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Quality and in Vivo Assessment of Precooked Weaning Food From Quality Protein Maize, Soy Bean and Cashew Nut Flour Blends

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SUMMARY/ABSTRACT

BACKGROUND: The problem of infantile mortality caused by imbalance feeding of infant shortly after cessation of breastfeeding is still a serious concern in most developing countries. This study aimed at producing precooked weaning food of high nutrient quality that can alleviate the problem of malnutrition associated with weaning children from quality protein maize, soy bean and cashew nut.

METHOD: Three formulations were produced from various mixture of flours produced from QPM, soybean and cashew nut. The blends were reconstituted and precooked at 110⁰C. The products were subjected the proximate composition, mineral, functional and pasting properties, sensory, biological assessment tests using standard methods.

RESULTS: The results showed that the addition of both cashew and soybean to QPM improved the level of protein (9.84%), fat (4.50-14.03%), ash (1.90-2.30%) and selected mineral {calcium (280.50 – 350.55 mg/100g), potassium (228.50 - 399.90mg/100g), iron (3.50-4.20mg/100g), zinc (3.20- 4.15mg/100g)} of precooked weaning food. The final viscosity and pasting temperature ranged between 142.25 – 229.33RVU and 75.25 – 80.63⁰C respectively. The sensorial quality of the diet showed that the precooked diets were acceptable to the panellists but the control was the best. The in vivo studies showed higher growth rate (30.82 – 67.10g) in the soy and cashew substituted QPM group was the best among the formulated diets while the basal did not support growth (-15.22g). The protein efficiency ratio ranged between 1.90 and 2.94.

CONCLUSION: The study concluded that QPM substituted with both soy and cashew nut produced weaning food of comparable quality to the commercial weaning food and supported good growth responses in experimental animals.

Keywords: *protein, bulk density, growth performance, sensorial quality, swelling capacity*

Abbreviations
FER, Food Efficiency Ratio
NPR, Net Protein Retention
⁰C, Degree Celsius
PER, Protein Efficiency Ratio
QPM, Quality Protein Maize
RVU, Rapid Visco Unit

Introduction

In developing countries including Nigeria traditional weaning foods are known to be of low nutritive value characterized by low protein, low energy density and high bulk, because they are usually cereal–based. The protein content of cereals such as maize and guinea corn, which is often used, is of poor quality, being low in lysine and tryptophan amino acids which are indispensable for the growth of the young child (Ijarotimi and Keshinro, 2013). In the western Nigeria maize pap or *ogi* has been used as major weaning food this has been implicated in the aetiology of protein-energy malnutrition in children during the weaning period (Ikujenlola and Fashakin, 2005, Shiriki *et al*., 2015). This nutritional deficiency is responsible for most infantile mortality in the developing countries. Improved weaning and breastfeeding practices are essential to achieve the Millennium Development Goals (MDGs) for child survival and prevention of protein-energy malnutrition (Lutter and Rivera, 2003). To achieve this goal, formulation and development of nutritious weaning foods from local and readily available raw food materials have received a lot of attention in many developing countries (Plahar and Annan, 1994; Modu *et al*., 2010; Sodipo and Fashakin, 2011; Ijarotimi and Keshinro, 2013), however, locally available quality protein maize, soybean and cashew combination have not been tested for weaning foods. Quality protein maize is considered a bio-fortified food, because its nutritional profile has been improved using conventional breeding techniques. The grain of quality protein maize (QPM) varieties is like normal maize but contains nearly twice as much lysine and tryptophan, amino acids that are essential for humans and monogastric animals (Nuss and Tanumihardjo, 2011; Abiose and Ikujenlola, 2014). Soybean [*Glycine max* (L.) Merrill] has been extensively used as important source of dietary protein and oil throughout the world. Though, soybean is a widely cultivated crop, most of it is used as the raw material for oil milling, and the residue (soy meal) is mainly used as feedstuff for domestic animals (Liu, 1997). Soybean contains 35–40% protein on a dry-weight basis, of which, 90% is comprised of two storage globulins, 11S glycinin and 7 Sβ -conglycinin. These proteins contain all amino acids essential to human nutrition, which makes soy products almost equivalent to animal sources in protein quality but with less saturated fat and no cholesterol. Dry soybean contain 19% oil, 35% carbohydrate (17% of which dietary fibre), 5% minerals and several other components including vitamins (Liu, 1997, Ajay *et al*., 2011). Cashew is a highly nutritious and concentrated form of food, providing a substantial amount of energy. The cashew nut kernel has a pleasant taste and flavour and can be eaten raw, fried and sometimes salted or sweetened with sugar (Akinhanmi *et al*., 2008). It also contributes as an important source of invisible fat in the diet, being widely used in a variety of ways. The objectives of this study were to harness the potentials of these locally available crops (quality protein maize, soy bean and cashew nut) in the formulation and development of weaning food of high nutrient quality and to assess the quality of the weaning foods.

