DEVELOPMENT OF AN INFANT FOOD PRODUCT BASED ON FERMENTED MILK, CEREALS AND SOYBEAN[1]

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SUMMARY

The objective of this work was to develop an infant food product based on yogurt, cereals and soybean. The experimental conditions to obtain the yogurt using milk and liofilized microorganisms, were: incubation period, 5 hours, a temperature of 41 ± 1°C and innoculum concentration, 3%.

Two protein mixtures were prepared: 1) corn-yogurt, with a protein supply relation of 65/35%, and 2) wheat-soy-yogurt with a protein supply relation of 20/60/20%, respectively. The mixtures were fermented during 24 hours at 37°C and spray-dried thereafter.

Artificial flavors, sugar and maltodextrins were added to the final product, in order to develop and instant purée. The protein content of the product was 11%, with a net protein utilization (NPU) of 80% in relation to casein. Banana was the most acceptable flavor.

This type of product represents an alternative to preserve milk in developing countries, obtaining a suitable baby food product.

INTRODUCTION

Cow's milk is a valuable and widely used product in infant feeding. In many rural areas of the developing countries, however, it is not evenly and sufficiently available, even though its production is abundant in certain seasons. Lack of adequate conservation and transportation facilities partially explains this situation. A sizable part of the produced milk spoils,

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Manuscrito modificado recibido: 4–12–87.

1 The project was partially supported by a CONACyT grant.

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and is consequently wasted (1-3). The development of means for prolonging the useful life of milk applicable in rural areas of developing countries could result in both economical and nutritional benefits, saving the resource, and making it available for infant feeding.

Among the methods for milk preservation, fermentation is effective and simple enough to be carried out at the household level. Yogurt and similar products combined with cereals have been used in the Middle East to provide infant foods with a good amino acid balance; in that region of the world, dishes combining yogurt and high extraction or parboiled wheat flour are very popular (4-7), suggesting that mixtures of this kind could serve the purpose previously stated. For some years, our group has been working along these lines, developing mixtures of fermented milk and cereals at laboratory level, and testing them in rural areas of our country (8, 9).

The purposes of the present study were: 1) to determine the most favorable processing conditions at pilot level for the preparation of yogurt, and of fermented mixtures with cereals; and 2) starting from a fermented mixture based on yogurt and cereals, to develop a product for infant feeding. This product should be accepted by at least 70% of the members of a panel, and have the following composition per 100 g: protein content not less than 10 g, with a NPU not less than 70%, no more than 10 g fat and 4 g crude fiber, respectively; a moisture content not greater than 7 g, and 1.1 to 1.25 of lactic acid.

MATERIAL AND METHODS

Experimental Development

Preparation of yogurt — The most adequate conditions for the preparation of the yogurt were established according to the procedure illustrated in Figure 1.

Design of protein mixes — This was carried out by linear programming designed in our Institute, which optimizes the chemical score and minimizes ingredient costs. The best mixtures were: a) yogurt, 20%, wheat, 60%, and deffated soybean flour, 20%; and b) yogurt, 65%, and corn, 35%.

Fermentation of the mixtures — The selected mixtures were fermented at 37°C for a period of 24 hours, according to Figure 2, and dehydrated by spray-drying.

Procedure control — This was executed along the preparation of yogurt and of the fermented mixtures by means of the determination of acidity increase (as pH and as percentage of lactic acid). The raw materials, as well as the finished product, were controlled through proximal and microbiological analyses, evaluation of the protein quality, shelf life, and sensory characteristics.

Formulation of the infant food — Sugar, maltodextrins, artificial flavors and water were added in different amounts to the fermented mixture, selecting those which rendered the best results.

The selection was done by determination of the viscosity of the formulation, using a commercial product of 65,000 cps as reference, and employing sensory panels at laboratory level.

