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Report of Trip by H.H. Mottern

November 6, 1967 - April 30, 1968 to Bogotá, Colombia under PIO/T No. 514-097-2-70101 in regard to protein enrichment of arepas in cooperation with Instituto de Investigaciones Tecnológicas (IIT). Project 4364.

FINAL REPORT (Refer to Interim Report No. 1 to January 15, 1968).

Requested by: Ralph U. Battles IADS, Washington, D.C.

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1. SUMMARY AND HIGHLIGHTS

This Final Report, in conjuction with Interim Report No. 1, January 15, 1968 completes this project.

With the exception of developing a mechanical method of forming arepas the goals stated in the interim report have been accomplished.

A formula was developed for a mixed flour to be used in making enriched arepas with the minimal changes in the present product. These changes encompass pleasing color, desirable texture and established flavor preference.

The recommended formula for enriched arepa flour "ENRICAREPARINA" consists in 88.7 percent Opaque-2 flour, 5 percent soya flour, 5 percent corn gluten and 1.3 percent salt.

It appears that the process could be completely mechanized including the forming of the arepas but before this is undertaken it is advisable to determine the production scale by extensive market testing of enriched arepas to evaluate the potential volume of sales in any one locality.

The enrichment of arepas was greatly facilitated by the impending commercial availability (1969) of Opaque-2 corn in Colombia. This is made possible by hybrids of Opaque-2 developed by the Rockefeller Foundation at Tibaitata, Colombia with higher yields than the current open-pollanated varieties still largely grown in Colombia.

Application of the process to uncooked corn meal makes it applicable for widely scattered small businesses in Colombia.

2. RECOMMENDATIONS:

That technical assistance be given to companies making corn gluten and soya meal for feed purposes in order that sanitation be observed and flavor be improved to make a product of acceptable food quality.

That investigation of existing dough forming equipment be made to determine that this step in the manufacture of arepas can be mechanized.

That consumer testing, nutrition evaluation, market testing and test marketing be conducted to prove out the formulation and potential acceptability of the enriched arepa by the consuming sector of the populace.

3. REPORT:

INTRODUCTION

The author acknowledges the guidance and technical assistance of Dra. Teresa Salazar de Buckle, Chief, Analytical Section, and Dr. Pardo, Chemist, I.I.T., Bogotá, Colombia.

Arepas are the standard cereal in the diet of a large number of members of the lower economic group in Colombia, Venezuela and Panamá and constitute a large portion of the diet. They are unleavened corn cakes thicker than Mexican tortillas and usually not so large in diameter. They may vary in size in different localities from 5 cm. diameter and 15 mm. thick to 15 cm. diameter and 5 mm. thick. There are also fancy variations in shape including deep fat fried forms. Traditionally they are made by dehulling white corn either with lime (calcium hydroxide) or by dry or wet milling and cooking the resulting whole and broken grains for as long as 4 hours at the higher elevations of the Andes (2,000 to 3,000 meters). The cooked kernels are washed and cooled by rinsing with water. Made in this way much of the nutritional constituents of vitamins and minerals are lost. The cooled kernels are ground in a metal mill (formerly in a metate or stone mortar). The thick paste from the mill without addition of leavening or salt is kneaded into a dough (masa) with the hands and baked on a clay plate (tiesto) or wire grid over a charcoal fire. In some cases the arepa my be in direct contact with the charcoal. Baking is completed in 8-15 minutes and some burned spots are usually present even in more sophisticated methods such as on an electric grill. Baking is at a higher temperature than for wheat bread, either pan or biscuits.

The traditional arepa is bland in taste with a thin, smooth, tender crust. The inside is chalky white and has only a slight tendency toward flakiness. Hybrid yellow corn is not liked for human consumption and is

therefore little used for arepas, but is grown for animal feed and industrial use for starch and glue.

The campesino grows the corn he uses in arepas on his own tract (parcela). In the past much of the corn in Colombia has been consumed where grown and never reached commercial channels. As the campesino moves into the city as a laborer he buys dry hulled corn or prepared areas. An article in the daily paper in Bogotá "EL TIEMPO" March 14, 1968 stated that in El Rincón, an older section of Medellin where most of the arepas consumed in Medellín are made, 800 families are engaged in the enterprise of making arepas in crude factories set up in the kitchen or back yard. A daily total of 1,200,000 arepas are made and sold at 10 centavos each. It is this level of development that we are trying to reach with enriched arepas.

Hybrid corn is grown by large producers on contract with the larger users in Colombia. With higher yields there has been a tremendous increase in the proportion of hybrid to the total. The campesino has not yet learned to grow hybrid corn for his own use.

Research was conducted in 1966 at Instituto de Investigaciones Tecnológicas (IIT) toward the development of a commercial process for the manufacture of arepas (1). An English translation of the Summary, Conclusions and Recommendations is given herewith. This reports a distinct step forward in commercialization of the arepa process-viz-that of using ground corn with shorter cooking time than that required for whole grain. (In 1965 pre-cooked corn meal, Areparina, Productos Quaker, S.A. became commercially available) Distinct advances noted in the report were - the necessity of having the dough cold when kneading, the use of an oven that bakes both top and bottom simultaneously at a controlled period of time obviating the necessity of watching and turning the arepa, and the use of high temperature for baking to improve the appearance of arepas made with corn meal. Two points of issue are: first, in regard to standarization of the consistency of the dough with a Bostwick consistometer. To use the method requires 1:1 dilution with water. The cohesive character of the dough which develops on kneading is lost by dilution and this character is of the utmost importance. Secondly, it is stated that high moisture is conducive to the formation of a smooth crust. We have failed to find this to be true. Hand working of the dough and high temperature of baking are the two factors we have found to contribute to a smooth crust.

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(1) Commercialization of the Enriched Arepa and Its Nutritive Value, Yolanda Niño Orozco. I. I. T. Report, August 1966. Part 1, Laboratory Work.

Following is a translation of portions of this report.

"Summary"

"Corn is produced in Colombia in large quantities but the people have consumed it themselves in food products so that one does not find commercial industrialization. On the other hand it is a necessity to a majority for its nutritive value in the national diet.

"The present work contains data that serves as a basis for the standardization of the industrial process of arepa manufacture from the base of corn, hulled and enriched with soya flour.

"Hulled corn (germ and bran removed) is chosen as the raw material because it is corn that has undergone one step necessary in the preparation of arepas.

"The optimum conditions for the process were determined. It was found that whole de-hulled corn required 2-5 hours at 92°C to completely soften. The time necessary for cooking decreased if the grain was broken. A grain size that passes a No. 7 sieve and is held on No. 10 cooks quicker so that it serves to make arepas. In this case the corn softens to an adequate stage in only 13 minutes when heated at 92°C.

"It was found possible to use higher temperatures for cooking the corn if and when it did not exceed 110°C but if still higher temperatures were used the dough produced will be of inferior quality.

"It was found that (cooked) corn should be cold when it is milled and it was determined that the minimum time necessary for cooling the corn to 18°C was in accordance with the size of the grain.

