Proximate composition and physicochemical properties of formulated cassava, cowpea and potato flour blends

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Abstract. Most children are underfed due to current economic dispensations. Cassava is one of the cheapest, most popular root, and tuber crops in Africa. Cowpea is gaining preferential attention as the potential nutritional and flavouring additive in food formulation due to its nutritional benefits. This study explored the formulation of weaning food with cassava-cowpea-potato blends (CCP). Cassava flour (50%) was the same while cowpea and potato flour percentages were varied at 50:0%, 40:10%, 30:20% and 20:30% resulting in 4 blends. The titratable acidity, pH, qualitative screening of phytochemical (saponins, terpenoids and tannin), minerals (calcium, phosphorus contents) and proximate composition of formulated blends were evaluated. The protein content of the different blends ranged from 22.55 to 31.00 (g/100g). Increase in cowpea addition to the blend were directly proportional to the protein, calcium and phosphorus content which varied from 9.02 to 12.40%, 9.55 to 1.45 (mg/100g) and 3.10 to 4.55 (mg/100g) respectively in the blends. The moisture levels of the blends were lower than 10.50%. The phytochemical analysis revealed the absence of saponins and tannin in the blends. The formulated CCP blends can be prepared domestically to complement or replace the more expensive diets for children to achieve healthy and well-nourished children.

1 Introduction
Breastfeeding provides the ideal food for infants during the first six months of human life. Complementary feeding is the subsequent but gradual replacement of breast milk by a variety of diets, and weaning foods are introduced into infant diets which are usually semi-solid [1]. Weaning foods are administered appropriately when the infant has reached the weight of 5.9 kg at the age of 5-6 months [2]. After the first six months of a baby’s life, nutrients gotten from breast milk must be augmented to meet the nutritional demand of the child for healthy growth and development [3]. In several parts of the developing world, complementary feeding remains a nutritional challenge in children of 6–23 months. Only about 21% of breastfed children receive the minimum acceptable complementary feeding diets in Nigeria [4]. Others are often victims of poor feeding practices and dietary quality of homemade complementary foods [2]. From a nutritional perspective, protein, minerals and vitamins are fundamental in the development of a child. Cereal-based foods have been the foremost source of inexpensive weaning foods in developing countries for centuries [5]. Thus, protein-energy malnutrition is a re-current situation affecting infants and children in less-privileged households, settlements, and poor socio-economic groups in developing countries [6]. Cassava is to African peasant farmers what rice is to Asian farmers, or wheat and potatoes are to European
farmers [7]. Roots and tubers generally are one of the cheapest sources of dietary energy, in the form of carbohydrates, and the most popular of this food group are cassava, yam, cocoyam, Irish and sweet potatoes [8]. Cassava is a staple and affordable food which is predominant in Nigeria. Nigeria is currently the largest producer of cassava with over 50 million tonnes per annum [9]. Conversely, cowpea is an herbaceous legume grain that can be cooked as food, made into curry, stew or paste depending on individual culinary preferences [10]. Nigeria is the largest producer of cowpea and accounts for 61% of the production in Africa, and 58% worldwide [11]. Many children are currently consuming less quality foods at the expense of what they need for a healthy life. This is invariably due to the rising economic recession and market inflation being experienced by many nations. This study aims at developing a weaning food formulation using locally abundant crops as a partial solution to combating world food insecurity and malnutrition in children. Proximate and phytochemical analyses were done to assess the weaning food nutritional quality.

2. Materials and Methods

2.1 Materials

The materials for this research include cassava tubers (TME 419), potato (white variety) and cowpea (Ife brown variety). The cowpea and potato were procured from a local market in Omu-Aran, Nigeria. Cassava tubers (TME 419) were acquired from the Teaching and Research Farm at Landmark University, Omu-Aran. The culture media and analytical grade chemicals used.

