American Journal of Food Technology

ISSN 1557-4571

Academic Journals Inc.

www.academicjournals.com

American Journal of Food Technology 2 (7): 652-661, 2007
ISSN 1557-4571

Studies on Physicochemical Composition of Bennimix: A Traditional Weaning Food

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Abstract: The aim of this study was to determine the physicochemical composition of Bennimix Baby Food (BBF): a traditional weaning food produced in Sierra Leone and compared with cerelac which is similar to BBF in appearance. Results revealed that BBF was lower in protein content which was 14.1 g, but higher in carbohydrate, fat, fibre, ash, moisture and energy as compared to cerelac in the following amounts, 73.3, 6.3, 2.8, 2.1, 3.6 g and 478 cal, respectively. Vitamins for BBF were very small in quantity. Cerelac has significant ($p<0.05$) higher minerals than BBF and for the % protein calories it was 13.7%. The amino acids, BBF was lower in the age category of 0-1 year as stipulated by FAO/WHO expert report but higher in the second category (2-5 years). Some of the amino acids like Leucine, lysine threonine, methionine + cystine were 80, 60, 44 and 54 (mg gN^{-1}), respectively. The pasting properties of BBF were not significantly different ($p<0.05$) with cerelac. Some functional properties, BBF revealed good attributes as compared to cerelac and the difference was significant ($p<0.05$). Sensory qualities, flavour and taste were rated higher than cerelac however the others were rated lower than cerelac. BBF was successfully compared with Cerelac.

Key words: Bennimix, cerelac, physicochemical, amino acids

INTRODUCTION

In Sierra Leone, West Africa, BBF is produced traditionally at a large scale, it is a weaning baby food for the period of 6-24 months and it is a mixture of rice, sesame, cowpea and sugar (sucrose) in the percentages of 55, 15, 25 and 5%, respectively. Sierra Leone is among the most deplorable countries in the world in the area of weaning food and has the third highest infant mortality rate in the world (FAO, 2006). Available data shows that 143 deaths out of every 1000 live births occur among infants from 0-2 years old (FAO, 2006). This statistics clearly establishes the deplorable weaning food situation among the childhood population and its consequent malnutrition problems.

In Sierra Leone, weaning is a period of problems for the family and vulnerability for the survival of the child. Most families particularly those in the rural areas depend on traditional weaning foods and weaning practices that have to do with fermentation of corn as ogi, for the consumption of infants of weaning age (Jonsyn, 1985). The reason being, that is the only country in West Africa which does not have a properly constituted weaning food that is produced locally at industrial scale and also not based upon scientific investigations (Gizolme, 1997).

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The nutritional composition of BBF produced traditionally has not been established since its formulation between 1964 and 1966 by Dr. Pamela Greene. The BBF formula was only field tested for the rural mothers as a weaning formula but not investigated scientifically in a laboratory to know it nutritional composition and published in any journal, to ascertain whether it meets the Recommended Daily Allowance (RDA), Food Agricultural Organization (FAO), World Health Organization (WHO) and United Nations (UN) as recommended for infant in developing countries like Sierra Leone (IFHE, 1998). Its nutritional composition and its potential problems are not known by the Food Data Base (FDB, 1997). The Food Data Base is an institution that is responsible to collect information about weaning foods locally produced by different developing countries in the world.

In many developing countries, especially in tropical Africa, weaning foods are based on local staple diets made from cereals and legumes. These foods are usually prepared as liquid gruels for infants (Mensa-Wilmot *et al*., 2001). To be suitable for the feeding of young children, these foods are prepared in liquid form by diluting it with large quantity of water, thereby resulting in more volume but with low energy and nutrient contents (Egounlety, 2002). However, most cereals are limited in essential amino acids such as threonine, lysine and tryptophan thus making their protein quality poorer compared to animal protein. Their protein digestibility is also lower than that of animals, partly due to the presence of fibre and tannins which bind the protein thus making it indigestible (Pérez-Conesa *et al*., 2002).

