AJFAND ONLINE Scholarly, Peer Reviewed
African Journal of Food, Agriculture, Nutrition and Development
ISSN 1684 5374
Volume 11 No. 4
July 2011
Published by African Scholarly Science Communications Trust

EVALUATION OF THE SUITABILITY AND ACCEPTABILITY OF A NEWLY DESIGNED INFANT FLOUR FOR INFANT FEEDING IN THE DISTRICT OF BOPA IN SOUTH OF BENIN

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ABSTRACT

Infant feeding practices do not always fit with quantity and quality requirements, leading to low expression of growth potential. In Benin, 43.1% of children less than6 months old are exclusively breastfed with 68% of children aged 6-8 months receiving complementary food. The study aimed to produce infant flour from raw food ingredients available in Bopa district and to test its acceptability by 6-12 months old children. In a first step of the study, formulation and determination of nutritional characteristics of the infant flour occurred. A second step concerned acceptability tests of gruel made from formulated infant flour. The study sample was composed of sixty five mothers and their children. Children's acceptability test took place in the morning for three consecutive days. The gruel was consumed *ad libitum.* Mothers' acceptability test consisted of appreciation of organoleptic characteristics of the gruel and the infant flour processing.The infant flour was made of maize (65 %), bean (20 %) and peanut (15 %) and was manually processed. Chemical analysesshowed that it contains 4.3% of moisture, 69.3% of carbohydrates, 15.1% of proteins, 10.7% of lipids, less than 5% of crude fibres and 1.9% of ash. Its energy density (433.9 kcal/100g) was significantly greater than Codex Alimentarius standards ($p<0.05$).The infant flour contained microbial germs up to 4.8log CFU/g which was closed to maximum standard values. Total coliforms (1.7log CFU/g) were significantly lower than standard values. The flour was yeast, mould and pathogen (*Escherichia coli*) free. Hundred grams gruel was made from 40g of infant flour, 6g of malted maize and 250ml of stock of boiled greens leaves (*Solanummacrocarpum*). Dry matter content of gruel was 19.2% and its energy density was 81.5 kcal/100g. Basedon the ratio of intake and amount served, 83.3% of children accepted the gruel. However based on the ratio of the amount of porridge consumed during the testto the amount usually consumed by the children, 65.2% of the childrenaccepted the gruel. Mothers' appreciation of the gruel ranged from unpleasant to very pleasant with 40% as pleasant. Sixty percent of mothers judged the infant flour processing as easy and feasible. All mothers expressed their desire to feed their children with the gruel. Improving nutritional status of their children motivated their decision. It is concluded that integrating this infant flour in nutrition and counselling package targeted to mothers may be of a great benefit to the children.

Key words: Acceptability; Benin; Complementary food

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INTRODUCTION

In less developed countries, malnutrition is responsible for 60% of 10.9 million annual deaths of children under 5 yearsworldwide [1]. More than two thirds of deaths occurred in the early age and mostly resulted from inadequate feeding practices. Less than 35% of infants in the world are exclusively breastfed during the first six months of life. Complementary feeding usually starts soon or later with low nutritional and sanitary quality foods [1].

In Benin, infant and child feeding practices do not always fit with quantity and quality requirements, leading to low expression of growth potential [2]. In fact, 43.1% of children of less than 6 months are exclusively breastfed and 68% aged 6 to 8 months receive complementary foods in addition to breast milk [2]. The low trends observed may be explained by household food availability, inadequate maternal care and feeding practices [3].

Improvement in the quality of complementary foods may contribute to alleviation of child malnutrition in low income countries [4]. Indeed, the use of malted cereals has been shown to increase porridge's viscosity and thus increase its dry matter content. The reproducibility at household level of this process is a relevant opportunity that could contribute to improve house made complementary foods [4].
The aim of this study was to formulate a complementary food from ingredients available in a rural area of Benin and to test its acceptability among children aged 6 to 12 months prior to a nutrition education programme.

MATERIALS AND METHODS

This study was carried out in a rural area in the Bopa district in the south of Benin. Formulation of an infant flour and acceptability tests by mothers and their 6 to 12 months old children were the main steps of this study.

