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9. ABSTRACT

Corn fortified with 8% soy bean flour (50% protein) and 0.125% L-lysine HCl is improved in its biological value. It was thought that if this corn were consumed by persons living under natural conditions, a positive biological effect on the growth pattern of children, and on morbidity and mortality would be observed. To test this hypothesis, the corn consumed since June 1972 by the villagers of Santa María Cauqué, Guatemala, was fortified. Strong indicators provided by the research findings showed that it had been beneficial in reducing the infant mortality by 50%. Second to fifth-year mortality also clearly had been reduced, and morbidity during weaning had been lowered by 33%. These changes appear to be independent of socio-economic class. Even though a significant effect on postnatal growth was not evident, a positive tendency toward better growth increments was found in children 3 to 5 years old. No change in fetal growth was found; however the dietary intake of pregnant women was improved especially during the first six months of pregnancy. So far, there has been a very beneficial effect on the children's health. It is proposed that this project be continued, to increase the level of fortification to 10% and to find positive changes in other nutritional parameters.

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CORN FORTIFICATION:

A FIELD DEMONSTRATION MODEL

ANNUAL REPORT

October 16, 1974-December 31, 1975

ANNUAL REPORT SUMMARY SHEET

CORN FORTIFICATION: A FIELD DEMONSTRATION MODEL
CONTRACT No. AID-CSD-3357

Project Title and Contract Number

DR. JUAN JOSE URRUTIA, DIVISION OF ENVIRONMENTAL BIOLOGY
INSTITUTE OF NUTRITION OF CENTRAL AMERICA AND PANAMA (INCAP)

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January 1, 1971-March 31, 1976 Contract Period (as amended) From - To	October 16, 1974-Dec. 31, 1975 Reporting Period From - To
Total Expenditures and Obligations Through Previous Contract Year	$402,465.12
Total Expenditures and Obligations For Current Contract Year	$173,891.00

Narrative Summary of Accomplishments and Utilization:

Corn fortified with 8 percent soy bean flour (50% protein) and 0.125 percent L-lysine HCl is improved in its biological value. If persons living under natural conditions are fed with this corn, a positive biological effect on the growth pattern of children, and on the morbidity and mortality would be observed. To test this hypothesis, since June 1972, the corn consumed by the villagers of Santa María Cauqué, Guatemala, has been fortified. Strong indicators provided by the research findings, indicate that the intervention has been beneficial in reducing the infant mortality by 50 percent. The second to fifth year mortality has been also clearly reduced. Morbidity during weaning has been reduced by 33 percent. These changes appear to be independent of socioeconomical class. Even if a significant effect on postnatal growth was not evident, a positive tendency for better growth increments was found in children 3 to 5 years old. No change in fetal growth was found; however the dietary intake in pregnant women was improved, especially during the first six months of pregnancy.

So far, there is a very benefic effect in the children's health. It is proposed that this project is continued increasing the level of fortification to 10 percent, to find positive changes in other parameters associated to nutrition. A new grant proposal was submitted in October 1975.

B. PROJECT OBJECTIVES

The research objectives proposed in the original grant application are:

1. To determine the effect of fortification on nutrition of pregnant women and on fetal growth.

2. To determine the effect of fortification on the growth and development of children.

3. To determine the effect of fortification on disease incidence of children and on intestinal infection by Shigella.

4. To study the feasibility (management and economics) of corn fortification at the community level through the addition of a mixture containing protein, lysine, vitamins, and iron.

5. To evolve realistic operational guidelines and economic data applicable to a regional or national program of corn fortification.

C. ACCOMPLISHMENTS TO DATE

1. Principal findings

This annual report describes the analyses done on the data collected during three years from the 1st of June 1972 to the 31st of May 1975. In accordance to the decision taken during the site visit to the project in April 1975, the data for this analysis correspond to the information collected in Santa María Cauqué. The data from the control village, Santo Domingo Xenacoj, are not included in accordance to the site visitors decision, in the sense that the information from this village was not comparable to the experimental village, Santa María Cauqué.

The analysis of the data collected so far has yielded results which have vast public health implications. Briefly, the evidence to date shows that the corn fortification reduces infant mortality by 50 percent, and the morbidity rates, during the weaning period, by 33 percent. These analyses are described in detail in the next pages.

Fortification procedure

The field operation at the mill level, consisting in maintaining the collaboration of the village women and of the mill owners to add the fortifying mixture (Table 1), was run without problem. The first step consisting in obtaining permission from all the families, either the fortifying or the non-fortifying, to weigh the cooked corn at the mill, was a success. Some problems were identified during the first three months of the initiation of the project. First of all the villagers found a slight difference in the flavor of tortillas. Secondly and more important, it was found that tortillas kept for about 12 hours became sticky and developed a foul smell. This problem was analyzed; it was due to the high water solubility of the soy flour utilized in the fortifying mixture that increased the humidity of the tortillas. This was partially solved by draining the water content of the nixtamal during the weighing process, and by reducing the amount of water added to the corn during the milling process. Besides, women were asked to cook the tortillas a little longer to allow water evaporation. Another problem was that women did not accept the fortification when they were going to prepare "tamales" or "tamalitos", because these are food preparations that contain more water than tortillas, so their humidity increased as a consequence of the adding of the soy flour. Women also did not accept fortification when they had to feed other persons (employees), because they were afraid that the employees could note the change in flavor; or when their husbands stayed outside the village for 2 or 3 days, and had to take tortillas from their houses. Furthermore, the flour was not added when the corn was either not completely ripe (dry) or when it was attacked by insects, because when the flour was added the corn dough became sticky. This problem was solved by providing fresh corn at a reduced price to the collaborative families.

The collaboration of the fortifying families was determined on weekly basis in accordance to the fortification index. This index was calculated from the family weekly fortification data:

$$\text{Family weekly FI} = \frac{\text{Days of attendance to the mill}}{\text{Days of the week (6)}} \times \frac{\text{Amount of fortifying mixture added to cooked corn}}{\text{Pounds of cooked corn (nixtamal)}}$$

This index is cumulative, it permits to classify the families and reflects the level of cooperation of each one. The FI of one specific week is equal to the sum of the weekly indexes since the beginning of the fortification project, divided by the number of added weeks. A special index was prepared for each child born since the beginning of the observations in Santa María Cauqué (February 1964). To be able to compare children born at different periods, the time of gestation was considered. In this manner the child fortification index at the moment of birth, is equal to the family fortification index corresponding to the 39 weeks before delivery, (time considered as the average duration of pregnancy). For children born during the early months of the project, the number of weeks of gestation before June 1972, were given a value of 0.

In the older children who were born before the onset of the corn fortification project, the index corresponding to the date of any of the anthropometrical, dietary or morbidity surveys, was calculated taking the sum of the weekly family indexes at the moment of the survey, divided by the child age in weeks, plus the 39 weeks of gestation.

An analysis of the frequency distribution of the weekly family indexes, permitted to classify the families in accordance to the levels of cooperation; the low fortified group had a FI lower than 20; it was constituted by 51 percent of the families. The FI for the medium fortified group oscillated between 20 to 39, and corresponded to 13 percent of the families. The highly fortified group had a FI of 40 and more; 36 percent of the families belonged to this group. The consistency in the collaboration of the highly and medium fortified group is shown in Tables 2 and 3. It can be observed that the highly fortified group was very consistent in the fortification. However, there were two periods when the collaboration dropped. The first period corresponded to the sixth semester of observation, when their corn stocks became attacke by insects. The second period corresponded to the semesters 10th and 11th, when two new mills became in operation in the village. About one third of the families decided to mill their corn in these two mills. It took about six months to convince the mill owners to participate in the program; after this period th collaboration started to increase. At the present, the mean fortification index for these families is again over 70.

On the other hand, the medium fortified group, started with a FI between 42 to 47 during the first three trimesters. However, during the fourth trimester their FI has been dropping steadily. During the twelfth trimester half of the families of this group did not fortified their corn at all.

The intense campaign to convince the families to fortify their corn, was done only during the first three months of the study. Later on, it was found that the families were fortifying with a definitive pattern, and it was decided to stop the enrollment campaign. However, the fortifying mixture has been available in the four village mills free of charge. Any family can decide whether they want to fortify their corn or not.

