



Chemical, Photochemical Composition, Physical and Sensory Qualities of Acha-Guava Flour Blends and Biscuits



Ayo JA* and Johnson RG

Department of Food Science and Technology, Federal University Wukari, Nigeria

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*Corresponding author: Ayo JA, Department of Food Science and Technology, Federal University Wukari, Wukari, Nigeria

Abstract

The study investigated the chemical, phytochemical composition, physical and sensory qualities of acha-guava flour blends and biscuit the work was aimed at ameliorating the quality of acha-based biscuits with the addition of guava flour. Flour blends were produced by substituting guava flour into *acha* flour at 5, 10, 15, 20, and 25%. Proximate composition, pasting properties, functional properties, phytochemical composition, vitamins and mineral of the flour blends were determined. Biscuits were produced from the flour blends and the physical properties and sensory qualities of the biscuits were analyzed. The carbohydrate and protein decreased from 81.60 to 77.30 and 8.32 to 7.70%, respectively. The moisture content, fat content, fibre and ash content increased from 8.08 to 8.44, 1.28 to 2.63, and 0.21 to 2.5 and 0.20 to 1.62% respectively, with increase in the added guava flour (5-25%). Water absorption, foaming, and swelling capacity of *acha* flour increased from 2.35 to 2.83 ml/g, 4.13 to 7.65 ml/g and 5.75 to 7.74 ml/g, respectively. Bulk density and oil absorption capacity decreased from .89 to .85/cm³ and 2.10 to 1.81 ml/g respectively, with increase in the added guava flour (5-25%). The peak viscosity, trough viscosity, breakdown, final viscosity, and setback decreased from 2336.83 to 1107, 1535 to 935, 801 to 172, 3719.8 to 1863, and 2186.0 to 928 RVS, respectively, with increase in the percentage guava flour. Iron, carotenoid, vitamin C and total phenol increased from 4.0 to 25.0 ppm, 5.36 to 14.17 mg/100g, 1.94 to 7.96 mg/100g, and 0.22 to 0.86 mg/100g respectively, while phosphorus decreased from 1110.10 to 814.3 ppm with increase in percentage of added guava flour. There was an increase in break strength and spread ratio ranging from 1.35 to 2.64 kg and 4.53 to 5.15 respectively, as a result of the increase in level of guava-flour substitution. The reverse was observed for the thickness, diameter, volume and weight of the biscuit which ranges from .88 to .60 cm, 4.34 to 4.13 cm, 13.05 to 8.00 cm³, and 11.50 to 10.70 g respectively. Sensory qualities evaluated were colour, texture, taste, odour, crispiness, and general acceptability with an average mean score ranging from 4.60 to 7.65, 5.50 to 6.85, 6.10 to 7.45, 5.80 to 6.85, 5.55 to 6.85 and 6.20 to 7.95. The sample, 95:5% acha-guava blends is the most preferred and acceptable with average mean score of 7.95 and corresponding increment of 0.28, 2.22, 79.38, and 1.3% of ash content, protein, fat and crude fibre respectively.

Keywords: Water absorption; Foaming; *Acha* flour; Peak viscosity; Trough viscosity; Breakdown; Final viscosity

Introduction

Biscuit and Cookies are usually produced from wheat flour and they are the same product since the British call them biscuit while the Americans call them cookies [1,2] identified an increasing tendency among children and adults to move away from traditional eating pattern of three meals a day to eating snacks instead of meal. Biscuits enriched with carrot generally have been found to be rich in carbohydrate and protein; they contain fat (14.10 ± 0.08%), carbohydrate (69.31 ± 0.12%), ash (2.32 ± 0.03%), and protein (8.10 ± 0.01%), fibre (0.93 ± 0.01) and moisture (6.17 ± 0.02) as reported by [3].

Cereal grains like wheat, corn, rice, barley, sorghum, etc. provide 68% of the total world food supplies. Wheat is mainly used as a dietary staple, averaging two-thirds of total consumption [4]. Owing to shortage of wheat, several developing countries have devised programs to assess the feasibility of alternative sources for substituting or blending of wheat flour with other cereals [5].

Acha (*D. exilis*) is of considerable importance in Nigeria where it is commonly eaten, often in preference to other cereals, as many as three times a day as a porridge, couscous or non-alcoholic beverage, valued as a weaning food because of its low bulk and high caloric density with minimal processing requirement, it grows even where rainfall and soil fertility are poor and can be stored in closed containers for many years without need of preservatives [6].

Acha contains high water absorption capacity that gives it capacity to be utilized in baked foods. It also contains pentosans which gives it the ability to form gel in the presence of oxidizing agents at room temperature with high residual protein coupled with high levels of Sulphur and hydrophobic amino acid residues which makes it useful in baking [7]. The recent finding of the unique properties of acha flour, particularly in relatively lowering the blood glucose level and which could subsequently reduce the diabetic populace have made researchers to focus on *D. exilis* [8].

