NUTRIENT, ANTI-NUTRIENT AND SENSORY COMPOSITION OF COMPLEMENTARY FOOD PRODUCED WITH PIGEON PEA, ORANGE FLESHED SWEET POTATO AND CARROT

***Amadi, Joy A.C[1] and Ogbu, Confidence. C[2]**
[1]Department of Nutrition and Dietetics, Imo State University P.M.B. 2000, Owerri, Nigeria.
[2]Department of Nutrition and Dietetics, Imo State Polythenic, Umuagwo P.M.B. 1472 Owerri, Nigeria.
**Corresponding author:*Joyevans2012@yahoo.com

Abstract
Background: Indigenous complementary food can help in averting the consequences of malnutrition.
Objectives: The study sought to evaluate complementary food produced from pigeon pea, orange fleshed sweet potato (OFSP) and carrot.
Methodology: The samples were obtained from Relief market, Imo State, Nigeria. OFSP was peeled, washed, sliced, oven-dried at 50 for 45mins, milled and sieved. Pigeon pea was sorted and sprouted for 48hrs and 72hrs, oven-dried and milled. Carrot was sorted, washed, peeled and sliced, blanched, oven dried, milled and sieved. Four blends were formulated SSC_2 SSC_3, SSC_4, SSC_5 and SSC_1 (unsprouted OFSP). The samples were analyzed using standard methods. Data obtained was analyzed using statistical product and service solution (SPSS) version 22. Statistical significance was set at $P<0.05$.
Results: Protein ranged from 13.81-15.07 g/100g, fiber (2.01-3.95 g/100g), fat (8.59-13.11 g/100g), ash (3.02-5.43 g/100g), carbohydrate (69.09-73.39 g/100g), and moisture (7.32-9.83 g/100g). Zinc (32.36mg/100g) and vitamin A (8581mg/100g) were higher in SSC_2 while Calcium (124.50mg/100g) was highest in SSC_1, magnesium (152.50mg/100g), copper (105.45mg/100g) and vitamin C (27522.5mg/100g) were higher in SSC_3. Tannin (0.94mg/100g) was higher SSC_3, phytate (14.48mg/100g) was higher SSC_2 and oxalate (0.80mg/100g) was higher in SSC_5. SSC_5 was generally accepted among the formulated complementary foods.
Conclusion: The study revealed that formulating complementary food with orange fleshed sweet potato composite flour improves vitamin A and other micro and macro nutrients content of the food.

Key words: *orange fleshed sweet potato, complementary food, pigeon pea, carrot*

INTRODUCTION

Complementary foods are introduced at six months during transition period when breast milk could no longer satisfy the nutritional requirement of infants. Breast milk should be given alongside with complementary food till 2 years and beyond (1). During infancy, there is great need for adequate nutrition to meet the demands of rapid physical growth, which includes motor and physiological development, as well as mental development. In developing countries, complementary feeding is a major child survival strategy used to curb the deleterious consequences of under nutrition. Combination of cereals and legumes complement each other in balancing the amino acid profile of the diet. Another problem with most Nigerian traditional cereal complementary foods is that they are marginally poor in micronutrients.

Micronutrient deficiency (hidden hunger) and protein energy malnutrition (PEM) are killer disease among children in their transition period (2). This is because most mothers prepare and feed their children with gruels that cannot meet up the child's nutritional demands. The reason is not far-fetched because our traditional complementary foods pass through some processing technique which reduces its nutritional content. According to International Institute for tropical Agriculture (IITA) the micronutrient deficiency diseases among under 5 years children in Nigeria include the following vitamin A deficiency (23.3%), iron deficiency diseases (34.0%), iodine deficiency (13.0%) and zinc deficiency (20.0%) (3). Previous studies reported that micronutrient deficiency is evident among children with PEM which could be as a result poor exclusive breastfeeding practices, inadequate complementary food and inconsistency in feeding patterns of the growing children (4, 5, 6).

