

Research Article

Nutritional Evaluation of Complementary Food Gruels Formulated from Blends of Soybean Flour and Ginger Modified Cocoyam Starch

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Abstract: The use of ginger modified starch and soybean flour blends in the formulation of low-cost, nutritive complementary food gruels were studied. The complementary food samples were analyzed for their nutritional, functional, anti-nutritional and sensory properties. The nutritional composition of the samples showed that the protein content increased with increased supplementation with the soybean flour from 2.68% in sample A (10:90) to 3.97% in sample D (40:60). The functional properties of the samples showed an increase in the swelling index and water absorption capacities from samples A to sample D while the bulk densities were relatively constant. The complementary food samples also showed low levels of oxalate and phytate in the range of 0.03 to 0.06% for oxalate and 0.04 to 0.07% for phytate. The sensory evaluation carried out on the complementary food samples after reconstituting into gruel with warm water, milk and sugar showed that all the samples were well accepted by the judges.

Keywords: Cocoyam, complementary food, soybean

INTRODUCTION

Complementary foods are generally introduced between the ages of six months to three years old as breastfeeding is discontinued. While breastfed infants are often able to maintain adequate growth through their sixth month, additional nutrients are required to complement or, in some cases, replace breastfeeding completely. The main concern is making sure that there is no gap between nutrient requirements and what a child is able to consume, absorb and utilize. Most infants suffer from malnutrition not because of the economic status of the country but because of inability to utilize the available raw materials to meet their daily requirements (Annan and Plahar, 1995). Adoption of recommended breastfeeding and complementary feeding practices and access to the appropriate quality and quantity of foods are essential components of optimal nutrition for infants and young children (Lutter and Rivera, 2003).

Complementary feeding period is the time when malnutrition starts in many infants contributing significantly to the high prevalence of malnutrition in children under 5 years of age worldwide (Daelmans and Saadeh, 2003). Nutritional status in children is most vulnerable during the complementary stages when both macro and micronutrients may be insufficient to maintain growth and development. Most of the traditional complementary foods are predominantly

made of starch based cereals like maize, sorghum, millets, etc and hence of poor nutritional value, they do not satisfy the infant basic needs of protein because they have limited levels of protein both qualitatively and quantitatively. Many factors contribute to the vulnerability of children during the complementary feeding period. The complementary foods are often of low nutritional quality and given in insufficient amounts. When given too early or too frequently, they displace breast milk (Villapando, 2000; WHO, 2002).

Legumes are rarely used for complementary food because of the problems of indigestibility, flatulence and diarrhea associated with their use. However, Uwaegbute and Nnanyelugo (1987) noted that 67% of their study population satisfactorily used cowpea products for complementary.

Modification of cassava starch using ginger (*Zingiber officinale*) has been reported by Daramola and Osanyinlusi (2006). Starch modification can be broadly classified or grouped into four classes namely: physical, chemical, enzymic and biological modifications (James and West, 1997). Among these modification methods chemical means is the most frequently used process (Daramola and Osanyinlusi, 2006). However, there are legislative restrictions on the use of new synthetic chemicals for modifying starch while the use of higher concentrations of existing ones are banned (James and West, 1997). The prohibition is for consumer and worker safety, environmental concern

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and economic reasons. This has now led to the need for research into naturally occurring starch modifying agents. Ginger used as a seasoning agent and as preservatives have been reported to improve the functional properties of cassava and rice starches, respectively (Daramola and Osanyinlusi, 2006).

This study was aimed at formulating complementary diets from soybean flour and ginger modified cocoyam starch at different substitution levels as well as to evaluate the proximate, anti-nutritional, functional and sensory properties of the food blends.

MATERIALS AND METHODS

Source of materials: The raw cocoyam cormels (*Xanthosoma sagittifolium*), soybean seeds (*Glycine max*) and ginger (*Zingiber officinale*) were purchased from Ekeukwu Owerri Market in Owerri, Imo State. Ingredients and chemicals used for analysis were of high grade.

The method of Daramola and Osanyinlusi (2006) was used in the production of ginger modified cocoyam starch with slight modification. Two hundred grams cocoyam cormels were washed peeled and wet milled using double disc attrition milling machine. Five grams ginger grates were mixed with starch-water suspension and stirred periodically for 30 min at room temperature. Ginger grates were sieved out and starch milk obtained was washed several times. The starch recovered was dried in hot air oven (gallenkamp model) at 50°C until a constant weight was obtained. The starch was dry milled using Thomas Wiley Mill model ED-5 and stored in air tight plastic containers prior to use.