Guava (*Psidium guajava*) is usually consumed as fresh fruit, being a flavorful and healthy alternative for a snack. It is also served with cream and sugar for dessert or combined with other fruits in cocktails and salads [9]. Guava juice is also very popular, being an excellent juice alternative for infant feeding or may be eaten with salt, pepper, vinegar, soy sauce or may be preserved into jam, butter, marmalades, relishes, and chutneys (Glaucia et al. 2012). Few studies have been conducted on the phytochemistry and total antioxidant capacity of guava, especially processed guava juice or puree. However, it is well documented that guava contains a very high amount of vitamin C, anthocyanin, lycopene, and carotenoids, [10].

The leaves of guava are used traditionally by many people to overcome a wide range of diseases, while the guava fruits are believed to overcome several of problems and a source of antioxidants [11]. Red guava fruit is also believed to help cure dengue hemorrhagic fever (DHF). Guava fruit contains vitamin C, two times higher than other fruits such as orange which makes it an important compound that has an antioxidant activity [12]. Other compounds in guava fruit are carotenoids such as beta-carotene, lycopene, and beta-cryptoxanthin, and polyphenols [13]. Lycopene is associated with the prevention of cardiovascular damage due the LDL oxidation as the impact of dyslipidemia [14]. Antioxidant content in guava fruit can be used as a source of natural antioxidants; these include vitamins A, C, and E as well as numerous non-nutritive compounds such as polyphenolics, flavonoids, carotenoids, and thiol-containing compounds. Lycopene content in guava fruit is proven to prevent or delay the oxidative damage of lipids, proteins and nucleic acids caused by reactive oxygen species (ROS) [12].

Recent investigations in relation to the unrealized ability of acha to ameliorate the crises of diabetes and its deficiencies in some nutrient, have called for its fortification to bridge the existing gap. The abundance and perishability of guava with its high nutrient content calls for processing to reduce wastage and could be used as a fortifier or enriched food product with relatively low nutrient.

Fortification of acha biscuits with guava could improve the antioxidant, minerals, vitamin content and add value to the sensory qualities of food products. Also, the use of guava could reduce post-harvest losses, create more market for the raw material and increase the quest for production of nutritious food by food industries. The objective was to determine the chemical,

Production of acha-guava composite biscuit

Table 1: Proximate Composition of acha-guava flour blends.

| Acha Flour | Guava powder | Moisture Content | Ash Content | Crude Protein | Fat Content | Carbohydrate | Fiber |
|------------|--------------|-------------------------|------------------------|------------------------|------------------------|--------------------------|------------------------|
| % | % | (%) | (%) | (%) | (%) | (%) | (%) |
| 100 | 0 | 7.75 ^b ±.42 | .20 ^d ±.02 | 8.32 ^a ±.03 | 1.28 ^d ±.02 | 81.60 ^a ±.39 | .21 ^d ±.03 |
| 95 | 5 | 8.08 ^a ±.02 | .49 ^c ±.02 | 8.28 ^b ±.01 | 2.22 ^c ±.06 | 79.38 ^b ±.48 | 1.3 ^c ±.07 |
| 90 | 10 | 8.09 ^b ±0.06 | .77 ^c ±.55 | 8.25 ^c ±.02 | 2.36 ^b ±.05 | 78.96 ^{ab} ±.54 | 1.6 ^{bc} ±.05 |
| 85 | 15 | 8.11 ^b ±.10 | 1.05 ^b ±.09 | 8.23 ^c ±.02 | 2.49 ^b ±.02 | 78.53 ^c ±.47 | 1.9 ^b ±.03 |

phytochemical composition, physical, and sensory qualities of acha-guava flour blend biscuits.

Materials and Methods

Materials

Cream colored *acha* grains (*D. exilis*) purchased from Jos central market in Plateau state, Nigeria while the fresh guava (*Psidium guajava* (red colored) was obtained from Bayesa, Ussa Local Government, Taraba State, Nigeria. Other ingredients such as baking fat (Simas), baking powder (Omega), and salt (*Dangote* table salt) were purchased from Wukari New market, Taraba state, Nigeria.

Methods

Preparation of *acha* flour

Acha flour was produced using the method described by Ayo et al. [8]. Acha grains were winnowed to remove chaff and dust. Adhering dust and stones were removed by washing in water (sedimentation) using local calabashes and floating foreign materials by decanting. The washed and de-stoned grains were drained and dried in a cabinet drier (Model: CD0005, FT3) at 40°C to a moisture content of about 12%. The dried grains were milled using Attrition milling machine (Inch15HP Super 150-180 Kilogram Tw-HM-1016) and sieved (0.3µm aperture size). The flour was packaged in polyethylene bag and stored at 5°C as *acha* flour for later use.