Since BBF is now produced at a large scale in the country and now exported to other countries in West Africa as weaning food (Gizolme, 1997) but yet still little is known about its physiochemical properties. Therefore the aim of this work was to investigate the physicochemical properties of BBF, compared some of its properties to a cereal-based weaning food (Cerelac) and analyzed the essential amino acids as determined by the FAO/WHO (1990) EXPERT report.

MATERIALS AND METHODS

Fifty packets (400 g each) of BBF were kindly donated to us by the, Bennimix factory in Bo, the second capital city of Sierra Leone. The Cerelac weaning food was purchased from a supermarket in Wuxi, People's Republic of China. They were kept under the conditions as stipulated by the concerned manufacturers.

The chemicals and reagents used were of analytical and food grade quality obtained from the chemical store of Jiangnan University Wuxi, PR China, manufactured by Sinopharm Chemical Reagent Co., Ltd. (SCRC) Shanghai PR China.

BBF is produced according to the flow chart (Fig. 1). The flow chart was given to us and reproduced with the kind permission of the Bennimix factory, while Cerelac flow chart has been shown in many works that are related to weaning foods (Sefa-Dedeh *et al*., 2003). Cerelac was used to compare with BBF because is a cereal-based food internationally accepted by many countries in the world as weaning food for the age bracket prescribed for BBF also (1/2-5 year). Moreover Cerelac is one of the weaning food sole in Sierra Leone.

This research was conducted in the State Key Laboratory of the School Food Science and Technology, Jiangnan University, Wuxi, People's Republic of China between March to June 2007.

Chemical Analysis

BBF was analyzed for moisture, ash content, protein, dietary fibre using the standard method of AOAC (1995). Total lipids, ether extract and carbohydrate contents were determined using AACC (1998). While the determination of vitamins: thiamine, nacine, Vit B12, Vit D Vit A and Vit. C was done according to the Association of Vitamins Chemists as described by Ranganna (1986).

The determination of some minerals (calcium, iron, copper, potassium lead) for both BBF and Cerelac was done with Varian Flame Atomic Absorption Spectrophotometric (SPECTRAA 220,

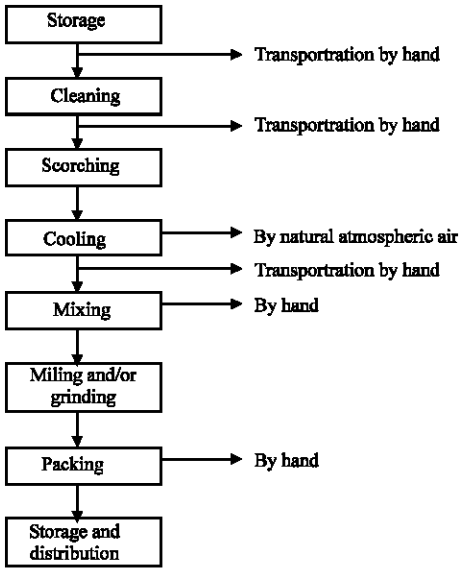

Fig. 1: The production flow chart of Bennimix baby food

USA). BBF was analyzed for amino acids; the BBF was dissolved in 3.5% 5-Aulfosalicylic Acid (SSA). After filtration and centrifugation, the supernatants were submitted to online derivatization by o-Phthaldialdehyde (OPA) and reversed phase high Performance Liquid Chromatography (RP-HPLC) analysis in an Agilent 1100 (Agilent Technologies, Palo Alto, CA 94306, USA) assembly system using a Zorbax 80A C_{18} column (4.6 id×180 mm) as by the conditions set by the equipment manufacturer. The amount of asparagine and glutamine was determined as aspartic acid and glutamic acids, respectively.

The carbohydrate content was obtained by difference according to the AOAC (1995) method. The total energy (kcal) was calculated by multiplying the digestible carbohydrate and protein contents by four and the fat content by nine using AOAC (1995) method.

