Influence of Plantain and Sprouted Soybean Pastes on the Nutrient and Proximate Composition of Two Species of Cocoyam Puddings as a Complementary Food

Innocent N. Okwunodulu^{1,a*}, Daniel M. Uluocha^{1,b},
Felicia U. Okwunodulu^{2,c}

¹Department of Food Science and Technology Michael Okpara University of Agriculture,
Abia State Nigeria

²Chemistry Department Michael Okpara University of Agriculture Umudike, Abia State
Nigeria

*anncntokwu@yahoo.com, ^buluochadaniel@gmail.com, ^cokwunodulufelicia@gmail.com

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Abstract. Nutrients and proximate composition of the puddings prepared from *ede-ocha* (*Xanthosoma sagittifolium*) and *ede-cocoindia* (*Colocasia esculenta*) pastes were evaluated. Paste from each cocoyam variety was separately blended with firm ripe plantain, sprouted soybean pastes in the ratio of 100% cocoyam, 90% cocoyam:10% soybean, 25% cocoyam:65% plantain:10%soybean, and 45% cocoyam:45% plantain:10% soybean and mixed with equal quantities of seasonings. The formulated blends were wrapped in plantain leaves and boiled for 30 minutes. Values obtained showed that pudding from *ede-ocha* had a higher moisture content (56.25%), protein (4.47%), fat (1.84%), ash (2.57%), crude fiber (2.46%), iron (0.58mg), and calcium (5.12mg) than *ede-cocoindia*, which had 5.52%, 4.29%, 1.49%, 2.45%, 2.11%, 0.36% and 5.01% respectively. Also, puddings from *ede-cocoindia* had higher carbohydrate (39.28%), vitamin A precursor (62.90µg), vitamin C (33.05mg) and zinc (0.35mg) than that from *ede-ocha* which had 35.46%, 60.80 µg, 20.50 mg, and 0.32mg respectively. The *ede-ocha*, therefore, made a better nutritious pudding than *ede-cocoindia*.

Introduction

Complementary foods (CF) are non breast milk or proven nutritional companion prepared from family meals or specially prepared meal. They are introduced to the diet of breast feeding infants and young children as from six months to two years or more [1]. The CF may be solids, semi-solids or liquids [1, 2]. Due to high cost of nutritious proprietary foods which are beyond the reach of most nursing mothers in developing countries like Nigeria, CFs formulation from local staples had proved a better option [3, 4].

Puddings are popular Nigeria steamed paste prepared from mixture of wet milled root or tuber crops with seasonings such as salt, pepper, crayfish, salt, palm oil and many others, wrapped and steamed in banana leaves and the likes. Water gives soft and smooth consistency to the pudding, crayfish gives protein [5], onions provide flavor, calcium, proteins and iron. Salt supplies sodium chloride, plantain leaves imparts desirable flavour while palm oil adds colour, carotene, energy and fat. Puddings are eaten by adults and infants as complementary or weaning food.

Both cocoyam varieties are tropical root vegetables grown for their edible starchy corms whose potential nutritional components have been reported [7]. They are under-utilized, mainly eating or as soup thickener after boiling [6]. Extreme small sizes of cocoyam starch granules make it easily digestible and suitable for complementary food formulation [3, 7]. Cocoyam corms contain substantial amounts of protein, vitamin C, thiamin, riboflavin, niacin and significant amounts of dietary fiber [8]. Cocoyam has protein content of 5.87%, carbohydrate content of 88.46% on fresh weight basis [9]. Nutritionally, the cormels of *ede-ocha* (tannia) are slightly superior to *ede-cocoindia* (taro) in energy and proteins; but lower in calcium, magnesium, zinc, and trypsin [10]. Both species are valuable sources of the micro-nutrients needed to overcome 'hidden hunger' [11]. The nutritional

importance of cocoyam depends on the presence of anti-nutritional factors like oxalates [12] and phytates whose higher concentration affects their utilization [7, 10] as they prevent digestion and absorption of essential nutrients [13]. Peeling, grating, soaking, fermentation [14], and prolong (30min) cooking [10] remove cocoyam anti-nutrients [15]. Vitamins are susceptible to both processes while minerals are affected only by leaching. Free amino acids could also be leached or may react with sugars to form protein-oxalate complexes. Starches may be hydrolyzed to sugars. The percentage loss would depend partly on various factors such as the cooking temperatures and on the method of processing [16].