Preparation of guava flour

The procedure as described by Sanjinez-Argandona et al. [15] was modified and used in the preparation of guava flour. Fresh Matured and ripe guava fruit were obtained. Washed, sorted, peeled, sliced and steam blanched (Hughes Blancher Model #:02-1471) for 3min. The sliced guava fruit were dried at 40°C in oven (San-Del Model 50) and milled using attrition mill (Inch15HP Super 150-180 Kilogram Tw-HM-1016) and sieved (0.3µm aperture size). Packaged in a polyethylene bag and stored (at temperature 5°C).

Formulation of flour blend

The guava flour was mixed with acha flour separately at different proportions (5:95, 10:90, 15:85, 20:80 and 25:75) while one hundred percent (100%) acha flour and wheat was used as the control. The flours were thoroughly mixed using a Kenwood blender to a uniform blend by Ayo & Gidado [3].

| | | | | | | | |
|----|----|-------------------------|------------------------|-------------------------|------------------------|--------------------------|-----------------------|
| 80 | 20 | 8.28 ^{ab} ±.29 | 1.34 ^b ±.75 | 7.97 ^{cd} ±.02 | 2.56 ^a ±.03 | 77.51 ^{cd} ±.26 | 2.2 ^b ±.03 |
| 75 | 25 | 8.44 ^a ±.48 | 1.62 ^a ±.06 | 7.70 ^d ±.02 | 2.63 ^a ±.03 | 77.30 ^d ±.02 | 2.5 ^a ±.04 |

* Average mean score with the same letter(s) on the same column are not significantly different, p=0.05.

The recipe adopted for the work is shown in Table 1 as described by Ayo & Gidado [3]. The guava powder was substituted into acha flour at 5, 10, 15, 20 and 25% respectively. The sweet potato powder was beaten into the fat until fluffy and acha-guava composite flour and other ingredients were added, while mixing at a medium speed of Kenwood blender. The method described by Ayo & Gidado [3] was used to produce the biscuits.

Proximate composition determination

The proximate analysis of samples for moisture content, crude protein, ash, Crude fat, Carbohydrate and crude fiber was carried out on the flour as described by AOAC [16].

Determination of minerals and vitamin

The phosphorous, iron and Vitamin B1 of the acha-guava flour blends were determined as described by AOAC [16] methods while the Vitamin C content was determined by direct calorimetric method as described by Kalia [17].

Determination of phytochemicals

Carotenoids content of the acha-guava flour blends was determined as described by Krishnaiah et al. [18] method, while the total polyphenol was determined by Folin-Ciocalteu's method using gallic acid as standard as described by Priyanka [19].

Functional properties determination

The functional properties: - bulk density, water absorption capacity, oil absorption capacity, foam capacity and swelling power of the acha-guava flour blends were determined as described by Onwuka [20].

Determination of pasting properties

Pasting properties of the acha-guava composite flour were determined using the Rapid Visco Analyzer (RVA-4, Newport Scientific, Australia and Thermocline for Windows programme).

Determination of physical properties

The breaking weight, volume, break strength and spread ration of acha-guava composite biscuit were determined using the method described by Ayo et al. [8].

Sensory Evaluation

The sensory quality of the acha-guava biscuits was evaluated using twenty untrained panelists, randomly selected from Department of Food Science and Technology Federal University Wukari, Nigeria based on their familiarity with the biscuit. The biscuits, appropriately coded (ACH, RJG, EYM, and AMD) and of the same size and temperature (29 ± 3°C) were placed in white plastic plates separated by compartment and placed in sensory laboratory. The panelists rinsed their mouths with bottled water after tasting each sample and were not allowed to make comment during evaluation to prevent influencing other panelist.

A nine-point Hedonic scale with one (1) representing "extremely dislike" and nine (9) "extremely like" was used, presented as a questionnaire. The qualities assessed were color, texture, taste, flavor, crispness and general acceptability as described by Ayo & Gidado [3].

