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# Production and Quality Assessment of Custard from Cornstarch Fortified with Roasted African Yam Bean and Solar Dried African Bush Mango

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***Authors' contributions***

*This work was carried out in collaboration between both authors. Author CSA designed the study, managed the literature searches, performed the statistical analysis, and wrote the first draft of the manuscript. Author IEMN managed the analyses of the study and approved the final manuscript. Both authors read and approved the final manuscript.*

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## ABSTRACT

Corn, roasted African yam bean and solar dried bush mango, were processed into flours and was used to produce custard. The samples, cornstarch: roasted African yam bean: African bush mango flours (CSTF: AYBF: ABMF) were blended in the ratios of 90:5:5, 85:5:10, 80:5:15, 75:5:20, 70:5:25, respectively and were evaluated for chemical composition, functional properties, microbial quality and sensory properties. The addition of African bush mango significantly ($p < 0.05$) increased the moisture, crude fat, crude protein, ash content, and crude fiber from 7.27 to 8.87, 1.42 to1.85, 2.14 to 2.78, 7.45 to 7.89 and 1.32 to 1.69%, respectively while the addition of African bush mango decreased the carbohydrate from 80.39 to 76.92%, pro-vitamin A, vitamin $B_1$, $B_2$, $B_9$ and vitamin C increased with addition of African bush mango from 0.88 to 1.82, 0.85 to 1.63, 0.39 to 0.62, 0.21 to 0.35 and 0.84 to 1.64 (%), respectively. The anti-nutrients phytate, oxalate, heamaglutenin, trypsin inhibitor, tannins, hydrogen cyanide and saponin significantly ($p < 0.05$) decreased from 2.89 to1.43 mg100g$^{-1}$, 0.59 to 0.47mg/100g$^{-1}$, 0.76 to 0.48 HIUmg$^{-1,}$ 0.69 to 0.54 TIUmg$^{-1}$, 19.94 to 11.91mg/100g$^{-1}$, 2.43 to 0.82 mg/100g$^{-1}$ and 0.59 to 0.42 mg/100g$^{-1}$,

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respectively. The addition of African bush mango increased the swelling capacity, wettability, viscosity and gelation capacity from 4.32 to 5.75%, 37.33 to 43.67 sec, 1.31 to 2.278 cp and 21.67 to 23.33% while water absorption capacity and bulk density decreased with an increased African bush mango from 14.67 to10.67% and 1.18 to 0.84 g/dm$^{-3}$. The total viable count ranged from 2.0x10$^{4}$ cfug$^{-1}$ to 1.0x10$^{4}$cfu/g, except for the control which has high total viable count of 8.6 x10$^{3}$cfu/g.

*Keywords: Cornstarch; cereals; fruits; legumes; analogue; processing.*

## 1. INTRODUCTION

"Custard is a yellow (golden) powdery substance. Custard powder is flavored cornstarch with added colour, and could be fortified with vitamins or protein to increase the nutritional value" [1]. "Custard is a good substitute for breakfast cereals such as Quaker oats, cornflakes, ogi and ready- to-serve cereals. Custard powder is predominantly made of starch such as tapioca or cornstarch along with flavouring such as vanilla, salt and annatto for colour" (Quolton, 2016). "Custard powder is also produced by mixing powdered cornstarch, food colour, powdered milk, flavor essence among others. It is prepared by mixing desirable quantity of custard powder with little quantity of water to form a mixture and then stirred continuously till the required gruel thickness is achieved" [2]. "Nutritionally, custard is a source of digestible carbohydrate for cheap energy supply and dietary fiber" [1]. The production of custard powder from cornstarch with flavorings might be very poor in nutrients especially in protein and vitamins. Therefore, fortification of this food with high-quality leguminous plant and a rich vitamin fruit such as African yam bean and African bush mango might improve its protein and vitamin quantity.

"African yam bean is a leguminous plant which contains relatively high amount of protein which could complement the protein in cereal grains, because the chemical and nutritional characteristics of African yam bean make them natural complements to cereal-based diet" [3]. "The proteins of African yam bean are high in lysine, an essential limiting amino acid in most cereals" [4]. "African bush mango (*Irvingia gaboniesis*) is a fruit rich in vitamin C, minerals and phytochemicals such as flavonoids, alkanoids and tannin" [5]. "Processing of the fruit pulp into different forms other than consumption of the pulp would help to reduce post-harvest losses and equalize availability in between seasons in addition to providing essential vitamins, mineral and phytochemicals to the diets" [6]. The main aim was to produce and evaluate the quality characteristics of flour as well as custard powder from cornstarch, African yam bean and fortified with African bush mango blends

## 2. MATERIALS AND METHODS

### 2.1 Procurement of Materials

Yellow corn *(Zea mays)* variety was purchased from Ogige main market in Nsukka Local Government Area. African bush mango was collected from Ezimo while African yam bean was purchased from Obollo-Afor market, both in Udenu Local Government Area, Enugu state.

### 2.2 Preparation of the Plant Materials for Analysis

#### 2.2.1 Processing of corn starch

"During the preparation of starch, two kilograms (2 kg) of yellow corn, free from dirt and other foreign materials such as stones, sticks, and leaves was used as described" by Ihekoronye and Uzomah, [7]. The corn was weighed, cracked into grits, soaked in tap water for 24 hours with the occasional change of water at intervals of 6 hours to prevent fermentation. Thereafter, the steeped grits were drained and wet milled with warm water into fine slurry. The resulting starch slurry was filtered with a muslin cloth and allowed to sediment for 6 hours. The residue was decanted, put into bag to dewater and then dried in an oven at 50$^{o}$C (Model Techmel and Techmel TT 9053, USA). The dried starch was milled and sieved to pass through 400 mm mesh sieve. The starch produced was finally package in low density polyethylene bag.

#### 2.2.2 Processing of roasted African yam bean flour

"African yam bean was processed according to the method described" by Ndife et al. [8]. Five kilograms (5 kg) of African yam bean seeds was sorted from stones, sands, leaves and other foreign materials, was weighed, washed, drained and roasted by subjecting it in a slow fire with slight turning until the seed coat begin to cracked. After roasting, the use of manual winnowing and aspiration was applied to remove lighter dust and chaff. The roasted African yam bean was milled and sieved using 300 mm mesh and then packaged in an airtight container and designated as African yam bean flour.

#### 2.2.3 Processing of solar dried bush mango pulp

African bush mango was processed using the procedure described by Mircea [9]. Three kilograms (3 kg) of the ripe African bush mango was washed, peeled, sliced, and then, treated with sodium metabisulphite of 10 g in 1000 mL of water for 10 minutes. The pulp was dried using solar dryer with model (passive solar dryer') until it becomes pliable, milled, sieved with 300 mm mesh packaged in air tight container and designated as solar dried.

**Table 1. Proportion of Cornstarch and African yam bean flour (%)**

| Sample Code | Cornstarch | African yam bean flour |
|---|---|---|
| CSTF: AYBF | 100 | 0 |
| CSTF: AYBF | 0 | 100 |
| CSTF: AYBF | 90 | 10 |
| CSTF: AYBF | 80 | 20 |
| CSTF: AYBF | 70 | 30 |
| CSTF: AYBF | 60 | 40 |
| CSTF: AYBF | 50 | 50 |

*CSTF= cornstarch flour; AYBF = African yam bean flour*

Table 1, shows the proportion of cornstarch and African yam bean flour.

After getting the best blends of cornstarch and African yam bean, solar dried African bush mango was used to fortify the product (custard). Then commercial custard was used as the control.

### 2.3 Proximate Analyses (%)

"The proximate composition of the samples was determined to ascertain their nutrient composition. All determinations were carried in triplicate samples. Moisture content, crude protein, crude fats, crude fiber, ash, and carbohydrate content were determined according the standard procedure" of AOAC [10].