"Using either a clay plate (tiesto) or an electric oven for the preparation of the arepas did not cause any differences in the amount of flavor and aroma. The appearance of the arepas baked in the electric oven was more uniform.

"An initial temperature of 330°C (658°F) was suitable for the oven. Using this temperature the arepas required 25 to 28 minutes in the open oven and 15 to 18 minutes in a closed oven to be done. During the baking the arepa lost water, the sugar content increased, and the starch diminished.

"After evaluating different physical apparatus it was found that the measure of the consistency is a good index for knowing the degree of cooking of the corn. Following a special method and using the Bostwick consistometer (diluting with an equal quantity of water) it was observed that when the

dough had the quality desired in arepas it gave a consistency of $11^{\pm 1}$ at 20°C., producing arepas with very good texture.

"Soya and cottonseed cake were used to supplement the protein of corn and increase the nutritive value of the arepas. When soya was added at 10 percent (dry basis) it raised the protein content of the arepa 50 percent and the results of the organoleptic tests were higher than that given to the arepa prepared from the base of corn and salt only (1.3 percent on dry weight of flour . See p.16 of report). Also the storage life of the arepa at 18°C is prolonged a little.

"Cottonseed cake did not give good results because the characteristics of odor and taste prejudiced it.

"Conclusions"

"1) - Since corn is one of the principle agricultural products and the arepa a food of great national consumption, the commercialization is justified of an arepa enriched in nutritive value with the aim of effectively contributing to the improvement of the diet of the Colombian people.

"2) - Of the three classes of arepas consumed in Colombia (those prepared with a base of hulled yellow corn, a base of hulled white corn and those prepared with pounded corn), the most popular are those prepared from a base of pounded corn.

"3) - The process of cooking the corn is the most important factor in the preparation of arepas. The larger the particles of grain, the higher the temperature and the longer the time necessary for optimum cooling.

"4) - The smallest size at which one can handle corn for production of dough is a size that passes a No. 7 sieve and is retained on a No. 10. In this case the corn is in good condition for cooking in 13 minutes.

"5) - When the temperature of cooking is above 110°C the dough becomes more gelatinous giving the arepas a gummy texture.

"6) - The dough must be cold when it is worked in order to obtain arepas of good texture. The time of cooling depends on the size of the granule of maize.

"7) - There is no noticeable difference between the arepas baked in a clay plate and those baked in an electric baker in amount of aroma and flavor, but the appearance of the arepas is more uniform when they are baked in the electric baker.

"8) - The temperature of the inside center of the arepas does not go above 90°C Before the arepas are done the temperature of the external portion can rise to 250°C.

"9) - In the open electric baker the arepas required from 25 to 28 minutes for baking. In the closed oven the arepas required from 15 to 18 minutes for this toasting.

"10) - High temperatures (during baking) and moisture in the outside part of the arepas a little before introduction into the oven favor the appearance of the arepas produced.

"11) - The Bostwick consistometer is a rapid method and sufficiently exact to judge the cooking of the corn. Each change in the time variables, degree of grinding the corn, moisture retained on the surface, and time of cooking affected the reading of the consistency.

"12) - When the dough with which the arepas are made shows a consistency at 20°C of 11 $\pm$ 1 the texture of the product will be excellent (diluted 1 to 1).

"13) - The addition of soya flour besides increasing the nutritive value extends the storage life of the arepas. Imported and domestic Mancini (Manteca La Americana) soya flours improve the flavor of the arepas. The soya flour made in the Institute produced in the arepas a sweet flavor little desired. (slightly undesirable).

"14) - The addition of soya required no change in the process of making the arepas, the soya flour can be added with the salt.

"15) - The enriched arepas kept well during 24 hours without the necessity of special packing.

"16) - Cellophane and polyethylene kept arepas for 3 days at 18°C and 65 percent relative humidity. (a climate like Bogotá). At 25°C and 80% relative humidity they were protected for one day only.

"17) - Common Kraft paper gave no appreciable protection to the arepas.

"Recommendations"

"1) - Commercialization of arepas from hulled corn is more simple than with whole grain because the process of hulling and scalping (de-germing?) the corn is eliminated.

"2) - Since corn can be cooked in different ways a cost study is recommended so that industry can choose between milling the corn or cooking for a longer time.

"3) - The temperature of cooking (the corn or meal) should not exceed 110°C, nor should the (cooked) corn be kneaded while hot because it produces a very gelatinous dough.

"4) - The enclosed electric baker is more practical since it avoids the work of turning the arepas and presents less loss of heat, reducing the time necessary for baking.

"5) - Examination of the swollen grains of starch can be related to the texture shown by the arepa. It is recommended to continue investigations initiated in this respect with the idea of obtaining sufficient statistical data.

"6) - The addition of soy flour with or without fat is recommended not only because of higher nutritive value of the arepas but also the shelf life is prolonged.

"7) - Use of deodorized soy flour is recommended in the supplementation of the arepas in order to avoid off flavors and odors that lower the quality of the product.

"8) - To improve the nutritive value it is preferable to use full-fat soy flour in place of using de-fateed soy flour. It is recommended to make a biological analysis with white rats or with chickens in order to prove experimentally the improvement of the nutritional value.

"9) - If it is necessary to preserve the arepa for a period longer than 24 hours in a climate such as Bogotá it is recommended packing in cellophane or polyethylene which affords good protection to the product. In order to preserve the arepas in a more adverse climate it is necessary to use other kinds of packing materials or some additive that protects the arepas from deterioration." (end of translation).

On November 28, 1967 a conference was held at IIT at which the arepa project was outlined. Various sources and types of corn and protein materials were discussed. It was proposed that samples of maize from 5 different regions be obtained as follows: Valle del Cauca, Antioquia, Llanos Orientales, Bajo Magdalena and Sabana de Bogotá and that the following sources of protein be considered; soybean, soybean meal, residue from soya milk preparation and sesame. Cottonseed meal was added for consideration and investigation.

A survey was made to determine the available raw materials. At a conference at I.I.T. on December 1st with Dra. Salazar de Buckle, Dr. Iregui and Dr. Moncada it was decided that Dr. Iregui would obtain samples representing the various types of corn available in Colombia.

After visits to Rockefeller Foundation at Tibaitatá and to Productos Quaker and Maizena in Cali (2) it was decided in view of the impending availability of Opaque-2 corn with high protein and high lysine and the interest in this variety by commercial companies that Opaque-2 would be given prime consideration. Quaker has developed a pre-cooked flour for arepas from Opaque-2. This was selected for the corn fraction of the enriched arepas since it offered the greatest increase in protein availability with the minimum change in texture and color of arepas.

Secondly it was decided to use soya to correct the deficiency of lysine in the use of corn gluten of 60% percent protein. The availability of good quality soya flakes from Manteca La Americana in Cali supported this decision. An interim report covering the period November 6, 1967 to January 15, 1968 was prepared by H. H. Mottern on this initial phase of the study.

