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Nutrient Composition And Sensory Evaluation Of Sorghum Based Complementary Food Fortified With Soybean, Carrot And Crayfish

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Abstract
The nutritional composition and sensory characteristics of sorghum-based complementary food fortified with soybean, carrot and crayfish at different substitutional levels were evaluated using standard analytical procedures. The results revealed that moisture,ash,fat,fibre,protein and carbohydrate content values range from 7.73% to 13.07%, 1.84% to 4.66%, 39.48% to 44.02%, 0.02% to 2.01%, 13.59% to 24.51% and 16.31% to 27.44% respectively. The selected minerals showed that calcium, zinc, magnesium, manganese, and iron varied from 1.61 to 15.56mg/100g, 0.05 to 4.71mg/100g, 3.51 to 8.80mg/100g, 0.22 to 7.78mg/100g and 0.02 to 6.68mg/100g respectively. Vitamin A showed an appreciable amount in the sample with the inclusion of carrot.Values obtained met the Codex Alimentarius Commission Guidelines for formulated complementary foods for older infant and young children. The sensory properties revealed that sample E (60% sorghum, 25% soybean, 10% carrot and 5% crayfish) was most preferred and this has provided a basis for the development of an acceptable complementary food that can provide the needed protein and other nutrients, thereby combating protein energy malnutrition in infants.

Keywords:*complementary food, nutrient composition, sensory evaluation, fortification, formulation.*

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I. Introduction

Complementary foods are foods given to young childs and older infant when breastmilk is no longer sufficient to meet the nutritional demands after the exclusive breastfeeding period. In order to meet an infant's nutritional demands, complementary foods must be given in a timely, sufficient, safe, and appropriate manner; otherwise, growth may falter [1]. Evidence indicates that the weaning phase, when complementary foods are introduced, may be able to lower infant mortality in sub-Saharan Africa [2]. The quality and quantity of protein consume during their formative years is crucial for children's mental and overall development. Children who consume too little protein may develop kwashiorkor [3]. In babies, low-quality or low-protein diets have a significant impact on their longevity and metabolic health [4]. Developing nations have abundant plant resources that are cheap, readily available, and high in nutrients. When combined in the right amounts, these resources can cover the nutritional needs of newborns and children [5,6].

Encyclopedia (2018) states that soybeans (*Glycine max L*) are herbaceous legume plants classified as animals in the papillionoida subfamily of the leguminosae family. It's a rich resource because of its range of oil content (17% to 25%) and protein level (35% to 45%). Vitamins B1 and B2 can also be found in soybeans. Specifically, soy protein has an amazing balance of amino acids compared to other commonly found plants, and it approaches the dietary criteria set forth by the Food and Agriculture Organization Nutrition Guidelines [7].

The carrot (*Daucuscarota*) is an herbaceous plant that is rich in vitamins B, C, D, and E and contains approximately 87% water. Carrots in their raw state are a good source of pro-vitamin A and potassium. They also include thiamine, folic acid vitamin C, vitamin B6 and magnesium. Carrots contain beta-carotene, an antioxidant that scavenges free radicals, which are linked to diseases like muscle degeneration, cancer and heart disease [8].

Crayfish (*Euastacusspp*) is one of the less affordable source of obtaining animal protein. Crayfish (*Procambarusclarkii*) are small, watery crustaceans that resemble lobsters. These are marine foods that are rich in a variety of vitamins and minerals, including vitamins A, D, E, and K, vitamin B6 and B12, zinc, iron, calcium, phosphorus, magnesium, sodium, and other macronutrients necessary for a child's development[5,9].Many research on supplemental weaning foods have been conducted over the years. A study was conducted to assess the quality of premium fast weaning foods made from crustaceans, vegetables, legumes, and tubers by [10].

A mixture design approach in makinga cereal-based complementary meal for betternutritional quality was studied by [11,12]].According to [12], a combination design technique was used to create a cereal-based complete diet consisting of many blends of sorghum/millets, crayfish, soybeans, and ginger for baby nutrition. Additionally, [3] investigated the biological evaluation of weaning blends of grains and legumes for newborn feeding, and [8] investigated the features of complementary foods made from sorghum, sesame, carrot, and crayfish. Thus, the objectives of the current study are to formulate complementary foods based on sorghum that are enhanced with blends of soybean, carrot, and crayfish and evaluate the nutrients (chemical composition) as well as sensory qualities of the complementary foods produced.

