AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTON, D. C. 20523
BIBLIOGRAPHIC INPUT SHEET

FOR AID USE ONLY
Batch 60

1. SUBJECT CLASSIFICATION
A. PRIMARY
Food production and nutrition — AQ10-0100-0000
B. SECONDARY
Food processing--Cereals

2. TITLE AND SUBTITLE
Global malnutrition and cereal fortification, chapt. 9: Case study, Thailand

3. AUTHOR(S)
(100) Austin, J.E. (101) Harvard Univ. School of Public Health

4. DOCUMENT DATE	5. NUMBER OF PAGES	6. ARC NUMBER
1977	69 p.	ARC

7. REFERENCE ORGANIZATION NAME AND ADDRESS
Harvard

8. SUPPLEMENTARY NOTES *(Sponsoring Organization, Publishers, Availability)*

9. ABSTRACT
In Thailand, where cereal (particularly rice) is the dietary staple, fortification of rice is a promising means of reducing problems of malnutrition. This chapter discusses a set of five barriers that must be addressed in considering a fortification program: nutritional need, commodity system structure, technology, consumer acceptability, and intervention economics. Special emphasis is given to rice milling and the unique set of problems this presents for nutrition intervention. The pilot project conducted in Thailand established that nutritional deficiencies exist in a significant proportion of the population. The technology for the fortification process is available and can be implemented in a centralized or decentralized system. However, fortification is not an "invisible" intervention. Consumers interviewed in the pilot project villages said they could distinguish fortified rice, and that it had an undesirable taste, odor, color, and cooking characteristic. Yet most said they were willing to eat fortified rice if it was beneficial. The major drawback of the current fortification project is the cost. The government might consider micro- rather than macro-level fortification. In rural areas, this could easily be done through existing day care centers. In urban areas, micro-fortificants could be added to the rice sold to low-income consumers through the government-subsidized shops.

10. CONTROL NUMBER
PN-AAD-784

11. PRICE OF DOCUMENT

12. DESCRIPTORS
Grain crops
Economic analysis
Malnutrition
Methodology
Rice
Supplements
Technology transfer
Thailand

13. PROJECT NUMBER

14. CONTRACT NUMBER
AID/ta-C-1172 GTS

15. TYPE OF DOCUMENT

AID 590-1 (4-74)

CHAPTER 9

THAILAND CASE STUDY

Delane Welsh
Sopin Tongpan
Christopher Mock
Eileen Kennedy
James Austin

Introduction

Thailand is a country whose main dietary staple is cereal, in particular rice. Like Guatemala and Tunisia, a set of barriers exist that must be addressed in considering a fortification program. This chapter explores each of the five barriers - nutritional need, commodity system structure, technology, consumer acceptability, intervention economics - for Thailand. Special emphasis is given to rice milling and the unique set of problems this presents for nutrition intervention.

Barrier I: Nutritional Need

At first glance, Thailand would appear to be a country where a poor dietary intake is not a problem. The 1972 Food Balance Sheet (Agricultural Statistics, 1972) for Thailand showed an average per capita caloric consumption of 2,580 calories; this is well above the recommended intake of 2,100 calories. The question then becomes: Is there a real need for a nutrition intervention?

A closer examination of data reveals that country-wide averages like Food Balance Sheet Statistics (Agricultural Statistics, 1972/73) mask nutrient deficiencies that do exist in subgroups of the population. Dietary, clinical and anthropometric data do exist to substantiate this.

A survey of rural-urban eating habits for heads of household conducted during 1972-73 (Pi Solyabutra, 1974) showed an average caloric intake of 1,821 for the rural residents and 1,504 for persons living in the Bangkok slums. In this case, the caloric adequacy reflected in the Thai FBS is not supported by data from local-level studies in both rural and urban areas.

In a typical rural community where income level is low with consequently less money transactions, variations in the eating pattern of the population generally are limited and markedly influenced by the community's ecology. In general, all members of the family jointly share the meal; there is no special distribution of protein or other essential nutrients to pregnant, lactating women or growing children.

In the rural areas, the typical meal pattern consists of cooked rice consumed with "Kaeng" or "Nam Prick," vegetables and small amounts of protein food such as fish, meat or egg. The protein food is usually considered as appetizer, not main item of the diet. The preparation of "Kaeng" in the rural areas is simple, no coconut milk is used in the preparation. Vegetables are consumed fresh.

The "Nam Prick," which is almost the only source of protein for rural Thais is usually a mixture of shrimp paste, dried fish, meat or vegetables with chillies and some kinds of condiment. Fermented fish and chillies usually constitute the "Namprick" in the Northeast, while in the North it is prepared with fermented soybeans, meat or vegetables as the principal ingredient. In the South, mostly in the muslim community, fermented sauce is widely used. Nam Prick is consumed with leafy greens or other vegetables, either raw or cooked. In Bangkok, Nam Prick is usually consumed with vegetables and Pla-tu (a variety of marine fish), other fish or egg, thus contributing more high-quality protein than the typical rural diet. As can be seen from Table 9.1, residents of the Bangkok slum areas have a higher percentage of animal protein than their rural counterparts.

