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Nutritional Analysis of Formulated Complementary Foods from Selected Nigeria Crops

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Abstract: The study investigates the nutritional quality of complementary foods produced from some local food crops. The raw materials include wheat, soybeans and carrot. Wheat, soybeans and carrot were prepared in the ratio 60:30:10 (WSC blend), and 50:30:20 (WSD blend). While wheat and soybeans only in 60:40onl WS blend. The chemical composition, functional properties, nutritional qualities of the foods samples were determined using standard AOAC 2010 methods. The data obtained was subjected to ANOVA. Crude protein, fat, moisture, β-carotene, calcium, magnesium, iron and OAC are significantly higher in WSD blend at (p<0.05), while there was no significant difference in OAC at p<0.05. Significantly, WSC blends has higher amount of sodium, potassium at p<0.05. Trypsin inhibitor was absent in WSC and WSD blends. WAC, Gel temp, pH, Copper, Energy value and CHO are significantly higher in WS blend. It could be observed from these results that there are many complementary foods that can be formulated to meet the increasing demand for balance diet locally. This may reduce morbidity and mortality rate among the population of the developing countries.

Keywords: Antinutrients, Complementary foods, Elemental characterization, Nutritional analysis

1.0 Introduction

When breast milk is no longer enough to meet the nutritional needs of the infant, complementary foods should be added to the diet of the child. The transition from exclusive breastfeeding to family foods, referred to as complementary feeding, typically covers the period from 6 to 18-24 months of age, and is a very vulnerable period Laswai and Kulwa, (2010). It is the time when malnutrition starts in many infants, 89contributing significantly to the high prevalence of malnutrition in children less than five years of age world-wide (WHO, 2012*)*.

Complementary feeding should be timely, meaning that all infants should start receiving foods in addition to breast milk from 6 months onwards. It should be adequate, meaning that the complementary foods should be given in amounts, frequency, and consistency and using a variety of foods to cover the nutritional needs of the growing child, while maintaining breastfeeding, Laswai and Kulwa, (2010). Foods should be prepared in a safe manner, meaning that measures should be taken to minimize the risk of contamination with pathogens. And they should be given in a way that is appropriate, meaning that foods are of appropriate texture for the age of the child and applying responsive feeding following the principles of psycho-social care *(*WHO, 2012*)*.

The adequacy of complementary feeding (adequacy in short for timely, adequate, safe and appropriate) not only depends on the availability of a variety of foods in the household$_s$ but also on the feeding practices of caregivers, Solomon, (2005). Feeding young infants require active care and stimulation, where the caregiver is responsive to the child clues for hunger and also encourages the child to eat. This is also referred to as active or responsive feeding (WHO, 2012*)*.

Complementary feeding becomes necessary when breast milk or infant formula is no longer sufficient to meet the nutritional requirement of an infant and as such other foods and liquids along with the breast milk or a breast milk substitute are needed. The age range for complementary feeding is generally 6-24 months, *(*UNICEF, 2003*)*. Scientifically, it has been proved that breast milk is the perfect food for the infants during the first six months of life, Solomon, (2005). It contains all the nutrients and immunological factors, required by infants in maintaining optimal health and growth. However, at the age of six months and above, birth weight is expected to have doubled, breast milk is no longer sufficient to meet the nutritional needs of the growing infants. Nutritious complementary foods are therefore introduced also known as weaning foods which typically covers the period from six to twenty-four months of age *(UNICEF ,2003)*.

Childhood under nutrition remains a major health problem in resource- poor setting. Approximately one-third of children less than five years of age in developing countries are stunted (low height -for-age), and large proportions are also deficient in one or more micronutrients. Recent data shows that just over half of 6-9months old are breastfed and given complementary foods and only 39 per cent of 20-30 month olds are provided with continued breastfeeding (*UNICEF, 2003).* It is well recognized that the period from birth to two years of age is the critical window for the promotion of optimal growth, health, and development. Insufficient quantities and inadequate quality of complementary foods, poor child-feeding practices and high rates of infection have a detrimental impact on health and growth in these important years. Even with optimum breastfeeding children will become stunted if they do not receive sufficient quantities of quality complementary foods after six months of age (UNICEF, 2003). An estimated six per cent or six hundred thousand under-five deaths can be prevented by ensuring optimal complementary feeding.

Education for improved feeding practices is another essential component. Evidence shows that mothers are willing to prepare enriched complementary foods if they are culturally acceptable, and that improving maternal knowledge and feeding practices can lead to increased dietary intake and growth of infants. Good counseling and negotiation with the mother in health system and community health care setting is crucial to ensuring optimal complementary feeding practices. This study thereby aimed at investigating the nutritional value of locally formulated foods for children.

