Consumer Acceptance of Dehydrated Banana Weaning Food in Costa Rica

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Abstract. An infant cereal using banana, rice, and soybean was developed to supply the needs of the Costa Rican Program for Food and Nutrition, which eventually will be introduced into the national market. This food, which uses principally nationally produced raw materials, is in the form of small flakes and can be consumed with either milk or water. The cereal was fortified with vitamins and minerals and was designed as a complementary food for weaning. The process for preparation of the cereal consists of cooking to destroy the inhibitors in the soybean to acceptable levels, gelatinization of the rice starch, inactivation of the banana enzymes, and dehydration of the mixture by drum drying to 5% MC.

Optimization studies of the ingredients, using the chemical score as a nutritional index with the banana content maintained at 40%, indicated that the best complement between rice and soybean proteins was achieved in mixtures with 10.5% and 16.5% soybean dry weight. The cereal, according to chemical and microbiological analyses and taste panels, was stable after 12 months' storage in a package of laminated paper, aluminum, and polyethylene. The cereal developed was produced on a commercial scale. The product has high caloric value and exhibits the functional characteristics (viscosity, dispersability, water absorption, and texture) recommended for this type of food. The acceptance of the cereal was evaluated in a study "Food for children under two years" during the first phase of the field experiment. For this evaluation a group of 50 families each with a child under age 2 was selected in an urban zone exposed to the risk of malnutrition. The results based on the information given by the mother or person in charge of feeding the child demonstrated a good acceptance of the product.

Faced with the need of the Costa Rican government's Food and Nutrition Programme for low-cost, easy-to-distribute, and nutritional foods that would be well accepted by the public, the Food Technology Research Centre (Centro de Investigaciones en Tecnología de Alimentos — CITA) has concentrated its efforts on developing food products of this kind. One example is banana-flavoured dehydrated infant cereal. The aim of this project was to develop a supplementary food for the weaning period, which might be taken with water or milk. In designing the product, locally produced raw materials were used: bananas, to make use of the nonexportable surplus from Costa Rica's banana crop; rice, which is grown locally; and whole soybeans, to improve the mixture's protein quality, supply the oil necessary for processing, and add calories. The use of other legumes (cowpeas and pigeon peas) as alternatives to soybeans was also studied. With this product, the aim was to supplement the amino acids lysine, tryptophan, and threonine, in which cereals are deficient, and methionine, of which legumes and oilseeds often contain only limited amounts (Rosenberg and Culik 1957; Bressani et al. 1972 a, b). The project assessed the effect of varying the proportions of soybeans and rice on the nutritive value and functional characteristics of the final product. The banana content was kept constant at 40% thus ensuring that the banana flavour would be maintained in the product. The final formula, enriched with soybean oil to increase its caloric content and fortified with vitamins and minerals, was prepared on an industrial scale and yielded a cereal having the functional properties recommended for foods of this kind. The product's acceptability was assessed under a project entitled "Food for children under two years of age." The primary goal of this project was to further the development of high-calorie foods for use by children under age 2 during the

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FOOD DRYING

Proceedings of a Workshop
Held at Edmonton, Alberta, 6-9 July 1981

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Abstract/Résumé/Resumen

The authors of this volume include researchers and scientists from many countries that encompass diverse climatic, geographic, and socioeconomic conditions. Their disciplines were also numerous: home economics, food science, nutrition, physics, and engineering.

The workshop covered the most important areas in the design and operation of a drying system. These are: drying requirements, consumer acceptance, heat and mass transfer, and heat sources. Within drying requirements, the need for drying the product is discussed as well as drying times and rates, sample preparation, quality changes during drying, rehydration problems, and problems with storage of the dried product. The section on consumer acceptance includes the effects of drying on the nutritive value of food, the introduction of a dried food to the consumer market, and how consumers provide valuable information to scientists to help in improving a process or product. The theory and design of a drying chamber and process control are explained under heat and mass transfer and an operational, full-scale drying system is examined. Finally, under heat sources, a number of examples are given in the use of the sun, petroleum products, agriculture wastes, and wood as heat sources for a drying process. A final concluding commentary is made on the overall recommendations derived from the workshop and proposals for future work are given.

