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Formulation of Weaning Food from Fermented Maize, Rice, Soybean and Fishmeal

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Abstract: The use of fermented maize flour, soybean flour, rice flour and fish meal in weaning food formulation was investigated. Two blends, A and B, were formulated with and without fishmeal respectively. Blend A had soybean (20.09%), maize flour (43.96%), rice (31.81%) and fishmeal (4.14%) whilst Blend B had soybean (25.97%), maize flour (51.53%) and rice flour (22.5%). Chemical, sensory, microbial and shelf life evaluations were conducted. The protein and energy content in A and B were 19.13% and 404.34 kcal; 17.18% and 395.43 kcal respectively. The blends had low levels of minerals due to the removal of fish bones and grain pomace during formulation. The microbial count of the formulations - 1 x 10 cfu/ml of bacteria in A and B, 2 x 10^2 cfu/ml and 1.5 x 10^2 cfu/ml of mould in A and B respectively and 1.8 x 10^2 cfu/ml and 2.0 x 10^2 cfu/ml of yeast in A and B-were within the acceptable range of 1 x 10^5 cfu/ml, hence they are wholesome for consumption after 30 days. There was no significant difference (p>0.05) between the shelf life parameters of A and B after 30 days. The formulations were evaluated by 50 nursing mothers using a 5-point hedonic scale. Eighty-eight percent showed acceptance of the product requesting that it be processed on market scale. The facial expressions of babies fed with the product were also used for product assessment- 36% of the infants exhibited likeness, 10% dislike, 32% neither like nor dislike and 22% slightly disliked the products. There was no significant difference (p>0.05) between the acceptability of the products. The blends can therefore be used as alternatives to the weaning foods in the Ghanaian market as well as other countries in the world to improve the nutritional status of children and help to curb protein-energy malnutrition.

Key words: Weaning food, maize, rice, soybean, protein-energy malnutrition and fishmeal

INTRODUCTION

The widespread problem of infant malnutrition in the developing world has stirred efforts in research, development and extension by both local and international organizations. As a result, the formulation and development of nutritious weaning foods from local and readily available raw materials have received a lot of attention in many developing countries. Malnutrition is a major health problem in developing countries and contributes to infant mortality, poor physical and intellectual development of infants, as well as lowered resistance to disease and consequently stifles development. Protein-energy malnutrition generally occurs during the crucial transitional phase when children are weaned from liquid to semi-solid or fully adult foods. During this period, children need nutritionally balanced, calorie-dense supplementary foods in addition to mother's milk because of the increasing nutritional demands of the growing body (Cameroon and Hofvander, 1971; Berggren, 1982; Sajilata *et al.*, 2002; Umeta *et al.*, 2003). Thus, weaning food plays a vital role in the all round growth, development and mental health of children.

Generally, foods eaten in developing countries contain high levels of carbohydrate with very low or no proteins due to the high cost of protein rich foods and some traditional beliefs about feeding infants with protein foods.

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. The effects of the supplementation are highly beneficial, since nutritive value of the product is also improved.

This project studied the combination of local and readily available raw materials which are inexpensive to develop a nutritious infant food with long keeping quality and overall consumer acceptability. Cereals (maize and rice), pulses (soybean) and fishmeal were used.

MATERIALS AND METHODS

Source of material: Soybean (*Anidaso variety*) and maize (*Obatanpa variety*) were obtained from Technology Consultancy Centre (TCC), KNUST, Kumasi; rice (*Sikamon variety*) was obtained from Inland Vallies

Rice Development Project and fishmeal was obtained from the Kumasi Central market, Kumasi, Ghana. The formulations used were based on the material balance performed on the chemical composition of the raw materials.

Preparation of soybean flour: The soybeans were sorted for stones, rot and other physical defects. The beans without defects were cleaned, soaked for 3 h, dehulled, solar dried to 9.59% moisture content and roasted under an open flame until golden brown. The roasted beans were allowed to cool, milled with a hammer mill and sieved with a 75 micron mesh to obtain the flour.