Functional Properties

Bulk density for BBF and Cerelac, was determined by the method of Wang and Kinsella (1976). The final materials tested were expresses as g mL^{-1}. For water absorption, it was tested by the method described by Cegla *et al*. (1977), 6 g of both BBF and Cerelac were weighed in a 100 mL beaker separately. Water was pipetted into each beaker and the amount of water was recorded. The slurries were carefully stirred and allowed to equilibrate for one hour at 26°C. After the water has been completely absorbed, the samples were treated with 10 mL water portions with 10 min interval before visual observation. The volume that gave a complete absorption of water was recorded. The apparent viscosity of BBF and Cerelac was done according to Quinn and Beuchat (1975). The two samples (BBF and Cerelac) were stirred into cold water and mixed into a uniform mixture to form slurries; the slurries were put in a boiling water bath (75°C) and constantly stirred until they boiled and were left for a period of three minutes. The samples were then removed and cooled down at room temperature (23-25°C) and the viscosity was calculated by measuring with a Brookfield Synchro-electric Viscometer (BSEV-2230-Japan), using RVT Spindle No. 4 at a constant speed of 100 rpm. The conversion was done into cps units.

For the pasting properties, the two samples (BBF and Cerelac) their slurries were heated from 40 to 92.5°C at the rate of 3°C min^{-1}, maintained at 92.5°C for 15 min and then cooled to 40°C at the

same rate and their pasting properties were determined by a Rapid Visco Analyzer (RVA-4, Newport Scientific, Warriewood, USA) this was done to observe how the two products behaves when subjected to heat and see their spoonability. All the measurements were triplicated.

Sensory Evaluation of the Bennimix Food

The sensory evaluations of the boiled BBF and Cerelac were carried out to determine and assess its organoleptic characteristics according to Duncan (2005). A nine-member panel of judges consisting lecturers, students and laboratory assistants in the sensory and evaluation department of the Jiangnan University, Wuxi, PR China was constituted. The rationale for that selection was because of their experiences in weaning food properties that is formulated from cereals and legumes and getting parents to allow their children to take part was difficult as the food has never been accessed for nutritional composition. Nonetheless another study on the acceptability of the food by mothers and infant is on the way after knowing its nutritional composition. The members of the panel were told to rate both the BBF porridge that has been prepared for fifteen to twenty minutes which is the recommended time that is stipulated for it to be ready for consumption and Cerelac since it is an instant food, hot water was added and stirred it to give the gruel that is fed to children. The rating was done for colour, texture, taste, consistency, appearance and aroma (Flavour) The rating was presented on a 9-point Hedonic scale ranging from 9 = like extremely to 1 = dislike extremely by using Score Card Method. The evaluation was done according to the method given by Amerine *et al.* (1965). All the figures obtained were values represent means of three replicates from the panelists.

Statistical Analysis

The results were subjected to statistical analysis of variance (ANOVA), using a Statistical Analysis System (SAS, 2002). The Significant of difference between means were determined by Duncan's Multiple Rang Test (DMRT), where $p<0.05$ was considered for significant difference.

RESULTS AND DISCUSSION

The nutritional composition of BBF is shown in (Table 1). It reveals some moderate differences with the Cerelac food used to compare with. The protein was less than the Cerelac but the difference was not significant ($p<0.05$). But the raw materials of the BBF, one could have thought the protein content will be very high because they used both sesame and cowpea in the production of BBF. Those two crops are high in protein content. The result was an indication that during the processing stages that was where the protein was denatured because of the excessive use of heat and protein is not stable to high heat (Mensa-Wilmot *et al*., 2001). The production flow chart of the BBF did not indicate at any point where defatting of the sesame seeds is taking place and the removal of the seed coat also for both the cowpea and sesame (Fig. 1). It has been proved that defatted and dehulled sesame seed have higher protein content than not defatted and not dehulled (Sato, 2003).

Both the carbohydrate and fat were higher as compared to Cerelac and the differences were significant ($p<0.05$). The moisture content was also higher than the Cerelac; the difference was also significant ($p<0.05$). Our result with regards to the above properties corroborated the findings of Dorosko and Rollins (2003). This might not be good for the BBF if it is to have a stable shelf life. The BBF has some minerals like iron, calcium, copper, potassium, lead, as 10.5, 230, 123, 78, 0.91, (mg/100 g), respectively), Cerelac has its own minerals as 15.9, 570, 174, 102, 0.05 (mg/100 g), respectively (Table 1). The above mineral contents for BBF were enough for the age of infants the food is meant for consumption. Present result corroborated the findings of Dorosko and Rollins (2003), they studied infant formula prepared by rural and semi-rural women in South Africa.

