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Research Article

Evaluation of weaning food blends from modified millet and groundnut cake flour

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Abstract: Millet grains are used in the production of traditional weaning foods, but they lack adequate nutrients. In order to solve malnutrition among the infants in developing countries, there is need to fortify commonly consumed low protein staple foods with inexpensive plant protein sources. Flour samples were produced from germinated and steeped millet as well as groundnut cake using standard processing techniques. The germinated flour and steeped flour were complemented with groundnut cake flour in ratio of 1:1 in order to improve the nutrients quality of the blends. Samples obtained were analysed for proximate composition (moisture, protein, fat, crude fibre, ash, carbohydrate and energy) and functional properties (viscosity and water hydration capacity) using standard methods. Data derived from this study were analysed for ANOVA using SPSS. The moisture, protein, fat, crude fibre, ash, carbohydrate, energy, viscosity and water hydration capacity ranged from 2.60-740%, 9.70-27.05%, 4.25-13.00%, 1.90-2.35%, 1.31-2.65%, 52.63-74.25%, 381.25-435.72 Kcal, 201.25 - 3360.00 cps and 0.415 -1.305 ml/g respectively. The inclusion of groundnut cake flour in blends significantly influenced all the dependent variables at 95% confidence level. Conclusively, germination and supplementation significantly increased the nutrient quality of the blends and improved their functional properties.

Keywords: Millets; groundnut; germination; supplementation; weaning food

1. Introduction

One way to bridge the `food gap` leading to protein energy malnutrition which is the most widespread nutritional disorder among children in the developing countries is to introduce low cost weaning foods produced from locally available raw material (Livingstone et al., 1993). As the importance of energy in preventing malnutrition is now well recognised, there is need for nutritionally balanced, energy dense and easily digestible weaning foods based on simple technologies (Livingstone et al., 1993).

Complementary feeding can be defined as the intake of other foods along with breast milk (continued breastfeeding) in order to complement nutrients supplied by breast milk (Ngwu, 2005). Weaning period is defined by the World Health Organisation as the "progressive transfer of the infant from breast milk as the sole source of nourishment to the usual family diet (Huffman & Martin, 1994; Caulfield et al., 1999).This usually starts when infant are 4-6 months old. Foods consumed by young children during the weaning process are referred to as supplementary foods because they are served along with breast milk (Imonikebe & Iroriteraye, 2009). In most developing countries, these foods are grossly inadequate in calories, protein, and micronutrients resulting in poor growth and malnutrition (Mbata et al., 2009). Gruels made from traditional weaning food are bulky and nutritionally inadequate and they are usually made from cereals and tubers (Mbata et al., 2009). Protein and high energy are two most problematic aspects of nutrition in Nigeria, leading to infants' protein energy malnutrition (Mariam, 2005). Maternal mortality rate in Nigeria is

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a public health concern and is reported to be the root cause of malnutrition which accounts for over 50% of deaths of children and represents 25 percent of the total number of deaths of children under-five (UNICEF, 2011).

Cereal grains are the most important sources of the world's food and they have a significant role in human diet throughout the world. Millet is one of the most important drought-resistant crop that is widely grown in the semi-arid tropics of Africa and Asia, and it constitutes a major source of carbohydrates for people living in these regions (Saleh et al., 2013). However, millet grain is now receiving increasing interest from food scientists, technologists, and nutritionists, because of its important contribution to national food security and its potential health benefits (Saleh et al., 2013). Millet has been found suitable for large scale utilisation in the manufacture of food products such as baby foods, snack foods and dietary foods (Subramanian & Viswanathan, 2007; Liu et al., 2012). Also, germination and lactic acid fermentation which are traditional food processing technologies have been proposed as means to improve nutrient density of complementary foods (Mbithi-Mwikya et al., 2000).

Germination or malting of cereal grains results in some biochemical modifications (increase in free amino acids, increase in total sugars, decrease in the dry weight and decrease in starch content) and produces malt with improved nutritional quality which can be used in various traditional recipes (Parameswaran & Sadasivam, 1994). It also increases the calcium, iron, and zinc contents of finger and pearl millets (Krishnan et al., 2012). Germination has also been found as a most promising method for greatly reduction of dietary bulk or customary high carbohydrate in cereals in order to make them suitable for weaning diets production in developing countries (Theodore et al., 2009). However, supplementation of germinated cereal with leguminous protein source might further increase the protein content of the cereal based weaning food prepared from them.