Plantain (*Musa paradisiaca*) is a starchy staple crop with high carbohydrate content (31 g/100g), low fat content (0.4 g/100g) and a good source of energy [17]. Plantain is also good source of vitamins and minerals [18], particularly iron (24 mg/kg), potassium (9.5 mg/kg) and calcium (715 mg/kg). Plantain also contains vitamin A precursor, ascorbic acid, thiamin, riboflavin, niacin and dietary fiber. Nutritional composition of plantain varies with variety, maturity, soil type and degree of ripeness [19]. Ripe plantain had been reported to have more minerals which are freed during ripening for more availability than in unripe plantain [20]. Plantain is also a good source of anti-oxidants, flavonoids, insignificant levels of toxic compounds [21] and trace amount of serotonin that dilates the arteries to improve blood circulation. Regular consumption helps to cure anemia and maintain a healthy heart [22]. Plantain is used as foods, breakfast cereals, and baby complementary foods [23].

Soybean which belongs to the family leguminosae is a cheap source of good quality protein because of its good balance of the essential amino acids [24], and high quality oil. Soybean contains vitamins, minerals and some anti-nutrients such as phytates, trypsin inhibitors and haemagglutinins most of which can be destroyed during processing. Absence of cholesterol, lactose and presence of essential amino acids makes soybean vital for infant growth and maintenance [25]. Soybean had been reported to contain 43% of protein, 19.5% of fat, 21% of carbohydrates and provides 432 kcal per 100g [25]. Soybean is used in production of soy flour, baby foods and others for meeting protein-energy requirement [26].

Sprouting is an age long act of improving the nutritive value of legumes during which there is reduction in anti-nutrients and flatulence causing oligosaccharides (stachyose and raffinose), thereby increasing protein digestibility and sensory properties [25]. Also, sprouting increases vitamins, mineral (calcium, copper, manganese, and zinc) nutrient bioavailability [27] and free amino acid [28]. Sprouted soybean had been used to formulate complementary foods [4, 29]. Other uses of soybean such as baking of cake have been reported [30]. This study aims at comparing the nutritional and proximate values of puddings from *ede-ocha* and *ede-cocoindia*

Materials and Methods

Both *ede ocha* (*Xanthosoma sagittifolium*) and *ede cocoindia* (*Colocasia esculenta*) cocoyam varieties used in this study were procured from the cocoyam programme of the National Root Crops Research Institute Umudike. Soybean (*Glycine max*), firm ripe plantain (*Musa paradisiaca*) and seasonings such as pepper, cray fish and salt were purchased from Urbani main market in Umuahia, both in Abia State, Nigeria.

Production of soybeans paste

The method described by Okwunodulu and Okwunodulu [4] used for production of soymilk from sprouted soybean was adopted for production of sprouted soybean paste as shown in Fig. 1.

Production of cocoyam paste

Cocoyam roots were sorted, cleaned, peeled, washed to remove impurities and milled without adding water to obtain cocoyam paste (Fig. 1).

Production of plantain paste

Firm ripe plantain fingers were sorted, cleaned, peeled, washed and milled directly with water addition to obtaining plantain paste (Fig. 1).

Production of complementary pudding

Eight samples of complementary puddings were formulated. Each sample was formulated as indicated in Table 1 following the procedure in Fig. 1. Samples 101 to 104 were prepared with *ede-ocha* wet paste while samples 105 to 108 with *ede-cocoindia* wet paste. Same ingredients are added to each formulation. Only the proportions of cocoyam, plantain and soybean pastes were varied within the 600g stated in Table 1. Samples 101 - 100% cocoyam, 102 - 90% cocoyam, 10% soybean, 103 - 25% cocoyam, 65% plantain, 10% soybean, 104 - 45% cocoyam, 45% plantain, 10% soybean, 105 - 100% cocoyam, 106 - 90% cocoyam, 10% soybean, 107 - 25% cocoyam, 65% plantain, 10% soybean, 108 - 45% cocoyam, 45% plantain, 10% soybean.

Table 1. Recipe for pudding production

Ingredients	Quantity
Cocoyam, plantain and soybean Paste	600 g
Onion	25 g
Water	150 ml
Palm oil	120 ml
Crayfish	120 g
Salt	1.5 g

Figure 1. Production flow chart for *ede-ocha* and *ede-ccocoindia* pudding production

Analysis

All the pudding samples were subjected to nutrient and proximate analyses separately in triplicates as described below. The mean of the triplicate values were used for statistical analyses. Carbohydrate was calculated as difference (100% - values of all components).

Moisture content determination

Gravimetric Oven Drying Method protocol described by Onwuka [31] was used. Ten grams (10g) of the sample was put into a previously cleaned and weighed moisture can, dried in the oven at 105°C for 3 hours, cooled in a desiccator and weighed after. The process was repeated at an hour interval until a constant weight was obtained. The final dry weight was recorded and used to calculate the percentage moisture content of the sample as shown below:

$$\% \text{ Moisture content} = \frac{W_2 - W_3}{W_2 - W_1} \times \frac{100}{1},$$

where W_1 = initial weight of empty can, W_2 = weight of can + sample before drying, W_3 = weight of can + sample after drying.