Preparation of rice flour: Brown rice with intact bran was used. The rice was screened for stones, rot and other defects, cleaned, dried and milled and sieved with 75 micron mesh to obtain the flour with 8.91% moisture content.

Preparation of fishmeal: Fish was cleaned and dried to flakes with 6.17% moisture content. The flakes were milled to obtain the meal.

Preparation of fermented maize flour: The maize grains were sorted for stones, rot and other defects. Grains without defect were cleaned, soaked for 2 days and solar dried to 9.97% moisture content and milled to obtain fermented maize flour.

Analysis: Proximate analysis was carried out on the raw soybean, maize and rice flours, fishmeal and the blends. The moisture content percentage crude protein, crude fat, crude fibre and ash content were determined based on the official methods of analysis (AOAC, 1990). Percentage carbohydrate was determined by difference. The food energy level was determined by calculation using the Atwater factor (Southgate and Durnin, 1970). Calcium, potassium, phosphorus and iron contents were also measured based on the AOAC (1990).

Table 1: Composition of blends

Blend	Soybean flour (%)	Maize flour (%)	Rice flour (%)	Fishmeal (%)
A	20.09	43.96	31.81	4.14
B	25.97	51.53	22.5	-

Preparation of weani choice infant mix: Material balance method was used to determine the formulation ratios of the blends (Table 1).
The composite were blended to obtain desirable texture, consistency, flavor and overall acceptability. Cinnamon was added during the mixing process as a flavor enhancer (Fig. 1).

Sensory evaluation: Sensory evaluation for the formulated weaning meals was conducted by 50 nursing mothers using a five-point hedonic scale with score ranging from ‘Like extremely (5)’ to ‘Dislike extremely (1)’. The evaluated parameters were flavor (taste and aroma), texture, appearance and overall acceptability. The panelists were encouraged to feed the formulation to their babies to allow examination of facial expressions of infants.

Statistical Analysis: The data obtained was statistically analyzed (analysis of variance) using Statistical Package for Social Scientists (SPSS version 13).

Microbial analysis: The products were packaged in Laminated Aluminum foil. Freshly prepared formulations were subjected to microbial analysis immediately after preparation and at a 10 days interval. The packaged products were also tested for bacteria, mould and yeast. Serial dilutions were made from 1 g of each sample dissolved in 9 ml of distilled water. Using the Pour Plate Method, each diluent was plated out on a plate count agar for bacteria count and malt extract for yeast and mould counts. The plates were incubated at 37°C for 48 h for bacterial growth and at 27°C for 3 days for yeasts and mould. Colonies developed after incubation was counted. Hazy colonies formed on plates were designated as “Too Numerous To Count” (TNTC).

Table 2: Nutritional composition of soybean, rice, maize, fishmeal and formulations

Parameter/Sample	Rice	Maize	Soybean	Fishmeal	A	B
Moisture (%)	8.91	9.97	9.59	6.17	5.47	6.87
Protein (%)	8.25	11.19	47.63	69.44	19.13	17.18
Fiber (%)	2.35	1.30	4.60	1.25	2.84	3.07
Fat (%)	1.31	4.06	19.10	5.08	9.38	8.75
Ash (%)	1.69	4.60	4.61	8.16	2.33	2.14
Carbohydrate (%)	77.49	68.34	14.47	9.90	60.85	61.99
Energy (Kcal/100 g)	*	*	*	*	404.34	395.43
pH	*	*	*	*	5.40	5.30
Iron (mg/100 g)	*	*	*	*	71	16
Phosphorus (mg/100 g)	*	*	*	*	146	147
Calcium (mg/100 g)	*	*	*	*	51	71
Potassium (mg/100 g)	*	*	*	*	263	244

Values are means of triplicate determinations, standard deviations are in parenthesis, *Values were not measured