Table 9.1

Percentage of Animal Protein in Different Diets

Rural	31.0
Bangkok (slum area, Dindaeng)	40.0
Bangkok (middle class, Bangkok)	50.0

A nutrient analysis of the rural meal pattern shows not only that caloric and protein intakes are insufficient but also that micronutrient intake is often inadequate. Table 9.2 compares nutrients consumed by heads of households in 10 provinces in rural Thailand for 1962 and 1966. Despite the fact that applied nutrition projects had been in effect between the 1962 and 1966 surveys, inadequate intakes of calcium, thiamine and riboflavin are still present. However, nutritional deficiencies are most critical in periods of rapid growth. Malnutrition influences morbidity rates for various diseases, maternal and perinatal mortality rates, life expectancy and other health statistics. A variety of vital statistics may therefore be considered as indirect indicators of the nutritional status. The vital statistics of Thailand show in the 0-4 year age category, 51,396 children or 22.5% of total deaths in 1971 could be attributed to malnutrition (Khangarasthiti, 1972).

Birth weight of the newborn (under 15 days) is an indication of nutritional status of the mother during pregnancy. Several observations indicate that severe undernutrition in terms of total calories significantly reduces the birth weight of the full-term infant. The average birth weight of Thai infants in the rural areas ranges from 2.5-2.6 kilograms (Faculty of Public Health, 1972/73) while the Bangkok middle-class families had a mean birth weight of 3.1 kilograms.

The situation is equally as critical when assessing the nutritional status of preschool individuals. A recent study of early protein calorie malnutrition (PCM) in slum areas of Bangkok revealed that PCM was widespread in the 0-5 year old children (Khanjara Sthiti, 1972). Nutritional status was determined by anthropometric methods; each of the 1,154 children in the study were classified by calculating the observed weight as a percentage of expected weight for age in months.

Table 9.2

Comparison of Nutrients Consumed per Head/Day

Nutrients	1962 Survey		1966 Survey	
	Average Intake	Percent of Adequacy	Average Intake	Percent of Adequacy
Calories	2093	100	2054	100
Fat (gm)	11.0		12.1	
Carbohydrate (gm)	425.4		417.5	
Animal Protein (gm)	17.3		17.8	
Vegetable Protein (gm)	38.8		38.2	
Total Protein (gm)	56.1	93	56.0	93
Calcium (mg)	357	51	433	67
Phosphorous (mg)	808		812	
Iron (mg)	10.6	124	11.9	134
Vitamin A (I.U.)	1111.	45	2812	111
Vitamin B1 (mg)	0.80	78	0.82	89
Vitamin B2 (mg)	0.45	38	0.50	46
Niacin (mg)	17.7	135	18.1	148
Vitamin C (mg)	38.0	166	47.0	204

Source: Ministry of Health, 1967, Period C Report on Nutrition, 1966-1967-1968, Bangkok.

The anthropometric results showed that the middle-class and rural Thai boys had mean height and weights fully equal to the North American standard of the 50th percentile during the first six months of life. However, the slum Thai boys fall well below the 50th percentile in weight during the first six months and fall below the third percentile during the second six months of life.

It is not until the second year of life that the mean heights and weights for rural and urban slum children are similar; the familiar "flattening" of the growth curve is seen in the post-weaning period. The data indicate that the nutritional status of the urban population is adversely affected at a much earlier age than that of the rural children; the decline in breast feeding of urban infants may well account for this. In the present study, 22 percent of the preschoolers had never

been breast fed and 23 percent were weaned within the first six months. This can be contrasted with the rural situation where most of the children are weaned after six months. This closely parallels the disparities in growth between urban slum and middle-class Thai children. Both the anthropometric and dietary data indicate that undernutrition is a problem for a substantial proportion of the Thai population.

Barrier II: Commodity System Structure

In order to address the nutritional needs of the Thais through a fortification program, the government must be able to coordinate the project with the existing commodity system structure. It must be possible to identify points within the system that will allow effective penetration of the nutritionally vulnerable groups. Production, milling, wholesaling and retailing are possible points at which the fortification can be considered.

Production

Rice farming dominates the agricultural section of Thailand. Despite the overwhelming importance of rice in the Thai economy, only a few systematic analyses of the rice system have been done.

Rice is grown in every one of the seventy-two Changwats (provinces) in Thailand, with the most concentrated area being in the Central Plains, particularly on the Chao Phya delta. Precise data on the number of farmers and their average farm size are not available. Estimates made in 1971 were 95.2 million rai (15.2 million hectares) of land in farm holdings. If the average size of farm holding is 30 rai (4.8 hectare), as a 1969/70 sample survey indicates, then there might be about 3.2 million farmers. The number is probably not less than that, and could be as high as 4 million. The 1971 estimate of paddy land was 68 percent of total land in farm holdings, or about 65 million rai (10.4 million hectares). This varies from 36 percent in paddy in the South to 79 percent in the North East. The proportion of farms growing some rice is not known, but is probably between 85 and 90 percent of all farms. Farms not growing any rice would include corn and cotton-soybean farms in the Central Plain, cassava farms in the East and North East, and rubber farms in the South.

Amounts produced per farm, consumed by the producers, and hence marketable surplus is not known, and therefore can only be speculative. Table 9.3 shows regional data on tenure situation, average farm size, and estimated number of farms. Farm sizes are largest in the East and Central Plain regions, which are commonly thought to be the sources of Thailand's marketable surplus, part of which is exported. Farm sizes are smallest in the South and North regions, and these regions may barely be self sufficient of actually import some from the Center and East. The smaller the farm, the less likely it is to produce any for sale, and very small farms may in fact have to purchase some rice for home consumption. This is substantiated by survey data (Mock, 1975) from sonsumers in Northern Thailand. Of the 39 surveyed, 32 indicated that almost all the rice brought to the local mills was used for home consumption and during certain periods additional rice had to be purchased because their crop was not sufficient to meet family needs. Also, small, full tenant farms may have to deliver substantial amounts to landlords for rent, and have to buy some rice for home consumption.