Table 1: Nutritional composition of BBF as compared to cerelac food

Nutrients	Bennimix food	Cerelac
Protein (g/100 g)	14.1±1.01	15.5±1.1
Carbohydrate (g/100 g)	72.3±0.03	68.9±0.2
Moisture (g/100 g)	3.6±1.1	2.5±0.1
Ash (g/100 g)	2.1±0.02	2.7±0.1
Fibre (g/100 g)	2.8±1.1	1.4±0.1
Fat (g/100 g)	6.30	3.2±1.1
Vitamin A (Iu/100 g)	0.10	
Vitamin D (Iu/100 g)	0.80	
Vitamin B_{12} (Iu/100 g)	<0.30	
Nacine (ug g^{-1})	0.80	
Thiamin (ug g^{-1})	2.50	
Iron (mg/100 kg)	10.50	15.90
Calcium (mg/100 g)	230.00	570.00
Copper (mg/100 g)	123.00	174.00
Potassium (mg/100 g)	78.00	102.00
Lead	0.91	0.05
Energy (cal)	478.00	435.00
Protein calories (%)	13.70	14.80

Units in bracket indicate nutrient density per gram of the sample; Values are means±SD of three independent determinations; =Protein %X4/total energy of formulation

Table 2: Amino acid profiles of BBF

		FAO/WHO/UN		
Amino acids (mg gN^{-1})	Bennimix food	0-1 year	2-5 years	EAA[b]
Histidine	25	26	19	
Isoleucine	29	46	28	28
Leucine	80	93	66	66
Lysine	61	66	58	58
Methionine	54[c]	42	25	25
Threonine	44	43	34	34
Valine	30	55	35	35
Aspartic acid	36	52	31	
Glutamic acid	26	31	26	
Tryptophan	18	19	11	11
Arginine	23	25	20	
Serine	27	28	25	
Proline	15	17	12	
Glycine	20	21	20	
Alanine	32	35	30	
Tyrosine	26	28	20	
Phenylalanine	35	20	18	31

Values are means±SD of three independent determinations; [b]: Suggested profile of essential amino aid requirements for adults (FAO/WHO, 1990); [c]: Methionine+Cystine

For the amino acids as compared with the suggested pattern of requirement by FAO/WHO for human beings particularly infants (FAO/WHO, 1990) approved amount for the two categories (0-1 and 2-5 years) of age of children, almost all of the amino acids for children below one year is less in the BBF, but the difference was not significant ($p<0.05$) for some of them while almost all of its amino acids were in line or a little above the approved amount for children above one year to five years as shown in Table 2. The essential amino acids were present and in higher amount, their amounts were significant ($p<0.05$) The EAA were isoleucine, leucine, lysine, threonine, valine tryptophan, phenylalanine and methionine with cystine, 29, 80, 61, 44, 30, 18, 35 and 54 (mg g^{-1} protein), respectively. According to our results, Valine is less than the recommended amount by FAO/WHO (1990) expert report. Some of the results of BBF of EAA were in accordance to Mensa-Wilmot *et al*. (2001) with the exception of Valine and Isoleucine which were in lower

