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Fortification of Sorghum Flour with *Adenopus breviflorus bent* seeds Flour as Infant Formula Mixes

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Abstract

Adenopus breviflorus benth seed is an underutilized protein rich seed while sorghum is one of the commonest grains used for making infant weaning food in Nigeria as palp or "Ogi". However, this grain has been reported to have carbohydrate content which makes it not sufficient to give balanced diet needed by growing babies. Fermented sorghum flour was therefore fortified with *Adenopus breviflorus* seeds flour which is a plant protein source as to prevent kwashiorkor in children. Fermented dried sorghum flour (FDSF) was fortified with roasted *Adenopus breviflorus* seed flour (RASF) in the ratios 90:10; 80:20; 70:30 and 60:40 respectively. Proximate and mineral compositions of the formulated mixes were determined and compared with those of some market baby food samples. Proximate analysis of sorghum shows that it has very high percentage of carbohydrate (69.8 %) with protein and fat contents being (13.64 %) and (4.10 %) respectively. On the other hand, the proximate analysis of RASF shows that it has high percentage of fat (47.6 %), high protein content (28.17 %), and low carbohydrate content of (9.96 %). The compounded products from fortification of fermented sorghum flour with RASF shows that the carbohydrate content decreases while protein and fat content increased with increasing percentage of RASF and corresponding decrease in sorghum flour ratio. The organoleptic tests of the different products were also carried out. On the average, the FDSF with -RASF mixtures were highly accepted due to the pleasant taste, flavor, colour, and odour brought about by the presence of RASF. The mineral content of these winning mixes compared favourably with those of some market samples as to meet the nutritional needs of the growing baby at much lower cost.

Keywords: Fortified, Mixes, Sorghum, *Adenopus breviflorus benth,* Protein

Introduction

In Nigeria, one major factor for the high prevalent of kwashiorkor (a protein deficiency syndrome) is the widespread use of a low protein source marsh or pap (ogi) for weaning babies. Several commercial weaning mixes are being marketed nowadays but they are too expensive for the population of low socio-economic status, especially those in the rural areas. It is therefore imperative to formulate inexpensive weaning mixes of low cost and high nutritive value from locally, readily available sources to meet the nutritional demands of a growing infant.

Majority of the mothers in Nigeria breast feed their babies at least for the first three months of life, unless there are circumstances which prevent this (Bamiro et al., 1993). Some infants sustain excellent growth over the first nine to twelve months of life despite breast milk being their main source of nutrition, (Bamiro et al, 1993). Most infants however fail to show satisfactory growth after four months of life, unless their intake is supplemented with other foods. Most of those infants' formulae (milk) substitutes are expensive and not easily affordable by the average income mothers (Bamiro, et al., 1993).

Apart from protein and energy, weaning diets of infants in developing countries require more calcium, vitamin A and D, iron and some important trace elements. These can be obtained by combining the local staples presently available in the country. Combination of commonly used cereals with inexpensive plant protein sources like legumes can be used. Cereals are deficient in lysine but have sufficient sulphur containing amino acids which are limited in legumes (Tsai *et al*., 1975; Wang and Daun, 2006; Iqbal *et al*., 2006; Shewry, 2007) whereas legumes are rich in lysine (Amankwah et al., 2009).

Proteins are needed for the formation of enzymes, hormones, antibodies, haemoglobin, and antitoxins. They help to control the alkalinity of the blood and the osmotic pressure of the blood and the vessel (Uddoh, 1980). Protein malnutrition in the first two years of a child's life may result in, permanent detrimental effect or mental development, learning ability and behaviour (Uddoh, 1980). It is therefor, important to formulate inexpensive weaning mixes of low cost and high nutritive values from local and readily available sources, which will meet the nutritional demands of a growing infant.

Materials and Methods

Preparation of Materials

Sorghum seeds were bought from Oja Oba in Akure, Ondo State, Nigeria, handpicked to remove stones and other contaminants and fermented naturally by soaking in clean distilled water for three days. The fermented sorghum was washed, drained and oven dried at 90 ^{o}C – 100 ^{o}C until the grains were properly dried, milled to fine flour (FDSF) and kept in air tight bottle for further use and analysis. *A. breviflorus* seeds were gotten from Auchi market and the local name of the seed is "Egwoli". The *A. breviflorus* seeds were roasted in a clean vessel, milled into fine flour to produce Roasted A. breviflourus seed Flour (RASF) and stored in a labelled, clean, dried amber bottle.

Compounding of Weaning Mixes

Weaning mixes of fermented, dried sorghum flour (FDSF) and roasted *Adenopus breviflorus benth* seeds flour (RASF) were made by weighing 90:10, 80:20, 70:30, 60:40 grams of FDSF to RASF into four different clean and dried amber bottles and labelled as A1, A2, A3 and A4, respectively.