2.2 Methods

2.2.1 Cassava, cowpea and potato blends production. The cowpea was cleaned by manual sorting of stones, dirt, and broken grains. 1.5 kg of cowpea was weighed and soaked for 6 hours, drained, dehulled, steamed and dried at 60°C in hot air oven using the method of Elemo et al., [12] with little modification. The dried cowpea was milled into powder and stored at room temperature for further analyses. Unblemished potato tubers were washed under flowing tap-water peeled and diced manually using a sharp clean steel knife into thin sheets of 3 mm. These were later placed on clean perforated stainless steel trays and dried in hot air dryer at 60°C, 100% fan speed and 50% flap for 12 hours. The dried potato sheets were milled, and the flour was weighed, and packed in portions of 50g each into polyethylene bags at room temperature (26 ± 2 °C) for further analyses [13]. A modified method of Rodríguez-Sandoval et al., [14] was used in the production of the cassava flour used in this study. Samples of sweet variety of freshly harvested cassava tubers (TME 419) were weighed (3 kg), washed and peeled manually. The peeled cassava tubers were rinsed in water and drained with a sieve (state mesh dimension). The cassava was allowed to ferment for 48 hours and drained. The fermented cassava was boiled for 15 min before draining again, left to cool at room temperature, placed on perforated stainless steel trays, dried at 60°C, 100% fan speed, and 50% flap for 12 hours before milling into flour.

2.2.2 Experimental design. The experimental formulation used was as stated by Laryea et al. [15] with some modifications (Table 1), and was carried out in triplicate. The percentage of cassava inclusion was constant while cowpea and potato was varied.

Table 1. Experimental formulation adopted for cassava, cowpea, and potato (CCP) blends

| Sample code | Cassava (%) | Cowpea (%) | Potato (%) |
|-------------|-------------|------------|------------|
| A           | 50          | 40         | 10         |
2.2.3 Determination of titratable acidity and pH. The total titratable acidity (TTA) of CCP blends was determined for all samples to quantify the acid produced in the formulated weaning food. Total titratable acidity of lactic acid (g/ml) was calculated. A pH meter (Corning Scholar 425, UL Laboratories, Shenzhen, China) was used to determine pH values of 5g of reconstituted flour in 50 ml of distilled water [16].

2.2.4 Determination of proximate composition and mineral content. Proximate analysis of CCP samples were done in triplicates and analyzed for crude protein, crude fat, ash composition, crude fibre. Calcium content, phosphorus content, starch content and total reducing sugar of the blends were also evaluated according to the methods of the Association of Analytical Chemists, [16].

2.2.5 Qualitative analyses of Terpenoids, Tannins and Saponins. Terpenoids qualitative screening was carried using Salkowski test, to 5 ml of CCP extracts, 2 ml of chloroform and 3ml concentrated H2SO4 were added and gently mixed in a conical flask. Formation of reddish brown coloured layer at the interface indicates the presence of terpenoids. Tannin screening was carried out using10ml of distilled water and Ferric chloride reagent was added to 5 ml extracts of CCP followed by gentle stirring. Blue- black, green, or blue- green precipitate indicates the presence of tannins. For saponins screening; 0.5 g of CCP with 50 ml of distilled water was boiled in water bath for 10 minutes; filtered with Whatman 125 mm filter paper. 10 ml of the filtrate and 5 ml of distilled water was vigorously agitated to form a stable froth. Emulsion formation on addition of 3 drops of olive oil shows a positive result for saponins [16].