Crude protein determination

Kjeldahl Method of Onwuka [31] was used. One gram (1.0g) of the sample was mixed with 10mls of concentrated H_2SO_4 in a digestion flask. A tablet of selenium catalyst was added before heating in a fume cupboard until a clear solution was obtained (i.e. the digest) which was diluted to 100mls in a volumetric flask.

10mls of the digest was mixed with equal volume of 45% NaOH solution in a kjeldahl distillation apparatus. The mixture was diluted into 10mls of 4% boric acid containing 3 drops of mixed indicator (bromocresol green/methyl red). A total of 50mls of distillates was collected and titrated against 0.02N EDTA from green to deep red endpoint. The N_2 content and hence the protein content was calculated using the formula below:

$$\% \text{ Protein} = \% N_2 \times 6.25$$

$$\% N_2 = \frac{100}{W} \times \frac{N \times 14}{1000} \times \frac{V_t}{V_a} TBK,$$

where w = weight of sample, N = normality of titrant (0.02 H_2SO_4), V_t = total digest volume (100ml), V_a = volume of digest analyzed (10ml). T = titre value of sample and B = titre value of blank.

Ash content determination

Muffle furnace ignition method described by Onwuka [31] was used. Three grams (3g) of the sample was measured into washed, dried and weighed porcelain crucible and ignited in the muffle furnace at 550°C. The sample was allowed to ash to a grayish white ash, brought out from the furnace using a forcep and left in a desiccator to cool. The cool porcelain was weighed and ash content calculated as shown below:

$$\% \text{ Ash} = \frac{W_3 - W_1}{W_2 - W_1} \times \frac{100}{1},$$

where W_1 = weight of empty crucible, W_2 = weight of crucible + food before drying and W_3 = weight of crucible + ash.

Fat content determination

Soxhlet ether extraction protocol of Onwuka [31] was employed. Three grams (3g) of the sample was weighed into a thimble and placed into a reflux flask fitted to a weighed 300ml round bottom flask. A 300ml round bottom flask was filled with 250ml of petroleum ether (Bp 40 to 60°C) and placed on a heating mantle preset at 60°C to reflux for about 6h during which the vapour rises and leaches all the oil from the sample in the thimble into the round flask. Thereafter, the thimble containing the sample was removed from the reflux flask and the excess was either recovered by

heating leaving only the oil in the round bottom flask. The flask was detached from the set up and placed on the oven set at 105°C to dry off excess ether, allowed to cool in a desiccator and then reweighed and the oil was calculated as shown below:

$$\% \text{ Fat} = \frac{\text{Weight of fat}}{\text{Weight of sample}} \times \frac{100}{1} \%$$

Crude fiber determination

The method of Onwuka [31] was used. Two (2g) grams of each sample were digested with 200 ml of 1.25% H₂SO₄ solution under reflux for 30 min boiling. The digest was allowed to cool and then filtered with Buckner funnel equipped with muslin cloth. The residue was washed thrice with hot water, scooped into a conical flask and digested with 200 ml of 1.25% NaOH solution under reflux for 30 min boiling. The digest was cooled, filtered and washed thrice with distilled water. The residue was drained and scooped into a previously dried and weighed crucible and then put into the oven to dry at 105°C to a constant mass. The dish with its content was reweighed after drying and then placed in the muffle furnace to ash at temperature of 550°C for 3 h. The ash was withdrawn at the end and put in a bell jar and reweighed. The weight of fiber was calculated as a percentage of weight of sample analyzed as below:

$$\% \text{ Crude fiber} = \frac{W_2 - W_3}{\text{Weight of sample}} \times \frac{100}{1} \%$$

where W₂= weight of crucible + sample after boiling, washing and drying and W₃= weight of crucible + sample as ash.

Calcium determination

The EDTA complexometric titration method described by James [32] was used. 10g of the sample was dispensed into separate conical flasks, pinches of the masking agents (potassium cyanide, potassium ferrocyanide and hydroxyl hydrochloride) were measured into each flask and 20ml of ammonia buffer was added to raise the pH. The flask containing sample at 10.0 pH a pinch of Erichrome dark black indicator was added and titrated against 0.02N EDTA solution while Solochrome dark blue indicator was added and titrated against 0.02N EDTA solution at pH of 12.0. A reagent blank was titrated as a control. The calcium content of the samples was calculated using the standard that 1ml of 1N EDTA has an equivalence of 20.04mg calcium.

$$\% \text{ calcium} = (100/W \times N/100 \times V_f/V_a),$$

where W= Weight of sample analyzed, V_f = Volume of extract, V_a = Volume of extract used and N = Normality.