Techniques of production, irrigation, and type of rice produced are shown by region in Table 9.4. People in the North and part of the North East (north and eastern parts, bordering Laos) regions prefer glutinous rice, and produce it largely for their own consumption, although small amounts are exported, mainly to Laos. Only when the individual farmer is able to produce a sizeable marketable surplus in these two regions, does he then start planting some non-glutinous varieties for sale. The decline in proportion of glutinous in the North from 1959 to 1970 is thought to represent just this sort of increased production for sale outside the region. Accordingly, a fortification program in the North would have to employ glutinous rice in order to ensure acceptability.

Milling System

Thailands rice production is characterized by a large number of farmers, approximately 3.2 million, producing rice for home consumption or small parcels of land (Table 9.3). Interaction with this many individual farmers at the production level is impractical when considering the logistics of a fortification program. The local mills are an alternative intervention point. However, even at this level, the milling system is very atomistic. Table 9.5 shows that in the six provinces included in the Changwat Nakorn Pathom Survey (1974) there is an estimated 4,177 mills. It is not clear exactly how many mills are currently operating in Thailand.

Table 9.3

Tenure Situation, Farm Size, and Number of Farm Holdings in Thailand, 1969/70

	Full Owner	Part Owner Part Tenant	Full Tenant	Total
		percent of total land in farms		
Central Plains	43.60	45.02	11.38	100
North	61.43	33.84	4.73	100
Northeast	73.99	23.35	2.66	100
East	46.73	36.04	17.22	100
Sourth	58.20	41.04	0.76	100
Kingdom Total	62.18	32.04	5.78	100
		average rai per farm holding		
Central Plains	33.26	41.37	27.55	36.26
North	24.80	23.61	21.74	24.25
Northeast	28.74	36.01	20.68	30.22
East	41.06	50.75	33.15	43.19
South	21.55	25.99	9.57	23.94
Kingdom Total	29.05	34.33	18.79	30.13
		number of farm holdings		
Central Plains				425,615
North				741,764
Northeast				1,417,858
East				163,716
South				493,257
Kingdom Total				3,242,210

Source: Calculated from Thailand Agricultural Statistics in Brief Bangkok: Division of Agricultural Economics, Ministry of Agriculture and Cooperatives, 1975.

Table 9.4

Table 9.4

Areas Planted and Irrigated, Method of Planting and Type of Rice, by Geographic Region, Thailand, 1959-'70

	North	Northeast	Central	South
Area planted (1966) as per cent of total kingdom	6·0	42·0	44·0	8·0
Area irrigated as per cent of (1966) total kingdom	10·0	10·0	77·0	3·0
Area irrigated as per cent of area planted	40·4	7·9	45·0	9·5
Method of planting (1959)				
Transplanted	99·6	98·4	54·8	71·3
Broadcast	0·4	1·6	45·2	28·7
Type of rice (1959)				
Non-glutinous	8·5	28·2	96·7	95·7
Glutinous	91·5	71·8	3·3	4·3
Type of rice (1970)				
Non-glutinous	15·2	36·3	96·0	96·1
Glutinous	84·8	63·7	4·0	3·9

Sources: area planted, Thailand, Ministry of Agriculture, Division of Agricultural Economics 1967: 48; area irrigated, Thailand, Ministry of Agriculture, Division of Agricultural Economics 1967: 174–5 (includes state irrigation projects, people's irrigation projects, and tank irrigation projects, irrigation area only); method of planting, Kulthongkham and Ong 1964:7; types of rice, for 1959 Kulthongkham and Ong 1964: 6, for 1970 unpublished data from Department of Agricultural Extension, Ministry of Agriculture, Bangkok.

Table 9.5

Sample Size and Estimated Total Number of Rice Mills

Province	Sample Size	Estimated Number of Rice Mills
Phrae	165	925
Phichit	153	579
Ayuthya	105	154
Chaiyaphum	187	923
Kalasin	155	738
Songkhla	216	858
Total	981	4,177

Source: Six Changwat Survey

Although the Ministry of Industry is administratively responsible for maintaining a register of rice mills, their list is incomplete. In 1956, it was estimated that there were 6,067 mills in the whole Kingdom, with 3,518 of these with a capacity of less than 5 tons per day, 2,179 of 5 to 30 tons, 273 of 31 to 65 tons, 56 to 66 to 100 tons, and 41 of over 100 tons per day capacity. Formerly, government permission had to be obtained before building new mills but this regulation was abandoned in the late 1960's with a subsequent rapid expansion in the number of small mills located in producing areas.

A survey of 21 of the 29 mills involved in a pilot fortification project in the Northeast (Mock, 1975), indicated that a fairly high proportion of the equipment was new (less than 10 years old) suggesting that the number of small mills may in fact be expanding.

Although mills are still required to register with the Ministry of Industry, not all do and mills stopping operation do not "de-register," hence the number of mills in the Kingdom is not known. It is probably more than 10,000, it might be 20,000, and it could even be significantly higher.

Two critical issues must be considered if the mills are to be the entry point for the fortificant:

(1) Can the target group - the nutritionally vulnerable - be reached through this Mechanism? Urban/Rural differences must be considered.

(2) Will the millers cooperate?

Coverage

First, in order to reach the target group through the milling system. The assumption is that people use the mills. The traditional way to mill rice in Thailand was hand pounding at home by the farmers. This removed the husk and part of the bran. However, this practice was presumed to decline as mechanical mills developed in the mid-1800's.