### 2.4 Determination of Moisture Content

The moisture content of the sample was determined according to the standard procedure of AOAC [10]. The crucible was washed and dried in an oven at $100^0$C for 1 hour. The weight of the crucible was taken as ($w_1$). Two grams (2 g) of each sample was weighed separately before drying and the weight was taken as ($w_2$), then after drying it was reweighed and the weight was taken as ($w_3$).

$$\% \text{ Moisture content} = \frac{w_2 - w_3}{w_1} \times \frac{100}{1}$$

Where; $W_1$ = the weight of the crucible; $W_2$ = Weight of the sample before drying; $W_3$ = weight of the sample after drying.

### 2.5 Determination of Crude Protein Content

The crude protein content of each sample of the flour was determined according to the modified Kjeldahl method of AOAC [10]. Two grams (2 g) of the sample was weighed into a conical flask and 20 mL of concentrated sulphuric acid and a pinch of digestion catalysts was added for homogenization, then it was transfer into a digestion rack for heating until a greenish clear solution appears. The solution was then allowed to cool and made up to 100 mL with distilled water. Then, 10 mL was pipetted and transferred into the distillation flask and then 10 mL of NaOH and 10 mL of 2% boric acid (methyl red indicator) was placed under the condenser. The ammonia liberated was absorbed by boric acid indicator and this was titrated with 0.01M Hydrochloric Acid (HCl). The volume of the HCl at which the color would change from green to pink was taken, the reading was taken and calculated as the titer value. The crude protein would be obtained as:

$$\% \text{ Crude protein} = \frac{0.0001401 \times T \times 20 \times 6.25}{W}$$

Where: T= titre value; W=weight of the digested sample; 0.0001401 of nitrogen;

Therefore, protein% =N ×6.25 (conversion factor of protein).

### 2.6 Determination of Crude Fat Content

The use of Soxhlet extraction method of AOAC [10] was used to determine the fat content of each flour sample. The extraction flask was washed with petroleum ether, dried, cooled and weighed. Two grams (2 g) of each sample was weighed into the extraction thimble ($W_1$). It was then placed back in the Soxhlet apparatus. The washed flask was filled to about three quarter of its volume with petroleum ether (b.pt 40 to 60 $^{o}$C). The Soxhlet extractor were reflux for 3 hours, the petroleum ether evaporated leaving only oil in the flask at the end of the extraction ($W_2$). The oil in the extraction flask was dried in an oven at temperature 105 $^{o}$C for 20 minutes, cooled in desiccators and weighed.

% fat = weight of flask + oil –weight of empty flask/weight of sample×100

Where: $W_1$= weight of sample used; $W_2$ = weight of flask + oil.

### 2.7 Determination of Crude Fiber Content

The crude fiber content of the sample was determined according to AOAC [10] method. Five grams (5 g) of the sample was weighed into 250 volumetric flask and fat was extracted with petroleum ether by stirring, allowed to stand for about 1 hour and decanted. Then, 200 mL of diluted sulphuric acid was added and the beaker was placed on digestion apparatus with pre-adjusted hot plate and boiled for 30 minutes, cooled and filtered through a Buchner funnel. After filtering, the insoluble matter was washed with boiled water until it becomes free of acid. The residue was placed back into the original flask by means of a wash bottle containing 200 mL of 1.25% sodium hydroxide solution and reheat again for 30 minutes. The mixture was allowed to stand for 1 hour, filtered with boiled water, collected the residue put into a crucible and oven dried at 105$^{o}$C for 1 hour then weighed.

Crude fiber (%) =

$$\frac{\text{Oven dried sample - weight of sample incineration}}{\text{Weight of sample taken}} \times 100$$

### 2.8 Determination of Ash Content

Ash content was determined according to the method of AOAC [11]. Crucible was washed and dried in an oven at 105 $^{O}$C for 30 minutes ($W_1$). Then, two grams (2 g) of the sample was placed in a crucible, and was dried or ignited in oven at 105 $^{o}$C for 1 hour, cooled and weighed ($W_2$). The samples (mg/ 100g).

$$\%\ \text{ash} = \frac{(w_3 - w_1)}{(w_2 - w_1)} \times 100$$

Where: $W_1$ = weight of dish; $W_2$ = weight of dish +sample before drying; $W_3$ =weight of dish + sample after drying.

### 2.9 Determination of Carbohydrate Content (%)

The carbohydrate content of the flour in each case was determined by difference according AOAC [11]. The sum of all other proximate content (% moisture,% ash,% crude protein,% fat) was calculated and the total sum was subtracted from 100% carbohydrate.

% carbohydrate content. =100 − (% moisture +% ash +% fat +% crude protein +% protein)

### 2.10 Determination of Vitamin Content of Flours and Fortified Custard Powder from Cornstarch, African Yam Bean and African Bush Mango (mg/ 100g)

#### 2.10.1 Determination of pro-vitamin A

The vitamin A content was determined using the procedure described by modified AOAC [11] method. One gram (1g) of the sample was weighed into 50 mL conical flask and dissolved in 10 ml of acetone, shake gently and allowed to stand for 20 minutes; decanted to obtained clear solution. Thereafter, 5 mL of hexane was added and two distinct layers were observed and the upper layer was collected with curvets and the absorbance was taken by 453 nm using an ultraviolet spectrophotometer and was calculated using the expression.

$$\text{Pro} - \text{vitamin A mg}/100\text{ g} = \frac{100 \times au\ x\ d\ x\ C}{w \times as}$$

Where

w = weight of sample analyzed
Au = absorbance of the sample solution
As = concentration of standard solution
C = concentration of standard
d = dilution factor

#### 2.10.2 Determination of vitamin B content

Vitamin B content was determined using a modified AOAC [11] method. One gram of sample was macerated, homogenized with 50 mL of sodium hydroxide solution and filtered into a 100 ml flask. Thereafter, 10 mL of filtrate (solution) was pippeted into a beaker and 10 mL potassium dichromate was added for color development. A blank sample were prepared and absorbance was taken at 560 nm. The values of each were calculated thus;

$$\text{Con.(mg)} = \frac{\text{Abs} \times \text{Df} \times \text{volumeof cuvette}}{\text{E}}$$

Where

Abs = Absorbance
Df = Dilution factor
E = Extinction coefficient.

#### 2.10.3 Determination of vitamin C

The titration method was used to determine the vitamin C content (Onwuka, 2018). Two grams of the sample was weighed in a volumetric flask, mixed hot water to form a paste and 100 mL of distilled water was added, mixed thoroughly and filtered to get a clear solution. Then, 25 ml of 0.5% oxalic acid (stabilizing agent) and 2.5 mL acetone was added. The solution was titrated with indophenol solution until a faint pink color develops.

$$\text{Vitamin C mg / 100g} = \frac{100}{W} \times \frac{Vf}{Va}$$

Where

W = weight of sample analysed
Vf = total extract volume
Va = volume of extract situated
0.88 mg Vitamin C = $0.01MCUSO_4$

### 2.11 Determination of Anti-nutritional Factors of Flours and Fortified Custard Powder from Cornstarch, African Yam Bean and African Bush Mango

#### 2.11.1 Determination of Hydrogen Cyanide (mg/ 100g)

Hydrogen cyanide content was determined using Fasset (1996) method. A known quantity of the sample (0.5 g) was weighed, homogenized with 50 ml of distilled water, shaken gently and allowed to stand for 24 hours. Then, the sample was filtered using (Whatman No. 1). One mililiter (1 ml) of the filtrate pipetted into a conical flask, 1ml of alkaline picrate solution was added and heat for 10 minutes, before cooling in a desiccator and reading was taken using uv-visible spectrophotometer 752 USA, at wavelength of 280nm.