Groundnut cake is the residue obtained after extraction of oil and it contains 45–60% protein, 22–30% carbohydrate, 3.8–7.5% crude fibre and 4–6% minerals (Purohit & Rajyalakshmi, 2011). However, utilisation of meal or defatted meal as a complementary food might serve as an excellent vehicle for enhancing the utilisation of groundnut protein in the diets of malnourished people in developing countries. Therefore, formulation of weaning foods from the blends of germinated millet flour and groundnut cake flour should be studied.

2. Materials and methods

2.1. Materials

Pearl millet grains (10.0 kg) and groundnuts (3.0 kg) used for this study were purchased from Maiduguri Monday Market during the dry season.

2.2. Methods

2.2.1. Preparation of steeped millet flour (SGMF)

Steeped millet flour was prepared according to the method described by Chibuzo and Ali (1994).The millet grains were sorted to remove foreign matter and spoilt grains. They were then weighed and soaked in water that was 3 times their weight by volume. The grains were steeped for 16 h. This was done for the grains to swell and to improve the colour and the palatability of the grains. The grains were then drained and sun dried for 10-12 hours. The grains were then milled using a hammer mill (laboratory mill type No. 1G97) with aperture size of 0.8mm. The flour was then sieved (using a local sieve), weighed and packaged in high density polythene bags as steeped millet flour (SGMF). The flow chart for the production of steeped millet flour is presented in Figure 1.

2.2.2. Preparation of germinated millet flour (GMF)

Germinated millet flour was prepared according to the method described by Chibuzo and Ali (1994). The millets were steeped for 6 hours, drained, and germinated for a period of 48 hours. The grains were sun dried for 10-12 hours then milled using a hammer mill (laboratory mill type No. 1G97) with aperture size of 0.8mm. The flour was then sieved, weighed, and packaged in polythene bags as germinated millet flour (GMF). The flow chart for the production of germinated millet flour is presented in Figure 1.

2.2.3. Preparation of groundnut cake flour

Groundnut cake flour was prepared according to the method described by Chibuzo and Ali (1994). Groundnuts were sorted, weighed and roasted slightly at 160oC for about 5 minutes in a conventional oven. The roasted groundnuts were cooled and the coats were removed by abrasion. The spoilt and burnt groundnuts were removed before grinding into paste using a local mill. Boiling water was then added to the paste (1.975ml/1kg paste) and stirred until oil oozed out, which took about 15 min. The oil was drained out and the groundnut cake flattened on a rolling board, cut into cubes and fried in the extracted oil until a golden brown colour was obtained. The cake was then drained and cooled. The flow chart for the production of groundnut cake flour is presented in Figure 2.