Zinc determination

Zinc was determined according to AOAC [33] method. One gram (1g) of the sample was first digested with 20ml of acid mixture (650ml concentrated HNO₃, 80ml perchloric acid (PCA). About 5ml of the digest was diluted to 100ml with distilled water and subjected to AAS reading. Also a standard solution of various zinc concentrations of 0.0, 0.2 and 1.0 was prepared and subjected to AAS to generate the standard curve. The concentration was calculated by extrapolation on the standard curve.

Determination of iron

The iron content was determined by spectrophotometric method of James [32]. One gram (1g) of the sample was first digested with 20ml of acids mixture (650ml concentrated HNO₃, 80ml perchloric acid and 20ml concentrated H₂SO₄). The digest was diluted by making up to 100ml with distilled water. 2ml of the sample solution was pipette inside a flask before 3ml buffer solution, 2ml hydroquine solution and 2ml bipyridyl solution were added. The absorbance reading was taken at wavelength of 520nm and the blank was used to zero the instrument. Also, a standard solution of iron

was prepared by dissolving 3.512g of $\text{Fe}(\text{NH}_4)_2(\text{SO}_4) \cdot 6\text{H}_2\text{O}$ in water and two drop of 0.5N HCL was added and diluted to 500ml with distilled water. The iron standard was further prepared at different concentration at 2ppm to 10ppm by diluting with distilled water. 3ml buffer solution, 2ml hydroquinone solution and 2ml bipyridyl solution were added. Absorbance reading was taken at 520nm. The readings were used to plot a standard iron curve for extrapolation.

Vitamin A determination

Spectrophotometric method of Okwu and Josiah [34] was employed. Five gram (5g) of sample was dissolved in 30ml of absolute alcohol (ethanol) and 3ml of 5% potassium hydroxide was added. The mixture was boiled under reflux for 30 minutes, cooled rapidly with running water, filtered; 30ml of distilled water was added and transferred into a separating funnel. The lower layer was discarded and the upper layer was washed with 50mls of distilled water. The extract was evaporated to dryness and dissolved in 10mls of isoprophyl alcohol and its absorbance was measured at 325nm and vitamin A was calculated as.

$$\text{Vit. A (mg/100g)} = \frac{100}{w} \times \frac{au}{as} \times c,$$

where au = absorbance of test sample, as = absorbance of standard solution, c = concentration of the test sample and w = weight of sample.

Determination of vitamin C

The method used was as described by Ukwu and Josiah [34]. 10g of the sample was extracted with 50ml EDTA/TCA extracting solution for 1 hour and filtered through a Whatman filter paper into a 250 ml conical flask, 10ml of 30% KI and 50mls of distilled water was added. Starch indicator (2ml of 1%) was added and titrated against 0.01ml CuSO_4 solution to a dark endpoint.

$$\text{Vit. C (mg/100g)} = 0.88 \times \frac{100}{5} \times \frac{V_f}{20} \times \frac{T}{1},$$

where V_f = volume of the extract, T = Sample titre – blank titer.

Statistical analyses

Mean data obtained from triplicate analyses were subjected to analysis of variance (ANOVA). A completely randomized design using SPSS version 22 was used to analyze the data. Means were separated using Duncan multiple range test at 95% confidence level ($p < 0.05$).

Results and Discussion

Proximate results of the puddings from both cocoyam varieties were presented in Table 2. Moisture content (56.25%) of *ede-ocha* pudding in sample 101 (100% cocoyam) was significantly ($p < 0.05$) higher than 52.55% from *ede-cocoindia* pudding in sample 105 (100% cocoyam). The difference could be due to variety. Same reason may explain higher MC in sample 104 (45% cocoyam, 45% plantain, 10%) than 108 (45% cocoyam, 45% plantain, 10% soybean) which were their least MC values. The puddings MC from 100% cocoyam of both varieties were significantly higher than their counterparts with plantain and soybean pastes in their formulations. Protein must have bound with some water [30, 35] resulting lower MC. The more the moisture, the softer the pudding texture. Water also helps to maintain smooth paste consistency [5], lubricates and adds juiciness during eating and swallowing. Therefore, puddings from 100% *ede-ocha* will be easier to swallow than that from *ede-cocoindia* and those with plantain and soybean in their formulation.