#### 2.11.2 Determination of tannin (mg/ 100g)

Tannin was determined according to the method described by Dawra et al*.* [12]. Then, 0.5 g of the sample was macerated, homogenized with 50 ml of distilled water, filtered and pipetted, 3 ml of distilled water, then added 0.01N ferric chloride in 0.01N hydrochloric acid and 3 ml of 0.1 M potassium ferricyanide was also transferred for color to change green and this was taken using uv -visible spectrophotomer 752 USA.

$$\text{Tannin} = \frac{absorbance\ of\ test\ sample}{Absorbance\ of\ standard} \times \frac{Concentration\ of\ standard}{1}$$

#### 2.11.3 Determination of saponin (mg/100g)

Saponin was determined according to the method described by Brunner [13]. The sample (0.5g) was measured in a beaker and 10 ml of petroleum ether was added to homogenized. The solution was filtered and decanted into a test tube. The test tube was placed in a hot boiled water to allow for evaporation of the petroleum ether and thereafter cool in a desiccator for 10 minutes. The residue was dissolved with 6 mL of ethanol, mixed very well and 2 mL was pipetted and transferred into test tube before adding 2 mL of chromogens solution, and it was allowed to stand for 30 minutes and the reading was taken using uv-visible spectrophotometer 752 USA at wave length of 250 nm.

$$\text{Saponin}\left(\frac{\text{mg}}{100\text{g}}\right) = \frac{Saponin\ +\ evaporating\ dish - evaporating\ dish}{Sample\ size}$$

#### 2.11.4 Determination of trypsin inhibitor (TIU /mg)

Trypsin inhibitor was determined by the method of Maxwell et al*.* [14] method. Then, 0.5 g of the sample was weighed into a centrifuge tube. Then, 10 ml of phosphate buffer was added, stirred and allowed to stand for 1 hour. The solution was centrifuged for 5 minutes and 2 mL was transferred into another test tube before 5% of trichloro acetic -acid and 0.2 mL of casein was added, mixed and allow to stand for 1 hour. Then, the resultant solution was centrifuged to separate the liquid from the residue and thereafter decanted into a curvetbefore the reading was taken using a uv -visible spectrophotometer 752 USA, at wavelength of 410 nm.

#### 2.11.5 Determination of heamaglutinins (HIU/ mg)

The determination of heamaglutinins was carried by the method described by Lorbetskie et al. [15]. Then, 2 grams of each sample were weighed and 50 ml of solvent of mixture of isobuttyalcohol and trichloroacetic acid was added, shaken thoroughly to extract the heamagglutinin. The mixture was filtered through a double layer filter paper and maintained in water bath for 2 hours at 80$^{o}$C and allowed to cool. The absorbance of the filtrate was taken at 220 nm on digital spectrophotometer 21D.

## 2.12 Determination of Some Functional Properties of Flours and Fortified Custard Powder from Cornstarch, African yam Bean and African Bush Mango

### 2.12.1 Determination of bulk density (g/ dm$^{-3}$)

Bulk density of the sample was determined using the gravimetric method described by Onwuka (2018). A weighed sample (10 g) was put in a calibrated (10 mL) measuring cylinder. Then the bottom was tapped repeatedly onto a firm pad on a laboratory bench until a constant volume was observed. The bulk density was calculated as the ratio of the sample level to the volume occupied by the sample after tapping.

Calculation:

$$\text{Bulk density (g/ml)} = \frac{Weight\ of\ sample\ (g)}{Volume\ of\ sample\ (ml)}$$

### 2.12.2 Determination of Water absorption capacity (%)

Water absorption capacity was determined according to the method described by Onwuka (2018). One gram (1 g) of the sample was weighed into a conical graduated centrifuge tube, mix with 10 ml of distilled water for 30 seconds. The sample was allowed to stand for 30 minutes at room temperature and then centrifuge for 30 minutes. Then, the volume of free water was read directly from the graduated centrifuge tube.

Water absorption capacity (%)

mL of water absorbed = 10-mL decanted

grams or mass of water absorbed = ml of water x density of weight

$$\text{Therefore, \% water absorption capacity} = \frac{Mass\ of\ water\ absorbed}{Mass\ of\ sample} \times \frac{100}{1}$$

### 2.12.3 Determination of viscosity (Cp)

Viscosity was determined using the method described by Onwuka (2018). Then, 0.5 g of the sample was measured into a beaker and homogenized with 50 ml of distilled water, stirred for 2 hours at room temperature. The viscosity of the solution was determined using Oswald viscometer.

### 2.12.4 Determination of Wettability (sec)

Wettability was determined according to Onwuka (2018) method. Into a 25 mL graduated cylinder five gram (5 g) of the sample was measured into. Then, a finger is placed over the open end of the cylinder, it was inverted and clamp at a height of 19 cm from the surface of a 600 mL beaker containing 500 mL of distilled water. Thereafter the finger was removed to allow the test material to be dumped. The wettability was taken as the time required for the sample to be completely wet.

### 2.12.5 Determination of gelation capacity (%)

The gelation concentration was determined according to the method described by Onwuka (2018). The sample (5 g) of each and put into separate test tube. A suspension was made 5 mL of distilled water, heated with continuous stirred for an hour in a boiling water bath followed by rapid cooling under running water at room temperature cold tap water. Thereafter, the test tube was cooled further for 2 hours at 4$^{o}$C. The gelation capacity of each samples was determined at the point of concentration when the sample from the inverted test tube would not fall or slip.

### 2.12.6 Determination of swelling capacity (%)

The swelling capacity of the flour samples were determined as the ratio of the swollen volume to the ordinary volume of a unit weight of the flour. The method of Abbey and Ibeh (1998) was used. One gram (1g) of the sample was weighed into a clean dry measuring cylinder. The volume occupied by the sample was before 5 mL of distilled water was added to the sample and this was left to stand for an hour after which the volume was recorded again. The index of the swelling capacity of the sample was given as:

$$\text{Swelling capacity} = \frac{Volume\ occupied\ by\ the\ sample\ after\ swelling}{Volume\ occupied\ by\ the\ sample\ before\ swelling}$$

## 2.13 Microbiological Analysis of Fortified Custard Powder from Blends of Cornstarch, African Yam Bean and African Bush Mango

### 2.13.1 Total viable count of custard powder ($cfug^{-1}$)

The total viable count was determined using the pour plate method described by Prescott et al. [16]. A serial dilution was done using sterilized test tubes. A26 gram of nutrient agar was dissolved in 500 mL of distilled water which were homogenized. The sample and sterilized quarter strength of ringer solution was used. Then, 1 ml of the sample and 9 ml ringer solution was made for serial dilutions. The diluted solution was pipetted into a marked sterile Petri dish, rocked or swirled to mix and incubated at 37 $^{o}$C for 24 hours. After incubation, a colony counter was used to count the number of colonies and represented as $cfug^{-1}$ (colony forming unit per gram).

$$\text{Total viable count (TVC)} = \frac{N}{V \times D}$$

Where,

N = Number of colonies
V = Volume of dilution used.
D = dilution factor

## 2.14 Mould Count of Fortified Custard Powder from Blends of Cornstarch, African Yam Bean and African Bush Mango

Mould count was determined according to Prescott et al. [16]. Fifteen grams (15 g) of Sabouraud Dextrose Agar (SDA) was prepared and diluted with 500 ml of distilled water. The SDA media was added to 1 ml of the sample in the Petri dish, mixed and allowed to set before incubating at 37$^{o}$C for 24 hours. After incubation, the number of colonies was counted and presented as colony forming unit per gram.

## 2.15 Sensory Evaluation of Fortified Custard Powder from Blends of Cornstarch, African Yam Bean and African Bush Mango

The fortified custard samples were assessed by thirty (30) members of semi- untrained panelist that was selected randomly from the Department of Food Science and Technology and Department of Crop Science University of Nigeria, Nsukka. The samples were evaluated for colour, consistency, flavor, flavor, taste, aftertaste, mouth feel and overall acceptability on a 9-point Hedonic scale (where 9= extremely like and 1= extremely dislike) as described by Ihekoronye and Ngoddy [7]. The samples were presented in coded plates, served plain without the addition of any sweetener (sugar) to find out the most acceptable blend.

## 2.16 Experimental Design and Data Analysis

The data generated from the flour blends was subjected to T-test for mean separation while that of custard was subjected to one-way analysis of variance (ANOVA) using the Statistical Product for Service Solution (SPSS) version 23 and Duncan's New Multiple Range Test was used to separate the treatment means. Significance was accepted at $P < 0.05$ according to steel and Torrie (1980).