Formulation of infant flour

The aim was to formulate infant flour that meets Codex Alimentarius requirements [5]. The infant flour was formulated from raw food ingredients available and consumed in the study area. Maize was the energy source with cowpea and peanut acting as the main protein sources. Lipids were obtained from the peanut. These ingredients were combined in precise doses. The flowchart of the flour formulation was simplified such that it is reproducible at household level. Malted maize (15% of the infant flour) was added to the formulated infant flour to prepare the gruel that was cooked using the stock from boiled green leafy vegetables (*Solanummacrocarpum*). To prepare 100g of gruel, 40g of infant flour, 6g of malted maize and 250ml of *Solanummacrocarpum* stock was used.

An assessment of production costs of the porridge has been done in the purpose of comparison with costs of other locally produced infant foods. Therefore, estimations were based upon prices of ingredients from the local markets. Green leafy vegetables

and workers' wages were not included in calculations since they were considered as the household inputs.

Data related to the composition, chemical and microbiological characteristics of the infant flour were collected after analyses done in the Laboratory of Food Microbiology and Biotechnology of the Faculty of Agronomic Sciences, University of Abomey-Calavi (FSA/UAC). The following characteristics were triple-assessed to describe nutritional content of the infant flour:

- Dry matter and ash contents were determined using official analysis methods,
- Crude proteins were determined using the Kjeldahl method,
- Lipids content was extracted and estimated by the Soxhlet method, using ether of petrol,
- Crude fibres were assessed by Osborne and Voogt method (Osborne and Voogt, 1978),
- Carbohydrates content was obtained by difference and energetic density was calculated using Atwater coefficients,
- pH was determined with official analysis methods, using pH meterInolar730 [6].

Counting of total flora, faecal and total coliforms, yeast and mould was done. To ensure good analyses, samples were taken right after opening a sachet of the infant flour. Germs were identified by correspondence with the culture media [7].

Dry matter and energy density of the porridge were determined using the formula suggested by Ouédraogo and collaborators [8].

Acceptability test

The acceptability test was a sensory evaluation of the porridge prepared with the infant flour. Prior to this, a survey was performed in targeted households identified through the help of medical staff of health centres in the study area. The aim of the survey was to generate information about complementary feeding practices in the study area to help estimate the amount of porridge to be fed to the children.

Mothers were provided information on the test procedure and their assessment of the porridge was recorded. They were asked not to feed their children with any food including breast milk before coming for the test. Mothers and their children were separated from each other to avoid interference.

The children were fed *ad libitum* with a specific amount of gruel in a standard bowl. Indeed all children were fed in bowls of same size and colour. Two repetitions inside an episode were offered to each child. When a child had consumed the whole amount of gruel offered during the first repetition, the same amount was immediately offered to him in order to continue the episode.

On the other hand, when the child did not consume the whole amount of gruel served during the first repetition, the remaining amount was offered to him at the first

repetition of the following episode, after a five minute-break [3]. A child could then have one or two repetitions inside an episode and also had to make three episodes in order to confirm his attitude (denial or acceptance to continue the gruel consumption). During the acceptability test, each child was followed by an observer whose function was to give the gruel to the mother, to ensure that the child was not encouraged or forced to eat; and to fill out the questionnaire.

The acceptability test always took place early in the morning between 7 and 8 am for three consecutive days. Number of episodes, gruel's quantity consumed by episode and period of consumption were recorded. Other variables such as total quantity of gruel consumed and speed of the gruel ingestion were also calculated.

Anthropometric data (weight and length) were also measured along with acceptability test in order to describe the sample.

Mothers' assessment of the gruel was a relevant indicator for further steps in the programme implementation. Mothers were asked to assess the taste, consistency and colour of the gruel using a five level Likert scale ranging from unpleasant to very pleasant.

Sampling for acceptability tests

A group of 123 children aged 6 to 12 months were identified from a list provided by health centres. Children's age was reported from health books or birth certificates in the village health centre. Where these documents were unavailable, social or national events was used for age estimation. A questionnaire was administrated to mothers on infant feeding habits.