Chemical analysis of the tortillas

The amount of protein and of total free lysine was higher in the fortified tortillas as shown in Table 4. Enriched tortillas had an average of 2.0 percent gram of protein and 36.2 percent mg of total free lysine more than the non-fortified tortilla. Although these differences were highly significant, the amount of protein in the enriched tortilla was only half of what was expected. Several explanations have been found for this partial failure in the fortification procedure. First of all, the problem of the consistency of the fortifying flour had to be considered; because of its fluffy consistency, housewives did not like so much flour to be added to their nixtamal, when the amount to be milled weighed more than 10 or 12 pounds. Second, the amount of flour plus the amount of water added during the milling process, caused an increase in the volume of the corn dough, which reduced the final concentration of the fortifying mixture, in the cooked tortillas. For all these reasons, it can be concluded that the corn fortification was reached at the level of 4-6 percent and not at 8 percent. This was shown in the PER of fortified tortillas which oscillated between 1.90 to 2.19, and did not reach the value of 2.76 as expected.

Socioeconomic status of the families

To establish the socioeconomic status of the village families, the family's head was interviewed on 12 variables: land tenure, cattle and poultry possession; material utilized for the houses (floors, walls and roofs); water availability; fecal and waste disposal; literacy; scholarity and shoe wear. Each variable was given a maximum value of 3 points and a minimum of 1; the highest value was assigned to the families who had better conditions. A socioeconomic index was formed by the sum of these variables. The lower value was of 12 points and the maximum of 36.

The analysis of this information did not show differences among the three groups of families classified in accordance to the fortification index.

The socioeconomic index for the families with and without children are presented in Tables 5 and 6. No significant differences were found. The group with the lower fortification index showed a tendency to have a better socioeconomic index. However, these differences were not statistically significant. A special index on three main variables: land tenure, scholarity, and shoe wear was formed for the families. The mean and standard deviation for these variables are shown in Tables 7 and 8. The means in both groups of families were not different and also no differences within groups were found in relation to the fortification index.

Conclusion. These data show that the tendency to fortify the corn in the so called "fortifying families" apparently is not related to social or economical reasons.

Relationship between the Fortification Index and physical growth

Physical growth measurements are widely used to assess the impact of nutritional and health interventions. In this regard, height and weight measurements have been found to be the most useful, given their high reliability and sensitivity to changes in nutrition and health. Consequently, the relationship between participation in the corn fortification program and growth in height and weight was analyzed.

First of all, it was investigated whether the intervention has had an impact on fetal growth. Table 9 presents the relationship between birth weight and the fortification index, for all full term children born between 1st June 1972 to 31st May 1975. Clearly, there is no apparent impact of the intervention on birth weight. Table 9 also shows that this finding is not due to differences in birth order to the child, maternal height or gestational age. Moreover, similar analyses with height and head circumference of the newborn have also fail to show an effect. Lastly, it was found through regression analyses that the fortification index is not related to growth in the newborn either before or after controlling for the influence of the potentially confounding factors, already mentioned (Table 10). Therefore, it was concluded from these analyses that participation in the corn fortification program has had no impact on fetal growth.

The second series of analyses explored the relationship between the fortification index and postnatal physical growth. It was expected that an effect on height would be seen in 1, 2, 3 and 4 year old children since at these ages, children growing at substantial rates, would be consuming relatively large quantities of tortillas. Table 11 shows that there is no apparent relationship between attained height and fortification for children under 8 years of age in the period of June 1972 to May 1975. Thus, fortification would seem to have little impact on early growth. In order to control for the influence of factors constant to the family, such as socioeconomic status and level of collaboration with the program, it was carried out the following analysis. Sibling pairs were selected in families where growth information was available for both siblings at any of the following ages: birth, 6, 15, 24, 36, and 60 months, and where the older sibling had reached the age in question before the fortification program, while the younger sibling reached the same age during the program. Thus, for every age the older sibling had no opportunity to benefit from the program. The analysis consisted of comparing the height and weight of both siblings; the expectation being that the younger sibling would be taller and heavier on account of fortification. The results of these analyses are shown in Table 12. None of the comparisons between sibling pairs either for height or weight or for the various ages reveal differences. Therefore, it was concluded that even after controlling for constant

factors in the family, corn fortification does not seem to have an impact on physical growth.

All the analyses described so far have looked at the relationship between fortification and attained size. While an impact of corn fortification was expected in the previous analyses, the chances of observing an impact are enhanced if one relates the fortification index to growth increments. Thus, it is shown in Table 13 the relationship between changes in the fortification index of the child from 3 to 5 years of age, and changes or increments in growth during the same period. Though the correlations shown in Table 13 are not significant, they do indicate a strong tendency for growth increments in both height and weight to be related to changes in the fortification index.

Bone development is usually considered as an indicator of maturation. In this sense, the criterion to define the effect of the intervention on maturation was the analysis of the effect of corn fortification on bone development.

The correlation between the number of hand and wrist ossification centers and the fortification index in children from 6 months to 8 years of age is presented in Table 14. It can be seen that no significant correlation was found at any of the life periods analyzed. Analyses of variance of the presence of selected hand and wrist ossification centers at ages 2, 4 and 6 years in reference to the fortification index are shown in Tables 15, 16, and 17 respectively. It can be noticed that even for specific bone centers, no significant differences were found in the order of appearance of these ossification centers. An analysis of variance in relation to the carpal ossification centers is shown in Table 18. The differences on the number of ossification centers did not become significant at any age.

Cortical thickness of the second metacarpal is a good indicator of the nutritional status of children suffering malnutrition. It was carried out a correlation analysis, between the cortical thickness and the fortification index in children aged 6 months to 8 years. The results are presented in Table 19. No significant differences were found.

In summary, the analyses carried out to date suggest that corn fortification has had no impact upon physical growth and on bone development. There remains the possibility, however, that an effect on growth rates could be shown if corn is fortified at a higher level.

Relationship between the Fortification Index and morbidity

One of the expected effects of the corn fortification project was that it would lead to a reduction of morbidity rates in the child.

To test this question, the health status of a subsample of children (birth to 36 months) was carefully monitored, through weekly home visits, by a nurse. The ill children were visited by the field physician to establish the diagnosis and prescribe the treatment.

Table 20 shows the number of children for whom data are available for semester periods between the ages of 0 to 3 years. It would be noted that morbidity information was gathered on a cohort of children; this explains, therefore, the small sample sizes.

Analyses of the morbidity data show that respiratory infections and diarrheal diseases account for more than 80 percent of the morbidity. This is not unlike what is found in other areas of the developing world. These two entities have also been shown to be one of the main associated causes of mortality in young children in the Americas (13).

No differences in disease incidence between the children with low, middle and high fortification were found. However, the duration and severity of the infectious diseases were found to be less during the weaning period (12 to 30 months of age) in the group of children highly fortified.

The relationship between the corn fortification index and various morbidity items are presented in Tables 21 to 29. In these analyses, the morbidity information is expressed in terms of percentage of the time ill p r semester For example, 10 percent of the time ill with fever is equivalent to 18 days with fever in six months. Analysis

of variance was applied to the morbidity data. Results are expressed as the percent of time ill in three groups of children classified in accordance to the fortification index. Tables 21 and 22 show that the group described as low according to the fortification index, was nearly twice as sick with upper and lower respiratory infection as the high group during the weaning period. The differences between the two groups of children were even larger for the duration of diarrhea (Table 23). Table 24 suggests that corn fortification also leads to fewer days ill with associated illnesses, that is to say, association of respiratory and diarrhea illness, or also respiratory or diarrhea illness associated to conjunctivitis and/or stomatitis. These differences were noticeable during the weaning period. Although a trend consisting with a longer duration in the children with low fortification was found, very few of the differences were significant in accordance to the analyses of variance. However, when the rates of the low and high groups were compared, the differences became significant. This trend was not found for other diseases, such as skin infections, conjunctivitis and stomatitis alone. Lastly, Table 25 shows that there is a negative relationship between the corn fortification index and the percentage of the time ill with any infectious illness.

It was also found a reduction in the severity of disease manifestation. Tables 26 and 27 show that the children highly fortified suffered less days of fever and of diarrhea with 7 or more stools per day.

As a way of summary, Tables 28 and 29 present the differences between the high and low fortification groups (high-low) and the total reduction in number of illness days and of days with less severe manifestation of illness respectively. Clearly, children in the high fortification group suffered less days of illness. The total reduction of disease duration amounts to 67.5 days. This corresponds to a reduction of 33 percent, in relation to disease duration during weaning in the group of children with low fortification.

In summary, the evidence to date strongly suggests that the corn fortification process reduces the duration, as well as the severity of infectious illnesses during weaning. During this period of life morbidity problems

are more frequent and severe. The lack of effect during the first year of life, could be related to the fact that children do not begin to consume tortillas in appreciable amounts till they are about 1 year of age.