On December 20, 1967 the formula for enriched arepas was proposed on the basis of correcting the deficiency of corn gluten in lysine by adding an equal quantity of 50 percent protein soya flour along with corn gluten (see H.H. Mottern notebook p.20). Thus a mixture of Opaque-2 90 percent, soya flour 5 percent and corn gluten 5 percent, yields a flour with 15.3 percent protein and 4.1 g lysine per 16 g N.

Due to delay in receipt of corn gluten this formula was not made into arepas until February 16, 1968 (see p.92 of H.H. Mottern Notebook) Salt was included in the formula at a concentration of 1.3 percent of the total weight of the harina. This level of salt had been found desirable in previous work on arepas at I.I.T.

The plan of attack for this project presupposes that in enriching the arepa some change will be made but that it is desirable to keep this change minimal with regard to color, texture and flavor. It is also assumed that the consuming sector will be the laborer - the campesino who has moved to the city and brought his eating habits with him. It is concluded that to overcome prejudices in regard to differences between enriched arepas and the established "Peto" arepa minimal changes must be made in an acceptable manner. Thus the color must be pleasing and the flavor a familiar one like corn. Also cost must be low. Preferably a convenience factor should be

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(2) See Interim Report by H. H. Mottern - January 15, 1968

included, such as less cooking.

EQUIPMENT:

Milling: I.I.T. does not have equipment for milling corn (removing hulls and germ). However a Raymond Pulverizer (hammer mill) was available for grinding material to a flour. A CONDUXWERK pin mill rotating at 1500 RPM did not give as fine a grind as the Raymond mill.

A Reitz disintegrator was tried with both dry and soaked (wet) corn but it did not yield a preferential breaking of the endosperm without high losses due to adherance of the endosperm to the hull.

MIXING:

A model 305 Sprout-Waldron Mixer was obtained with the AID equipment purchase but installation was not completed. Since it can be heated by a steam jacket it would seem to have use in steaming soy flakes and corn gluten and cooking raw corn meal and mixed harinas for arepas as well as mixing harina.

Small quantities of harina, up to 3.5 Kg. were mixed in a "ROTAMIXER" tumbling mixer and in a table model Hobart mixer, both located in the Farinology Laboratory.

KNEADING:

The mixing bowl from a Brabender farinograph was used to work small quantities of dough. It was turned by a motor with a reduction gear. It handled 300-400 g. batches of masa very well in five minutes working time.

A Braibenti pasta mixer-extruder was used in mixing 5 to 6 kilogram batches of harina and 12.5 to 15 K. of masa. Ten minutes working time of the masa was satisfactory if in addition the masa was extruded through the screw mechanism without the die. More time was required for mixing the masa if the screw extruder was not used.

A DRAIS mixer-dough maker, manufactured by Drais Werke in Mannheim, Walhof, Germany, Model F1-1960 Ser. No. 32648, was used to mix 4 to 5 Kg. of enriched harina and from 7.5 to 12.5 Kg. of masa. This machine did a through job of mixing the harina in 10 minutes running time. In making the dough, water was added to the harina in the mixing bowl while the

mixer was operating. Mixing was continued for one minute, then the mixture was allowed to stand for 5 minutes before working the masa for ten minutes.

A slicer for arepas was developed by Drs. Salvatore Merola and Peter Montes S. of the Engineering Section of I.I.T. It consisted in a series of fine "piano" wires strung between rigid steel rods. The wires were spaced to give the desired thickness to the areas.

BAKING-EQUIPMENT:

No baking oven was available that would give sufficiently high temperature (ca = 400°C) and infra-red heat necessary to gelatinize the crust of the arepa and bake without excessive drying. The Simon Rotary Test oven in the Farinology Laboratory when operated at the maximum temperature of 266°C (510°F) dried the surface of the arepa excessively yielding a hard dry crust wity many cracks and required 30 minutes to produce light browning.

The I.I.T. enclosed electric oven used in previous work was reported to give good results by Yolanda Niño in the 1966 report. However, it was in a bad state of repair with the upper heating coil being loosely supported and dropping close to the arepas supported on an iron grid. Because of dangers of shorting and of electrical shock it was not used.

An oven was constructed using two 1000 watt. open grid hot plates obtained for $50 Col. from Ley's. The heating element of one was secured by two rows of double pointed tacks straddling the coils and inserted into drilled holes in the transite sheet backing. An additional 6 mm transite sheet was placed back of the heating element to prevent contact with the protruding points of the tacks. This hot plate was inverted over the other at a height of 15 cm. frame to frame. The grill provided with the hot plate was supported 8.5 cm. above the bottom hot plate in such a manner that it could be inserted when filled with arepas, and removed when baking was complete. The two hot plates were surrounded on all sides with common clay brick. Two bricks standing on edge in front served as a door to the oven.

A General Electric Toaster-Oven was used to bake up to 4 arepas. Since arepas require a longer time at a higher temperature than toast, the thermostatic setting was changed to accomodate the required conditions. It performed nicely.

MATERIALS AND METHODS

Arepas from "Peto"

Although the traditional method of making arepas call for soaking the corn and wet milling to remove the husk and germ there is a large quantity of arepas prepared from corn that has been dry milled or wet milled and dried. This process is used mostly by the campesino who has moved into the city and no longer grows corn on his own farm (milpa or parcela). Both white and yellow corn were cooked at 93°C (elevation 2600 m.) for 3½ to 4 hours or longer. When considered soft enough to mill the cooked corn was cooled by several washings with cold water and put through a hand operated mill similar to a coffee grinder. These mills are sold in large quantities for grinding cooked "peto".

HARINA FOR AREPAS

The smaller the particle size the faster corn can be cooked but if too fine it cannot be washed free of solubles. Corn meal (called grits in Colombia) was cooked in 15 to 20 minutes at 93°C., allowed to cool and worked up into a masa. To accurately time the cooking, 150 g of grits were stirred into 200 to 225 cc of boiling mater. As soon as wetted the mixture was placed in the inner vessel of a double boiler and allowed to remain for the specified time. The inner vessel was then placed in a pan of cold water to cool. After cooling to 35°C or below the cooked meal was worked into a masa. Arepas made in such manner have a different flavor than those from "peto" but are consumed to a minor extent. Such dough can be enriched by incorporating an enriching mixture into the masa at the time of working.

Pre-Cooked Arepa Harina, "AREPARINA"

The preferred method of enriching arepas is to combine the enriching materials into a pre-cooked and pre-mixed harina which needs only be added to cold water to form a masa. This gives an accurate composition to the mixture and provides the maximum convenience to the house-wife next to direct purchase of arepas.

RAW MATERIALS

Proposed Specifications for raw materials are included in Appendix.