Statistical Analysis

All the analyses were conducted in duplicates in completely randomized design. The data were subjected to analysis of variance using Statistical Package for Social Science (SPSS) software version 23, 2017. Means where significantly different were separated by the least significant difference (LSD) test. Significance was accepted at p<0.05

Results and Discussion

Proximate Composition of acha-guava flour blends

Flours and flour blends were produced from *acha* and guava flour blend and proximate composition is presented in Table 1. The carbohydrate and protein decreased from 81.60±.39 to 77.30±.02 and 8.32±.03 to 7.70±.02%, respectively. The decrease could be due to poor protein content level in guava flour. The moisture content, fat content, fibre and ash content increased from 8.08±.02 to 8.44±.48, 1.28±.02 to 2.63±.03, and .21±.03 to 2.5±.043 and .20±.02 to 1.62±.06% respectively, with increase (0-25%). The effect of adding guava to acha are significant, p>0.05. The 75:25% *acha*-guava samples had the highest value for moisture content, crude fibre, fat and ash, while the 100:0% *acha*-guava samples had the highest value for protein and carbohydrate

The increase in moisture content could be due to the relative increase in the fibre content of the added guava as it is hygroscopic. Fibers have the ability of absorbing moisture. The crude fibre increased with increase in added guava powder. This could be due to the presence of high dietary fibre content in fruits and vegetables [21]. Accurately measuring the fibre content of foods is critical to making a sound benefit claim, whether it is a nutrient claim, structure-function claim, or health claim [22].

Ash content indicates the presence of mineral matter in food. Increase in ash content indicates that samples with high percentage of ash will be good sources of minerals. The carbohydrate decreased with increase in guava powder addition. The results obtained in this study are within the ranges earlier reported for *acha* [23]. Ayo & Gidado [3] reported similar range for biscuits from *acha* and carrot flour. Olapade et al. [24] also reported a similar range for biscuits from *acha* and cowpea flour. The carbohydrate contents of these samples are an indication that the products are good sources of energy.

Functional properties of acha-guava flour blends

The result of the functional properties of *acha*-guava flour blends are shown in Table 2. The effect of added guava flour (0-

25%) on water absorption, foaming, and swelling capacity of *acha* flour increased from 2.35±.07 to 2.83±.11ml/g, 4.13±.70 to 7.65±.16ml/g and 5.75±.02 to 7.74±.08ml/g, respectively. Bulk density and oil absorption capacity decreased from .89±.01 to .85±.014g/cm³ and 2.10±.141 to 1.81±.01ml/g, respectively (Figure 1). The 75:25% *acha*-guava samples had the highest value for water absorption, swelling and foaming capacities and lowest value for bulk density and oil absorption capacity. The increase

in the WAC could be due to molecular structure of the guava flour [25]. The effect is significant different, p>0.05. Functional properties are the intrinsic physico-chemical properties that reflect complex interaction between the composition, structure, confirmation and physico-chemical properties of protein and other food components and the nature of the environment in which these are associated and measured.

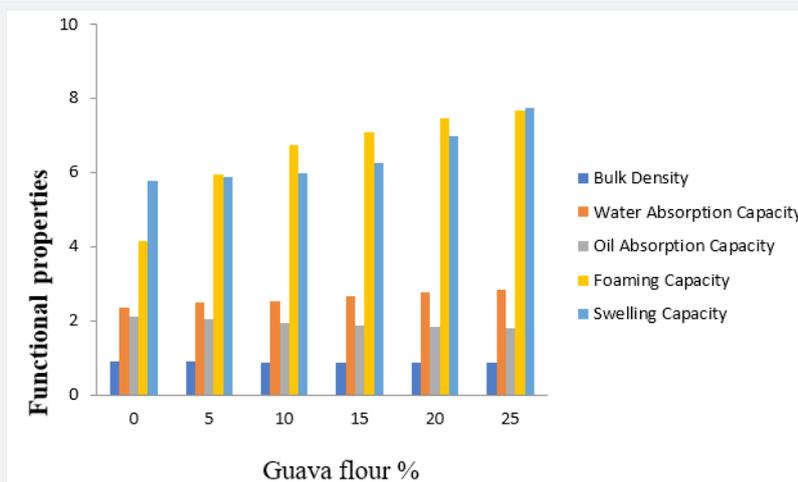


Figure 1:

Table 2: Functional properties of *acha*-guava flour blends.

| Acha flour (%) | Guava Powder (%) | BD (g/cm ³) | WAC (ml/g) | OAC (ml/g) | FC (ml/g) | SC (ml/g) |
|----------------|------------------|-------------------------|------------|------------|-----------|-----------|
| 100 | 0 | .89±.01 | 2.35±.07 | 2.10±.14 | 4.13±.70 | 5.75±.02 |
| 95 | 5 | .89±.00 | 2.50±.14 | 2.05±.07 | 5.93±.16 | 5.88±.03 |
| 90 | 10 | .88±.00 | 2.53±.09 | 1.93±.06 | 6.75±.24 | 5.96±.05 |
| 85 | 15 | .87±.00 | 2.66±.04 | 1.85±.07 | 7.07±.32 | 6.24±.06 |
| 80 | 20 | .86±.01 | 2.75±.07 | 1.83±.04 | 7.45±.25 | 6.99±.07 |
| 75 | 25 | .85±.014 | 2.83±.10 | 1.81±.01 | 7.65±.16 | 7.74±.08 |

* Average mean score with the same letter(s) on the same column are not significantly different, p=0.05.