# 3. RESULTS AND DISCUSSION

## 3.1 Proximate Composition of Cornstarch and Roasted African Yam Bean Flours

The results showed the proximate composition of sample cornstarch flour (CSTF) and roasted African yam bean flour (RAYBF) as shown in Table 2. The moisture, crude protein, crude fat, ash, crude fiber and carbohydrate contents of sample were 11.73, 5.53, 12.05, 2.22, 1.59 and 66.89%, respectively were significantly ($P < 0.05$) different from values of proximate composition obtained for sample RAYBF 6.06, 20.80, 1.28, 2.49, 1.65 and 67.74%, respectively. Nwodo et al. [17] reported that "proximate composition of African yam bean (*Sphenostylis stenocarpa)* consumed in South-Eastern Nigeria was found to contain moisture content of 8.86, crude protein 21.40, fat 7.35, ash 5.78, crude fiber 2.68, and carbohydrates 51.78%, respectively. This showed that African yam bean is important food sources that could be exploited particularly in the developing countries where there was shortage of animal protein and under nutrition facing many families".

## 3.2 Anti-nutritional Factors of Cornstarch and Roasted African Yam Bean Flours

The anti-nutritional compositions of the cornstarch and roasted African yam bean flours are shown in Table 3. For cornstarch flour,

**Table 2. Proximate composition (%) of cornstarch and roasted African yam bean flours**

| Samples / composition (% ) | CSTF | RAYBF |
|---|---|---|
| Moisture | 11.73$^{c}$±0.00 | 6.06$^{d}$±0.01 |
| Crude Protein | 5.53$^{d}$±0.01 | 20.80$^{e}$±0.00 |
| Crude fat | 12.05$^{b}$±0.00 | 1.28$^{a}$±0.00 |
| Crude fiber | 1.59$^{f}$±0.00 | 1.65$^{b}$±0.01 |
| Ash | 2.22$^{e}$±0.01 | 2.49$^{c}$±0.00 |
| Carbohydrate | 66.89$^{a}$±0.01 | 67.74$^{f}$±0.01 |

*Values are means of triplicate determinations ± standard deviation. Means on the same row with the different superscripts is significantly (P < 0.05) different. CSTF = Cornstarch flour; RAYBF= Roasted African yam bean flour.*

*T- Test was used to obtained the mean separation of the flour blends*

the anti-nutrients saponin, hydrogen cyanide, trypsin inhibitor, heamaglutenin, tannin, oxalate, phytate were 0.36mg/100g, 0.05 mg/100g, 0.50mg/100g, 0.53TIU/mg, 0.65HIU/mg, 0.54mg/100g and 2.25 mg/100, respectively, while the anti-nutritional factors of roasted African yam bean (RAYBF) were 0.22, 0.02, 0.35, 0.62, 0.74, 0.58 and 2.30 mg/100, respectively. Chikwendu et al*.* [18] reported that roasting of Bambara groundnut reduced the saponin levels in flours from 0.16 to 0.02 mg/100. The hydrogen cyanide content was also reduced from 0.49 to 0.25 mg and 0.26 to 0.06 mg. The importance of roasting in the processing of plant foods cannot be over emphasized, in that it is one of the simplest and cheap food processing techniques for reducing anti-nutrient and improving the nutritional quality of local staples in many homes.

**Table 3. Anti-nutritional Factors of Cornstarch and Roasted African Yam Bean Flour**

| Samples/ Parameters | CSTF | RAYBF |
|---|---|---|
| Saponin (mg/100g) | 0.36$^{b}$±0.11 | 0.22$^{b}$±0.00 |
| Hydrogen cyanide (mg/100g) | 0.05$^{a}$±0.00 | 0.02$^{a}$±0.01 |
| Trypsin inhibitor (TIU/mg) | 0.50$^{c}$±0.00 | 0.35$^{c}$±0.01 |
| Haemaglutenin (HIU/mg) | 0.53$^{d}$±0.00 | 0.62$^{e}$±0.00 |
| Tannin (mg/100g) | 0.65$^{f}$±0.00 | 0.74$^{f}$±0.00 |
| Oxalate (mg/100g) | 0.54$^{e}$±0.00 | 0.58$^{d}$±0.00 |
| Phytate (mg/100g) | 2.25$^{g}$±0.00 | 2.30$^{g}$±0.00 |

*Values are means of triplicate determinations± standard deviation. Means on the same row with the different superscripts is significantly (P < 0.05) different. CSTF = Cornstarch flour, RAYBF= roasted African yam bean flour*

*T- Test was used to obtained the mean separation*

## 3.3 Proximate Composition (%) of Cornstarch and Roasted African Yam Bean Flour Blends

The proximate composition (%) of cornstarch and roasted African yam bean flour blends are presented in Table 4. Samples CSTF and RAYBF contain moisture (3.16 to 4.81), crude protein (7.44 to 12.53), crude fat (4.11 to 5.22), crude fiber (1.38 to 1.77), ash (2.29 to 2.290) and carbohydrate (75.54 to 78.61), respectively. It was observed that sample 90:10 had the highest moisture content (4.81%) while sample 50:50 had the lowest value (3.16%). It was also observed that 50:50 had the highest crude protein content (12.53%) while sample 90:10 had the lowest value (7.44%). Sample 90:10 had the highest fat content (5.22%) had the lowest value (4.11%). It was also observed from the results that sample 50:50 had the highest crude fiber content (1.77%) while 90:10 had the lowest value (1.38%). From the result, sample 90:10 had the highest carbohydrate content (78.61%) while sample 50:50 had the lowest value (75.54%) on the addition of African yam bean.

It was shown that there were significant (*P* < 0.05) differences in the various blends for all the parameters. There was a decrease in the moisture, fat and carbohydrate content, which could probably be due to increase of roasted African yam bean flour. However, crude protein, crude fiber and ash were observed to increase progressively. This depicts that the blending of CSTF and RAYBF in custard powder fortification would have a significant impact in solving nutrition problems, particularly protein-energy malnutrition. Okoye et al*.* [19] reported that crude protein content of the flour blends increased steadily with increased substitution with African yam bean, while carbohydrate decreased. Obasi et al*.* [20] reported that at 5% level of confidence, roasted brown African yam bean had the highest ash content (4.21%), followed by roasted white African yam bean which had an ash content of 4.17% and raw brown African yam bean which had 4.05% ash. Raw white African yam bean had ash content of 3.97%. The high crude protein content of the varieties is an indication that its use could help reduce protein-deficiency conditions such as kwashiorkor.

## 3.4 Anti-nutritional Factors of Cornstarch and Roasted African Yam Bean Flour Blends

The anti-nutritional factors of sample of cornstarch and roasted African yam bean flours are shown in Table 5. The values ranged from: Saponin (0.40 to 0.53 mg/100g), hydrogen cyanide (0.14 to 0.27 mg/100g), trypsin inhibitor (0.43 to 0.57 TIU/mg), hemeaglutenin (0.61 to 0.73 HIU/mg), tannin (0.43 to 31.05 mg/100g), oxalates (0.61 to 0.72 HIU/mg), and phytate and (2.76 to 3.49 mg/100g), respectively for the different blends.

