flour, this invariably was projected into the calculated energy value of the snacks. This increase in the carbohydrate content can be attributed to the high carbohydrate content of cardaba bananas as seen in the *chinchin and* peanut burger snacks produced from 100 % cardaba banana flour samples (i.e. samples D and H). Carbohydrates are a macronutrient essentially required daily in large quantities for the supply of energy and structural balances.

Selected Antioxidant properties of the cardaba banana enriched *chinchin* and peanut burger snacks

According to Asif (2015), foods naturally containing antioxidant activity compounds or those enriched with antioxidant activity compounds are interest of the populace because of their capability to neutralize free radicals that the body produces. Based on this justification, *Chinchin* and peanut burger snacks enriched with cardaba banana flour samples were produced, and the total phenolic content (TPC) and 1.1-diphenylpicrylhrazine (DPPH) were determined (Table 5).

TPC values of 42.12 to 51.63 µgGAE/100 g were observed for cardaba banana enriched *chinchin* , *chinchin* produced from 100 % cardaba banana flour had higher TPC compared to *chinchin* produced from 100 % wheat flour. The cardaba banana enriched peanut burger had values ranging from 54.53 to 63.07 µgGAE/100 g, peanut burger produced from 100 % cardaba banana flour had lower TPC compared to peanut burger produced from 100 % wheat flour. By compositing, samples with 70 % wheat flour and 30 % cardaba banana flour had higher TPC, Babalola and Taiwo (2019) reported a total phenolic content of cardaba banana flour of 15.0 to 46.00 µgGAE/100 g for differently processed cardaba banana flour.

Baba and Malik (2015) quoted TPC as one of the tools for conducting a quick determination of any antioxidant activity, the sequence of operation of TPC is based on the inherent phenolic compounds.

These Phenolic compounds have redox potential and as such are capable of donating hydrogen atoms to stabilize free radicals i.e. acting as antioxidants (Soobrattee *et al*., 2005). Another established method of determining the antioxidative power of any substance is the use of DPPH, DPPH is a stable radical, and using it to measure antioxidant activity requires a very short time (Yamin *et al.*, 2021). According to Gulcin (2020), DPPH is an effective antioxidant assay because of its sensitivity and reproducible quality, it is important in lipid oxidation inhibition mechanism.

The DPPH value of the *chinchin* samples ranged from 42.12 to 51.63 % and the DPPH value of the peanut burger samples ranged from 54.53 to 63.07 %, both snacks from 100 % cardaba banana flour had higher DPPH than the snacks from 100 % wheat flour. Compositing wheat flour with cardaba banana flour increased the percentage of DPPH in both *chinchin* and peanut burger snacks. The presence of a higher percentage of DPPH in the snack samples from composite flour is an indication of the higher inhibitory power of these snacks on the oxidation mechanism.

Inhibition of linoleic acid oxidation of *chinchin* and peanut burger

Figure 1 shows the inhibition pattern of the *chinchin and* peanut burger snacks, the absorbance for all samples increased till the third day, with snacks from 100 % cardaba banana flour having the highest peak. The increase in absorbance shows the effectiveness of the antioxidative power of the samples to inhibit oxidations in fried snacks which agrees with the work of Babalola *et al* (2021) on veggie peanut burgers. The subsequent declination in the absorbance pattern of all the samples may be the declination power of the inhibitor in the samples or that all oxidations generated had been successfully inhibited. Jayaprakasha *et al.* (2001) stated that the depletion might be due to the limited reactive oxidation products i.e. reduction in the production of hydroperoxides.

The body's system is not capable of synthesizing sufficient antioxidants to prevent the ever-continuous threat of reactive oxygen species (ROS), snacks have become essential sources for these antioxidants. Frequent consumption of these snacks might serve as an assurance of continuous inhibition of any ROS that might have been accrued in the body system. The elimination of oxidations in the body has been linked to a reduction in the occurrence of Non-Communicable Diseases (NCD) (Ayoka *et al.,* 2022) like cancers, diabetes, cardiovascular diseases, etc.