High WAC of composite flour suggests the potential of the flours in the formulation of foods such as sausage, dough and bakery products where hydration to improve dough handling is a preferred characteristic. The observed variation could be due to different protein concentration, their degree of interaction with water and conformational characteristics [26]. The increased swelling capacity of flours depends on the particle size, variety and type of processing methods. The results agreed with the reported quality attributes of biscuit from *acha* (*digitariaexilis*) flour supplemented with cowpea (*vignaungiculata*) flour by Olapade et al. [24].

The decreased OAC of the flour blends upon addition of guava flour might be attributed to the molecular structure of starch which is loosely linked, allowing for more penetration of liquid materials. The blends could also be used in formulations for products such as ground meat, doughnuts and pancakes, where oil absorption is not of paramount importance [27]. The bulk density

of flour is measured without the influence of any compression. This revealed that bulk density depends on the particle size and moisture content of flours. The high bulk density of flour could suggest their suitability for use in food preparations. However, low bulk density would be great significance in the preparation of complementary foods [28].

Pasting Properties of *acha*-guava flour blends

The results of the pasting properties are shown in Table 3. The peak viscosity, trough viscosity, breakdown, final viscosity, and setback decreased from 16.83±.50 to 1107±.50, 1535±.50 to 935±.50, 801±.50 to 172±.50, 3719.8±.29 to 1863±.50, and 2186.0±.50 to 928.0±.50RVS, respectively, with increase in the percentage guava flour. The effect of adding guava powder are significant, p>0.05, for all the parameters except for peak time. The 100:0% *acha*-guava Sample had the highest values for all the properties. Pasting properties are dependent on the rigidity of starch granules, with consequent effect on the granule swelling

potential and the amount of amylose leaching out in the solution [29]. The high content of starch in the 100:0% *acha*-guava (control) sample, compared to other samples may contribute to

some extent, to the higher pasting viscosity observed which could be the resultant effect of decrease in viscosities with decrease in the *acha* flour proportion.

Table 3: Pasting properties of *acha*-guava flour blends.

| Acha Flour | Guava Powder | Peak1 | Trough1 | Break Down | Final Viscosity | Setback | Peak Time | Psting Temp |
|------------|--------------|--------------------------|-------------------------|-------------------------|--------------------------|--------------------------|------------------------|-------------------------|
| % | % | (RVU) | (RVU) | (RVU) | (RVU) | (RVU) | (mins) | (°C) |
| 100 | 0 | 2336 ^a ±.50 | 1535 ^a ±.50 | 801 ^a ±.50 | 3719.8 ^a ±.29 | 2186.0 ^a ±.50 | 5.27 ^a ±.50 | 81.68 ^b ±1.6 |
| 95 | 5 | 2070 ^b ±.50 | 1450 ^b ±.50 | 620 ^b ±.50 | 3030 ^b ±.50 | 1580.0 ^b ±.50 | 5.40 ^a ±.50 | 84.05 ^b ±.50 |
| 90 | 10 | 1894 ^{bc} ±.50 | 1341.5±.60 | 552.5 ^c ±.40 | 2784.5 ^c ±.50 | 1443 ^{bc} ±.50 | 5.34 ^a ±.50 | 85.9 ^b ±.50 |
| 85 | 15 | 1718 ^c ±.50 | 1233 ^c ±.50 | 485 ^c ±.50 | 2539 ^c ±.50 | 1306.0 ^c ±.50 | 5.27 ^a ±.50 | 87.75 ^a ±.50 |
| 80 | 20 | 1412.5 ^d ±.60 | 1084 ^{cd} ±.50 | 328.5 ^c ±.50 | 1201 ^{cd} ±.50 | 1117 ^d ±.56 | 5.34 ^a ±.50 | 87.50 ^a ±.50 |

* Average mean score with the same letter(s) on the same column are not significantly different, p=0.05.

High values of breakdown associated with high peak viscosities could be related to the degree of swelling of the starch granules during heat treatment. The peak viscosity often correlates with the quality of end-product and also provides an indication of the viscous load likely to be encountered by a mixing cooker (Sanaa and El-Sayed, 2004). The lower setback viscosities of *acha* starches could make the suitable for preparing gels with tendencies to synereses [30].