Materials and methods

Materials

Quality protein maize was purchased from the research farms Obafemi Awolowo University, Ile-Ife, Nigeria. Soy bean and cashew nut were purchased from Ile-Ife central market, Ile-Ife, Nigeria.

Methods

Material preparation

Quality protein maize and Soybeans flours were prepared using the method described by Shiriki *et al*. (2015). The grains of quality protein maize and soybeans were separately cleaned and washed in clean tap water. The maize was air dried for 12 hours. The soybeans were soaked in tap water for 12 hours and washed by rubbing between the palms to remove testa, then washed again several times with more water until most of the testa were washed out. It was then boiled for 30 minutes in water, air dried for 48 hours and then dried in an oven at 70˚C for 30 minutes. (Soaking and roasting were intended to remove the beany flavour).

The maize and the processed soybeans were separately milled in a disc attrition mill (ASIKO All, Addis, Nigeria) and sieved using a 420 μm sieve.

Roasted unsalted cashew nut was sorted for wholesomeness. The cashew nut flour was obtained by pulverizing the roasted cashew nut in a wooden mortar for size reduction and milling in a 2L Excella grinder into a smooth powder. The respective flour was packaged in polyethylene bag for further use.

Formulation and production of precooked weaning diets

The various flours were formulated to produce precooked samples used as the experimental diets by blending the flours at different ratios. QPM: Cashew: Soybean 100:0:0; 70:30:0; 70:15:15. Each blend was thereafter reconstituted in boiling water (1:2 flour: water) for 15 minutes and dried in an oven at 110^{0}C for 20 hours. The dried component was milled and packaged in polyethylene bag (FAO/WHO 1991, Ikujenlola and Adurotoye, 2014).

Methods of analysis

The proximate composition determination of the samples

The proximate composition (protein, fat, ash, moisture and crude fibre) of the diets was determined in triplicate using the standard procedures of Association of Official Analytical Chemists - AOAC (2005). Five grams of each formulated samples were used to determine the moisture content in a hot-air circulating oven (Galenkamp). Ash was determined by incineration of 2 grams each of the food samples in a Gallenkamp muffle furnace at 550 ºC (Gallenkamp, size 3) (Method No 930.05) (AOAC, 2005). Crude fat was determined by exhaustively extracting 10 grams of each sample in petroleum ether (boiling point, 40 to 60 ºC) in a Soxhlet extractor (Method No 930. 09). Protein (N × 6.25) was determined by the Kjeldhal method (Method No 978.04) using 0.5 gram each of the formulated samples (AOAC, 2005). Crude fibre was determined after digesting 5 grams each of fat-free samples in refluxing 1.25% sulfuric acid and 1.25% sodium hydroxide (Method No 930.10) (AOAC, 2005).

The carbohydrate content was determined by subtracting the summed up percentage compositions of moisture, protein, fat, crude fibre, and ash contents from 100 g of the sample [100% - (moisture % + protein % + fat % and ash %)].

Energy was determined by calculation from fat, carbohydrate and protein content using the Atwater's conversion factor; 4.0 kcal/g for protein, 9.0 kcal/g fat and 4.0 kcal/g for carbohydrate (Iombor *et al*., 2009).

Mineral compositions determination of the samples

AOAC (2005) methods were used to determine mineral compositions of the samples. One gram of sample was digested with nitric/perchloric/sulphuric acids mixture in ratio 9:2:1 respectively, filtered and the filtrate in a 5 ml volumetric flask was loaded to Atomic Absorption Spectrophotometer, (model703 Perkin Elmer, Norwalk, CT, USA). The standard curve for each mineral (calcium, iron, and zinc), was prepared from known standards and the mineral value of samples estimated against that of standard curve.