Current data on the proportion of farmers who still hand-pound is nonexistent; Table 9.6 presents estimates from millers in six rural areas of Thailand and represents their judgement of the prevalence of hand pounding.

Table 9.6

Percent of Rice Production That is Milled by Hand Pounding

Province	
Phrae	1
Phichit	1
Ayuthya	0
Chaiyaphum	12
Kalasin	0
Songkhla	15

Four of the six areas indicated zero to one percent hand pounding; this would indicate that hand pounding is most likely not a barrier to the use of mills as the link between consumers and the fortification program. In addition, 100 percent of the consumers surveyed in the pilot fortification villages (Mock, 1975); indicated that they used mills rather than hand pounding. Utilization of mills by consumers does not appear to be a problem in rural Thai provinces as was also the case in

Guatemala and Tunisia. However, the milling system is quite different for urban residents. The number of rice mills in Bangkok has now decreased to only a few and are primarily trade mills -- that is -- mills that are involved in wholesale and retail rice marketing rather than service milling for producers who bring their own rice to the mill.

Two different intervention systems would have to be designed to reflect the urban/rural milling patterns.

Miller Surveys

To evaluate the feasibility of implementing a fortification effort through the local millers in rural villages, it is important to determine the millers' attitude toward participation and the barriers using this type of decentralized system. Data from two different sources, the Six Changwat Survey (Welsh, 1976) and Pilot Project Millers Survey (Mock, 1975) were used to assess the possibility and practicality of nutrition intervention at the milling stage.

For the Six Chagwat Survey it was felt that usefulness of information could be maximized by carefully choosing the Changwats on the basis of regional location, type of rice produced and degree of self-sufficiency or surplus in production as compared with consumption needs.

Six Changwats were selected as follows:

Phrae--North--glutinous rice--rice deficit
Phichit--North Central--non-glutinous--large surplus
Ayuthya--Central--non-glutinous--large surplus
Chaiyaphum--Northeast--one-half glutinous, one-half non-glutinous--rice deficit
Kalasin--Northeast--glutinous--surplus
Songkhla--South--non-glutinous--surplus

The number of rice mills that were sampled and the total number estimated to be in each of the six Changwats is shown in Table 9.5. We did not use a constant sampling fraction, but instead used a rather subjectively determined fraction. In general, we tried to interview all of the big mills, most of the medium sized mills, and somewhere between 10 and 20 percent of the smaller mills. Thus we

actually sampled 68 percent of the mills in Changwat Ayuthya, where the average size of mill is much larger than in Changwat Phrae, where we sampled only 18 percent of the mills.

Size

How one defines "size" of rice mill depends somewhat on the purpose of measuring size. For our purposes, capacity seems to be more appropriate than dimensions of components or some other measure. We have chosen capacity per 24 hour period because we found that most mills run for 24 hours at some time or other during the peak season of milling, and therefore millers were able to visualize such a quantity and to give us what we felt to be fairly reliable answers. This approach avoids the conceptual difficulty of the theoretical maximum output as determined by engineering data which can rarely be reached without a high level of variable cost. In fact, our respondents included time for service and maintenance and very minor repairs when they reported on throughput in a 24 hour period.

The distribution of the sample mills by size, as determined as described above, is shown in Table 9.7. The differences among Changwats is somewhat related to the magnitude of rice production in the Changwat. Those with large, exportable, surpluses of non-glutinous rice, namely Ayuthya and Phichit, have larger size mills on the average than the others. Ayuthya is a much older rice growing area than Phichit, and its mills are also larger on the average. Although Kalasin has an exportable surplus, about one-half of it is glutinous rice, as shown in Table 9.8 which has a much narrower market than non-glutinous rice, so some of the glutinous surplus may move in paddy form.

In addition to the Six Changwat Survey, twenty-one of the twenty-nine mills that participated in the pilot fortification effort in Thailand were surveyed (Mock, 1975). All the mills were located in rural areas surrounding the northern city of Chiang Mai; these mills are considered typical of the small rice mills throughout Thailand.

Most of these mills consist of a small, usually bamboo structure with earthen floors. All of the mills visited have one milling machine, a simple Engelberg machine with stone rollers. The machines are all powered by small diesel motors, most of which have 10 horsepower, although a few are as small as 5 horsepower and one has 18 horsepower.

Table 9.7

Capacity (24 hours) in Metric Tons of Paddy

Capacity (tons/ 24 hrs)	Phrae	Phichit	Ayuthya	Chaiya-phum	Kalasin	Songkla	Total
	- - - - - - - - - - - percent of each size - - - - - - - - - -						
0-10	98.8	35.5	11.4	83.4	93.6	96.7	75.3
11-20	1.2	26.2	17.1	11.2	3.3	2.8	9.4
21-30	0	17.6	32.4	2.6	1.3	0	6.9
31-40	0	8.5	11.4	1.6	0.6	0	2.9
41-50	0	6.5	12.4	0.6	0.6	0.5	2.7
51-60	0	1.9	8.6	0	0	0	1.2
61-70	0	0.6	4.9	0.6	0	0	0.7
71-80	0	1.3	0	0	0.6	0	0.3
81-90	0	0	0.9	0	0	0	0.1
91-100	0	1.9	0.9	0	0	0	0.5
Total	100	100	100	100	100	100	100

Source: 981 sample mills

Table 9.8

Type of Rice Milled

Type of Rice	Phrae	Phichit	Ayuthya	Chaiya-phum	Kalasin	Songkla	Total
			percent of each type				
Non-glutinous only	0	85.6	100	15.0	0	82.4	45.0
Glutinous only	93.3	0	0	5.3	54.0	0	25.0
Both	6.7	14.4	0	79.7	46.0	17.6	30.0
Total	100	100	100	100	100	100	100

Source: 981 sample mills

The Engelburg machines are usually classified as small if they have a maximum capacity of 6 tons of paddy/24 hours. All of the mills (Table 9.9) in this survey were small with the largest having only a maximum capacity of 4.9 tons of paddy/day.