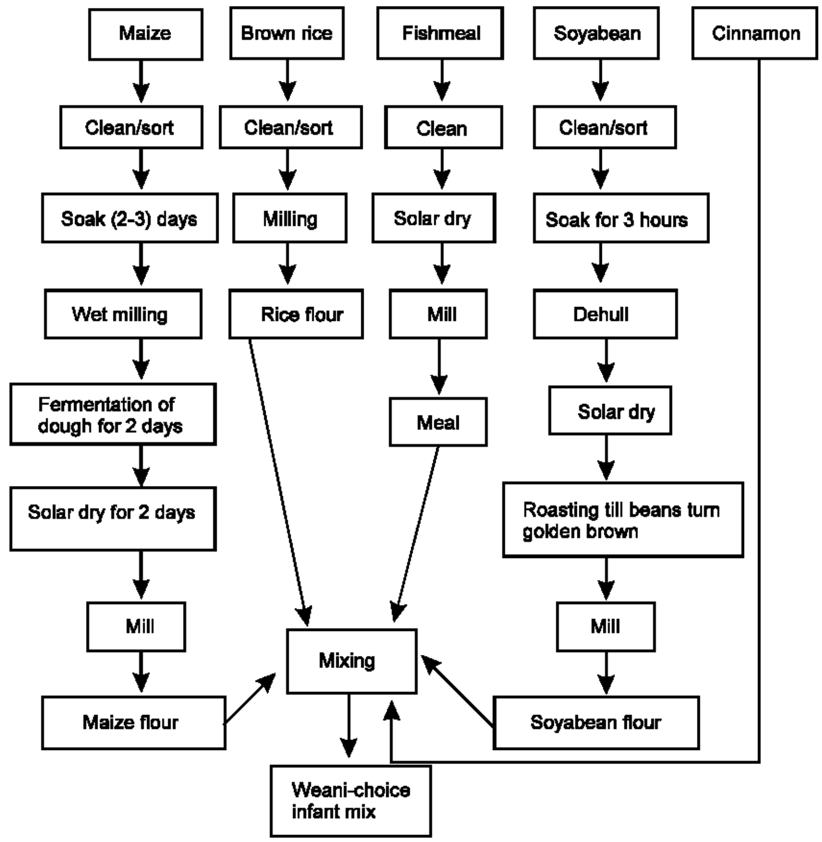

Fig. 1: Preparation of weani-choice infant mix

RESULTS AND DISCUSSION

Nelson (1992) reported that moisture content is used as a quality factor for prepared cereals which should have 3-8% moisture content. The low moisture contents of formulations A and B (5.47% and 6.87% respectively) are required for convenient packaging and transport of products (Oduro *et al.*, 2007). The high protein contents of the formulations were contributed by the soybean and fishmeal. According to FAO/WHO (1982) a minimum protein content of 15% is required for maximum complementation of amino acids in foods and growth, thus, the formulations satisfy the protein demand of infants (Sanni *et al.*, 1999). A fat composition of 9.38% and 8.75% in formulations A and B respectively correspond to the recommended fat level for weaning foods (Protein Advisory group, 1972) which is about 10%. The fat content of a food sample can affect its shelf stability. This is because fat can undergo oxidative deterioration, which leads to rancidification and spoilage. Hence a food sample with high fat content is more liable to spoilage than one with a lower fat content. 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).

The calories in an infant's diet are provided by protein, fat and carbohydrates (Harper, 2003). The protein caloric content contributed to products A and B were equivalent to 76.52 kcal and 68.78 kcal respectively, forming 18.92% and 17.38% of the energy content in the products. The fat caloric content of formulations A and B were 84.42 kcal and 78.72 kcal representing 20.88% and 19.92% respectively and the carbohydrate caloric contents were 60.19% and 62.71%. The carbohydrate caloric contents for both products were slightly higher than the Protein Advisory Group (1972) values of 50-60%, whereas the protein and fat contents fall within the recommended ranges of 10-20% and fat levels of below 30%. This implies that the products would supply the needed energy to meet infants' growth demands. The ash content of the products, which gives an idea of the mineral content, increased with the addition of the fishmeal. Although A and B had low ash contents, they are acceptable by the Protein Advisory Group (1972) standard which recommended that the ash content should not exceed 5%. Iron and potassium were higher in A (0.17 mg/100 g and 2.63 mg/100 g respectively) compared to B (0.16 mg/100 g and 2.44 mg/100 g respectively). On the other hand, calcium and phosphorus were lower in A (0.51 mg/100 g and 1.46 mg/100 g respectively) than in B (0.71 mg/100 g and 1.47 mg/100 g respectively) and this variation was due to the removal of bones from the fish used in the formulation, thus, to have an increase in calcium and phosphorus, the bones must be added to the formulation. Moreover, calcium and phosphorus contents of raw materials for weaning food can also be greatly reduced by the exclusion of grain pomace which contain most of the minerals (Sanni *et al.*, 1999).