Potassium value was determined using Flame photometer (Sherwood Flame Photometer 410, Sherwood Scientific Ltd. Cambridge, UK).

Functional properties determination

The selected functional properties of the diets determined included bulk density, water absorption capacity, oil absorption capacity, swelling capacity and reconstitution index of the flours were determined following the methods described by Suresh and Samshe (2013).

Pasting properties determination

Pasting characteristics were determined with a Rapid Visco Analyzer (RVA) (Model RVA 3D+, Newport Scientific Australia). First, 3.0 g of the sample was weighed into a dried empty canister; then 25 ml of distilled water was dispensed into the canister containing the sample. The solution was thoroughly mixed and the canister was well fitted into the RVA as recommended. The slurry was heated from 50-95°C with a holding time of 2 min followed by cooling to 50°C with 2 min holding time. The rate of heating and cooling were at a constant rate of 11.25°C per min. Peak viscosity, trough, breakdown, final viscosity, set back, peak time and pasting temperature were read from the pasting profile with the aid of thermocline for windows software connected to a computer (Newport Scientific, 1998).

Sensory evaluation

Sensory evaluation of the coded samples was carried out by a ten member semi-trained panel drawn from the University community. All panel members were either nursing mothers or had nursed baby before, who are used to weaning food. The panellists were given specific instructions on what to do. The attributes evaluated were colour, texture, aroma, taste and overall acceptability. Scoring was done on 9-point Hedonic scale where 9 represents liked extremely and 1 disliked extremely (Agu *et al*., 2015)

Biological Evaluation of Samples

Thirty weaning albino rats aged 30 - 35 days with average initial weight of 53.30 - 54.12 g were obtained from the Faculty of Pharmacy, Obafemi Awolowo University, Ile-ife, Nigeria. The rats were randomly distributed into six groups comprising five rats each. The rats were housed in individual metabolic cages in a room at 28 ±2 °C. The rats were acclimatized for four days and thereafter fed with three experimental diets, basal and control (*Cerelac*- a commercial formula) diets with water *ad libitum* daily for 28 days. These diets were made to contain approximate 10% protein (iso nitrogenous diet) except for the basal diet which was non protein diet. The feed intake was measured daily and body weight at 3 days intervals. Data on feed consumption and spilled food were collected by recording the feed measured out for each rat at the beginning and the quantity remaining after feeding. Gain or loss in weights of the rats was also recorded. Protein Efficiency Ratio (PER), Feed Efficiency Ratio (FER) and Net Protein Utilization (NPU) were calculated. The experimental rats were sacrificed with chloroform at the end of 28 days, dissected and the weight of tissues - heart, spleen, lung, hind limb and kidney were taken using electronic weighing balance (Ikujenlola and Fashakin, 2005; Shiriki *et al*., 2015).

Statistical analysis

All determinations were done in triplicate and subjected to statistical Analysis of Variance (ANOVA) using SPSS version 18 statistical package (SPSS, Inc., USA) to determine variation between means. Duncan Multiple Range Test (DMRT) was used to separate means. Significant variation was accepted at $p<0.05$.

Results and Discussion

Proximate composition of pre cooked weaning food

The proximate composition of the samples of precooked weaning food formulated and produced from blends of quality protein maize, cashew and soybean is presented in Table 1. The crude protein ranged between 9.86 and 16.75%. The addition of both cashew and soybean increased the value protein of the blends. Modu *et al*. (2010) and Bintu *et al*., (2015) in similar studies reported increase in protein when cereal was fortified with legume. Quality protein maize has been reported to contain good quality protein in terms of lysine and tryptophan (Prassanna *et al*., 2001; Abiose and Ikujenlola, 2014). Children in the developing countries are highly susceptible to protein energy malnutrition due to imbalance in the level of protein consumed shortly after cessation of breastfeeding or on the account of unplanned pregnancy. According to FAO/WHO Codex Alimentarius Standards for weaning foods the protein content should range from 14.52 to 37.70 g/100 g (FAO/WHO, 1994). The protein content of the blends falls within the recommended range. The protein content of the commercial weaning food which served as control was 15.50%.

