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Full Length Research Paper

Nutrient composition of commonly used complementary foods in North western Nigeria

K. M. Anigo[1]*, D. A. Ameh[1], S. Ibrahim[1] and S. S. Danbauchi[2]

[1]Department of Biochemistry, Ahmadu Bello University, Zaria Nigeria.
[2]Department of Medicine, Ahmadu Bello University, Zaria Nigeria.

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Studies on the nutrient composition of commonly used complementary foods in North Western Nigeria were carried out using Kaduna, Kebbi and Niger states as case studies. Ready to eat complementary food samples were collected from mothers with children older than 6 months but younger than 24 months and evaluated for its nutrient components using standard procedures. Results obtained showed that guinea corn and millet paps were the first foods introduced to children in the zone. The ash content ranged from 0.63±0.01 to 1.21±0.20 g/100 g with the crude protein ranging from 1.38±0.30 to 3.15±0.01 g/100 g and crude fat 0.07±0.01 to 2.56±0.06 g/100 g. Levels of lysine (1.55 to 3.11 g/100 g protein) and methionine (0.70 to 1.15 g/100 g protein) were below the international reference values of 4.2 and 2.2 for lysine and methionine, respectively. Zinc content ranged from 4.16 to 7.47 mg/100 g and iron content was between 17.82 and 33.88 mg/100 g. Phytates (0.04±0.01 to 0.12±0.02 mg/100 g), tannins (12.95±5.79 to 56.54±11.59 mg/100 g) and free cyanide (0.05±0.01 to 0.74±0.04 mg/100 g) levels in the commonly used complementary foods were low. There is low protein intake by children in the zone since their diet is mainly based on cereal with no other supplementation.

Key words: Nigeria, north west, complementary foods, nutrient composition

INTRODUCTION

Adequate nutrition and health care during the first several years of life is fundamental to the attainment of the Millennium Development Goals (MDGs) for child survival and the prevention of malnutrition (Lutter, 2003). Malnutrition is brought about by the inadequacy or over-consumption of one or more of the essential nutrients necessary for survival, growth and reproduction, as well as productivity at work (UNICEF, 2001). It lowers the body's resistance to disease, exposing it to disease-causing agents. Young children are the most vulnerable and if not adequately addressed, malnutrition can lead to a permanent negative impact on their quality of life (Sandoval-Priego et al., 2002).

Complementary feeding usually begins at 6 months and continues up to the age of 24 months when transition from exclusive breastfeeding to semi-solid foods begins. It is at this stage that the nutritional requirements of many infants are not met, thus leading to the onset of malnutrition that is prevalent in children under 5 years of age worldwide (Daelmans and Saadeh, 2003). A newborn Nigerian baby has a 30-times higher chance of dying before the age of 5 years than a baby born in the developed, industrialized countries (UNICEF, 2001). Data available on the regional prevalence of diarrhea, undernutrition and under 5 years mortality rate in Nigeria showed a strong correlation among these three factors, with each of them far more prevalent in northern than southern part of Nigeria (UNICEF, 2001). Anigo et al. (2009) also reported high prevalence of malnutrition in children in the zone with introduction of complementary foods at much earlier age than the 6th month recommended by WHO. The levels of microbial contamination in the commonly used complementary foods in the zone were found to be high when compared to acceptable standard values. High levels of contamination by the following species: *Salmonella* and *Shigella* were detected with *Staphylococcus* and fungi predominant (Anigo et al., 2007) which call for more attention to be paid to complementary feeding practices in the zone.

*Corresponding author. E-mail: mkanigo@yahoo.com. Tel: 2348073197086.

Table 1. Proximate composition of commonly used local complementary foods in Kaduna State (g/100 g dry matter).