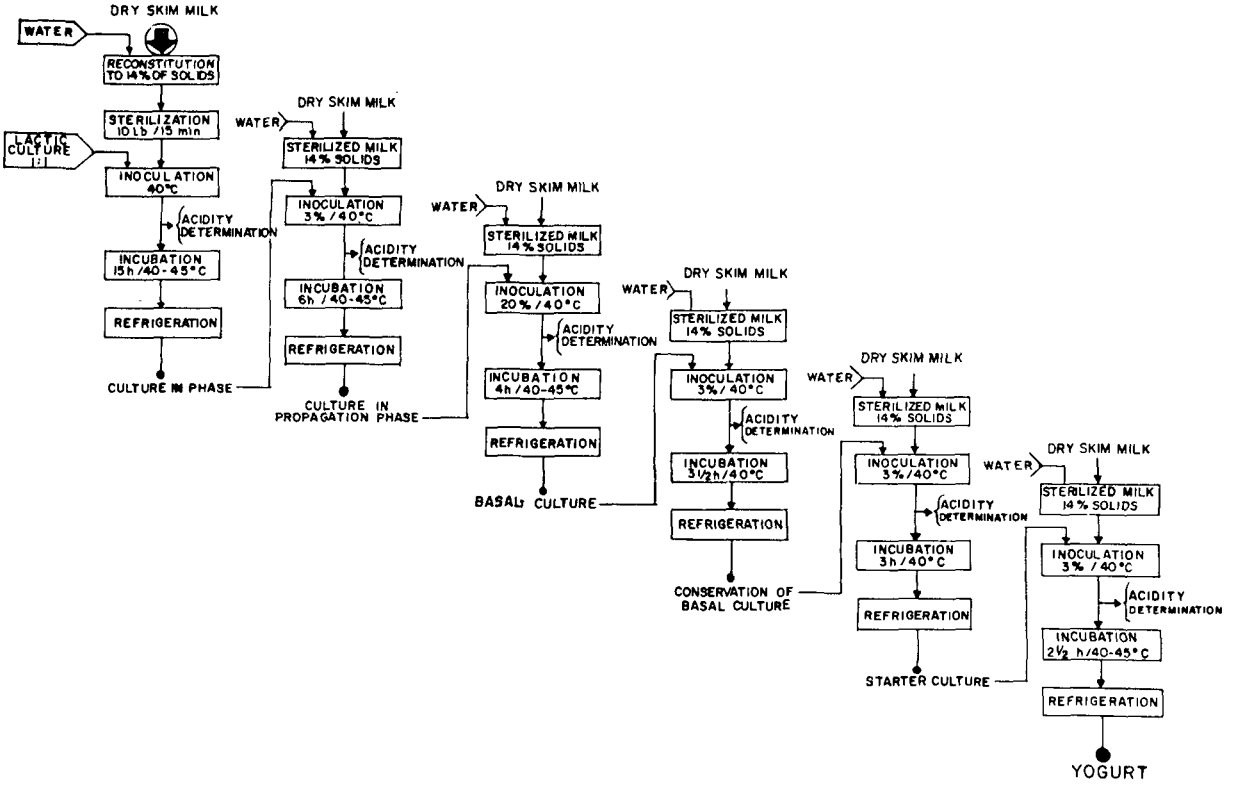


FIGURE 1

Preparation of yogurt at pilot level

Evaluation — The raw materials and the final product were evaluated by proximal and microbiological analyses and by sensory and biological tests.

Raw Materials

The raw materials selected were: 1) powdered skim milk; 2) defatted soy flour; 3) wheat flour; 4) uncooked milled corn; 5) lactic cultures (*Streptococcus thermophilus* and *Lactobacillus bulgaricus*) from

