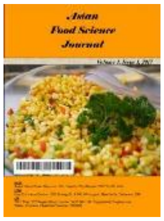

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Micronutrients in African Yam Bean-carrot Flours and Acceptability of Its Gruels for Complementary Food

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Authors' contributions

This work was carried out in collaboration between all authors. Author REK designed the study, wrote the protocol, read the draft manuscript. Author PEO performed the laboratory work, managed the literature searches and wrote the draft of the manuscript and author JKI co-supervised the study. All authors read and approved the final manuscript.

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ABSTRACT

Aims: To explore the benefits of the African Yam Bean (AYB) and carrot composite flour blend for combating the problem of micronutrient deficiency in Nigeria.
Place and Duration of Study: Chemistry Department, Benue State University, Makurdi and Advance Animal Science Laboratory, Covenant University, Ota, Ogun State, Nigeria, between December, 2017 and April, 2018.
Methodology: Production was done in three stages: first, AYB was processed into flour, carrots into powder and finally the blend formulation of the AYB and Carrot composites was prepared by material balancing in the ratio of 100:0, 80:20, 70:30, 50:50 and 0:100. Chemical and micronutrient evaluation was then carried out. Standard procedures of AOAC were then used to analyse the

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micronutrients in the samples and the sensory qualities of the gruel was evaluated using nine-point hedonic scale. The data were subjected to one way ANOVA and Duncan Multiple Range Test to detect the significant differences.

Results: The results obtained shows that beta carotene (vitamin A precursor), thiamine, vitamin B_2, B_6, and B_{12} content of formulations increased in the range from 10.26±0.04 - 102.19±0.00, 0.19±0.01 - 0.22±0.00, 0.05±0.00 - 0.95±0.01, 4.68±0.01 - 15.39±0.01 respectively with addition of carrot powder in a blend. The calcium, iron, potassium, magnesium and sodium content of the flours ranged from 10.51±0.01 - 39.16±0.05, 1.26±0.01 - 10.94±0.02, 407.94±0.06 - 90.69±0.01, 49.24±0.03 - 70.33±0.00 and 86.23±0.02 - 106.31±0.02 respectively. The products were moderately liked by the panellist with the least sample 70:30 liked slightly.

Conclusion: The results of this study indicate that these composite flour blends could be considered as an alternative source for formulating products with high acceptability and micronutrient content especially vitamin A. However, the biological value of this composite flour needs to be known and reconciled with chemical composition before it could effectively be used in weaning children.

Keywords: African yam beans; carrot; composite flour; vitamin A.

1. INTRODUCTION

Vitamin A Deficiency related disease (VAD) is one of the major micronutrient deficiencies affecting children and pregnant women [1]. Report on the effect of Vitamin / Mineral deficiency by UNICEF indicated that approximately 25% of Nigerian children will grow up with low immunity and over 80,000 children in Nigeria die each year from the increased susceptibility of infection due to VAD [2]. This has prompted the need to search into alternative means to tackle the persisting hiding hunger challenges in Nigeria.

Many researchers have recommended legume-fruit / vegetable composite flour used in the making of complementary foods in a bid to meet the needs of children and other vulnerable population in Nigeria [3,4]. Composite blend flours from two or more varied food materials mixed to improve nutritional content and complement each other's properties have more quality than that produced from an individual component of foods [5].

Children are normally given these staples in form of gruel [6]. In developing countries like Nigeria, complementary foods are based on starchy tubers or on cereals, which are nutritionally inadequate for children growth and development [7]. Infants and younger children, whose dietary habits differ from those of adults, require special attention and enrichment of food commodities, which is a very attractive and economic way to prevent and control mineral and vitamin deficiency [8]. Hence, the use of these two crops, which are under-utilised by food industries in the production of formulated food products of high nutritional quality.

African Yam Bean (AYB) (*Sphenostylis stenocarpa*) is an indigenous legume of West and tropical Africa. The seed of African Yam Bean (AYB) have a distinctive flavour [9] and contain nutrients and minerals that are comparable to other food legumes [10]. However, unlike other legumes, it is less-known and under-utilised in different food applications in Nigeria [11]. It is rich in minerals [12], but low in vitamins like carotene and vitamin B_6. Thus, the fortification with vegetable crops that are high in these vitamins will improve the nutritional quality of this legume seed.