Several criteria were used for sampling: age (6-12 months), feeding mode (spoon or cup), usual time of first meal (7-8 am) and parents' agreement. After analysing the data collected based on the questionnaire, sixty five mothers and their children (of which there was a twin) who fulfilled the selection criteria and accepted to participate to the study were enrolled [9].

Data analysis

Children anthropometrical measurements were entered and analyzed by using Epi Info (version 6.03; Center for Disease Control and Prevention, World Health Organization 1996).

Nutritional and microbiological characteristics of the infant flour were compared to Codex Alimentarius standards through a conformity test of means. After ensuring that required conditions were met, analysis of variance was used to examine difference in gruel intake between three consecutive days of test and within child day-to-day variations. Proportion of gruel consumed by the child during the test, duration of the test and average speed of gruel consumption were calculated for each child. Statistical Package for Social Sciences software (SPSS 16.0) was used for statistical analyses. The statistical significance for all analyses was set at 5% and all tests were two-sided. Data collected during mother's acceptability test was analyzed in a descriptive way.

Representatives of the Ministry of Health in the department of Mono, local health authorities in Bopa district gave their verbal approval for the implementation of the study. Administrative local authorities such as Prefect and Mayor were informed about the study and gave their verbal consent. Selected mothers were informed about their duties and right in participating in the study.

RESULTS

Formulation of infant flour

The combination of ingredients used was: 65 % of maize, 20% of cowpea and 15 % of peanut. This was the best combination among all those which were tried out. The cost of one kilogramme of the infant flour was estimated at1.40 US$ during the bumper period and1.66 US$ during the lean period (table 1).

Characteristics of the infant flour

The energy density of the flour (433.9 kcal/100g) was found to be significantly greater than the recommended value (p=0.001). Proteins (15.1%) and lipids contents (10.7%) were not significantly different from the standard values suggested by the Codex Alimentarius (p=0.184 and p=0.056 respectively). Crude fibres content was lower than the recommended value of 5% (p=0.001) (table 2). The pH of infant flour was 6.1 and its water content was 4.3%.

Total aerobic and mesophile flora of the flour were not different from the recommended values (p=0.199). Total coliforms were significantly lower than the 3 log CFU/g recommended by Codex Alimentarius (p=0.002). No yeasts, moulds or pathogens *(Escherichia coli)* were found in the flour (table 3).
The gruel prepared had the following characteristics: dry matter of 19.2% and energy density of 81.5 kcal/100g.

Results of pre survey

The pre survey showed that children's diet was mainly based on breast milk. Cereals based gruel was the major complementary food (91.1%) consumed by children. Three types of porridges were available: maize flour porridge consumed by 55.3% of the children, mixed flour porridge consumed by 24.4% of the children and fermented maize porridge consumed by 11.4% of the children. Mixed flour used as complementary food was often made of maize, biscuits, rice and small dried fishes. A small proportion of children were already fed on family diets (8.9%).

On average 100g (±44) of porridge was served to children. Two thirds of cube sugar was added to the porridge. The standard deviation observed explained the large variability of porridge intake within targets.

Moreover, 46.4% of the children usually drank porridge with a spoon, 31.3% drank it directly from the cup and 20.5% were actively encouraged to drink. Food taboos were mostly related to religion or cultural belief. A variety of green leafy vegetables such as *Solanum macrocarpum* are consumed in the study area; because it is a common and locally available food item, it was chosen for this study.

Description of sample

Sixty five mothers and their children participated to the acceptability test. Sex ratio (male / female) of children sample was 0.83. Among enrolled children, 4.6% were moderately wasted, 10.8% were stunted and 15.2% underweight. Prevalence of malnutrition was slightly higher in males than in females (table 4).

Acceptability test with children

Analyses of variance for consumption speed and percentage of gruel consumed showed no significant difference between the three days ($p>0.05$). Therefore, mean values over the three test days were calculated for each parameter used as indicators of acceptability of the porridge by the children.

When percentage of gruel consumed with a threshold of 50 % was considered, analysis revealed that 83.3% of children accepted the gruel [9] (table 5). However, when the amount of gruel consumed during the test was compared to that usually consumed by the children, 65.2% of children accepted the gruel [10] (table 6).