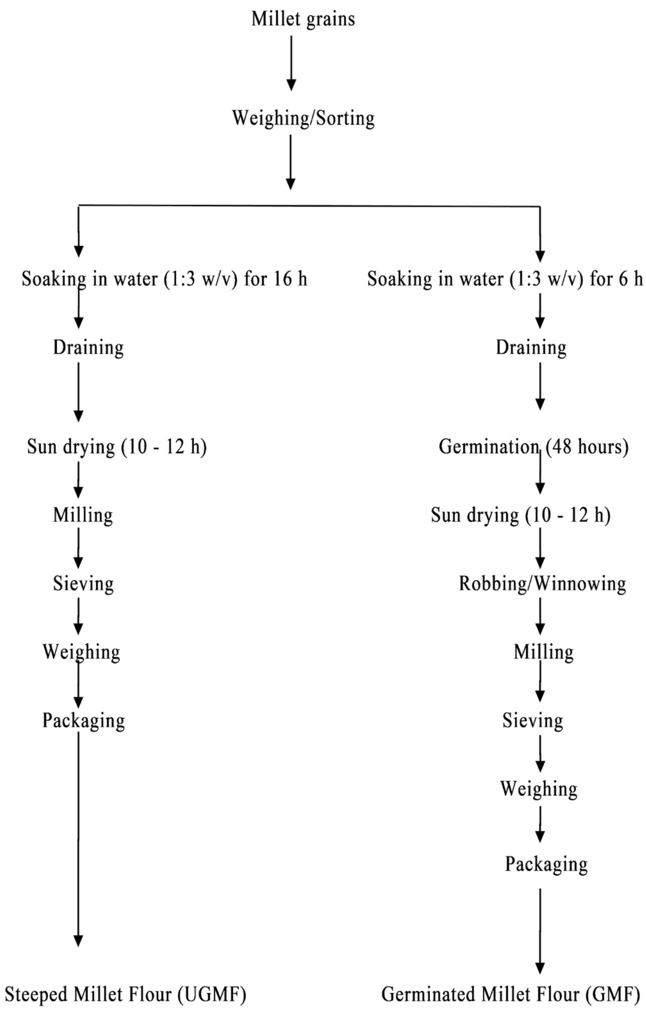

Figure 1: The flowchart for preparation of germinated and steeped millet flour

2.3. Analyses

2.3.1. Chemical composition

The chemical composition (moisture, protein, ash, fat, crude fibre, carbohydrate and energy) of the samples were evaluated using the standard AOAC procedure (AOAC, 2005).

2.3.2. Viscosity

Viscosities of gruels from the samples were measured following the method of Mosha and Svanberg (1983). Flour and water were mixed in a glass beaker (17.5g flour with 100 mls of water) which was heated in a boiling water bath to reach a cooking temperature of 95°C and it was boiled for 7 to 10 mins. The gruel was then kept at this cooking temperature for 15 mins with occasional stirring. This gruel was placed in water bath maintained at 40°C and the viscosity was measured at this temperature using a Brookfield viscometer.

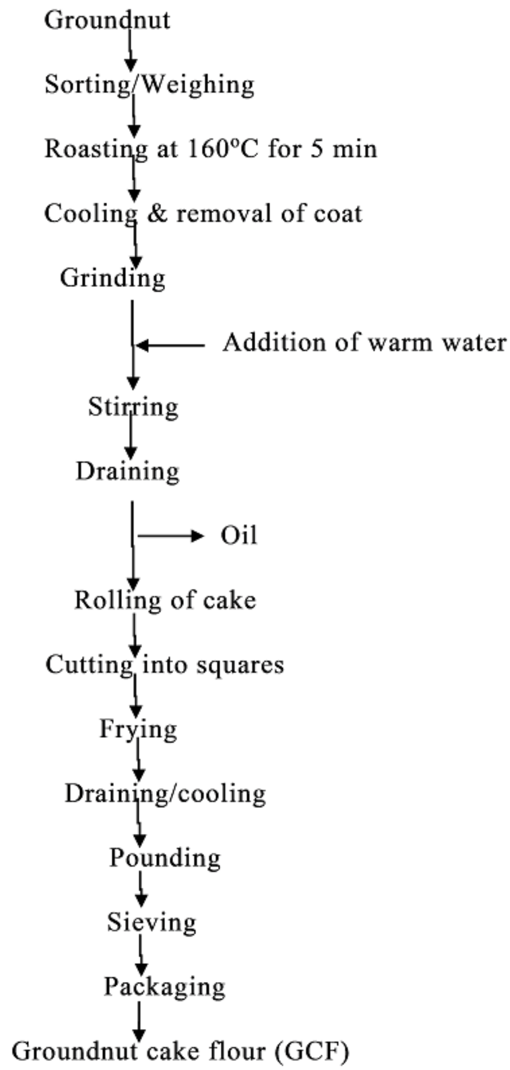

Figure 2: Flow chart the production of groundnut cake flour

2.3.3. Water hydration capacity

The water absorption capacity of the samples was determined according to Quinn and Paton (1979) method. Two grams of each sample was placed in a centrifuge tube of known weight. Five mills of water was added into the tube and the tube allowed to stand for 30 minutes. The mixture centrifuged at 300 rpm for 10 min. The supernatant was decanted and the residual gel was weighed. Water hydration is the weight in grams of the residual gel per gram of dry sample. It was determined at 30oC and 70°C in three replicates for all samples.

2.4. Statistical analyses

Data were expressed as mean ± SD and were analysed by one-way ANOVA test using SPSS statistical programme.