3. Results and Discussion

Results from the study showed that the moisture content of the formulated CCP blends increased as the quantity of added cowpea increased (Table 2). The highest moisture content of 10.21% was recorded in blend D (50% cassava, 50% cowpea) while the lowest was 9.30% for blend B (50% cassava, 20% cowpea, 30% potato). The levels of moisture content in the formulated blend flours were lower than the recommended moisture levels 14% for safe storage of flour [17]. The results from this study were in agreement with the findings of Bamidele et al. [18] and Adenuga [19] for root-based foods. Moisture content of the product is a significant indicator in the shelf life of the food as high moisture content facilitates degradation and spoilage by microorganisms [20]. The protein content of the different blends ranged from 22.55 to 31.00 (g/100g). The protein content increased as cowpea flour addition increased. It is simply logical to attribute this outcome to the influence of the high protein content of cowpea flour. Dietary protein is essential during production of new cells, hormones, maintenance of the body system and repairs of worn out tissues [21]. The fat contents of the blends were between 6.54 and 7.85 g/100g with the highest documented in formulated sample D (50% cassava and 50% cowpea flour). Similar trends were observed in fat (1.00-3.13 g/100g) and total ash (5.54-7.85 g/100g) contents of the blends. The ash content of all the formulated CCP blends were slightly higher compared with the recommended (5%) value by WHO. Based on the Advisory Group of World Health Organisation, total ash contents of 5%, moisture content of 5-10% and 20% of protein are recommended for weaning foods [22]. The highest fibre content of 3.81% was recorded in D (50% cassava and 50% cowpea flour). The calcium (9.55 - 15.5 mg/100g) and
phosphorus (0.31 - 0.46) contents of the blends increased with increasing levels of cowpea. Nevertheless, the total sugar content of B (4.19) was higher than A (50% cassava, 40% cowpea, 10% potato), C (50% cassava, 30% cowpea, 20% potato) and D (50% cassava, 50% cowpea) with the value of 1.81, 1.81 and 1.82 respectively. The sugar content of the blends also reduced as cowpea flour quantity reduced. The pH value of the cassava-cowpea-potato blends ranged from 6.77 – 6.85 (Table 3). The pH values for 100% cassava flour, cowpea 100% and 100% potato prior to formulation CCP blends were 6.31, 7.08 and 6.39 respectively. The total titratable acidity of CCP blends was between 0.04 - 1.05. CCP blend with 50% cassava-20% cowpea-30% potato had the lowest moisture content (9.14 %), lowest protein content (22.55 g/100g), lowest fat content (1.00), lowest ash content (6.54 g/100g), lowest calcium (9.55 mg), lowest phosphorus (3.10 mg), though it was still within the recommended protein level for weaning diets. The phytochemical qualitative screening showed the absence of saponins and tannin in the ethanol extracts of all samples. This may be due to pretreatment handling of cassava and cowpea which involved soaking and cooking prior to drying. The reduction in the quantity of anti-nutrients in blends may be due to leaching of the anti-nutrients into water from long soaking [23]. Saponins and tannin presence in food have been documented to delay mineral absorption and palatability of the food depending on the quantity [24]. Their absence in the formulated CCP blends is important to enhancing their nutrient value as well as their organoleptic properties. Terpenoids was present in different concentrations in samples A, B, C, E, F and G. High concentrations of terpenoids have implications for antioxidant, anti-inflammatory, and anti-microbial potentials of the blends [25, 26].

4. Conclusions

The chemical composition of the formulated weaning foods from the study showed that the formulation/blend with 50% Cassava-50% cowpea had the best nutritional quality. All the formulated diets had protein and total ash requirement for weaning diets above the prescription of the WHO. Likewise, the phytochemical screening showed the absence of tanins and saponins in all formulated diets. Therefore, CCP blend (50% Cassava-50% cowpea) is the most qualified from the study to be used as complementary food. Integrating it into daily weaning diets or serving it whole could qualify it as a cheap alternative meal for children with competitive advantage in fulfilling the potential dietary requirement.

Table 2. Chemical composition of cassava, cowpea, and potato (CCP) blends (g/100g)

| Blends  | Moisture | Protein | Fat  | Fiber | Ash   | Carbohydrate | Sugars | Calcium |
|---------|----------|---------|------|-------|-------|--------------|--------|---------|
| A       | 9.73±0.02b | 28.50±0.01a | 2.30±0.02b | 1.63±0.03c | 7.51±0.02b | 50.33±0.01b | 3.40±0.02b | 13.40±0.01a |
| B       | 9.14±0.04c | 22.55±0.02d | 1.00±0.01d | 2.10±0.01b | 6.54±0.01c | 55.67±0.01a | 4.19±0.03b | 9.55±0.02a |
| C       | 9.64±0.01b | 24.78±0.04c | 1.45±0.01c | 1.66±0.01c | 6.62±0.02c | 55.85±0.02a | 3.80±0.01c | 11.70±0.01c |
| D       | 10.21±0.00a | 31.00±0.01a | 3.13±0.01a | 3.81±0.02a | 7.85±0.01a | 44.00±0.01c | 4.82±0.01a | 15.45±0.01a |

Different letters in the same column indicate significant mean difference by Tukey’s LSD test at P<0.05

A: 50% Cassava, 40% Cowpea, 10% Potato, B: 50% cassava, 20% cowpea, 30% Potato, C: 50% Cassava, 30% Cowpea, 20% Potato, D: 50% Cassava, 50% cowpea.