Les auteurs de ce volume sont des chercheurs et des techniciens venus de pays très différents les uns des autres du point de vue climat, géographie et conditions socio-économiques. Les disciplines représentées étaient aussi très diverses: économie domestique, alimentation, nutrition, physique, génie mécanique.

Le colloque a examiné les questions les plus importantes en ce qui concerne la conception et l'utilisation d'une installation de séchage: besoins en matière de séchage, l'accueil du consommateur, transmission de la chaleur et évacuation de l'humidité, sources de chaleur. Le chapitre sur les besoins en matière de séchage traite de la nécessité et de la durée de cette opération, de la préparation des échantillons, de l'action du séchage sur la qualité du produit, des problèmes de réhydratation et des problèmes de stockage du produit sec. Le chapitre sur l'accueil du consommateur traite des effets du séchage sur la valeur nutritive du produit, de la commercialisation d'un produit sec et de l'aide que peuvent apporter les consommateurs à l'amélioration d'un procédé ou d'un produit. Le chapitre sur la transmission de la chaleur et l'évacuation de l'humidité traite de la théorie et de la conception d'un séchoir, des modes de réglage et décrit une installation en service. Enfin, le chapitre sur les sources de chaleur donne des exemples l'utilisation du soleil, des produits pétroliers, des déchets agricoles et du bois. Un exposé des conclusions dégagées par le colloque et de ses recommandations est présenté à la fin de l'ouvrage.

Los autores de este volumen comprenden investigadores y científicos de varios países que, en conjunto, abarcan diversas condiciones climáticas, geográficas y socio-económicas. Sus disciplinas respectivas también son numerosas: economía del hogar, ciencias de alimentación, nutrición, física e ingeniería.

El cursillo abarcó los aspectos más importantes en el diseño y operación de un sistema de deshidratación. Estos son: requisitos de la deshidratación, aceptación por el consumidor, trasferencia de calor y masa y fuentes de calor. Entre los requisitos se examina la necesidad de deshidratar el producto así como los tiempos e índices del proceso, preparación de muestras, cambios en calidad durante le deshidratación, problemas que presenta la rehidratación y problemas resultantes del almacenamiento del producto deshidratado. La sección de aceptatión por el consumidor comprende los efectos de la deshidratación sobre el valor nutritivo del alimento, la introducción de un alimento deshidratado en el mercado del consumidor, y como éstos a su vez proveen información valiosa a los científicos ayudándoles a mejorar un proceso o producto. Se explican la teoría y diseño de la cámara de deshidratación y el proceso de controlbajo trasferencia de calor y masa, examinándose un sistema operativo de deshidratación a escala comercial. Finalmente, y bajo el concepto de fuentes de calor, se citan varios ejemplos relacionados con el uso del sol, de productos petrolíferos, y desechos agrícolas, así como el de la madera como fuentes de calor para procesos de deshidratación. Se efectua un comentario final sobre recomendaciones generales derivadas del cursillo al tiempo que se efectúan propuestas para el trabajo futuro.

Contents

weaning period and in populations exposed to the risk of malnutrition. The specific objectives may be listed as follows:

(1) To evaluate the acceptability and nutritional impact of various food products that are potentially effective for preventing malnutrition in urban and rural populations exposed to the risk of malnutrition.

(2) To make progress in developing stronger hypotheses regarding the key factors and relationships that affect results when food products are introduced on a noncommercial basis to families resident in these areas.

(3) To consolidate a research methodology applicable to the social context of Costa Rica, and to other similar social contexts, to provide a basis for future studies in this field.