Table 9.9

Capacity of Fortification Machinery in Mills in Pilot Project Area of Chiang Mai

Capacity (ton/day)	Number of Mills
less than 1.0	4
1.0 to 1.9	7
2.0 to 2.9	2
3.0 to 3.9	2
4.0 to 4.9	3

A second aspect affecting size is the type of rice mill. The business functions of rice mills range from completely service to completely trade. Small mills tend to do only service milling for farmers who retain ownership of the paddy, and very large mills tend to do only trade, milling only paddy that the mill itself owns.

The functions, or type of operation of the sample mills in the Six Changwat Survey is shown in Table 9.10. Except for Songkla, there is a strong relationship between size and function. It is easier to custom mill small lots of paddy for farmers with a small mill than with a large mill. One reason is that the amount of rice that stays in the mill becomes important. For example, in a m ' that can handle 100 kilograms per hour, probably less than one kg remains inside the machine after a batch is run through. And 100 kg batches are not unusual in service milling. But 50 to 100 kg or more may remain inside a very large mill, say one with capacity of 100 tons. An individual farmer's batch would "get lost" inside such a mill. Another reason is that the effective area for service milling is much smaller than for trade milling, as farmers are very sensitive to the inconvenience caused by distance when wishing to purchase milling services. "Smaller" in this sense also includes ease of travel. For example, a farmer may equate 0.5 km of carrying a bag of paddy to be milled on his shoulder to 10 or even 15 km of travel on a pickup or bus on a hard surface road. Thus, the three most remote Changwats in our sample, Phrae, Chaiyaphum, and Kalasin, also contain the highest proportion of service only mills (Table 9.10) and a high proportion of small mills under 10 tons capacity per day (Table 9.7).

The information gathered from the pilot project millers is similar. Of the 21 surveyed, 15 were service only mills catering to local village farmers. The implication of these two surveys for nutritional intervention at the milling stage is that the more remote it is and the poorer road system a Changwat has, the more small, widely dispersed, service-only mills it will have. Thus, the populations in those regions could not likely be reached by using the larger, more centralized trade mills for a fortification program.

Fee

A final aspect of mill system operation to consider is charges to the customer. In the service mills, a common milling payment is for the milling to be done for the bran and small brokens. The farmer brings the paddy and receives all of the milled head rice, and sometimes the brokens, while the miller keeps the bran, and sometimes the broken rice, as a milling fee. Three of the millers interviewed in the Chiang Mai area (Mock, 1975) provide free milling if the customer leaves the

Table 9.10a

Type of Operations, by Percent of Each Type, by SM of SCRMS

Type of Operations	Phrae	Phichit	Ayuthya	Chaiya-phum	Kalasin	Songkla	Average
	- - - - - - - - - - - - percent of each type - - - - - - - - - -						
Service	82.4	55.5	27.6	81.3	81.9	60.6	67.3
Buy paddy and sell milled rice	1.8	20.3	33.3	13.3	7.1	6.5	12.1
Both	15.8	24.2	39.1	5.4	11.0	32.9	20.6
Total	100	100	100	100	100	100	100

Table 9.10b

Type of Operations, by Number of Mills of Each Type, by SM of SCRMS

Type of Operations	Phrae	Phichit	Ayuthya	Chaiya-phum	Kalasin	Songkla	Average
	- - - - - - - - - - - - number of mills - - - - - - - - - - - -						
Service	136	85	29	152	127	131	660
Buy paddy and sell milled rice	3	31	35	25	11	14	119
Both	26	37	41	10	17	71	202
Total	165	153	105	187	155	216	981

bran. However, if the customer retains the bran, a fee ranging from .5 to 1.25 Baht (U.S. $.025 to U.S. $.0625) per bushel basket (10 kg) is charged. The average fee in the mills visited is .93 Baht/bushel or .145 Baht (U.S. $.073) per kilo of white rice output. About half of the millers set no minimum requirement on the quantity of paddy to be milled at one time. However ten of the millers reported a minimum of 10 pounds. In the Six Changwat Survey the proportion of millers charging a fee above and beyond the bran varies from a low of two to four percent in Phichit and Ayuthya, to a high of 84 percent in Phrae. The proportion charging the additional fee appears to vary inversely with the transportation network, which in turn determines both the degree of competition and farmer attitudes toward paying for services. For example, in Ayuthya, the network of waterways and roads, plus a long history of mechanical milling, has resulted in a highly competitive milling structure, whereas, in a more remote area with poorer communications facilities, the miller, even though he is very small, and perhaps even a farmer himself, is able to extract a higher rent from mill ownership.

In Nakorn Pathom, which has an excellent communications network, service milling is so competitive that millers not only cannot charge for milling but in fact they must add an additional service, that of picking up the paddy at the farm and delivering the milled rice back to the farmer in order to stay in business. In this context consumers would likely resist paying for fortification. On the other hand, the millers might offer fortification as a "bonus" to attract more farmers to their mills.