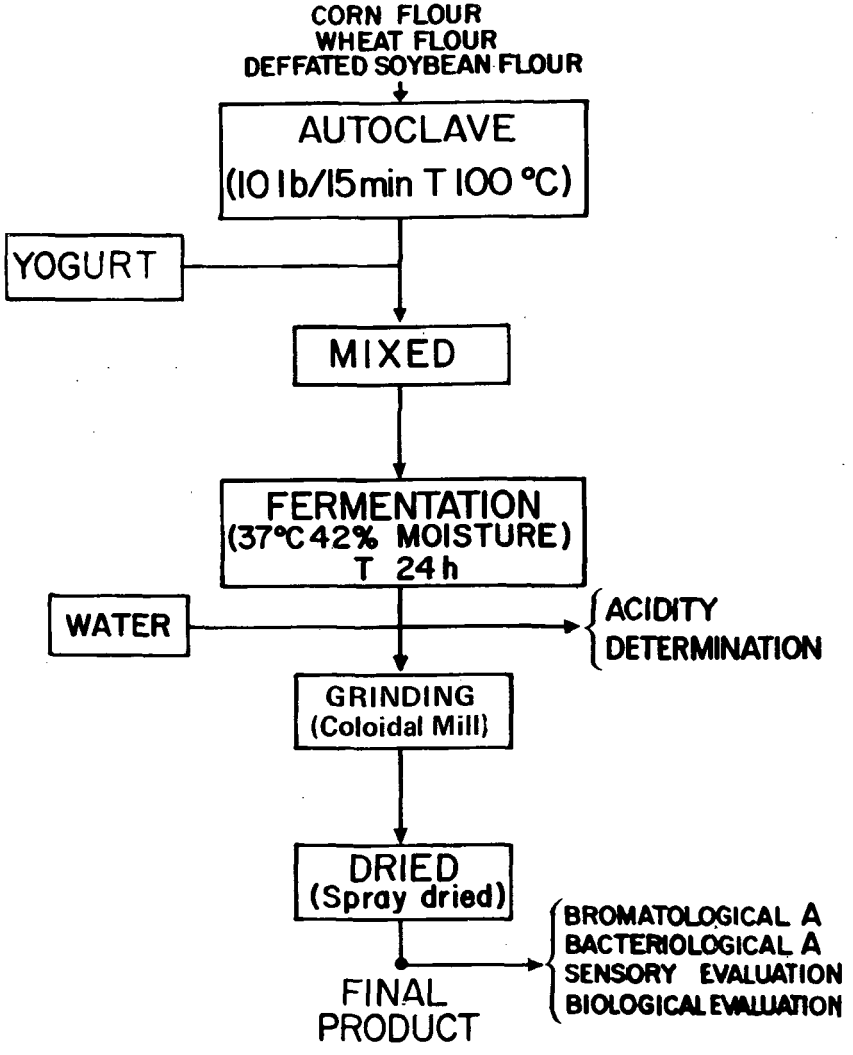


FIGURE 2

Procedure to obtain a fermented mixture based on yogurt and cereals

Cuamex, S.A., 6) two different maltodextrins (maltrin 10 y maltrin 30) from Glucosa, S.A.; and 7) eleven artificial flavors from Firmenich, S.A.

Methods of Analysis

Proximal — Humidity, using ovens (10); protein by the Kjeldahl method (11); ether extract, by the continuous extraction method (12); ashes, by incineration (13), and crude fiber by the acid and alkaline hydrolysis procedure (14).

Physical and chemical — The analyses were carried out as follows: temperature, with a Taylor thermometer (-10 to 110°C); acidity, as a percentage of lactic acid (15); pH using a Beckman Zeromatic Potentiometer (16); viscosity of the mixture when rehydrated in the form of "baby purée", by means of a Brookfield RVF viscosimeter at 20°C, with a No. 6 spin and at a 2 rpm speed (a commercial baby cereal was used as reference); and granulometry, by means of screens.

Microbiological — Total bacterial count was determined by using DIFCO plate agar culture medium (17); determination of fungi and yeasts on plate, with an agar-potato-dextrose culture medium (PDA) added with 10°/o tartaric acid (17); presumptive coliform test count, by dilution in Durham trochar tubes with a lauril-sulphate-triptose culture (LST) (17); and determination of the most probable coliform number, in Durham tubes (17).

Protein quality evaluation — A quantitative amino acid analysis of the mixture was performed by the Stein and Moore method (18) using a model 116 Beckman automatic analyzer. Determination of tryptophan was done using the technique of Spies and Chambers (19). Protein efficiency ratio (PER) was determined according to the Campbell method (20), and net protein utilization (NPU) as established by the Miller procedure (21).

Sensory Evaluation of the Product

Laboratory level — A panel test was carried out with a total of 30 non-trained judges. Preference tests (22) were undertaken for the purpose of selecting the most acceptable type and concentration of artificial flavors.

Community level — Evaluation at this level was carried out in a rural community (Santiago Texcaliacac) located 60 km Southwest of Mexico City. The panel was integrated by 160 persons: 40 panel members were children from four months to one year of age, and the rest were school-age children and mothers who offered the product to their four-month - 1 year-old babies. The product (25 g) was packed in plastic bags and handed to the mothers with instructions for its preparation. Then, it was tested, and a graphical facial questionnaire of acceptability was applied immediately after (21). A good-quality product was considered when 70°/o of the panelists accepted it in three levels: moderately, much, or extremely acceptable.

RESULTS AND DISCUSSION

Corn and wheat were selected on the basis of price and availability.

In order to reach 20-30°/o of protein content in the basic mixture, defatted soybean flour was employed; the main protein sources in the mixture were soybean and milk.

The bacteriological control performed on the raw material gave results which satisfied the standards established by the Mexican Health Authorities.

Since the fungi counts were high in corn, wheat and soy flours (500 col/g), these were autoclaved for 10 minutes at 100-120°C and 10 lb/in^2 pressure.