Carrots (*Daucus carota* L) are root vegetables from the umbelliferous plant. They are the best-known plant source of pro-vitamin A carotenoids [9]. Carrot is a good source of some essential vitamins and minerals especially vitamin A (β-carotene) [13,14,15]; in appreciable quantities when compared with other commonly consumed vegetables [16]. However, carrots are highly seasonal and perishable. As a result of this factor, commercial exploitation of carrot has been limited in most developing countries despite its potentials [17].

A number of authors have investigated the use of different Nigerian indigenous foods: Ibeanu and others [18] made a ready-to-eat infant complementary gruel from blending hunger rice, beniseed and soya bean; Madukwe et al. [19] blended roasted melon seed, maize and cowpeas and its gruels proved more nutritious with good acceptance; Nwogwugwu and coresearchers [20] developed a novel weaning food, containing varying quantities of pap and AYB with good acceptance; Ngwu et al. [21] used different treatment on AYB and observed that it increased its nutrient content with their gruel acceptability. Report has shown that micronutrient food fortification is effective when it is acceptable to the consumer and complies with the use thereof and that consumer compliance and acceptability should precede micronutrient fortification projects [22].

It is on this backdrop of the prevalence of micronutrient deficiency in Nigerian children that informed the research objectives. Apparently, this study is focused on investigating the micronutrients and sensory acceptability of AYB flour and carrots powder in the formation of a complementary gruel for children.

2. MATERIAL AND METHODS

The main materials collected for this research are: brown African yam beans, carrot, lime orange and sugar cubes, which were purchased in Makurdi, Benue State, Nigeria. The samples were prepared at the Benue State University, Makurdi, while mineral and vitamin analysis was carried out in Covenant University, Ota, Ogun State, Nigeria.

2.1 Processing of AYB Flour and Carrot Powder

The method described by Ngwu et al. [21] was used with modifications. Five kilogram (5 kg) of AYB was weighed, sorted, washed and sundried after fermentation for 48 hours. The roasted bean was coarsely grinded, winnowed to remove the seed coats and grinded into flour using attrition mill and packed.

The method described by Marvin [23] was adopted and modified by using grater with no chemical added to prevent browning. Carrot root was sorted, washed with table salt solution and rinsed with portable water. After which the carrot was peeled, rinsed and manually grated. The grated carrot was blanched with hot water at 90°C for 3 min and pre-dried by air on thin layer polythene for 8 h. The carrot was dried in an air oven (Genlab OV/100/F) at 60±5°C for 14 h. The dried carrot was finally grinded into powder using blender (Binatone BLG-40C, China), and sieved using muslin cloth, then packed in an air-tight container.

2.2 Composite Blends

The AYBF and carrot powder was blended together using mass balancing method and formulation ratios, five sample groups: 100% AYBF (control) is A^1; 80% AYBF + 20% Carrot powder (blend) is AC^2; 70% AYBF + 30% Carrot powder (blend) is AC^3; 50% AYBF + 50% Carrot powder (blend) is AC^4; and 100% Carrot powder (control) is C^5 composites. Fig. 1 shows the flow chart of AYB flour and carrot powder composite blends.

