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Full Length Research paper

Functional, anti-nutritional and sensory acceptability of *taro* and soybean based weaning food

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Functional, anti-nutritional and sensory acceptability of taro-and soybean based weaning food were investigated. Three weaning diets (A,B,C) each differing in the ratio of taro and soybean seed flours were formulated and fortified with vitamin mixture and sucrose. The diets were assayed for functional, anti-nutritional and organoleptic properties. Results showed that the levels of the anti-nutrients were significantly lower ($p < 0.05$) in diet A (Taro: 50.2%, soybean; 36%), than diets B (Taro; 46.2%, soybean; 40%) and C (Taro; 60%, soybean; 26.2%). Diet A was not significantly different ($p < 0.05$) from the Reference. Swelling index, water absorption capacity, and bulk density were significantly ($p < 0.05$) lower in diet A than in diets B, C and Reference. Diet A was most acceptable ($p < 0.05$) to the panelists and there was no significant different ($p < 0.05$) with Reference. The results showed that Diet A had the desired characteristics of a weaning food, hence could be used as low-cost weaning food to provide sufficient nutrients and energy for a growing child.

Key words: Functional anti-nutrients, sensory properties, water absorption, swelling index, weaning food.

INTRODUCTION

Nutritionally, there are two biological revolutions in life, the first one is the change from the intra-uterine nutrition to breastfeeding at birth, and second is the weaning to other foods other than milk (Mosha and Lorri, 1987). In these two transitional periods, the first one may involve some problems but no greater risk even under poor hygienic and social conditions, the second one however which is the "weaning period" can be a period of problem and increased vulnerability to infections for the survival of a child. The weaning period mean the period which an infant becomes accustomed to foods other than milk. This period covers the time between six months to about two and a half years of age (Gordon et al., 1968). In developing countries commercial weaning foods are very expensive and out of reach of low-income families. This may pose a risk to the life of children as they may be susceptible to malnutrition. In Nigeria the traditional weaning food is a thin cereal gruel (which is highly deficient in protein) usually made from maize (*Zea mays*), millet (*Pennisetum americanum*) or guinea corn (*Sorghum* spp) called akamu; 'ogi' or 'koko' depending on the cereal used. Unfortunately, the traditional method of their preparation is accompanied by severe nutrient loss which aggravates the poor nutritional quality of the diet (Adeniji and Potter, 1978), thus leading to a vicious circle of malnutrition and infection, possibly leading to death, resulting in high infant mortality and morbidity amongst weaning age children (Mensa et al., 2001). However, the formulation and development of nutritious weaning foods from local and readily available crops has received a lot of attention, stimulating interest, in the use of legumes notably soybeans, groundnuts and cowpeas in supplementation with cereals/starchy root tubers (Akinrele and Edwards 19-71), Abbey and Nkanga (1988); Chau, (1988), Alwinick et al., (1988).

Taro (Colocasia esculenta) is an underutilized root crop with promising economic value. It is energy-rich, available and quite affordable. The utilization of Taro could be increased by developing suitable processing technology and securing consumer acceptance. The aim of this research is to formulate a low-cost nutrient dense weaning food from taro and soybean composite flours. This research would provide an affordable weaning food in order to reduce the incidence of malnutrition and hence

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reduction of infant mortality and morbidity.

MATERIALS AND METHODS

Raw taro-cocoyam corms (*Colocasia esculenta*) and soybean seeds (*Glycine max*) were purchased from a local market in Calabar, Nigeria. The raw materials were physically examined to ensure they were disease-free and then stored in a cool dry placed and used within 24 h.

In the production of taro flour, the taro corms were peeled and steeped immediately in portable tap water at room temperature (25°C) for 10 min to prevent the browning of the peeled corms. The peeled corms were then washed in portable tap water to remove the surface starch (mucilages) and then sliced to 2 min thickness using a manual kitchen slicer. The sliced taro was then cooked for 30 min after which the water was drained and dried in an oven (Gallenkamp Model) on aluminum foil lined on perforated aluminum trays at 60°C until a constant weight was obtained. The dried taro corms was milled to flour using a hammer mill, (Model, Christy and Norris Ltd; Chemsfold, England) and then sieved into fine flour particles using a mesh screen sieve of 300 microns size to obtain the cooked taro flour (CTF).