3. Results and discussion

The chemical composition and functional properties of the flours and blends are discussed below. The initial protein content of the supplement (GCF) was determined to be 42.55%. High protein content obtained in the supplement is an indication that the results from the blends are not likely to be badly influenced by their protein contents.

3.1. Proximate composition

3.1.1. Moisture

The moisture content obtained from the weaning food samples ranged from 2.60-7.40% (Table 1) with the blend of germinated millet flour and groundnut cake flour having the lowest moisture content and steeped millet flour having the highest moisture content. The moisture content of food products is a measure of their vulnerability to microbial attack and hence spoilage (Olusanya, 2008). Generally, the moisture contents observed in this study are far below 10.0%, indicating that they might have good storage advantage.

3.1.2. Protein

The protein content obtained from weaning food samples ranged from 9.70-27.05% (Table 1) with the blend of germinated millet flour and groundnut cake flour having the highest protein content and steeped millet flour having the lowest protein content. From Table 1, it was observed that two distinct factors were responsible for the increase in protein contents of the blends. Firstly, it was noticed that the protein contents of samples containing considerable proportions of GCF increased significantly. Secondly, it was observed that germination also contributed to the highest protein value recorded in the blend of germinated millet flour and groundnut cake flour. Proteins play some important roles in proper maintenance and growth of the body (Duru-Majesty et al., 2012; Raji et al., 2018). Cereal meals enrichment with legumes had been reported by Philip and Itodo (2006) who established that such blend resulted in a higher protein quality than if administered only as cereal meals. Germination also releases protease enzyme which is responsible for breaking down of complex poly peptide bonds into simpler ones, which results into increase in the protein content of the germinated substrate (Inyang & Zakari, 2008). Therefore, blending of germinated millet flour with groundnut cake flour might contribute significantly to the daily protein requirements of 22–56 g (NRC, 1975).

3.1.3. Fat

The fat content obtained from weaning food samples ranged from 4.25-13.00% (Table 1). The blend of germinated millet flour and groundnut cake flour had the highest fat content, while the germinated millet flour had the lowest fat content. It was observed that samples enriched with GCF had higher fat contents, while samples that did not contain GCF had lower fat contents. This implies that GCF might be a fat source and its inclusion in the blends significantly influenced their fat contents. Fats are saturated lipids at room temperature (Kritchevsky, 1996, Duru-Majesty et al., 2012) which play protective roles in the body system (Olusanya, 2008). Some important fatty acids that are derived from fat include omega-3-fatty acid, and these fatty acids are noted for their roles in the body system (Obidoa et al., 2010). However, low level of fat obtained in samples without inclusion of GCF, could mean that they might have good storage advantage over the blends that was fortified with GCF. In addition, relatively low fat contents obtained in the unfortified sample might be advantageous to health as well as extending the product shelf life in terms of delaying onset of rancidity (Arisa et al., 2013).

3.1.4. Ash

The ash content obtained from weaning food samples varied from 1.31-2.65% (Table 1), with the blend of steeped millet flour and groundnut cake flour having the highest ash content and the germinated millet flour having the lowest ash content. An index of mineral contents in a biota is the ash content of a sample (Akubugwo et al., 2007). Samples analysed contained considerable amount of ash contents, and this is an indication that they might contain moderately high mineral values. Highest ash content in the blend of steeped millet flour and groundnut cake flour could mean that the minerals content in sample is higher than that of others.

3.1.5. Crude fibre

The crude fibre content obtained from the weaning food samples varied from 1.90-2.35% (Table 1). This reveals that the blend of steeped millet flour and groundnut cake flour had the highest crude fibre content, while the germinated millet flour had the lowest crude fibre content. Adequate intake of dietary fibre can lower the level of serum cholesterol and reduce the risk of developing hypertension, constipation, diabetes, colon cancer and coronary heart disease (Ishida et al., 2000). The crude fibre contents obtained in this study might contribute to daily intake of dietary fibre, with a possibility of lowering the risk of constipation and coronary heart disease.