Pigeon pea (Cajanus cajan) is an underutilized protein and mineral cheap legume (7, 8). Pigeon pea has been used to enhance indigenous cereals and tuber based complementary feeds (9, 10). Processing of pigeon pea improves both nutritional and sensory properties (6) as well as reducing the anti-nutrient inherent in them (11, 12). Orange fleshed sweet potato (OFSP) is a biofortified root crop of sweet potato (*Ipomoes batatas*) which has more micronutrient content especially vitamin A. Consumption of OFSP among children has been reported to enhance vitamin A intake, serum retinol concentration and micronutrient (13, 14). OFSP contains more beta- carotene which is the major precursor of vitamin A and it also contains ascorbic acid than the cream fleshed sweet potatoes (15). One hundred and twenty-five grams of boiled OFSP provides vitamin A daily nutrient intake for a child (16) coupled with other micronutrients (vitamin C, K, E and B vitamins), dietary fiber and antioxidants (17). The sugar in sweet potato has a low glycemic response because the sugar is released into blood stream gradually (18).

Carrot (*Ipomoea batatas*) is a root vegetable medicinal plant rich in B vitamins as well as vitamin C and E (19). It is also a good source of carotenoids which functions well in maintaining the retina especially for night vision and in low light periods. The vitamin A content of carrot and OFSP helps to fight infections which are prone to the vulnerable children. The study sought to evaluate the nutrient, antinutrient and sensory evaluation of complementary food made from OFSP, pigeon pea and carrot.

MATERIAL AND METHODS

Material Procurement

Pigeon pea and carrot were purchased from Relief Market in Owerri, Imo State while OFSP was purchased from International Institute of Tropical Agriculture (IITA), Ibadan Nigeria. The processing equipment required was sourced from the Department of Nutrition and Dietetics, Imo State University, Owerri.

Preparation of Sprouted Pigeon Pea (SPP)

Five kilograms (5kg) of pigeon pea was sorted to remove unwanted materials. It was washed and soaked in water in the ratio of 1:3 (w/v) and allowed to sprout for 72hours by microflora inherent in them. At the end of fermentation, soaking water was completely drained and allowed to sundry. The fermented grains were milled into flour and sieved using 70mm mesh screen and the flour samples were packed in air tight polythene bags and stored in the refrigerator until analyzed.

Preparation of orange fleshed sweet potato (OFSP)

Six kilograms of OFSP was peeled and washed. It was cut into pieces and oven dried at 50^{o}C for 45 minutes and milled into flour. The flour was sieved using 300

Table 1: Sample Formulation of fortified complementary food

Sample	SPP (g)	OFSP (g)	CAT (g)
$SO_{100}C$	-	100	-
$24S_{70}O_{30}C_{50}$	70	30	50
$24S_{60}O_{40}C_{50}$	60	40	50
$72S_{70}O_{30}C_{50}$	70	30	50
$72S_{60}O_{40}C_{50}$	60	40	50

Key:

$SO_{100}C$**:** 100% Orange fleshed sweet potato (OFSP)
$24S_{70}O_{30}C_{50}$**:**70% 24hr sprouted pigeon pea: 30%OFSP: 50%carrot
$24S_{60}O_{40}C_{50}$**:**60% 24hr sprouted pigeon pea: 40%OFSP: 50%carrot
$72S_{70}O_{30}C_{50}$:70% 72hr sprouted pigeon pea: 30%OFSP: 50%carrot
$72S_{60}O_{40}C_{50}$:60% 72hr sprouted pigeon pea: 40%OFSP: 50%carrot

Nutrient and antinutrient analysis

The samples were analyzed for proximate composition (%protein, %ash, %fibre, %fat and % carbohydrate) and vitamin C using standard methods by AOAC (21). Vitamin A was determined using spectrophotometric method described by Pearson (22). Phytate (23), tannin (24) and oxalate (25) were determined as specified. All analysis was done in triplicates.

Statistical method

Means and standard deviation were calculated for all the samples. One way analysis of variance (ANOVA) and turkey tests were used to separate and compare the means (26).