For soybean flour production, soybean seeds were sorted and unwanted materials removed. The cleaned seeds were washed in water and soaked overnight, and the water drained. The soybean were washed with portable tap water, drained and then cooked in water twice its volume for 30 min. The cooked soybeans were dehulled, dried, milled to flour to obtain cooked soybean flour (CSF) as for taro flour.

In the weaning food formulation, three diets (A, B and C) differing from each other with respect to the ratio of their soybean and taro flour composition were formulated (Table 2). Hofvander and Underwood (1987) method for formulating the weaning diets which was based on the technical report of the Protein Advisory Group (PAG) of the United National System was used. The three diets were fortified with a vitamin mixture and sucrose obtained from the Department of Biochemistry, University of Calabar in proportions specified by the A. O. A. C. (1990). The appropriate amounts of taro and soybean flours were weighed using an electronic balance (J. T. series, Japan), mixed and stored in sealed air tight containers for analysis. *Nutrend* a commercial weaning diet produced from maize and soybeans by Nestle Nigeria Plc was purchased and used as the reference sample for the analysis; all the analyses were carried out in duplicates.

Analysis

Anti-nutritional Evaluation: Oxalate level was estimated by the method of Dye (1956). The oxalic acid was extracted from the sample and precipitated as calcium salt. They were then dissolved in hot 25% sulphuric acid. The concentration of oxalates in the solution was determined by titration with $KMnO_4$. The precipitation of other calcium salts such as calcium tatarate and calcium malate was excluded by carefully controlling the pH.

Estimation of phytates was by the method described by McCance and Widowson (1953). Phytic acid was precipitated with excess ferric chloride and the phytin was determined directly by estimating the amount of phosphorus present in the ferric phytate precipitate.

Functional property: Water Absorption capacity (WAC) was determined by the centrifuge method of Sosulski (1962). About 1.5 g of the sample was weighed into 25 ml centrifuge tube and 9ml distilled water added. The content of the centrifuge tube was stirred for 30 s with a glass rod. The suspension was given a 10 min rest interval during which the particle adhering to the sides of the tube were scrubbed down with the glass rod. The suspension was mixed 7 additional times (each period lasting for 20 s with 10 min rest period after each mixing). The tube was centrifuged (Model: MSE England) at 5100 rpm for 25 min after which the water was decanted and percentage absorbed water calculated as the ratio of weight retained of sample multiplied by 100.

Bulk density was determined by the method of Murphy et al., (2003). The sample was filled into a 10ml graduated cylinder up to the 10 ml mark. The cylinder was tapped (agitated) for 5min to eliminate air space between the flour blends in the cylinder (packed bulk density, PBD). For Loose Bulk Density (LBD), space was not eliminated by tapping.

Swelling index (SI) was estimated by the method described by Leach et al., (1995). About 1g of the sample was weighed and transferred into a clean dry test tube and then weighed. The sample was then dispersed in 50 ml of distilled water using a magnetic stirrer. The resulting slurry was heated at desired temperatures; 40, 50, 60, 70, 80, 90°C, for 30 min in a thermostat water bath (Model: Tecmel and Techmel, Texas, USA). The mixture was cooled to room temperature (25°C) and then centrifuged at 2,200 rpm for 15 min. The residue obtained was reweighed and the swelling index calculated as the ratio of the difference in weight of the flour multiplied by 100.

Sensory test: The method of Larmond (1977) was used for the sensory evaluation. The samples (50 g) were reconstituted with 250 ml of hot water and 45 g of added milk. The samples were coded in random order and then served hot to sensory panelists of 15 nursing mothers. The samples were rated using a 9 point hedonic multiple comparison scale. Panelists were asked to rate the samples twice according to a scale of 1 - 9, where I was extremely better than R and 9 was extremely inferior to R. The samples were evaluated for colour, mouth feel, taste, aroma, consistency, and overall acceptability. The panelists were given cracker biscuits and water to rinse their mouth after each sampling. The evaluation was done in a well lit room in the Biochemistry, Department.