Results of the intestinal infection by Shigella in children

For the identification of Shigella in the feces of the cohort children, fecal weekly cultures were collected from each cohort child. The fecal samples were processed in accordance to the procedures utilized in the Santa María Cauqué studies since 1964 (14).

In Table 30 are shown the number of cultures processed per semester of life. No marked differences in the incidence of the Shigella infections in the three groups of children were found. The duration of the Shigella infections is presented in Table 31. There were no differences between the groups.

The previous findings provide evidence that the frequency and duration of intestinal infections by Shigella, was not different in the three groups of children.

These data do not coincide with the morbidity findings, which showed that the duration and severity of diarrheal disease was reduced in the group of children with a higher fortification index. In regard to this, it must be mentioned that the methodology, to measure the duration of an infectious process is different in both circumstances. For example, the presence of clinical manifestations of disease can be recorded day by day, while in the case of an intestinal infection, the duration can be determined only by the isolation of the agent. Another factor to be considered is that the number of samples was obtained from only 60 cohort children.

A study as the one here presented should be continued with a larger sample of children, in order to assess the intestinal infections by this agent. In this manner it will be obtained information to correlate the findings with the morbidity survey.

Relationship between the Fortification Index and 0 to 5 year mortality

Since the beginning of the field operations in Santa María Cauqué in 1964, preschool mortality data have been continuously collected.

The cause of death was determined either by pre-morten diagnosis done during the course of the disease, or by interrogations to the child's parents on the characteristics of the final episode of the fatal disease. In more than 90 percent of the cases the field physician or the nurses had the opportunity to examine the child during the course of the fatal disease.

All births and deaths were recorded, in this manner it was possible to determine the number of newborns and inhabitants for each specific age from 1 to 5 years of age.

The mortality rate of 3 sets of families grouped according to the family fortification index has been compared. These groups are: the low fortified (FI of 0-19); the medium fortified (FI of 20-39) and the high fortified group (FI of 40-100). Because of the long term data available it has been possible to calculate in the same families the infant mortality rates during the period before corn fortification (January 1964 to May 1972). This baseline mortality data is presented in Table 32. Though, the low fortified group appears to have the highest mortality rates, the differences are not statistically significant.

The infant mortality rate for the period of corn fortification is presented in Table 33. The rates are expressed per 1000 deliveries, in each of the three fortification groups. The highest infant mortality rate corresponds to the low and medium fortified group. These figures are not significantly different from the baseline rates shown in the same groups of families before the fortification period ($P > .05$). On the other hand, the infant mortality rate for the group of children with high fortification is now nearly 3 times lower than that of the other two groups. In comparison to the baseline values, the high fortified group has experienced a 50 percent reduction.

Table 34 shows that this reduction in infant mortality is not due to a decrease in the proportion of low birth weight babies. First of all, the proportion of low birth weight babies is similar across all three groups. Secondly, the relationship between corn fortification and infant mortality is still evident within the range of low birth weight babies. The mechanism involved, therefore, appears to be independent of birth weight.

The relationship between corn fortification and mortality during the second, third, fourth and fifth year of life is shown in Table 35. The rate for the second year of life is similar in the low and the high fortified groups. However, during the third to fifth year of life not a single death was observed for the group of children with a fortification index of 40-100. The total number of deaths were 9, 6 and 3 for the low, medium and high groups of fortification respectively. The rate of mortality for the whole village corresponding to this period of life here studied (see Table 36) was not significantly reduced, but it is important to notice that the mortality for children with high fortification was reduced to a third, and that no deaths were observed after the age of two years in this group of children.

Though the data are suggestive of a strong impact on mortality, there are important and alternative hypotheses that must be discarded. The principal one would state that the apparent association is due to self-selection. That is, the factors which led families to participate in a novel activity such as the fortification also cause the mortality to be much lower. As was presented in page 7 of this report, the analyses of the socioeconomic characteristics of high and low fortified groups, did not show any difference. A survey of the attitudes toward child care and use of preventive and curative medical services also did not show differences between the group with high and low fortification.

In summary it could be stated that corn fortification has had an effect in infant mortality and during the third, fourth and fifth year of life.

Relationship between the Fortification Index and the intake of calories and protein of preschool children

The dietary information was collected by the one week recall method. The surveys were practiced every week during the whole period of the study. The interviewers visited each child's home in a pre-determined day; if the interview did not take place on that day, they could practiced the survey into the two following days. They asked the child's mother what the child had eaten the previous week. They began asking about the breakfast, lunch and dinner of the previous day, then the day before and so on, until they completed one week. The surveyors helped the mothers to remember the child's diet by asking key questions. In order to be able to know the amount of food eaten by each child, it was prepared a list with the average weights of all the available foods in the village. Alone with this every six months it was determined in each child's home the amount of some cooked foods of frequent use served to the cohort children. In this manner, it was possible not only to know the cooked food equivalent of each home measurement (tablespoon, teaspoon, etc.), but the increase of the quantity of food as the child was getting older. In order to calculate the portion served to each cohort child, in the case of mixed dishes, the recipes and the number of servings in each preparation were obtained.

Means and standard deviations of the mean daily intake of calories and protein of children were calculated in accordance to the fortification index, at six months intervals from 18 to 36 months of age. The intake for each specific age was calculated from the dietary surveys conducted during a period of four weeks. Table 37 shows that there were no differences in the mean daily intake of calories at any age. A similar result was found when the mean daily intakes of protein at the different life periods studied were calculated (see Table 38). In conclusion it can be said that no relationship between the fortification index and the mean daily intake of calories and protein in children was found.

Relationship between the Fortification Index and morbidity during pregnancy

This section describes the first analysis of the morbidity during pregnancy done on the data collected since the beginning of the project. As soon as a pregnancy was detected, the field nurse began the weekly morbidity surveillances to determine the health status of the women during pregnancy. The clinical diagnosis was confirmed by the field physician. The duration and the severity of the infectious diseases were found out by daily visits of the nurse. She inquired about the presence of symptoms, the number of stools per day in the diarrhea cases; also, she recorded the temperature of the ill pregnant women. The physician visited them every two or three days, independently of the nurse visit to confirm the diagnosis and prescribe the treatment. A urine culture for the determination of significant bacteriurias (a count of $\geq 10^5$ bacteria per ml of urine), was carried out every 4 weeks.

The incidence and duration of infectious diseases was calculated for all the pregnant women, in order to establish the basal information on morbidity during pregnancy. The number of episodes of infectious illnesses per trimester of pregnancy is shown in Table 39. Respiratory infections were the most frequent; the upper respiratory tract was affected three times more frequently than the lower tract. Diarrheal disease was the second in frequency. Clinical symptoms of urinary tract infections were found in a fourth of the women while significant bacteriurias were identified in 21 percent of the pregnant women. It was observed that the disease incidence was higher during the second and third trimester, which indicate a higher susceptibility during the last months of gestation.

The duration of the illness is presented in Table 40. Respiratory tract infections showed the longest duration. Although diarrheas were frequent, its course was short. The duration of urinary tract infections which was determined clinically by the symptoms persistence was short; however, the duration of bacteriurias was longer; preliminary information has shown that the mean duration of bacteriurias was around 8 weeks. As it was observed with the incidence, it was found that the disease duration was longer during the last part of gestation. As an average the women showed a total of 21 days of infectious illnesses during pregnancy.

It was determined that only 17 percent of women were free of infectious illnesses during pregnancy. On the other hand 52 percent suffered 1 or 2 episodes of illness; 22 percent had 3 or 4 episodes, and 9 percent had 5 or 6 episodes of illness.

The previous information shows that pregnant women in the rural area are subjected to a very intense force of infection and that they are ill during an average of 8 percent of the pregnancy duration.

A comparison of the incidence of infectious diseases during the first trimester of pregnancy in women with abortion and term pregnancies is presented in Table 42. There were no differences in the incidence of respiratory infection, diarrheal disease, conjunctivitis, stomatitis and skin infection. However, twenty five percent of the women with abortions had significant bacteriuria, compared to only six percent in the women with term pregnancies.

After establishing the incidence of infectious diseases for the pregnant women population, a comparison of the percent of time will with infectious diseases during pregnancy per categories of the corn fortification index was carried out. The results are presented in Table 43. It can be noticed that no differences were found within the three groups of women. This first analysis shows that to the present no effect of the corn fortification on morbidity during pregnancy has been identified.