Acceptability test with mothers

Almost all the mothers (98.5%) judged the gruel sweet. However one mother found it tasteless. None of the mothers found the porridge acidic. Regarding the colour of the gruel, 18.5% of mothers found it acceptable and 81.5% judged it good. For consistency aspects, about 29% of mothers found the porridge too consistent. It is worth mentioning that most of these mothers had children aged 6 months, who were being fed with complementary foods. About 69% of mothers judged the gruel to have medium consistency and hence appropriate for feeding their children. The proportion of mothers that found the porridge to be too fluid was 1.5%.

Mothers' overall assessment of the gruel revealed the following: none of the mothers identified the gruel as unpleasant; 1.5% of mothers were neutral; 21.6 % of mothers appreciated the porridge as acceptable; and 40% and 36.9% of mothers appreciated the porridge as pleasant and very pleasant respectively.

Moreover, 60% of mothers claimed that the flow chart for the formulation of the infant flour is easy and feasible at household level. It is necessary to underline that three mothers made and used the infant flour to prepare porridge for their children during the study period. All the study mothers have expressed a desire to feed their children with the infant flour.

DISCUSSION

Raw food ingredients used for the formulation of the infant flour (maize, bean and peanut) and their respective proportion (65%, 20% and 15%) were similar to the ones used for Bitamin flour (millet 67%, bean 20%, peanut 10% and pulp of baobab's fruit 3%) promoted in Republic of Niger[11]. Millet and baobab pulp were used as cereal and minerals and vitamins sources respectively whereas in the Benin infant flour, maize and water from boiled leafy vegetable were used. Although leafy vegetables are

sources of minerals and vitamins it was assumed that they could potentially increase the gruel content in these micronutrients.

Differences observed between these infant flours may be explained by dietary patterns in sahelian areas that are characterized by use of millet and baobab (*Adansonia digitata).* Indeed, baobab pulp contains proteins (30%), lipids (29.6%) and high level of minerals [12] which can compensate for the low proportion of peanut in *Bitamin* flour.

Malted maize was used as ingredient in the preparation of the gruel. The proportion of malted maize was purposely high because of its low amylase activity. Moreover, the low sensibility of cereals starch compared to that of cassava could also explain this trend [13].

Suggesting to mothers the production of malted maize at household level can also raise concerns about aflatoxin contamination. In Kenya and Malawi, aflatoxin contamination of malted grains has been reported by Kenji et al. [14]. Therefore, it will be crucial during further steps of this programme, especially during nutrition education phase of beneficiaries to emphasize on this issue and even organize practical exercises going in this direction.

The use of small dried fishes as ingredient for making infant flour is an interesting alternative that should help to diversify infant complementary feeding. They are animal proteins of good nutritional quality and digestibility. Mothers who fed their child with infant flour enriched with small dried fishes should be encouraged.

Previous studies on locally produced infant flours [15] reported smaller energy density compared with the infant flour produced for this study. This may be explained by the relatively high amount of peanut used. It has been reported that proteins content for infant flours produced in Africa fluctuate from 8.2% to 21.3% [16]. It was the case for this study. Differences often observed between flours may be probably due to protein sources and/or processing effects. Regarding lipids content, it was on average twice higher than in other infant flours available in local markets (*Rimalait a*nd *Cerelac-maize*)[15]. This should not be seen as negative point but rather as a positive owing that the content is still within Codex Alimentarius requirements. It is important to highlight the importance of lipids in the absorption of minerals and liposoluble vitamins, thus their presence in the infant flour could suggest the effectiveness of this potential effect. Moreover peanut contains linoleic acid [17], an essential fatty acid that may help improve cognitive or development capacities of children [18, 19]. The ongoing international discussion about lipid-based nutrients supplements in the treatment or prevention of wasting can also support the crucial role of lipids in complementary foods.