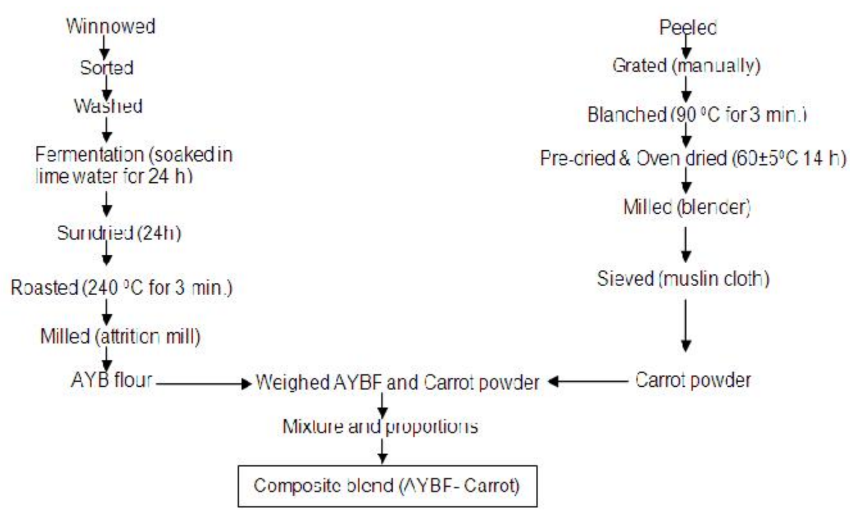

Fig. 1. Flow chart for the processing of AYB flour and carrot powder composite blend

2.3 Vitamin Content Analysis

2.3.1 Vitamin A (Beta-carotene)

This method involved chromatographic separation and quantitative determination at 325 nm as described by AOAC [24]. Five (5) g of the samples were weighed and placed in 100 mL volumetric flasks and homogenised. The samples were saponified with ethanoic KOH (antioxidant added) for 30 min and transferred into the separatory funnel, rinsed using H_2O/ETOH and repeatedly extracted with hexane. The samples were separated and determined by HPLC using MEOH/H_2O, 95/5 (v/v) as the mobile phase. A UV detector set at 325 nm was used to detect the amount of retinol content of the samples.

2.3.2 Vitamin B_1 (Thiamine) and Vitamin B_2 (Riboflavin)

Vitamin B_1 and B_2 were determined, as described by AOAC [24] using HPLC, 5 g of homogenised samples were weighed into 100 mL volumetric flasks and 0.1 N HCl was added and mixed then autoclaved for 30 min at 121°C. After the samples cool down interfering substances were precipitated by adjusting the pH to 6.0, which was followed immediately by readjusting the pH to 4.5. This was then diluted to volume with water and filtered. Afterwards, 5 mL of 6% enzyme (Mylase 100) was added and incubated for 3 h at 45-50°C, it was then cooled and the pH adjusted to 3.5 and diluted with water to volume, mixed and then filtered. After that 10 mL of the diluted extract was oxidised by passing it through a sepPak c_{18} cartridge followed by 5 mL 0.01 M phosphate buffer at pH 7.0. The vitamins were then separated by HPLC using a 4.6mm x 25cm ultra-sphere ODS, 5 columns or equivalent and detected by fluorescence at 360 nm/415 nmex/em. The concentrations of the vitamins were measured from the peak height and area of sample and standard while the contents of Biotin, Riboflavin and Thiamine were obtained by calculation using equation 2.1:

$$\mu g/g = C \times V \times (DF/MT) \qquad (2.1)$$

Where:

C = Concentration of vitamin in μg/ml obtained from peak height or area of sample and standard
V = Sample volume, mL
DF = Dilution Factor
MT = Sample Mass, g

2.3.3 Vitamin B_6 (Pyridoxine)

AOAC [24] method was used in the determination of vitamin B_6. Two (2) g portion of each of the formulated samples was weighed into 500 mL Erlenmeyer flask and 200 mL 0.4 M HCl was added. The solution was autoclaved for 2 h at 121°C, cooled to room temperature and the pH was adjusted to 4.5 with 6 M KOH. The solution was diluted to 250 mL with water in a volumetric flask and filtered through Whatman No. 40 paper. A 40-200 mL filtered aliquot was taken for chromatography. Desired amount of the filtered extract was placed on ion exchange column in 50 mL portions and allowed to pass completely through with no flow regulation. Beaker and column were washed 3 times with 5 mL portions of hot 0.02 CH_3COOK (pH 5.5). Pyridoxal was eluted with two 50 mL portions of boiling 0.04 M CH_3COOK (pH 6.0) using 100 mL volumetric flask as receiver. Pyridoxine was eluted with two, 50 mL portions of boiling 0.1 M CH_3COOK (pH 7.0), using 100 mL volumetric flask as receiver. Pyridoxamine was eluted with two 50 mL of boiling $KClK_2HPO_4$ (pH 8.0) solution, using 250 mL beaker as receiver and the pH adjusted to 4.5. Pyridoxine and pyridoxal eluates were diluted to 100 mL and pyridoxamine to 200 mL with water. Ten (10) mL each of the standard pyridoxine, pyridoxal and pyridoxamine solution was then neutralised with KOH and adjusted pH 4.5 with CH_3COOH. The resulting solutions were each put on column, washed and eluted as above. Eluted pyridoxine and pyridoxal standards were diluted to 100 mL and pyridoxamine to 200 mL with water. Each standard was diluted to 1.0 mg/mL with water.

