

Original Research Article

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Study on Cereal-Legume Based Complementary Foods for Infants

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ABSTRACT

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Malnutrition is still public health problem in some parts of the world and causes irreversible damage at infant stage. Infants require high energy and nutrient dense foods because of their high growth velocity. Feeding fortified complementary blended foods is one of the options to treat malnourished infants. These foods are prepared with cereal-legume blend, oil, sugar, vitamin/minerals and animal source protein. Complementary foods with high sugar content (> 15%) are not recommended to treat malnourished group. Animal source protein in complementary foods leads to hike in production cost. The purpose of this paper was to study the complementary foods for infants to make alternative inexpensive product formulation with low added sugar. Market survey was conducted on existing cereal-legume based foods for infants. Based on ingredients composition, products were short listed and a food formulation was selected to make an alternative. Kansas State University developed Corn-Soy blend and Sorghum-Soy blends, advanced versions in complementary foods were considered as control in this study for formulating an alternative composition. Complementary food with inexpensive plant source protein and sugar content less than 10% was recommended to meet nutrient density.

Introduction

Malnutrition could be related to a complexity of factors, causing inadequate feeding practices during the most vulnerable period of life, the weaning period, the age between 6 and 24 months in which the infant changes from breast-feeding to the family meal. It can categorise to be under-nutrition and over-nutrition. Undernourishment to children is the curse for the future generation as they are not

efficient in workforce. Infants and young children are especially vulnerable to undernourishment because they have a high growth velocity and also high energy and nutrient needs.

Growth velocity up to the age of about 2 years is especially high; during this period brain development reaches almost 90% of adult size. Nutrient requirements are also often proportionally greater for children than for

adults, making it important to consume diets of high nutritional quality (Ebbeling *et al.*, 2002).

For any food product development, many factors affect its preference and acceptability. Some factors are intrinsic to the product, such as physical, textural, sensory and other factors are extrinsic, such as social and cultural factors. Marketing studies regarding the determinants of food consumption have consistently shown that consumer choices are largely determined by taste (Drewnowski, 1997). In developing complementary foods, strategies to improve the consistency and energy density include; i) modification of the dry matter composition by malting and fermentation (Devi *et al.*, 2014; Gernah *et al.*, 2012); ii) addition of sugar and oil (de Pee, 2009); iii) chemical and enzymatic starch modification; and iv) extrusion cooking (Hoan *et al.*, 2010).

Complementary or weaning foods are generally fortified to treat malnourished children. Such fortified complementary foods are simply mentioned as fortified blended foods (FBFs) in this study. FBFs are a combination of binary blends of cereals and legumes, with oil along with added sugar, vitamin/mineral premix and a possible source of milk based protein in it. The grains and legumes should be partially precooked in order to boost their digestibility, denature anti-nutritional factors, and reduce the cooking time required (Wood *et al.*, 2008).

In many commercial food products, the manufacturers add extra ingredients to minimize the price but it affects the quality of the product. At best, these extra ingredients are nutritionally empty, and at worst, they are nutritionally dangerous, particularly when consumed by infants (Mishra and Dwivedi, 2015). For instance, many FBFs are high in sugar. Every calorie taken up by these

ingredients is a lost opportunity for infant to eat a nutrient rich food that will facilitate proper growth and development. Studies from high-income countries have shown that a high sugar intake (above 15%) has a negative influence on certain important nutrients, such as zinc, where the nutrient density was below the recommended level. In United Kingdom, the food industry, including retailers, manufacturers, restaurants and cafes has been challenged to cut 20 per cent of sugar from a range of products by 2020 from 2016 (G. Smith, UK, Newsletter (New Food)). In 2003, the report of a joint World Health Organization (WHO) / Food and Agriculture Organization (FAO) expert consultation on diet, nutrition and prevention of chronic diseases recommended that added sugar intake should not go above 10% at the population level. Breast milk contains less than 10% sugars (Lactose). Infants perceive about 75% nutritional requirements from breast milk and rest of the nutrition adopted through FBFs gradually from the age of above 6 months. Giving a FBF with high sugar content over a long period may make it difficult for the child later to accept a diet with no or very low sugar content. The amount of sugar should generally not exceed 10% in FBFs, although 20% for up to a few weeks may be acceptable for treatment of wasted children (Michaelsen *et al.*, 2009).