The crude fat ranged from 4.50 to 14.03%. Sample 70% QPM: 30% cashew nut had the highest fat content while sample 100% QPM had the lowest fat content. The addition of legume and oilseed accounted for the increase in fat content of the blends. Cashew and soy bean contain about 40 and 20% oil respectively. Weaning food is not expected to have high fat content (>10%) to prevent rancid and off flavour conditions during storage. However, high fat can increase the energy content resulting from fat component of the diet. The fat content of the control was 9%.

Table 1: *Proximate Composition of weaning food (%)*

Sample	Protein	Fat	Ash	Moisture content	Crude Fibre	Carbo-hydrate	Energy (kcal)
QPM	$9.84_c\pm2.50$	$4.50_c\pm0.80$	$1.90_b\pm0.50$	$9.41_b\pm 0.25$	$2.60_b\pm0.70$	$71.75_a\pm0.60$	$366.86_a\pm5.50$
QPM: Cashew	$14.72_b\pm3.26$	$14.03_a\pm1.55$	$2.03_a\pm0.40$	$8.20_c\pm0.65$	$2.90_a\pm0.80$	$58.12_b\pm0.60$	$417.63_a\pm5.62$
QPM: Soy: Cashew	$16.75_a\pm3.23$	$11.50_b\pm1.05$	$2.30_a\pm0.20$	$8.80_b\pm0.50$	$2.30_c\pm0.40$	$58.35_b\pm0.50$	$403.90_a\pm5.75$
*Control	15.50	9.00	5.00	4.00	5.00	61.50	389.00
FAO/WHO	>15.00	10.00-25.00	<3.00	<5.00	<5.00	64.00	400.00-425.00

***Control= The proximate composition as it appeared on the label**

Ash content ranged from 1.90 to 2.30%. Ash is an important nutritional indicator of mineral content (Fennema, 1996). The control has 5.00% ash. All the formulated samples recorded low ash content compared to the control but were comparable to the standard of FAO/WHO (1991) recommendation for weaning food. The addition of both soy and cashew nut flours increased the ash content and by implication the mineral content of the products.

The moisture content of the samples ranged between 8.20 and 9.41%. The residual moisture content of weaning diets is a function of drying temperature, loading depth, drying time and dimension of material. The moisture content in the samples was higher than the moisture of the control. The addition of both cashew and soybean did not increase the moisture content. Bassey *et al*.(2013) reported lower moisture of 5.45% for similar products from banana base The low moisture content of the product will have a positive effect on its shelf stability as the higher the moisture content the less stable the food will be toward oxidation reactions if other environmental factors are favourable.

The crude fibre ranged between 2.30 and 2.90%. The addition of cashew accounted for the increase in fibre of the diet. High dietary fibre content has been reported to impair protein and mineral digestion and absorption in human subjects (Whitney *et al*., 1990). Infants require less fibre in their diet because of these reasons and due to inability of their gastrointestinal system to handle it. The recommended fibre should be less than 5% for infants' food (PAG, 1971).

The carbohydrate of the weaning food samples ranged between 58.12-71.75%. The traditional weaning foods are known to be high in carbohydrate. The QPM supply most of the carbohydrate at the expense of both soybean and cashew nut which are legume and oil seed respectively. A range of 41.13 to 73.79 g/100 g carbohydrate is recommended by Codex Alimentarius Standards (FAO/WHO, 1994).

The energy density of the samples depends on the values of fat, protein and carbohydrate of the diets. Infants require adequate supply of energy to meet all the physiological functions of the growing system. The energy value of the samples ranged between 366.86 and 417.63kcal. The addition of both soy and cashew increased the energy content of the fortified diets. According to Okoye *et al*. (2010) the energy content of blends produced from sorghum flour which is blended with African yam bean flour at the levels of 10%, 20%, 30%, 40% and 50% ranges from 382.98 - 362.10kJ. Inadequate supply of energy with marginal supply of protein is responsible for protein energy malnutrition which is prevalent among children in the developing countries (Waldlaw, 2000).