Pasting time of *fonio* grains (*acha*) reported by Jideani et al. [31] was significantly higher than that obtained in this study which could be due to climatic and soil factors. A higher pasting temperature indicates high water-binding capacity, higher gelatinization tendency and lower swelling property of starch-based flour due to high degree of associative forces between starch granules [32]. Pasting temperature is one of the properties which provide an indication of the minimum temperature required for sample cooking, energy costs involved and another components stability. Therefore, from the results obtained, 100% *acha* samples could be said to be more sensitive to heat treatment with less energy consumption, thereby saving time and cost. Ayo & Gidado [3] reported a similar range for pasting properties of *acha*-carrot biscuits.

Minerals, vitamins and phytochemical composition of *acha*-guava flour blends

The results minerals, vitamins and phytochemical composition of *acha*-guava flour blends shown are shown in Table 4. Iron, carotenoid, vitamin C and total phenol increased from 4.0±.50 to 25.0±.50ppm, 5.36±.04 to 14.17±.06mg/100g, 1.94±.05 to 7.96±.02mg/100g, and .22±.03 to .86±.02mg/100g respectively, while phosphorus decreased from 1110.10±.50 to 814.3±.50ppm with increase in percentage of added guava flour. The effect of adding guava to *acha* flour are significant, p>0.05 on the vitamin C and phosphorous content. The 75:25% *acha*-guava samples had the highest value for iron, carotenoid, vitamin C and total phenol. Iron and vitamins (vitamin C and B₁) increased as the levels of substitution of guava flour with *acha* increased (5-25%). The findings agreed with that of Ayo et al. (2010) and Igbabul et al. (2014). Carotenoids are abundant in the red, yellow, orange, and green colored vegetables and fruits. They are, after chlorophyll, the second most widely occurring plant pigment found in nature (MacDougall 2002). The high degree of hydration and long carbon chain length of these molecules makes them hydrophobic and therefore fat-soluble molecules. The major purpose of carotenoids in the human diet is to serve as precursors to pro-vitamin A, a required nutrient for humans (MacDougall 2002).

Table 4: Minerals, Vitamins and Phytochemical composition of *acha*-guava flour blends.

| Acha Flour | Guava Powder | Iron | Phosphorus | Carotenoid | Total Phenol | Vitamin C | Vitamin B1 |
|------------|--------------|-------------------------|---------------------------|-------------------------|------------------------|------------------------|------------------------|
| % | % | (ppm) | (ppm) | (mg/100g) | (mg/100g) | (mg/100g) | (mg/100g) |
| 100 | 0 | 4.0 ^d ±.50 | 1110.10 ^a ±.50 | 5.36 ^d ±.04 | .22 ^d ±.03 | 1.94 ^a ±.05 | .22 ^d ±.03 |
| 95 | 5 | 15.0 ^c ±.50 | 1011.9 ^b ±.35 | 6.45 ^c ±.05 | .31 ^c ±.02 | 6.06 ^b ±.20 | .31 ^c ±.02 |
| 90 | 10 | 16.0 ^c ±.50 | 961.95 ^c ±.65 | 7.10 ^b ±.07 | .55 ^{bc} ±.02 | 7.22 ^a ±.12 | .55 ^{bc} ±.02 |
| 85 | 15 | 17.0 ^b ±.50 | 912.9 ^c ±.70 | 7.75 ^b ±.03 | .78 ^b ±.02 | 7.84 ^a ±.08 | .78 ^b ±.02 |
| 80 | 20 | 21.0 ^{ab} ±.50 | 863.6 ^{cd} ±.63 | 10.5 ^{ab} ±.05 | .82 ^{ab} ±.02 | 7.9 ^a ±.06 | .82 ^{ab} ±.02 |
| 75 | 25 | 25.0 ^a ±.50 | 814.3 ^d ±.50 | 14.17 ^a ±.06 | .86 ^a ±.02 | 7.96 ^a ±.02 | .86 ^a ±.02 |

* Average mean score with the same letter(s) on the same column are not significantly different, P=0.05.

The vitamin C is one of the most abundant antioxidants consumed, with fruits being the main source of the nutrient. Because L-ascorbic acid is an excellent reducing agent and is abundant in nature, it may help stabilize phenolics and other antioxidants during processing by the donation of hydrogen

atoms. These compounds could also impart color, astringency, and bitterness and possible nutritional properties [33].