Table 3. Physicochemical and qualitative phytochemical analysis of cassava, cowpea, and potato (CCP) blends

| pH          | Total titratable acidity | Saponins | Terpenoids | Tannin |
|-------------|--------------------------|----------|------------|--------|
|             |                          |          |            |        |

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|   | A    | B    | C    | D    | E    | F    | G    |
|---|------|------|------|------|------|------|------|
|   | 6.82 | 6.77 | 6.78 | 6.85 | 6.31 | 7.08 | 6.39 |
|   | 0.50 | 1.05 | 1.00 | 0.95 | 0.80 | 0.04 | 0.51 |
|   | Nil  | Nil  | Nil  | Nil  | Nil  | Nil  | Nil  |
|   | +    | +    | +    | +    | +    | +    | +    |

Keys: + means detected and Nil not detected.

A: 50% Cassava, 40% Cowpea, 10% Potato, B: 50% cassava, 20% cowpea, 30% Potato, C: 50% Cassava, 30% Cowpea, 20% Potato, D: 50% Cassava, 50% cowpea, E: 100% Cassava flour, F: 100% cowpea flour, G: 100% Potato flour.

References

[1] Tiencheu B, Achidi A U, Fossi B T, Tenyang N, Flore E, Nggongang T and Womeni H M 2016. Formulation and Nutritional Evaluation of Instant Weaning Foods Processed from Maize (Zea mays), Pawpaw (Carica papaya), Red Beans (Phaseolus vulgaris) and Mackerel Fish Meal (Scomber scrombus) American J. of Food Sci. and Tech. 4 149–159.

[2] Du Plessis L, Kruger H, and Sweet L 2013. Complementary feeding: A critical window of opportunity from six months onwards. South African Journal of Clinical Nutrition, 26 129–140.

[3] Abeshu M A, Lelisa A, and Geleta B 2016. Complementary Feeding: Review of Recommendations, Feeding Practices, and Adequacy of Homemade Complementary Food Preparations in Developing Countries-Lessons from Ethiopia. Frontiers in Nutrition 3 41 1-9http://dx.doi.org/10.3389/fnut.2016.00041

[4] Macauley H 2015 Cereal Crops: Rice, Maize, Millet, Sorghum, Wheat. Feeding Africa: An Action Plan for African Agricultural Transformation 1–36.

[5] Olaran A F and Abiose S H 2018 Proximate and antioxidant activities of bio-preserved ogi flour with garlic and ginger. F1000Research 7 1–13.

[6] Nyakurwa C S, Gasura E and Mabasa S 2017 Potential for quality protein maize for reducing protein-energy under nutrition in maize dependent sub-Saharan African countries: a review. Africa Crop Sci. Journal 25 521–537.

[7] Montagnac J A, Davis C R and Tanumihardjo S A 2009 Processing Techniques to Reduce Toxicity and Antinutrients of Cassava for Use as a Staple Food. Comprehensive Reviews in Food Sci.& Food Safety 8 17–27.

[8] Van vugt D and Franke A C 2018 Exploring the yield gap of orange-fleshed sweet potato varieties on smallholder farmers’ fields in Malawi. Field Crops Research 21 245–56.

[9] Awolu O O and Oseyemi G F 2016 Physicochemical and rheological properties of optimised Cocoyam-based. Food Technology 30 65–84.

[10] Maidala A and Dass Y H 2017 Utilization of Cowpea Seeds (Vigna Unguiiculata (L) Walp) by Broiler Chickens: An Overview. Research J. of Food Sci. & Quality Control 3 50–6.