Complementary Foods	Dry Matter	Ash	Crude Fat	Crude Protein	Crude Fibre	Total Carbohydrate
KDFN	17.70±0.02^{b}	1.22±0.02^{c}	1.91±0.14^{a}	4.67±0.03^{b}	1.51±0.06^{a}	92.21±0.15^{d}
KDGP	7.80±0.03^{e}	1.53±0.03^{b}	0.95±0.36^{b}	4.24±0.48^{b}	1.42±0.02^{b}	93.28±0.13^{c}
KDLP	7.95±0.04^{d}	1.21±0.20^{c}	2.02±0.04^{a}	3.07±0.06^{c}	1.51±0.06^{ab}	93.69±0.28^{b}
KDMP	8.90±0.01^{c}	0.52±0.01^{d}	1.66±.036^{ac}	2.17±0.06^{d}	0.65±0.03^{c}	95.65±0.39^{a}
KDPS	28.70±0.10^{a}	3.50±0.56^{a}	1.40±0.14^{bc}	5.23±0.03^{a}	0.92±0.02^{c}	89.87±0.68^{e}

Values are means ± SD of triplicate determinations. Values with different superscripts in a column differ significantly ($p<0.05$). KDFN = Fura nono, KDGP = Guinea corn pap, KDLP = Millet pap, KDMP = Maize pap, KDPS = Maize Porridge (pate).

Although the causes of malnutrition are many and diverse, inadequate intake of foods and essential nutrients is a major contributory factor and yet this subject is poorly researched in many developing countries including Nigeria (Kikafunda, 2003). Njongmeta et al. (1999) reported that one of the main problems in combating and preventing infant malnutrition and diarrhea in Africa is the lack of reliable data on complementary feeding practices that could guide the development of intervention measures. Any programs to improve complementary feeding must first conduct nutritional assessment of local foodstuff (George et al., 2004). Such a practice will help not only to identify the nutritional status of local diets, but may also lead to effective strategies being developed for the purpose of enhancing the nutrient composition of these traditional diets. It is against this background that attention should be focused on the promotion of household level good nutritional practices that are beneficial to the survival of children and women in this part of Nigeria. Therefore, it is vital that a study on the risk factors that that are associated with complementary feeding practices is conducted.

MATERIALS AND METHODS

Study Area

This study was carried out in North Western Nigeria based on agro-ecological zones of the country (UNICEF, 2001). In this zone, three States (Kaduna, Kebbi and Niger) were randomly selected based on the principal food crop grown and involving sixteen communities in eight Local Government Areas. Mothers with children older than 6 but younger than 24 months were selected and paired. In the absence of the biological mother, the person considered to be the child's caretaker (Father, Aunt, Grandmother) qualified for selection (Anigo et al., 2009).

Sample collection

Ready to eat complementary food samples commonly used in each of the selected states were collected from mothers and/or caretakers, placed in containers maintained at 4°C, and transported to the laboratory for chemical analyses.

Chemical analysis

Sample analyses and preparation of standard solutions were done according to the procedures published by AOAC (1990). Total carbohydrate (%) was determined by difference as 100% - (%moisture + %crude protein + %crude fat + %ash). Amino acid profile was determined using the method described by Spackman et al. (1958). Samples in solution were subjected to acid digestion following the method described by Allen (1974). Mineral element concentrations were determined using Zeeman Polarized Atomic Absorption Spectrophotometer (Hitachi, model 180-80) while phosphorus was determined spectrophotometrically by the Vanadomolybdate method (AOAC, 1990). Phytic acid was determined by the method of Wheeler and Ferrel (1971) and tannin was assayed by the vanillin-HCl (Earp et al., 1981). Cyanide content was determined according to the method of Ikediobi et al. (1980).

Statistical analysis

Results were expressed as mean ± standard deviation. The difference between groups of each parameter was determined using the t-test (Duncan, 1955) and statistical significance were claimed at $P<0.05$.

RESULTS

Results for the proximate composition of complementary foods commonly used in the study areas are presented in Tables 1-3. Crude protein content of commonly used complementary foods in Kaduna State ranged from 2.17±0.06% for KDMP to 5.23±0.03 for KDPS (Table 1). KDLP had the highest crude fat content (2.02 ± 0.04%) while KDPS had a significantly ($p<0.05$) higher ash and crude protein contents. There are significant differences ($p<0.05$) in the total carbohydrates of all the food samples analyzed for Kaduna State. The proximate composition of those commonly used in Kebbi State is presented in Table 2. KBGP and KBFN had the lowest (1.38±0.30%) and highest (7.16±0.02%) crude protein content respectively. The crude fat content ranged from 0.07±0.01% for KBGP and KBDM to 2.93±0.39% for KBFN while ash content ranged from 1.06±0.02% for KBDM to 2.60± 0.41% for KBLP. There were significant differences ($p<0.05$) in the ash content while KBFN recorded signifi-

Table 2. Proximate composition of commonly used local complementary foods in Kebbi state (g/100g dry matter).