**Table 4. Proximate compositions of cornstarch and roasted African yam bean flour blends**

| Sample blends / Parameters (%) | Moisture | Crude Protein | Fats | Crude Fiber | Ash | Carbohydrate |
|---|---|---|---|---|---|---|
| CSTF+RAYBF (90:10) | 4.81$^{a}$±0.00 | 7.44$^{e}$±0.00 | 5.22$^{a}$±0.00 | 1.38$^{e}$±0.01 | 2.29$^{e}$±0.00 | 78.61$^{a}$±0.40 |
| CSTF+RAYBF(80:20) | 4.56$^{b}$±0.01 | 7.93$^{d}$±0.01 | 4.82$^{b}$±0.01 | 1.55$^{d}$±0.00 | 2.60$^{d}$±0.01 | 78.49$^{b}$±0.03 |
| CSTF+RAYBF(70:30) | 4.15$^{c}$±0.00 | 9.64$^{c}$±0.01 | 4.65$^{c}$±0.01 | 1.65$^{c}$±0.01 | 2.69$^{c}$±0.00 | 77.22$^{c}$±0.02s |
| CSTF+RAYBF(60:40) | 4.05$^{d}$±0.01 | 10.33$^{b}$±0.00 | 4.61$^{d}$±0.01 | 1.70$^{b}$±0.00 | 2.85$^{b}$±0.01 | 76.49$^{d}$±0.02 |
| CSTF+RAYBF(50:50) | 3.16$^{e}$±0.00 | 12.53$^{a}$±0.01 | 4.11$^{e}$±0.00 | 1.77$^{a}$±0.01 | 2.90$^{a}$±0.00 | 75.54$^{e}$±0.01 |

*Values are means of triplicate determinations ± standard deviation. Mean on the same column with different superscripts are significantly (P < 0.05) different*
*CSTF=Cornstarch flour and African yam bean flour, RAYBF= Roasted African yam bean flour*

**Table 5. Anti-nutritional factors of cornstarch and roasted African yam bean flour blends**

| Sample / parameters | Saponin mg100g$^{-1}$ | Hydrogen cyanide mg100g$^{-1}$ | Trypsin Inhibitor TIU/mg | Haemaglutenin HIU/mg | Tannin mg100g$^{-1}$ | Oxalate mg100g$^{-1}$ | Phytate mg100g$^{-1}$ |
|---|---|---|---|---|---|---|---|
| CSTF+RAYBF (90:10) | 0.40$^{e}$ ±0.00 | 0.27$^{a}$±0.00 | 0.43$^{d}$±0.00 | 0.61$^{e}$±0.01 | 0.43$^{d}$±0.00 | 0.61$^{e}$±0.00 | 2.76$^{e}$±0.00 |
| CSTF+RAYBF (80:20) | 0.47$^{d}$±0.00 | 0.27$^{a}$±0.00 | 0.51$^{c}$±0.01 | 0.64$^{d}$±0.00 | 29.13$^{d}$±0.00 | 0.64$^{d}$±0.01 | 2.98$^{d}$±0.00 |
| CSTF+RAYBF (70:30) | 0.49$^{c}$±0.00 | 0.25$^{c}$±0.01 | 0.54$^{b}$±0.007 | 0.69$^{c}$±0.00 | 30.03$^{c}$±0.00 | 0.67$^{c}$±0.00 | 2.99$^{c}$±0.00 |
| CSTF+RAYBF (60:40) | 0.51$^{b}$±0.01 | 0.20$^{d}$±0.00 | 0.56$^{a}$±0.00 | 0.71$^{b}$±0.01 | 30.26$^{b}$±0.01 | 0.71$^{b}$±0.00 | 4.01$^{a}$±0.01 |
| CSTF+RAYBF(50:50) | 0.53$^{a}$±0.00 | 0.14$^{e}$±0.00 | 0.57$^{a}$±0.005 | 0.73$^{a}$±0.01 | 31.05$^{a}$±0.01 | 0.72$^{a}$±0.01 | 3.49$^{b}$±0.00 |

*Values are means of triplicate determinations ± standard deviation. Means on the same column with different superscripts are significantly (P <0.05) difference.*
*CSTF=Cornstarch, RAYBF= Roasted African yam bean flour*

**Table 6. Sensory scores of cornstarch and roasted Africa yam bean flour blends**

| Sample / sensory attributes | Color | Consistency | Flavor | Taste | Aftertaste | Mouth feel | Overall Acceptability |
|---|---|---|---|---|---|---|---|
| CSTF (100:0) | 7.23$^{a}$±0.73 | 6.30$^{a}$±1.26 | 5.67$^{ab}$±1.52 | 6.13$^{b}$±1.61 | 6.05$^{abc}$±1.60 | 6.13$^{a}$±1.41 | 5.58$^{b}$±1.47 |
| RAYBF (100:0) | 2.17$^{c}$±0.83 | 3.97$^{c}$±2.61 | 2.23$^{c}$±1.28 | 1.93$^{d}$±1.05 | 1.67$^{d}$±0.88 | 2.43$^{d}$±1.14 | 2.87$^{d}$±1.07 |
| CSTF+RAYBF(90:10) | 7.57$^{a}$±0.73 | 5.67$^{ab}$±1.24 | 6.57$^{a}$±1.04 | 7.77$^{a}$±1.19 | 6.07$^{ab}$±0.98 | 5.90$^{ab}$±0.88 | 8.13$^{a}$±0.63 |
| CSTF+RAYBF(80:20) | 6.23$^{b}$±1.52 | 5.97$^{ab}$±1.63 | 5.33$^{b}$±2.07 | 4.77$^{c}$±2.01 | 4.83$^{bc}$±1.64 | 5.20$^{bc}$±1.56 | 5.50$^{c}$±1.70 |
| CSTF+RAYBF(70:30) | 6.00$^{b}$±1.70 | 5.67$^{ab}$±1.90 | 5.17$^{b}$±2.44 | 5.07$^{c}$±2.18 | 5.30$^{abc}$±1.93 | 5.27$^{bc}$±2.02 | 5.70$^{c}$±1.90 |
| CSTF+RAYBF(60:40) | 5.93$^{b}$±1.48 | 5.33$^{b}$±2.07 | 5.30$^{b}$±2.10 | 5.27$^{bc}$±2.43 | 5.00$^{bc}$±2.57 | 4.93$^{c}$±2.23 | 5.57$^{c}$±2.18 |
| CSTF+RAYBF(50:50) | 5.83$^{b}$±1.58 | 5.50$^{ab}$±1.81 | 5.07$^{b}$±2.07 | 4.70$^{c}$±2.23 | 5.00$^{bc}$±2.15 | 5.13$^{bc}$±2.11 | 5.40$^{c}$±2.03 |

*Values are means of triplicate determinations ± standard deviation of 30 evaluations. Mean on the same column with different superscripts are significantly (P < 0.05) difference*
*CSTF=Cornstarch flour; RAYBF= Roasted African yam bean flour*

**Table 7. Proximate composition (%) of fortified custard powder from blends of cornstarch, African yam bean and African bush mango flour blends**

| Samples/ Parameter (%) | Moisture content | Crude Fat | Ash | Crude Protein | Crude Fiber | Carbohydrate |
|---|---|---|---|---|---|---|
| CSTF+RAYBF+ABMF (90:5:5) | $7.29^{f}$±0.01 | $1.42^{f}$±0.01 | $2.14^{e}$±0.00 | $7.45^{e}$±0.00 | $1.32^{f}$±0.00 | $80.39^{b}$±0.01 |
| CSTF+RAYBF+ABMF (85:5:10) | $7.52^{e}$±0.01 | $1.44^{e}$±0.0 | $2.32^{d}$±0.00 | $7.75^{d}$±0.00 | $1.33^{e}$±0.01 | $79.63^{c}$±0.06 |
| CSTF+RAYBF+ABMF (80:5:15) | $7.86^{d}$±0.00 | $1.64^{c}$±0.01 | $2.57^{c}$±0.01 | $7.76^{c}$±0.00 | $1.51^{d}$±0.01 | $78.65^{d}$±0.03 |
| CSTF+RAYBF+ABMF (75:5:20) | $8.72^{c}$±0.18 | $1.69^{b}$±0.01 | $2.59^{b}$±0.00 | $7.88^{b}$±0.00 | $1.62^{c}$±0.00 | $77.49^{e}$±0.18 |
| CSTF+RAYBF+ABMF (70:5:25) | $8.87^{b}$±0.01 | $1.85^{a}$±0.00 | $2.78^{a}$±0.01 | $7.89^{a}$±0.00 | $1.69^{b}$±0.01 | $76.92^{f}$±0.02 |
| PHC (control) | $9.93^{a}$±0.01 | $1.53^{d}$±0.23 | $0.22^{f}$±0.00 | $1.13^{f}$±0.00 | $1.90^{a}$±0.00 | $85.67^{a}$±0.02 |

*Values are means of triplicate determinations ± standard deviation. Mean values on the same column with different superscripts are significantly (P < 0.05) different CSTF =cornstarch flour; RAYBF = roasted African yam bean flour and PHC = Plain Hollandia Custard (control)*