The acceptability of the product was assessed under a preliminary field trial in which three foods were administered experimentally: banana-flavoured dehydrated infant cereal, rice cereal, and a rice-and-bean cereal. Each cereal was given to a trial group of 50 families over a 2-month period. Another group of 50 families also took part as a control group, bringing the total population studied to 200. Each family had at least one child under age 2 who was being weaned or had already been weaned.

Method of Preparation

Basically, the method used to prepare the cereal consisted of precooking the ingredients and drying the resulting mash on a drum dryer. After being washed in running water, the whole soybeans were cooked at 121°C for 30 min; then the water used was drained off to remove the water-soluble carbohydrates, which are the main cause of flatulence (Rackis et al. 1970). Cooking the soybeans in this way reduced the concentration of inhibitors and flatulence-causing oligosaccharides (Shemer et al. 1973; Rackis et al. 1974). The rice and water were then added, and allowed to boil for 5 min to gelatinize the rice starch. At this point, the bananas were peeled and put in a tank with water and ascorbic acid (0.1% by weight) to prevent discoloration. The contents of this tank were then added to the soybeans and rice in the cooking pot and left to boil for 3 min to inactivate the banana's enzymes.

The cooked mixture was then transferred to a tank feeding into a Fitz mill. After milling, the mixture continued to another tank that in turn fed the drum dryer. The temperature of this tank was maintained at 70°C to keep the viscosity of the mixture low, reduce the cost of drying, and ensure that the film formed in the dryer was uniform. This temperature also prevented the growth of microorganisms (Jay 1973; Frazier 1978).

The pressure and velocity at which the drum dryer was operated were chosen on the basis of specific output in grams per hour and the functional characteristics of the resulting product (Fig. 1).

Results

Nutritional Aspects

To optimize the relative proportions of the ingredients in the banana-rice-soybean mixture, a chemical score was used as a nutrition index. A system of linear equations was used to calculate the chemical score of various banana-rice-soybean mixtures. The banana content was kept constant at 40% while the protein content varied from 8 to 18%. For each of these mixtures, the chemical score and caloric content were calculated. The chemical score was calculated on the basis of 1976 Food and Agriculture Organization of the United Nations (FAO) data, and the 1973 FAO/World Health Organization (WHO) guideline on amino acids was used as a reference. The results obtained indicated the optimum protein level to be from 10 to 12%; in other words, the optimum mixtures were found to be those containing between 10.5 and 16.5% soybean. The caloric content of the various mixtures was found to be virtually the same (Table 1).

Mixtures containing 30 and 40% soybeans were sent to the Instituto de Nutrition de Centro América y Panamá (INCAP) and the Tropical Product Institute (TPI) for the following biological analyses: protein utilization index (PER), net protein utilization (NPU), and net protein ratio (NPR). The results showed the quality of the mixture's protein to be from 63 to 77% that of casein, indicating that the mixture's protein quality is good although not excellent. This is because, even though the rice-soybean mixture contains a good variety of amino acids, the addition of the banana reduces the protein quality, possibly owing to a Maillard-type nonenzymatic discoloration during the drying process.

Functional Characteristics

To evaluate the functional characteristics of the mixtures studied, the analytical tests and methods used by the infant-food industry for