Yogurt preparation — The selection of the most adequate proportion of the cultures *(Lactobacillus/streptococcus) was* done by microscopic observation of the samples, reaching the proposed acidity.

Table 1 shows the *Lactobacillus bulgaricus/Streptococcus thermophilus* relation at different stages of the fermentation process, as well as the changes in acidity and pH. With a 3°/o inoculation, an optimum relation of 5/2 was obtained. This dilution was selected for tests at pilot level.

In order to reduce fermentation's cost and time, once the percentage of inoculum was selected, a "starter" culture –which reduces adaptation times and accelerates growth– was obtained through sequential cultures. In all the phases, a 3°/o concentration of the culture was used; a temperature of 40-45°C was mantained until an acidity of 1.10 g lactic acid/100 ml was obtained.

The behavior followed by the lactic cultures in the different activation phases is summarized in Figure 3. In general, the adaptation period of the microorganisms is reduced timewise, while growth is accelerated. Thus, during the "activation" phase, adaptation lasts four hr and growth lasts 11 hr, while for development of the starter culture, adaptation

TABLE 1

RELATION OF THE LACTIC CULTURE AND THE RESULTS OF pH AND ACIDITY DURING PREPARATION OF THE YOGURT

Inoculum	*Lactobacillus/Streptococcus* ratio	pH	Acidity (g lactic/100g)
Basal culture	1 - 1	4.5	1.3
1	10 - 4	4.4	1.3
2	4 - 3	4.2	1.2
3	5 - 2	4.3	1.1
4	6 - 3	4.3	1.1
5	3 - 1	4.0	1.2
6	4 - 1	4.0	1.1
7	6 - 2	4.0	1.2
8	8 - 1	3.9	1.2
9	2 - 5	3.9	1.2
10	1 - 10	3.9	1.2

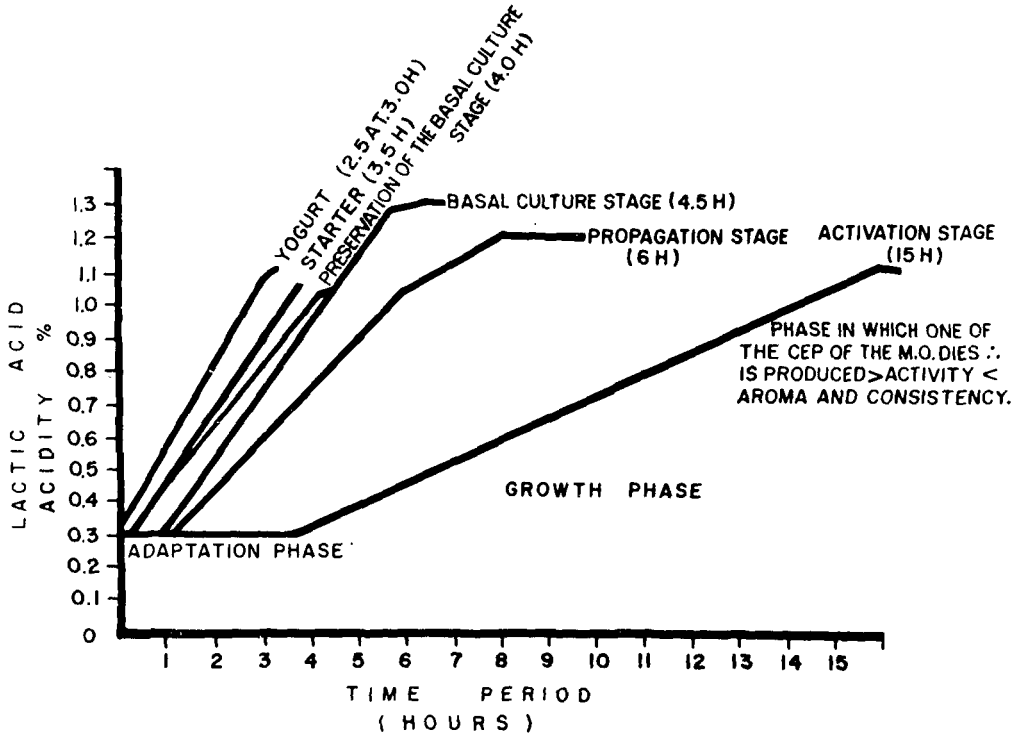


FIGURE 3

Adaptation phases of microorganisms for the preparation of yogurt

takes less than 30 minutes and growth takes only three-and-a-half hours. Using this starter for the yogurt preparation, adaptation is no longer needed, and growth proceeds until optimum acidity (1.10; pH 4.6) is reached at two-and-a-half hours. Yogurt was then prepared according to the selected procedure, using skim milk rehydrated to 14°/o solids, sterilized in autoclave (10 lb/in^2 pressure, 110°C, 5 minutes) and cooled to 40°C before adding the starter. The yogurt obtained presented good consistency, acidity and aroma. Briefly, the most favorable conditions for preparing yogurt at pilot plant level were: a 40 - 1°C temperature, a 2-1/2 hr period, and a 3°/o concentration of the starter culture.