Statisticsl test: Data were analyzed using the Statistical Package for Social Sciences (SPPS) Version 11.5 (SPPS Inc., Chicago, IL USA) at the 0.05 level for one way analysis of variance (ANOVA) test. Results were expressed at mean values ± standard deviation. The level of significance test was determined using the fisher's Least Significance Difference (LSD) test and Duncan's multiple range test.

RESULTS AND DISCUSSION

Anti-nutrional evaluation

The results of the anti-nutrients levels in the sample are shown in Table 1. There was a significant difference ($p < 0.05$) amongst the samples. For oxalates assessment samples B had the lowest (2.99 ± 0.02 mg/100 g) oxalate levels. This may be due to its low taro content (42.6%) as compared to Diets A (50.2%) and C (60%). The oxalate level in Diet C was significantly higher ($p \leq 0.05$) than that in the Reference diet, while that of Diet A compared favourably with that of the Reference, as there was no significant difference ($p < 0.05$) between the two samples. Consumption of high levels of oxalates causes corrosive gastroenteritis, shock convulsive symptoms, low plasma calcium, high plasma oxalates and renal damage (Kelsay, 1985). Also oxalates like phytates limit the availability of calcium in the body (being calcium binders) by forming insoluble calcium oxalates salts, hence de-

Table 1. Anti-nutritional contents of weaning Diets (mg/100).

Anti-nutrients	A	B	C	Reference diet
Oxalates	$3.04^b \pm 0.06$	$2.99^c \pm 0.02$	$3.38^a \pm 0.03$	$3.10^b \pm 0.01$
Phytates	$0.07^c \pm 0.04$	$0.57^a \pm 0.05$	$0.18^b \pm 0.01$	$0.07^c \pm 0.03$

*value with the same superscript in the same row is not significant ($p < 0.05$).

Table 2. Composition of diet.

Component	Diet A	Diet B	Diet C
Cooked Taro-cocoyam flour (CTF)	50.2	46.2	60
Cooked soybean flour (CSF)	36	40	26.2
Vitamin mix	0.8	0.8	0.8
Sucrose	13	13	13
Total	100	100	100

The vitamin mix contained vitamin A (4.5 g) vitamin D (0.25 g), vitamin E (5.0 g), Ascorbic acid (45.0 g), Inositol (5.0 g), $Cacl_2$ (72 g), Riboflavin (1.0 g), thiamin-Hcl (1.0 g), pyridioxine-Hcl (1.0 g), vitamin K_1 (2.25 g), Ca-Pantothenate (3.0 g), Biotin (20 µg), folic acid (90 µg) and vitamin B12 (1.35 µg).

Table 3. Functional properties of the weaning diet samples.

Parameters	Diet samples			Reference
	A	B	C	
Water Absorption Capacity WAC (%)	$140.30^d \pm 0.58$	$159.90^b \pm 0.23$	$153.10^c \pm 0.32$	$219.90^a \pm 0.06$
Packed Bulk Density (PBD)	$0.53^b \pm 0.01$	$0.54^b \pm 0.01$	$0.58^a \pm 0.06$	$0.59^a \pm 0.01$
Loose Bulk Density (LBD)	$0.36^d \pm 0.06$	$0.42^a \pm 0.04$	$0.41^c \pm 0.02$	$0.47^a \pm 0.05$
Swelling Index (SI)	$3.40^d \pm 0.06$	$4.10^b \pm 0.11$	$3.70^c \pm 0.12$	$4.60^a \pm 0.06$

*Values with the same superscript in the row are not significant ($P < 0.05$).

creasing the utilization of the mineral by the bones and tissues (Eka and Osagie, 1998). However the level of oxalates in the samples was within safe limit as to warrant any harmful effect to an infant.

Phytate levels were significantly higher ($p < 0.05$) in sample B, which had a higher amount of soybeans (40.0%) and so this higher level could be due to the high level of phytates in legumes (Eka and Osagie, 1998). Phytates level in the Reference sample was significantly lower ($p < 0.05$) than that in sample B and C, but was of the same value with that of sample A. studies on some leguminous plants by Aletor and Omodara (1994), have shown that high levels of phytates in human nutrition are toxic and limit the bioavailability of calcium, magnesium, iron and phosphorus by the formation of insoluble compounds or salts with the minerals. These minerals are indispensable to the child as they play important roles in the long term effects of growth, bone and tissue development in infants (Nelson and Cox, 2000).