Physical composition of *acha*-guava blend biscuits

The physical properties of the *acha*-guava flour blend biscuits are shown in Table 5. There was an increase in break strength and

spread ratio ranging from 1.35±.01 to 2.64±.01kg and 4.53±.01 to 5.15±.01, respectively, as a result of the increase in level of guava-flour substitution. The reverse was observed for the thickness, diameter, volume and weight of a piece of biscuit which ranges from .88±.02-.60±.00cm, 4.34±.0-4.13±.04cm, 13.05±.07-8.00±.14cm³, and 11.50±.00 - 10.70±.71g respectively. The 85:15% *acha*-guava samples had the highest breaking strength and weight, 75:25% had lower values in volume, thickness and diameter, and 95:5% samples had the highest in diameter, thickness and volume

respectively. The effect of adding guava powder are significant, p>0.05, for weight. The increased spread ratio observed in guava-flour substituted biscuit samples could be due to the difference in the particle sizes and characteristics of the constituent flours of guava and *acha* (Agu et al, 2007). Joel et al. [34] and Olapade et al. [24] reported similar trend in biscuits from wheat and full fat soya and biscuit from *acha* flour supplemented with cowpea flour. The spread ratio could be an indicator of biscuit quality.

Table 5: Physical properties of *acha*-guava flour blends biscuit.

| Acha Flour % | Guava Flour % | Break Strength (kg) | Spread ratio | Diameter (cm) | Thickness (cm) | Volume (cm ³) | Weight (g) |
|--------------|---------------|-------------------------|------------------------|------------------------|-----------------------|---------------------------|-------------------------|
| 100 | 0 | 1.35 ^d ±.01 | 4.84 ^b ±.06 | 4.28 ^a ±.04 | .70 ^a ±.00 | 10.04 ^c ±.16 | 10.70 ^a ±.71 |
| 95 | 5 | 1.95 ^c ±.01 | 4.53 ^c ±.01 | 4.34 ^a ±.06 | .88 ^a ±.02 | 13.05 ^a ±.07 | 11.45 ^a ±.07 |
| 90 | 10 | 2.29 ^{ab} ±.02 | 4.67 ^{bc} ±.3 | 4.29 ^a ±.07 | .84 ^b ±.07 | 12.17 ^{ab} ±.06 | 11.48 ^a ±.06 |
| 85 | 15 | 2.64 ^a ±.01 | 4.80 ^b ±.06 | 4.25 ^a ±.00 | .79 ^b ±.01 | 11.20 ^b ±.21 | 11.50 ^a ±.00 |
| 80 | 20 | 2.58 ^c ±.04 | 4.97 ^b ±.4 | 4.19 ^b ±.02 | .73 ^b ±.07 | 9.6 ^d ±.65 | 11.42 ^a ±.00 |
| 75 | 25 | 2.52 ^c ±.03 | 5.15 ^a ±.01 | 4.13 ^b ±.04 | .60 ^d ±.00 | 8.00 ^d ±.14 | 11.35 ^a ±.07 |

* Average mean score with the same letter(s) on the same column are not significantly different, p=0.05.

Sensory evaluation of *acha*-guava flour blend biscuits

The sensory qualities evaluated are presented in Table 6. The result showed that the average mean score for colour, texture, taste, odour, crispiness, and general acceptability ranged from 4.60±2.19-7.65±1.09, 5.50±1.76-6.85±1.09, 6.10±1.74-7.45±1.09, 5.80±1.39-6.85±1.38, 5.55±2.09-6.85±1.69 and 6.20±1.9-7.95±.76. The effect of guava was significant, p>0.05, for colour, texture, taste, crispiness and general acceptability. The relative increase in the average mean scores for texture could be

due to the increasing fibre content of the guava with effect on the crispiness of the biscuit. The value for odour of the biscuits was not significantly different (p<0.05) from each other. The sample, 95:5 % *acha*-guava blends is the most preferred and acceptable with average mean score of 7.95±.76. This effect on the sensory could be due to inherent flavor compounds in guava. Ayo & Gidado [3] reported a similar range for sensory qualities of *acha*-carrot biscuits and Dabels et al. [35] also reported similar range of wheat, *acha* and mung bean composite biscuit (Figure 2).