2.0 Materials and Methods

2.1 Materials

Soya beans (Glycine Max), wheat and carrot were obtained by market survey from Oje market, Oke Gada Ede, Osun State, Nigeria.

2.1.1 Sample Preparation

The wheat and soya flour were cleaned and winnowed to remove stones and dirty particles respectively, the wheat flour was washed with water and steeped for (6-12) hours. The soaked wheat was then spread on a tray and cover with a dark cloth and kept in the dark room for 3days **to** germinate. Water was sprinkled on it daily to keep it moist. This germination **process** produces the enzymes that break down the starch into sugar and shorter length Solomon, (2005).

The germinated grains were then allowed to dry in an oven at 55-60°C. The malted grains were grinded into flour and sieve (30mm). While the soya bean was cleaned and winnowed to remove dirty particles and debris. Then blanched by pouring into boiling water and left for 10 minutes. It was then drained and poured into a cold water to remove the testa, dried in an oven at 60°C and grinded to obtain soya flour. The carrot was cleaned and washed with clean water; it was then grated into smaller fragments, dried in the oven at 50^0C after which it was blended again to obtain carrot flour.

2.1.2 Sample Formulation

- WSC BLEND: Wheat, Soya beans and Carrot (60:30:10 w/w).
- WSD BLEND: Wheat, Soya beans and Carrot (50:30:20 w/w).
- WS BLEND: Wheat and Soya beans (60:40:0 w/w).

2.2 Methods

2.2.1 Analytical Procedures

Samples were analyzed chemically according to the Official Methods of Analysis described by the Association of Official Analytical Chemist (A.O.A.C., 18th EDITION, 2005). All analysis was carried out in triplicate.

2.2.2 Physico-chemical properties: Among the physico-chemical parameters determined are

- Crude protein (AOAC official method 988.05)

- Crude fat or ether extract (AOAC official method 2003.06)
- Dry matter and moisture (AOAC official method 967.08)
- Ash (AOAC official method 942.05)
- Crude fibre (AOAC 958.06)
- OP nitrogen-free extract (nfe)
- OP carbohydrate
- OP energy value

2.2.3 Elemental characterization: those determined are

- OP Mineral elemental composition (aoac, 975.11)
  - Calcium, Potassium and Sodium
  - Phosphorus (Spectrophotometric Method) (AOAC, 975.16)
  - Mg, Cu, Fe, Zn, (using BUCK 200 AAS AOAC, 975.23)

2.2.4 Beta carotene determination

The absorbance of samples as well as working standard solutions was read on a Cecil 2483 UV Spectrophotometer at a wavelength of 450nm against blank.

2.2.5 Anti Nutrients determination

- Phytate
- Trypsin inhibitor activity (tia): the casein digestion method
- Oxalate estimation

2.2.6 Functional properties

Selected functional properties analyzed were:

- **Water and Oil Absorption Capacity (WAC and OAC)**
- **Bulk density (bd)**
- **Gelatinization temperature (GT)**
- **P^H Determination**

2.3 Statistical Analysis

The data were analyzed using SPSS version 16.0. The mean and Standard Error of Means (SEM) of the six replicate of samples were calculated. The analysis of variance (ANOVA) was performed to determine significant differences between the means of proximate composition, minerals, antinutritional factor sensory attributes and functional properties.

3.0 Results and Discussions

3.1 Results

Table 1.0 mean value (± s.d) for proximate composition of the formulated blends

Sample	% Crude protein	% Crude fat	Crude fibre %	Moisture %	Ash %	B- carotene μg/ 100g	CHO%	Energy value Kcal/100g
WSC	24.69 ±0.30^{b}	1.28± 0.05^{b}	16.30± 0.05^{a}	10.62± 1.09^{b}	2.99±0.14^{a}	62.21±0.28^{b}	44.12^{b}	286.76^{b}
WSD	25±0.24^{a}	1.29± 0.05^{a}	16.29± 0.06^{a}	13.03±0.58^{a}	2.29±0.03^{b}	65.60±0.78^{a}	42.09^{c}	280^{c}
WS	22.38±0.15^{c}	2.60±0.03^{c}	1.73±0.03^{b}	10.05±0.12^{b}	0.90±0.80^{c}	51.72±0.49^{c}	62.34^{a}	362.28^{a}
NESTLE CERELAC	15.0	9.00	2.95	2.50	2.60	-	67.95	413.0

WSC blend: 60:30:10, WSD blend :50:30:20, WS blend: 60:40, values are means of 6 replicate