Complementary Foods	Dry Matter	Ash	Crude Fat	Crude Protein	Crude Fibre	Total Carbohydrate
KBDM	20.70±0.02a	1.06±0.02d	0.07±0.01d	2.19±0.60cd	0.02±0.00c	96.69±0.62a
KBFN	15.19±0.11b	2.47±0.29ab	2.93±0.39a	7.16±0.02a	1.21±0.01a	87.44±0.34d
KBGP	6.37±0.03e	2.24±0.04b	0.07±0.01d	1.38±0.30d	0.16±0.05b	96.31±0.34a
KBLP	8.75±0.15c	2.60±0.41a	2.25±0.01b	2.83±0.60bc	1.21±0.01a	92.33±0.61c
KBMP	7.59±0.11d	2.15±0.01c	1.06±0.04c	3.02±0.02b	0.02±0.01c	93.77±0.05a

Values are means ± SD of triplicate determinations. Values with different superscripts in a column differ significantly ($p<0.05$).
KBDM = Tuwo (Dami), KBFN = Fura nono, KBGP = Guinea corn pap, KBLP = Millet pap, KBMP = Maize pap.

Table 3. Proximate composition of commonly used local complementary foods in Niger state (g/100g dry matter).

Complementary Foods	Dry Matter	Ash	Crude Fat	Crude Protein	Crude Fibre	Total Carbohydrate
NGFN	17.97±0.01^{b}	1.25±0.01^{b}	1.65±0.72^{b}	2.61±0.01^{c}	1.44±0.03^{a}	94.49±0.69^{a}
NGMG	9.99±0.01^{d}	0.63±0.01^{d}	2.56±0.06^{a}	3.15±0.01^{a}	0.86±0.03^{b}	93.66±0.08^{b}
NGRG	18.95±0.05^{a}	3.41±0.46^{a}	2.21±0.10^{b}	2.53±0.03^{d}	1.41±0.01^{a}	91.85±0.55^{c}
NGTW	12.89±0.16^{c}	1.15±0.01^{c}	2.13±0.01^{b}	2.71±0.01^{b}	1.36±0.08^{a}	94.01±0.04^{a}

Values are means ± SD of triplicate determinations. Values with different superscripts in a column differ significantly ($p<0.05$).
NGFN = Fura nono, NGMG = Guinea corn/millet pap, NGRG = Rice/groundnut pap, NGTW = Tuwo.

Table 4. Amino acids composition of three most commonly used complementary foods in North Western Nigeria (g/100 g protein).

Amino Acids	FAO*	KBGP	KDLP	NGMG
Aspartate		3.78	4.15	3.92
Serine		2.32	2.09	1.02
Glutamate		5.81	4.74	4.46
Proline		0.64	0.45	0.63
Glycine		2.58	2.85	1.72
Alanine		4.02	3.15	2.23
Cystine		0.66	0.72	0.52
Tyrosine		2.09	2.43	2.09
Lysine	4.2	2.52	3.11	1.55
Histidine		1.38	1.25	0.72
Arginine		4.08	3.57	4.59
Threonine	2.8	2.05	1.59	1.22
Valine	4.2	3.54	3.06	1.71
Methionine	2.2	1.15	0.89	0.7
Isoleucine	4.2	2.59	3.26	1.51
Leucine	4.2	5.16	4.68	3.51
Phenylalanine	2.8	2.87	2.94	2.36

KBGP = Guinea corn pap, KDLP = Millet pap, NGMG = Guinea corn/millet pap.
*Food and Agricultural Organization Reference values (FAO/WHO, 1998).

cantly ($p<0.05$) higher crude fat, protein and fibre. Proximate composition results for commonly used complementary foods in Niger State (Table 3) which revealed that NGMG had significantly ($p<0.05$) higher crude protein (3.15±0.01%) and crude fat (2.56±0.06%) contents. There are significant differences ($p<0.05$) between ash contents of the food samples from Niger state.