Relationship between the Fortification Index and the dietary intake in pregnant women

The dietary intake of the women was determined during the pregnancy by the method of one week daily record. Three dietetic surveys were carried out corresponding to each trimester of pregnancy. Each survey covered a period of seven days; the interviews were done during the morning and evening of each day from Monday to Friday. The early visit was to find out about the women's breakfast and to observe the preparation of foods served at noon. The second visit was to determine the amount of food eaten at lunch by the pregnant women. With this purpose the interviewers weighed the tortillas, the raw vegetables and fruits available in each home. Furthermore, the recipes of the mixed dishes

were obtained as well as the number of servings of each preparation. It was also determined the weight of the servings of some cooked foods of frequent use such as black beans, rice, etc. Besides, the interviewers found out what the family was going to have for supper, and in the following morning visit the amounts of food eaten by the pregnant women at supper time was determined; this was repeated daily. The diets corresponding to Saturday and Sunday were obtained the following Monday by the recall method.

Dietary surveys were practiced in a total of 174 pregnant women. The analyses were done in the diets of 105 women, who were followed up during the three trimesters of pregnancy. The rest either had dietary surveys in one or two trimesters or did not have a complete prenatal record.

To establish the relationship among the level of fortification and the dietary intake some correlations were done (see Table 44). It was found a positive correlation between the fortification index and protein from corn, protein from soy, total vegetal protein, total protein, and protein from fortified tortillas. Based on these findings, an analysis of variance was done to find differences among the three fortified groups. The findings are shown in Table 45. It can be seen that the consumption of tortillas in the highly fortified group of women was significantly higher than in the other groups.

Since the calories produced by fortified and unfortified tortillas were alike (214 and 212 calories per 100 g of tortillas respectively), it can be concluded that the increase in the intake of calories, vegetal and total protein was due to a higher consumption of tortillas. The difference found in the intake of vegetal protein in the two extreme groups of fortification was of 9.5 g; 5.3 g of this protein were provided by the soy added to corn.

The relationship between the corn fortification index and the mean daily intake of calories and protein per trimester of pregnancy is presented in Tables 46, 47 and 48. Obviously the corn fortification produced an effect in the sense that the highly fortified group consumed more calories during the first and second trimesters of pregnancy (Table 46). The consumption of vegetal protein showed a direct relationship with the fortification index. The differences

within groups are shown in Table 47. However, the intake of animal protein was the same in the three groups of women, see Table 48. As the consumption of this nutrient in the rural areas is determined by the economic condition, this finding can be considered as evidence that the socioeconomic condition of the families was similar in the families of the three groups of pregnant women.

In summary it can be concluded that corn fortification produced an increase in the daily intake of tortilla in the women who fortified their corn at high level. The differences were clearly noticeable in the daily intake of calories during the first and second trimesters and also in the intake of vegetal protein during the length of pregnancy. The highly fortified women had a mean daily intake of 244 calories higher than the non fortifying women during the first trimester of pregnancy. During the second and third trimesters the mean daily intake was of 260 and 78 calories more respectively. The intake of vegetal protein for the fortifying women was 9.6, 5.9 and 6.5 g more during each trimester of pregnancy respectively. It was found that the lowest intake of calories and vegetal protein in the unfortified women corresponded to the first trimester of pregnancy. This finding shows that corn fortification had an effect during the period of pregnancy when the food intake is reduced due to the nausea and anorexia of pregnancy. As a consequence, corn fortification was a positive factor in improving the diet of the women during the first six months of pregnancy.

2. Operational significance

The analyses of the data collected so far has yielded results which have vast public health implications. The results strongly indicate that corn fortification, even at a low level of 4 to 6 percent, reduces the infant mortality rate by 50 percent. A reduction in the second to fifth year mortality rates was also clearly noticeable. Besides, morbidity during the second and third year of life was also reduced by 33 percent; this period coincides with the weaning process. These positive changes appear to be independent of socioeconomical class. Even if a significant effect on postnatal growth was not evident, the relationship between changes in the fortification index of the 3 to 5 year old children with their corresponding growth increments showed a positive tendency. No change in fetal growth was found; however, the dietary intake in pregnant women, was improved, in the sense

that the highly fortified group had an average of 200 extra calories provided by a higher consumption of corn per day. These preliminary finding on the effect of corn fortification on pregnant women, are suggestive that this intervention could also produce a benefit in the health of these women.

So far, there is a very benefic effect in the children's health, but not in their physical growth. So, it is necessary to find positive changes in other parameters associated to nutrition such as: increments in the newborn's weight, and a clearer effect on the postnatal growth.

3. Side effects of the work

The information obtained so far is in the scope of the project objectives. For the application of the findings, an approach consisting in the distribution of the fortifying mixture at the community level, through cooperatives or other community associations should be utilized. The experience gained through the research activities in the addition of the fortifying mixture at the mill level, assures an easy handling in similar settings.

4. Research design

No changes in the research designs were made during the development of the project. However, due to the fact that the fortifying mixture currently being added to the corn, increases the final volume of the corn dough making it difficult to reach the expected 8 percent level of fortification, the consistency of the mixture should be changed to a pelletized form. It also should be added to corn at 10 percent level to obtain 8 percent of final concentration in the corn dough.

The research design should be irproved by:

a) increasing the level of fortification; b) increasing the consistency of fortification; c) increasing the sample size to study the effect of fortification on the child morbidity; d) increasing the number of families who fortify their corn at a constant high level; e) increasing the time of the field observation.

The research findings suggest that it is of great importance to continue the corn fortification project during three or more years at the same place of the previous study, but at a higher level (10%), to enhance the possibility of replicating the results already observed.

D. DISSEMINATION AND UTILIZATION OF RESEARCH FINDINGS

1. Project output

a) Mata, L.J., J.J. Urrutia, B. García, R. Bressani, P. Lachance, and M.A. Guzmán. A model for maize fortification with soy bean flour, lysine and other nutrients in a low socioeconomic rural community. Nutritional Improvement of Maize, Institute of Nutrition of Central America and Panama (INCAP), Bressani, R., J.E. Braham and M. Béhar (Eds.), 1973.

b) Urrutia, J.J., L.J. Mata, F. Trent, J.R. Cruz, E. Villatoro, and R. Alexander. Infection and low birth weight in a developing country. Am. J. Dis. Child., 129:558-561, 1975.

c) Capparelli, E., and L.J. Mata. Microflora of maize prepared as tortillas. Applied Microbiol., 29:802-806, 1975.

d) Urrutia, J.J., B. García, L.J. Mata, and R. Bressani. Reporte preliminar del efecto biológico de la fortificación del maíz con harina de soya y lisina. In: Memorias de la Primera Conferencia Latinoamericana sobre la Proteína de Soya, México, 1975. (In press).

e) Urrutia, J.J., and L.J. Mata. Infección en la mujer embarazada y su influencia en el producto de la concepción. In: Aspectos Perinatales del Parto Prematuro y del Retardo de Crecimiento Intrauterino, Montevideo, Uruguay. (In press).

2. Dissemination

The research findings have been included in the Annual Progress Report of INCAP every year since 1973. This information has been circulated into the Public Health authorities of Central America.

The paper entitled "Preliminary report of biological effect of the corn fortification with soy flour and lysine" was presented at the "First Latin American Conference on Soy Protein" in November, 1975 and will be published by the American Society of Soy about June 1976. The recent findings about the effect of corn fortification on morbidity and mortality will be presented at the National Congress of Pediatrics of Guatemala in March 1976.

E. WORK PLAN FOR THE COMING YEAR

The project will end on the 31st of March 1976. A new grant application has been presented in October 1975.

F. INVOLVEMENT OF MINORITY PERSONNEL AND WOMEN

Four persons are in charge of adding the fortifying flour to the corn and keeping the records of daily assistance at each of village mills. The four are Indians from Santa María Cauqué. Three of them are minors: two women and one boy. The fourth person is a woman. They work for the project on contractual basis

Other women working for the project are: Four auxiliary nurses; one dietary technologist and two dietary assistant; one immunology technician, one laboratory helper, one data clerk and one secretary. All of them are Guatemalans, non Indians. With the exception of one nurse and one dietary assistant, who live in Santa María Cauqué, all live in Guatemala City.

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Table 1

Fortifying mixture for corn*
corn fortification project,
Santa María Cauqué

Ingredient	Composition of supplement %	Content in 8% added to corn, g
Soybean flour	97.5000	7.800000
L-lysine HCl	1.5000	0.120000
Thiamin	0.0268	0.002144
Riboflavin	0.0162	0.001296
Niacinamide	0.1930	0.015440
Ferric orthophosphate**	0.6000	0.048000
Vit. A 250-SD***	0.0313	0.002504
Corn starch	0.1327	0.010616
Total	100.0000	8.000000

* Developed by R. Bressani, unpublished data.