Sensory evaluation: The mean scores from sensory evaluation showed that the formulated samples were moderately accepted (Fig. 2). There was no significant difference ($p>0.05$) between attributes of the blends. Eighty six percent of the nursing mothers preferred sample A to sample B. The evaluation of the samples by babies, measured by observing their facial expressions to identify signs of like or dislike of the formulations, recorded that 36% of the infants showed high degree of acceptance for the products by delightfully taking the products whereas 10% showed signs of dislike for the product by frowning, 32% of the infants neither liked nor disliked the product by their show of indifference whereas 22% exhibited slight dislike for the products when fed. On the other hand, the 88% of mothers showed acceptance of the products and requested that the products should be made available on the market. They based their desire for the product on its convenience, affordability and nutrient content.

The expression of dislike for the products was because some of the babies were already accustomed to a particular kind of weaning food. It could also be that the time for the sensory evaluation was not favorable since most of the babies might have been fed to satisfaction. Although 74% of the panelists demanded that no ingredient should be altered during eventual mass production, 14, 2 and 10% of the panelists suggested the removal of fish, rice and soybean respectively from the products.

Microbial analysis: Microbial analysis was conducted on freshly prepared samples to determine if blends are wholesome for consumption. Bacteria counts were low (10 cfu/ml) in A and B, however high counts were obtained for mould (2.0×10^2 cfu/ml and 1.5×10^2 cfu/ml) and yeast (1.8×10^2 cfu/ml and 2.0×10^2 cfu/ml) for A and B respectively.

A food product for consumption should have microbial count below 1×10^5 cfu/ml. The International Microbiological Standard recommended limit of bacteria contaminants for food of less than 10^6 cfu/g (Anon, 1974) whereas Rombouts and Nouts (1995) revealed that bacterial counts obtained in plants food were in the order of 12×10^7 to 10^8 cfu/g. Low bacteria counts were obtained as a result of high standard of personal hygiene and quality maintenance of good manufacturing practices observed during the food formulation process.

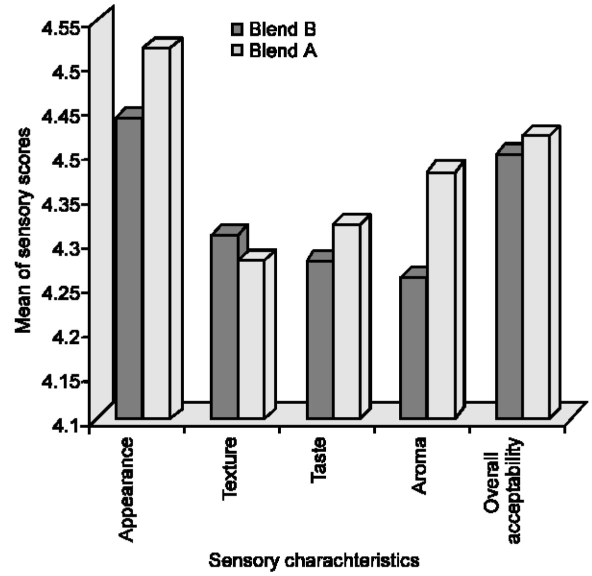

Fig. 2: Mean score for the sensory evaluation of formulations A and B

Shelf life studies: The products were packaged in laminated aluminium foil and stored at ambient temperature of 25°C for periodic analysis. The ability of the packaging material to prevent moisture and oxygen permeability, withstand impact and protect product from insects and pests attacks were exploited.