Crude protein content of *ede-ocha* puddings (4.51%) in sample 102 (90% cocoyam, 10% soybean) was significantly ($p < 0.05$) higher than 4.29% from *ede-cocoindia* puddings in sample 106 (90% cocoyam, 10% soybean). The difference could be due to variety effects as both had same 10% soybean paste inclusion. Protein content superiority of *ede-ocha* over *ede-cocoindia* reported by [10] was substantiated by higher protein content (3.35%) of 100% *ede-ocha* puddings than 3.22% from 100% *ede-cocoindia* pudding. Inclusion of plantain and soybean in the puddings increased

significantly their protein contents, but the increase in *ede-ocha* puddings were more than that in *ede-cocoindia*. Despite these, consumption of 300 to 400g and 310 to 420g of puddings from *ede-ocha* and *ede-cocoyam* respectively will meet the recommended protein daily intake of 9.1g/d [36] which is possible considering infants' stomach capacity of 200ml [37]. Protein is an essential nutrient for proper growth and development of the body of infants and young children and a major structural component of muscle tissues which helps to repair increase and maintain children muscle mass. Besides, protein is also a component of child's blood, organs, skin and glands [38].

There is varietal influence on fat content of the puddings of both cocoyam varieties. This was reflected on significantly ($p < 0.05$) higher fat content of *ede-ocha* pudding (1.84%) in sample 104 (45% cocoyam, 45% plantain, 10% soybean) than 1.49% from *ede-cocoyam* pudding in sample 108 (45% cocoyam, 45% plantain, 10% soybean). The variation may also be attributed to higher (39.28%) carbohydrate content of *ede-cocoindia* than 35.46% from *ede-ocha* puddings which may have proportionally reduced the total percent fat content despite higher fat content (1.21%) of *ede-cocoindia* than *ede-ocha* (0.95%). Besides, all the pudding samples from both varieties with same formulations were significantly difference ($p < 0.05$) from each other. Fat contribution from the puddings of both cocoyam varieties agrees with recommendations of vegetable oil inclusion in infant and children foods [39] to increase the energy density and transport vehicle for fat soluble vitamins. Fat will aid infant in swallowing the puddings while enhancing the flavor for increase acceptability.

Ash, an index of mineral content of the puddings exhibited significant ($p < 0.05$) variations with cocoyam variety. Maximum ash content (2.57%) was from *ede-ocha* pudding in sample 104 (45% cocoyam, 45% plantain, 10% soybean) while the lease value (2.31%) was from *ede-cocoindia* in sample 104 (45% cocoyam, 45% plantain, 10%). Also, significant higher ash content (2.14%) of sample 105 containing 100% *ede-cocoindia* than 2.01% in sample 101 with 100% *ede-ocha* follow suit and also validated the report of [10] that *ede-cocoindia* contains more mineral than *ede-ocha*. It is interesting to note that despite same formulations and higher ash content of *ede-cocoindia*, ash content of sample 104 (45% cocoyam, 45% plantain, 10% soybean) was higher than sample 108 (45% cocoyam, 45% plantain, 10% soybean). This may mean that vitamin - mineral interactions [29] which are nutrient loss [40], and leaching of mineral [16] may have been higher in *ede-cocoindia* than in *ede-ocha*. Ash is an indication of the amount of minerals (trace elements) with a well defined biochemical functions in the human body [41]. Iron works in synergy with protein and copper to produce red blood cells that transport oxygen from lungs to all the tissues for maintaining all body's life functions like fuelling the cell division and growth of a developing body [42]. Iron deficiency leads to anemia which is a preventable disease through food fortification or formulations for infants and young children [43]. Calcium is mainly used for bones, teeth blood clotting, nerve, muscle health, and others [42, 44].

Maximum crude fiber content of *ede-ocha* pudding (2.46%) in sample 103 (25% cocoyam, 65% plantain, 10% soybean) which was significantly ($p < 0.05$) higher than 2.10% from *ede-cocoindia* pudding in sample 107 (25% cocoyam, 65% plantain, 10% soybean) confirmed the differential varietal effects. Both samples have the same formulations. The value (2.46%) from *ede-ocha* pudding compared better to 2.54% reported by Olayiwola et al [45] from pudding prepared from cocoyam flour than 2.10% from *ede-cocoindia* pudding. The difference could be as a result of lower MC of cocoyam flour which may have increased the ash content by proportion. Consumption of 2 to 3g/d of puddings from both cocoyam varieties will meet fiber RDI of 5g.d [46] for infants aged between 6months to one year which made them a good fiber source [8]. Crude fiber is a carbohydrate subtype consisting of soluble and insoluble portions responsible for normalizing infant's bowel movement prevents constipation and helps control blood pressure [46].

Significant higher carbohydrate content of *ede-cocoindia* pudding (39.28%) in sample 105 (100% cocoyam) than *ede-ocha* (35.46%) in sample 104 (100% cocoyam) could be traced to varietal difference. Same reason holds for the significant ($p < 0.05$) higher carbohydrate content from all *ede-cocoindia* puddings than their counterpart from *ede-ocha* with same formulation. This validated the superiority of *ede-cocoindia* over *ede-ocha* reported by Akpan and Umoh [10]. However, consumption of 158 to 330 g/d and 175 to 370g/d respectively of puddings from *ede-cocoindia* and

ede-ocha will meet the infant's total carbohydrate RDI of 60 to 95g/d per serving for infants aged between 6 to 12 months [36]. These will also meet 130g/d of total carbohydrate daily intake for children beyond 12 months [47]. Lower quantity of *ede-cocoindia* is required to meet the RDI than *ede-ocha*. Carbohydrates provide energy needed to fuel children's metabolism, supports growth, keeps their brain and nervous systems working and maintains overall health [47].