2.3.4 Cyanocobalamin (Vitamin B_{12})

The AOAC [24] method was used in determining vitamin B_{12}. One (1 g) of each sample was weighted into a 250 mL volumetric flask. Hundred (100 mL) of distilled water was added and spanned or shaken for 45 min and made up to mark with distilled water. The sample mixture was filtered into another 250 mL beaker, rejecting the first 20 mL that had been filtered. Another 20 mL filtrate was collected. To the filtrate, 5 mL of 1% sodium dithionite solution were added to decolourise the yellow colour. Standard cyanocobalamin of range 0-10 μg/mL was prepared from stock cyanocobalamin. A sample blank made up to mark with distilled water was also prepared. The absorbance of samples as well as standard was read at a wavelength of 445 nm on a spectronic 21D spectrophotometer.

Vitamin B_{12} = (Absorbance of sample x Gradient Factor x Dil. Factor/ Wt. of sample) (3.10)

2.4 Mineral Analysis

The mineral content of samples was estimated using the method described by AOAC [24].Each sample (2 g) was transferred into a crucible and ashed in a muffle furnace at 500°C for 3 h. The crucibles were removed after the ashing was completed. After cooling, 10 mL of 2 M HCl acid was added and heated directly until boiling point. The contents in each crucible were thereafter transferred into 50 mL volumetric flask and then diluted to 50 mL. The optical density of elements was determined using the Atomic Absorption Spectrophotometer (Model 2011-A).

2.5 Sensory Evaluation

Gruel was prepared from each of the flour samples in accordance with Ngwu et al. [21] procedures. The basic quality characteristics considered were colour, mouth feel, taste, flavour and overall acceptability. Evaluation was done by 20 panellists from among the Postgraduate students and Staff of Benue State University, Makurdi, Benue State, Nigeria. Each panellist was provided with five disposable cup and spoon to rate the quality of AC gruel sample attributes on a 9-point hedonic scale. The gruels presented was served warm and coded (A^1, AC^2–AC^4, C^5).

2.6 Statistical Analysis

The data obtained were reported as duplicate observations. The data were subjected to one way analysis of variance (ANOVA) using Statistical Package (SPSS) 20 software. Duncan Multiple Range Test was used to detect significant differences (*P* = .05).

3. RESULTS AND DISCUSSION

3.1 Vitamin Composition

The result of the vitamin composition of AYB flour and carrot powder composite is as shown in Table 1. The data shows that carrot control sample (C^5) is an important source of Vitamin A (Beta carotene), B_6, and B_{12} than AYBF control sample (A^1). This is an indication that the carrot powder can efficiently enrich AYBF with vitamin A precursor, and particularly the composite blend AC^4 (50:50) could be an important choice in the bid to reduce Vitamin A deficiency diseases (VAD).

There was an observed increase in Beta carotene among the composite formulation samples from 21.28 µg AC^2 (80:20) to 47.98 µg in AC^4 (50:50) with increasing carrot powder in the formulation. This is supported by an early study by Ibidapo et al. [3]. It also observed that carrot control sample (C^5) had the highest mean score of 0.22 mg thiamine within the samples, while AC^2 (80:20) blend had the least mean grade of 0.18 mg in the composite flours. There was no mean score grade difference among the composite samples. The WHO safe level recommendation of thiamine is 0.3 – 0.7 mg / day [25]. This indicates that the samples could meet the nutrient intake recommendation for children from 4 month to 6 years of age. The results shown in Table 1 indicate that the carrot control sample (C^5) examined contained slightly more Riboflavin (Vitamin B_2) at 0.95 mg than AYBF control sample (A^1) at 0.05 mg and that, as the ratio of carrot powder in the blend samples increases with the level of Vitamin B_2 composition with a difference of 0.32 mg between AC^4 and AC^2 blends. Riboflavin is vital in protein metabolism in the body [26]. The results of the sample blends (AC^2 to AC^4) showed that it could meet the nutrient intake requirement for infants and children given by WHO [25].