3.1.6. Carbohydrate

The carbohydrate contents obtained from the weaning food samples varied from 52.63-74.25% (Table 1). The blend of germinated millet flour and groundnut cake flour had the lowest carbohydrate content, while the germinated millet flour had the highest carbohydrate content. It was observed that inclusion of GCF significantly reduced the carbohydrate contents of the blends (Table 1). This suggests that GCF might have low carbohydrate content, being a good protein source. However, the recommended dietary allowance (RDA) values of 130g, 175g, and 210g of carbohydrate are recommended for adults, pregnant and lactating mothers respectively (Duru Majesty et al., 2012). Values lower than the recommended limit might be suitable for infant. Higher values of carbohydrate obtained in this study suggest that the samples might contribute significantly to the carbohydrate need of both infants and adults.

3.1.7. Energy value

The energy values obtained from weaning food samples ranged from 381.25-435.72 Kcal/100g (Table 1). The blend of germinated millet flour and groundnut cake flour had the highest energy value, while the steeped millet flour had the lowest energy value. It was noticed that inclusion of GCF contributed significantly to the increase in the energy values of the blends (Table 1). This is an indication that GCF might have high energy value as it was made from an oilseed (groundnut) which has a fat content of 40-44% (Makeri et al., 2011). Among the three common sources of energy (protein, carbohydrate and fat), fat has been rated as the highest energy yielding source (Michaelsen et al., 2003). Higher energy values in the blends imply that they might contribute immensely to the daily energy need of both infants and adults.

3.2. Functional properties

3.2.1. Viscosity

The values for the viscosities of the samples subjected to analysis ranged from 201.25 - 3360.00 cps (Figure 3). The blend of germinated millet flour and groundnut cake flour had the lowest viscosity value, while the steeped millet flour had the highest viscosity value. The inclusion of GCF considerably reduced the viscosity of the gruels made from the blends. Reduction in the viscosity of the gruels prepared from the blends might be due the nature of the GCF which is predominantly protein and fat base (Makeri et al., 2011). However, the reduction in the viscosities of the gruels prepared from germinated sample and its composite could be due to the breakdown of complex molecules by enzymes during germination, which might have resulted in less viscous soluble matter, including sugars and short chain dextrins as observed by Uvere et al. (2002).

3.2.2. Water hydration capacity

The values obtained for the water hydration capacity of the weaning food samples ranged from 0.785 -0.515 ml/g for the samples whose water absorption capacities were determined at 30^{o}C and varied from 0.415 -1.305 ml/g for the samples whose water hydration capacities

Table 1: Proximate composition of the weaning food samples

Sample	Moisture Content (%)	Protein Content (%)	Fat Content (%)	Crude Fibre (%)	Ash Content (%)	Carbohydrate Content (%)	Energy Value (Kcal/100g)
GMF	4.10±0.10^{c}	14.65±0.15^{b}	4.25±0.05^{d}	1.90±0.02^{c}	1.31±0.02^{c}	73.89±0.02^{b}	392.41±0.59^{c}
UGMF	7.40±0.20^{c}	9.70±0.00^{d}	5.05±0.05^{c}	2.21±0.03^{b}	1.38±0.02^{c}	74.25±0.14^{a}	381.25±0.99^{d}
GMF:GCF	2.60±0.20^{d}	27.05±0.35^{a}	13.00±0.03^{a}	2.20±0.01^{b}	2.52±0.05^{b}	52.63±0.10^{d}	435.72±0.09^{a}
SGMF:GCF	4.77±0.10^{b}	13.60±0.10^{c}	8.80±0.10^{b}	2.35±0.12^{a}	2.65±0.05^{a}	67.83±0.02^{c}	404.98±0.58^{b}

Data reported as Mean±SD. Values followed by the same superscripts in columns are not significantly different at $P < 0.05$.

Keys:
GMF - Germinated Millet Flour,
SGMF - Steeped Millet Flour
GCF - Groundnut Cake Flour