Mineral content of precooked weaning food

Mineral elements present in food are generally utilized to reduce the occurrence micronutrients malnutrition. The result of mineral element determination is summarized in Table 2. The composition of the elements calcium, potassium, iron and zinc in the various food samples varied. Calcium content ranged from 280.50 to 350.55 mg/100g, potassium ranged from 312.25 to 399.90 mg/100g, iron varied from 3.50 to 4.20 mg/100g and zinc ranged between 3.20 to 4.15 mg/100g. The addition of both cashew and soy bean to 70% QPM gave products of varied mineral contents. The value of mineral of the weaning diet was largely influenced by the content of the mineral in both soy and cashew. It was observed that cashew nut was low in some of the minerals determined. Calcium is required by the growing children for strong bones and teeth, development of muscles and nerves, blood clotting and for immune defence (Whitney *et al*., 1990). Zinc actively participates in healthy growth and development. Potassium is required for proper functioning of cells, tissue and organs in the body. It is also crucial to heart functioning and plays a key role in skeletal and smooth muscle contraction making it important for normal digestive and muscular function. Iron is an essential micronutrient for the synthesis of haemoglobin (an oxygen carrier in the red blood cells), myoglobin (used for muscle contraction) and enzymes/coenzymes (used in various metabolic path-ways) (Whitney *et al*., 1990).

Table 2. *Mineral element composition of weaning food (mg/100g)*

Sample	Calcium	Potassium	Iron	Zinc
QPM	$350.55_{a}\pm10.50$	$312.25_{b}\pm10.60$	$4.20_{a}\pm0.07$	$4.15_{a}\pm0.50$
QPM:CASHEW	$280.50_{c}\pm11.30$	$228.50_{c}\pm10.80$	$3.50_{c}\pm0.05$	$3.20_{c}\pm0.02$
QPM:SOY: CASHEW	$308.2_{b}\pm16.25$	$399.90_{a}\pm15.05$	$4.05_{b}\pm0.07$	$3.75_{b}\pm0.04$
Commercial (Control)	600.00	635.00	7.50	5.00
FAO/WHO	516.00	500.00	16.00	3.20

Children develop birth defects and inability to learn properly, among other long-term disabilities when minerals are in inadequate supply (Wierdsma *et al*., 2013). The result showed that the mineral composition of the diets was low in terms of calcium, potassium, iron and zinc, when compared with Commercial weaning food which served as control sample and FAO/WHO (1991) recommended values for infant formulas. The fact that the formulated food samples are plant based accounted for the low level of the mineral composition of the weaning foods, and besides, commercial formulas are usually fortified with micronutrients in order to meet the FAO/WHO guidelines for infant complementary food formulations.

Functional properties of formulated samples

Table 3 shows the selected functional properties of the samples formulated from blends of QPM, cashew and soy bean flours. The bulk density of the samples ranged from 0.73 to 0.77 g/ml. It was observed that addition of cashew led to the increase of the bulk density of the QPM (0.77 g/ml). Bulk density is a measure of heaviness of flour. The result is similar to the value (0.73 g/ml) reported for QPM by Ikujenlola and Adurotoye (2014). However, the range of values in this study is lower than the range (0.80g/cm^3 to 0.88 g/cm^3) reported by Ijarotimi and Keshinro (2013) for similar product.

The water absorption capacity of the samples ranged from 42.50 - 52.50%. The addition of cashew nut and soybean flour to the QPM reduced the water absorbing capacity of the diets. The water absorption capacity is an index of the maximum amount of water that a food product would absorb and retain (Marero *et al*., 1988). The microbial activities of food products with low water absorption capacity would be reduced. Hence the shelf-life of such product would be extended. High water absorption capacity is disadvantageous in complementary feeding as it limits the absorption of nutrients (Afam-Anene and Ahiarakwem, 2014).

Table 3. *Functional properties of the precooked weaning foods*

Sample	Water absorption capacity (%)	Bulk density (g/ml)	Reconstitution index (%)	Swelling capacity (%)	Dispersability (min)
QPM	52.50$_a$±3.30	0.74$_b$±0.02	89.47$_a$ ±3.54	86.86$_a$±3.75	4.67$_c$±0.58
QPM: Cashew	47.50$_b$±3.20	0.77$_a$±0.01	87.50$_a$±0.00	65.00$_b$±3.50	6.67$_b$±0.58
QPM: Cashew: Soybean	42.50$_c$±3.50	0.73$_b$±0.03	59.09$_b$±0.00	56.80$_c$±3.25	9.67$_a$±0.58