Functional groups determined by Fourier Transform Infrared (FTIR) Spectrometer

The working principle of FTIR is based on the vibration of the functional groups that are present within the macromolecules of the molecule, alongside indicating the structural changes within the molecular structures of the molecule via a shift in wave numbers (Chen *et al*., 2013; Saguer *et al.,* 2012). The frequencies and band assignments for the FTIR spectra (4000 – 500 cm-1) are presented in Table 6 and Table 7 for *chinchin and* peanut burger snacks respectively. All the *chinchin* samples (sample A-D), contained alkanes, Alkenes, Carboxylic acid, Ketones, Aromatics, Amides, and Amines compounds with similar wave numbers. Samples B, C, and D which contained substituted cardaba banana flour were made up alkane halides (R-F (C-F stretch)) while the *chinchin* sample without cardaba flour had ester group (RCOOR' (C-O stretch)), which were not present in the other *chinchin* samples that contained cardaba banana flour. The presence of alkyl halides in samples B, C, and D may suggest the availability of halogens in the cardaba banana. Also, the presence of ester compounds in the *chinchin* made of wheat flour only and its absence in the other samples that contained cardaba flour might imply that the presence of the cardaba flour enhanced the quick disappearance of the sweet-smelling compound from the product during the frying operations of the samples.

Table 4: The Proximate composition (%) and Energy value (kcal/g) of cardaba banana enriched *Chinchin* and peanut burger

Sample	Moisture	Fat	Fibre	Ash	Protein	Carbohydrate	Energy
A	8.65 ± 0.13[c]	3.56 ± 0.02[f]	1.26 ± 0.01[e]	0.94 ± 0.02[d]	10.94 ± 0.44[e]	74.65 ± 0.08[d]	374.40
B	8.51 ± 0.37[d]	3.55 ± 0.13[f]	1.25 ± 0.01[e]	0.94 ± 0.01[d]	10.94 ± 0.44[e]	74.81 ± 0.30[c]	374.95
C	8.16 ± 0.02[e]	3.67 ± 0.04[e]	1.25 ± 0.02[e]	0.93 ± 0.01[d]	9.07 ± 0.45[f]	76.92 ± 0.51[b]	376.99
D	7.95 ± 0.02[f]	3.47 ± 0.07[g]	1.24 ± 0.01[e]	0.92 ± 0.01[e]	7.82 ± 0.45[g]	78.60 ± 0.37[a]	376.91
E	8.83 ± 0.07[b]	4.21 ± 0.04[a]	1.40 ± 0.01[a]	1.17 ± 0.02[a]	32.82 ± 0.45[a]	51.57 ± 0.40[h]	375.45
F	9.10 ± 0.02[a]	4.10 ± 0.03[b]	1.38 ± 0.02[b]	1.15 ± 0.02[b]	29.69 ± .044[b]	54.58 ± 0.45[g]	373.98
G	9.10 ± 0.01[a]	3.91 ± 0.07[c]	1.35 ± 0.02[c]	1.15 ± 0.01[b]	27.19 ± 0.44[c]	57.30 ± 0.41[f]	373.15
H	8.61 ± 0.03[c]	3.78 ± 0.02[d]	1.30 ± 0.02[d]	0.99 ± 0.05[c]	26.69 ± 0.44[d]	58.63 ± 0.52[e]	375.30

Values are mean ± standard deviations of triplicate determinations, values with superscript along the same column are significantly (P<0.05) different from one another.

