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Production and Evaluation of Complementary Foods Made From Selected Local Food Materials

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Abstract
Malnutrition is prevalent in infants during complementary feeding in parts of developing countries. This is especially so, due to the high cost of infant formulas and other weaning foods in this region. This study compounded and evaluated some quality characteristics of complementary foods made from combinations of an underutilized root crop (trifoliate yam) and some readily available food materials. The complementary foods were made from trifoliate yam, kidney beans, tilapia fish, vegetable oil, sugar and either date and carrot (TKDC) or tiger nut and pawpaw (TKTP) in ratios of 60:10:10:5:5:7:3 or 60:10:10:5:5:5:5, cooked in stainless steel pot, dried, milled and analyzed for proximate, minerals, beta-carotene, tannin, amino acids profile, characteristics and impact on growth upon consumption. Proximate, minerals, vitamin, tannin and amino acid profile and sensory characteristics of complementary foods varied significantly ($P<0.05$) from one another with TKTP having higher protein (12.32%), fats (21.87 %), ash (5.2 %) contents than TKDC. However, in terms of overall acceptability (8.10) taste (8.10) and aroma (8.00), TKDC was better accepted than TKTP. Feeding of test animals with complementary foods resulted in weight gains of between 60.96g to 113.62g (TKTP) and 57.32 to 105.92 (TKDC). The complementary foods were comparatively nutritious and acceptable. ***Keywords: Production, evaluation, quality characteristic, complementary feeding, and nutrition***

Introduction

The global strategy for infant and young child feeding requires that infants should be exclusively breastfed for the first six months of life to achieve optimal growth, development and health and thereafter receive nutritionally adequate and safe complementary foods while breastfeeding continues for up to two years (WHO, 2015). Undernutrition and micronutrient deficiency (hidden hunger) are most prevalent among infants and young children aged 6 to 23 months in Nigeria (NDHS, 2018).

As babies get older, the energy and nutrient contribution from complementary food become increasingly important for them in meeting daily requirements (UNICEF, 2009). However, the small quantities of watery local cereal-based complementary food porridge commonly fed to them do not provide adequate calories and micronutrients to meet their daily requirements. The generally accepted recommendations for improving the nutritional status of children in this age group are to feed them locally available micronutrient-rich foods and to encourage local production of low-cost, industrially processed fortified cereal-based complementary foods. A nutritionally adequate complementary diet with locally available food materials requires the use of animal-source foods (WHO, 2010), which is usually expensive and beyond the reach of many low-income earners (Ijarotimi, 2009).

Commercial complementary foods are even more expensive than nutritionally adequate local complementary foods which affect their acceptability and affordability (Ijarotimi, 2009). World Health Organization (WHO) recommended the major criteria for a good-quality complementary food. This involves adequate protein content, the high energy value per unit of food volume, soft texture, low fibre content, adequate vitamins and minerals and trace or absence of anti-nutritional factors. The development of low-cost, high protein and micronutrient-dense food for infants has been a challenge for developing countries (Anyango *et al.*, 2011). This is particularly important in countries like Nigeria where malnutrition is still common (NDHS,2018).To address these nutritional problems, two low-cost nutritious complementary foods were formulated from an underutilized root crop, legume, nuts, fish and fruits and their nutritional characteristics and acceptability were tested.