The results shown in Table 1 indicate that the carrot control sample (C^5) examined is a good source of Pyridoxine (Vitamin B_6) at 15.39 mg. The table also shows a trend of increase in Vitamin B_6 content as the carrot composition in the blends increases. The 50:50 ratio blend (AC^4) has the highest among of Pyridoxine (Vitamin B_6) of the composite flour at 10.99 mg. The samples would be able to meet nutrient requirement recommendation during the first two years of children [27]. The 100% carrot sample (C^5) and AYBF sample (A^1) were shown to be good sources of Cobalamin (Vitamin B_{12}) at 12.20 mg and 11.15 mg respectively. Consequently, all the blends (AC^2 to AC^4) are good choice as sources of Vitamin B_{12} in the formation of complementary foods for children. The table also shows the trend of increase in Vitamin B_{12} content as the carrot composition in the blends increases or AYB content is reduced. All samples meet the recommended nutrient intakes of children for vitamin B_{12} of µg / day

[27], although it seems that the result as presented in Table 1 may have been affected by the duration of exposure of the samples to heat (heat labile vitamin) and water (leaching during blanching) when processing. All results show a significant difference at $p < .05$.

3.2 Mineral Composition

This section presents the results from mineral analysis. Table 2 shows that the mineral composition of the flours was significantly different at $P < .05$ and that AYBF control sample (A^1) and carrot control sample (C^5) have an appreciable level of the minerals tested. 100% AYBF (A^1) in particular is a good source of calcium, iron, potassium, sodium and magnesium. The composite blend AC^2 (80:20) particularly has a high mineral composition of 9.11 mg and it is an important blend for complementary food in Nigeria. It also shows that AYBF control sample (A^1) had higher calcium content (39.16 mg) in comparison to carrot control sample (C^5) with 10.5 mg. The observation is in agreement with the report given by Uguru and Madukaife [28]. The table indicates a decreasing trend in calcium composition as AYBF in the composite flour reduces with a range from 35.9 4 mg (AC^2) to 23.92 mg (AC^4). The blend sample 80:20 had the highest calcium composition at 35.94 mg making it an important choice for complementary food in Nigeria. Table 2 shows that AYBF control sample (A^1) is rich in iron with a high content of 10.94 mg and carrot control sample (C^5), low in iron at 1.26 mg. The table also shows a decrease trend in iron with a reduction in AYBF inclusion. This agrees with the findings of Okoye and Obi [29].

Table 1. Vitamin composition of AYB flour and carrot powder (AC) composite flour

	A^1 100:0 control	AC^2 80:20 blend	AC^3 70:30 blend	AC^4 50:50 blend	C^5 0:100 control
β-carotene (µg)	$10.26^{e}\pm0.04$	$21.28^{d}\pm0.02$	$39.02^{c}\pm0.00$	$47.98^{b}\pm0.02$	$102.19^{a}\pm0.00$
Thiamine (mg/100 g)	$0.19^{b}\pm0.01$	$0.18^{b}\pm0.00$	$0.19^{b}\pm0.00$	$0.20^{b}\pm0.01$	$0.22^{a}\pm0.00$
Riboflavin (mg/100 g)	$0.05^{e}\pm0.00$	$0.13^{d}\pm0.01$	$0.29^{c}\pm0.00$	$0.45^{b}\pm0.00$	$0.95^{a}\pm0.01$
Pyridoxine (mg/100 g)	$4.68^{e}\pm0.01$	$6.88^{d}\pm0.03$	$8.11^{c}\pm0.01$	$10.99^{b}\pm0.01$	$15.39^{a}\pm0.01$
Cobalamin (mg/100 g)	$11.15^{e}\pm0.02$	$11.31^{d}\pm0.01$	$11.46^{c}\pm0.01$	$11.68^{b}\pm0.01$	$12.20^{a}\pm0.02$

Values are mean ± SD of vitamin composition of AC flour blend. Samples with different superscript within the same row were significantly different (P < .05)