However, the phytate levels of the sample are within safe limit and therefore would not pose danger to the infant.

Functional properties

The result of the functional properties is shown in Table 3. There was a significant difference ($P < 0.05$) on the WAC of the samples. The highest WAC value was for the reference sample (219.90% ± 0.06), while sample A had the least value (140.30% ± 0.58). The high WAC of the reference sample could be attributed to the high temperature employed during drum drying of the product. Protein denaturation, starch gelatinization and swelling of the crude fibre, all of which occur during drum drying may be responsible for the high WAC of the drum dried Reference sample, as compared with the low oven drying (60°C) and cooking temperatures used for processing the taro and soybeans into flour (Narayana and Narasinga Rao, 1982). Soybean a major ingredient contained in the Reference sample contains large amount of protein which is made up of subunits structure and dissociates in heating (Catsimpodas and Meyer, 1970, Abbey and Ibeh, 1988), resulting in an unmasking of non-polar residues from within the protein molecule. Dev and Quensil (1988) reported that the subunits have more water binding sites

Table 4. Mean panelists score ratings of the weaning samples.

Attributes	samples			Reference
	A	B	C	
Colour	2.5^b	1.8^c	2.7^a	1.3^c
Mouth feel	1.3^a	2.3^c	1.8^b	1.2^a
Consistency	1.3^a	2.2^b	1.6^a	1.0^a
Taste	2.5^b	2.6^b	2.5^b	1.0^a
Aroma	2.0^b	1.8^a	2.1^b	1.6^a
Overall acceptability	1.8^a	2.1^b	2.0^b	1.6^a

*Values with the same superscript in the same row are not significant ($p < 0.05$).
** Lower values indicate greater preference acceptability.

(increase in the number of hydrophilic groups which are the primary sites of water binding of protein). In addition, the high WAC of the Reference sample could be related to starch damage of the flour (Milan-Camillo et al., 2000). Amongst the formulated weaning diets, sample B (with 40% soybean) had the highest WAC. This significant increase ($p < 0.05$) is perhaps due to the water binding properties of the legume protein (Nelson and Cox, 2000). The high WAC of sample C compared to sample A could be attributable to its high composition of taro starch (60% taro), thereby resulting in the presence of many exposed hydroxyl groups on the starch molecules which are available to hydrogen bond with water, therefore leaving the starch molecules heavily hydrated (Nelson and Cox, 2000). Soni et al., (1985) observed that high water binding is attributed to loose association of starch polymers in the native granules. However, weaning foods with high water absorption capacity is not desirable for infant feeding as the product would absorb more water and less solid, resulting in low nutrient density for the child. Therefore sample with the least WAC is preferred for a weaning food; consequently sample A with the least WAC value of 140.30 ± 0.58 is preferred.

The Bulk Density (BD) is a reflection of the load the sample can carry if allowed to rest directly on one another. The lower the BD value, the higher the amount of flour particles that can stay together and thus increasing the energy content that could be derivable from such diets (Onimawo and Egbekun, 1998). The BD values of the formulated weaning samples were significantly ($p < 0.05$) lower than for the Reference sample. The Packed Bulk Density (PBD) represents the highest attainable density with compression. Sample A had the lowest PBD value of 0.53 ± 0.01 and the value was significantly ($p < 0.05$) lower than the Reference sample (0.59 ± 0.01), however, the values were comparable. Loose Bulk Density (LBD) represents the lowest attainable energy without compression. There was significant ($p < 0.05$) difference in the LBD values of the samples. Sample A had the least LBD value of 0.36 ± 0.06 and this was significantly lower ($p < 0.05$) than the Reference sample with a value of 0.47 ± 0.06. The low bulk density values of the formulated weaning samples indicate that more of the samples could be prepared using a small amount of water yet giving the desired energy nutrient density and semi-solid consistency which can easily be fed to an infant (Mosha and Lorri, 1987).