Sensory evaluation

Sensory evaluation of the formulated complementary food was assessed with 50 nursing mothers attending immunization programme at Umuguma Primary Health Centre. They were selected using simple random sampling based on written informed consent. The mothers were taught on how to evaluate and fill the forms provided. Aroma, colour, taste, texture and overall acceptability were rated on a 9-point Hedonic scale, ranging from 1 = like extremely to 9 = dislike extremely (30). The judges were provided with glasses of water to rinse their mouth after testing.

Recipe for blend preparation

Ingredients

100g of different composite flour
500ml of boiling water
30g of powdered milk
5g of sugar

Method

One hundred grams of different composite flour was put in a bowl; the already 100ml of boiled water was poured into it and stirred until a uniform gruel was formed. The gruel was further put on fire using thermacool table gas with the gas knob at low heat temperature, stirred for 2minutes and brought down. Milk was added to the gruel and stirred very well with a clean table spoon. The samples were kept in a flask to maintain the serving temperature (40^{o}C) for sensory evaluation.

RESULTS

Moisture content decreased significantly from 9.83± 0.10% (sample SSC_4) to 7.32±0.08% (sample SSC_3) (Table 2). Protein content significantly ($p<0.05$) increased from 13.54±0.08% (sample SSC_4) to 15.07±0.11% in (sample SSC_3). Sample C was significantly higher ($p<0.05$) in crude fiber (3.95±0.10%) and ash (5.43±0.68%) content. Sample SSC_5 (3.95±0.01%) had the highest crude fat content while sample SSC_3 (8.59±0.13) had the lowest. Carbohydrate was significantly ($p<0.05$) higher in sample SSC_1 (73.39±0.18%).

Table 2: Proximate Composition of Complementary Food Samples

Sample	Moisture (%)	Protein (%)	Crude fiber (%)	Crude Fat (%)	Ash (%)	Carbohydrate (%)
SSC_1	$8.82^{d}\pm0.13$	$13.34^{a}\pm0.22$	$2.01^{a}\pm0.04$	$8.96^{b}\pm0.07$	$3.02^{a}\pm0.06$	$73.39^{b}\pm0.18$
SSC_2	$8.01^{c}\pm0.13$	$14.19^{c}\pm0.17$	$3.00^{c}\pm0.04$	$11.76^{d}\pm0.17$	$4.00^{b}\pm0.01$	$69.09^{a}\pm0.19$
SSC_3	$7.32^{a}\pm0.08$	$15.07^{d}\pm0.11$	$3.95^{d}\pm0.01$	$8.59^{a}\pm0.13$	$5.43^{c}\pm0.68$	$69.65^{a}\pm0.78$
SSC_4	$9.83^{e}\pm0.10$	$13.81^{b}\pm0.08$	$2.52^{b}\pm0.14$	$11.01^{c}\pm0.06$	$3.90^{b}\pm0.04$	$69.22^{a}\pm0.23$
SSC_5	$7.65^{b}\pm0.06$	$14.79^{c}\pm0.12$	$2.19^{a}\pm0.04$	$13.11^{e}\pm0.11$	$3.55^{ab}\pm0.08$	$68.74^{a}\pm0.04$

Values are means of triplicate determinations. Mean values with different superscripts in the same column are significantly different ($p<0.05$).

Key:

SSC_1: 100% Orange fleshed sweet potato (OFSP)

SSC_2**:** 70% 24hr sprouted pigeon pea: 30%OFSP: 50%carrot

SSC_3**:** 60% 24hr sprouted pigeon pea: 40%OFSP: 50%carrot

SSC_4: 70% 72hr sprouted pigeon pea: 30%OFSP: 50%carrot

SSC_5: 60% 72hr sprouted pigeon pea: 40%OFSP: 50%carrot

Micronutrient composition of the complementary food was shown in Table 3. Sample SSC_1 was significantly higher in calcium (124.50±2.12 mg/100g) while sample SSC_4 (92.50±2.12 mg/100g) was the lowest. Magnesium (152.50±0.70 mg/100g) and copper (105.45±1.17 mg/100g) significantly ($p<0.05$) increased in Sample SSC_3. Zinc (32.36±0.73 mg/100g) and vitamin A (8581.0±89.1 mg/100g) was significantly higher in sample SSC_2 while vitamin A was higher in sample SSC_1.