Key:
A^1 = 100% African yam bean flour (AYBF)
AC^2 = 80% AYBF + 20% Carrot powder
AC^3 = 70% AYBF + 30% Carrots powder
AC^4 = 50% AYBF + 50% Carrots powder
C^5 = 100% Carrot powder

Table 2. Mineral content of AC composite flour blend (mg/100 g)

	A^1 100:0 control	AC^2 80:20 blend	AC^3 70:30 blend	AC^4 50:50 blend	C^5 0:100 control
Calcium	$39.16^{a}\pm0.05$	$35.94^{b}\pm0.03$	$31.67^{c}\pm0.01$	$23.92^{d}\pm0.02$	$10.51^{e}\pm0.01$
Iron	$10.94^{a}\pm0.02$	$9.11^{b}\pm0.01$	$7.94^{c}\pm0.03$	$6.07^{d}\pm0.04$	$1.26^{e}\pm0.01$
Potassium	$407.94^{a}\pm0.06$	$369.49^{b}\pm0.71$	$310.11^{c}\pm0.01$	$236.96^{d}\pm0.05$	$90.69^{e}\pm0.01$
Sodium	$106.31^{a}\pm0.02$	$101.02^{b}\pm0.03$	$98.23^{c}\pm0.01$	$93.54^{d}\pm0.08$	$86.23^{e}\pm0.02$
Magnesium	$49.92^{d}\pm0.02$	$49.24^{e}\pm0.03$	$53.34^{c}\pm0.01$	$58.35^{b}\pm0.02$	$70.33^{a}\pm0.00$

Values are mean ± SD of scores of Mineral content of composite flour. Samples with different superscript within the same column were significantly different

Key:
A^1 = 100% African yam bean flour (AYBF)
AC^2 = 80% AYBF + 20% Carrot powder
AC^3 = 70% AYBF + 30% Carrots powder
AC^4 = 50% AYBF + 50% Carrots powder
C^5 = 100% Carrot powder

The result presented in Table 2 shows that AYBF control sample (A^1) is a very rich sources of potassium (407.94 mg.), a much higher level compared to carrot control sample (C^5) at 90.69 mg. The table also shows a decreasing trend in potassium with a reduction in AYBF inclusion. These findings are in line with those of Okoye and Obi [29]. The 80:20 sample blend had the highest potassium composition at 369.49 mg, making it the best choice among the blends for a potassium rich complementary food. Sample A^1 is a rich source of sodium (106.31 mg.), 20.08 mg higher than sample C^5 (86.23 mg). This result was supported by Adeola et al. [30]. All the samples were below the upper limit of sodium intake for children in United Kingdom [25]. Table 2 shows that 100% carrot powder is a rich source of magnesium (70.33 mg), in comparison with AYBF control sample (A^1) at 49.92 mg. The table indicates a decreasing trend in magnesium as carrot powder in composite flour reduced. This result is supported by the works done by Okaka et al. [31] and Adeola et al. [30].

3.3 Sensory Evaluation

Sensory evaluation gives us the opportunity of evaluating consumer compliance and acceptability. The gruel prepared from the AYB + Carrot blends were evaluated for quality. The sensory property of the products and its acceptability by consumers is presented in Table 3. The organoleptic attributes selected for evaluation were appearance, colour, flavour, taste, mouth feel and overall acceptability. The results show that the produced gruels were not significantly different in terms of its sensory attribute at P > .05 and that they were generally accepted by the panellist with good grades, hence we concluded that incorporation of carrot powder into AYB makes good gruel products. In terms of appearance of the gruel samples, Table 3 shows that sample AC^4 (50:50 blend) was the most preferred with a 6.80 mean score and gruel from AYBF control sample (A^1) the least preferred. The AC^4 (50:50 blend) composite appearance complement each other well thereby enhancing the gruel. It also shows that among the blends (AC^2–AC^4), as carrot powder ratio increases, the appearance of the product improved. Therefore, the addition of carrot powder into AYB improved the appeal comparing the mean score of sample AYBF control sample (A^1) to the AC^4 or 50:50 blend. Table 3 shows that sample AC^2 (80:20 blend) was the most preferred with a 6.60 mean score and carrot control sample (C^5) gruel the least preferred in terms of flavour. This implies that the flavour of gruel with 20% supplementation of carrot was most preferred. Comparing the control samples (A^1 and C^5) gruels seems to show that the distinct and pronounced aroma of the AYB was preferred to that of carrot – this has been well articulated by many researchers [9,21].