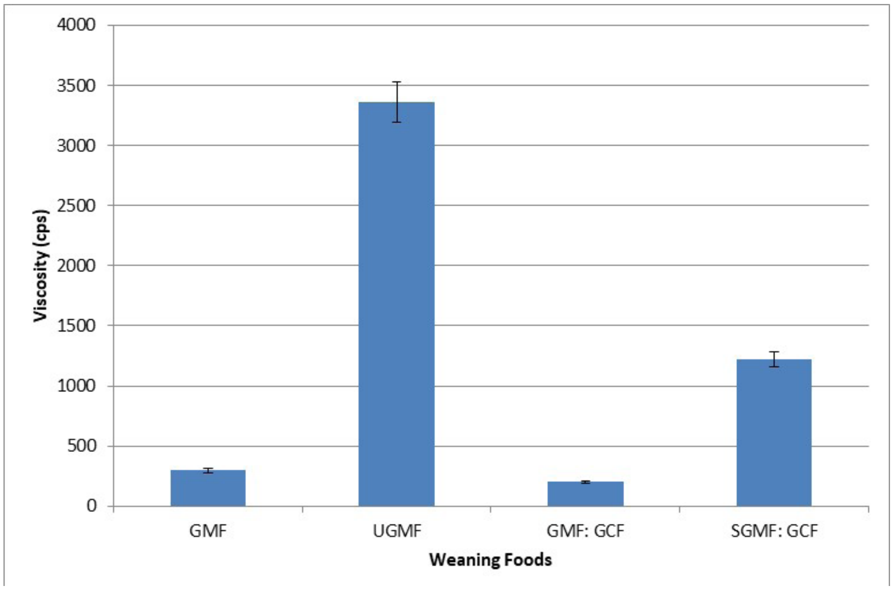

Figure 3: Viscosities of gruels prepared from millet based weaning foods
Data reported as Mean± SE
Keys:

GMF	-	Germinated Millet Flour,
UGMF	-	Steeped Millet Flour
GCF	-	Groundnut Cake Flour

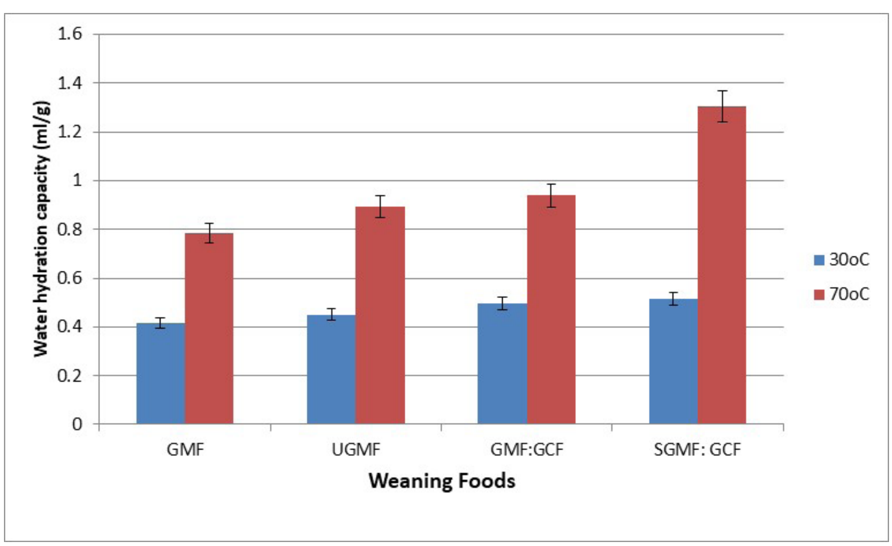

Figure 4: Water hydration capacity of the weaning food samples
Data reported as Mean± SE
Keys:

GMF	-	Germinated Millet Flour,
SGMF	-	Steeped Millet Flour
GCF	-	Groundnut Cake Flour

were determined at 70°C (Figure 4). It was observed that the temperature at which the parameter was determined had a significant influence on the values of the water hydration capacity obtained. Higher values were noticed, when the water hydration capacities were determined at 70°C, suggesting that partial gelatinisation might be occurring at this temperature. The values obtained in this study were lower than the average value reported by Tulyathan et al. (2002) for the composite samples of jackfruit seed flour and starch (2.05ml/g). However, lower viscosities obtained in this study was in line with the findings of Theodore et al. (2009), who researched on weaning food produced by substituting 'ogi' with bambara- nut flour and concluded that lower water hydration capacity was desirable in weaning foods for making thinner gruels with high energy density per unit volume.

4. Conclusion

The study revealed that germination could significantly improve the protein content of millet based weaning food. Moreover, fortification of millet based weaning food with groundnut cake flour increased the nutrient quality of the blends and improved their functional properties. Consumption of gruels made from the blends, most especially from the blend of germinated millet flour and groundnut cake flour might reduce the occurrence of malnutrition and macronutrient deficiency in infants and children.

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