**Table 8. Vitamin content of fortified Custard powder from blends of Cornstarch, African yam bean and African bush mango flour**

| Samples / Parameter (mg/ 100g) | Pro-vitamin A | Vitamin $B_1$ | Vitamin $B_2$ | Vitamin $B_9$ | Vitamin C |
|---|---|---|---|---|---|
| CSTF+RAYBF+ABMF (90:5:5) | $0.88^{f}$±0.00 | $0.85^{e}$±0.01 | $0.39^{f}$±0.00 | $0.21^{d}$±0.01 | $0.84^{f}$±0.01 |
| CSTF+RAYBF+ABMF (85:5:10) | $0.93^{e}$±0.01 | $0.88^{d}$±0.00 | $0.44^{e}$±0.00 | $0.21^{d}$±0.00 | $0.89^{e}$±0.00 |
| CSTF+RAYBF+ABMF (80:5:15) | $1.04^{d}$±0.00 | $0.90^{c}$±0.00 | $0.52^{d}$±0.00 | $0.24^{c}$±0.01 | $0.90^{d}$±0.00 |
| CSTF+RAYBF+ABMF (75:5:20) | $1.27^{c}$±0.00 | $1.30^{b}$±0.01 | $0.58^{c}$±0.00 | $0.28^{b}$±0.01 | $1.30^{c}$±0.00 |
| CSTF+RAYBF+ABMF (70:5:25) | $1.82^{b}$±0.00 | $1.63^{a}$±0.00 | $0.62^{b}$±0.00 | $0.35^{a}$±0.01 | $1.64^{b}$±0.01 |
| PHC (control) | $1.87^{a}$±0.01 | $0.88^{d}$±0.01 | $0.73^{a}$±0.01 | $0.36^{a}$±0.02 | $1.67^{a}$±0.01 |

*Values are means of triplicate determinations ± standard deviation. Mean values on the same column with different superscripts are significantly (P < 0.05) different. CSTF= cornstarch flour; RAYBF= roasted African yam bean flour and PHC= plain Hollandia custard (control)*

**Table 9. Some selected functional properties of fortified custard powder from blends of cornstarch, African yam bean and African bush mango flour**

| Samples/ Parameters | Water Absorption capacity (%) | Swelling capacity (%) | Bulk density ($g/dm^{-3}$) | Wettability (sec) | Viscosity (cp) | Gelation capacity (%) |
|---|---|---|---|---|---|---|
| CSTF+RAYBF+ABMF (90:5:5) | $14.67^{a}$±0.58 | $4.32^{e}$±0.00 | $1.18^{e}$±0.01 | $37.33^{c}$±0.58 | $1.31^{e}$±0.075 | $21.67^{b}$±1.53 |
| CSTF+RAYBF+ABMF (85:5:10) | $11.67^{b}$±2.89 | $4.57^{d}$±0.00 | $0.88^{a}$±0.00 | $41.33^{b}$±1.53 | $1.87^{d}$±0.013 | $22.57^{c}$±0.58 |
| CSTF+RAYBF+ABMF (80:5:15) | $10.67^{b}$±1.16 | $5.07^{c}$±0.01 | $0.86^{b}$±0.00 | $42.67^{ab}$±1.16 | $2.24^{c}$±0.004 | $22.33^{a}$±2.08 |
| CSTF+RAYBF+ABMF (75:5:20) | $10.67^{b}$±1.16 | $5.36^{b}$±0.01 | $0.85^{c}$±0.00 | $42.67^{ab}$±1.53 | $2.45^{b}$±0.006 | $23.33^{a}$±0.58 |
| CSTF+RAYBF+ABMF (70:5:25) | $10.67^{b}$±1.16 | $5.75^{a}$±0.00 | $0.84^{c}$±0.00 | $43.67^{a}$±0.58 | $2.78^{a}$±0.004 | $23.33^{a}$±0.58 |
| PHC (control) | $10.67^{b}$±1.16 | $3.92^{f}$±0.052 | $0.82^{d}$±0.008 | $35.67^{c}$±1.16 | $1.11^{f}$±0.004 | $22.57^{c}$±1.73 |

*Values are means of triplicate determinations ± standard deviation. Means on the same column with different superscripts are significantly (P < 0.05) difference. CSTF = cornstarch flour; RABMF = roasted African bush mango flour; ABMF =African bush mango flour and PHC = Plain Hollandia Custard*

It was observed that saponin, hydrogen cyanide, and tannin decreased progressively from 0.40 to 0.53, 0.14 to 0.27 mg/100g), respectively with the increase in proportion of roasted African yam bean flour while trypsin inhibitor, haemaglutenin, oxalates and phytate increase in their levels with increases in the percentage of roasted African yam bean flour. However, which is in agreement with Usman (2012) who reported anti-nutrients in formulated breakfast cereals from blends of Africa yam bean flour and defatted coconut. Generally, antinutrients are considered toxic, for instance, tannins may form insoluble complexes with proteins, thereby decrease the digestibility of protein [21]. It was observed that sample 90:10 was the best blend of cornstarch and roasted African yam bean flour in all the parameters since it had low anti-nutrient content.

### 3.5 Sensory Scores of Cornstarch and Roasted African Yam Bean Flour Blends

The sensory scores of sample flour and roasted African yam bean flour blends are presented in Table 6. The sensory scores observed shows that all the attributes evaluated are significantly ($P$ < 0.05) different from unblended sample. RAYBF (100:0) gave the least score of 2.87 in the overall acceptability of the sensory scores. On the other hand, 90:10 blends of cornstarch and roasted African yam bean gave highest scores in color, consistency, flavor, taste, and overall acceptability of 7.57, 5.67, 6.57, 7.77, 6.07, 5.90 and 8.13, respectively. It was generally observed that all the sensory parameters investigated showed decreasing scores as the percentage of roasted African yam bean increased in the blended samples. Akintuke [22], determined some of the sensory qualities which decreased significantly ($P$ < 0.05) with increasing quantity of African yam bean flour.

### 3.6 Proximate Composition of Fortified Custard Powder from Blends of Cornstarch, African Yam Bean and African Bush Mango

The proximate composition from the best blends of the three samples consisting of corn-starch, roasted African yam bean and dried African bush mango flour as shown in Table 7. The moisture, crude fat, ash, crude protein, crude fiber and carbohydrate contents ranged from 7.29 to 8.87, crude fat 1.42 to 1.85, ash 2.14 to 2.78, protein 7.45 to 7.89, crude fiber 1.32 to 1.69, and carbohydrate 76.92 to 80.39%. The plain Hollandia custard (control) which was used as the control had, 9.93, 1.53, 0.22, 1.13, 1.90, and 85.67%, respectively. The results showed that there was a significant ($P$ < 0.05) difference and also showed that 90:5:5 had the lowest moisture content (7.29%). The plain Hollandia custard had the highest moisture contents (9.93%). The ash content of plain Hollandia custard (0.22) were significantly lower than that of the individual blends. Conversely, crude fiber and carbohydrate contents of plain Hollondia custard (control) 1.90 and 85.60%, respectively were found to be significantly (p < 0.05) higher compared with those of the various blends. Generally, it was observed that the moisture content increased with an increase in African bush mango this could be probably due to the fact that African bush mango flour absorbed moisture during storage. This led to the high moisture content of the blended flour. The results showed that the plain Hollandia custard which was used as the control had a protein content of 1.13% which was significantly (p < 0.05) different and lower compared to the formulated sample. Sample 70:5:25 has the highest protein content (7.89%). Okoye et al. [19] reported that African yam bean is a nutrient- dense, having high protein content which agreed closely with the report of Alozie et al. [23].

"Carbohydrate content decreased with an increase in African bush mango flour and decrease in cornstarch. This could probably be due to the fact that the amylopectin that formed after reconstitution was very low as the quantity of corn-starch flour were varying as reported by" Martens et al. (2018). "Ash content of formulated custard powder increased with an increase in quantity of African bush mango flour when compared to the plain Hollandia custard (control). Sample 70:5:25 had higher ash content (2.78%) than the control (0.22%) which could be as a result of high mineral content in African bush mango as reported by" Awaziem [24]. "It could also be as a result of the roasted African yam bean flour used for the processing of the formulated sample" [20]. "Crude fat content of the formulated sample increased with increase in African bush mango flour due to the fat content of African bush mango pulp (3.20%) as reported by" Mbaeyi and Anyanwu [25].