II. Materials And Methods

Disease-free sorghum grains, soybeans, carrots, and crayfish were sourced from a departmental store in Abeokuta, Ogun State, Nigeria. Sorghum flour was subsequently produced using a modified version of the method outlined by [13].The grains were soaked in clean portable waterfor 8 hours, dried at 70°C for 48 hours, milled using laboratory hammer mill and then sieved (250µm screen). Soybeans flour was produced by sorting out wet, cleaned and steeped in warm water for 10 hours, precooked for 15 minutes at 100°C,dehulled, rinsed with clean water, and dried in a cabinet dryer at 100°C for 6 hours then milled and sieved to obtain flour (250µm screen) [13].Carrot powder was produced by washing the carrot fruits with clean portable peeled with the aid of stainless knives, sliced(56mm thickness), blanched for 3 minutes in hot water containing sodium metabisulphate to prevent browning and discolouration, dried in cabinet dryer at 50ºC for 12hours,milled and sieved(150µm sieve). Crayfish was sorted, oven dried, dry milled and sieved with a 75 micro aparture sieve to obtain smooth flour as shown in Figures (1 – 4). All the flours produced were store in zip lock bags ready for diet formulation and analysis formulation.

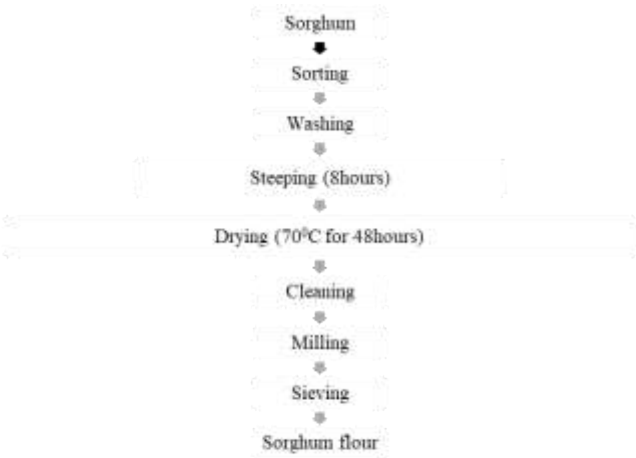

Fig. 1 Flow chart for the production of sorghum flour

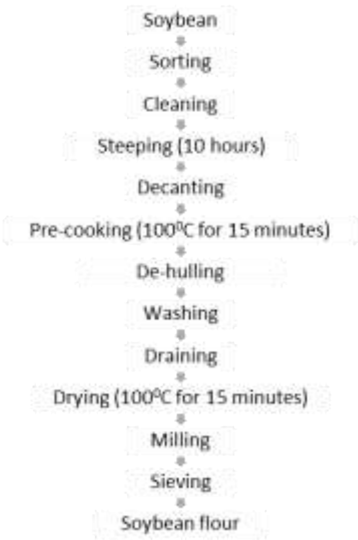

Fig. 2 Flow chart for the production of soybean flour

Fig. 3 Flow Chart for the production of Carrot flour

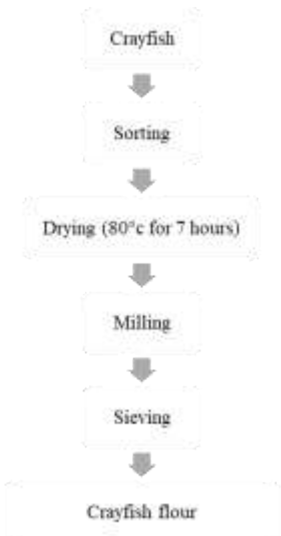

Fig. 4 Flowchart forThe Production Of Crayfish Flour

Formulation of complementary weaning foods
Different proportions of complementary weaning foods were formulated from the combination of sorghum, soybean, carrot and crayfish flours.