OPAQUE-2 CORN

The Rockefeller Foundation at Tibaitatá, Colombia, has developed a hybrid strain of corn with the Opaque-2 gene. Seed will be ready for release in quantity in 1969. A commercial source can be obtained by contract growing. Although it does not produce as large yields as yellow dent hybrid the yield is higher than open pollenated varieties. Opaque-2 meal contains 12.6 percent protein (dry wt.) and 4.1 g lysine per 16 g N compared with 8.8 percent protein and 2.6 g lysine per 16 g N for regular corn. Opaque-2, becuase of its softness, does not mill well by the wet process. In dry milling a harina with 3.75 percent lipids is obtained. Opaque-2 can be used either as the pre-cooked product, Areparina, produced by Quaker or by cooking ordinary corn meal, known as grits in Colombia, for 15 minutes at 93°C in a double boiler. Quaker made available for our work experimentally pre-cooked harina from Opaque-2 corresponding to their commercial "AREPARINA" made from white corn.

In view of impending availability of Opaque-2 corn in Colombia in 1969 and the availability of experimentally pre-cooked meal from productos Quaker in Cali, this become the logical starting material. Should there be a desire to start manufacture of enriched arepa before Opaque-2 is commercially available, intermediate steps can be taken with available corn or if it is desired to use raw corn meal this too can be accomplished by precooking the enriched harina and cooling before working the dough.

SOYA

Soya flakes of fair quality of 50 percent protein and only slight beany flavor were obtained from Manteca La Americana at Cali. The first lot was steamed to reduce the beany flavor. A second lot had so little beany flavor it was used without steaming. After steaming the flakes were dried at 70°C for 1 hour. Flour was made by griding in a Raymond Pulverizer using the 1/64th screen. A Condux-Werk pin mill rotating at about 1500 r.p.m. was tried but it did not give as fine a flour as the Raymond. An Alpine Kolloplex pin mill rotating up to 14,000 r.p.m. is recommended for this use. Manteca La Americana sells 50 percent soya meal for 1500 pesos per metric ton, equivalent to 1.50 pesos per kilo or 4 ¢ U.S. per pound.

Plans are underway for the construction of a 300 ton. per day soy plant in Cali by Lloreda Grasas, Calle 30, No. 10-22 Cali. The plant is

German built and is to be in operation by June 1969. Part of their production is intended for food use. This plant alone could process as much as the entire 1967 production of 72,750 tons of soybeans in Colombia in only 242 days operation. This shows the confidence in the future increase of soya production in the country. Some of the increase in acreage is coming from farmers who have been growing sesame but are turning to soya because of the difficulties that sesame culture has encountered. Other acreage is coming from change over from cotton production.

Defatted soy flour is under study at I.I.T. Two products were considered for enriching arepas. One was the residue from the preparation of soy milk by extraction of ground de-corticated beans with hot water. This is a bland product of good color and flavor but contains only 30 percent protein. This was rejected because it is not available commercially nor would it be a main product from soya. Furthermore, because of its lower protein content larger quantities would need be used. Ten percent of 50 percent protein soy flour was found to alter the texture of arepas appreciably and the same would likely be the case with the soy milk residue.

A second process under study at IIT involves grinding decorticated soy in a Raymond mill, extracting the full fat flour in 10 kg. lots in a specially constructed jacketed vessel equipped with an agitator, then steaming to desolventize and heating to 120°C for 20 min. to eliminate beany flavor and destroy trypsin inhibitor. This is not a commercial process. In large scale operation, beans are flaked to facilitate exposure to the solvent. A good product was obtained in the laboratory and likely will be obtained in the pilot plant but the process does not seem adaptable to large scale use for a minimum cost product. It would be better to work with existing companies such as Manteca La Americana to up-grade the process to make edible defatted soy flour at little increase over present costs. When better soy flours are available by whatever process they can be used in the I.I.T. arepa formula.

CORN GLUTEN

Corn gluten is available from Maizena, S.A. in Cali at 2,700 pesos per metric ton. This is only slightly higher than corn meal at 2200 pesos per metric ton and represents a cost of 1.20 pesos per pound for the gluten and one peso per pound for corn flour. Maizena estimates that a food grade gluten can be made for a 10 percent increase in price.

Maizena, S.A., a subsidiary of Corn Products of Canada Ltd., uses the liquid cyclone process in separating corn gluten from starch. The plant employs 9 stages of 160 centrifugal tubes for each stage. The plant is

operated 24 hours a day 5 days per week. Sr. Oswald Martinez and Dr. Leo Artz were told of the use of the process on cottonseed flour and were referred to Southern Utilization for details.

COTTONSEED FLOUR:

Productos Quaker uses about 20 percent cottonseed flour and 20 percent soya flour in Incaparina. The cottonseed flour is made from pre-press cottonseed cake. It is dark colored and a sample obtained had 8.72 percent fat.

Glandless cotton has not previously been grown in Colombia. A sample of Deltapine Smooth Leaf Glandless cotton seed was sent to Sr. Ismael Collazos R. of the Institute for cotton development in Bogotá, in August 1966, This was planted in the Codazzi area in Cesar province in Colombia. The crop was harvested in February of 1968. Sr. Collazos has promised a report on its growth characteristics. A 2-pound sample of Acala Glandless cotton seed was furnished Sr. Collazos who had it planted in the Cauca Valley in March 1968. This is the first known introduction of glandless cotton into South America. A sample of glandless cotton seed flour made from Gregg 25 C was brought into Colombia for trial in the arepa project.

A sample of liquid-cyclone prepared cottonseed flour was received from Mr. H.L.E. Vix, Chief, Engineering and Development Laboratory, Southern Utilization Division, New Orleans, La. This had the following analysis:

Moisture	1.0%	Lipids	0.64%
Protein	68.9	Fiber	2.6
Free Gossypol	0.07	Ash	8.49
Total Gossypol	0.25	Nitrogen Solubility	98.28
EAF Lysine g./ 16 g N	3.84		

This sample had good color and flavor but the free gossypol is considered too high for use in a food product. Further reduction of free gossypol would likely reduce the EAF lysine below the 3.84 g per 16 g N of the present sample.

SESAME:

Sesame flour was given only minor consideration because of production problems facing the farmers who are turning to growing soya instead. There is one powder product "Pochito" on the market in Colombia that uses

5 percent sesame flour along with soya. It is used for a variety of purposes such as a beverage and in soups.

EXPERIMENTAL

Raw materials were analysed and results are summarized in Table 1.

Both Brabender amylographs and farinographs were determined by Sr. Pardo on the various harinas available. Results of the amylographs are summarized in Table 2.

Results of the farinographs are shown in Table 3. The uncooked corn flours did not give results under conditions obtaining in the farinograph.

Potentiometric titrations of some of the corn flours were made also by Carlos Pardo.