Microbial counts immediately after packaging indicated that microbes were absent, however, exponential growth and thus numerous yeast cells were observed on plates and thus were designated as 'Too Numerous to Count' (TNTC). This could be due to contamination during sampling, inoculation or incubation.

The protein content, moisture and pH of packaged product were measured over 30 days period (Fig. 4).

A depletion of protein from 19.35%-19.29% for A and 17.23%-17.16% for B were observed. This change, however, still meets the recommended protein content for weaning food (Protein Advisory Group, 1972). The moisture in formulation A fluctuated from 6.85% after 10 days, through 6.48-6.67% after 30 days whilst formulation B exhibited an increase in moisture content after 10 days from 6.25-7.89%. Nonetheless, the resulting moisture contents of both formulations fall within the moisture content of 3-8% recommended by Oduro *et al.* (2007). The change in moisture content could be due to ineffective sealing of the packaged product, hence, increase in air movement and moisture content which could mar product characteristics with time. It is recommended that care must be taken in the

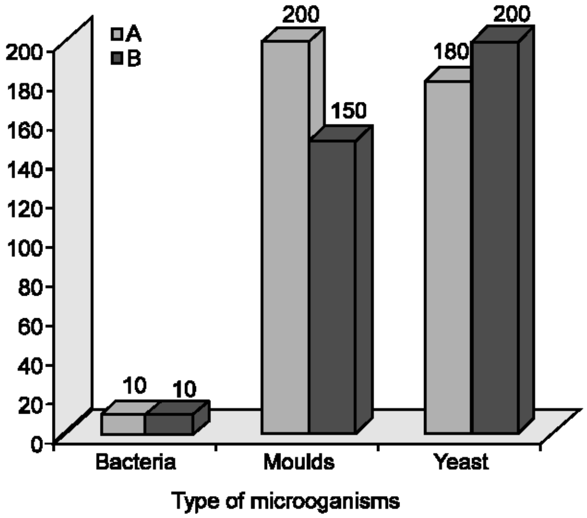

Fig. 3: Microbial load in formulations A and B

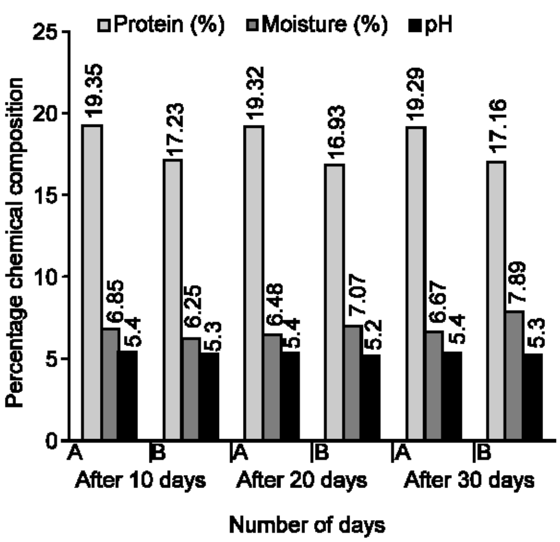

Fig. 4: Shelf-life studies of products A and B showing change in protein, moisture and pH with time

packaging of the product to prevent the transfer of moisture and air.

There was no significant difference ($p>0.05$) between the protein and moisture contents before and after the 30 days evaluation period. This implies that formulation A the same shelf life as B and that both formulations can be stable after 30 days of formulation. The packaging material was able to protect the products from insect attacks that could have introduced pathogenic organisms to the stored food. The products will have longer shelf life if stored at low temperatures, due to slow air movement and low moisture diffusion coefficient. Sufficient time must be given to the study of product characteristics in order to establish true product life span.

Conclusion: This study showed that formulations of weaning food from maize, rice, soyabean with or without fishmeal can be produced. This provides alternatives to the weaning foods in the Ghanaian market as well as other countries in the world. The inclusion of fishmeal and soyabean furnished the food with the required protein content. There were low levels of minerals as compared to recommended dietary allowance therefore further work can be done on the fortification of the weaning food. The formulations had acceptable sensory and microbial qualities and wholesome after 30 days.

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