Table 3: Micronutrient composition of complementary food samples

Samples	Calcium(mg/100g)	Magnesium (mg/100g)	Copper (mg/100g)	Zinc(mg/100g)	Vitamin A(mg/100g)	Vitamin C(mg/100g)
SSC_1	$124.50^{e}\pm2.12$	$84.00^{a}\pm1.41$	$66.21^{a}\pm0.85$	$18.42^{a}\pm0.18$	$5561.5^{a}\pm75.6$	$24392.5^{e}\pm412$
SSC_2	$101.50^{b}\pm0.70$	$130.50^{b}\pm0.70$	$97.06^{b}\pm1.11$	$32.36^{c}\pm0.73$	$8581.0^{e}\pm89.1$	$21672.0^{b}\pm316$
SSC_3	$112.00^{c}\pm1.41$	$152.50^{d}\pm0.70$	$105.45^{c}\pm1.17$	$25.95^{b}\pm0.32$	$7258.5^{c}\pm147.7$	$27522.5^{d}\pm225$
SSC_4	$92.50^{a}\pm2.12$	$142.50^{c}\pm0.70$	$97.06^{b}\pm0.32$	$26.10^{b}\pm0.21$	$8126.5^{d}\pm156.2$	$16617.5^{a}\pm295$
SSC_5	$104.00^{b}\pm1.14$	$151.50^{d}\pm0.70$	$98.17^{b}\pm0.80$	$25.43^{b}\pm0.534$	$6516.0^{b}\pm48.08$	$17414.5^{a}\pm297$

Values are means of triplicate determinations. Mean values with different superscripts in the same column are significantly different ($p<0.05$).

Key:

SSC_1: 100% Orange fleshed sweet potato (OFSP)

SSC_2**:** 70% 24hr sprouted pigeon pea: 30%OFSP: 50%carrot

SSC_3**:** 60% 24hr sprouted pigeon pea: 40%OFSP: 50%carrot

SSC_4: 70% 72hr sprouted pigeon pea: 30%OFSP: 50%carrot

SSC_5: 60% 72hr sprouted pigeon pea: 40%OFSP: 50%carrot

Anti-nutrient composition of complementary food was shown in Table 4. Samples reduced in sample SSC_5 (0.69±0.07mg/100g), sample SSC_1 (0.63±0.00mg/100g) and sample SSC_2(12.69±0.15mg/100g) for tannin, phytate and oxalate respectively.

Table 4: Anti nutrient composition of complementary food samples

Sample	Tannin(mg/100g)	Phytate(mg/100g)	Oxalate(mg/100g)
SSC_1	$0.88^{c}\pm0.10$	$12.69^{a}\pm0.15$	$0.72^{c}\pm0.03$
SSC_2	$0.84^{b}\pm0.02$	$14.48^{c}\pm0.16$	$0.54^{a}\pm0.06$
SSC_3	$0.94^{d}\pm0.07$	$13.86^{b}\pm0.14$	$0.63^{b}\pm0.12$
SSC_4	$0.68^{a}\pm0.08$	$17.25^{d}\pm0.19$	$0.75^{d}\pm0.02$
SSC_5	$0.69^{a}\pm0.07$	$16.08^{e}\pm0.12$	$0.80^{e}\pm0.05$

Values are means of triplicate determinations. Mean values with different superscripts in the same column are significantly different (p<0.05).