Amino acids composition of the three (KBGP, KDLP and NGMG) most commonly used complementary foods in the zone (Table 4) indicated that KBGP had significantly ($p<0.05$) higher values compared to KDLP and NGMG for most of the amino acids. Table 5 showed that sodium, potassium, calcium, magnesium, manganese and phosphorus were significantly ($p<0.05$) higher in KB GP while KDLP recorded significantly ($p<0.05$) higher values of iron and zinc. Manganese levels in all the most commonly used complementary foods in the zone were higher than the RDA for children up to one year.

Presented in Tables 6 - 8 are results of antinutritional factors in commonly used complementary foods in the zone. For those commonly used in Kaduna state (Table 6) the phytates content were not significantly different ($p>0.05$) but concentrations of tannins were significantly ($p<0.05$) higher in KDFN (48.35±18.95 mg/100 g) and KDPS (59.27±9.46 mg/100 g). Significantly ($p<0.05$) higher total and bound cyanide concentrations of 1.21±0.04 mg/100 g and 0.51±0.01 mg/100 g were res-pectively obtained in KDFN. KDGP (0.88±0.02mg/100g) had significantly ($p<0.05$) higher free cyanide concentration. KBMP shows similar phytate concentration to that of KBFN and KBGP (Table 7). KBMP also had significantly ($p<0.05$) lower tannin (23.76±11.59 mg/100 g) concentration while KBGP had significantly ($p<0.05$) higher total and free cyanide concentrations of 0.72±0.04 mg/100 g and

Table 5. Mineral element concentration of three most commonly used complementary foods in North Western Nigeria (mg/100g dry matter).

Complementary foods	Na	K	Ca	Mg	P	Mn	Fe	Zn
RDA (Up to 1yr)$^{+}$	120	500	400	40	300	0.3-0.6	6	5
KBGP	150.47^{a}	217.78^{a}	87.11^{a}	74.21^{a}	171.32^{a}	3.47^{a}	17.82^{c}	5.78^{b}
KDLP	73.74^{b}	99.64^{b}	79.71^{a}	36.52^{b}	91.97^{b}	2.99^{b}	33.88^{a}	7.47^{a}
NGMG	73.78^{b}	99.70^{b}	31.90^{b}	28.24^{b}	92.03^{b}	2.99^{b}	21.93^{b}	4.16^{c}
SEM	14.76	22.73	13.53	8.17	15.27	0.09	2.78	0.55

Values with different superscripts in a column differ significantly ($p<0.05$). KBGP = Guinea corn pap, KDLP = Millet pap, NGMG = Guinea corn/millet pap, SEM = Standard error of means, $^{+}$Recommended dietary allowance (Guthrie, 1989).

Table 6. Antinutritional factors in commonly used complementary foods in Kaduna State (mg/100 g).

Complementary Foods	Phytates	Tannins	Total cyanide	Free cyanide	Bound cyanide
KDGP	0.05±0.01^{a}	26.49±9.46^{bc}	0.99±0.02^{b}	0.88±0.02^{a}	0.11±0.01^{c}
KDMP	0.05±0.01^{a}	26.49±9.46^{bc}	0.68±0.04^{c}	0.45±0.02^{c}	0.22±0.02^{b}
KDFN	0.06±0.02^{a}	48.35±18.95^{ab}	1.21±0.04^{a}	0.70±0.05^{b}	0.51±0.01^{a}
KDLP	0.04±0.01^{a}	12.95±5.79^{c}	0.30±0.04^{d}	0.05±0.01^{d}	0.05±0.01^{d}
KDPS	0.09±0.02 ^{a}	59.27±9.46^{a}	0.61±0.09^{c}	0.53±0.27^{bc}	0.29±0.10^{b}

Values are means ± SD of triplicate determinations. Values with different superscripts in a column differ significantly ($p<0.05$). KDFN = Fura with nono, KDGP = Guinea corn pap, KDLP = Millet pap, KDMP = Maize pap, KDPS = Maize Porriage (pate).