Pricing is the major concern for food manufacturers. Hence, additional sugar is added to compensate the energy requirements from cereal-legume blend and also to achieve flow requirements of the FBF for infants in stipulated conditions. FBFs produced in the United States of America have to meet the requirements from the United States Department of Agriculture (USDA), while the locally produced FBFs are controlled by organizations such as the World Food Program (WFP) and United Nations Children's Fund (UNICEF). Another predominant factor

to influence price of product is protein source used in the product. This problem can be tackled by utilising locally available and low cost raw materials such as corn, sorghum and soybean. Growers will be benefitted by value addition to their produce consistently. Production of FBFs from locally available materials would result affordable cost of product. Keeping in view of above facts a survey was conducted on commercially available complementary foods for infants to formulate FBF.

Materials and Methods

Market survey was conducted to select appropriate FBF as control sample (Fig.1). Recent reports asserted that malnutrition in infant stage is crucial and still there is a need to do research with locally available raw materials. The number of chronically undernourished people in the world is estimated to have increased to 815 million, up from 777 million in 2015 although still down from about 900 million in 2000 (FAO *et al.*, 2017).

A survey was conducted in Bapatla town, Adilabad and Bhopal surroundings (Andhra Pradesh, Telangana and Madhya Pradesh states of India respectively. Collected information about existing FBFs distributed for infants and their ingredients by visiting local market, Anganwadi centres (Rural mother, child care and feeding centres funded by local Government) and households. Public distribution foods [Integrated Child Development Scheme (ICDS) India, WFP and United States Agency for International Development (USAID)] and previous research works related to FBFs were also considered in this study. Nutritional and ingredients information was noted from product labels of existing FBFs and made a list of products. Ingredients in existing FBFs were identified to arrive at optimum nutritional structure of

product. Short listed product specifications were considered as the base for new product formulation. Product formulation was prepared manually. Processing cost has been found to vary with technology adopted for production. Therefore, cost comparison is difficult to maintain. However, ingredients proportion in production was considered to shortlist the complementary foods, and also suitable technologies were discussed for production of cost effective alternative complementary food.

Results and Discussion

Market survey on FBFs for infants gave an idea about existing products (Table 1). The complementary food market in India was highly organized and predominantly dominated by a single player, Nestle. Other major players operating in India include Abbott Nutrition, Nutricia, Raptakos, Amul, Pristine Organics, British Life Sciences, Mead Johnson, Babyvita and Manna Foods. Nestle branded baby foods contain on average 28% animal source protein (skim milk powder) and 9% added sugar and are well accepted (Kampstra *et al.*, 2017).

Developing and under developed countries are the potential destination for complementary food manufacturers with huge untapped market. Commercial complementary foods were expensive because of import and handling costs in addition to production cost. Public distribution program foods were alternative source for economically backward family children. Production of weaning foods from locally available and low cost raw materials such as cereals and legumes was recommended by the ICDS and FAO to overcome the malnutrition among children in under developed and developing countries (Satter *et al.*, 2013). However, technology adopted for production also makes difference in product safety and cost. Soybean is an

inexpensive plant source of protein whose protein quality is considered equivalent to animal protein (FAO, 1991). Addition of soybean can act as a good source of protein in formulated food products besides offering other functional, nutritional and health benefits (Friedman and Brandon, 2001).

GAIN (Global alliance for improved nutrition) developed a FBF named Balamrutham distributed in India and was well accepted product. USAID and WFP distributed products such as CSB+ (Corn Soy Blend Plus, non-extruded product) and super cereal plus (extruded product) are popular in low income countries. CSB14 (Corn Soy Blend 14th edition) and SSB14 (Sorghum Soy Blend 14th edition) were developed by Kansas State University and implemented in MFFAPP (Micronutrient Fortified Food Aid Products Pilot) program, Tanzania (Joseph, 2016).

Traditional complementary foods like *Uggu*, *Sattu*, *Gatka* and *Ragi malt* are giving healthy competition to commercial products. These traditional products are made with locally

grown produce and easy to prepare at home. But these foods have low energy density compared to commercially available complementary foods.

Based on the market survey, commercially viable cereal-legume based complementary foods to mitigate malnutrition were identified. CSB+ is one of the most valuable FBFs extensively distributed food material in USAID programs (USDA, 2014). Balamrutham (non-extruded) was widely distributed FBF in Andhra Pradesh and Telangana states of India in ICDS program.