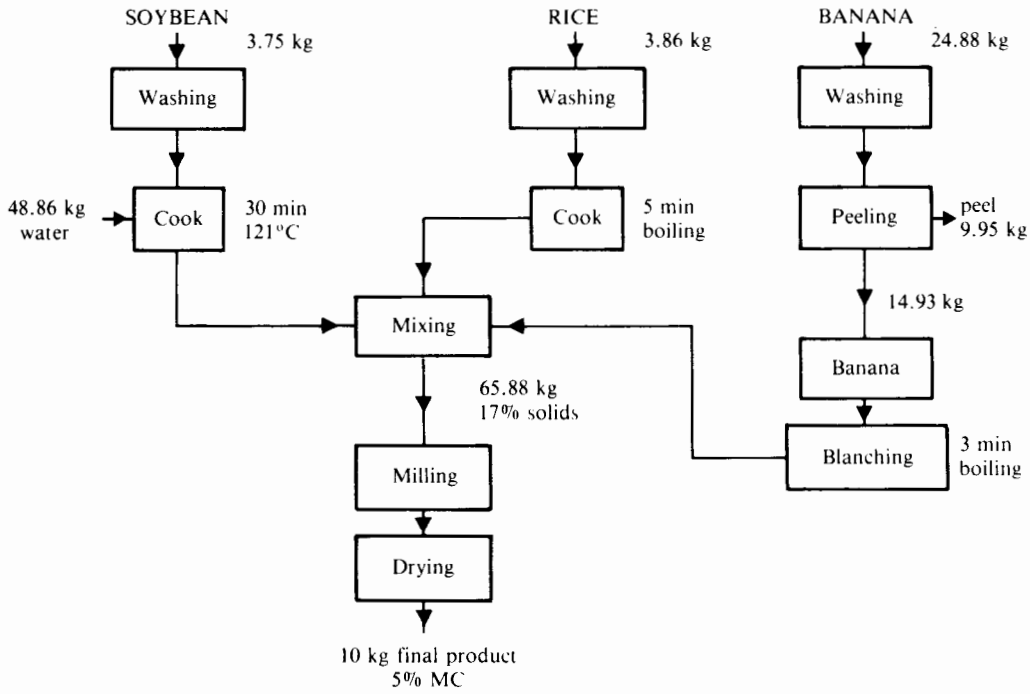

Fig. 1. Material balance for a mixture of 40% ripe bananas (70% MC), 30% rice (13% MC), and 30% whole soybean (10.4% MC).

quality control in this type of product were used, on the basis of information supplied by Productos Gerber de Centro América, S.A.

The various mixtures, containing different percentages of soybeans, and prepared on an industrial scale under different drying conditions, were rated for: density, solubility, water absorption, texture, tendency to form lumps, and viscosity. The findings indicated that the ingredients in the mixture have a greater influence on the final product, and particularly its level of quality, than do the drying conditions. As the mixture's rice content was increased, the final product's water-absorption rating was found to be adversely affected. Whether prepared on a small scale or on an industrial scale, the mixtures were found to have the recommended properties for this type of product (Table 2), similar to those for infant cereals produced by Productos Gerber de Centro América, S.A.

Sensory Evaluation of the Product and Storage Properties

The composition of the R_{40}, G_{40}, and S_{40} mixtures are: R_{40} = 40% cowpeas, 20% rice, and 40% bananas; G_{40} = 40% pigeon peas, 20% rice, and 40% bananas; and S_{40} = 40% soybeans, 20% rice, and 40% bananas. As an initial step, the three mixtures were studied for acceptability and storage properties.

Samples were stored for 12 weeks in three different commercially available packages. Chemical and microbiological analyses and sensory evaluations were carried out both before and after storage.

Differences Between Mixtures

The mixtures differed significantly as to colour, smell, texture, and flavour (Tukey test). The results showed the soybean mixture (S_{40}) to be superior to the cowpea and pigeon pea mixtures (R_{40} and G_{40}) in terms of flavour, colour, and smell. As regards texture, the data indicated that the R_{40} mixture, which yields a crunchier final product, was more highly rated.

Differences in Packaging and Storage Periods

There was no significant difference found between the types of packaging in any of the sensory characteristics analyzed for any of the mixtures. This confirms that the three kinds of

Table 1. Characteristics of different mixtures of soybean–rice–40% banana (S).