Table 2.0 mean value (±s.d) for mineral composition of formulated blends

WSC blend 60:30;10 WSD blend: 50:30:20, WS blend;60:40, values are means of 6 replicate

Table 3.0 mean value (± s.d) anti nurtient of the formulated blends

SAMPLE	% PHYTATE	%OXALATE	TRYPSIN INHIBITOR (Tiu

			/mg
WSC	0.016±0.00016[c]	0.029±09.0022[b]	0±0.00[b]
WSD	0.024±0.0016[a]	0.012±0.0014[c]	0±0.00[b]
WS	0.22±0.02[b]	0.33±0.02[a]	12.09±0.10[a]

WSC blend 60:30:10, WSD blend:50:30:20, WS blend 60:40, values are means of 6 replicate

Table 4.0 mean value (±s.d.) for functional properties

Sample	pH	Temperature(^{0}c)	Oil Absorption capacity (OAC) g/ml	Bulk density g/ml	Water absorption capacity (WAC) g/ml
WSC	7.34±0.12[b]	68.3±17[c]	103± 15.65[a]	0.61±0.05[a]	93.65±10.43[c]
WSD	7.22±0.14[c]	69.3± 1.7[b]	116± 2.16[a]	0.50±0.00[c]	79.46± 16.00[b]
WS	7.69±0.11[a]	76±1.94[a]	103.12±14.82[a]	0.50±0.08[b]	120± 1.00[a]

WSC blend: 60:30:10, WSD blend:50:30:20, Ws blend: 60: 40, values are mean of 6 replicate

3.2 Discussions

3.2.1 Proximate composition: presented in Table 1.0

Protein is very essential to life due to its presence in all living tissues, both plants and animals. It contains nitrogen the vital element that is very essential to life. Protein is responsible for growth, regulation of body process and provides energy (Otitoola, 2008). The protein content of the three blends was significantly different at (p> 0.5). WSC and WSD protein content (24.69 ± 0.30%) and (25 ± 0.24%) was significantly higher than WS blend (22.38 ± 0.15%). This might be due to the inclusion of carrot in both the WSD and WSC blends. However, it is expected that WS blend will have higher protein value than the WSD and WSC blends because WS blend have more proportion of soybeans than in the WSD and WSC blends, but it was not so. Protein content present in the three blends met the Recommended Dietary Allowance for protein which is (13-14g). And also higher than the commercially sold baby food, which is 15.0%. This value obtained is similar to work done by Laswai and Kulwa, (2010) on nutrient content and acceptability of soybean based on complementary food and obtains protein to be 22.23%.

Fats have been found to be a source of protection of organs and bones from injury by serving as protective padding and insulated the body against cold (Otitoota. 2008). Crude fat in WS blends (2.60±0.03%) was significantly higher (p<0 05) due to high amount of Soya bean present that was 40g (40%) than WSC blend (1. 28±0.05%) which have 30g (30%) of soya beans included, the fat value obtained was closed to the value obtain by *Theobald et a1*, (2005). Who work on nutritional quality, storage stability of composition food, and got a value of (2.41 ± 0.31). The low fat content will help to prevent rancidity in the food. The Recommended Dietary Allowance for fat is (10-25g*)* so the blends do not meet the RDA standard for fats and commercial sold weaning baby food (9.0g) so it has to be supplemented with crops rich in fats such as groundnut in order to meet the Childs need.

Crude fiber was significantly higher in WSC blend (16.30±0.05%) and WSD blend (16. 29±0.06) at (p<0.05) due to the presence of carrot in the blend, which have been known to be a good rich dietary fiber and help to soften and increase the bulk of stools thereby reduce the problem of constipation in children Shipard,*(*2005). There was lower amount of crude fiber in WS blend (1.73±0.3%) due to absence of carrot. The high amount of crude fiber in WSC and WSD blend was higher than that reported by Anigo et al (2010) 1.74 ± 0.02.

Moisture content is an index of water activity (a_w) of food and is one of outstanding qualities which are widely used as a parameter in the processing and testing of foods. WSD blend had the highest moisture content (13.03± 0.58) which might due to the blend not properly dried, while WSC and WS blend have (10.05± 0.12) and (10.62± 1.09) respectively. These observed values were close to the work done by Laswai and Kulwa, (2010) on nutrient content and acceptability of soybeans based complementary food and obtain moisture to be 13.02%. Low moisture content indicates high shelf life Samuel, (2004).