Manual production technology used to produce the infant flour led to an increased amount of fiber compared with semi industrial infant flours produced in Benin. Maize shelling was not included in the flowchart diagram, thus increasing the overall fibre content on the flour. Regarding total ashes content, it was lower than values reported

for *Cereso* and *Cerelac–maize* in Benin [15]. The high mineral content of *Cereso and Cerelac* compared to the in infant flour in this study is due to added minerals and vitamins during processing. Because the newly proposed infant gruel is cooked with water from boiled vegetable leaves (*Solanum macrocarpum*), at least slight improvement of the total mineral content of the gruel was expected as dark green leafy vegetables are important sources of minerals (calcium and iron) and vitamins (pro vitamin A and folic acid) [20, 21]. However, appropriate mineral content is not guaranteed thus, requiring more detailed proximal analyses. Amylase activity has been reported to be effective at pH above 4 [22]. The infant flour proposed offers appropriate condition for amylases contained in added malted maize.

Besides the above mentioned characteristics, high levels of total aerobic, mesophil pathogens and total coliforms found in the infant flour were certainly due to hygienic conditions during processing. Absence of fermentation could also explain microbial contamination. A focus should therefore be put on hygiene while training mothers.

Energy density of the gruel obtained with the proposed infant flour was higher than that of gruels commonly produced in Africa (*Bitamin* in Niger, *Musalac* in Burundi and *Misola* in Burkina Faso[11, 23–26]. However, the gruel had a lower energy density than *Vitafort* produced in Congo. This difference in energy density maybe explained by the use of BAN 800 MG, an enzyme produced by NOVO industry SA used as ingredients in the production of *Vitafort* [27].

According to current standards, recommended protein content of a complementary food is 2g for a child aged 6 to 9 months with average milk consumption of 666ml and 3g for a child aged 9 to 11 months with average milk consumption of611ml[28]. The protein density of the gruel was 2.9%, which means the protein needs of infants aged 6 to 12 months will be met upon consumption of the formula.

Based upon hypothesis made by Vis et *al.* in their work in Democratic Republic of Congo, it is expected that 360 kcal out of an average of 740 kcal needed by a young child of 6 months would be provided through complementary foods [29]. To meet these requirements, the child should drink the gruel more than once a day because of his limited gastric volume (on average 170ml) [30].

A kilogram of the infant flour cost between 1.40 US$ (700 FCFA) in high season and 1.66 US$ (830 FCFA) in lean period. Semi industrial infant flours locally produced cost 1.5 US$ per box of 400g (*Cereso*) and 1.5 US$ per box of 500g (*Beau Bébé*). Physical and economic accessibility to these semi industrial flours constitute major problems for most of mothers in Bopa district [31]. It is important to remind that for semi industrial infant flours, wages, packing, materials depreciation and some others costs are included in production cost. Although the comparison may not be adequate these figures show that the infant flour is about half cheaper than semi industrial infant flours. Giving that monthly incomes in rural areas are well below 34.0 US$ [32], strategies to help reduce households' investment in good quality of complementary foods for children should be promoted.

Irrespective of the criteria used for gruel acceptability, the gruel was accepted by more than half of the study children. There was no statistically significant between days difference in the gruel consumption by these children. This implies that over the three days, children consumed on average the same amount of the gruel prepared with the newly proposed infant flour. This gruel was judged as non acidic by all mothers because of the absence of fermentation in the process of the flour. In south of Benin, consumption of acidic porridge purchased from street vendors is very common. The use of fermentation was avoided because it is very likely to extend the duration of the process and surely limit the adoption of the proposed porridge. Almost all the mothers (98.5%) judged the gruel as sweet. This is a consequence of the combination of the effect of malted maize and the addition of sugar to the gruel.The high acceptance of the gruel by children may be seen as a motivation for the implementation of next steps such as testing the benefits of such infant flour on growth outcomes. In addition many mothers were supportive of the gruel and did show great interest in feeding their child with the infant flour.

CONCLUSION

The infant flour proposed in this study offers potential benefits that can help improve nutritional status of 6 to 12 month-old children in rural south Benin. Beside potential benefits that this infant flour can offer, there is need to integrate individual production of this infant flour in a nutrition and counselling package offered to mothers in order to assess its benefits on nutritional outcomes of targeted children

ACKNOWLEDGEMENTS

The authors would like to thank the staff of the Laboratory of Food Microbiology and Biotechnology of the Department of Nutrition and Food Sciences of the Faculty of Agricultural Sciences of the Abomey-Calavi University in Benin, for their technical assistance. We express our gratitude to the staff of the health centre of Lobogo in Bopa District for their assistance in the field. We are indebted to mothers and their children for their active participation in the study. We are very much grateful to the Nestlé Foundation in Switzerland for the financial support to this research programme.