Mixture	% dry base		% protein	kcal/100 g	Chemical score	Limiting amino acid
S_5	Soybean Rice	5 55	8	390	82	Lysine
$S_{7.5}$	Soybean Rice	7.5 52.5	9	391	86	Lysine
$S_{10.5}$	Soybean Rice	10.5 49.5	10	392	90	Lysine
$S_{13.5}$	Soybean Rice	13.5 46.5	11	393	92	Sulfur-containing
$S_{16.5}$	Soybean Rice	16.5 43.5	12	393	90	Sulfur-containing
S_{22}	Soybean Rice	22 38	14	395	86	Sulfur-containing
S_{25}	Soybean Rice	25 35	15	395	85	Sulfur-containing
S_{30}	Soybean Rice	30 30	17	396	84	Sulfur-containing
S_{40}	Soybean Rice	40 20	20	399	81	Sulfur-containing

packaging used share similar characteristics. During the storage periods, there was no difference for flavour, colour, or texture. The only significant difference found was for smell, which deteriorates somewhat after 6 weeks storage, but was still within the acceptable range. During the 12-week storage period, no variations in moisture content occurred in any of the mixtures in the three types of packaging studied. Total count, coliform, and fungus analyses after storage indicated that the product presents no microbiological problems.

Batches of the S_{30} mixture were stored for 1 year and then were analyzed for microbiological counts and moisture content. Comparison of the results of analyses conducted within 24 hours of processing and those of analyses conducted after 1 year's storage confirmed the good microbiological quality of the product, as no significant changes in the moisture level or number of microorganisms were found. It was also demonstrated that no large changes in moisture level took place in the packaging during the product's year in storage.

Industrial-Scale Production

The product was prepared on an industrial scale using the facilities at the Productos Gerber de Centro América cereal plant in Costa Rica. It was fortified with vitamins and minerals and enriched with 10% soybean oil to increase its caloric content.

The industrial-scale preparation process is semicontinuous. First, the banana pulp is mixed with the rice and soybean meal, and then the rest of the ingredients are added, with water, to produce a mixture that has a total solids content of approximately 17% (Fig. 2).

After drum drying, the resulting product is in the form of small flakes that smell and taste of banana. Its chemical composition and caloric content are as follows: moisture, 4.90%; protein, 10.20%; fat, 13.85%; ash, 3.30%; carbohydrates, 67.50%; fibre, 0.70%; reducing sugars, 9.40%; caloric content, 463 kcal/100 g (dry); thiamine, 1.58 mg/100 g; riboflavin, 1.90 mg/100 g; niacin, 14.08 mg/100 g; calcium, 634 mg/100 g; phosphorus, 528 mg/100 g; and iron, 15–25 mg/100 g. The product meets Gerber's standards as regards functional characteristics and microbiological analyses. The prepared food product was packaged in aluminum/polyethylene laminate bags each containing 265 g, and then distributed to the households taking part in the study of acceptability and nutritional impact.

Table 2. Functional characteristics of the S_{30}, S_{22}, $S_{16.5}$, and $S_{10.5}$ (S = soybean–rice–banana) mixtures processed according to seven different drying conditions.