The significance of a low WAC is that it is desirable for making thinner gruels with high caloric density per unit volume. According to earlier reports of Desicharkar (1980); Ikujenlola and Fashakin (2005); Sodipo and Fashakin (2011); low water absorption capacity is achievable by germination process which activates the inherent amylase enzymes in grains; these enzymes saccharify or dextrinify the starch in the grains to dextrin and maltose which absorbs little water when cooked. According to WHO (2003) appropriate complementary food is the one which produce a gruel or porridge that is neither too thick for the infant to consume nor so thin that energy and nutrient density are reduced. Therefore, low water absorption capacity is desirable in complementary food for making thinner gruels with high caloric density per unit volume.

The swelling capacity varied from 56.80 - 86.86%. The 100% QPM had the highest swelling capacity while the addition of cashew and soy reduced the swelling capacity. Kinsella (1976) states that swelling causes changes in hydrodynamic properties of food thus impacting characteristics such as body, thickening and increase viscosity to foods. Swelling index is an important factor used in determining the amount of water that food samples would absorb and the degree of swelling within a given time. Lower swelling capacity is an advantage in complementary feeding as it increases the nutrient density of the food and the child is also able to consume more in order to meet the nutrient requirement (Afam-Anene and Ahiarakwem, 2014).

The values for reconstitution index ranged from 59.09 - 89.47%. All the formulated diets reconstituted well. However, it was observed that the addition of cashew and soybean flours led to the decline of the reconstitution index. The reduction could be explained on the basis of the starch in the samples containing both cashew and soybean which is low compared to the QPM sample. During reconstitution starch is gelatinized; the more the starch the better the reconstitution.

Pasting characteristics of the food

Several changes may occur upon heating a starch-water system, including enormous swelling, increased viscosity, translucency and solubility and loss of anisotropy (birefringence). These changes are defined as gelatinization (Ikegwu *et al*., 2010). The pasting temperature of the weaning diets ranged between 75.25 and 80.63^{0}C (Table 4). The pasting temperature of the normal corn starch, *Brachystegia eurycoma* flour and starch according to Ikegwu *et al*. (2010) are 84.80, 88.25 and 84.10°C, respectively which are higher than the temperature range of these samples. However, the pasting temperature obtained was considerably higher than that for wheat starch 55.6-63.0°C, chick pea 63.5-69.0°C and horse bean 61.0-70°C starches (Lineback and Ke, 1975; Shimelis *et al*., 2006).

The pasting temperature range of the diets were higher than the gelatinization temperature of 70.5 °C reported for *Ogi* (fermented corn) flour by Oluwamukomi *et al*. (2005); 66.7 °C and 67.2 °C for white and red sweet potato flours reported by Osundahunsi *et al*. (2003). The pasting temperature is one of the pasting parameters which provide an indication of the minimum temperature required for sample cooking, energy costs involved and other components stability (Shimelis *et al*., 2006). The peak viscosity which is the ability of starch to swell freely before their physical breakdown. The values of peak viscosity of the flour samples from this study varied between 128.50 and 208.67 RVU (Table 4). These values were higher than the range reported by Adenekan *et al*., (2014) for pigeon pea varieties but lower than those obtained for cowpea flour (340 RVU) according to Olopade *et al*. (2005). Diet of high viscosity is not suitable for weaning food because this may cause choking and difficulty during feeding of the infants (Marero *et al*., 1988). High peak viscosity is an indication of high starch content (Osungbaro, 1990). The low peak viscosity and final viscosity of the diets implies that the complementary diets will form a low viscous paste rather than a thick gel on cooking and cooling (Omueti *et al.* 2009). The set back value of the weaning diets indicates how cohesive the gruel will be on cooking. The set back ranged between 60.17 and 122.92 RVU the addition of both soy and cashew nut flour increased the set back values of the products. This may be as a result of the high fat content of the diets. It has also been reported that low set back is an indication that the starch has a low tendency to retrograde or undergo syneresis during freeze thaw cycles (Ikujenlola and Fashakin, 2005). This means that the diets can be stored at low temperature with low tendency to retrograde. The pasting time ranged between 5.33 and 5.88 minutes. There were increase in the peak time to achieve gelatinization of the soy and cashew fortified diets.