The method of Ikpeme-Emmanuel *et al.* (2009) was used in the production of soybean flour. The soybean seeds were sorted and unwanted materials removed. The clean seeds were washed in water and soaked overnight and the water drained. The soybean was cooked in water twice its volume for 30 min. The cooked soybean seeds were dehulled, dried and milled into flour to obtain cooked soybean flour.

The complementary diet from blends of soybean flour and ginger modified cocoyam starch were formulated as shown in Table 1.

Proximate analysis of complementary food from blends of soybean flour and ginger modified cocoyam starch: The proximate compositions of the complementary diet were determined using the method of AOAC (2000).

Evaluation of anti-nutritional factors:

Determination of oxalate: The permanganate titration method described by Onwuka (2005). A measured weight of the sample was suspended in 100 mL of distilled water and 5 mL of 6 mHCL was added. The mixture was digested by heating at 100°C for an hour.

Table 1: Blend formulation of the complementary food samples

Components	Diet A	Diet B	Diet C	Diet D
Cooked soybean flour	10	20	30	40
Modified cocoyam starch	90	80	70	60

It was cooled and filtered. Then the mixture PH was adjusted by adding 2 drops of methyl red indicator followed by drop wise addition of concentrated aqueous ammonia solution (NH₄OH) until a faint yellow colouration was obtained, at PH between 4-4.5. The mixture was heated to 90°C in a water bath, cooled and filtered (to remove ferrous ion precipitates). The filtrate was again heated 90°C and 10 mL of 5% CaCl₂ solution was added with constant stirring. It was allowed to cool and then allowed to stay overnight in the refrigerator (5°C) the mixture was centrifuged at 3000×g for 5 min. The supernatant was decanted and the precipitate was dissolved in 10 mL of 20% H₂SO₄. The solution was made up to 100 mL with distilled water and titrated against 0.05 KM_nO₄ solution to a faint pink color which persisted for 30 sec. The oxalate content was given by the relationship that 1 mL of 0.05 m KM_nO₄ solution = 0.00225 g oxalate. The formular below was therefore used to calculate the oxalate content:

$$\% \text{ oxalate} = \frac{100 \times \text{titre} \times 0.00225}{W}$$

where,

W = Weight of sample used

Determination of phytate: The oberlease spectrophotometer method described by Onwuka (2005) was used. A weighed processed sample (2 g) was extracted by mixing it with 50 mL of 0.2N HCL solution and shaken for 30 min. It was filtered through Whatman No. 42 filter paper to obtain the extract. Meanwhile, standard phytate solution (sodium phytate), was prepared and diluted to a chosen concentration. An aliquot, 0.5 mL of the extract as well as 1 mL of the standard phytate solution were put in separate test tubes and treated with 1 mL ferric solution (ferric ammonium sulphate). The tubes were corked with stoppers and boiled in a water bath for 30 min. They were cooled in ice for 15 min and then allowed to attain room temperature, then 2.0 mL of 2, 2-Bipyrimidine solution was added to each tube, mixed well and their respective absorbances were read in a spectrophotometer at 519 nanometer wavelength, the formular below was used to calculate the phytate content of the sample:

$$\% \text{ phytate} = \frac{100 \times \text{au} \times \text{c} \times \text{Vt}}{N \text{ as } 1000 \text{ Va}}$$

where,

W = Weight of sample

Au = Absorbance of sample
As = Absorbance of std phytate solution
C = Concentration of std phytate (mg/mL)
Vt = Total extract volume
Va = Vol of extract used

Evaluation of functional properties:

Swelling Index (S.I): Swelling index was calculated using the method of Ukpabi and Ndumele (1996). Ten grams of the processed sample was weighed and dispersed into 100 mL measuring cylinder, leveled and the volume noted. Distilled water was added to help the cylinder and allowed to stand for 1 h. The volume was then recorded and the swelling index calculated as the ratio of the final volume to the initial volume:

$$S = V_2/V_1$$

where,

S = Swelling index
V₁ = Initial volume
V₂ = Final volume

Water Absorption Capacity (WAC): This was determined as the weight of the water absorbed and held by one gramme of the sample (Okaka and Potter, 1997). One gramme of the sample was weighed and put into a weighed test tube. Ten mL of distilled water was added to the tube and mixed very well. The mixture was allowed to stand for 30 min at room temperature. The mixture was centrifuged at 3500 rpm for 30 min. The supernatant was decanted and the residue in the test tube was inverted over an absorbent paper (tissue pad). It was allowed to drain/dry completely before the tube and its content was weighed. By difference the weight of water absorbed and held by the sample was obtained. It was calculate as shown below:

$$WAC = \frac{W_2 - W_1}{W}$$

where,

W = Weight of sample
W₁ = Weight of empty tube
W₂ = Weight of tube + water absorbed