Key:

A: *Chinchin* from 100 % wheat flour
B: *Chinchin* from 70 % wheat flour + 30 % cardaba banana flour
C: *Chinchin* from 60 % wheat flour + 40 % cardaba banana flour
D: *Chinchin* from 100 % cardaba banana flour

E: Peanut burger from 100 % wheat flour
F: Peanut burger from 70 % wheat flour + 30 % cardaba banana flour
G: Peanut burger from 60 % wheat flour + 40 % cardaba banana flour
H: Peanut burger from 100 % cardaba banana flour

Table 5: Selected Antioxidant properties of cardaba banana enriched *Chinchin* and peanut burger

Sample	TPC(μgGAE/100g)	DPPH (%)
A	9.91 ± 0.28^{g}	42.12 ± 0.01^{g}
B	9.98 ± 1.37^{f}	42.36 ± 0.08^{f}
C	11.39 ± 1.02^{e}	44.50 ± 1.30^{e}
D	11.89 ± 0.32^{d}	51.63 ± 0.43^{d}
E	13.06 ± 0.60^{b}	54.53 ± 0.17^{c}
F	13.25 ± 0.11^{a}	63.07 ± 0.06^{a}
G	13.25 ± 0.11^{a}	63.07 ± 0.02^{a}
H	12.75 ± 0.47 ^{c}	58.80 ± 0.22^{b}

Values are mean ± standard deviations of triplicate determinations, values with superscript along the same column are significantly (P<0.05) different from one another.

Key:
A: *Chinchin* from 100 % wheat flour
B: *Chinchin* from 70 % wheat flour + 30 % cardaba banana flour
C: *Chinchin* from 60 % wheat flour + 40 % cardaba banana flour
D: *Chinchin* from 100 % cardaba banana flour

E: Peanut burger from 100 % wheat flour
F: Peanut burger from 70 % wheat flour + 30 % cardaba banana flour
G: Peanut burger from 60 % wheat flour + 40 % cardaba banana flour
H: Peanut burger from 100 % cardaba banana flour

Also, all the peanut samples made with or without cardaba banana flour contained alkanes, carboxylic acids, Amides, Alkenes, and Aromatics compounds. However, comparing the *chinchin* with the peanut burger, Ketones, and esters were found to be present in *chinchin* products but absent in the peanut burger samples. This trend may suggest that differences in the mode of processing of the two products and the ingredients used, apart from the wheat and cardaba banana flours as the reason for the variations in the existence of the compounds observed.

Sensory acceptability of the snacks

Sensory evaluation of *chinchin* and peanut burger snacks from composite flours (of refined wheat and cardaba banana fruit) was carried out using semi-trained panelists who are regular consumers of these snacks, this was done with the view of assessing the adaptability and acceptability of the consumers to the recipe adjustment of these snacks for ‘health purposes’.