Fermentation of the mixtures — Composition of the selected mixtures is presented in Table 2. These mixtures were prepared and fermented according to Figure 2. Fermentation was stopped after 24 hr when 2°/o acidity —which is recommended for these mixtures— was reached. In comparison with the mixtures fermented at the laboratory and domestic levels, a reduction in fermentation time, from five days to 24 hours, was achieved. Once fermentation of the mixture was concluded, water was added until the temperature (37°C) decreased to 20°C. The mix was then passed through a colloidal mill to uniform particle size, and then dehydrated with a spray drier, obtaining a brownish pink powder with a slightly acid taste and an aroma very much like that of malted wheat.

Formulation of the baby food — Up to 50 g of sucrose were added to 100 g of the fermented mixture, so as to provide enough sweetness, and counterbalance its acid taste; for optimal viscosity, 0.8 g of maltodextrin per 100 g of solids was needed. Water (130 and 100 ml for mixtures *a* and *b* respectively) was added for appropriate consistency. Banana was the preferred flavor. It was initially supposed that acid flavors such as orange and pineapple would be the most liked, since the basic mixture has an acid taste and these flavors could contribute to reinforce it, disguising the bitter of soybean flavor. Nevertheless, panelists preferred those flavors traditionaly employed in the preparation of baby foods, sush as apple, banana and vanilla. It was established that a concentration of 0.3 g of these flavors per 100 g of the formulation, was adequate. The formulations of the baby food are detailed in Table 3.

Evaluation — Composition of the yogurt and of the fermented mixtures is presented in Table 4. The microbiological analysis proved that the mixtures reached adequate sanitary conditions for human consumption.

The PER and NPU obtained with the two mixtures and plain yogurt are given in Table 5. The values of yogurt were similar to those obtained for casein; both mixtures showed a similar protein quality, equivalent to 90 and 80°/o of a PER and NPU of casein's, respectively. These values are satisfactory and compare favorably with those found in other studies (9, 23). The sensory evaluation of the products developed from the two mixtures at laboratory level revealed good acceptability in both cases, with slightly better results for the product based on yogurt-wheat-soybean. Considering these results and its calculated amino acid composition, the product prepared from the yogurt-wheat-soybean mixture was selected for the acceptability tests at community level. The results of this test are summarized in Figure 4, which demonstrates that the product was

TABLE 2

COMPOSITION OF THE SELECTED MIXTURES

(100 g mixture)

Ingredients	Amount needed (g)	Total protein (%)	Crude protein (g)	Ether extract (g)	CHO (g)	Amino acids as % of FAO/OMS 73*			Energy (kcal)
						Lysine	Meth. + Cys.	Tryptophan	
Wheat	48.3	20.0							
Soybean	36.6	60.0	25.4	3.0	56.6	113.0	93	137.2	355
Yogurt	15.2	20.0							
Corn	71.2	35.0							
Yogurt	28.8	65.0	13.1	3.9	74.4	85.2	113	122.2	385

* FAO/OMS 73: Lysine 4.8; Methionine + Cystine 3.5; Tryptophan 1.0 g/16 g N.

TABLE 3

FINAL FORMULATION OF THE FERMENTED MIXTURES FOR PREPARATION OF THE BABY FOOD
(g/100 g)

Mixture based on	Amount of mixture	Water	Sugar	Malto-dextrins*	Banana flavoring
Yogurt-wheat-soybean	35.6	46.4	17.8	0.30	0.10
Yogurt-corn	34.5	50.0	13.5	1.75	0.25

* Maltodextrins (Maltrin 10).