** Contains 28.1% Fe.

*** 75,000 mcg Retinol/g.

Table 2

Variability in the fortification frequency in the highly fortified group* (FI: 40-100), corn fortification project, Santa María Cauqué, June 1972-May 1975

Trimesters of observation	Fortification index	Trimesters of observation	Fortification index
1	64±22**	7	71±17
2	69±20	8	75±16
3	71±21	9	78±22
4	75±19	10	55±26
5	79±17	11	51±31
6	55±13	12	60±34

* 94 families.

** Mean ± one standard deviation.

Table 3

Variability in the fortification frequency in the medium fortified group* (FI: 20-39), corn fortification project, Santa María Cauqué, June 1972-May 1975

Trimesters of observation	Fortification index	Trimesters of observation	Fortification index
1	42±27**	7	32±27
2	47±27	8	24±24
3	42±27	9	27±31
4	37±23	10	14±19
5	27±33	11	17±25
6	26±20	12	23±31

* 23 families.

** Mean ± one standard deviation.

Table 4

Protein and total free lysine in a sample of 918 tortillas corn fortification project, Santa María Cauqué, June 1972-May 1975

Variables	498 fortified tortillas	420 unfortified tortillas	t value	p
Protein (g%)	10.7±1.2	8.7±1.1	26.45	<.001
Total free lysine (mg%)	55.9±23.2	19.7±13.1	28.31	<.001

Table 5

Frequency distribution of the family socioeconomical index in the families with children (≤10 years old) in accordance to the Fortification Index, corn fortification project, Santa María Cauqué, June 1971

Fortification index	Number of cases	Socioeconomical Index				
		≤19	20-23	24-27	28-31	≥32-36
0-19	108	9(8)*	24(22)	38(35)	32(30)	5(5)
20-39	22	0	8(36)	5(23)	9(41)	0
40-100	93	7(8)	17(18)	38(41)	28(30)	3(3)
		X^2 = 8073		P = Not significant		

* Number of cases (rounded percentage).

Table 6

Frequency distribution of the family socioeconomical index in the families without children (>10 years old) in accordance to the Fortification Index, corn fortification project, Santa María Cauqué, June 1971

Fortification index	Number of cases	Socioeconomical index				
		≤19	20-23	24-27	28-31	32-36
0-19	31	3(10)*	2(6)	9(29)	16(51)	1(3)
20-39	9	0	1(11)	3(33)	5(55)	0
40-100	9	1(11)	3(33	1(11)	4(44)	0
		X^2 = 6.777		P = Not significant		

* Number of cases (rounded percentage).

Table 7

Family socioeconomical index of three variables in the families with children (<10 years old) in relation to the family Fortification Index, corn fortification project, Santa María Cauqué, June 1971

Fortification index	Number of cases	Socioeconomical index		
		Land tenure	Scholarity	Shoe wear
0-19	108	1.98±0.83*	1.94±0.67	2.24±0.98
20-39	22	2.05±0.84	1.73±0.63	2.09±1.02
40-100	93	2.06±0.76	1.88±0.64	2.17±0.98

* Mean ± one standard deviation.

Table 8

Family socioeconomical index of three variables in the families without children, corn fortification project, Santa María Cauqué, June 1971

Fortification index	Number of cases	Socioeconomical index		
		Land tenure	Scholarity	Shoe wear
0-19	39	2.18±0.88*	1.72±0.79	2.03±1.01
20-39	2	2.50±0.70	1.50±0.71	1.00±0.00
40-100	9	2.22±0.83	2.00±0.71	2.33±1.00

* Mean ± one standard deviation.

Table 9

Relationship between birth weight and the Fortification Index in full term infants,* corn fortification project, Santa María Cauqué, June 1972-May 1975

Variables	Fortification Index 0-19 $\bar{x} \pm$ S.D.	20-39 $\bar{x} \pm$ S.D.	40-100 $\bar{x} \pm$ S.D.
Birth weight (grams)	2643±324	2702±285	2571±314
Fortification Index	4±6	29±5	65±13
Birth order	4.1±3.1	4.2±2.9	4.8±3.6
Mother's height (centimeters)	143±4.2	145±5.3	144±4.7
Gestational age (weeks)	39.3±1.2	39.3±1.1	39.1±1.5
Number of cases	124	27	71

* Premature babies (< 37 weeks of gestational age) excluded.

Table 10

Correlation between Fortification Index, and birth order, mother's height, and newborn weight, height and head circumference, corn fortification project, Santa María Cauqué, June 1972-May 1975

Variables	Number of cases	Correlation coefficient (r)
Birth order	189	.153
Mother's height	189	.094
Newborn weight	189	-.115
Newborn height	189	.030
Newborn head circumference	189	-.051

Table 11

Correlation between Fortification Index and child height from birth to 8 years of age, corn fortification project, Santa María Cauqué, June 1972-May 1975

Age (years)	Number of cases	Correlation coefficient (r)
0	214	.045
1	168	-.118
2	167	-.045
3	153	.000
4	139	.010
5	126	.057
6	109	.021
7	108	.091
8	109	.021

Table 12

Mean and standard deviations ($\bar{x} \pm$ S.D.) of heights and weights in sibling pairs, corn fortification project, Santa María Cauqué, June 1972-May 1975

Age (months)	Number of sibling-pairs	Height (centimeters)		Weight (grams)	
		Sibling 1*	Sibling 2**	Sibling 1	Sibling 2
0	76	45.7±1.8	46.3±1.6	2569(307)	2634(380)
6	76	59.6±2.3	58.9±0.9	6242(687)	6351(857)
15	76	68.0±2.7	67.5±2.6	7320(893)	7210(878)
24	64	74.4±3.8	74.1±3.6	8586(1004)	8641(998)
36	64	79.9±3.9	80.2±4.3	10304(1276)	10389(1253)
60	66	92.2±4.4	92.7±4.1	13509(1498)	13615(1580)

* Sibling 1 born before corn fortification.

** Sibling 2 born after corn fortification.

Table 13

Relationship between changes in the Fortification Index and growth increments from 3 to 5 years, corn fortification project, Santa María Cauqué, June 1972-May 1975

Variables	Number of children	Correlation coefficient (r)
Weight	56	.169
Height	55	.100

Table 14

Correlation between the number of hand and wrist ossification centers and the Fortification Index, from 6 months to 8 years of age, corn fortification project, Santa María Cauqué, June 1972-December 1975

Age (months)	Number of cases	Number of ossification centers	Correlation coefficient (r)
6	76	2.4±1.8*	.060
12	114	3.3±2.6	-.051
18	139	4.9±3.9	.018
24	158	7.0±4.9	-.019
30	137	9.9±5.8	-.001
36	135	13.9±5.7	.000
42	124	16.5±4.9	-.095
48	121	18.0±4.6	.013
54	121	20.5±3.3	.045
60	109	22.1±3.5	.079
72	86	23.9±2.2	.106
84	42	25.4±2.3	-.139
96	19	26.6±2.0	-.250

* Mean ± one standard deviation.

Table 15

Analysis of variance of the presence of selected hand and wrist ossification centers at age two years in relation to the Fortification Index, corn fortification project, Santa María Cauqué, June 1972-December 1975

Ossification center	Fortification Index 0-19 (102)*	20-39 (24)	40-100 (37)	P
Radius	66(65)**	19(74)	26(70)	N.S.***
Metacarpal I	12(12)	2(11)	4(11)	N.S.
Metacarpal II	34(33)	5(26)	14(38)	N.S.
Metacarpal III	29(28)	4(21)	12(32)	N.S.
Metacarpal IV	21(21)	4(21)	10(27)	N.S.
Metacarpal V	19(19)	3(16)	7(19)	N.S.
Proximal phalanx II	49(48)	9(47)	18(49)	N.S.
Proximal phalanx III	69(68)	13(68)	28(70)	N.S.
Proximal phalanx IV	47(46)	8(42)	19(51)	N.S.
Proximal phalanx V	23(23)	5(26)	9(24)	N.S.
Middle phalanx III	17(17)	5(26)	8(22)	N.S.
Middle phalanx IV	21(21)	5(26)	7(19)	N.S.
Distal phalanx I	55(54)	10(53)	20(54)	N.S.

* Number of cases.