Bulk Density (B.D): The method of Onwuka (2005) was used. Ten grams of each sample was measured into a clean 100 mL graduated measuring cylinder and its volume was recorded in each case. Then in each case, the bottom of the cylinder was tapped repeatedly on a padded table until no further reduction was seen in volume. Its volume was recorded as the packed volume. The bulk density was calculated for both the loose and packed version using the general formula below:

$$\text{Bulk density (g/cm}^3\text{)} = \text{B.D} = \frac{\text{weight of sample (g)}}{\text{Volume occupied (cm}^3\text{)}}$$

Sensory evaluation: Sensory evaluation was conducted for the complementary food sample by a (15) member semi-trained panelists consisting of staff and students of Imo State University Owerri, amongst whom were nursing mothers. The method of Larmond (1977) was used, for the sensory evaluation. Fifty grams each of the complementary food samples were reconstituted with 250 mL of water (warm), 45 g of added milk and 5 g of sugar. The samples were rated using a 9 point hedonic scale with 9 indicating “liked extremely”, 5 indicating “neither liked nor disliked” and 1 indicating “disliked extremely”. The samples were evaluated for taste, aroma, colour, mouth feel, 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 Food Science laboratory of Imo State University Owerri.

Statistical analysis: Analysis of Variance (ANOVA) was carried out at 0.05 level to determine the difference among the samples using one factor randomized design. ANOVA as described by O’Mahony (1986) and the fisher’s Least Significance Difference (LSD) test were used.

RESULTS AND DISCUSSION

Table 2 shows the result of the nutritional composition of the complementary food gruels. The percentage mean crude protein content were in the range of 2.68±0.09 - 3.97±0.08. There was significant difference (p<0.05) amongst the samples. Sample D (40:60) was significantly higher (p<0.05) than the other samples. The low protein content of the complementary food samples may be due to the high ginger modified cocoyam starch contents of the samples. The protein level however can be improved by adding milk during reconstitution of the food samples to provide more protein for the infant as seen in some conventional complementary foods like cerelac which has different formula for infants in different age groups (six months to two years). The result also indicates that the protein content increased with increased quantities of the soybean flour addition. Okoye *et al.* (2010) reported similar findings in the development of complementary food with sorghum and African yam bean. Also a similar observation was made in a research study by Adebayo-Oyetoro *et al.* (2011) which showed an increase in the protein content with corresponding increase in the proportion of bambara flour supplementation in complementary food production from ofada rice flour blend.

Table 2: Proximate composition of soybean-cocoyam complementary food blends

Parameters	A	B	C	D
Protein	2.68 ^d ±0.08 ^d	3.90 ^c ±0.08 ^c	3.56 ^b ±0.08	3.97 ^a ±0.08
Ash	0.23 ^a ±0.02 ^a	0.46 ^a ±0.02 ^a	0.52 ^a ±0.02	0.57 ^a ±0.01
Fibre	0.81 ^d ±0.04 ^d	0.93 ^c ±0.01 ^c	1.02 ^b ±0.03	1.11 ^a ±0.02
Fat	1.22 ^d ±0.02 ^d	1.49 ^c ±0.02 ^c	1.73 ^b ±0.02	1.93 ^a ±0.02
Carbohydrate	78.55 ^a ±0.12 ^a	78.71 ^a ±0.71 ^a	80.66 ^a ±0.13	80.87 ^a ±0.50
Moisture content	16.51 ^a ±0.03 ^a	14.51 ^a ±0.04 ^a	12.51 ^{ab} ±0.03	11.55 ^{ab} ±0.20

Means in the same row with the same superscript are not significantly different at p<0.05

Table 3: Anti-nutrient composition of soybean-cocoyam based complementary food samples

Parameters	A	B	C	D
Oxalate	0.03 ^a ±0.01	0.04 ^a ±0.01	0.04 ^a ±0.01	0.06 ^a ±0.01
Phytate	0.07 ^a ±0.00	0.06 ^a ±0.00	0.05 ^a ±0.00	0.04 ^a ±0.00

Means in the same row with the same superscript are not significantly different at p<0.05

There was no significant difference (p<0.05) in the ash contents of the complementary food samples. The percentage mean ash content were in the range of 0.23±0.02-0.57±0.01. The result shows that the ash content increased with increase in soybean flour addition with sample A (90:10) having the lowest ash content (0.23±0.02^a) and sample D (60:40) having the highest ash content (0.57±0.01^a).