Paddy Procurement

In the Pilot Project Survey, almost all of the customers of the project mills are rice farmers who produce their own paddy. Only a small proportion of the customers ever purchase their paddy, and a few customers are farm workers who receive the paddy in return for their labor. The millers who buy paddy to process and sell as white rice obtain the paddy directly from farmers. One of the millers reported that he grows his own paddy and sells his surplus in processed form in his mill. The millers who sell processed rice sell it to retail outlets, to marketplace vendors, and to individual customers who come to the mill.

What is apparent from the Six Changwat Survey data is that there is a positive relationship between size of mill (tons/day) and type of mill as shown in Tables 9.11a-9.11b. None of the mills with more than 70 tons capacity did any service milling. In fact, trade milling was the predominant activity in all mills with over 30 tons capacity.

It is sufficient here to point out that for nutritional intervention purposes, the larger the mill, the more likely it is to be a trade only mill, with the product owned by the mill owner, who is therefore the major person to be convinced if intervention is to be successful.

Seasonality

Seasonal patterns in rice milling are of importance to nutritional intervention from two standpoints: timing of the distribution of the fortificant and possible concentration of the product for a major promotional effort.

The data on seasonality of milling from the Six Changewat Survey are summarized in three tables: 9.12, 9.13 and 9.14. Table 9.12 shows actual amount milled in each of four quarters of the year, by Changwat. The quarters are based on the crop year. The main season (wet or monsoon season) crop harvest starts in December in most of the Central Plain, a little bit later in the North and Northeast, and much later in the South. But actual harvest (cutting of the stalks in the field) is followed by sun drying, threshing, and winnowing, which can take from two to six weeks to complete. Thus, although new crop milled rice will start to appear in certain markets by the second week of December (such as in Supanburi) the major movement of paddy to mills does not start until February.

Table 9.12 should be studied in comparison with Table 9.7 (capacity) and Table 9.13, which shows the relationship between actual amount milled and capacity, by quarter season. Conclusions that can be drawn from these three tables are as follows. First, the smaller the rice mill, the lower the rate of utilization (ratio of actual output to capacity). Second, the smaller the rice mill, the les the fluctuation in amount milled by season. This seems reasonable, because earlier it was shown that the smaller the mill, the more likely that it does service milling only, and farmers are likely to have their own rice milled for their own consumption at a steady rate throughout the year.

Table 9.11a

Correlation Between Size and Type of Operations

Type of Operations	Capacity (ton/24hr)									
	0-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100
	percent of each type									
Service	79.70	48.91	26.48	10.34	11.54	8.33	14.29	0	0	0
Buy paddy and sell milled rice	3.24	19.56	36.76	51.73	57.69	66.67	85.71	100	100	100
~~Mixed~~ Both	17.06	31.53	36.76	37.93	30.77	25.00	0	0	0	0
Total	100	100	100	100	100	100	100	100	100	100

Table 9.11b

Correlation Between Size and Type of Operations

Type of Operations	Capacity (ton/24hrs)									
	0-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100
	number of mills									
Service	589	45	18	3	3	1	1	0	0	0
Buy paddy and sell milled rice	24	18	25	15	15	8	6	3	1	4
~~Mixed~~ Both	126	29	25	11	8	3	0	0	0	0
Total	739	92	68	29	26	12	7	3	1	4

Table 9.12

Actual Amount Milled per Day in Four Quarters of the Crop Season

Quarter	Phrae	Phichit	Ayuthya	Chaiyaphum	Kalasin	Songkhla	Average
				Ton of Paddy			
February-April	0.75	9.62	15.23	4.20	1.02	0.48	5.20
May-July	0.46	7.01	10.39	2.65	1.27	0.63	3.70
August-October	0.42	5.41	7.08	1.72	0.79	0.46	2.60
November-January	0.57	5.00	7.28	1.10	0.79	0.37	2.50
Average	0.55	6.80	9.99	2.37	0.96	0.48	3.52
Actual/capacity (%)	10.74	33.39	32.93	30.89	14.81	8.79	28.04

Note: This classification is based on the actual rice producing season in Thailand.

Table 9.13

Relationship Between Amount Milled (tons of paddy) per Day and Size of Mill in Four Quarters of the Crop Season

Quarters	Capacity (ton/24hr)									
	0-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100
	Actual Input (ton/24hr)									
February-April	0.63	6.47	11.63	18.61	25.75	35.32	48.29	38.00	40.00	58.12
May-July	0.67	3.76	7.28	14.21	14.30	32.50	31.57	35.67	30.00	50.63
August-October	0.40	2.32	5.61	8.39	11.88	25.05	23.14	29.00	30.00	40.00
November-January	0.59	2.26	5.77	5.74	7.93	20.27	24.14	24.50	30.00	28.75
Average	0.57	3.70	7.57	11.74	14.96	28.28	31.78	31.79	32.50	44.38