[11] Bentley J, Olanrewaju A, Madu T, Olaosebikan O, Abdoulaye T, Wossen T, … Tokula M 2017 Cassava farmers’ preferences for varieties and seed dissemination system in Nigeria: Gender and regional perspectives. Retrieved from www.iita.org

[12] Elemo G, Elemo B O and Okafod J N C 2011 Preparation and Nutritional composition of a weaning food formulated germinated sorghum (Sorghum bicolor) and steamed cooked cowpea (Vignaunguiiculata Walp). American J. of Food Sci. & Tech. 6 413–421

[13] Alawode E K, Idownu M A, Adeola A A, Oke E K and Omoniyi S A 2017 Some quality attributes of complementary food produced from flour blends of orange flesh sweetpotato, sorghum, and soybean. Croatian J. of Food Sci. and Tech. 9 122–9.

[14] Rodriguez-Sandoval E, Fernández-Quintero A, Sandoval-Aldana A and Cuvelier G 2008 Effect of
processing conditions on the texture of reconstituted Cassava dough. Brazilian J. of Chem. Eng. 25 713–22.

[15] Laryea D, Wireko-Manu F D and Oduro I 2018 Formulation and characterization of sweet potato-based complementary food, Cogent OA 4 1-15 151726

[16] AOAC 2010Official methods of analysis of AOAC International. Gaithersburg MD: AOAC International. Retrieved from https://www.worldcat.org/title/official-methods-of-analysis-of-aoac-international/oclc/649275444

[17] Tharise N, Julianti E and Nurminah M 2014 Evaluation of physico-chemical and functional properties of composite flour from cassava, rice, potato, soybean and xanthan gum as alternative of wheat flour. I F R J 21 1641–9.

[18] Bamidele O P, Fasogbon M B, Oladiran D A and Akande E O 2015 Nutritional composition of fufu analog flour produced from Cassava root (Manihot esculenta) and Cocoyam (Colocasia esculenta) tuber Food Sci. and Nutrition 3 597–603.

[19] Adenuga W 2010. Nutritional and sensory profiles of sweet potato based infant weaning food fortified with cowpea and peanut. J Food Technol. 8 223–8.

[20] Achidi A U, Tiencheu B, Tenyang N, Womeni H M, Moyeh M N, Ebini L T and Tatsinkou F 2016 Quality evaluation of nine instant weaning foods formulated from cereal, legume, tuber, vegetable and crayfish. International Journal of Food Sci. and Nutrition Eng. 6 21-31.

[21] Kolawole F L, Akinwande B A and Ade-Omowaye B I 2018 Chemical composition, colour, functional and pasting properties of orange-fleshed sweet potato, Pleurotustuberregiumsclerotium and their flour blends. Annals Food Sci. and Technology 19 423-32.

[22] FAO/WHO/UNICEF/ Protein Advisory Group (PAG),(2007).Nutrition Bulleting (2) Energy and protein requirements. Report of a joint FAO/WHO/UNU expert consultation. Geneva, (WHO Technical Report Series, No. 724).

[23] Yasir A and Asif A 2018 Impact of Processing on Nutritional and Antinutritional Factors. Annals of Food Science and Tech 19 199–215.

[24] Margier M, Georée S, Hafnaoui N, Remond D, Nowickin M, Du Chaffaut L, Amiot M and Reboul E 2018 Nutritional Composition and Bioactive Content of Legumes: Characterization of Pulses Frequently Consumed in France and Effect of the Cooking Method. Nutrients 10

[25] Doughari J H 2012 Phytochemicals: Extraction methods, basic structures and mode of action as potential chemotherapeutic agents. In: Rao, V (Ed.), Phytochemicals: A global perspective of their role in nutrition and health. In Tech Open, Rijeka 538.

[26] Lawal A R, Olayinka B U, Murtadha R A, Ayinla A and Etejere E O 2018 Comparative Analysis of Phytochemical and Proximate Composition of Allium sativum L. and Zingiber officinaleRosc.Nigerian Journal of Basic and Applied Science 26 82-7.