** Number (rounded percentage) with ossification center present.

*** N.S. = Not significant.

Table 16

Analysis of variance of the presence of selected hand and wrist ossification centers at age four years in relation to the Fortification Index, corn fortification project, Santa María Cauqué, June 1972-December 1975

Ossification center	Fortification Index 0-19 (75)*	20-39 (16)	40-100 (30)	P
Triquetral	26(35)**	7(44)	12(40)	N.S.***
Lunate	7(9)	1(6)	3(10)	N.S.
Metacarpal I	46(61)	11(69)	22(73)	N.S.
Metacarpal II	73(97)	15(94)	28(93)	N.S.
Metacarpal III	75(100)	15(94)	27(90)	N.S.
Metacarpal IV	67(89)	13(81)	25(83)	N.S.
Metacarpal V	58(77)	13(81)	23(77)	N.S.
Proximal phalanx I	41(55)	8(50)	16(53)	N.S.
Proximal phalanx V	66(88)	15(94)	26(87)	N.S.
Middle phalanx II	57(76)	12(75)	22(73)	N.S.
Middle phalanx III	67(89)	13(81)	22(73)	N.S.
Middle phalanx IV	65(87)	13(81)	23(77)	N.S.
Middle phalanx V	23(31)	9(56)	8(27)	N.S.
Distal phalanx II	33(44)	7(44)	10(33)	N.S.
Distal phalanx III	58(77)	12(75)	26(87)	N.S.
Distal phalanx IV	56(75)	11(69)	25(83)	N.S.
Distal phalanx V	34(45)	9(56)	16(53)	N.S.

* Number of cases.

** Number (rounded percentage) with ossification center present.

*** N.S. = Not significant.

Table 17

Analysis of variance of the presence of selected hand and wrist ossification centers at age six years in relation to the Fortification Index, corn fortification project, Santa María Cauqué, June 1972-December 1975

Ossification center	Fortification Index 0-19 (38)*	20-39 (19)	40-100 (30)	P
Ulna	2(5)**	0	2(7)	N.S.***
Triquetral	31(82)	16(84)	26(87)	N.S.
Lunate	21(55)	11(58)	16(53)	N.S.
Scaphoid	8(21)	3(16)	11(37)	N.S.
Trapezium	11(29)	8(42)	13(43)	N.S.
Trapezoid	6(16)	5(26)	9(30)	N.S.
Metacarpal I	35(92)	19(100)	29(97)	N.S.
Middle phalanx V	31(82)	17(90)	26(87)	N.S.

* Number of cases.

** Number (rounded percentage) with ossification center present.

*** N.S. = Not significant.

Table 18

Analysis of variance of the number of the carpal ossification centers of children in relation to the Fortification Index, corn fortification project, Santa María Cauqué, June 1972-December 1975

Age (years)	Fortification Index 0-19	20-39	40-100	P
1	2.00* (67)	2.00 (23)	2.14 (23)	N.S.**
2	2.08 (102)	2.05 (19)	2.03 (37)	N.S.
3	2.17 (72)	2.22 (23)	2.20 (40)	N.S.
4	2.47 (75)	2.50 (16)	2.50 (30)	N.S.
5	3.09 (58)	3.33 (12)	3.41 (39)	N.S.
6	4.03 (38)	4.26 (19)	4.50 (30)	N.S.
7	5.64 (22)	5.30 (8)	5.05 (19)	N.S.

* Mean (number of cases).

** N.S. = Not significant.

Table 19

Correlation between the cortical thickness of the second metacarpal and the Fortification Index from 6 months to 8 years of age, corn fortification project, Santa María Cauqué, June 1972-December 1975

Age (months)	Number of cases	Cortical thickness (mm)	Correlation coefficient (r)
6	76	0.92±0.19*	-.066
12	114	0.95±0.24	.176
18	139	0.99±0.26	-.055
24	158	1.12±0.25	-.156
30	137	1.18±0.28	-.018
36	135	1.18±0.30	-.082
42	124	1.21±0.28	-.067
48	121	1.25±0.29	.099
54	121	1.38±0.31	-.081
60	109	1.41±0.33	.140
72	86	1.54±0.32	.041
84	42	1.68±0.34	.008
96	19	1.82±0.35	-.271

* Mean ± one standard deviation.

Table 20

Number of children at various ages: morbidity analysis, corn fortification project, Santa María Cauqué, June 1972-November 1975

Groups of fortification*	Age intervals, months					
	0-5	6-11	12-17	18-23	24-29	30-35
0-19	19	26	35	40	42	33
20-39	7	9	11	11	14	12
40-100	7	8	14	16	19	22
Total	33	43	60	67	75	67

* Classified by Fortification Index.

Table 21

Percent of the time ill with upper respiratory infection per categories of the corn Fortification Index and age of the child
corn fortification project
Santa María Cauqué, June 1972-November 1975

Groups of fortification*	Age intervals, months					
	0-5	6-11	12-17	18-23	24-29	30-35
0-19	11.0**	8.5	10.9	9.1	9.5	9.0
20-39	8.8	9.4	10.1	7.6	8.3	6.3
40-100	15.9	10.0	6.8	5.3	6.5	5.1
p	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

* Classified by Fortification Index.

** Rate per 100 child-days.

Table 22

Percent of the time ill with bronchitis and bronchopneumonia per categories of the corn Fortification Index and age of the child, corn fortification project
Santa María Cauqué, June 1972-November 1975

Groups of fortification*	Age intervals, months					
	0-5	6-11	12-17	18-23	24-29	30-35
0-19	10.4**	8.5	8.3	7.4	8.8	3.5
20-39	16.7	10.1	6.8	5.4	2.9	3.4
40-100	15.9	8.9	5.7	3.1	4.6	4.6
P	N.S.	N.S.	N.S.	N.S.	$<.025$	N.S.

* Classified by Fortification Index.

** Rate per 100 child-days.

Table 23

Percent of the time ill with diarrhea per categories of the corn Fortification Index and age of the child, corn fortification project, Santa María Cauqué, June 1972-November 1975

Groups of fortification*	Age intervals, months					
	0-5	6-11	12-17	18-23	24-29	30-35
0-19	10.2**	11.9	16.8	13.6	15.8	9.3
20-39	12.0	9.8	12.1	7.2	9.8	9.0
40-100	11.7	17.1	7.6	9.9	6.9	8.2
P	N.S.	N.S.	<.10	N.S.	N.S.	N.S.

* Classified by Fortification Index.

** Rate per 100 child-days.

Table 24

Percent of the time ill with associated illnesses* per categories of the corn Fortification Index and age of the child corn fortification project
Santa María Cauqué, June 1972-November 1975

Groups of fortification**	Age intervals, months					
	0-5	6-11	12-17	18-23	24-29	30-35
0-19	6.4***	6.5	7.3	6.5	6.7	3.4
20-39	7.3	6.5	6.0	5.7	4.9	2.6
40-100	9.5	9.1	4.6	2.7	2.9	2.3
p	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

* Respiratory plus diarrhea; respiratory plus conjunctivitis and/or stomatitis; diarrhea plus conjunctivitis and/or stomatitis; conjunctivitis plus stomatitis; respiratory plus diarrhea plus conjunctivitis and/or stomatitis.

** Classified by Fortification Index.

*** Rate per 100 child-days.

Table 25

Percent of the time ill with infectious illnesses per categories of the corn Fortification Index and age of the child, corn fortification project, Santa María Cauqué, June 1971-November 1975

Groups of fortification*	Age intervals, months					
	0-5	6-11	12-17	18-23	24-29	30-35
0-19	28.6**	27.8	33.3	29.6	32.8	20.4
20-39	36.7	31.4	32.8	24.5	21.1	20.1
40-100	40.8	32.1	22.8	19.5	17.8	19.5
P	N.S.	N.S.	N.S.	<.10	<.025	N.S.

* Classified by Fortification Index.

** Rate per 100 child-days.

Table 26

Percent of the time ill with fever per categories of the corn Fortification Index and age of the child, corn fortification project, Santa María Cauqué, June 1972-November 1975

Groups of fortification*	Age intervals, months					
	0-5	6-11	12-17	18-23	24-29	30-35
0-19	3.8**	6.9	9.2	7.8	10.4	4.9
20-39	5.6	7.6	7.4	4.8	5.8	5.6
40-100	3.5	5.3	4.0	4.3	3.7	5.4
P	N.S.	N.S.	$<.05$	N.S.	$<.005$	N.S.

* Classified by Fortification Index.