Mixture	Drying conditions (psi)	Drying conditions (rpm)	Density (g/cm^3)	Solubility (%)	Water absorption level[a]	Texture (I)	Tendency to form lumps (II)	Viscosity (cP)[a]	Quality on basis of (I) and (II)[b]
S_{30}	50	2.25	0.19	27.0	1	Loose	None	1280	1–1
	80	2.25	0.17	31.0	1	Loose	None	1360	1–1
	80	3.25	0.19	33.0	1	Loose	None	1280	1–1
	80	4.50	0.21	37.0	1	Loose	None	1280	1–1
	100	3.25	0.16	33.0	1	Loose	None	1360	1–1
	100	4.50	0.20	32.0	1	Loose	None	1200	1–1
	100	5.50	0.19	39.0	1	Loose	None	1120	1–1
S_{22}	50	2.25	0.21	27.4	1	Loose	Moderate	910	1–3
	80	2.25	0.19	35.6	1	Loose	Moderate	770	1–3
	80	3.25	0.22	24.5	2	Loose	Moderate	915	1–3
	80	4.50	0.15	27.4	3	Loose	Slight	1840	1–2
	100	3.25	0.14	31.6	2	Loose	None	1255	1–1
	100	4.50	0.20	36.0	2	Loose	Slight	1130	1–2
	100	5.50	0.15	33.5	1	Loose	Slight	940	1–2
$S_{16.5}$	50	2.25	0.18	34.6	3	Loose	Moderate	1180	1–1
	80	2.25	0.24	47.8	2	Loose	Moderate	1010	1–1
	80	3.25	0.23	38.9	2	Loose	None	1280	1–1
	80	4.50	0.23	37.2	2	Loose	Slight	880	1–2
	100	3.25	0.18	34.3	3	Loose	None	1450	1–1
	100	4.50	0.16	33.7	3	Loose	None	1215	1–1
	100	5.50	0.11	33.4	2	Loose	None	1170	1–1
$S_{10.5}$	50	2.25	0.18	38.3	3	Loose	None	1354	1–1
	80	2.25	0.12	36.3	3	Loose	Slight	1600	1–2
	80	3.25	0.18	38.6	3	Loose	None	1794	1–1
	80	4.50	0.17	37.8	3	Loose	None	No reading (over 100)	1–1
	100	3.25	0.16	36.3	3	Loose	None	1700	1–1
	100	4.50	0.17	43.7	3	Loose	None	1450	1–1
	100	5.50	0.12	32.8	3	Loose	None	1440	1–1

[a]Viscosity is determined with the Brookfield Spindle No. 4 using the amount of water corresponding to the water-absorption figure for the mixture in question.
[b]Level of quality according to the scale established by processors of infant foods: levels 1 and 2 are good, level 3 must be reported, and level 4 must be rejected.

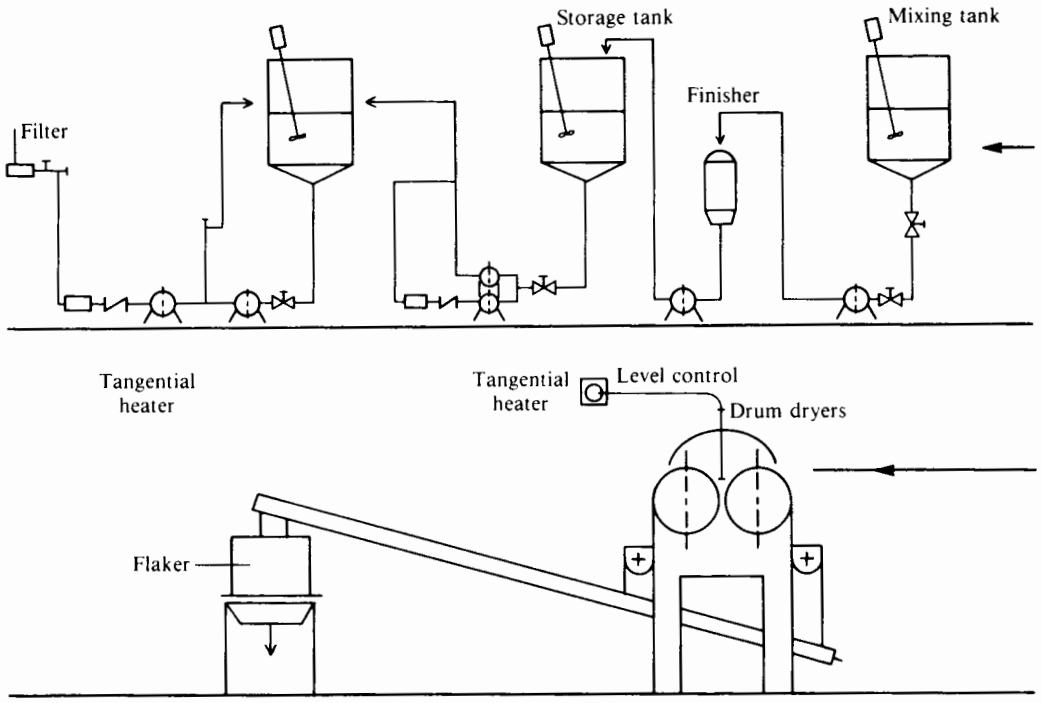

Fig. 2. Process line for industrial-level production.