Table 2. Proximate composition of puddings prepared from two varieties of cocoyam blended with plantain and soybean [%]

Samples	MC	Crude protein	Crude fat	Ash	CF	Carbohydrate
101	56.25 ^a ±0.21	3.35 ^c ±0.01	0.95 ^f ±0.01	2.01 ^f ±0.01	1.94 ^c ±0.01	35.46 ^c ±0.01
102	55.05 ^b ±0.07	4.51 ^a ± 0.28	1.82 ^a ± 0.02	2.32 ^d ±0.10	1.98 ^d ±0.02	34.34 ^b ±0.01
103	54.40 ^c ±0.14	4.47 ^b ± 0.02	1.82 ^a ± 0.01	2.37 ^c ±0.01	2.46 ^a ±0.01	34.52 ^b ±0.01
104	54.05 ^c ± 0.07	4.45 ^b ± 0.02	1.84 ^a ± 0.01	2.57 ^a ±0.03	2.41 ^b ±0.01	34.65 ^f ±0.01
105	52.55 ^d ± 0.35	3.22 ^f ± 0.01	1.21 ^e ± 0.01	2.14 ^c ±0.01	1.64 ^e ±0.01	39.28 ^a ±0.03
106	51.15 ^f ± 0.07	4.29 ^c ± 0.01	1.36 ^d ± 0.03	2.45 ^b ±0.01	1.77 ^f ±0.01	38.99 ^b ±0.01
107	52.10 ^{de} ±0.28	4.20 ^d ± 0.01	1.43 ^c ± 0.01	2.35 ^c ±0.01	2.10 ^c ±0.01	37.86 ^d ±0.03
108	51.90 ^e ±0.14	4.17 ^d ± 0.01	1.49 ^b ± 0.02	2.31 ^d ±0.01	2.11 ^c ±0.02	38.03 ^c ±0.01

The values are mean triplicate determinations ±standard deviations. Mean values in same column with different superscripts (a-f) are significantly different (p<0.05). Values in same column with same superscripts are not significantly (p<0.05) different. Sample 101-104 are produced from *ede-ocha* and 105-108 from *ede-cocoindia*. 101 = 100% cocoyam, 102 = 90% cocoyam, 10% soybean, 103 = 25% cocoyam, 65% plantain, 10% soybean, 104 = 45% cocoyam, 45% plantain, 10% soybean, 105 = 100% cocoyam, 106 = 90% cocoyam, 10% soybean, 107 = 25% cocoyam, 65% plantain, 10% soybean, 108 = 45% cocoyam, 45% plantain, 10% soybean. MC=moisture content and CF= crude fiber

Vitamin composition of the puddings

Vitamin content results of puddings from both cocoyam varieties were presented in Table 3. Varietal effects increased significantly (p<0.05) the vitamin A content of the puddings from 60.80µg (*ede-ocha* puddings) in sample 103 (25% cocoyam, 65% plantain, 10% soybean) to 62.90µg (*ede-cocoindia*) pudding in sample 107 (25% cocoyam, 65% plantain, 10% soybean). The difference was validated by higher vitamin A content (13.55µg) of 100% *ede-cocoindia* than 12.95µg from 100% *ede-ocha* puddings despite same formulations. Vitamin A is a vital micronutrient in complementary foods which deficiency is of public health concern worldwide. However, puddings from *ede-cocoindia* require ingestion of 794g which is lower than 822g from *ede-ocha* to meet vitamin A RDI of 500 µg/d [48] for infant and young children aged between 6 months to 2 years.