** Rate per 100 child-days.

Table 27

Percent of the time ill with diarrhea of 7 or more stools per day per categories of the corn fortification and age of the child, corn fortification project Santa María Cauqué, June 1972-November 1975

Groups of fortification*	Age intervals, months					
	0-5	6-11	12-17	18-23	24-29	30-35
0-19	3.1**	3.2	4.8	4.6	4.6	1.9
20-39	2.0	2.7	5.0	2.2	2.7	2.7
40-100	2.2	4.0	1.4	1.8	1.3	2.1
P	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

* Classified by Fortification Index.

** Rate per 100 child-days.

Table 28

Reduction in number of illness days in the highly fortified compared with the low fortified children, during the second and third year of life, corn fortification project, Santa María Cauqué, June 1972-May 1975

Diseases	Age intervals, months				
	3	4	5	6	Total
Total diarrhea	16.4*	6.7	15.8	2.3	41.2**
Upper respiratory tract infections	4.2	3.8	3.0	3.9	14.9
Lower respiratory tract infections	2.6	3.8	4.2	1.4	9.2
Total days of infectious illnesses	18.9	18.2	27.0	3.4	67.5

* The figures given show the reduction of illness days per semester of life between the highly fortified and low fortified groups.

** Reduction of illness days during the second and the third year of life.

Table 29

Reduction in number of days with fever and diarrhea with 7 and more stools per day in the highly fortified compared with the low fortified children during the second and third year of life, corn fortification project, Santa María Cauqué, June 1972-May 1975

Symptoms	Semesters of life				Total
	3	4	5	6	
Total days of fever	9.4*	6.0	12.2	0.7	28.3**
Days of diarrhea with 7 and more intestinal movements a day	6.1	5.0	5.9	0.0	17.0

* The figures given show the reduction of illness days per semester of life between the highly fortified and low fortified group.

** Reduction of illness days during the second and the third year of life.

Table 30

Number of fecal cultures done at 6 month intervals in 3 groups of children observed from birth to 3 years of age, corn fortification project, Santa María Cauqué, June 1972-May 1975

Groups of children*	Age intervals, months					
	0-5	6-11	12-17	18-23	24-29	30-35
0-19	529**	485	624	889	930	784
20-39	198	200	195	258	280	259
40-100	182	176	242	313	397	379

* Classified by Fortification Index.

** Number of cultures.

Table 31

Duration of Shigella infection, carriers and cases 3 groups of children observed from birth to 3 years of age, corn fortification project, Santa María Cauqué, June 1972-May 1975

Groups of children*	Duration in weeks**		
	1 %	2-4 %	5-8 %
0-19	58	37	4
20-39	38	51	9
40-100	61	32	7

* Classified by Fortification Index.

** Two isolations were considered independent infections if separated by more than 2 weeks.

Table 32

Infant mortality before corn fortification

Santa María Cauqué, January 1964-May 1972

Groups of fortification*	Number of deliveries	Number of deaths			Rate
		Stillbirths	0-11 months	Total	
0-19	255	8	26	34	133**
20-39	43	0	5	5	116
40-100	206	8	14	22	107
Total	504	16	45	61	121

* Classified by Fortification Index.

** Rate per 1000 deliveries.

Table 33

Infant mortality during corn fortification

Santa María Cauqué, June 1972-May 1975

Groups of fortification	Number of deliveries	Deaths			Rate
		Stillbirths	0-11 months	Total	
0-19	133	5	15	20	150*
20-39	21	0	3	3	143
40-100	98	2	3	5	51
Total	252	7	21	28	111

* Rate per 1000 deliveries.

Table 34

Infant mortality in low birth weight babies (<2.5 Kg) born during corn fortification project, Santa María Cauqué, June 1972-May 1975

Groups of fortification	Number of deliveries	Number of LBW babies	Percent of all deliveries	Number of deaths	Rate
0-19	133	53	39.8	9	170*
20-39	21	8	38.1	2	250
40-100	98	37	37.8	2	54

* Rate per 1000 deliveries.

Table 35

Second to fifth year mortality during corn fortification

Santa María Cauqué, June 1972-May 1975

Mortality (years)	Groups of families by Fortification Index									Total		
	0-19			20-39			40-100					
	No. of children	No. of Deaths	Rate	No. of children	No. of Deaths	Rate	No. of children	No. of Deaths	Rate	No. of children	No. of Deaths	Rate
Second	132	3	23*	24	3	125	108	3	28	264	9	34
Third	116	3	26	24	0	0	99	0	0	239	3	13
Fourth	75	2	27	17	3	176	72	0	0	164	5	30
Fifth	61	1	16	14	0	0	65	0	0	140	1	7
Total 2nd-5th	384	9	23	79	6	76	344	3	9	807	18	22

* Rate per 1000 children of that age.

Table 36

Second to fifth year mortality
before corn fortification,
Santa María Cauqué, January 1964-May 1972

Mortality	Number of children	Number of deaths	Rate
Second year	454	26	57*
Third year	389	13	33
Fourth year	376	5	13
Fifth year	357	1	3
Total	1576	45	29

* Rate per 1000 children of that age.

Table 37

Relationship between the Fortification Index and the mean daily intake of calories in children from 18 to 36 months of age, corn fortification project, Santa María Cauqué, June 1972-May 1975

Age (months)	Fortification Index	Number of children	Calories
18th	0-19	23	405±194*
	20-39	7	488±229
	40-100	29	459±272
	Total	59	453±250
24th	0-19	28	712±289
	20-39	5	485±113
	40-100	32	733±360
	Total	65	705±319
30th	0-19	22	966±283
	20-39	6	1004±318
	40-100	33	903±258
	Total	61	936±271
36th	0-19	15	1121±349
	20-39	6	1131±494
	40-100	24	1019±273
	Total	45	1068±329

* Mean ± one standard deviation.

Table 38

Relationship between the Fortification Index and the mean daily intake of protein in children from 18 to 36 months of age, corn fortification project, Santa María Cauqué, June 1972-May 1975

Age (months)	Fortification Index	Number of children	Animal protein (g)	Vegetal protein (g)	Total protein (g)
18th	0-19	23	1.2±1.8*	7.5± 3.1	8.7± 4.5
	20-39	7	4.5±4.0	7.8± 3.6	12.2± 6.7
	40-100	29	3.6±3.6	8.8± 5.0	10.4± 7.1
	Total	59	1.8±3.2	8.2± 4.3	10.2± 6.3
24th	0-19	28	2.7±2.5	13.8± 6.2	16.5± 7.3
	20-39	5	1.5±1.0	10.1± 2.4	11.6± 1.9
	40-100	32	3.0±5.1	14.8± 7.3	17.8±10.8
	Total	65	2.7±4.0	14.0± 6.7	16.8± 9.0
30th	0-19	22	2.4±2.4	19.5± 5.0	21.9± 6.2
	20-39	6	2.6±0.8	22.5± 7.5	25.0± 7.3
	40-100	33	2.3±3.1	20.6± 6.8	22.9± 7.3
	Total	61	2.4±2.6	20.4± 6.2	22.7± 6.9
36th	0-19	15	3.7±2.3	23.1± 7.9	26.7± 7.9
	20-39	6	3.1±1.3	24.5±10.5	27.6±10.3
	40-100	24	2.2±1.4	24.1± 7.4	26.3± 7.3
	Total	45	2.8±1.8	23.8± 7.8	23.8± 7.8

* Mean ± one standard deviation.

Table 39

Incidence of infectious diseases during pregnancy[1]

Santa María Cauqué, January 1972-October 1975

Trimester of pregnancy	Respiratory tract infection		Diarrheal disease	Other illnesses[2]	Urinary tract bacterial infection	
	Upper	Lower			Clinical	Bacteriuria[3]
1	58(28)[4]	11(5)	12(6)	9(4)	7(3)	12(6)
2	78(38)	21(10)	20(10)	9(4)	16(8)	15(7)
3	83(40)	30(15)	41(20)	18(9)	28(14)	17(8)
Incidence per 100 pregnancies	219(106)	62(30)	73(36)	36(17)	51(25)	44(21)

1 Data obtained from 209 pregnant women observed prospectively from conception to delivery.

2 Conjunctivitis, otitis media, stomatitis and skin infections.

3 ⩾100,000 bacteria per milliliter of urine.