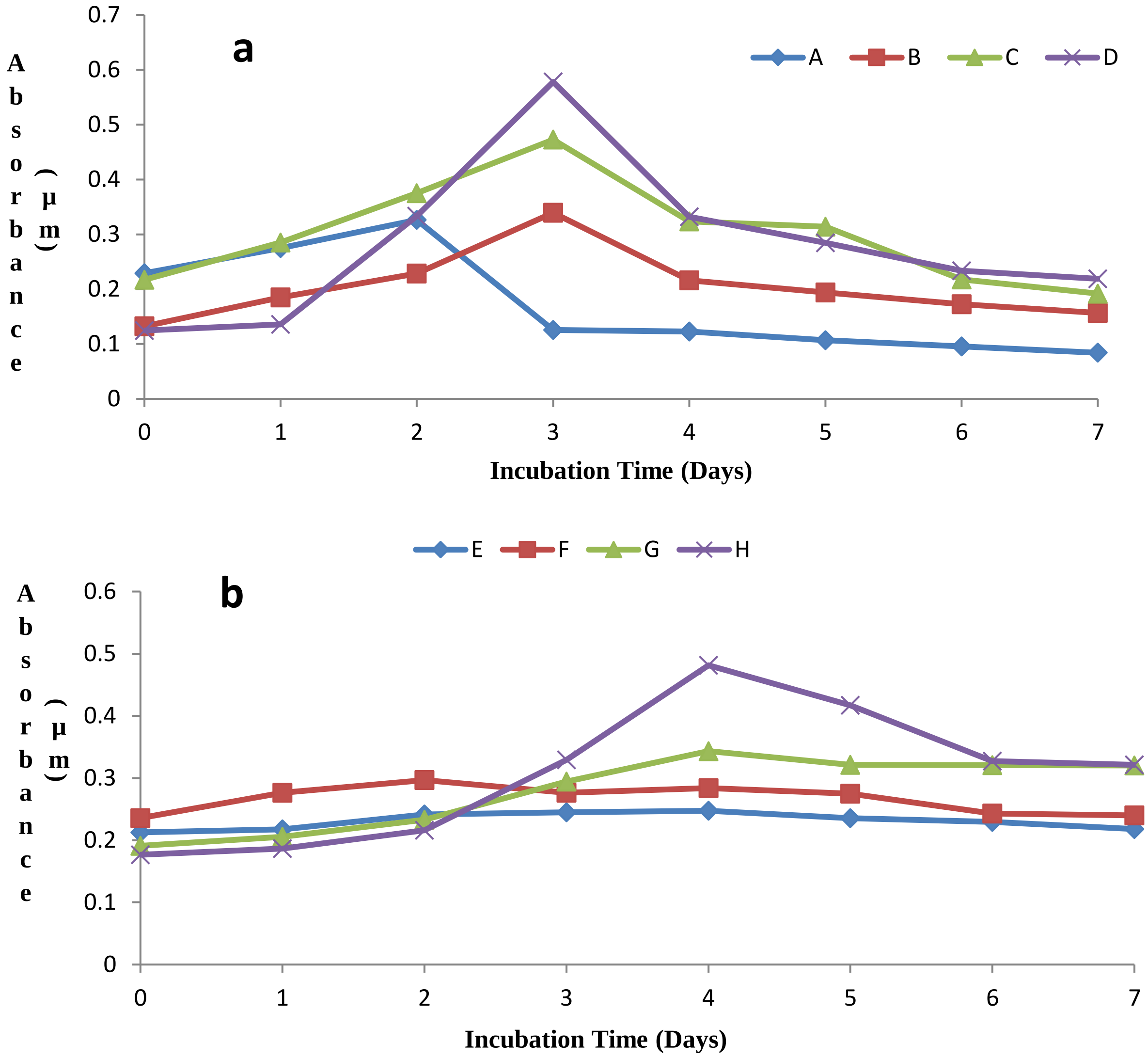

Figure 1: Inhibition of linoleic acid oxidation of (a) *chinchin* and (b) peanut burger

Key:

A: *Chinchin* from 100 % wheat flour

B: *Chinchin* from 70 % wheat flour + 30 % cardaba banana flour

C: *Chinchin* from 60 % wheat flour + 40 % cardaba banana flour

D: *Chinchin* from 100 % cardaba banana flour

E: Peanut burger from 100 % wheat flour

F: Peanut burger from 70 % wheat flour + 30 % cardaba banana flour

G: Peanut burger from 60 % wheat flour + 40 % cardaba banana flour

H: Peanut burger from 100 % cardaba banana flour

Table 6: FTIR peak assignment for enriched *chinchin* with cardaba banana flour

Functional Group	A	B	C	D	Suggested Nutrient
RCH_2CH_3 (CH stretch)	2924.18	2924.18	2924.18	2924.18	Alkanes
trans RCH=CHR (=CH out of plane)	721.40	721.40	721.40	721.40	Alkenes
RCO-OH (s broad)	2854.74	2854.74	2854.74	2854.74	Carboxylic acids
Ketones (R_2CO 5-ring, – C=O stretch doublet)	1747.57	1747.57	1747.57	1747.57	Ketones
(C-C in ring), Ar C-C stretch	1458.23	1458.23	1458.23	1458.23	Aromatics
RCONHR’ 4-ring (C=O stretch)	1747.57	1747.57	1747.57	1747.57	Amides
RNH_2, R_2NH (N-H wag amines)	721.40	721.40	721.40	721.40	Amines
RCOOR’ (C-O stretch)	1165.04	ND	ND	ND	Esters
Conj. Dienes/ 6.7.8-ring (C=C stretch)	ND	1654.98	1654.98	ND	Alkenes
R-F (C-F stretch)	ND	1161.91	1161.91	1161.91	Alkyl halides
P-OR esters/ Si-OR	ND	ND	1026.16	1026.16	Misc.
Monosubst., ortho & meta-disub. (C-H out of plane)	ND	ND	ND	756.12	Aromatics