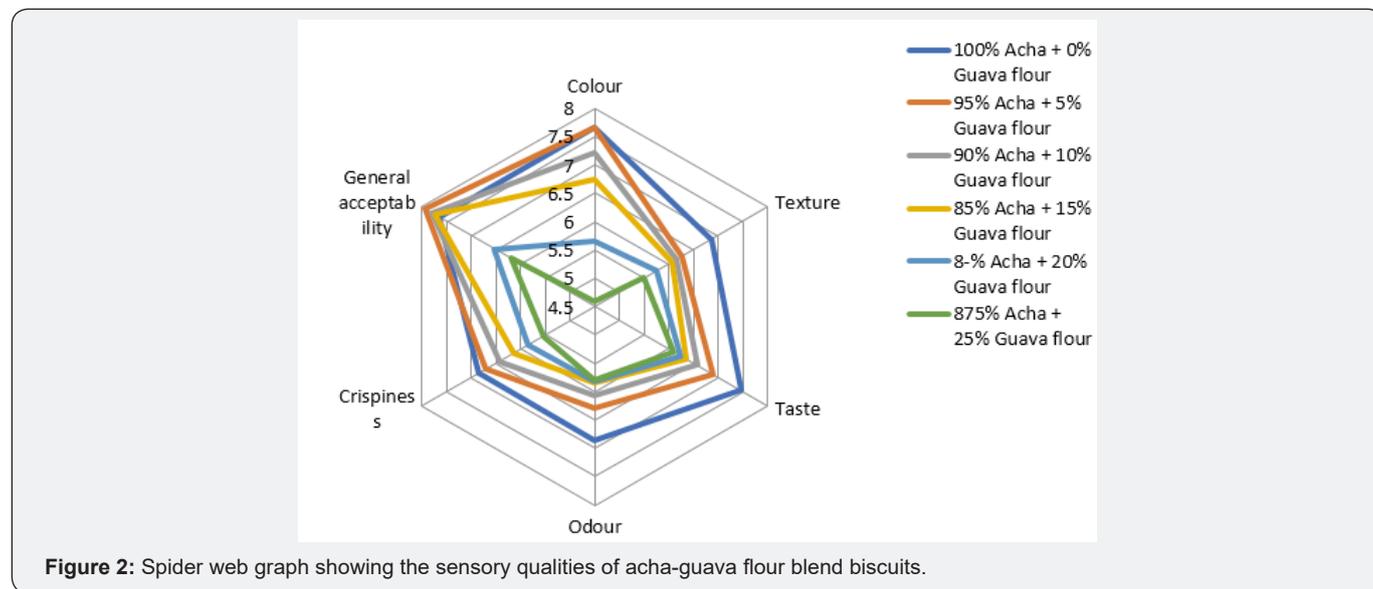


Table 6: Sensory qualities of *acha*-guava flour blends biscuit.

| Acha Flour% | Guava powder% | Colour | Texture | Taste | Odour | Crispiness | General acceptability |
|-------------|---------------|-------------------------|--------------------------|--------------------------|-------------------------|--------------------------|------------------------|
| 100 | 0 | 7.65 ^a ±1.09 | 6.85 ^a ±1.09 | 7.45 ^a ±1.09 | 6.85 ^a ±1.38 | 6.85 ^a ±1.69 | 7.65 ^a ±.81 |
| 95 | 5 | 7.65 ^a ±1.09 | 6.25 ^{ab} ±1.56 | 6.90 ^{ab} ±1.29 | 6.30 ^a ±1.92 | 6.70 ^{ab} ±1.62 | 7.95 ^a ±.76 |
| 90 | 10 | 7.20 ^a ±1.03 | 6.15 ^{ab} ±1.63 | 6.57 ^b ±1.61 | 6.08 ^a ±1.52 | 6.43 ^{ab} ±1.73 | 7.81 ^a ±.67 |

| | | | | | | | |
|----|----|-------------------------|--------------------------|-------------------------|-------------------------|--------------------------|-------------------------|
| 85 | 15 | 6.75 ^a ±1.12 | 6.05 ^{ab} ±1.79 | 6.35 ^b ±1.95 | 5.85 ^a ±1.72 | 6.15 ^{ab} ±1.72 | 7.75 ^a ±.79 |
| 80 | 20 | 5.65 ^{ab} ±1.2 | 5.75 ^b ±1.3 | 6.23 ^b ±1.70 | 5.83 ^a ±1.61 | 5.85 ^b ±1.45 | 6.53 ^{ab} ±.89 |
| 75 | 25 | 4.60 ^b ±2.19 | 5.50 ^b ±1.76 | 6.10 ^b ±1.74 | 5.80 ^a ±1.39 | 5.55 ^b ±2.09 | 6.20 ^b ±1.9 |

* Average mean score with the same letter(s) on the same column are not significantly different, p=0.05.

Conclusion

In conclusion, enriched biscuit with guava-flour substitutions were found to be nutritionally superior in fat content, fibre, iron, carotenoid total phenol, vitamin C and B₁ respectively. The sample with 5% guava flour was most preferred corresponding relatively high improvement in the ash, fat, fibre, iron, carotenoid, vitamin C, total phenol and vitamin B₁ content of the *acha* based biscuits. The appearance and crispiness of the *acha*-guava biscuit were greatly improved and acceptable.

The use of *acha*-guava flour blends in biscuits will go a long way in enhancing nutrition, health and wellbeing of the consumers and reduce the dependence on wheat flour. The properties of *acha*-guava could also make it a good candidate for use as edible blend and as raw material for several domestic and industrial purposes and in medical sector, *acha* could recommended as a dietary supplement for diabetic patients due to its high fibre content minerals and vitamins as result of added guava flour.

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