TABLE 1

ANALYSIS (AS IS BASIS)

	Moisture	Fat	Ash	Fiber	Protein
"Areparina", Current 71215-Ar-1	12.30%	1.23%	0.67%	1.78%	9.77%
"Areparina"71215-Ar-2 Opaque-2	12.20	3.77	1.20	2.12	11.18
White corn meal Indumaíz 71206-H1	13.50	2.10	0.56	1.14	8.88
Yellow corn meal Indumaíz 71206-H-2	13.30	2.33	0.93	1.56	8.90
Maiz "peto" Commercial 71219-H-5	11.20	2.28	0.87	1.79	9.90
"Paisarina" Flour for arepas 71221-H-4	13.40	0.00	0.33	2.70	9.37

TABLE 2

CHANGES OF VISCOSITY WITH TEMPERATURE USING BRABENDER AMYLOGRAPH

Rate of Heating: 1.5°C/minute
Time at 90°C. = 20 minutes

Rate of cooling: 1°C/minute
Concentration, (dry basis) 10%

SAMPLE	Tg C	Mg	Vm BU	Mn	Vr BU	Ve BU	Mn - Mg	Vm - Vr BU	Ve - Vr BU	Ti °C
White corn meal degerminated, Indumaiz 71206-H-1	74	35	560	66	560	900	31	0	340	21
Yellow corn meal degerminated, Indumaiz 71206-H-2	72	34	410	46	370	710	12	40	340	21
degerminated corn flour "Paisarina" 71221-H-4	75	36	660	66	660	880	30	0	220	21
Corn meal "Pato" commercial 71219-H-5	75	36	320	66	320	760	30	0	440	21
"Areparina" Quaker current manufacture 71215-Ar-1	74	35	80	66	80	165	31	0	85	21
"Areparina" Opaque-2 experimental 71215-Ar-2	74	35	100	66	100	210	31	0	110	21

TABLE 2. Continuation

Tg = Temperature of gelatinization.

Mg = Minutes to reach the temperature Tg.

Vm = Maximum viscosity during heating.

Mn = Minutes to obtain Vm.

Vr = Viscosity after 20 minutes at 90°C.

Ve = Viscosity on cooling to 50°C.

Mn - Mg = Ease of cooking.

Vm - Vr = Stability of the starch.

Ve - Vr = Index of gelatization.

Ti = Initial temperature.

TABLE 3

FARINOGRAPH RESULTS

25 g. Flour 37.5 cc. Water

	Maximum Strength	Absorption cc.H_2O/100 g.	Development Minutes	Stability Minutes	Tolerance B. U.	Volumetric Index	Temperature C
Areparina 71215-Ar-1	615	150	3-3/4	4-3/4	45	56	30
Areparina Opaque-2 71215-Ar-2	690	150	2-1/4	2-1/4	120	42	30
Sample-1	465	150	5	7	35	56	30
Sample-2	450	150	4-1/2	6-3/4	35	56	30
Sample-3	510	150	2	2-3/4	50	38	30
Sample-4	505	150	2-1/2	2-1/2	40	39	30
Hard Wheat	500	61.5	2-1/2	11	40	70	30 (1)
Soft Wheat	500	52	2	3	115	38	30 (1)

TABLE 3. Continuation

Sample 1: Areparina current manufacture with 5% soya flour.

Sample 2: Areparina current manufacture with 10% soya flour.

Sample 3: Areparina, Opaque-2 with 5% soya.

Sample 4: Areparina, Opaque-2 with 10% soya.

See: Matz, Samuel A. Ph. D.
Baking Technology and Engineering
The Avi Pusblishing Co., Inc. (1960)
West Port, Connecticut

FORMULATION

In enriching arepas the object was to make the least change possible consistent with a substantial degree of protein enrichment. Enrichment of harina, either pre-cooked or raw, with the indigenous materials selected makes only minor changes. It is important to keep the changes minimal so that they will be acceptable. Color may be different if it is pleasing. Convenience of preparation contributes to acceptability of an otherwise less desirable product as witnessed by acceptability of pre-cooked rice in U.S.A.

The greatest boost in enrichment with the least change in character comes from the use of Opaque-2 corn. The color of the arepa made with Opaque-2 corn is light yellow and not as deep yellow as arepas made entirely from yellow hybrid corn. Instead of being bland as in peto the flavor is more like that of roasted corn, a familiar flavor greatly liked by the Colombian people.

Incorporation of as much as 10% of soya or cottonseed flours changes the texture of the center of the arepa from a flaky to a gummy consistency. At five percent levels this change is minimal. Incorporation of as much as 10 percent corn gluten does not change the consistency noticeably but this protein is deficient in lysine (2.3 g per 16 g.N.). Mixing equal parts of 50 percent protein soya flour with 60 percent protein corn gluten restores the lysine balance. Incorporation of 10 percent of this mixture in a formula with Opaque-2 corn meal increases the protein content from 11.1 percent to 15.3 percent. The natural yellow color developed by Opaque-2 on baking arepas masks the yellow color of corn gluten and the slightly brown color of presently available soya flour when these are added at a 5 percent level. It is a happy marriage, or dare one say "triangle".

Both glandless and liquid-cyclone prepared cottonseed flours gave acceptable color and flavor. Arepas made with inclusion of ten percent of these two flours were comparable in color and texture with those made with the same amount of Colombian soya flour. They have the same gummy texture in the center. When used as the source of enriching protein they maintain the lysine content of Opaque-2 corn close to the FAO recommended level, but when they are combined with an equal part of corn gluten to render the texture desirable the low lysine content of the corn gluten is not corrected. Pre-press cottonseed flour of the quality used by Productos Quaker in Incaparina in Colombia greatly darkened the arepa so that it was totally unacceptable from the standpoint of color.

Following the above considerations and with results of experiments the following formulation for enriched arepas, "I.I.T. ENRICAREPARINA", was evolved.

Opaque-2 corn meal, precooked	88.7%
Soya flour from steamed flakes	5.0%
Corn gluten, steamed	5.0%
Salt, fine flake, dairy	1.3%

This mixture has the following calculated protein and lysine make up.

PROTEIN MAKE-UP OF "I.I.T. ENRICAREPARINA"

	Opaque-2 Corn Meal	Corn Gluten (1)	Soy Flour	I.I.T. Enrica-reparina
PROTEIN	11.1%	60% min.	50%	15.3
MOISTURE	12.2	10 max.		
PROTEIN DRY BASIS	12.6	66.7 min.		
I.I.T. FORMULA	88.7%	5%	5%	98.7%
PROTEIN CONTRIBUTED g/100g	9.8 g.	3 g.	2.5 g.	15.3 g.
LYSINE g/16 g.N IN PROTEIN	4.1 g.	2.3 g.	6.4 g(2)	4.1 g.
CONTRIBUTED	0.41%	0.05%	0.16%	0.62%

(1) Values supplied by Maizena, S.A. Cali, Colombia
(2) Mean of value given by Altschul Processed Plant Protein Foodstuffs (1958) P. 881.

Lysine determinations by I.I.T. showed g. per 16 g.N for the enriched harina and g per 16 g.N for the baked arepas. Lysine and tryptophan values as well as PER are also being determined on both the harina and the baked arepas under the direction of Dr. O.C. Johnson of the U.S. Public Health Service, Bethesda,Maryland.