Various food processing techniques are in use for preparation of complementary foods like extrusion process and conventional processes including germination, roasting, milling, baking, cooking, drying and fermentation. Extrusion process is a contemporary food processing technology to produce wide variety of foods and products that are microbial safe because it is a high temperature and short time process and extrusion process is best suited for large scale production and leaves no effluents.

Fig.1 Markey survey plan

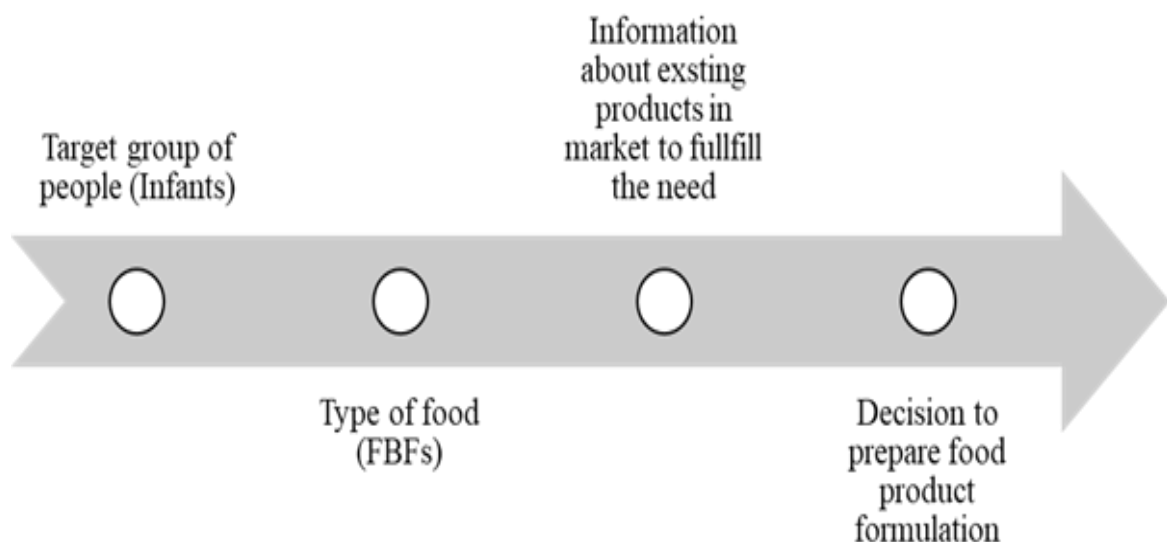


Table.1 Cereal-Legume based complementary foods for infants

Product	Source	Major ingredients %	Processing technique
Nestle Cerelac Fortified Baby Meal with Milk Wheat	Nestle	Wheat flour (48.3), milk solids (32.9), sugar (11.8), soybean oil and vitamins and minerals	Roasting
Farex rice	Farex	Milk solids (41.5), rice flour (40.5), soy oil and minerals	Roasting
Balamrutham	ICDS in India	Roasted Wheat (55), Bengal Gram (5), Skimmed Milk Powder (10), Sugar (20) and Oil (10)	Roasting
Sorghum soy blend (SSB14)	MFFAPP* in Tanzania (Joseph, 2016)	Sorghum flour (63.4), soy flour (15), vegetable oil (9), vitamin & mineral premix (3.1), sugar (15) and whey protein (9.5)	Extrusion
Corn soy blend (CSB14)	MFFAPP in Tanzania (Joseph, 2016)	corn meal (63.4), soy flour (15), vegetable oil (9), vitamin & mineral premix (3.1), sugar (15) and whey protein (9.5)	Extrusion
Sorghum cowpea blend (SCB14)	MFFAPP in Tanzania (Joseph, 2016)	corn meal (63.4), soy flour (15), vegetable oil (9), vitamin & mineral premix (3.1), sugar (15) and whey protein (9.5)	Extrusion
Corn-Soy blend (CSB13)	USDA, 2008	Corn meal (69.55), soy flour, (21.85), vitamin & mineral premix (3.1)	Roasting
Super cereal plus	WFP, 201 5	Corn (58), soy flour (20), skimmed milk powder (8), sugar (10), vegetable oil (3), and vitamin & mineral premix (1.7).	Extrusion
CSB plus	USDA, 2014	Corn (78.47), Whole soybeans (20), Vitamin/Mineral (0.20), Tri-Calcium Phosphate (1.16), Potassium chloride (0.17)	Roasting
Protein enriched sorghum malt	Jiddere and Filli, 2015	Sorghum malt & bambara groundnut	Malting and extrusion
Micro nutrient beverage powder	Tripathi <i>et al.</i> , 2014	Malted finger millet (47), glucose (20), hibiscus powder (22), citric acid (0.5) and vanilla (0.5)	Malting and extrusion
Millet based complementary food	Devi <i>et al.</i> , 2014	Sorghum (50), rice (30), soybean (20) and malted finger millet (15)	Malting and Extrusion
Health drink powder	Kumar <i>et al.</i> , 2013	Malted finger millet, pulses & skim milk powder	Malting
Extrusion cooking of pearl millet	Sumathi <i>et al.</i> , 2007	defatted soy flour & pearl millet (70)	Extrusion
Pigeon pea based weaning food	Mohammed <i>et al.</i> , 2011	Sorghum (65) and pigeon pea (35)	Drum drying
<i>Uggu</i>	Indian Traditional food	Rice (44), pigeon pea (22), (green gram (22) and black gram (12)	Roasting
<i>Gatka</i>	Traditional food	Malted sorghum and salt/sugar (non-fortified)	Fermentation
<i>Ragi malt</i>	Traditional food	Malted finger millet and salt/sugar (non-fortified)	Fermentation