Table 7: FTIR peak assignment for enriched peanut burger with cardaba banana flour

Functional Group	E	F	G	H	Suggested Nutrient
RCH_2CH_3 (CH stretch)	2924.18	2924.18	2924.18	2924.18	Alkanes
C=C-CO-OH/ RCO-OH (s broad)	2854.74	2854.74	2854.74	2854.74	Carboxylic acids
RCONHR’ (C=O stretch)	1654.98	1654.98	1654.98	1654.98	Amides
Conj. Dienes/ 6,7,8-ring (dienes)	1654.98	1654.98	1654.98	1654.98	Alkenes
C-C in ring (Ar C-C stretch)	1458.23	1458.23	1458.23	1458.23	Aromatics
N-O nitro comp. (Alif. Nitro)	1377.22	1377.22	1377.22	1377.22	Misc.
S=O sulfate (S=O sulfate ester)					
P-H phosphine (P-H phosphine sharp)	2364.81	ND	ND	ND	Misc.
RCONHR’ (NH out of plane)	ND	1543.10	1543.10	1543.10	Amides
R-Br (C-Br stretch)	ND	ND	ND	532.37	Alkyl halides

From Figure 2, the snacks had scores above 6.0 on a nine-point hedonic scale which is an indication of the acceptability of the snacks, this is in tandem with Akinsola *et al.* (2020) report that scores above 5.0 indicates a general acceptability of the snack.

Snacks made from 100 % cardaba banana and from cardaba banana-wheat composite flour are well accepted, however, for both snacks, *chinchin and* peanut burgers from 100 % wheat flour were better preferred in terms of appearance, crunchiness, and overall acceptability. This preference might be due to panelists being accustomed to the regular appearance and crunchiness of these snacks but alien to the improved snacks. The taste and flavor of these snacks from compositing with cardaba banana were well accepted by the panelists, this might be one of the strengths of compositing with cardaba banana flour.

In terms of overall acceptability, all the *chinchin* samples were preferred, this is an indication that the influx of *chinchin* produced from refined wheat-cardaba banana flour will be mostly accepted in the large market. However, for the peanut burger samples, samples G and H were less accepted, an improved method for the incorporation of cardaba banana flour into the production of well-accepted peanut burgers might be compositing at a lower percentage (i.e. 10 – 20 %).