Key:

SSC_1: 100% Orange fleshed sweet potato (OFSP)

SSC_2**:** 70% 24hr sprouted pigeon pea: 30%OFSP: 50%carrot

SSC_3**:** 60% 24hr sprouted pigeon pea: 40%OFSP: 50%carrot

SSC_4: 70% 72hr sprouted pigeon pea: 30%OFSP: 50%carrot

SSC_5: 60% 72hr sprouted pigeon pea: 40%OFSP: 50%carrot

The sensory evaluation of the complementary food was shown in Table 5. The sensory attributes ranged from 7.05-7.50 for aroma, taste (6.12-7.02), aroma (6.22-7.51), texture and consistency (6.05-6.34) and general acceptability (6.23-7.81). SSC_5 was generally accepted (p<0.05).

Table 5: Sensory scores of complementary food samples

Parameter	SAMPLE SSC_1	SSC_2	SSC_3	SSC_4	SSC_5
Colour	7.50^c	7.05^d	7.13^d	7.16^b	7.30^d
Taste	7.02^c	6.12^a	6.30^b	6.17^a	6.20^a
Aroma	7.51^c	6.22^a	6.28^b	7.06^{ab}	6.93^c
Texture/consistency	6.05^a	6.07^b	6.12^a	6.16^a	6.34^b
General acceptability	7.10^b	6.23^c	6.43^c	7.75^c	7.81^e

Values are means standard deviation of triplicate determinations. Mean in the same row with the same superscript are not significantly different at P< 0.05. LSD = least significant difference

Key:

SSC_1: 100% Orange fleshed sweet potato (OFSP)

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SSC_3**:** 60% 24hr sprouted pigeon pea: 40%OFSP: 50%carrot

SSC_4: 70% 72hr sprouted pigeon pea: 30%OFSP: 50%carrot

SSC_5: 60% 72hr sprouted pigeon pea: 40%OFSP: 50%carrot

Discussions

The protein content was relatively high to provide 100% of the recommended dietary allowance by World Health Organization with respect to protein intake among children which is 10 to 12% (1). This is consistent with previous works that researched on complementary food fortification with legume (28, 29, 30). The increased protein content could be attributed to the sprouting activities employed. Protein content of the complementary food was highest at 72 hours sprouting. During sprouting there is breakdown of protein-tannin and protein-phytate complexes which enhances protein bioavailability and absorption (31). However, the study disagrees with Adewale *et al*. (32). The crude fiber content of the complementary food was consistent with Mathew *et al*. (33) who reported 2.5% crude fiber in pigeon pea. Whereas Ukozor and Okere (28) reported a lower value of 0.49 to 1.36% in complementary food using pigeon pea and bambara nut and Okuda *et al*. (34) on complementary food produced from sorghum, pigeon pea and carrot. The increased fiber content of the complementary food was as a result of carrot and orange fleshed sweet potatoes that were added during preparation. Higher fiber content is not always encouraged in formulation of infant feeds, because of the problems of indigestibility associated with it. But, the fibre contained in the formulated food is within the acceptable limit. It was observed that crude fiber decreased significantly on 72 hours sprouting unlike 48 hours sprouting which was the highest crude fiber recorded. This disagrees with Shah *et al.* (35) who reported that crude fiber was decreased at 48 hours sprouting of Ramzan. However, the study agreed with previous studies that sprouting increased fibre content of food on the 48hrs sprouting but decreased on the 72hrs sprouting time (36, 37). This was possible due to the utilization of starch during sprouting period (36). The study also shows that 100% orange fleshed sweet potatoes (sample SSC_1) contains fibre. This is consistent with Haile and Getahum (38).

Ash content of the complementary food was higher than Okudu *et al.* (34). It was also observed that the complementary food decreased after 48 hours sprouting. This is inconsistent with Masood *et al.* (39) on effects of sprouting time on mungbean and chicken pea, it was reported that ash content increased after 48 hours. Fat content of the complementary food was higher than previous studies (28, 32). The increased fat content could be attributed to the decreased carbohydrate content during sprouting and the contribution of fat from orange flashed sweet potatoes and carrot. However, the fat is a plant source which is not harmful. Carbohydrate agrees with previous work

(40). Also, the high carbohydrate content could be contributed by the potatoes.