Table 4: *Pasting characteristics of formulated weaning foods (RVU)*

Sample	Peak 1 viscosity	Trough 1	Break down	Final viscosity	Set back	Pasting time(min)	Pasting temperature(°C)
QPM	133.50	85.08	48.42	142.25	60.17	5.33	80.25
QPM: cashew	208.67	140.75	67.2	226.05	85.33	5.42	75.25
QPM: cashew :soy	128.50	106.42	22.08	229.33	122.92	5.88	80.63

*RVU = Rapid Visco Unit (1RVU = 12Centipoise)

Sensory Evaluation

The decision on what type of food to be consumed by infant depends largely on the mother and caregivers, more than often their preference is the choice of the infant. One of the factors considered in choosing any food is the sensorial quality; this determine to a reasonable extent the acceptance of the food or otherwise. The precooked weaning foods were presented to mothers who were either nursing children or who had nursed baby before. Their preference is presented in Table 6. Their responses showed that all the food products were acceptable to the panellists at varying degrees with respect to colour, taste, aroma and texture. In all, the commercial diet and *ogi* (traditional weaning food) were the most acceptable with respect to all sensorial factors except aroma in the case of *ogi*. The precooked diets were ranked high in sensorial factors such as taste and aroma.

Table 6. *Sensorial qualities of formulated precooked weaning foods and controls.*

	Ogi	QPM	QPM:Cashew	QPM:Soy:Cashew	Commercial
Colour	6.3_a	5.2_c	5.5_b	5.8_a	6.4_a
Taste	5.7_a	5.0_c	5.7_a	5.4_b	6.5_a
Aroma	5.1_b	4.9_b	5.8_a	5.6_a	6.6_a
Consistency/ Texture	6.0_a	4.9_b	5.1_b	5.1_b	6.5_a
Overall acceptability	6.1_a	4.1_b	4.0_b	4.4_b	6.8_a

The overall acceptability of the samples showed significant differences ($p<0.05$) between the controls and the formulated precooked diets. There was no significant difference ($p>0.05$) between the two controls. The acceptance of ogi over the formulated diets could be as a result of the fact that the panellists are use to it and well accustomed to it over the years. From the panellists' assessments it could be inferred that the sensorial qualities of the formulated precooked products should be improved to meet the desire of the intending consumers.

Biological evaluation of precooked weaning food

Feed consumption rate

The rate at which the experimental animals ate the food varied (80.50-126.40g) with the various food samples. It was observed that the group placed on commercial control diet consumed more than the other groups while the soy and cashew substituted groups did not consumed as much as the control. The rate of consumption is a function of the texture, taste and aroma/ flavour of the diet. The commercial diet was sweeter than the other food samples. The presence of the cashew in the other sample could account for reduced rate of consumption because according the previous studies it causes satiety and this reduces rate and volume of what is consumed. The quantity of food consumed and the composition of the food are factors that determine the nutrition of the consumer.

Growth performance

The overall growth performance of the test animals is shown in Fig.1. The mean growth rate of the animals ranged between 30.82 – 67.10g. All the formulated diets supported positive growth except the basal diet (non protein diet). The highest weight gain over the period of investigation was recorded for the commercial diet while second best diet was the QPM fortified with soy bean and cashew nut flour. In addition, it was observed that fortifying QPM with soybean and cashew improved the rate of growth of the animals. The addition of the legume and oil seed imparted positively on the protein quality of the products this attested to the increased rate of growth in the groups fed with fortified diets. According to Waldlaw (2000) protein is essential for growth, repair of worn out tissues especially among children. QPM is a new hybrid of common maize which according to Prassanna *et al*. (2001) and Abiose and Ikujenlola (2014) contain lysine an essential amino acid at a reasonable quantity higher than that of common maize. Lysine is essential for non ruminant animals including man. The group fed with basal diet had a negative growth rate, the animals were observed to be sluggish during feeding exercise and this was due to the fact that the sample lacks protein. Similar scenario could be imagined when human is nutritional depleted and serious hunger has set in, such individual becomes moody and unwilling to participate in any energy sapping activities. Decline in the height for age and weight for age standard by infant cause stunting and wasting respectively which accounts for infantile mortality in children in the developing countries (FAO/WHO, 1991).

