Development, production, and quality control of nutritional supplements for a national supplementation programme in Mexico

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Abstract

The objective of this study was to develop supplements for nutritional support of children less than two years old and for pregnant and lactating women under a multidisciplinary Programme of Education, Health, and Nutrition (PROGRESA) that the Mexican Government is implementing for populations in extreme poverty. Nutrient composition, physicochemical properties, and feasibility of production and utilization were considered in designing the supplements. The nutrient composition took into account the dietary patterns and nutritional status of the target populations. The ingredients and processing methods were selected considering local availability and production at a relatively low cost while maintaining a supplement of a high quality that would be widely accepted by the target population. The final products were initially evaluated for acceptability by 40 children, 52 pregnant women, and 62 lactating women. Nine products were developed: six for children and three for women. The children's products were three powders that were used to prepare a beverage with chocolate, vanilla, and banana flavours and three powders that were used to prepare a more viscous solution in the form of pap with the same three flavours. After the acceptance test, the use of the pap supplements was recommended for children four months to two years of age. The supplements for women were also powders used to prepare a beverage with vanilla or banana flavour or with no flavour. The products were widely accepted in sensory evaluation tests. For the children's products, the average scores were 4.11 to 4.29 for the beverage and 3.98 to 4.15 for the viscous mixture (range, 1 to 5). The women's products received average scores of 4.75 to 5.70 from pregnant women and 4.80 to 5.40 from lactating women (range, 1 to 7). Evaluation in the community demonstrated that the supplements were widely acceptable and well consumed. Today more than three million rations of supplements are consumed every day, and an evaluation of their potential benefits is being carried out.

Introduction

In 1997 the Mexican Government initiated a Programme of Education, Health, and Nutrition (Programa de Educación Salud y Alimentación; PROGRESA) to improve the living conditions of families in extreme poverty. PROGRESA is a multidisciplinary programme covering three areas that are closely related. In the area of education, PROGRESA provides scholarships for every child under 18 years old attending school between the third year of primary school and the third year of secondary school. The programme is also directed to improving educational services and stimulating the involvement of parents in education. In the area of health services, PROGRESA offers a strategic plan that includes actions to improve maternal and child health, prevent and quickly attend to infectious diseases, and improve health education. In the area of food availability and nutrition, the programme provides cash to families to make food more available to them and offers a nutrient-supplementation plan for children under two years age and for pregnant and lactating women. About four million families meet the programme's criteria for extreme poverty. A detailed description of the beneficiaries, the programme, and its evaluation has been published [1].

An important instrument of the nutritional component of PROGRESA is the availability of nutritional supplements that can improve the nutritional status of the target population. Several factors should be considered in the development of an adequate nutritional supple-

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ment [2, 3]. First, to ensure the nutritional quality and composition of the supplement, the product should include all of the nutrients that are adequate for the target population in forms that are readily available. Second, the supplement should be well tolerated and accepted by the target population in terms of its flavour and appearance. Previous food supplementation programmes in Mexico failed because the supplements were not attractive to the targeted populations [4, 5]. Third, the supplement should be easy to use, be stable, and have a shelf-life long enough to allow for adequate distribution and utilization. Finally, the supplement should be produced at low cost. The production process should be as simple as possible so that it can be produced locally.

The purpose of this study was to develop methods of production and quality control for nutritional supplements used in the PROGRESA Programme.

Methods

Characteristics and nutritional composition of supplements

The supplements were formulated to have the following characteristics: they should be a good source of those nutrients known to be deficient in the Mexican population; the ingredients needed for production should be available in the country in sufficient quantities and at a relatively low cost; the processing costs should be low enough to allow the supplements to be produced locally; the flavour and appearance of the supplements should be highly acceptable to the target population; the final form of the supplements should allow their appropriate distribution and consumption; and the packaging should allow good use and conservation of products.

The nutrient composition of supplements was defined after careful revision of available data on the existence of nutritional deficiencies in different regions of the country [5–8]. The supplements should contribute to the intake of high-quality protein, energy, and the vitamins and minerals that are known to be deficient in Mexico. Table 1 shows the nutrient composition of the supplements and the content of nutrients for each daily ration. The supplements were developed for children aged four months to two years and for pregnant and lactating women.

Processing and production of supplements

The supplements consisted of instant dry whole milk, hydrolysed cornstarch with a dextrose equivalent of 20, sugar, flavours, and a pre-mix of vitamins and minerals defined according to the nutrient composition given in table 1. The supplement for children could be prepared as a low-density beverage or as a pap of higher viscosity. The pap and the beverage were evaluated for acceptability and preference to determine the better alternative. The supplements for children came in chocolate, vanilla, and banana flavours, and those for pregnant and lactating women came in vanilla, banana, and natural (no flavour added) flavours. The supplements were processed by dry mixing the ingredients (fig. 1). The samples were packaged in laminated envelopes that allowed for an adequate shelf-life. A detailed description of the processing and packaging of the products has been published elsewhere [3].