The use of a premixed harina for arepas permits the standardization of the product at a pre-determined level of enrichment. Nutritional and analytical evaluation of the present formula may dictate modifications but it is thought these will be of a minor nature and will not greatly alter the present concept. For example it may not be desirable in some cases to use pre-cooked corn. Quaker states they have little sale of areparina in 35Kg. bags but the sale of the 500g. bags has "increased tremendously". This means the arepa factories have not converted to the use of pre-cooked flour. Arepa factories larger than the household enterprises may install equipment for pre-cooking on the premises and combine the steaming of the soya and gluten with

the cooking so that a product of low microflora population is obtained. Such a product made into arepas may have a longer shelf life from a microbiological standpoint and be suitable for packaging in polyethylene. Ten minutes steaming of such a mixture at 100°C., cooling, then working the dough is only slightly more complex than using pre-cooked harina mixture and offers the arepa manufacturer a choice of sources of corn meal from the many millers in Colombia.

STEAMING

Steaming of soya flakes and corn gluten was accomplished in a double boiler "MODEMEL" which had a perforated unit into which a standard 60-mesh sieve was fitted. This sieve was covered with about 100g of material. Soya was steamed for 15 minutes and corn gluten for one hour.

A steam jacketed kettle equipped with Teflon scraper blades was used once to steam corn gluten. Using 10 Kg. of gluten, agitation was not satisfactory. Addition of 10L. water during the heating period caused some of the material to form balls which did not dry as fast as the remaining granular material. This necessitated grinding and the damp material of the balls clogged the Raymond mill. The ground material had a moisture content of 23.16% and had to be oven dried for preservation. Although the material produced had a satisfactory flavor the many difficulties with this equipment make it unsuitable for mixing and steaming. A better method was to steam in a bacterial autoclave at 115°C. for 15 minutes while exposed in a layer 15 mm. deep in a shallow aluminium tray.

DOUGH MAKING

Working or kneading the corn meal-water mixture is an integral and necessary part of the process of preparing the corn dough (masa) for arepas. Corn meal does not develop the characteristics of gluten in wheat and must depend upon partial gelatinization of the starch to form a cohesive dough. On the other hand if the starch is over cooked the dough becomes gummy or pasty and loses desirable characteristics. In the antioqueño process using peto, the grinding mill plus hand working accomplishes the desired result so that the masa can be molded with the hands into desired shapes. Working by hand is not too laborious for a family operation but industrialization of the process necessitates mechanical equipment. Fortunately, existing dough making equipment is satisfactory for working masa for arepas. Both Braibenti pasta (alimentary paste) equipment and the "Drais" Mezclador-Amasador (mixer-dough maker) were found satisfactory for use.

Probably the Sprout-Waldron double spiral mixer purchased under the AID Project could be used for mixing both the enriched harina and for working the dough. This equipment was not operable because of incompletion of wiring of the over-load cut-out and installation of steam connections.

Hobart equipment might also be used for this purpose. The small table Model Hobart mixer was in constant use by the Farinology Laboratory and was available only once for mixing harina.

Dough is best used to mold arepas within a few hours after working. Dough kept satisfactory as far as odor of spoilage could be detected when stored at room temperature (15°C) over night but became brittle and needed reworking before molding into arepas. When stored at 0°C the dough kept for 3 to 4 days but became very brittle and required steaming and cooling before reworking and forming into arepas. This change in dough character is attributed to retrogradation of the gelatinized starch.

FORMING AREPAS

Arepas are traditionally formed by hand, a time consuming operation. It was thought that if the dough could be extruded then it could be sliced by a wire knife. Extrusion was accomplished in the Braibenti pasta machine but the largest die available was 25 x 37 mm. This collet was worked into a roll of a diameter desired for arepas. The slicer developed by the engineering section of IIT was used to slice the roll. It did a beautiful job of slicing but left a rough surface which permitted the arepa to dry out on baking thus forming a rough crust. For this reason slicing was abandoned.

The method resorted to under the conditions of lack of availability of suitable mechanical equipment was to pull out blobs of dough that weighed 55-60 g. These sections were rolled into balls in moistened palms and flattened somewhat by pressure of the palms, then placed in an aluminium ring 66mm. diameter by 11mm. high. This diameter was determined by the arepa made in the mold of this size fitting into polyethylene tubing of available size. The mass of dough was pressed into the shape of the ring on a flat plate by a wide spatula. The aluminium ring, spatula and dough board were kept greased with a light coating of corn oil containing antioxidants, (Eastman Chemical Co., BHA and BHT). This oil permitted re-use of the equipment without sticking which was very bothersome when water was used as the lubricant.

The arepa was further smoothed and edges rounded by rubbing over a metal surface such as a small shallow pan with rounded edges. The only equipment of this sort available that gave satisfactory performance was the top of a Planter's key opening nut can of the 6 3/4 oz. size. This smoothing of the edges permitted the arepa to be baked evenly without burned edges and added to the attractive appearance of the baked product. A visit is planned to American Machine and Foundry Co. in Brooklyn, N.Y., May 28th, in regard to equipment for mechanically shaping the dough.

BAKING

Ordinarily arepas are baked over a charcoal fire or, in more sophisticated families, on a wire grid over an iron range or an electric grill. An ordinary oven with a maximum temperature of 232°C (450°F) dries out the surface of the arepa before baking. It is therefore necessary to use a much higher temperature such as that in a General Electric toaster-oven to get fast gelatinization of the surface so that moisture is retained and a soft crust is formed. Thus, the rotary oven in the I.I.T. Farinology Laboratory gave an undesirable tough crust with a doughy center. A temperature of 320°C (608°F) was stated to be the baking temperature in the experimental oven used by Dra. Niño O.of IIT in 1966. Because of the small size of this oven it likely cooled down markedly on being loaded and only slowly or partially regained the original temperature during the baking period. There is apparently no suitably designed oven in Colombia for baking arepas both top and bottom simultaneously. Nor could the typical arepa eating family afford such a luxury. Small bakeries are able to attain the necessary temperatures in brick ovens.

The "Ley" oven gave only mediocre results. Because of uneveness of heating and loss of heat at the front and sides some arepas were burned and others under-baked. Aluminium foil was placed over intervening grids in an effort to eliminate the hot spots. This it did to some extent, enabling 12 arepas to be baked at one loading. However, the equipment was of inferior design and did not withstand the high temperature of continuous operation for more than a few weeks, and had to be repeatedly repaired or replaced.

The General Electric Toaster-Oven was modified by adjusting the automatic thermostat-timer to a higher temperature than would ordinarily be required for dark toast. This worked satisfactorily for baking up to 4 arepas at a time, placing the arepas so that one was directly over the bimetallic detecter of the thermostat. The size was consistent with obtaining two bakings of 3 or 4 arepas each from an experimental sample of dough mixed in the Brabender farinograph unit from 150 g. of flour and 225 cc. of water.