"The result showed that formulated custard powder was significantly ($P$ < 0.05) different from the control (PHC). The crude fiber increased with increase in African bush mango flour and this could be due to the fibrous nature of the solar dried bush mango flour as reported by" Ajibade et al. [26]. “Carbohydrate content was found to decrease as level of dried African bush mango flour increased; which could be as a result of variation in the quantity of cornstarch and bush mango as reported by” Ajibade et al*.* [26].

### 3.7 Vitamin Content of Fortified Custard Powder from Blends of Cornstarch, African Yam Bean and African Bush Mango

The vitamin contents of custard analogue powder from the flour blends of Cornstarch, roasted African yam bean and African bush mango flours was presented in Table 8. Pro-Vitamin A, vitamin $B_1$, $B_2$, $B_9$, and C contents ranged from 0.88 to 1.82, 0.85 to 1.63, 0.39 to 0.62, 0.21 to 0.35, and 0.84 to 1.64 (mg/100g). While plain Hollandia custard (PHC) which was used as the control had 1.87, 0.88, 0.73, 0.36 and 1.67 (mg/100g) respectively. Pro-vitamins A, $B_1$, $B_2$, $B_9$ and vitamin C of the different blend samples 85:5:10 to 70:5:25 increased as the amount of African bush mango flour increased. This increase could be due to high content of Beta-carotene and vitamins in African bush mango, when compared with the values 0.77, 0.86, 0.46, 0.45 and 0.24 (mg/100g) as reported by Shiriki et al*.* [27].

### 3.8 Some Selected Functional Properties of Fortified Custard Powder from Blends of Cornstarch, African Yam Bean and African Bush Mango

“The functional properties of custard powder from the flour blends of cornstarch, roasted African yam bean and African bush mango are presented in Table 9. The water absorption capacity of the fortified custard powder ranged from 10.67 to 14.67% and it was higher than that of the plain Hollandia custard which was used as the control (10.67%). This study showed increased in swelling capacity of the blended samples ranged from 4.32 to 5.75 (%) which is significantly ($P$ <0.05) difference from the control 3.92%. This could be due to the fact that the cornstarch used for the study were inherently high in starch protein complex as reported by” Ikegwu et al*.* [28]. “The decrease in bulk density could be due to the presence of more crude fiber in African bush mango which is in accordance with the observations made by” Singh et al*.* (1996). This study showed increased in wettability, viscosity and gelation capacity and it ranged from 37.33 to 43.67 sec, 1.31 to 2.78 Cp and 21.67 to 23.33%. This could be attributed to presence of cornstarch and African yam bean which agreed closely with the report of Onyarekua and Adeyeye, [29]. This authors obtained wettability, viscosity and gelation temperature values of 42.33 to 43.56 sec, 1.45 to 2.62 Cp and 22.43 to 23.34 (%), respectively.

### 3.9 Anti-nutrients Content of Fortified Custard Powder from Blends of Cornstarch, African yam Bean and African Bush Mango Flour

“The anti-nutrient contents of fortified custard powder from the blends of cornstarch, African yam bean and African bush mango flours are presented in Table 10. The results showed that the anti-nutrient content from the flour blends decreased as the amount of African bush mango increased. These were significantly ($P$ < 0.05) difference from that of the control sample. The phytate value ranged from 1.43 to 2.89 mg/100g and it was lower than those of kidney bean (40.8 mg/g) as reported” by Olaofe et al*.* [30], soybean (40.5%) and cowpea (20.4 mg/g) as reported by Aletor and Omodara [31] Phytate could affect digestibility by chelating with calcium or proteolytic enzymes. Oxalate value of the samples was very low and ranged from 0.37 to 0.59 mg/100g. “The presence of oxalate has undesirable effects on calcium absorption and utilization. This acid combines with calcium to form calcium oxalate which passes through the intestine unabsorbed. The amount of oxalate formed depends on the amount of oxalic acid in the food as reported” by Kumar et al*.* (2019). It was also observed that Heameaglutenin and trypsin inhibitor, were low and ranged from 0.48 to 0.76 Hiu/mg, and 0.54 to 0.69 Tiu/mg, respectively. Tannin content in the samples generally could be considered to be of little nutritional significance, though the levels of the tannin in this study ranged from 9.63 to 19.94 mg/100g were higher than those in *M.pruriens* 0.3 to 7.8g/100g as reported by Agbede and Metor [32]. Hydrogen cyanide and saponin were also low and ranged from 0.82 to 2.43 mg/100g and 0.42 to 0.59 mg/100g, respectively. The plain Hollandia custard which was used as the control had phytate1.87 mg/100g, oxalate 0.62 mg/100 g, heamaglutenin 0.50HIU/mg, trypsin inhibitor 0.39TIU/mg, tannin 10.04 mg/100g, hydrogen cyanide 0.04 mg/100g and saponin0.33 mg/ 100g, respectively.

**Table 10. Anti-nutritional factors of fortified custard powder from blends of corn-starch, African yam bean and African bush mango flour blends**

| Samples/ Parameters | Phytate mg100g$^{-1}$ | Oxalate mg100g$^{-1}$ | Haemaglutenin HIU/mg | Trypsin Inhibitor TIU/mg | Tannin mg100g$^{-1}$ | HCN mg100g$^{-1}$ | Saponin mg100g$^{-1}$ |
|---|---|---|---|---|---|---|---|
| CSTF+RAYBF+ABMF (90:5:5) | 2.89$^{a}$± 00 | 0.59$^{b}$±0.00 | 0.76$^{a}$±0.01 | 0.69$^{a}$±0.00 | 19.94$^{a}$±0.00 | 2.43$^{a}$±0.00 | 0.59$^{a}$±0.00 |
| CSTF+RAYBF+ABMF (85:5:10) | 2.67$^{b}$±0.00 | 0.55$^{c}$±0.00 | 0.75$^{b}$±0.01 | 0.68$^{b}$±0.01 | 18.21$^{b}$±0.00 | 1.96$^{b}$±0.00 | 0.57$^{b}$±0.00 |
| CSTF+RAYBF+ABMF (80:5:15) | 1.59$^{d}$±0.00 | 0.50$^{d}$±0.00 | 0.69$^{c}$±0.01 | 0.57$^{c}$±0.00 | 15.17$^{c}$±0.00 | 1.52$^{c}$±0.01 | 0.52$^{c}$±0.00 |
| CSTF+RAYBF+ABMF (75:5:20) | 1.57$^{e}$±0.00 | 0.47$^{e}$±0.00 | 0.68$^{d}$±0.00 | 0.56$^{d}$±0.00 | 11.91$^{d}$±0.00 | 1.28$^{d}$±0.01 | 0.48$^{d}$±0.00 |
| CSTF+RAYBF+ABMF (70:5:25) | 1.43$^{f}$±0.01 | 0.37$^{f}$±0.01 | 0.48$^{f}$±0.00 | 0.54$^{e}$±0.00 | 9.63$^{e}$±0.01 | 0.82$^{e}$±0.00 | 0.42$^{e}$±0.00 |
| PHC (control) | 1.87$^{c}$±0.01 | 0.62$^{a}$±0.01 | 0.50$^{e}$±0.01 | 0.39$^{f}$±0.01 | 10.04$^{f}$±0.26 | 0.04$^{f}$±0.01 | 0.33$^{f}$±0.01 |

*Values are means of triplicate determinations ± standard deviation. Means on the same column with different superscripts are significantly (P < 0.05) different. . CSTF = cornstarch flour; RABMF = roasted African bush mango flour; ABMF =African bush mango flourand PHC = Plain Hollandia Custard*