Materials and Methods

Fresh trifoliate, kidney beans, tilapia fish, dates, tiger nut, carrot and pawpaw were purchased from Oja Ota Market, in Ado Odo Ota local government area of Nigeria. Trifoliate yam (3520 g) was washed, peeled, sliced, parboiled, oven dried and milled into flour. Tilapia fish (3000 g) was oven-dried at 60 C and milled into flour. Kidney beans (3000 g) were washed, dehulled and washed thoroughly, boiled at 100C for 30 minutes, dried at 65C for 11H, and milled into flour. Tiger nut (1000 g) was cleaned, sorted, washed, drained, oven-dried at 60C for 18H and milled into flour. Carrot (1500 g) was cleaned, washed, sliced, dried at 60C for 24H, and milled into flour. Dates (1500 g) were cleaned, sorted, oven-dried at 60 C for 24H and milled into flour. Fresh pawpaw (1500 g) was washed, peeled, sliced and blended into pawpaw puree. The trifoliate yam, kidney beans, tilapia fish, vegetable oil, sugar and either date and carrot (TKDC) or tiger nuts flours and pawpaw (TKTP) in ratios of 60:10:10:5:5:7:3 or 60:10:10:5:5:5:5 were used to produce the different complementary foods. TKTP sample was prepared from trifoliate yam, kidney bean, tilapia fish, sugar and pawpaw, vegetable oil and tiger nut. Exactly 600g of trifoliate yam was weighed into a pot,100g of tilapia fish, 100g of kidney beans, 50g of tigernuts,50g of pawpaw, 50mL of vegetable oil, 50g of sugar and 150mL of water were added, mixed and cooked for 15minutes. After cooking, the food was spread on an oven tray to dry at 60C for 20 H and milled into flour using a grinding machine. TKDC was prepared from trifoliate yam, kidney bean, tilapia fish, salt and carotenoid dates. About 600g of trifoliate yam were measured into a pot, 100g of kidney bean, 100g of tilapia fish, 50g of carrot, 50g of dates, 1500mL of water, 30g of sugar and 70mL of vegetable oil were added, mixed and cooked for 15 minutes. After cooking the food was spread on a tray and dried at 60C for 20H and milled into flour using a grinding machine.

Chemical analysis

The moisture content of samples was determined using the hot-air oven (Galenkamp) method described by Kirk and Sawyer (1991). Fat content was determined using the method described by AOAC (1990). Ash content was determined by incinerating (550C) 5 g of the samples in a Gallenkamp muffle furnace using Method No 930.05 of AOAC (1995). Crude fat was determined by extracting fat from the sample (5 g) with petroleum ether (boiling point, 40 to 60C) in a soxhlet extractor (Method No 930.09) (AOAC, 2005). Protein (N × 6.25) was determined by the Kjeldahl method (Method No 978.04) (AOAC, 1995). Crude fibre was determined after digesting 2 g of fat-free sample in refluxing 1.25% sulphuric acid and 1.25% sodium hydroxide (Method No 930.10) (AOAC, 1995). The carbohydrate content was determined using the difference method. The gross energy was determined with a Gallenkamp ballistic bomb calorimeter (Gallenkamp ccb-330-010L, UK) (AOAC, 2005).Sample(5 g) was digested with a mixture of concentrated nitric acid, sulphuric acid and per chloric acid (10:0.5:2, v/v) and analysed using an atomic absorption spectrophotometer (GBC 904AA; Germany). The mineral content (calcium, iron and zinc) of the flour samples was determined using the method described by AOAC, (2005). Vitamin Awas analyzed according to the method of AOAC, (1993). The amino acid composition of samples was measured on hydrolysates using an amino acid analyzer (Sykam-S7130) based on a high-performance liquid chromatography technique. Sample hydrolysates were prepared following the method of Ijarotimi, 2009. Tannin contents were determined by the modified vanillin-HCl methods (AOAC, 2005). A standard curve was prepared using catechin (Sigma Chemicals) after correcting for blank, and tannin concentration was expressed in mg/100g.

Sensory evaluation

Sensory evaluation of the complementary foods was carried out to determine the acceptability of the taste, aroma, texture, colour, and overall acceptability of the foods by a 50panellist made up of lactating mothers with children aged 6 to 24 months using a 9-point hedonic scale rating described by Land and Shepherd (1984). 20 albino rats were used to study the effects of consumption of the complementary on weight gain. The rats were divided into 4 groups of 5 rats each. The groups were named: the TKTP group which were fed with complementary food made of trifoliate yam, kidney beans, tilapia fish, tiger nuts and pawpaw. TKDC group fed with complementary food made of trifoliate yam, kidney beans, tilapia fish, dates and carrots, a group fed with commercial complementary food (cerelac) and another with control(standard rat feed). The rats were fed for 28 days with TKTP, TKDC, commercial complementary food (cerelac) and standard rat feed. The rats were fed with standard rat feed for one week while they adapted to their new environment. They were subsequently fed twice daily with 20g/ feeding of the different complementary foods and water for 3 weeks (21 days). The weights of the rats were taken every two days using Gallenkamp beam balance.