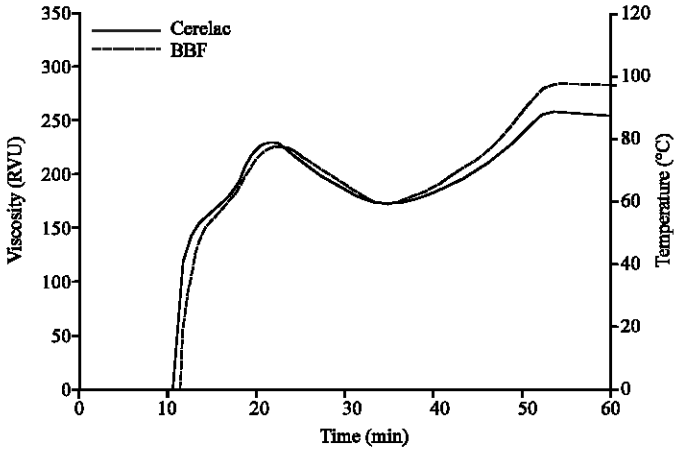

Fig. 2: Amilograph pasting characteristics of extruded cerelac and BBF

amount than there results. They investigated the protein quality evaluation of cowpea-based extrusion cooked cereal/legume weaning mixtures. However, the BBF is produced to cover the period from 6-24 months according to the producer's instructions in the sachet the food is packeted for sales. The child for a healthy growth needs these amino acids. One essential amino acid that is usually absent in infant food produced from just cereals is methionine and cystine, but the amount of methionine and cystine in BBF was observed to be in high amount (54 mg gN^{-1}), however, those two amino acids are always high in sesame seeds (Lopez *et al*., 2003), that was why the BBF has that amount.

When the two samples were analyzed for their pasting properties by heating them, the difference was not significant ($p<0.05$), it was observed that at 10 min the Cerelac exhibited higher past of (150RVU) it kept on increasing gradually up to 20 min and the BBF also increased as the time was increased though below the line of Cerelac. At 20 min Cerelac was (230RVU) while BBF (225RVU) when the temperature was 80°C (Fig. 2). After that, the two samples dropped, when the heating time was prolonged between 30-35 min the two samples fell on the same line until when the time was extended to 40 min then the BBF gradually increased more than the Cerelac. The increased of pasting observed from BBF was observed also when the viscosity of the BBF was analyzed. The viscosity was high as the pasting properties of the BBF as these two always correlate.

From the results obtained it was observed that BBF was able to have that pasting properties even at high temperatures (88 and 96°C) the pasting was (250 and 280 RVU, respectively) which is still within an acceptable range for infant formula. As it has been reported that most of the food items particularly infant foods prepared within the range of 80°C and above which is considered as high temperature, will exhibit a pasting property that will be good for infant consumption (Kulkarni *et al*., 1991). At the above temperatures (88 and 96°C) BBF exhibited a gradual increase as the time was also increased; this was observed because solution conditions, such as time, ionic strength and temperature affect pasting of food made from cereals and legumes. The high temperature helped to denature the protein and exposes more sites of the present starch granules that are in that food, it can increases the pasting properties. It was reported that the pasting properties of globular proteins (which is mostly found in sesame and peas) generally decrease as time and temperature are decreased and increase when the two are increased (Modler and Emmons, 1977). The high pasting properties were actually dependent on the high protein and carbohydrate concentrate in sesame seed, cowpea and rice respectively which are the main raw materials of BBF. The formation of paste composed of swollen starch granules dispersed in the heated solution also increases the pasting properties of infant foods

(Genovese and Rao, 2003). Present result was in accordance with the results of Sandhu *et al*. (2007) they compared a native and acid thinned normal and waxy corn starches and studied the physicochemical, thermal, morphological and pasting properties.

The pasting properties was studied also to see how appropriate the food will be for the child but according to the results BBF shows good pasting properties as the results were within accepted range which will not stick along the throat of the child while eating it.

Functional Properties

Some of the functional properties investigated in BBF revealed to be higher than those of Cerelac as shown in Table 3. The bulk density of BBF was higher than the one for Cerelac and the difference was significant ($p<0.05$). It was attributed to the high presence of carbohydrate in the food. That indication is highly correlated with the high viscosity and pasting of BBF because when the food absorbed more water, it will lead the food to have a thick gel that gives the high viscosity of the food (Nout and Ngoddy, 1997), which is really not good for young babies who are consumers of BBF, but this again depends on several molecular properties such as size, shape, flexibility and hydration of the protein. Because solutions of randomly coiled polymers displays greater viscosity. Also the ability of the protein and carbohydrate to absorb water and swell affects its viscosity and this can be seen in food containing protein and carbohydrate (Pérez-Conesa *et al*., 2002) which BBF is not an exception.

The water absorption capacity was higher in BBF than Cerelac. It was due to the high carbohydrate content also which was observed in BBF. As high carbohydrate increases the water absorption capacity of most food systems (Dorosko and Rollins, 2003).