**Table 11. Sensory scores of fortified Custard powder from blends of cornstarch, roasted African yam bean and African bush mango flour blends**

| Sample/ Parameters | Color | Consistency | Flavor | Taste | Aftertaste | Mouth feel | Overall Acceptability |
|---|---|---|---|---|---|---|---|
| CSTF+RAYBF+ABMF (90:5:5) | 4.80$^{c}$±1.10 | 3.00$^{b}$±1.31 | 5.60$^{a}$±1.22 | 2.37$^{c}$±0.96 | 3.00$^{b}$±1.23 | 3.33$^{bc}$±0.96 | 2.87$^{c}$±0.97 |
| CSTF+RAYBF+ABMF (85:5:10) | 6.57$^{a}$±0.90 | 6.63$^{a}$±1.03 | 5.37$^{a}$±1.27 | 6.17$^{a}$±1.21 | 4.03$^{a}$±1.54 | 4.83$^{a}$±1.12 | 6.23$^{a}$±1.28 |
| CSTF+RAYBF+ABMF (80:5:15) | 2.33$^{d}$±1.03 | 2.73$^{b}$±1.26 | 3.10$^{c}$±1.40 | 3.20$^{b}$±1.77 | 3.23$^{c}$±0.94 | 3.87$^{b}$±1.78 | 2.97$^{b}$±1.45 |
| CSTF+RAYBF+ABMF (75:5:20) | 2.87$^{d}$±1.11 | 2.47$^{b}$±1.17 | 3.80$^{b}$±1.52 | 2.87$^{bc}$±1.07 | 3.07$^{b}$±1.36 | 3.33$^{bc}$±1.18 | 3.23$^{b}$±1.38 |
| CSTF+RAYBF+ABMF (70:5:25) | 2.28$^{d}$±1.142 | 2.38$^{b}$±0.91 | 3.32$^{bc}$±1.40 | 2.37$^{c}$±1.03 | 3.00$^{b}$±1.23 | 3.10$^{c}$±1.27 | 2.43$^{bc}$±1.11 |
| PHC (control) | 5.60$^{b}$±1.22 | 2.63$^{b}$±1.35 | 3.07$^{c}$±1.26 | 2.90$^{bc}$±1.42 | 3.53$^{d}$±1.14 | 5.30$^{a}$±1.49 | 6.21$^{c}$±1.13 |

*Values are means of triplicate determinations ± standard deviation. Means on the same column with different superscripts are significantly (P < 0.05) different. CSTF = cornstarch flour; RABMF = roasted African bush mango flour; ABMF =African bush mango flour and PHC = Plain Hollandia Custard*

**Table 12. Microbial count of fortified custard powder from blends of cornstarch, African yam bean and African bush mango flour blends**

| Samples/ Parameters | Total viable count (cfug$^{-1}$) | Mould count (cfu /g) |
|---|---|---|
| CSTF+RAYBF+ABMF (90:5:5) | 2.0x10$^{4}$ | ND |
| CSTF+RAYBF+ABMF (85:5:10 | 2.1x10$^{4}$ | ND |
| CSTF+RAYBF+ABMF (80:5:15) | 1.2x10$^{4}$ | ND |
| CSTF+RAYBF+ABMF (75:5:20) | 1.1x10$^{4}$ | ND |
| CSTF+RAYBF+ABMF (70:5:25) | 1.0x10$^{4}$ | ND |
| PHC (control) | 8.6x10$^{3}$ | 1.0x10 |

*Values are means of triplicate determination ± standard deviation. Means on the same column with different superscripts are significantly (P < 0.05) different. CSTF = cornstarch flour; RABMF = roasted African bush mango flour; ABMF =African bush mango flour and PHC = Plain Hollandia Custard. ND = Not Detected*

From the research, according to the following authors [33-35] (Adewusi et al. 1995) it was indicated: phytate 2.12 (mg/100g), oxalate 0.79 (mg/100g), tannin 8.46 (mg/100g), HCN 3.14 (mg/100g), saponin 0.30 (mg100g) respectively meet the international standard. Therefore, from this study, there was a general reduction in the content of all the anti-nutritional factors as the amount of African bush mango increased, this could be as a result of processing that destroyed the anti-nutrient according to Obiakor [36] since tannins are mostly located at the seed coat roasting is one of the simplest and cheapest food processing techniques for reducing the anti-nutrients and improving the nutritional quality of local staples food in many homes. And also it showed that African bush mango has minimal anti-nutritional factors. Onwuka (2018) stated that "dehulling which took place after roasting must have contributed to the reduction of the level of tannin".

### 3.10 Sensory Scores of Fortified Custard Powder from Blends of Cornstarch, African Yam bEan and African Bush Mango Flour Blends

The sensory scores of custard powder from cornstarch, roasted African yam bean and African bush mango flour blend are presented in Table 11. The sensory scores for color ranged from 2.28 to 6.57, consistency 2.38 to 6.63, flavor 3.32 to 5.60, taste 2.37 to 6.17, after taste 3.00 to 4.03, mouth feel 3.10 to 4.83 and overall acceptability2.43 to 2.87 while the control had scores of 5.60, 2.63, 3.07, 2.90, 3.53, 5.30 and 6.21 for color, consistency, flavor, taste, aftertaste, mouth feel and overall acceptability respectively. The sensory scores showed no significant difference in samples 90:5:5; 75:5:20; and 70:5:25 in aftertaste, no significantly difference in samples 90:5:5; 80:5:15; 75:5:20 and 70:5:25, in color and 90:5:5 and 75:5:20 in mouth feel. For taste, no significant ($P$ < 0.05) difference were observed for 75:5:20 and the control. From the results, sample 85:5:10 had the highest score (6.23) in overall acceptability. It was further observed that the control sample had significantly ($P$ < 0.05) higher score in mouth feel (5.30) and overall acceptability (6.21). Akintuke [22] reported a significantly ($P$ < 0.05) decreased in mouth feel with increasing quantity of African yam bean flour in the formulation of custard powder. After reconstitution into gruel with boiling water which was served plain without sweetener showed that the fortified custard powder with 85:5:10 was the most acceptable (6.23).

### 3.11 Microbial Count of Fortified Custard Powder from Blends of Cornstarch, African Yam Bean and African Bush Mango Flour Blend

The total viable count of fortified custard powder from the blends of cornstarch, roasted African yam bean and African bush mango flours are shown in Table 12. The total viable count ranged from $2.1\times10^4$ to $1.0\times10^4$ cfu/g while the control sample had the highest total viable count ($8.6\times10^3$ cfu/g) after incubation for 24 hours. This could be as a result that the control sample had stayed long on the shelf before it was purchased. This observation was in conformity with the work of Obiakor (2008) who gave total viable count of $2.2\times10^4$ to $1.0\times10^3$cfu/ for African yam bean flour and pearl millet flour packed in low density polyethene bags, respectively. From the results, it was shown that no mould growth was detected for both fortified samples and the control sample. According to Deibel et al. [37], "it stated that $1.2\times10^4$ cfu/g meets the International Microbiological Standards Recommended units of bacterial counts for dry and ready-to-eat foods and the values obtained in the present study are within standard" [38-40].

## 4. CONCLUSION

This study showed that flours could be produced from corn, African yam bean, and African bush mango pulp. Nutrient-rich custard could be produced from the blends of cornstarch, roasted African yam bean and African bush mango flours. The blended samples had increased in moisture, crude protein, ash and crude fiber, as the level of African bush mango increased, while carbohydrate content decreased as level of African bush mango increased. The addition of African bush mango flour improved in pro-vitamin A, vitamin $B_1$, $B_2$, $B_9$, and C contents. There was an increased in swelling capacity, viscosity, and gelation while water absorption capacity, bulk density and wettability decreased as African bush mango increased. There was a general decrease in all the anti-nutrients.

The study showed that the total viable count ranged from $2.1\times10^4$ to $1.0\times10^4$ cfu/g and also there was no mould growth detected from the blended samples. The sensory scores showed sample 85:5:10 had the highest scores in all the sensory parameters (color, consistency, flavor, taste, mouth feel, and overall acceptability) was preferred by the panelists and equally African bush mango improved the micronutrient composition in the formulated custard. African yam bean and African bush mango flours could be used to fortify custard which are low in protein and some micronutrient. Also, the consumption of food-based on African yam bean varieties would be an important step towards alleviating protein-energy malnutrition in the developing countries.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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