Proximate Analysis

Standard procedures as described by Association of Official Analytical Chemists (AOAC, 1990) were used for sample treatment and analysis.

Mineral Analysis

Mineral analysis was carried out according to Oshodi, 1990. The elements determined were sodium, potassium, calcium, magnesium, manganese, phosphorus, iron, zinc and copper.

Organoleptic Test

Organoleptic test of the compounded weaning mixes was carried out to determine the acceptability of the samples. The samples were given to a panel of three people to rate the following parameters: taste, colour, odour, texture, flavour and general acceptability.

The remarks given were graded as follows:
5 = Excellent
4 = Very good
3 = Good
2 = Fair
1 = Poor
The results are the average of replica results of members of panel.

Results and Discussion

Proximate analysis of FDSF and RASF in Table 1 shows that FDSF has high carbohydrate content (69.88 %) and low fat and protein contents of 4.10 % and 13.60 %, respectively. On the other hand, RASF has higher fat content (47.65 %), protein content (28.17 %) and lower carbohydrate value (9.96 %). This is consistent with the results 28.60 % protein content obtained for the crude protein of *A. breviflorus* by Oshodi, 1990.

Table 1: Proximate Composition of Fermented, Dry Sorghum Seed flour (FDSF) and Roasted *A. breviflorus* Seed Flour (RASF) (%)

	Sample	
Parameter	FDSF	*RASF*
Protein	13.64	28.17
Fat	4.10	47.65
Fibre	1.30	4.90
Moisture	1.30	4.43
Ash	1.45	4.15
Carbohydrate	69.88	9.96

RASF: Roasted *Adenopus breviflorus benth seed flour*
FDSF: Fermented dried sorghum seed flour

This shows that sorghum when given to infants as ogi (infant weaning palp) cannot meet the daily required nutritive value needed for growing babies. RASF has higher fat and protein contents of 47.60% and 28.17%, respectively than FDSF (Table 1). The sorghum seeds were purposely fermented because this was a more conventional way of preparing ogi in Nigeria. It has been reported that fermentation helps to improve probiotic and nutritional quality of foods (Tsafrakidou et al., 2020). Table.2 shows the proximate analysis of the fortified sorghum, which is FDSF with *RASF* (Samples A). Carbohydrate content of the compounded formulae ranged from 50.90 % to 67.90 % and protein content ranged from 17.60 % to 21. 70 %. Compounded infant formulated mixes A1 to A4 will therefor meet the protein demand of infants, since the minimum protein content of 15% is required for maximum complementation of amino acids in foods for proper growth of babies (FAO/WHO 1982; Sanni et al., 1999). Fat content of the formulated mixes ranged from 10.00% to 21.00 %. These are comparable with the fat composition of 9.38% and 8.75% in formulated infant formulae by Amankwah et al., (2009). Furthermore, high intake of fat especially saturated fatty acids has been shown to increase the level of cholesterol in the blood; however, this is not the case with unsaturated fats (Oduro et al., 2007) such as fat found in soybean (Lanna et al., 2005) and cereals (Ngeh-Ngwainbi et al., 1997; Szalai et al., 2001). Moisture content of the formulated mixes ranged from 2.03 % to 8.08 %. The values for the moisture content of samples A1 to A4 are consistent with the report of Nelson (1992) that moisture content is used as a quality factor for prepared cereals which should have 3-8 % moisture content. Low moisture content of food enhance longer shelf life needed for packed food and transportation period before consumption (Oduro et al., 2007). Formulated *RASF* mixes with FDSF gives good qualities as baby weaning formulae in terms of the protein and fat contents to meet the required nutrients for babies (Nelson, 1992; Oduro et al., 2007; Sanni et al., 1999). However, the results of the data for samples A1 to A4, shows that there is gradual decrease in carbohydrate contents, while there is approximately increase in protein and fat contents of the samples, Table 2.

These results are similar to the nutritive values of some market samples of baby weaning food in Table 4, with carbohydrate contents ranging from 55.40 % to 66.40 %, protein content ranged from 11.90 % to 17.00 %, fat content ranged from 9.00 % to 27.70 %, moisture content ranged from 2.00 % to 4.00 %, while ash content ranged from 2.30 % to 3.80 %. FDSF-RASF mixes will provide cheaper means of meeting the daily protein requirement of 2.2 g/100 Kcal for 3 months old infants and 1.6 g/ 100 Kcal for infants over 3 months (Niels, 1994).