The apparent viscosity was also higher than cerelac and the difference was significant ($p<0.05$). The results of the functional properties of BBF were in accordance with the ones reported by Kulkarni *et al*. (1991) they studied sorghum malted-based weaning food formulation: Preparation, functional properties and nutritive value. The aspect of high viscosity could be corrected by changing the processing to fermenting the raw materials or germinate the rice or add α-amylase to help in the degradation of the carbohydrate to reduce the viscosity as these have been reported in many studies in cereals and legumes combination (Simango, 1997).

Sensory Evaluation

The organoleptic properties of BBF were (Table 4). For flavour, it was rated good to very good while Cerelac was rated in that area as fair to good. The flavour of the BBF was rated good to very

Table 3: Some functional properties of BBF and cerelac

Properties	Bennimix food	Cerelac
Bulk density (g mL^{-1})	1.73±0.1[a]	0.50±0.2[a]
Water Absorption capacity (g/100 g)	290.00±3.7[b]	150.00±2.5[a]
Apparent Viscosity (CPS) (at 20% W/W gruel concentration)	2730.00±2.0[a]	2250.00±9.0[b]

[a]: Values represent means of three replicates±standard deviation; means values with different letter(s) in the same column are significant at level ($p<0.05$)

Table 4: Sensory evaluation quality attributes of porridges of Bennimix food and cerelac

	Bennimix food		Cerelac	
Quality attributes	HS	SCM	HS	SCM
Colour	6.0	Fair to good	8.5	Good to very good
Flavour	8.0	Good to very good	6.0	Fair to good
Texture	6.5	Fair to good	6.8	Fair to good
Taste	7.7	Good	7.1	Liked moderately
Consistency	6.7	Fair to good	7.5	Good
Appearance	6.1	Fair to good	8.3	Good to very good
Overall acceptably	7.2	Liked moderately	8.5	Good to very good

HS = Hedonic Scale, SCM = Score Card Method

good by the panelists while cerelac was rated fair to good. Since BBF has sesame as part of it raw materials it is the one that responsible for the appealing flavor that made the panelists to rate it higher than the cerelac, as sesame under goes roasting during the process of the production of BBF that gives the food that outstanding flavour, because lots of researches have reported that roasted sesame seeds can give different aroma that are appealing to people (Schieberle *et al*., 1996). But for appearance, texture and colour of BBF were rated fair to good. It is because the seed coats of the various raw materials (Sesame, cowpea) were not removed and these two material seed coats are black or brown in the case of sesame seed while cowpea has black spot. For the taste, BBF was rated higher than cerelac; sugar is added to BBF during the production which is the factor that is responsible for the sweet taste of BBF. Present results supported the findings of Ukhun and Ukpebor (1991). They studied the production of instant plantain flour, sensory evaluation and physico-chemical changes during storage. The type of sugar should be investigated to know if it is appropriate and to the required amount for infants. For the overall acceptability BBF was rated as liked moderately while Cerelac rated good to very good. This could be improved if the raw materials are treated with all the precautions they need to bring out a very good product for infants.

CONCLUSIONS

The physicochemical properties of BBF were investigated and compared its properties with those of Cerelac. According to the results some of the nutritional properties of BBF were observed to be lower than Cerelac but the difference was not significant ($p<0.05$), but some were higher and the difference were significant ($p<0.05$). The amino acids, BBF was lower in the category of age of 0-1 year as stipulated by FAO/WHO expert report but higher in the second category (2-5 years). The functional properties of BBF were observed to have good attributes as compared to Cerelac and the difference was significant ($p<0.05$). Sensory qualities, flavour and taste were rated higher than Cerelac however the others were rated lower than Cerelac.

BBF was successfully analyzed and compared with Cerelac which was used as a standard product.

ACKNOWLEDGMENTS

We will like to extend our profound gratitude to the Bennimix factory in Sierra Leone for given us the permission to investigate their product and providing us BBF for the purpose of analyzing it for this work. And also the government of Sierra Leone for the thought that, it is necessary to scientifically investigate the physicochemical properties of the food and to the Chinese Government for the financial support given to us to do the analysis in one of their leading key lab in a renowned food science university. Lastly our thanks to the University chemical store and the analysis centre for helping us to come out with reliable results in our findings.

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