Ash content shows the amount of inorganic element present in a food. Ash was high in WSC blends (2.99± 0.14%) this can be attributed to the presence of carrot and soybeans compare to WS blend (0.90± 08%). WSC value was comparable to the work done by Modu et al.,(2009) 2.30±l.27. β-Carotene is a precursor for vitamin A which is essential for good sight. WSD has the highest amount of β-carotene, (65.60±0.78), when compared to WS blend in which carrot is absent, and having lower amount of β-carotene (5l.72±0.49). β-carotene shows significant differences at ($p<0.05$).

Carbohydrate provides the body with energy which is a ready source of energy. Carbohydrate was high in WS blend (62.34%) compare to WSC blend (42.09%). This was close to Recommended value for Carbohydrate (64 ±0.4%). Which when consumed provide the needed energy for the children. The value was close to the work carried out by Compaore *et al.*, (2011) on Nutritional Properties of Enriched Local Complementary Flours and obtains carbohydrate to be (63.95±0.04), and baby food (67.95%).

WHO have recommended that foods fed to infant and children should be energy-dense ones.The energy value for WS blend was 362.28kcal which was higher, when compare to WSC blend (286.76 kcal) and WSD blend (280 kcal). The value obtained for formulated food fell short of RDA, (650kcal/100g) and fall below the commercially sold baby food (4l3kcal/100g) which means the blend should be complemented with energy dense food or by increasing the amount of or proportion of wheat so as to meet the energy requirement for children/infants. This value obtained for formulated blends was in concordance with the work of Laswai and Kulwa, (2010) and that reported a value of 376.27kcal/100g.

3.2.2 Elemental Characterization: as presented in table 2.0

Sodium is an extracellular cation involved in the regulation of plasma volume, acid- base balance nerve and muscle contraction. High dietary sodium has been associated with essential hypertension Laswai and Kulwa, (2010).

Sodium showed significant different in the three blends, which is essential to maintain fluid and bone balances. WSC blend had the highest amount of sodium (33.4±0.85 mg/l00g) than WSD blend (32.8. ±1.11 mg/l00g) and WS blend (24.5±0.69 mg/l00g*)*. These values obtained fall below the RDA standard which is 120, the loss in nutrient might be due to processing. The child needs to consume the blends once to supply the needs of the child. Sodium shows significant differences at $p<0.05$. Potassium was significantly higher in WSC blend (1143±5.21mg/ 100) ($p>0.05$) this may be as a result of the carrot in general, and low in WS blend (1126±0.69mg/100). This was higher than the one obtained by Solomon, (2005) to be 500mg/100, and higher than the commercially sold baby food (700mg/100g). Potassium shows significant difference at $p<0.05$.

Calcium is a vital component of teeth and strong bone. Calcium *is* generally low in cereals. Calcium was significantly higher in WSD blend which might be as a result of carrot and soybeans, than when compare to WS blend (78.3±0.25 mg/l00g) that was not having any carrot (p>.05). Calcium value obtained fall below the RDA for calcium which is 400 (WHO), it was also below the one obtained by the commercial sold baby food (420mg/l00g). This loss might be as a result of the processes involved in food production, which means the blends have to be fortified/complement with milk product so as to meet the child's nutritional needs. This value was higher than that obtained by Solomon, (2005) 67.2±00m, g/100g. Magnesium was significantly higher in WSD blend (366 ± 42. 11 mg/l00g) and WSC blend (302 ± 2.44 mg/l00g) this increase may be as *a* result of addition of carrot. When compared to WS blend (225± 2.65) having a lower amount. The value obtained was higher than the RDA recommended which is 40g (WHO). So the three blends were adequate in supplying the necessary nutritional needs of the children. Magnesium shows significant difference ta (p>.05). The value for magnesium was much higher than the one obtained by Anigo et al., (2010) 146.9lmg/100g.

Iron is an important trace element in the human body which plays crucial roles in haemopoiesis, control of infection and cell mediated immunity, Blaskaram and Beard, (2001). Iron was significantly higher in WSD blend (11.98±0.24 mg/l00g) and WSC blend (11.93 ±0.5 mg/100g) and WS blend (10.1 ±0.5 mg/l00g). The value for the three blends fall within the RDA recommendation 6.0 (WHO). This was similar to the one obtained for the commercial sold baby food (10.1mg/l00g). The value obtained was more than the one reported by Modu et al., (2009) 8.05±0.42 mg/l00g.