Table 7. Antinutritional factors in commonly used complementary foods in Kebbi State (mg/100 g).

Complementary Foods	Phytates	Tannins	Total cyanide	Free cyanide	Bound cyanide
KBFN	0.11±0.01^{a}	68.83±5.79^{a}	0.24±0.01^{b}	0.21±0.02^{b}	0.03±0.01^{ab}
KBGP	0.12±0.02^{a}	56.54±11.59^{ab}	0.72±0.04^{a}	0.65±0.04^{a}	0.06±0.02^{a}
KBLP	0.04±0.01^{b}	44.25±5.79^{b}	0.21±0.02^{b}	0.18±0.02^{b}	0.03±0.02^{ab}
KBMP	0.11±0.00^{a}	23.76±11.59^{c}	0.18±0.02^{b}	0.17±0.01^{b}	0.01±0.00^{b}

Values are means ± SD of triplicate determinations. Values with different superscripts in a column differ significantly ($p<0.05$). KBFN = Fura with nono, KBGP = Guinea corn pap, KBLP = Millet pap, KBMP = Maize pap.

0.65±0.01 mg/100 g respectively. Bound cyanide concentrations of KBGP (0.06±0.02 mg/100 g) and KBMP (0.01± 0.00 mg/100 g) were significantly different ($p<0.05$). Phytate content of commonly used complementary foods in Niger state (Table 8) was significantly ($p<0.05$) higher in NGRG (0.17±0.00 mg/100 g). Concentration of tannins (56.54±11.59 mg/100 g), total cyanide (0.76±0.01 mg/100 g) and free cyanide (0.74± 0.01 mg/100 g) were significantly ($p<0.05$) higher in NG MG while NGTW (0.14± 0.02 mg/100 g) recorded significantly higher bound cyanide concentration ($p<0.05$).

DISCUSSION

Traditional cereals and grain legume crops play important roles in the diet of many people in Africa and Asia, and are major sources of proteins, carbohydrates, vitamins and minerals hence traditional weaning foods are based on them (Mbofung and Fombang, 2003). Results from this study showed the commonly used complementary foods in the zone are cereal based with very low crude protein values (Tables 1-3) compared to the RDA value of 13-14 g/day (NRC, 1989) for infants up to 1 year of age. Crude fat contents obtained were also very low (Tables 1-3) and will not be able to meet the RDA value of 10-25 g/day for infants (NRC, 1989). According to Oguntona and Akinyele (1995) a dry weight estimate of 65 g is the daily intake of local weaning foods by a 6 months old infant through which the child is expected to meet the RDA. Hence to meet the 25 g RDA requirement for fat the complementary foods need to contain 38.46 g/100 g. This result is in line with the report of FAO (2001) that the first weaning food a baby eats is usually a soft or semi-liquid food made from starchy staple but a plain porridge prepared from cereals and water is not sufficiently rich in energy and it lacks protein and essential vitamins and that it is important to add other

Table 8. Antinutritional factors in commonly used complementary foods in Niger State (mg/100 g).

Complementary Foods	Phytates	Tannins	Total cyanide	Free cyanide	Bound cyanide
NGFN	0.05±0.01^{c}	23.76±11.59^{b}	0.36±0.04^{b}	0.33±0.02^{b}	0.03±0.01^{b}
NGMG	0.11±0.09^{ab}	56.54±11.59^{a}	0.76±0.01^{a}	0.74±0.01^{a}	0.02±0.01^{b}
NGRG	0.17±0.00^{a}	37.42±9.46^{ab}	0.21±0.02^{c}	0.18±0.02^{c}	0.04±0.02^{b}
NGTW	0.12±0.02^{b}	40.25±5.79^{ab}	0.32±0.02^{b}	0.18±0.02^{c}	0.14±0.02^{a}

Values are means ± SD of triplicate determinations. Values with different superscripts in a column differ significantly ($p<0.05$).
NGFN = Fura with nono, NGMG = Guinea corn/millet pap, NGRG = Rice/groundnut pap, NGTW = Tuwo.

foods like protein-rich legumes. Innocenti declaration (1990) stated that children from 6 months of age should continue to be breastfed and receive appropriate complementary foods that are adequately rich in energy and micronutrients, prepared and stored in hygienic conditions to reduce the risk of contamination (Allen and Gillespie, 2001). Access to nutritionally adequate and safe diet at all times is one of the most basic rights of individual, yet for significant households in Africa this remains difficult to achieve (FAO, 2001).