Table 2: Proximate composition of Compounded Fermented Dried Sorghum seed flour (FDSF) fortified with Roasted *Adenopus breviflorus benth seed flour* (RASF)

	Ratio of FDSF to RASF			
Parameter (%)	A1 (90:10)	A2 (80:20)	A3 (70:30)	A4 (60:40)
Protein	15.75	17.69	19.32	20.30
Carbohydrate	67.95	55.96	52.00	50.90
Fat	10.30	15.00	15.80	21.70
Crude fibre	2.15	2.90	3.70	2.90
Ash	1.84	1.01	1.21	1.15
Moisture	2.03	7.44	3.03	7.50

Table 3: Mineral Content of RASF Fortified with FDSF Mixes (mg/100g sample)

	Ratio of FDSF to RASF			
Mineral	A1 (90:10)	A2 (80:20)	A3 (70:30)	A4 (60:40)
Na	95.00	101.00	110.00	120.00
K	400.00	410.00	460.00	463.00
Ca	280.00	289.00	304.00	361.00
Mg	34.00	31.00	29.00	28.00
Cu	0.53	0.23	0.21	0.41
Zn	4.60	4.30	3.90	4.10
Fe	16.00	16.00	15.00	17.00
Mn	0.90	0.87	0.97	1.10

Table 3 shows the mineral composition of Compounded Fermented Dried Sorghum seed flour (FDSF) fortified with Roasted *Adenopus breviflorus benth* seed flour (RASF). Considering the mineral content of the formulated mixes in Table 3, sodium ranged from 95 mg/ 100g to 120 mg/ 100 g, potassium from (400 to 463) mg/100g, calcium (280 to 361) mg/ 100 g, showing that they have high mineral contents needed for the formulation of strong bones and other functional growth required by babies. These results are similar to the manufacturers' specifications for market sampled baby food products in Table 4 with Sodium (85.00 – 245.00) mg/100g, calcium (390 - 590) mg/100g and potassium (570 - 740) mg/100g.

Table 4: Proximate Composition (%) and Mineral Content of Some Market Baby Food Samples (mg/100g sample)

	Trade Name of Baby Food				
Parameters	NUTREND	CERELAC	FRISOCREM	SMA	BABEENA
Carbohydrate	63.70	66.30	64.00	55.40	66.00
Crude Protein	16.00	15.50	15.80	11.90	17.00
Crude Fat	9.00	9.00	13.20	27.70	9.50
Crude Fibre	5.00	2.90	1.80	ND	ND
Total Ash	2.30	3.80	3.20	ND	ND
Moisture	4.00	2.50	2.00	ND	ND
Na	85.00	245.00	170.00	200.00	360.00
K	570.00	715.00	ND	740.00	720.00
Ca	390.00	590.00	500.00	560.00	600.00
Mg	ND	ND	ND	40.00	ND
Cu	ND	ND	0.20	62.00	ND
P	260.00	475.00	ND	62.00	ND
Zn	7.00	ND	2.00	ND	ND
Fe	10.00	7.50	9.00	1.30	ND
Mn	ND	ND	ND	ND	ND

ND means not determined

Organoleptic Test Result of Compounded Fermented Dried Sorghum seed flour (FDSF) fortified with Roasted Adenopus breviflorus benth seed flour (RASF)

Table 5 shows the result of the organoleptic tests. FDSF compounded with RASF to give A1, A2. A3 and A4 all gave pleasant flavour and light brown pleasant colour. The pleasant flavour can be as a result of Maillard reactions that would have occurred during the roasting of *Adenopus breviflorus bent* seeds which is rich in carbohydrate, protein and oil. All the samples have very good (4) appearance and flavour while A3 and A4 have very good (4) overall acceptance compared to A1 and A2 that had good (3) overall acceptance. This indicate that addition of RASF increases the flavour and acceptability of the compounded infant mixes with the FDSF.

Table 5: Result of Organoleptic Tests of the Formulated Mixes

Parameter	A1	A2	A3	A4
Appearance	4	4	4	4
Colour	4	3	3	4
Taste	4	3	4	4
Texture	3	3	3	3
Flavour	4	4	4	4
Overall acceptance	3	3	4	4

Results are mean of replicate panellist submissions

The raw materials (sorgum and Adenopus breviflorus benth seeds) are relatively cheap and available in local markets. Although, *Adenopus breviflorus benth* seed is underutilized and almost going into extinction, its high nutritional content with high health benefits is worthy of note.

Conclusion

In conclusion, fortifying sorghum, that is mainly carbohydrate, with a highly *Adenopus breviflorus benth* seed flour, which has higher protein content than sorghum, gives compounded infant formulae that are more nutritious, with nutritional values comparative to manufactured baby weaning market samples

Conflict of Interests

The authors declare that there is no conflict of interest.

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