*Micronutrient Fortified Food Aid Products Pilot

Table.2 Final composition of Corn-Soy blend

	CSB14 (Control)	CSB* (0% sugar)	CSB (5% sugar)	CSB (10% sugar)	CSB (15% sugar)
<i>Corn flour</i>	48.4	55.9	49.9	43.9	37.9
<i>Defatted soy flour</i>	15.0	32.0	33.0	34.0	35.0
Oil (%)	9.0	9.0	9.0	9.0	9.0
Vitamin premix (%)	3.0	3.0	3.0	3.0	3.0
Mineral premix (%)	0.1	0.1	0.1	0.1	0.1
Sugar (%)	15.0	-	5.0	10.0	15.0
Whey protein (%)	9.5	-	-	-	
Total	100.0	100.0	100.0	100.0	100.0
Energy (kcal per 100 g)	387.00	393.59	395.34	397.09	398.04

*Corn-Soy Blend

Different variants of FBFs using extrusion technology were developed at Kansas State University (KSU) based on FAQR (Food Aid Quality Review) recommendations for public health distribution program. Recently developed FBFs contained animal source protein (WPC80, Whey Protein Concentrate 80% purity) and sugar to achieve viscosity within prescribed USDA standards of 9-21 cm/min. Products are well accepted in Tanzania (Joseph, 2016). However, there is a possibility to reduce the cost of product by replacing expensive WPC80 with plant based protein sources such as soy protein. KSU developed FBFs named as CSB14 and SSB14 are advanced formulations than those developed under WFP and USAID. CSB+ and super cereal plus FBFs need to cook five to ten minutes to prepare porridge but CSB14 and SSB14 required only one-minute cooking.

Recent studies on protein quality and protein efficiencies of CSB14 and SSB14 were compared with CSB+ via experiments on rats and broiler chickens. Results revealed these FBFs have higher protein quality and iron bioavailability compared to CSB+ (Fiorentino

et al., 2017). Also, field trials demonstrated the efficacy FBFs (CSB14 and SSB14) in combating micronutrient deficiencies and supporting linear growth in children (Delimont *et al.*, 2017).

Keeping in view of above facts, CSB14 and SSB14 formulations were considered as control samples for reformulation. CSB14 and SSB14 formulations have 15% sugar content and 9% WPC80. Improved formulations with better nutritional and energy per unit serve prepared based on CSB14 as control (Table 2) were considered for further work of evaluation of flow properties.

Complementary foods to treat malnourished infants and children should be limited to addition of sugar less than 15%. To improve energy and nutrient density of complementary foods, novel food processing technologies such as extrusion has to be adapted for traditional food formulations. Incorporation of underutilised crops in these foods leads to reduction of the cost of product. From the market study, new formulations were prepared for further improvement in existing product. These formulations are used to

conduct experiments to evaluate effect of process variables on flow properties.

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