Samples flour (%)(%)	Sorghum flour (%)	Soybean flour (%)	Crayfish flour (%)	Carrot flour
A	100	0	0	0
B	70	15	5	10
C	75	10	5	10
D	65	20	5	10
E	60	25	5	10

Chemical Analysis
The proximate composition was determined using standard analytical method (AOAC 2010). Minerals like calcium, zinc, manganese, magnesium and iron were analysed using Atomic Absorption Spectrophotometry(AAS) method described by AOAC (2010). Vitamin A was determined using HPLC method described by Achinkann et al., (2013).

Determination of Vitamin A
Determination of Vitamin A 10g of complementary food was treated with 5ml ammonia concentration of 25% and 20ml ethanol (96%).The sample was then treated with a 40ml mixture of ethereal ether (containing 0.0025% Butylated Hydroxytoluene(BHT) as an antioxidant) and 40µm petroleum ether. The mixture was vigorously shaken using a mechanical shaker for 5 minutes to facilitate extraction. The upper ethereal phase was carefully transferred to a round-bottom flask and concentrated under vacuum using a rotary evaporator at 35℃ to remove excess solvent. Sample saponification involved adding a volume of 30ml potassium hydroxide, 5% ethanol solution (96%) to the residual material. The samples underwent magnetic stirring for 3 hours in a dark environment. Next, samples were transferred to a separation funnel with 30ml water and 30ml hexane. The hexane was discarded, and the thin phase underwent re-extraction with hexane. The hexamical phases were remixed and rinsed with the next phase using a separation funnel. Standard solutions and samples were injected using a HPLC scheduled with shimodzu system purp and Rheodyne injector. The mobile phase contains acetonictril-methanol 85:15 in the isocratic system. Standard solutions and samples were injected in a HPLC system equipped with a shimodzu LC 2D AT pumping system, a water 990 detector with a data proceeding 80g tul. Furthermore, it was equipped with a Rheodyne injector with a 20µm drop and a spherisorb RD18 Column, 25cm in length, 4.6 internal diameter and particle size of 5µm.

Preparation of Porridges
100g of each sample flour was combined with 550ml of deionized water to create a thick paste. The mixture then heated in a temperature-controlled Thermos water bath at 75℃ for 15 minutes. Finally, the porridge was mixed with 2g of granulated sugar. The porridge samples were cooled at an ambient temperature (28±2ºC) to 40ºC. This temperature ensures optimal palatability and nutritional retention. After that, the samples were kept apart in thermoflasks to ensure that the serving temperature remained constant at 40ºC.

Sensory Evaluation of Fortified Complementary Weaning Foods
Sensory qualities of the complementary food were assessed by nursing mothers, trained and conversant panel of judges drawn from the polytechnic community. The samples were assessed for the following attributes; color, taste, flavour, texture, and overall acceptability. The samples were randomly presented and coded in such a way that the panelists recorded the sensory qualities of each sample using a 9-point hedonic scale, where 9 represent the highest preference and 1 the lowest.

Statistical Analysis
Data collected were subjected to analysis of variance (ANOVA) to identify significant difference among sample means. Duncan’s Multiple Range Test (DMRT) was used to separate the means ($p \leq 0.05$) with statistical package for social science version 16.0 for windows (SPSS Inc. Illinois, USA).

III. ResultsAnd Discussion

Table 1. Proximate Composition of Complementary Food from Sorghum, Soybean, Carrot, Crayfish.

Samples %	A	B	C	D	E
Moisture	13.07^{e}±0.01	11.87^{d}±0.01	10.24^{c}±0.01	9.25^{b}±0.01	7.73^{a}±0.01
Ash	1.84^{a}±0.01	2.51^{b}±0.02	3.34^{c}±0.06	4.23^{d}±0.01	4.66^{e}±0.01
Fat	43.42^{d}±0.03	39.48^{a}±0.03	41.13^{b}±0.01	43.31^{c}±0.01	44.02^{e}±0.01
Fibre	0.65^{b}±0.01	0.02^{a}±0.01	1.23^{c}±0.02	1.88^{d}±0.01	2.01^{e}±0.02
Protein	13.59^{a}±0.02	19.51^{b}±0.02	20.47^{c}±0.02	22.01^{d}±0.01	24.51^{e}±0.01
Carbohydrate	27.44^{e}±0.02	26.53^{d}±0.01	23.66^{c}±0.01	19.11^{b}±0.01	16.31^{a}±0.01