4 Number of episodes (rounded percentage).

Table 40

Days of illness due to infectious disease[1]

Santa María Cauqué, January 1972-October 1975

Trimester of pregnancy	Respiratory tract infection		Diarrheal disease			Other Illnesses[2]	Urinary tract infection[3]
	Upper	Lower	Without mucus	With mucus and/or blood	Total		
1	2.8[4]	.9	.2	.0	.2	.4	.4
2	3.5	1.3	.5	.0	.5	.4	.8
3	4.0	2.3	.9	.3	1.2	1.1	1.5
Mean	3.2	1.5	.6	.1	.7	.6	.9

1 Data obtained from 209 pregnant women observed prospectively from conception to delivery.

2 Conjunctivitis, otitis media, stomatitis and skin infections.

3 Based on symptom's duration.

4 Mean days of illness per 100 days.

Table 41

Relationship between the incidence of infectious diseases during pregnancy[1] and the newborns' weight
Santa María Cauqué, January 1972-October 1975

Weight of newborns (g)	Number of mothers	Respiratory tract infection		Diarrheal disease	Other illnesses[2]	Bacteriurias[3]
		Upper	Lower			
⩽2300	44	36(82)[4]	14(32)	11(25)	9(21)	12(27)[5]
2301-2700	78	89(114)	20(26)	26(33)	12(15)	10(13)
⩾2701	75	86(115)	23(31)	28(37)	15(20)	9(12)
Total	197	211(107)	57(29)	65(33)	36(18)	31(16)

1 Data obtained from 209 pregnant women observed prospectively from conception to delivery.

2 Conjunctivitis, otitis media, stomatitis and skin infections.

3 ⩾100,000 bacteria per milliliter of urine.

4 Number of episodes (rounded percentage).

5 Differences statistically significant ($X^2 = 3.89$ $P < 0.05$).

Table 42

Comparison of the incidence of infectious diseases during the first trimester of pregnancy in women with abortion and term pregnancies
Santa María Cauqué, January 1972-October 1975

Pregnancy	Number of subjects	Respiratory tract infection		Diarrheal disease	Other illnesses	Urinary tract bacterial infection	
		Upper	Lower			Clinical	Bacteriuria
Abortion	56	15(27)*	3(5)	4(7)	4(7)	3(5)	14(25)
Term	209	58(28)	11(5)	12(6)	9(4)	7(3)	12(6)
	x^2	0.012	0.000	0.134	0.680	0.450	13.870
	P	N.S.	N.S.	N.S.	N.S.	N.S.	<0.005

* Number of cases (rounded percentage).

Table 43

Percent of the time ill with infectious diseases during pregnancy per categories of the corn Fortification Index, corn fortification project, Santa María Cauqué, January 1972-October 1975

Groups of fortification*	Number of women	Infectious diseases				
		Upper respiratory infection	Lower respiratory infection	Diarrheal disease	Urinary tract infection	Other illnesses**
0-19	97	2.9***	1.7	0.7	0.8	0.8
20-39	24	3.7	0.8	0.5	0.3	0.1
40-100	65	3.4	1.4	0.6	1.3	0.7
P		N.S.	N.S.	N.S.	N.S.	N.S.

* Classified by Fortification Index.

** Conjunctivitis, otitis media, stomatitis and skin infections.

*** Rate per 100 person-days.

Table 44

Correlation between Fortification Index and some variables in 105 pregnant women diets*, corn fortification project, Santa María Cauqué, June 1972-May 1975

Variables	Correlation coefficient (r)	P
Protein from corn	.327	<0.01
Protein from soy	.683	<0.01
Vegetal protein other than corn or soy	-.011	
Total vegetal protein	.256	<0.01
Animal protein	-.079	
Total protein	.222	<0.05
Protein from fortified tortilla	.710	<0.01
Protein from unfortified tortilla	-.584	<0.01
Grams of tortilla	.154	
Calories not derived from tortilla	-.075	
Total calories	.153	

Mean daily intake, derived from three, one week daily record surveys, corresponding to each trimester of pregnancy.

Table 45

Analysis of variance of the diets of three groups of 105 pregnant women*, corn fortification project, Santa María Cauqué, June 1972-May 1975

Variables	Fortification Index 0-19 (41)**	20-39 (24)	40-100 (40)	P
Tortilla (g)	479	476	574	<0.010
Calories not from corn	741	732	766	N.S.
Total calories	1801	1745	2024	<0.005
Total protein (g)	46.1	46.3	55.3	<0.005
Animal protein (g)	6.9	7.6	6.6	N.S.
Vegetal protein (g)	39.2	39.0	48.7	<0.005
Protein from corn (g)	21.6	22.5	30.6	<0.005
Protein not from corn (g)	17.6	16.5	18.1	N.S.
Protein from soy (g)	0.0	2.0	5.3	<0.005

* Mean daily intake, derived from three, one week daily record surveys, corresponding to each trimester of pregnancy.

** Number of cases.

Table 46

Relationship between the corn Fortification Index and the mean daily intake of calories during pregnancy corn fortification project, Santa María Cauqué, June 1972-May 1975

Fortification index	Number of women	Trimesters of pregnancy		
		First	Second	Third
0-19	41	1687±486*	1742±485	1840±432
20-39	24	1783±423	1835±462	1742±474
40-100	40	1931±450	2002±472	1918±444
t test:	0-19/20-39	1.30	1.38	1.50
t test:	0-19/40-100	2.35**	2.45***	0.80

* Mean ± one standard deviation.

** $P < 0.05$

*** $P < 0.02$

Table 47

Relationship between the corn Fortification Index and the mean daily intake of vegetal protein during pregnancy corn fortification project, Santa María Cauqué, June 1972-May 1975

Fortification index	Number of women	Trimesters of pregnancy		
		First	Second	Third
0-19	41	36.1±12.2*	41.8±11.8	40.2± 9.8
20-39	24	39.4±10.6	42.3±11.3	38.9±11.6
40-100	40	45.7±13.1	47.7±13.3	46.7±12.1
t test:	0-19/20-39	2.00**	1.66	2.54***
t test:	0-19/40-100	3.42*****	2.12**	2.66****

* Mean ± one standard deviation.

** $p < 0.05$ *** $p < 0.02$

**** $p < 0.01$ ***** $p < 0.001$

Table 48

Relationship between the corn Fortification Index and the mean daily intake of animal protein during pregnancy corn fortification project, Santa María Cauqué, June 1972-May 1975

Fortification index	Number of women	Trimesters of pregnancy		
		First	Second	Third
0-19	41	7.5±4.2*	6.5±3.5	7.1±3.6
20-39	24	8.0±4.0	6.4±3.9	7.4±4.8
40-100	40	7.0±3.9	7.3±4.3	6.5±3.4
t test:	0-19/20-39	-0.98	0.84	-0.88
t test:	0-19/40-100	-0.56	0.92	-0.77

* Mean ± one standard deviation.

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NOTICE OF RESEARCH PROJECT

SUPPORTING AGENCY:

AGENCY FOR INTERNATIONAL DEVELOPMENT

AGENCY'S NUMBER(S):
Contract No: AID-CSD-3357
and/or
Control No:

TITLE OF PROJECT:

CORN FORTIFICATION: A FIELD DEMONSTRATION MODEL

PRINCIPAL INVESTIGATOR, ASSOCIATES — School or Division — Department

DR. JUAN JOSE URRUTIA — DIV. OF ENVIRONMENTAL BIOLOGY

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RECIPIENT INSTITUTION:
Name and Address: INSTITUTE OF NUTRITION OF CENTRAL AMERICA AND PANAMA (INCAP)
including P. O. BOX 1188
Zip Code. GUATEMALA, GUATEMALA, C.A.

PERIOD FOR THIS NAR:
Start Date: October 16, 1974
End Date: December 31, 1975
Annual Funding: $173,891.00

SUMMARY OF PROJECT: Be brief-200 word maximum: (Include Objective, Approach, Current Plans and/or Progress)

Corn fortified with 8 percent soy bean flour (50% protein) and 0.125 percent L-lysine HCl is improved in its biological value. If persons living under natural conditions are fed with this corn, a positive biological effect on the growth pattern of children, and on the morbidity and mortality would be observed. To test this hypothesis, since June 1972 the corn consumed by the villagers of Santa María Cauqué, Guatemala, has been fortified. Strong indicators provided by the research findings, indicate that the intervention has been beneficial in reducing the infant mortality by 50 percent. The second to fifth year mortality has been also clearly reduced. Morbidity during weaning has been reduced by 33 percent. These changes appear to be independent of socioeconomical class. Even if a signifi cant effect on postnatal growth was not evident, a positive tendency for better growth increments was found in children 3 to 5 years old. No change in fetal growth was found; however, the dietary intake in pregnant women was improved, especially during the first six months of pregnancy.

So far, there is a very benefic effect in the children's health. It is proposed that this project is continued increasing the level of fortification to 10 percent to find positive changes in other parameters associated to nutrition. A new grant proposal was submitted in October, 1975.