The swelling index (SI) values showed a significant ($p < 0.05$) difference among the samples. The SI values of the samples followed the same trend as the WAC. Sample A had the least (3.40 ± 0.06) SI value while the Reference sample had the highest (4.60 ± 0.06) SI value. The Swelling Index depends on the compositional structure of the sample. The WAC and SI are important parameters which ultimately determine the sample consistency (that is solid, semi-solid, or liquid). Flours with both high WAC and SI values hold large amounts of water during their preparation into gruels and thus become voluminous with a low energy and nutrient density (Cameron and Hofvander, 1982). Sample with the least SI value would provide a more nutrient-density for an infant such sample A would provide more nutrient density food for an infant.

Sensory test

Table 4 shows the result of the sensory evaluation of the samples. There was a significant ($p < 0.05$) difference in the colour ratings of the samples by the panelists. The Reference sample was significantly ($p < 0.05$) rated best, while sample C had the least colour rating. However, the rating scores were within acceptable range from 1.3 - 2.7. Sample B compared favourably with the Reference in the colour rating. Factors that many have affected the colour of the composite blends include the chemical composition of the taro and soybean, the drying temperature and duration, composition ratio of taro and soybean flours. Low colour ratings of weaning foods can decrease the acceptability as colour is an important organoleptic attribute which enhances the product acceptability. The colour ratings of the evaluated samples were within acceptable limits and therefore would not be objectionable to the infants, but could be further improved by adjusting processing conditions.

The mouth feel ratings ranged from 1.2 - 2.3. There was no significant difference ($p < 0.05$) in the mouth feel ratings of the Reference Sample and Sample A, but there was a significant difference ($p < 0.05$) between the Reference and Samples B and C. The Reference sample had the best mouth feel rating (1.2), followed by sample A, while sample B received the least mouth feel rating. The differences in the mouth feel ratings could be as result of the constitutional variations. The mouth feel is very important, as it would determine the amount of food an infant would consume, because infants can only swallow a smooth gruel and not a coarse product. However, mouth feel ratings of the composite blends were within acceptable limit.

The consistency ratings of the samples ranged from 1.0 - 2.2. There was no significant ($p < 0.05$) difference between the Reference sample and samples A and C. The Reference sample had the best consistency rating, and was followed by sample A, while sample B received the least consistency ratings of 2.2. WAC and SI are important parameters which determine the consistency of flour. A very thick consistency would need increased effort to swallow, and therefore may limit the food intake in young children who have not fully developed their ability in these aspect (King and Ashworth, 1987).

There was a significant difference ($p < 0.05$) between the Reference Sample and the formulated composite blends. However, the taste ratings of the formulated samples were not significantly different ($p < 0.05$). The Reference sample had the best rating in taste, followed by Sample A and C, and then closely followed by Sample B. However, the taste ratings of the samples were within acceptable range. The best score rating of the Reference would be as a result of flavouring addition in the product, as infants are likely to reject unflavoured foods. Therefore, to further improve the taste ratings, flavor additives might need to be incorporated into the formulated samples.

The aroma ratings of the samples ranged from 1.6 - 2.1. The Reference sample and sample B were not significantly different ($p < 0.05$) and also sample B and C did not show any significant difference ($p < 0.05$). The Reference sample was rated best for aroma, followed by sample B. The sample rating scores were within a favourable range (1.6 - 2.1), and thus the ratings compared favourably with each other. The best score rating for the Reference could be a result of the added flavourings. The high aroma rating of sample of B could be due to the presence of flavor imparted by the oils in the soybeans (which was present in a higher ratio as compared to the other formulated samples). Low aroma ratings could reduce the acceptability of the food by an infant. However, the aroma ratings of the samples were within acceptable range.

There was no significant difference ($p < 0.05$) in the overall acceptability ratings of sample A and the Reference sample, though the Reference received higher rating. However the overall acceptability of the samples B and C were within acceptable range.

Conclusion

The results showed that acceptable nutrient dense low-cost weaning food could be produced from taro and soybean composite flour. Amongst the formulated weaning foods, sample A, (CTF; 50.2%, CSF; 36%, vitamin mix 0.8%, sucrose 13%) had the most desired functional property, low levels of anti-nutrients and the best overall acceptability score rating and it compared favourably with that of the Reference. However, improving the colour, taste and aroma through flavor additives could further enhance the acceptability of sample A. Consequently the high rate of infant mortality and morbidity prevalence in Nigeria as a result of malnutrition would be greatly reduced by utilization of taro and soybean to provide a cheap high protein and energy dense weaning food.

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