Zinc is an essential micronutrient for human growth and immune functions Blaskaram and Beard, (2001). Zinc showed significant different in the three blends, the value for zinc was significantly higher in WSC blend (6.7±0.31mg/100g) and WSD blend *(*6.62±0.02 mg/l00g) at $p<0.05$ which might be to the contribution of carrot, but lower in WS blend (5.5± 025 mg/l00g), the value obtained for zinc fall within the RDA which is 5.0 (WHO). The three blends were able to promote neurological activity and memory which help to boost the memory of the child. The value was similar to the one obtained by

Ijarotimi and Keshinro, (2012) 5.5±0.0 mg/l00g. The value was also close to commercial sold baby food 7 mg/l00g

Copper helps in the formation of hemoglobin. It is significantly high in WS blend (680±0.05mg/l 00g) when compared to WSC blend (450±0.05 mg/l00g) and WSD (360±0.19 mg/l00g) $p<0.05$. A Similar result was obtained by Theobald et al., 2005 (470 ±0,00 mg/l00g), who work on nutritional quality and storage ability of composite foods.

3.2.3 Antinutriemt: shown in table 3.0

The three blends showed low amount of phytate (0.22±0.02) for WSC blend, (0.024 ± 0.001 6) for WSD blend and (0.016±0.0016) for WS blend. When consumed cannot pose any health hazard because the amount is small. The value was closed to that reported by Anigo et al., (2010) 0.01 ± 0.00. Oxalate rich food have adverse effect when eaten, because it binds to calcium causing calcium deficiency Bolhuis,(2003).WS blend has the highest amount (0.33±0.02) compare to WSD blend (0.029 ±0.0022). They cannot pose any health risk when consume because they are already in minute quantity, but they could be remove completely during food processing. Similar result by Ijarotimi and Keshinro , (2012) 0.32±0.19%). Oxalate shows significant different at $p<0.05$.

The presence of trypsin inhibitor in the diet leads to the formation of irreversible condition known as enzyme- trypsin inhibitor complexes Bolhuis, (2003). Trypsin inhibitor was absent in WSC blend (0±00) and WSD blend (0±0.00) but was significantly higher in WS blend (12.09±0.10Tiu/mg) p <0.05 this was as a result of high amount of soybeans applied, but might be reduced on the course of food processing. This values obtained was similar to the one reported by Ijarotimi and Keshinro, (2012) (0.12±0.01). Which could be handled during food processing to be bearest minimum level.

3.2.4 Functional properties: the followings could be observed from table 4.0

Gelation is a measure of consistency of a protein solution when it is heated at a certain temperature for a given period of time Etudaiye *et al.,(*2008). The Gelatinization temperature was high in WS blend (76^{0}C±1.94), when compared to WSC blend (68.3^0±1.7) and WSD blend (69.3^{0}C ±1.7) because of the presence of carrot. The temperature shows significant different at ($p<0.05$). The bulk density value is of importance in packaging Ijarotimi and Keshinro, (2012). The value for bulk density in WSC blend (0.61±0.05) was significantly higher than WSD blend (0.50±10.00) and WS blend (0.50 ±0.08). There was significant difference between the blends at ($p<0.05$). The value obtained was close to that reported by Adetuyi, et al., (2008) 0.61g/ml.

PH is a measure of the acidity or basicity of samples. It shows significant difference between the blends at ($p<0.05$). The value for WSC blend was 7.69±0.11 a bit higher than WSC blend (7.43±0.12) and WSD blend (7.22±0.14), which shows that the measurements are basic in nature. This was in concordance with the reported by Etudaiye *et al., (*2008). OAC is attributed mainly to the physical entrapment of oil Etudaiye *et al.*, (2008). Oil Absorption Capacity showed no significant difference ($p<0.05$). WSD blend has the highest amount (116±2.16), which shows the rate at which it can absorb oil Compared to WS blend (103.12±14.82) and WSC blend (103±15.65).

The differences in the water absorption capacities may be explained by their respective contents of hydrophilic constituent such as carbohydrates, which bind more water than protein and lipids Mbaeyi, (2005). WAC Shows significant differences at ($p<0.05$). WS blend had the highest amount (120±1.00g/ml) because there is absence of carrot particles in it compared to WSC blend (93.65±l0.43) and WSD blend (79.46±16.00) which have carrot in it. So WS blend will require more water when consumed than the other blends.

4. Conclusion

The results from this study suggest that proper reformulation and fortification of these local diets can provide nutritious foods that are suitable not only for weaning, but also as rehabilitation diet to malnourished children. This is believed to be a practical food-based approach aimed at combating the problem of malnutrition among infants and children in Nigeria and other developing countries. These formulated blends meet the child nutritional needs because all the raw material used in food composition are locally available and does not require special skill for the preparation, hence are cost effective. The results showed the Formulated as a good source of protein and energy contents that could contribute calories to human and help to combat the problem of malnutrition in convalescent children.

The formulated complementary food is recommended for children and adults because of its high nutritional content. Mothers should be enlightened about the crops that is available, and should be aware of the risk involved on consumption of only starchy food/gruels.

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