TASTE PANEL RESULTS

Preliminary testing was conducted informally among laboratory associates to determine acceptability. Since the arepa is not very enticing alone but needs something additional such as butter, or marmalade, these were provided in some instances. However, it became difficult to determine which the panelists were evaluating. It did show that when well known spreads were provided the enriched arepa of Opaque-2 corn, soya and corn gluten was acceptable. Surprisingly while most liked the corn flavor of the arepas made with 100 percent Opaque-2 others still preferred the peto type. It was considered by H. Mottern without previous preference that the Opaque-2 arepa was definitely

better but that a good part of this improvement was lost when the mixed harina containing soya and corn gluten was baked into arepas. Even this arepa was considered better than peto my Mottern. In a small taste panel of 6 members using a hedonic scale of 5 the enriched arepas containing Opaque-2 corn, and 5 percent each of corn gluten and soya flour received a rating of 4.0 to one of 4.5 for peto. Since the two are readily distinguished by color, taste and other characteristics this difference if significant may be influenced by previous food preferences. It does indicate that enriched arepas are acceptable to the group. Further and larger taste tests were conducted by I.I.T. (See Appendix 2).

The enriched arepas were shown to Dr. Roberto Rueda Williamson of the Instituto Nacional de Nutrición (INN), who thought it would be a highly acceptable product because the flavor was that of sweet corn that the people were accustomed to and was well liked.

The dietician of a school administered by the Catholic Relief Society in Bogotá considered the arepas well worthy of testing in the school but because of technical difficulties in obtaining satisfactorily reliable data under conditions of serving at the school the idea was not further pursued. Technical personnel at Productos Quaker considered the product worthy of market testing and will so recommend to management. They are very interested in working with IIT in developing improved food grade soya flour and corn gluten and have interested suppliers (Manteca - La Americana and Maizena) in making changes that may be recommended to convert from the present manufacture of feed to food use.

MANUFACTURING PROCESS

Suggested material specifications are given in the Appendix for corn meal, pre-cooked corn meal, soya flakes, corn gluten and salt. An outline of the process is shown on the following page. When steamed (de-odorized and low bacteria count) soy flour becomes available that part of the process including the grinding can be eliminated. Similarly in regard to corn gluten, when a de-odorized and low bacteria product is available the specifications can be changed. In any event it seems best to first mix an enriching mixture which is added to the corn meal in a mixer in which the dough will be worked. Either raw or pre-cooked corn meal can be used. If raw corn meal is used, and this is recommended if the arepas are to be packed and held for sale more than one day - then the mixture should be steamed 10 minutes at 100°C to cook the meal and reduce the microbiological flora. The cooked dough must be cooled before working. The time of working will depend on the type of equipment and quatity of dough but should be from 5 to 10 minutes.

OUTLINE OF AREPA MANUFACTURE

Corn Meal	Soya Flakes	Corn Gluten	Salt
88.7%	5%	5%	1.3%

Soya Flakes:
- Steam 15 min. at 100°C.
- Dry
- Grind → Mix

Corn Gluten:
- Steam 15 min. at 115°C.
- Dry
- Mix

Salt → Mix

Mix:
- Enriching Mixture
- Mix
- Add 1½ parts water → Enricareparina
- Mix 1 min. and let stand 5 min.
- Work dough
- Form Arepas
- Bake, cool, pack

If precook meal is not used steam cook 10-15 at 100°-93°C
- Cool → Work dough

PACKAGING

The arepas are hand formed using a mold to uniformly size them so that they pack neatly. After baking it is necessary to cool to prevent moisture condensing on the package. The cooling room should be clean and provided with a supply of filtered air above atmospheric pressure to reduce contamination. Packing should be in polyethylene of about 15 mil thickness as it provides protection as well as good appearance at minimum cost and is readily available from Colombian manufacture. The shelf life obtained will depend to a large extent on cleanliness and precautions taken after the arepas are baked. Addition of sorbic acid or calcium propionate will retard mold growth. It was noticed 4 days after baking that arepas showed presence of ropy organisms as evidenced by filaments on breaking the arepa apart. I.I.T. is determining total count and contamination with organisms causing ropiness in milk and bread (bacillus mesintericus?) on row materials, mixtures and baked arepas.

CONCLUSION

A formula and process have been developed for arepas of increased protein content using Opaque-2 corn meal 88.7 percent, soya flour 5 percent, corn gluten 5 percent and salt 1.3 percent. The formula should be regarded as flexible and success not attainable without concerted effort to obtain the necessary raw materials of required specifications and perhaps not practical without intensive promotion to convince the consumer of the importance of adequate protein nutrition. Moreover, since it is intended that the enriched product compete in the market place, consumer acceptance studies and economic considerations may dictate modification of the formula. Thus, from the standpoint of flavor acceptance the percentages of soya and corn gluten may be reduced or completely eliminated using Opaque-2 corn meal alone. On the other hand if Opaque-2 corn meal is not available commercially at a competitive price the gluten will need to be eliminated and the percentage of soya will need to be increased to compensate for the low lysine content of regular corn meal. Such change would be accompanied by a reduction in acceptability. A 100 percent Opaque-2 arepa should develop greater acceptability than the present peto product once the consumer has been introduced to it in an attractive package and it has thus gained status.

The process also must be regarded as flexible. Because of the unavailability of a choice of experimental equipment many of the operations were studied with substitute equipment that was not necessarily the one with optimum performance. The process should not be thought of in starting big but as one for small business to grow on. Changing eating habits is highly unpredictable. Although there is ecological need for enriched arepas as an economical source of protein, the consuming public is unaware of it and with lack of approach by radio, newspapers and television it may take years and more acute development of protein malnutrition to effect a realization of the need to change the diet.

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APPENDIX I

RECIPE FOR PREPARING AREPAS

Enriched arepas containing twice the available protein of ordinary arepas are made from a precooked mix containing Opaque-2 corn flour, soya flour, corn gluten, and salt.

To 1½ cups of cold water in a 2-quart mixing bowl or sauce pan add, while stirring, 1 rounded cup of enriched arepa mix. Continue stirring for one minute until all the mix is wetted and mixture thickens. Compact into a lump and let stand 5 minutes for moisture to equalize.

Knead or work with hands and thumbs the crumbly mixture until a cohesive dough is formed. Pull out lumps the size of an egg and roll between slightly moistened palms into a ball and finally flatten to ½ inch or less. Moisten fingers and smooth sides to eliminate splitting. Bake to a medium brown in a General Electric toaster-oven set at dark toast without tray, or on a grid ½ to 1 inch above previously heated burner set at medium to high to give a dull red heat. Thickness of arepa, intensity of heat, and distance from source are inter-dependant and may require adjustment to give the desired toasting of crust and eliminate gumminess in the center. Baking in an ordinary oven set at 450°F dries out the arepas without developing the desired roasted corn flavor. Makes 8-10 arepas, of average size.

APPENDIX II

LARGE TASTE PANEL TEST OF ENRICHED AREPAS

Vs. OPAQUE-2

In order to determine the acceptance of enriched arepas several possibilities were considered. It was finally decided to use IIT personnel as a more complete and accurate appraisal could be made of each individual's reaction. This permits a more careful and detailed examination of the results.