Means in the same row with different superscript are significantly different (P<0.05)

Key

Sample A: Complementary food (control) sample 100% sorghum

B:Complementary food (70% sorghum, 15% soybean, 10% carrot, 5% crayfish)

C:Complementary food (75% sorghum, 10% soybean, 10% carrot, 5% crayfish)

D:Complementary food (65% sorghum, 20% soybean, 10% carrot, 5% crayfish)

E:Complementary food (60% sorghum, 25% soybean, 10% carrot, 5% crayfish)

Table 2: Selected Mineral Composition of the Complementary Food from Sorghum, Soybean, Carrot, Crayfish.

Samples (mg / l00g)	A	B	C	D	E
Calcium	1.61^{a}±0.01	2.71^{b}±0.01	3.80^{c}±0.01	7.92^{d}±0.01	15.56^{e}±0.01
Zinc	4.71^{e}±0.00	0.55^{a}±0.04	0.05^{d}±0.01	2.55^{b}±0.01	3.71^{c}±0.01
Magnesium	3.51^{a}±0.01	4.69^{b}±0.01	5.91^{c}±0.01	7.78^{d}±0.01	8.80^{e}±0.01
Manganese	7.78^{d}±0.01	0.22^{a}±0.01	1.04^{c}±0.01	0.66^{b}±0.01	1.15^{d}±0.01
Iron	0.02^{b}±0.01	0.22^{a}±0.00	3.40^{c}±0.00	5.29^{d}±0.0	6.68^{e}±0.00
Vitamin A	0.11^{a}±0.00	0.13^{b}±0.00	0.14^{a}±0.00	0.15^{d}±0.00	0.19^{c}±0.00

Values with the same superscript in the same column are not significantly different (P<0.05)

Table 3: Sensory characteristics of the Complementary Food from Sorghum, Soybean, Carrot, and Crayfish.

Samples	A	B	C	D	E
Color	6.70^{a}±1.42	6.90^{a}±1.37	7.50^{a}±0.85	7.10^{a}±1.79	7.40^{a}±1.17
Aroma	6.90^{a}±1.10	6.70^{a}±1.16	6.60^{a}±1.71	6.80^{a}±0.92	6.50^{a}±1.35
Taste	7.60^{b}±1.09	6.00^{a}±1.25	6.00^{a}±1.05	7.10^{ab}±0.99	6.60^{ab}±1.51
Flavor	7.10^{b}±1.20	6.20^{ab}±1.52	5.70^{a}±1.34	6.40^{ab}±1.78	7.30^{b}±0.06
Texture	7.10^{a}±1.29	6.20^{a}±1.62	6.30^{a}±1.57	7.60^{a}±1.07	7.40^{a}±1.58
Overall Acceptability	7.10^{a}±0.74	6.80^{a}±1.40	7.00^{a}±1.05	7.20^{a}±1.14	7.30^{a}±1.4

Values are means of duplicate determination ± SD (Standard deviation)

Means in the same row with different superscript are significantly different (p>0.05)

IV. Discussion

The proximate composition of complementary food produced from sorghum, soybean, carrot and crayfish blends are as presented in Table 1. Moisture content ranged from 7.73 to 13.07% for all the samples under consideration. Elevated moisture levels in food promote microbial proliferation. The blend's low residual moisture content is beneficial since it lowers the microbial load and extends storage life.The observed moisture values are in line with the suggested moisture content range of 10–14% for food products made with flour [16].The observed moisture values are in line with the suggested moisture content range of 10–14% for food products made with flour [17]. The moisture contents are also within the range of 8.15 – 9.58% reported by[6] for the weaning food produced. Ash content of food materials in a non-organic compound reflecting the mineral contents of the food. Nutritionally, ash aids in metabolism of other organic compounds such as carbon-hydrates and fats. Ash contents ranged from 1.84 to 4.66%, with the control sample having the least value (1.84%) and sample E (60% sorghum, 25% soybean, 10% carrot and 5% crayfish) having the highest value of 4.66 %. The percentage ash, which is an indicator of the mineral content increased with alteration in the percentages of soybean, carrot and crayfish flour in all the developed recipes of the weaning food. [5] Sogo-Temi et al.,2023, reported ash content of 2.10% in a complementary food from plantain, velevet bean and crayfish while [17] reported 1.98 to 2.99% for complementary chets from pea-anchote flour blend revealing a higher values in theirpresent work.The present weaning diet being reported may include a high amount of mineral components because of its adequate ash content. The fat contents of the blends ranged from 39.48 to 44.02%, showing significant differences among samples (P≤0.05). Crude fat increases as the values of soybean, carrot and crayfish substitution increases, exceptfor sample A (i.e 100% sorghum). Dietary flour helps lower blood sugar and cholesterol, prolongs stomach fullness, and helps treat a number of illnesses [18].