The micronutrient composition of the complementary food was higher than previous studies (34, 41). Devi *et al.* (36) reported significant increase in the calcium content of sprouted mungbean and cowpea. The human body contains more calcium compared to other minerals (42). Calcium plays important role in muscle contraction, bone matrix, nerve impulse transmission, blood clotting and cell metabolism. In addition to the above, dietary calcium would prevent hypertension, improve weight control, reduce the risk of kidney stone and colon or breast cancer. Sprouting increased the magnesium, zinc and copper content but was more in the 72 hours sprouting. Okedu *et al.* (34) reported a lower value for similar work on complementary food using pigeon pea, carrot and sweet potatoes. The low value of micronutrient reported in that study could be as a result of the processing technique used. The pigeon pea was boiled and dries before formulation while in the present study, the pigeon pea was sprouted. Also, they used sweet potatoes not orange fleshed sweet potatoes which is an improved variety with more micronutrients. Magnesium is involved in the production of ATP, protein synthesis muscle contraction and blood clotting. Foods with fermentable and sprouted carbohydrate improve magnesium absorption (42). Magnesium content of the complementary food would meet up to one-third of the recommended nutrient intake of 400mg.

Zinc functions in many metabolic activities like fertility and reproduction, hormone activity, immune system, sexual maturation, protein and lipid metabolism, hemoglobin activity, gene expression, night vision, cell growth, and replication. Zinc status is important among the children in order to prevent diarrhea one of the killer diseases of the under five children. Copper participate as antioxidant as well as immune and cardiovascular functions. Copper deficiency is associated with anemia, decreased white blood cells and bone abnormalities (42). The study is inconsistent with Uppal and Basins (37), because they reported increase in vitamin C as the sprouting time increases. In the present study, vitamin C decreased in the 72 hours sprouting unlike the 48 hours sprouting. However, the complementary feed contains high vitamin C, though it was observed that 100% orange fleshed sweet potatoes contains more vitamin C than the formulated food. Vitamin C is involved in collagen synthesis and vital cell compounds like norepinephrine, epinephrine, neurotransmitter serotonin, steroid hormones and purine bases used in DNA synthesis. It also plays a distinct role in immune function and as antioxidant. It is useful in preventing scurvy in children.

The vitamin A increased in the formulated complementary compared to the control. This shows that pigeon pea and carrot especially used in food formulation contributed to the vitamin A content. But it was observed that the control 100% orange fleshed sweet potatoes contains high vitamin A. This supports previous study on nutrient assessment of orange fleshed sweet potatoes of different genotype (43). Vitamin A is not only involved in maintaining sight but also it functions in cell differentiation, immune system, reproductive and bone health. The vitamin A content of the complementary food would furnish the recommended intake of all age groups.

The anti-nutrients studied are within the permissible limit (44). Tannin was reduced more in the 72 hours sprouting than the control and 24 hours sprouting. Also the tannin content of 100% OFSP was higher than the formulated however still within acceptable limit. The phytate was more in the formulated food than the 100% OFSW. This shows that pigeon pea contributed to the increased phytate content of the complementary food. Amaglon and Coad (45) supported the study that complementary food from orange fleshed sweet potato is high in phytate. Phytate are known for their negative consequences on iron bioavailability in humans. The phytate content of the formulated food samples is below the threshold limit of phytate contents of 25mg or less in 100g of food samples as recommended by (46). Oxalate content of the complementary food samples was increased in the 72hours sprouting than the 48 hours sprouting and 100% OFSP. However, the oxalate content of the food samples was very low and below the lethal dose of 5g per 100g (47). The sensory evaluation shows that the nursing mothers accepted the formulated foods for colour, taste, aroma, texture and consistency and general acceptability. However, the most acceptable complementary formulated food was SSC_5.

Conclusion

The formulated complementary food samples contain adequate protein and micronutrient especially vitamin A. Oxalate, phytate and tannin content of the formulated complementary food samples were within the safe limit. All the formulated complementary foods were generally acceptable, with SSC_5 as the most acceptable complementary formulated food.

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