The fat composition of the complementary food samples showed they had low fat values. Sample D was significantly higher (p<0.05) than other samples with 1.93±0.02 while sample A had the lowest fat content of 1.22±0.0. The result showed that the higher the inclusion of soybean flour the higher the fat content. The observed increase in levels of protein and fat as the ratio of soybean flour in the blends increased may be attributed to the soybean added (cocoyam being a good source of carbohydrate) and is in agreement with the report that soybean is a rich source of protein and fat (Emovon, 1987; Oti and Akobundu, 2008).

There was significant difference (p<0.05) amongst the samples in terms of the moisture content with sample D (40:60) having the lowest moisture content value of 11.55±0.20. The moisture level of the samples decreased with increased inclusion of soybean flour. The decrease in moisture level with increase in level of substitution with soybean flour might serve as an indication of increased storage stability (Adebayo-Oyetero *et al.*, 2010). The result indicates that the sample D will have the best storage stability amongst the samples having had the lowest moisture content. There was no significant difference (p<0.05) in the carbohydrate content of the food samples. The increase in total carbohydrate is principally due to cocoyam, this crop having been shown to be a rich source of carbohydrate (Coursey, 1967). The carbohydrate levels are necessary as infants require energy to carry out their rigorous crawling and other activities as growth continues.

The results of the anti-nutritional evaluation of the complementary food samples are presented in Table 3. There was no significant difference (p<0.05) in the oxalate content of the samples. The oxalate level

decreased as the quantity of cocoyam starch in the samples decreased. Oxalates like phytates limit the availability of calcium in the body (being calcium binders) by forming insoluble calcium oxalates, hence decreasing the utilization of the mineral (calcium) by the bones and tissues (Eka and Osagie, 1998). Ikpeme-Emmanuel *et al.* (2012) reported low antinutrients in soybean-tigernut based complementary food. However the level of oxalates in the samples will not cause any harmful effect to an infant because it is within safe limits. The phytate level increased with increased level of cocoyam starch with sample A (90:10) having the highest phytate level of 0.07±0.00 and sample D (60:40) having the lowest phytate level, 0.04±0.00. The phytate levels are within safe limit and will not pose any danger to the infant because according to Aletor and Omodara (1994) high levels of phytates in human nutrition are toxic and limits the bioavailability of calcium, magnesium, iron and phosphorus by forming insoluble compounds or salts with minerals. These are minerals which are indispensable to the infant as they play important roles in the long term effect of growth, bone and tissue development in infants (Nelson and Cox, 2000).

The result of the functional properties of the complementary food samples are shown in Table 4. There was significant difference (p<0.05) in the swelling index property amongst the samples. The high values of samples C and D could be due to the high soybean flour content. The significant increase in the values may be due to the water binding properties of the legume protein (Nelson and Cox, 2000). However, complementary foods do not require high swelling index as the food would absorb more water and have less solid resulting in low nutrient density for the infant. Samples with least swelling index is preferred for a complementary food thus sample A with least swelling index value of 2.56±0.05 is preferred. The results for the water absorption capacity showed a significant difference (p<0.05) in the samples with WAC increasing with increased inclusion of soybean flour to the samples. The WAC values followed the same trend as the swelling index. Both S.I and WAC ultimately

Table 4: Functional properties of soybean-cocoyam based complementary food samples

Parameters	A	B	C	D
Swelling index	2.56 ^c ±0.05	2.76 ^b ±0.03	3.03 ^a ±0.04	3.03 ^a ±0.02
Water absorption capacity	0.56 ^d ±0.09	0.96 ^c ±0.05	1.36 ^b ±0.05	1.96 ^a ±0.69
Packed bulk density	0.71 ^a ±0.00	0.72 ^a ±0.00	0.71 ^a ±0.00	0.71 ^a ±0.00
Loose bulk density	0.34 ^a ±0.00	0.50 ^a ±0.00	0.36 ^a ±0.00	0.37 ^a ±0.00