TABLE 4

COMPOSITION OF THE YOGURT FERMENTED MIXTURES
(g/100 g)

Product	Humidity	Ashes	Crude protein	Ether extract	Crude fiber	Carbohydrates
Yogurt	88.0	0.7	3.2	3.4	0	4.7
Fermented mixture based on yogurt, wheat and soybean	5.1	3.8	27.8	3.1	1.8	58.4
Fermented mixture based on yogurt and corn	4.2	2.2	10.6	3.1	1.9	78.0

well accepted by 75o/o of the population. Needless to state, it was quite stimulating to observe the good acceptance of the product by the babies included in the study.

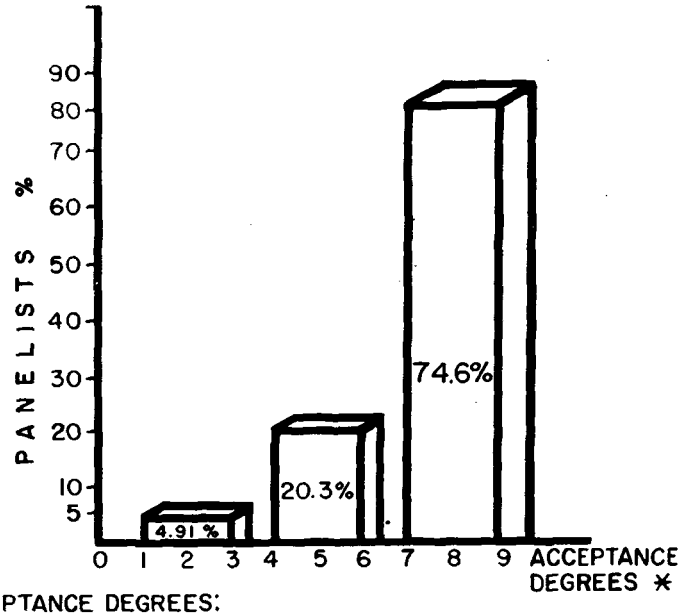
A 100 g portion of the baby purée prepated from 25 g of the dry product and water, provides 10 g of protein and 206 kcal. Thece percentages represent 50 and 23o/o, respectively of the Mexican protein and energy recommended allowances (24) for the 4 - 11 months-old-age group.

In conclusion, the developed product allows extension of the milk resources, making available a baby food with appropriate nutritional and acceptability characteristics.

TABLE 5

NET PROTEIN UTILIZATION (NPU) AND PROTEIN EFFICIENCY RATIO (PER) OF THE FERMENTED MIXTURES

Diets	PER	SD	PER as o/o of casein's PER	NPU	SD	NPU as o/o of casein's NPU
Casein	2.62	±0.73	100.0	59.8	± 4.9	100.0
Yogurt, wheat and soybean	2.35	±0.60	89.7	51.7	± 4.5	81.3
Yogurt -corn	2.41	±0.74	91.2	47.0	± 5.2	78.6
Yogurt	2.75	±0.25	104.0	61.4	± 7.1	103.0



* ACCEPTANCE DEGREES:
1-EXTREMELY DISLIKED UP TO 9, EXTREMELY LIKED
1+2+3-UNLIKED OR NOT LIKED
4+5+6=INDIFFERENCE
7+8+9=LIKED
(Nº OF PERSONS SURVEYED: 162)

FIGURE 4

Results from the product acceptance test based on yogurt-wheat-soybean

RESUMEN

DESARROLLO DE UN PRODUCTO INSTANTANEO PARA ALIMENTACION INFANTIL, CON BASE EN YOGURT, CEREALES Y SOYA

El objetivo de este trabajo fue obtener un producto de alto valor nutritivo para la alimentación infantil, con base en yogurt, cereales y soya. Las condiciones óptimas de elaboración de yogurt, a partir de leche descremada en polvo y cepas de microorganismos liofilizados, fueron: un período de incubación de 5 horas a 41 ± 1°C, y una concentración de inóculo de 3%. Se prepararon dos mezclas proteínicas: 1) maíz-yogurt, con una relación de aporte proteínico de 65/35% y, 2) trigo-soya-yogurt, con una relación de aporte proteínico de 20/60/20%, respectivamente. Las mezclas se fermentaron por 24 horas a 37°C y posteriormente se secaron por aspersión.

El producto final se adicionó de saborizantes, azúcar y maltodextrinas, con miras a formular una base para la preparación de una papilla "instantánea". El aporte proteínico de la papilla era de 11 g/100 g, con una utilización neta de proteínas del 80% en relación a la caseína. En cuanto a sabores, el de plátano fue el más aceptado. El desarrollo de este tipo de productos presenta una alternativa para la conservación de un valioso recurso, la leche.

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