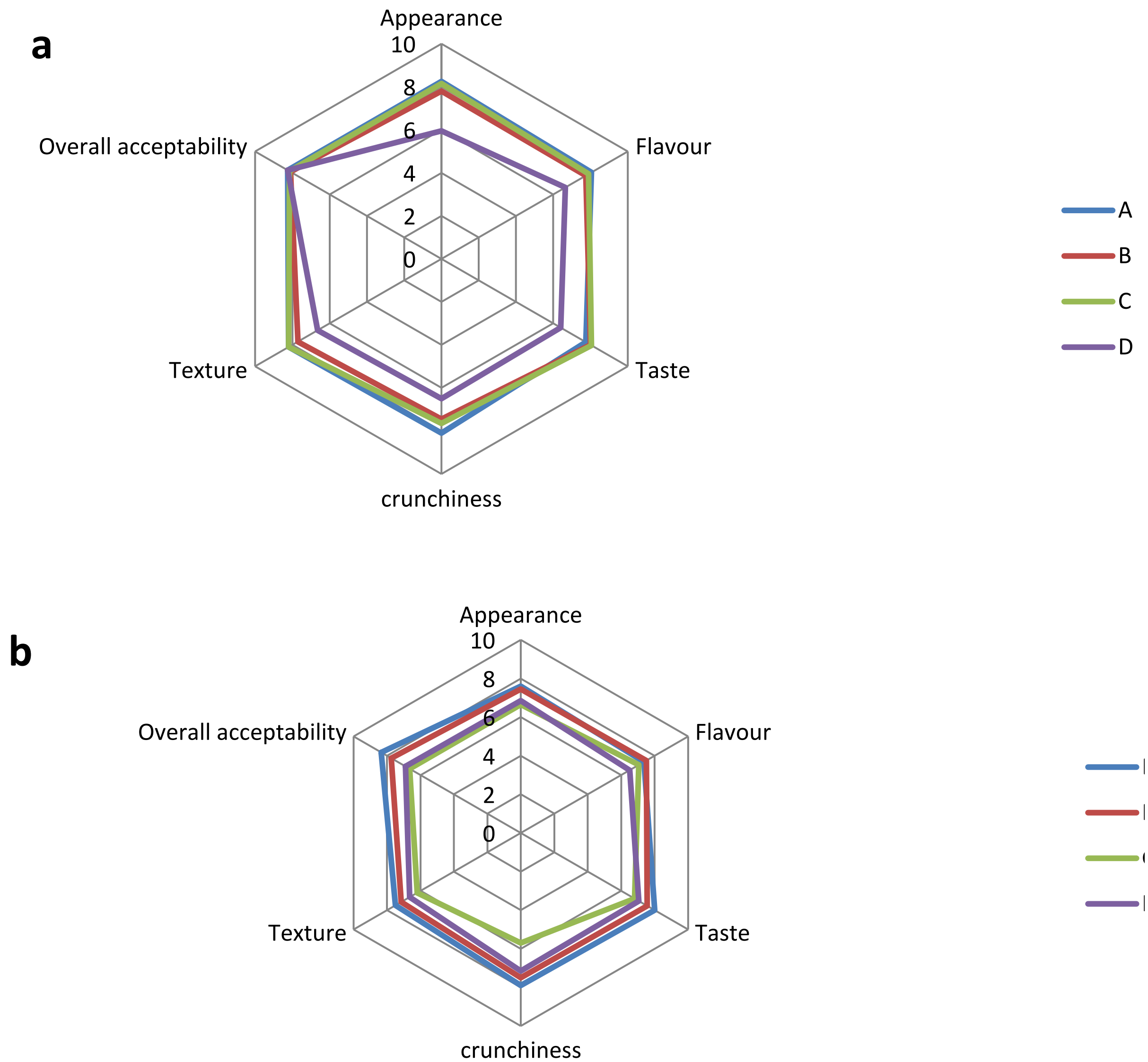

Figure 2: Radar chart for the sensory analysis of (a) *chinchin* and (b) peanut burger

Key:
A: *Chinchin* from 100 % wheat flour
B: *Chinchin* from 70 % wheat flour + 30 % cardaba banana flour
C: *Chinchin* from 60 % wheat flour + 40 % cardaba banana flour
D: *Chinchin* from 100 % cardaba banana flour

E: Peanut burger from 100 % wheat flour
F: Peanut burger from 70 % wheat flour + 30 % cardaba banana flour
G: Peanut burger from 60 % wheat flour + 40 % cardaba banana flour
H: Peanut burger from 100 % cardaba banana flour

CONCLUSION

The study concluded that compositing with cardaba banana improves the phytonutrient of snacks, 30 % cardaba banana and 70 % refined wheat flour had improved nutritional qualities, and hence the percentage inclusion should not be higher than 30 %. The effectiveness of the antioxidative properties determined (TPC and DPPH) was shown by the inhibition of the linoleic acid oxidation's initial increase before declination. Alkane halides were discovered in samples with cardaba banana instead of ester groups present in whole wheat samples.

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