In terms of taste, the table shows that the gruel samples from AC^2 (80:20) and C^5 (100% carrot) were equally most preferred with a 6.00 mean score. The addition of carrot had no significant impact on taste generally. This result is different from the research done by Nagarajaiah and Prakash [32]. In terms of how the gruel feels in the mouth, Table 3 shows that the gruel sample from AC^4 (50:50) was the most preferred with a mean score of 6.00. However, with the scores being so close, it implies that addition of

Table 3. Mean scores of AYB-carrot composite gruel sensory evaluation summary

	A^1 100:0 control	AC^2 80:20 blend	AC^3 70:30 blend	AC^4 50:50 blend	C^5 0:100 control
Appearance	$4.00^{b}\pm1.41$	$5.00^{ab}\pm1.58$	$6.00^{ab}\pm0.71$	$6.80^{a}\pm1.64$	$6.40^{ab}\pm3.29$
Flavour	$5.20^{a}\pm2.39$	$6.60^{a}\pm1.52$	$5.20^{a}\pm2.17$	$5.60^{a}\pm2.30$	$4.60^{a}\pm2.61$
Taste	$5.40^{a}\pm2.61$	$6.00^{a}\pm1.87$	$5.00^{a}\pm2.74$	$5.20^{a}\pm3.19$	$6.00^{a}\pm2.00$
Mouth feel	$5.20^{a}\pm2.05$	$5.40^{a}\pm1.34$	$5.60^{a}\pm2.07$	$6.00^{a}\pm1.73$	$5.40^{a}\pm1.14$
Colour	$3.80^{a}\pm1.30$	$5.40^{a}\pm1.82$	$6.40^{a}\pm1.52$	$6.40^{a}\pm3.05$	$6.80^{a}\pm3.35$
Overall acceptability	$4.60^{a}\pm2.97$	$6.00^{a}\pm1.00$	$5.80^{a}\pm2.17$	$6.60^{a}\pm2.07$	$6.60^{a}\pm1.67$

Values are mean ± SD of scores of 15 panellists. Samples with different superscript within the same row were not significantly different (P > .05)

Key:

A^1 = 100% African yam bean flour (AYBF)

AC^2 = 80% AYBF + 20% Carrot powder

AC^3 = 70% AYBF + 30% Carrots powder

AC^4 = 50% AYBF + 50% Carrots powder

C^5 = 100% Carrot powder

carrot made no significant impact on mouth feel generally. Most of the panellist preferred C^5 gruel colour (6.80 mean score) the most and A^1 gruel colour (3.80 mean score) the least. The colour of the composite flour improved from 5.40 in AC^2 gruel to 6.40 for AC^4 gruel, this indicates that carrot powder enhances the colour of the blends as proven by the carrot control sample (C^5) gruel. This result agrees with Nagarajaiah and Prakash [32]. Table 3 shows that AC^4 (50:50 blend) and 100% carrot (C^5) offered the most preferred gruels of all the samples with a 6.60 mean score each overall. Gruel from 100% AYBF (A^1) was the least preferred (4.60 mean score) overall. This agrees with work done by Ngwu et al. [21]. It also indicates that carrot powder incorporation into AYB improves the composite blends not only nutritionally but also its sensory attribute, therefore making AYB gruel more accepted and adopted as commercially ready-to-eat complementary foods.

4. CONCLUSION

The results of the study have revealed that it is safe and beneficial to consider complementing carrot powder with AYB in a composite blend as a highly rich source of micronutrients especially vitamin A and protein. The AC^2 (80:20) blend is suitable for mineral deficiency as it has high mineral composition while the composite blend AC^4 (50:50) is an important choice for reducing VAD due to its richness is Vitamin A.

The biological value of this composite flour needs to be known and reconciled with chemical composition before it could effectively be used in weaning children.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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