The arepas were baked fresh and served promptly while still slightly warm at designated stations free of interruptions where only the panelist and interviewer were present.

Panelists consisted of a broad spectrum from professionals to illiterate cleaning help and common labourers. The latter would be more representative of the enriched arepa future consuming sector.

Detailed analysis of the results follow:

Total number of panelists: 110

Original residence of the panelists was distributed as follows:

Group I	- Western Colombia	- 29	or	26%
Group II	- Central and Eastern (Including Nariño)	- 67	or	61%
Group III	- North-eastern Section	- 8	or	7%
Miscelaneous		- 6	or	6%

Group I represents the region of highest consumption of arepas but represented only 26% of the panel. Group II consisting of 61% of the panel are familiar with arepas but are only moderate or infrequent consumers. This group likes more sophisticated arepas made with cheese (farmers' cheese), eggs, pork skin, etc. and butter or some kind of spread.

The analysis of the preference according to the groups, is as follows:

	I	II	III
Enriched	12	23	0
Opaque-2	17	44	8

There is no significant difference shown by Group I, but Group II shows a decided preference for Opaque-2 significant at a level of 1%. In the case of Group III an absolute preference was shown for Opaque-2 also significant at a level of 1%.

The analyses of the results by groups with regard to flavor acceptability as a corn product and for flavor characteristics of arepas are as follows:

	Flavor as a corn product	Flavor characteristic of arepas.
GROUP I	Both samples acceptable with no significant difference	There is a preference for Opaque-2. The enriched had a foreign flavor.
GROUP II	Ditto	Ditto
GROUP III	The opaque-2 is preferred	Not characteristic of arepas.

Texture was found "very good" or "correct" by 82% of the panelists.

COMMENTS

It becomes apparent from the above that in order to have a more desirable and acceptable product, improvement in the quality of the protein additives must be made or the quantity reduced. In view of the high lysine content of the Opaque-2 (4.5 g per 16 g N) a reduction of the soya could be made without greatly affecting protein quality. Further work on this line is planned.

APPENDIX III

PROPOSED RAW MATERIAL SPECIFICATIONS

Corn Meal (Harina de Maíz)

The harina de maíz (corn meal) used in making arepas shall be of one of four types as specified.

A. Harina de maíz Opaque-2, pre-cooked.

B. Harina de maíz, (grit) Opaque-2, not cooked.

C. Harina de maíz, from common commercial white varieties, pre-cooked.

D. Harina de maíz (grit) from common commercial white varieties, not cooked.

The harina de maíz is prepared from the stated variety (Opaque-2 preferred) by either wet or dry milling and screening to the proper size known as "grit" in Colombia, but corresponding to fine ground corn meal in the U. S. If so specified, it shall be pre-cooked so that on mixing with cold water a dough can be formed (see test for pre-cooking).

Color: White or near white for commercial white varieties and slightly yellowish for Opaque-2.

Flavor: Bland in white varieties, but with slight corn flavor in Opaque-2.

Microbiological Standard: Not more than 100.000 per g. or to be established.

Particle Size:	Through 30 mesh,	100%
	Retained on 60 mesh, not less than	45%
	Passing 120 mesh, not more than	20%

Analysis:	Moisture not more than	13 %
	Protein, Opaque-2 not less than	11 %
	White " " "	8.5%
	Fat Not more than	4 %
	Ash " " "	1.4%
	Fiber " " "	2.5%

Packing: In 35 kg. cotton bags with 3 mil polyethylene liner.

Tests: For sieve size. Use Standard screens.

For precooking. Mix 100 g. of pre-cooked harina into 150 cc. of water at hydrant room temperature in a mixing bowl, stirring until moisture is uniform (about one minute). Compact to facilitate uniform absorption of moisture. Allow to stand five minutes. Work in mixing bowl of Brabender Farinograph for five minutes of knead with hands and thumbs first in the mixing bowl and then on a dough board for five minutes. Mixture should form a cohesive dough that can be molded into arepas.

Corn Gluten (Gluten de Maíz Amarillo)

Corn Gluten is the protein by-product obtained in the manufacture of starch wherein the wet milled corn is processed promptly by means of Merco centrifuges and Dorr-Clone liquid cyclones, effecting low microbiological population, filtered from excess moisture and dried. Protein content is not less than 6 per cent.

Flavor: Bland.

Color: Golden yellow when made from yellow varieties of corn.

Odor: Has disagreeable porcine odor in warm water which can be reduced by steaming (see test).

Analysis:

Moisture not more than	12 %
Protein not less than	60 %
Fat " more than	5 %
Crude Fiber not more than	2.5%
Ash " " "	1.5%
Lysine " " "	1.4%
Lysine g. per 16 g. N	2.3%
Tryptophane g per 16 g N	0.5%

Microbiological Standard: Not more than 100.000 per g. or to be established.

Particle size: (To be estabished).

Packing: In 50 kg. 5-ply, multiwall, unbleached Kraft paper bags with outer ply of bleached Kraft.

Tests: For odor removal, steam 200 g for 1 hour in 60 mesh sieve in "MODEMEL" (Sears) double boiler, or steam 15 minutes at 115°C in bacterial sterilizer when microbiological count is high. Place 5 g. sample in 50 cc. water and warm to 70°C. Smell and taste. Should be bland or have only mild flavor of pork.

De-Fatted Soy Flakes (Hojuelas de Soya Desengrasada)

Soy flakes are obtained by cleaning soy beans, cracking to loosen hulls, separating the hulls from the cracked beans, cooking or steaming the cotyledons thereby raising the moisture to about 18 percent, flaking in rolls, extracting the oil with hexane approved for use in food manufacture, removing the hexane completely in a desolventizer wherein the temperature is raised to destroy urease activity and trypsin inhibitor, then drying and cooling. If so specified they are ground to specified particle size. Protein content is not less than 50 percent.

Color: Off-White to light tan.

Odor: Free of beany odor and slightly suggestive of cereal.

Flavor: No beany flavor to slightly mild beany flavor, slightly toasted nut-like cereal flavor.

Microbiological Standards: Not more than 100,100 per g. or to be established.

Particle size of ground material: Through 60-mesh 98%
Through 120-mesh 74%

If flakes, thickness should not be more than 18 mil. and preferably 14 mil.

Packing: In 50 kg., 5-ply, multiwall, unbleached Kraft paper bags.

Tests: Determination of urease activity and residual antitrypsin factor should be run.

SALT (Sodium Chloride) Food Grade

Salt for arepas corresponds to the quick dissolving, fine flake, dairy salt used in butter manufacture in Colombia.

Microbiological Standards: (To be established).

Particle Size: (To be established).

Packing: 50 kg. Kraft paper sacks.

Tests: (To be established).

WATER

Water used in making arepas for commercial sale shall be potable, meeting the microbiological standards of U. S. Public Health Service for potable water entering interstate commerce.

HHM/jro.