Results and Discussion

The proximate and energy compositions of the complementary foods are presented in Table 1. The carbohydrate and energy content of TKDC were respectively 58.9% and 379.52 Kcal. The protein content of TKTP was 12.32% similar to the result of Philip *et al*., 2009 but higher than that of Egounlety, 2002 and less than the result of Kane *et al.* (2007). The protein content of 12.32% (TKTP) and 11.14% (TKDC) was slightly lower than the daily requirement of 13-14g/day stipulated by NRC, 1989. However, the protein content of TKDC was consistent with Anyango *et al*. (2011). The fat composition (21.87and 20.26% respectively for TKTP and TKDC) of the complementary foods were higher than that reported in a study conducted by Anigo *et al*., 2009 but met the recommended dietary allowance (RDA) of 10-25g fat for infants. Fat is very crucial in the absorption of fat-soluble vitamins and signifies a good indication for beta-carotene bioavailability in complementary food. The

Ash content of a food is a function of its mineral composition, the higher the ash content, the better the mineral content. Since the ash content of TKTP is significantly higher than that of TKDC, it may indicate that the mineral composition of TKTP may be higher than that of TKDC. The result of the ash composition of TKTP (5.24%) is higher than that reported by Egounlety (2002). The low moisture content of the samples (4.33 and 3.15% respectively for TKTP and TKDC) indicates a good shelf life and follows Codex Alimentarius, 2005. The higher carbohydrate composition of the TKDC sample indicates its better energy value potential land this is reflected in its higher energy value (379.52Kcal). This value is marginally similar to Mahgoub, 1999 and Kulkani *et al.* (1991). The fibre content of the two samples complied with those reported by Anigo *et al*. (2009) and Egounlety (2002).

The minerals, vitamin A and tannin compositions of the formulated complementary food samples are represented in Table 2. The Ca content of the complementary foods were O.254 and 0.261 g/100mg respectively for TKTP and TKDC. The Zn contents were 12.65 and 13.95mg/100g for TKTP and TKCD. The Fe content also followed the same trend showing that in all the parameters studied the values in TKDC were higher than those of TKTP. The mineral composition of the two formulated complementary foods is slightly higher than that of the report of Anigo *et al*. (2009) but lower than the values reported by Egounlety (2002). These minerals and vitamin A contents of the foods are believed will conveniently supply an RDA of 400mg/100g for the mineral requirement of the infant. But there was a significant difference ($P < 0.05$) in the levels of zinc and vitamin A content for the two samples and TKDC (13.95mg/100g) had the higher value for zinc while TKTP (3125.51μg/100g) had higher value for vitamin A content. This difference may have been as a result of the addition of pawpaw and tiger nuts in TKTP or dates and carrots in TKDC. This value is greater than that reported by Kulkani *et al.* (1991). Also, the tannin composition of the two complementary foods is higher than the values reported by USDA in 2011.

The amino acid profile of the formulated complementary foods is presented in Table 3. There was a significant difference ($p<0.05$)between the two formulated complementary foods in terms of isoleucine, lysine, histidine, leucine, methionine, threonine, alanine, glycine, proline, serine and cysteine with the value of TKTP being higher than that of TKDC. These amino acid values were higher than the report of Anigo (2009) but lower than FAO, 1998 recommendation and this can limit growth and brain development (Solomon, 2005). But there is no significant difference between the two complementary foods in terms of phenylalanine, tryptophan, valine, ornithine, arginine, aspartate, cysteine, glutamic acid and tyrosine. The higher proportion of amino acid composition in TKTP may be due to the pawpaw and tiger nut composition. Overall amino acid quality of the complementary foods was far better than the value reported by Nnakwe (1995) and Temple *et al. (*1996).

The results of the sensory evaluation of the complementary foods are shown in Table 4. The result showed that, overall, TKDC (8.10) was better accepted by the panellists in terms of taste, aroma, and overall, acceptability than TKTP (7.95). But TKTP (7.55) had better texture and this may be attributed to the pawpaw and tiger nut composition. There was no significant difference between the colour (7.45 and 7.50 respectively for TKDC and TKTP) of the two samples ($p>0.05$). That means that the colours of the two complementary foods were almost the same. This report is similar to the work of Ijarotimi *et al*. (2009).