Acceptability of the Product

The acceptability of the product was determined in the preliminary field trial mentioned earlier. The first step in this study was to conduct a survey to select 200 families living in four urban areas identified by Costa Rica's Nutrition Information Service as high malnutrition risk areas. Each of these families had at least one child under age 2 who either had been weaned or was being weaned and who became the central subject of the analysis unit. The families were split into four groups of 50 each, and were provided with food as follows: group 1, banana-flavoured dehydrated infant cereal; group 2, rice cereal; group 3, rice and beans; and group 4 was a control group that received no product.

Continuous records were kept on the provision and consumption of the banana and rice cereals, primarily to determine their acceptability and nutritional impact. The families in group 3 were provided with rice and beans to test a different hypothesis: that an increase in the availability of food for the adults in a family group would have a positive impact on the feeding of the infants in that group. For all four groups, the characteristics of each family's food intake, health conditions, and socioeconomic position were measured extensively. The nutritional impact of the food provided was determined by anthropometric means, and trained interviewers surveyed the mothers or other individuals responsible for the child's feeding to determine acceptability.

Information was sought on a series of variables relating to acceptability: knowledge and prejudices with respect to infant foods, the type of food provided to the child, the actual availability of food, and so on. An effort was also made to determine whether basic nutrition education, which was given to all four groups, and the trial itself were changing these factors. Specific acceptability factors for the infant foods were divided into five groups: organoleptic factors, the child's reaction upon consuming the food, ingestion, the results obtained in preparing the cereal, and ratings for the digestive and nutritive properties of the product provided.

The surveys of these factors were administered twice, once at the start and once at the end of the period during which the food was provided, to reveal any changes taking place and to check the consistency of the information obtained. The food was provided over a period of 8 weeks.

Results

Organoleptic

Each mother tasted the products and then was asked her opinion of characteristics of flavour, colour, and smell. The results showed that between 70 and 90% of the mothers rated the products as good or very good on a hedonic scale for all factors.

Preparation of the Cereal

In her own words, the mother described the consistency achieved in preparing the product. At the first interview, it was found that 60% of the mothers felt the product to be smooth and 5% felt it was lumpy. In the second interview, after 8 weeks, more than 80% felt that it was of a smooth consistency on preparation.

Ratings for the Product's Digestive and Nutritive Properties

The mother was asked for her opinion of the nutritive value of the product and how well the child digested it. More than 90% in both the first and second interviews said the nutritive value was either good or very good, and the same was true for digestibility (Table 3).

The product was thus given a fairly high rating, which agrees with the sensory analyses carried out under laboratory conditions. The mothers' opinions seemed to be better defined in the second survey, and, therefore, it seems more reasonable to attach greater importance to the data from that survey than to those from the first. The information obtained is not at odds with the recorded consumption. Acceptability of the rice cereal was also shown to be high. The data obtained for this cereal are not included in this report, as the differences between localities were not entirely eliminated (owing to the research being conducted under nonartificial conditions); hence, the data cannot be considered wholly comparable.

Table 3. Behaviour of children at the moment of eating and amount of product consumed.

	First application		Second application	
Reaction				
Liked very much	52.5	75.0	40.5	78.6
Liked slightly	22.5		38.1	
Disliked slightly	12.5		19.0	
Disliked very much	5.0		—	
Uncertain	—		2.4	
Missing values	7.5		—	
Portion eaten				
All	65.0	72.5	69.0	78.5
Almost all	7.5		9.5	
About half	5.0		4.8	
Less than half	2.5		4.8	
Hardly tasted	12.5		7.1	
Missing values	7.5		—	

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