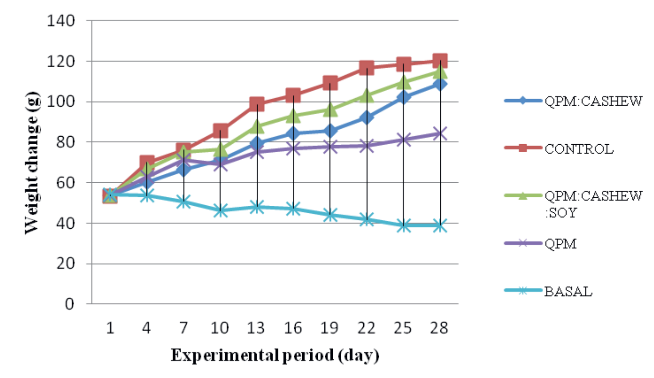

Fig.1 Weight changes of the experimental animals (g)

Weights of experimental animals' organs

The Fig. 2 shows the mean weight of the organs (heart, liver, kidney, spleen, lungs). The weight of the kidney varied from 0.28 - 0.94g, tissues 0.18 - 1.64g, livers 1.8 - 6.08g, hearts 0.25 - 0.62g, lungs 0.35 - 1.0g and spleens 0.13- 0.76g. The sizes and weights of the organs examined did not follow the trend of rate of growth. In most of the organ under consideration group fed with QPM fortified with 30% Cashew recorded the highest weight. The reason for this may not be separated from the fact that cashew contain high fat than soy bean and QPM. In human excessive enlargement of certain organs may portend danger, apart from the effect of food or diet, excessive exercise or worry can account for unnecessary enlargement of the heart.

Protein quality of precooked weaning food

The protein efficiency ratio (PER), food efficiency ratio (FER) and net protein ratio (NPR) of the groups is presented in Table 5. The PER ranged from 1.69 to 2.84. PER is based on the weight gain of a test subject divided by its intake of a particular food protein during the test period. The PER of the control (2.84) was the highest confirming the fact that the diet supported growth better than the other groups and that the growth was as a result of the contribution of protein. These observations are consistent with earlier report of significant increase in PER in rats as a result of improved nutritional composition (Shiriki *et al*., 2015). The lower values of protein indices recorded for the 100% QPM food product could be because lower quantity was consumed by the experimental rats. The PER reported by Shiriki *et al*. (2015) range between 1.69 and 2.04 for complementary food from Maize, Soybean and Peanut Fortified with *Moringa oleifera* Leaf Powder. The FER of the precooked weaning food ranged between -0.02 and 0.03. The ability of any food to improve or maintain the wellbeing of consumers depends on the quality and quantity of food consumed. The amount of food consumed by the rats varies and this affected the weight gain during the experiment. The commercial diet was consumed more than the other diets. The NPR ranged between 2.90 and 4.22. The lowest NPR was recorded for 100%QPM while the commercial sample had the highest value (4.22).

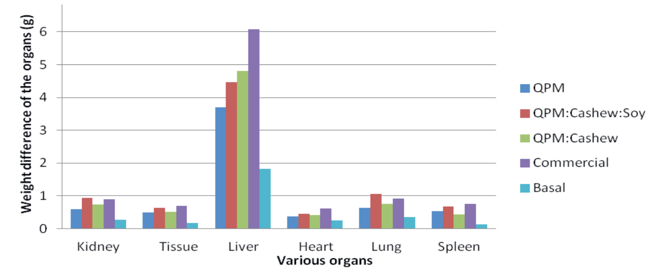

Fig. 2 Weights of various organs of experimental animals

Table 5. *Parameters determined for biological assay*

Group	PER	FER	NPR
QPM	1.69_c	0.02	2.90_d
Commercial diet	2.84_a	0.03	4.22_a
QPM:Cashew	2.11_b	0.03	3.34_c
QPM:Soy:Cashew	2.61_a	0.02	3.68_b
Basal diet	-	-0.02	-

Conclusion

The study concluded that precooked weaning food of high nutritional and sensorial qualities can be produced from blends of QPM, soy and cashew nut flours. The fortified blends promoted growth in the experimental animals and had sensorial qualities acceptable to the panellists. The sample containing both blend of soy and cashew was best with respect to the parameters evaluated and it compared favourably with the commercial weaning food which served as control.

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