The effect of the consumption of complementary foods on the weight gain of the test animals is shown in Table 5. The feeding of the test animals with the compounded complementary foods (60.96 to 113.62g (TKTP) and 57.32 to 105.92g (TKDC)) feeding between week 0 and week 3 led to higher weight gains when compared to the standard rat feed and the commercial complementary food. This increase in weight showed that the nutrients in the foods apart from being more in terms of quantity may have been more available for growth when compared to the other foods. This result is similar to that of Guthrie (1998), Okoye (1992) and Mariam (2005).

Conclusion

Nutritious and acceptable complementary foods can be made from trifoliate yam, kidney bean, tilapia fish, pawpaw, tiger nut, vegetable oil and sugar or trifoliate yam, kidney bean, tilapia fish, dates, carrot, vegetable oil and sugar. The nutritional quality of TKTP was better in terms of proximate composition, mineral, vitamin, amino acid composition and weight gain in test animals.

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Table 1: Proximate and Energy Composition of the Complementary Foods

Sample	Moisture (%)	Crude Protein (%)	Fat (%)	Fibre (%)	Ash (%)	Carbohydrate (%)	Energy (Kcal)
TKTP	4.33±0.0212	12.32±0.0989	21.87±0.0134	1.22±0.0141	5.24±0.0282	55.01±0.0169	349.53±2.277
TKDC	3.15±0.0282	11.14±0.0778	20.26±0.0707	1.14±0.0141	4.66±0.0212	58.9±0.071	379.52±2.135

Means ± standard deviation. TKTP: Trifoliate yam kidney beans tiger nuts and pawpaw. TKDC: Trifoliate yam kidney beans dates and carrots

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Table 3: Amino Acid Profile of the Complementary foods (g/100g)

Samples	TKTP	TKDC
Isoleucine	2.75± 0.0212	2.67± 0.0141
Lysine	2.95± 0.0283	2.87± 0.0283
Histidine	3.34± 0.00212	3.25± 0.0212
Phenylalanine	3.13± 0.0283	3.07± 0.0283
Leucine	5.44±0.0283	5.35± 0.0568
Tryptophan	1.26±0.0212	1.20± 0.0353
Methionine	1.54±0.0141	1.33± 0.0212
Threonine	2.52±0.0212	2.41± 0.0212
Valine	8.25±0.0212	8.13± 0.083
Ornithine	0.35±0.0283	0.30± 0.0141
Alanine	2.16±0.0212	2.04± 0.0141
Arginine	6.45±0.0736	6.30 ± 0.0141
Aspartic acid	2.15±0.0212	2.09± 0.021
Cysteine	4.09±0.0212	4.00±0.0353
Glutamicacid	11.66±0.0212	11.57± 0.0253
Glycine	3.06±0.0141	2.95± 0.0283
Proline	4.65±0.0283	4.54± 0.0283
Tyrosine	3.28±0.0212	3.20± 0.0283
Serine	1.91±0.0424	1.81±0.0212
Cystine	2.03±0.0283	1.93±0.0212

Means±standard deviation. TKTP: Trifoliate yam kidney beans tiger nuts and pawpaw. TKDC: Trifoliate yam kidney beans dates and carrots

Table 4: Sensory characteristics of the formulated complementary foods

Sample	Colour	Texture	Aroma	Taste	Overall acceptability
TKTP	7.45± 0.0212	7.55 ±0.7592	7.75 ± 0.638	7.90 ± 0.7880	7.95± 0.5104
TKDC	7.50 ± 0.864	7.30 ± 0.7327	8.00 ± 0.8580	8.10 ± 0.8335	8.10 ± 0.718

Means ±standard deviation. TKTP: Trifoliate yam kidney beans tigernuts and pawpaw. TKDC: Trifoliate yam kidney beans dates and carrots

Table 5: Effect of Consumption of Complementary Foods on Weight Gain

Sample	Week0 (G)	Week 1(G)	Week 2 (G)	Week 3 (G)
TKTP	60.96±0.10	74.380±16.16	95.293±15.83	113.62±13.58
TKDC	57.32±0.40	64.640±17.12	85.507±20.07	105.92±15.98
Cerelac	52.62±0.20	55.420±11.13	79.147±17.45	99.167±16.36
Control	56.6±0.30	64.353±12.33	81.433±12.66	100.13±13.60

Means± standard deviation. TKTP: Trifoliate yam kidney beans tigernuts and pawpaw. TKDC: Trifoliate yam kidney beans dates and carrots