Table 1: Estimated cost of the infant flour

Expenditure lines	Quantities	Purchase price (US$)	
		Plenty period	Lean period
Maize	1 tounglo	0.20	0.30
Cowpea (white)	¼ tounglo	0.15	0.18
Peanut	1 / 5 tounglo	0.11	0.14
Water (from tower)	1 bottle of 20L	0.04	0.04
Fuel (coal)	2 large cans of tomato	0.60	0.70
Grinding	Mixture	0.30	0.30
Total	1 kg of flour	1.40	1.66

"Tounglo" is a local equivalent to approximately 1 kg

Table 2: Nutritional and chemical characteristics of the infant flour

Nutritional characteristics	Infant flour (per 100g dry basis)				Standards (per 100g dry basis)	pvalue[a]
	Repetitions			Mean ± SD		
	1	2	3			
Energy kcal/100g	433.5	435.8	432.4	433.9 ± 1.7	400	0.001
Proteins %	15.1	15	15.1	15.1 ± 0.1	15	0.184
Lipids %	10.7	11	10.4	10.7 ± 0.3	10 – 25	0.056
Carbohydrates %	69.2	69.2	69.6	69.3 ± 0.2	–	-
Ash content %	1.9	1.9	1.8	1.9 ± 0.1	–	-
Crude fibres %	3.1	2.9	3.1	3.0 ± 0.1	< 5	0.001
Ph	-	-	-	6.1	-	-
Dry matter %	-	-	-	4.3	-	-

[a] p-values were obtained using conformity test of means

Table 3: Microbiological characteristics of the infant flour

Sanitary characteristics (log CFU/g)	Infant flour				Standards (log CFU / g)	pvalue[b]
	Repetitions			Mean ± SD		
	1	2	3			
Total aerobymesophil germs	4.8	4.7	5	4.8 ± 0.2	< 5	0.199
Total Coliforms	1.6	1.6	1.8	1.7 ± 0.1	< 3	0.002
Faecal coliforms	-	-	-	-	<2	-
Escherichia coli	-	-	-	-	<1	-
Yeast and mould	-	-	-	-	<3	-

[b]p-values were obtained using conformity test of means

CFU = Colony Forming Unit;

(-) absence of germs

Table 4: Nutritional status of targeted children (n=66)

Indicators	Male (n=30)	Female (n=36)	Targets (n=66children)
Wasting			
Mean Z-score W/H	-0.44 ± 1.09	-0.31 ± 1.02	- 0.37 ± 1.09
Z-score W/H<-2 (%)	6.7	2.9	4.6
Z-score W/H< -3 (%)	0.0	0.0	0.0
Stunting			
Mean Z-score H/A	-0.66 ± 1.07	-0.68 ± 0.84	- 0.67 ± 0.99
Z-score H/A< -2 (%)	13.3	8.6	10.8
Z-score H/A < -3 (%)	3.3	0.0	1.5
Underweight			
Mean Z-score W/A	-0.84 ± 1.14	-0.79 ± 0.99	- 0.81 ± 1.13
Z-score W/A < -2 (%)	16.7	13.9	15.2
Z-score W/A < -3 (%)	3.3	0.0	1.5

W/H: Weight-for-Height; H/A: Height-for-Age; WA: Weight-for-Age

Table 5:Classification of children according to percentage of ingested gruel

Class	Rate ingested	Number of infants	Proportion of children (%)
1	< 25	0	0
2	25 – 50	11	16.7
3	50 – 75	43	65.1
4	75 – 100	12	18.2
Total	-	66	100

Table 6: Comparison between quantity of gruel usually consumed and that consumed during the test

	Less than usual (<1)		More than usual (> 1)	Total
	< 0.5	0.5 ≤ quantity< 1		
Number of children	5	18	43	66
Proportion of children (%)	7,6	27,2	65,2	100

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