Table 9.14

Regularity of Rice Mill Operation by Year, 1971-1975

Province	Regularity	Year 1975	1974	1973	1972	1971	Average %
		percent					
Phrae	Normal	83	91	97	99.4	100	94.1
	Less than average	17	9	3	0.6	-	5.9
	Entirely stop	-	-	-	-	-	-
Phichit	Normal	56	66	78	82	84	73.2
	Less than average	43	30	19	13	12	23.4
	Entirely stop	1	4	3	5	4	3.4
Ayuthya	Normal	70.5	91	85	83	79	81.7
	Less than average	28.5	7	10	11	15	14.3
	Entirely stop	0.9	2	5	6	6	3.9
Chaiya-phum	Normal	67.7	67	66.8	83	87.5	74.4
	Less than average	32.3	32.	32.2	17	12.5	25.2
	Entirely stop	-	1	1	-	-	0.4
Kalasin	Normal	93	96	98	98	100	97
	Less than average	7	4	2	2	-	3
	Entirely stop	-	-	-	-	-	-
Songkhla	Normal	47	54	66	78	74	63.8
	Less than average	53	45	33	21	25	35.4
	Entirely stop	-	1	1	1	1	0.8
Average	Normal	69.5	77.5	81.8	87.2	87.4	
	Less than average	30.2	21.2	16.5	10.8	10.7	
	Entirely stop	0.3	1.3	2.5	2.0	1.8	

Lastly, the sensitivity of seasonal patterns to year-to-year variation is not precisely known. Table 9.14 shows some of the yearly fluctuations in the six provinces. A consistent pattern of either monthly or yearly irregularity would mean that the quantities of rice consumed varied and therefore the quantities of fortificant needed to insure a constant level of nutrient intake would also need to be varied.

Storage and Transportation

One-third of the mills in the Six Changwat Survey had storage facilities with the proportion varying from 12.5 percent in Kalasin to 85.7 percent in Ayuthya. Having storage facilities in conjunction with the mill is associated with size, as shown in Table 9.15. Of the 82 mills larger than 30 tons, only three did not have storage, while less than one-fifth of the smallest mills had any storage. Mills that had storage tended to have more storage relative to size the larger the size of mill. For example, the 11-20 ton mills had storage enough for 14 days' milling at maximum capacity, while the largest mills (91-100 tons) had storage capacity for 53 days of milling. It should be remembered at this point that the larger the mill, the more likely it is to engage in trade, and storage is essential for a merchant involved in buying paddy and selling milled rice. Mills with storage would be able to keep fortified and unfortified products separate in case of limited target populations.

The means of moving paddy from farms to mills and of milled rice from mills to consumers are shown in Tables 9.16 and 9.17 respectively. Table 9.16 shows movement of paddy by Changewat. A similar table showing milled rice movement would have almost identical data, i.e., milled rice tends to move from the mill by the same mode as paddy came to the mill. Likewise, Table 9.17 would show the same pattern, whether the data were for paddy into or milled rice out of the mill. The most striking observation from the data is the prevalence of non-motorized means of paddy/rice transport to the very small mills. Trains are not important means of rice transport anywhere, and ox carts are important only in the North, while water transport dominates in Ayuthya. From an intervention standpoint, mode of transport is important only from an accessibility, and identification, of the mill standpoint, as presumably the quantity of fortificant would be small enough such that transport, even by shoulder carry, would not be a problem.

Table 9.15

Relationship Between Size and Storage Facility

Storage	Capacity (ton/24hr)										Total
	0-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100	
	Percentage										(mo.)
No storage facility	81.46 (602)	33.70 (31)	16.18 (11)	3.45 (1)	3.85 (1)	-	14.29 (1)	-	-	-	(647)
Have storage facility	18.54 (137)	66.30 (61)	83.82 (57)	96.55 (28)	96.15 (25)	100 (12)	85.71 (6)	100 (3)	100 (1)	100 (4)	(334)
Total	100 (739)	100 (92)	100 (68)	100 (29)	100 (26)	100 (12)	100 (7)	100 (3)	100 (1)	100 (4)	(981)
Capacity of storage paddy (ton)/rice mill	1.2	289.75	488.99	748.39	1284.80	1454.17	2016.67	140.00	140.00	5312.50	

Note: Numbers in parentheses are number of mills in that cell of the table, represented by the percentage figure directly above them.

Table 9.16

Method of Transporting Paddy to the Mill, in Percent

Method	Phrae	Phichit	Ayuthya	Chaiya-phum	Kalasin	Songkhla	Average
	Percentage						
Trucks	6.0	68.0	41.0	20.7	11.3	10.3	26.20
Trains	0.6	0.6	0.2	0.2	-	0.1	0.28
Boats	-	5.0	56.0	-	0.5	5.4	11.15
Oxen carts	12.4	22.0	1.6	2.4	0.3	-	6.45
Others[a]	81.0	4.4	1.2	76.7	87.9	84.2	55.90
Total	100	100	100	100	100	100	100

[a]Bicycle, shoulder carry, head carry

Table 9.17

Relationship Between Size of Mill and Method of Transporting White Rice from the Rice Mill

Method	Capacity (ton/24hr)									
	0-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100
	Percentage									
Trucks	11.71	65.17	41.57	48.79	37.88	8.00	36.43	53.33	-	57.50
Trains	0.35	2.02	0.45	4.48	8.08	9.17	-	6.67	-	5.00
Boats	1.07	11.49	46.64	46.73	50.19	82.83	63.57	40.00	100	37.50
Ox carts	6.67	8.39	8.36	-	-	-	-	-	-	-
Others[a]	80.20	12.93	2.98	-	3.85	-	-	-	-	-

[a] Bicycle, shoulder carry, head carry

Cost

The only reliable cost data that are available for millers were gathered in the interviews with the mills involved in the pilot fortification project in Thailand. The main operating cost of the small mills in the project area is the fuel for their milling machines. The millers reported that in winter the mills use an average of 185 liters per month (at 2.5 ฿ or 12.5 cents per liter), although there is considerable range in the amount used in different mills, depending on the hours per day that the machines are operated. Maintenance of the machines and spare parts constitutes another major category of costs, which range up to 3000 ฿/year (U.S. $150) but average about 1500 ฿/year (U.S. $75). In winter the millers also use an average of about 7.4 liters of lubricating oil per month for the milling machines, which accounts for another 126 ฿ (U.S. $6.29) in costs. None of the millers reported having any rental costs, and almost all handled the milling operations by themselves and with family labor, but without any hired workers.