Most of the values obtained for the essential amino acids in the local complementary foods fell short of the FAO reference values (Table 4). This short-fall can limit growth and brain development of the children due to unavailable of these amino acids for use in the metabolic processes of the body (Solomon, 2005). Only leucine and phenylalanine in KBGP and KDLP met the FAO reference values while levels of lysine and methionine in the commonly used complementary foods were below the international reference values of 4.2 and 2.2 for lysine and methionine respectively (FAO/WHO, 1998). Protein-Protein Energy Malnutrition (PEM) has continued to pose challenges in Nigeria due to poor feeding practices and low quality of protein as a result of deficiency in essential amino acids and low protein digestibility (Nnakwe, 1995) which is commonly found in plant-based single diets (Temple et al., 1996). FAO/WHO (2001) reported that special emphasis should be placed on the micronutrient composition, nutrient bioavailability and utilization of local diets and also in the form these diets are actually consumed by the people. The mineral contents of the commonly used complementary foods in the zone were observed to be low except for iron and zinc which met the RDA values (Table 5). These short-falls could either be attributed to nutrient loss during processing, or poor micronutrient content of the plant-based diets (Solomon, 2005). Cereals and tuber-based foods constitute the main staples for most populations of the world at risk of micronutrient deficiencies (FAO/WHO, 2001) which is what was shown by this study. A lack of sufficient micronutrients in the diet affects the health and development of children and results in potentially life-threatening deficiency diseases such as anemia and vitamin A deficiency (FAO, 2001). A positive calcium balance is required throughout growth, particularly during the first two years of life and children of this age group are always at risk of calcium deficiency (FAO/WHO, 2001). In the weaning period, the iron requirements in relation to energy intake are the highest of the lifespan and the rapidly growing weaning infant has no iron stores and has to rely on dietary iron (FAO/WHO, 2001).

The presence of antinutritional factors such as phytates and tannins in foods like complementary foods has been reported to constitute an important handicap to the effective utilization of its nutrients in human nutrition (Mbofung et al., 1990). Most cereal-based diets have poor bioavailability of nutrients as a result of the presence of antinutritional factors such as phytates and tannins. Phytate (myo-inositol hexaphosphate) is an abundant plant constituent, comprising 0.5 to 6% of all cereals, nuts, legumes and oil seeds and normally found in the form of complexes with polyvalent cations, like iron, zinc, calcium and magnesium, and proteins (Urbano et al., 2000). Zinc absorption is inhibited by consumption of diets high in phytate, such as diets based on unrefined cereal (WHO, 1996). Phytates level in the commonly used complementary foods in states studied (Tables 6-8) were low and less than the 1% phytates reported to interfere with mineral availability (Erdman, 1979). Concentration of tannins in the commonly used complementtary foods (Tables 6-8) were lower than the 20 mg/100 g tannins reported in Tombrown (Plahar and Annan, 1994) indicating less unpleasant, dry and bitter mouth feeling caused by tannins which usually leads to reduced food intake and body growth (Fasuyi, 2005). The levels of cyanide in most of the commonly used complementary foods in the zone (Tables 6-8) were below the 1 mg/100 g safe level reported by FAO/WHO (1998), and cyanide lethal dose of 0.5 to 3.5 mg/kg human body weight.

Conclusion

Protein intake of children in the zone is low because their diet is mainly cereal-based with no supplementation. There is a need to increase programmatic approaches for the promotion of improved complementary feeding practices through increased availability as well as use of low-cost indigenous high-quality home-prepared complementary foods.

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