Varietal difference also manifested in the maximum vitamin C content of *ede-cocoindia* (33.05mg) in sample 107 (25% cocoyam, 65% plantain, 10% soybean) which was significantly (p<0.05) higher than 20.50mg from *ede-ocha* pudding in sample 103 (25% cocoyam, 65% plantain, 10% soybean). Also, vitamin C content (6.32mg) of 100% *ede-cocoindia* was significantly (p<0.05) higher than 4.81mg from 100% *ede-ocha* puddings. Lower vitamin C values obtained in 100% cocoyam of both varieties could be attributed to non incorporation of plantain and soybean which may mean that their vitamin C content is low. Plantain is a rich source of vitamin C [18, 19]. Though puddings from both cocoyam varieties were between 'good' and 'very good' sources of vitamin C [49], but more (195 to 832g) quantities of pudding from *ede-ocha* is needed to meet vitamin C RDI of 40mg for infants aged between 1 to 3yrs [50] than 121 to 633g from *ede-cocoindia* puddings. This implies that *ede-cocoindia* will meet vitamin C RDI easier than *ede-ocha* puddings and therefore a better source. Besides, as vitamin C is needed in trace amount for biological functions [32], it implies that cocoyam of both varieties in this study are adequate to meet infants' vitamin C RDI of 40mg. Vitamin C helps in maintaining healthy immune systems, fight infections, synthesis of collagens which gives structure and maintains healthy muscle, vascular tissue, tendons, ligaments, teeth, bones, gum, cartilage, joints, lining, skin and blood vessels [50]. Severe vitamin C deficiency leads to scurvy, a fatal disease [51] which causes malformation of infants' bone [49].

Table 3. Vitamin composition of puddings prepared from two varieties of cocoyam blended with plantain and soybean

Samples	Vitamin A [μg]	Vitamin C [mg]
101	12.95 ^g $\pm$ 0.07	4.81 ^b $\pm$ 0.01
102	22.15 ^f $\pm$ 0.21	8.70 ^b $\pm$ 0.00
103	60.80 ^b $\pm$ 0.78	20.50 ^{ab} $\pm$ 0.14
104	55.65 ^c $\pm$ 0.56	18.25 ^{ab} $\pm$ 0.14
105	13.55 ^g $\pm$ 0.07	6.32 ^b $\pm$ 0.01
106	26.3 ^e $\pm$ 0.07	11.10 ^b $\pm$ 0.14
107	62.90 ^a $\pm$ 0.14	33.05 ^a $\pm$ 0.07
108	45.35 ^d $\pm$ 0.07	11.95 ^b $\pm$ 0.07

Values are mean of triplicate determinations $\pm$ standard deviations. Mean values in same column with different superscript (a-g) are significantly different ($P < 0.05$). Sample 101-105 are produced from *ede-ocha* and 105-108 from *ede-cocoindia*. 101 = 100% cocoyam, 102 = 90% cocoyam, 10% soybean, 103 = 25% cocoyam, 65% plantain, 10% soybean, 104 = 45% cocoyam, 45% plantain, 10% soybean, 105 = 100% cocoyam, 106 = 90% cocoyam, 10% soybean, 107 = 25% cocoyam, 65% plantain, 10% soybean, 108 = 45% cocoyam, 45% plantain, 10% soybean.

Mineral composition of puddings

Table 4 presents the results of the mineral content of the puddings from both cocoyam varieties. The *ede-ocha* puddings which recorded maximum iron content of 0.58mg/100g in sample 103 (25% cocoyam, 65% plantain, 10% soybean) was significantly ($p < 0.05$) higher than 0.56mg/100g from *ede-cocoindia* pudding in sample 107 (25% cocoyam, 65% plantain, 10% soybean). Varietal difference can explain this as 100% *ede-ocha* pudding in sample 101 had more iron (0.45mg/100g) than 0.40mg/g from *ede-cocoindia* pudding in sample 105. Besides, both puddings had same formulation. Though puddings from both cocoyam varieties responded linearly to iron increase due to plantain inclusion in their formulations [18], but those from *ede-ocha* still maintained their significant superiority when compared to their corresponding counterparts. General lower iron content from the puddings of both cocoyam varieties apart from variety may be attributed to leaching during boiling [16] and interaction with calcium and vitamin C in the puddings [29]. Meeting iron RDI of 11mg/d [52] for infants aged between 6 months to 2 years requires consumption of higher quantities of the puddings ($> 1.896\text{kg}$) from both cocoyam varieties which makes the puddings poor sources of iron unless other iron rich food nutrients are used in the formulations. Therefore, the puddings should be taken along with iron rich foods. Iron works in synergy with protein and copper to produce red blood cells that transport oxygen from lungs to all the tissues where they are needed for maintaining all body's life functions like fuelling the cell division and growth of a developing body [42]. Advanced stage of iron depletion leads to anemia which is characterized with fatigue and shortage of blood [53].