There was significant differences (P ≤ 0.05) among the treated samples. The crude fiber ranged from 0.02 to 2.01%. It was observed that crude fiber increases as the inclusion of soybean, carrot and crayfish increases. The values of crude protein obtained in the present work are 13.59%, 19.51%, 20.47%, 22.01% and 24.51% for samples A, B, C, D and E respectively creating significant differences among samples (P<0.05). It was generally shown that the protein contents increase with the inclusion of soybean, carrot and crayfish in the complementary food. The ideal balance between proteins with lower and higher biological value to meet the right need for growth is achieved by following the FAO/WHO Codex Alimentarius Standard for weaning diet, which is set at 14.52 to 37.70g/100 [19]Thus, the various blends could provide adequate nutrition to combat protein-energy malnutrition if the blends are solely used to wean a child. Carbohydrate is the most significant and accessible source of energy. The values ranged from 16.31 to 27.44% revealing significant differences (P<0.05). According to [20].Carbohydrates are important in heart, brain, digestive nervous functions as well as immune system. The values obtained in this present research work is low than 60 – 75% specified by the Codex standard [21] for infant foods.

Mineral Composition

Table 2. Showed the selected mineral composition of the complementary food. The selected minerals evaluated, is calcium, zinc, magnesium, manganese, and iron revealed significant differences among samples (P<0.05). The higher contents of the minerals noticed in the various blends could be attributed to the presence of soybean and crayfish which are both protein sources from plants and animal. The calcium ranged from 1.61 – 15.50 mg/100g, Zinc from 0.05 – 4.71mg/100g, magnesium 3.51 – 7.78 g/100g, manganese 0.22 – 7.78mg/100g and iron 0.02 – 6.68mg/100g for sample A, B, C, D, and E respectively. Calcium supports strong teeth and bone formation in children. While zinc which is an integral content of almost 100 different enzymes play an essential role in all the major metabolic pathways. Carrot has been reported as good sources of both vitamin C and pro vitamin A (8).When forming an infant's diet, it is advantageous to include vegetable like carrots as basic elements. So as to upgrade their levels in complementary foods (Onabanjo et al, 2009). However, there are significant differences (P<0.05) among values obtained for the five samples.

Sensory Characteristics

The mean sensory ratings of complementary foods made from blends of sorghum, soybean, carrot, and crayfish are shown in Table 3. There were significant differences (P<0.05) in all the sensory attributes evaluated. The colour of the complementary food ranged from 6.70 – 7.50, with sample C (75% sorghum, 10% soybean, 10% carrot and 5% crayfish) has the highest value while sample A (100% sorghum – control) has the least value. The aroma ranged from 6.50 to 6.90 while the taste ranged from 6.00 to 7.60 for the samples. The overall acceptability as rated by the panelist showed that sample E (60% sorghum, 25% soybean, 10% carrot and 5% crayfish) was most accepted. This result has provided a basis for the formulation of an acceptable complementary food that can provide the needed protein and energy levels for infant growth.

V. Conclusion

The use of sorghum, soybean, carrot and crayfish at different substitutional levels for complementary weaning food formulation is encouraged. The formulations yield products with high nutrient values which can promote good growth among infants and young children. The addition of soybean and crayfish which are readily sourced, inexpensive and available can be used by nursing mothers to improve and supplements their traditional complementary foods in order to drastically lower the protein-energy deficiency in children.

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