Means in the same row with the same superscript are not significantly different at p<0.05

Table 5: Sensory results for soybean-cocoyam based complementary food samples

Parameters	A	B	C	D	E
Colour	8.00 ^a ±0.73	8.10 ^a ±0.32	8.30 ^a ±0.68	6.90 ^a ±0.72	8.10 ^a ±0.88
Mouth feel	7.30 ^a ±0.94	8.00 ^a ±0.89	7.80 ^a ±0.75	7.20 ^a ±0.93	7.80 ^a ±0.75
Aroma	7.20 ^a ±1.17	7.80 ^a ±0.98	7.70 ^a ±1.01	7.40±1.20	7.80 ^a ±0.83
Consistency	7.20 ^a ±1.42	7.53 ^a ±0.96	6.30 ^b ±0.41	6.29 ^{ab} ±1.20	5.80 ^b ±1.47
Taste	8.20 ^a ±0.91	8.00 ^a ±0.89	8.00 ^a ±0.96	7.30 ^{ab} ±0.93	8.10 ^a ±0.81
Overall acceptability	7.80 ^a ±0.75	7.70 ^a ±0.68	7.60 ^a ±0.61	7.50 ^a ±1.62	7.86 ^a ±1.00

Means in the same row with the same superscript are not significantly different at p<0.05

determine the sample consistency (that is solid, semi-solid or liquid). Flours with both high S.I and WAC values hold large amounts of water during preparation into gruels and thus become voluminous with low energy and nutrient density (Cameron and Hofvander, 1982). Sample A with least WAC value would provide a more nutrient-dense food for an infant.

There was no significant (p<0.05) difference in the bulk densities of the samples. The lower the bulk density value, the higher the amount of flour particles that can stay together and thus increasing energy content that could be derivable from such diets (Onimawo and Egbekun, 1998). The Loose Bulk Density (LBD) which is the lowest attainable density without compression was least for sample A, 0.34±0.00 and highest for sample D, 0.37±0.00 though the difference was very slight. The Packed Bulk Density (PBD) which is the highest attainable density with compression was relatively constant among the samples. The very slight increase in sample might be due to experimental errors. This low density values of the complementary food samples implies 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 result for the organoleptic analysis of the soybean-cocoyam based complementary food is shown in Table 5. There was no significant difference (p<0.05) in the color of the samples. However, the control sample E was rated least (6.9±0.72^a) while sample C (30:70) had the highest color rating of 8.3±0.68. The color rating of the formulated samples could be as a result of the raw (white) cocoyam starch used and the quantity of soybean flour used in the formulation. The high color rating of the formulated samples will enhance the acceptability of the complementary food samples by the infants. Sample D was rated least with value of 7.2±0.93 while sample B was rated highest with value of 8.0±0.89. The mouth feel is very important in a complementary food as it will determine the amount of food an infant would consume since they

can only swallow a smooth gruel not a coarse one. The mouth feel ratings were therefore within acceptable limit. There was no significant difference (p<0.05) among the samples in terms of the aroma. Sample A was rated least (7.2±1.17^a) while samples B and E were rated highest (7.8±0.98, 7.8±0.83). The aroma ratings increased with increased soybean flour addition. The increase in aroma ratings could be due to the presence of flavor imparted by the oils in soybean. Aroma enhances acceptability of complementary foods. The sensations of taste and smell are functions of flavor which is a complex of sensations (Iwe, 2007). It is the flavor of a food that ultimately determines its acceptance or rejection, even though its appearance evokes the initial response. The values for the consistency ratings of the samples by the panelists were in the range of 5.80-7.53. Sample B had the highest consistency rating while sample E had the least consistency rating. The taste of Sample D was significantly lower (p<0.05) than the other samples the taste ratings of the other samples were within acceptable limits for infants. There was no significant difference (p<0.05) among the samples in terms of general acceptability. The samples were generally accepted.

CONCLUSION

In this study attempt have been made to formulate a complementary food sample that will be of higher nutritive value and easily affordable. The results showed that acceptable low cost complementary food could be produced from ginger modified cocoyam starch and soybean flours. It is recommended that the complementary food gruel be fed to infants aged 10 months and above as obtained in different Cerelac products having different age consumption groups. The complementary food should also be taken with a good quantity of infant milk and less quantity of sugar or honey. This complementary diet is also recommended for adult consumers too.

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