Sensory evaluation and acceptability of supplements

In order to have supplements that were widely accepted, a series of sensory evaluations was carried out in 40 children six months to two years of age from a nursery

TABLE 1. Nutritional composition of supplements

Nutrient	Children's supplements		Women's supplements	
	g/100 g	g/ration (44 g)	g/100 g	g/ration (52 g)
Protein (g)	13.3	5.8	23	12
Energy (kcal)	440	1,941	480	250
Iron (mg	23	10	28.8	15
Zinc (mg)	23	10	28.8	15
Vitamin A (μg)	920	400	—	—
Vitamin E (mg)	13.8	6	19.2	10
Vitamin C (mg)	92	40	134.4	70
Vitamin B_2 (mg)	1.8	0.8	2.9	1.5
Vitamin B_{12} (mg)	16.1	0.7	5.0	2.6
Folic acid (μg)	115	50	192	100
Iodine (μg)	—	—	192	100

TABLE 3. Formulas of women's supplements

Ingredient (g/100 g)	Natural	Vanilla	Banana
Powdered whole milk	80.00	80.00	80.00
Sugar	9.61	9.61	9.61
Hydrolysed cornstarch	10.01	8.68	9.89
Vitamins and minerals	0.38	0.38	0.38
Flavour			
Vanilla	—	1.33	—
Banana	—	—	0.12

All ingredients must be carefully analysed before they are mixed. Analysis should include nutrient composition, stability, microbiological content, and physicochemical characteristics. The dry milk must be in a soluble form. The vitamin and mineral pre-mixes must be analysed for nutrient content. The hydrolysed cornstarch should be 20 dextrose equivalents to avoid unnecessary increments in osmolarity while at the same time allowing for good solubility. Each batch of flavours should be compared with standards to avoid a change in flavour profile. The dry ingredients can be mixed in a standard mixer after its efficiency has been tested for producing a homogeneous product; this is especially important for mixing the vitamins and minerals. It is critical to obtain a homogeneous product, and in order to assure mixing efficiency, analysis of some of the micronutrients could be used as markers. The final product should also be subjected to analyses for nutrient composition, microbiology, solubility, and sensory evaluation. The production and quality control of the supplements should be a straightforward operation in well-equipped laboratories and food plants.

Discussion and conclusions

Formulas were developed for use as nutritional supplements for Mexican children ranging between four months and two years of age and for pregnant and lactating women. The programme for which these supplements were developed is directed towards populations in extreme poverty living in different regions of the country. Several studies have identified marginal deficiencies of several nutrients in these populations, especially of some vitamins and minerals [7, 8]. Thus, the products were designed to contain those nutrients that are considered to be beneficial for these groups. The quantity and source of nutrients were based on the optimum for the different groups of beneficiaries in consideration of their habitual diets, regional variation in nutrient deficiencies, and the bioavailability of the different sources of nutrients. Given the large scope of the food component of PROGRESA, it was important to select the ingredients while taking into account their availability and cost in Mexico.

TABLE 4. Level of acceptance in sensory evaluation of supplements by children and by pregnant and lactating women.

Supplement	Acceptance (mean ± SD)
Children's beverage	
Vanilla	$4.26 \pm 0.88^{a,b}$
Banana	$4.11 \pm 0.99^{a,b}$
Chocolate	$4.29 \pm 0.85^{a,b}$
Commercial vanilla	3.94 ± 1.19^{a}
Commercial chocolate	4.38 ± 0.83^{b}
Children's pap	
Vanilla	$3.98 \pm 1.01^{a,b}$
Banana	3.67 ± 1.20^{a}
Chocolate	4.15 ± 0.96^{b}
Women's beverage evaluated by pregnant women	
Vanilla	4.75 ± 2.12^{a}
Banana	5.70 ± 1.50^{b}
Natural flavour	4.75 ± 2.00^{a}
Commercial vanilla	3.13 ± 2.19^{c}
Women's beverage evaluated by lactating women	
Vanilla	5.29 ± 1.93^{a}
Banana	5.48 ± 2.04^{a}
Natural flavour	4.84 ± 2.11^{a}
Commercial vanilla	3.45 ± 2.86^{b}

Means with different letters within same product are significantly different ($p < .05$).

Milk was selected as a major ingredient for the products after other sources, including cereals, soya, and amaranth, had been carefully evaluated. In light of the high incidence of lactase deficiency in Mexico, a potential limitation on the use of milk in the supplement is its high lactose content. Recent studies have evaluated the prevalence of lactase deficiency and lactose intolerance in Mexico [12–14]. Those studies included populations with different habitual intakes of milk and population groups from young children to the elderly from rural and urban regions of the country. After careful review of all the studies, it was concluded that lactase deficiency and lactose intolerance in Mexico do not constitute a limitation for using milk in food supplementation programmes or any other form of social assistance [15, 16].

The functional and physicochemical characteristics of the supplement that allow for its appropriate transportation, storage, distribution, and utilization are also important for its feasibility. The products developed are easy and inexpensive to transport, the ingredients and packaging chosen allow for a shelf-life of at least one year, and the production process for the supplements was chosen to be as simple and cheap as possible. The simple production process allows the supple-

ments to be produced in different regions of the country, therefore facilitating their distribution.

There are several aspects central to the programme's success. The supplements should be consumed in the recommended quantities; they should be consumed for the period of time that could be expected to make a nutritional impact on the target population; and the flavour, appearance, and texture should be acceptable to the target groups. The latter was emphasized during the development of the supplements. The new product's level of acceptability was excellent when compared with that of highly acceptable commercial products. Of course this was a short-term evaluation. The long-term acceptance and efficacy of the supplements and the supplementation programme need to be evaluated. More than three million rations of these supplements are consumed every day, and an evaluation of their potential benefits is being carried out.

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