Maximum zinc content (0.35mg/100g) obtained from *ede-cocoindia* pudding in sample 107 (25% cocoyam, 65% plantain, 10% soybean) was significantly ($p < 0.05$) higher than 0.32mg/100g from *ede-ocha* pudding in sample 103 (25% cocoyam, 65% plantain, 10% soybean) which may be traced to varietal differences as both puddings have same formulations. This was substantiated by significant ($0 < 0.05$) higher zinc content of 100% *ede-cocoindia* pudding in sample 105 (0.29mg/100g) than 0.28mg/100g from *ede-ocha* pudding. Zinc values obtained from puddings of both cocoyam varieties were lower than 0.44mg obtained by Olayiwola et al [45] from pudding prepared from cocoyam flour which may be due to drying and cocoyam variety used. Zinc content of all the puddings of both varieties will meet the RDI of 2mg to 3mg/day for infants aged between 6 months to 2 years [48] by consuming 625 to 1079g for *ede-ocha* puddings and 571 to 857g for *ede-cocoindia* puddings. Puddings from *ede-cocoindia* are therefore better zinc source and can meet the zinc RDI easier than that from *ede-ocha*. Despite this, both puddings are good zinc source for older children aged ($> 1\text{y}$) than young children as consumption of these quantities per day is feasible. Adequate zinc intake supports protein metabolism, wound healing, growth, immune function and others. In young children zinc deficiency results in retarded growth and learning ability [54].

Varietal influence was also noticed in the puddings calcium content. Maximum calcium value (5.12 mg/100g) from 100% *ede-ocha* puddings in sample 101 was significantly ($p<0.05$) higher than 5.01mg/100g obtained from 100% *ede-cocoindia* in sample 105. This justified the earlier report that plantain [18] and cocoyam [55] are good sources of minerals with *ede-ocha* being superior [10]. It is worthy to note that despite the difference, puddings from both cocoyam varieties exhibited lower calcium values in those puddings with plantain and soybean pastes inclusions than in their 100% counterparts. This could be attributed to interactions between protein and calcium content of the formulations [4]. Calcium is of tremendous importance to infants and young children especially in healthy development of their bones and teeth [56]. Due to general low calcium content of the puddings from both cocoyam varieties, consumption of more than 2700g will be required to meet calcium RDI of 270 to 600 mg/day [56] for infants aged between 7 to 12 months. This makes the puddings poor calcium sources for young infants, but their 100% cocoyam puddings were better.

Table 4. Mineral composition of puddings prepared from two varieties of cocoyam blended with plantain and soybean [mg]

Samples	Iron	Zinc	Calcium
101	0.45 ^e ± 0.16	0.28 ^h ± 0.01	5.12 ^a ± 0.00
102	0.39 ^g ± 0.01	0.30 ^f ± 0.12	5.00 ^c ± 0.01
103	0.58 ^a ± 0.01	0.32 ^d ± 0.03	4.11 ^g ± 0.00
104	0.51 ^c ± 0.03	0.31 ^e ± 0.12	4.40 ^e ± 0.21
105	0.40 ^f ± 0.02	0.29 ^g ± 0.00	5.01 ^b ± 0.02
106	0.36 ^h ± 0.01	0.33 ^c ± 0.10	4.70 ^d ± 0.01
107	0.56 ^b ± 0.00	0.35 ^a ± 0.21	4.00 ^h ± 0.01
108	0.48 ^d ± 0.02	0.34 ^b ± 0.01	4.32 ^f ± 0.14

Values are mean triplicate determinations ± standard deviations. Mean values in same column with different superscripts (a-h) are significantly different ($p<0.05$). Samples 101-105 are produced from *ede-ocha* and 105-108 from *ede-cocoindia*. 101 = 100% cocoyam, 102 = 90% cocoyam, 10% soybean, 103 = 25% cocoyam, 65% plantain, 10% soybean, 104 = 45% cocoyam, 45% plantain, 10% soybean, 105 = 100% cocoyam, 106 = 90% cocoyam, 10% soybean, 107 = 25% cocoyam, 65% plantain, 10% soybean, 108 = 45% cocoyam, 45% plantain, 10% soybean

Conclusions

Variety had significant influence in the nutrient and proximate composition of puddings from *ede-ocha* and *ede-cocoindia*. Puddings from *ede-ocha* variety had higher moisture, protein, fat, ash, fiber, iron and calcium, but lower in carbohydrate, vitamin A, vitamin C and zinc than that from *ede-cocoindia*. Puddings from 100% cocoyam of both varieties which recorded higher moisture content will likely be softer than their counterparts with plantain and soybean inclusion. Similarly, *ede-ocha* puddings will be softer for easier mastication and swallowing by the infants. With enhanced consumption *ede-ocha* puddings will likely contribute to infants' growth and strong bones by meeting their nutritional requirements than *ede-cocoindia*.

Besides, this study showed feasibility of compatible economical semi-solid nutritious complementary food from cheap and locally available raw materials from underutilized cocoyam, firm ripe plantain and sprouted soybean pastes. Though complementary puddings from *ede-ocha* performed better than *ede-cocoindia*, both are good sources of micronutrients liable to prevent infant malnutrition in developing countries like Nigeria. More so, it will mitigate post-harvest losses, boost cocoyam production and enhance food security.

Conflict of Interest

The authors declare that there is no conflict of interest.

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