On the basis of these data, as well as the information on average monthly input into the mills and milling fees, it is possible to estimate the average monthly revenues and costs for a typical small mill in the project area, during the winter months. Although most millers could not recall their exact costs during the remaining months of the year, these costs can be estimated using the data concerning the differences in average input and hours of operation in the mills during the four seasons of the year. This input data, combined with the information on milling fees can also be used to calculate the approximate revenues of the project mills during the spring, summer, and fall. An estimate of the average monthly revenues, operating costs, and net income for a typical small Thai mill during each season of the year is presented in Table 9.18. As the estimates demonstrate, the average net income derived from operating a small rice mill in the rural areas is extremely low -- only about $27 per month in the peak winter months, about $16 monthly during the spring and summer, and about $7 per month in the fall season. The millers may have under reported income, but it would appear that any fees which might be paid to the millers for their participation in an expanded fortification program could be set relatively low and would still act as an effective incentive since they would nevertheless constitute an important source of income for the millers.

Table 9.18

Hypothetical Monthly Income Statements for a Small Rice Mill in Winter, Spring, Summer and Fall

	Winter		Spring/Summer		Fall	
	Baht	Dollars	Baht	Dollars	Baht	Dollars
I. Net Revenues	1455	72.75	837	41.85	474	23.70
II. Costs						
1. Rent	-	-	-	-	-	-
2. Equipment	50	2.50	50	2.50	50	2.50
3. Machine Maintenance, Spare Parts	198	9.93	108	5.40	67	3.35
4. Machine Oil	126	6.29	68.0	3.40	43	2.13
5. Diesel Fuel	463	23.15	250	12.50	157	7.87
6. Salaries	-	-	-	-	-	-
Subtotal	837	41.85	476	23.80	317	15.85
7. Taxes (5% of revenues)	73	3.65	42	2.10	24	1.20
Total Costs	910	45.50	518	25.90	341	17.05
III. Net Income	545	27.25	319	15.95	133	6.65

Miller's Attitudes

A separate part of the Miller's Survey conducted in the pilot project villages (Mock, 1975) contained subjective questions about the Millers' attitudes toward participation in the program; as the critical gatekeepers in the intervention it is important to ascertain their willingness to participate in the system.

First, the participating Millers were asked if their handling of the fortification operations had caused them any problems. Seven of the nineteen responding millers said that no problems had been encountered as a result of the program. Nine of the millers did mention specific problems. One of the main problems noted by four millers was the extra time required to fill the feeders, attach and detach the feeder, supervise the fortification, and to keep the records for the project personnel. The other major problem, also mentioned by four different millers, was the strain on the engine and the much more frequent breakage of the engines drive shaft, due to the load of the feeder. One miller explained that project personnel had tried to assist him in finding a shaft for his machine which could bear the feeders load, but even the stronger shaft still has frequent breakage and need for replacement. Two of the millers also complained that they had lost some customers because of their dislike of the fortificant granules and their discomfort at being asked to accept the fortification. One of these millers explained that although he fortified the grain only for those customers who wished to participate, some customers "hate the drug" and thus will take their paddy to mills 3 or 4 km away to avoid being asked if they wished the fortification. The second miller also described how his customers "don't want to hear 'please take it'" (the fortification) and if they feel pressured will "run away to the other mills."

The millers were then asked how they thought the fortification operations could be improved. Eight of the respondents said that the present system was adequate and that they could think of no particular improvements which were necessary. However, six millers did offer specific suggestions which were as follows:

(1) The design or operation of the feeders should be modified so that they will put less of a load on the engines of the milling machines.

(2) The design or operation of the feeders should be changed to prevent the breakage of the drive shaft.

(3) The design or operation of the feeders should be changed so that the use of extra fuel would not be required.

(4) The feeders are adequate but could be eliminated altogether and the adding of the fortificants could be done by hand.

(5) The millers should be paid more than 125 ฿ (U. S. $6.25) per 25 kg case of granules dispensed.

(6) The project should be better explained to the villagers; explanatory lectures and educational programs should be longer and more frequent.

In order to obtain information which could be used in the determination of an appropriate incentive for the millers participation in a fortification program, the millers were asked several questions concerning the actual payments which they receive and whether they considered these payments to be adequate. The first question concerned the quantity of fortificants distributed each month by the millers; from this information the payments received by the millers could be estimated. The replies given by the millers and their estimated income from participation in the fortification program are illustrated in Table 9. 19.

Table 9.19

Number of Cases of Fortificants Dispersed by Pilot Project Millers Per Month in 1973 - 1974	Monthly Income Derived from Participation in the Program (125 b per case)		
Less than one case	4	<125 ฿	<$6.25
One case	4	125 ฿	$6.25
More than one case, but less than two cases	3	125-250	$6.25-12.50
Two cases	3	250	$12.50
More than two cases	1	>250	>$12.50

These data suggest that most of the millers partipating in the pilot project earned about 125 ฿ month or slightly more. This represents about 23 percent of their estimated monthly income in winter months, 39 percent of their estimated monthly income in the spring and summer months, and almost 94 percent of their estimated monthly income during the fall.

When they were questioned about the fee level which they felt would be appropriate, nine of fourteen millers said that they thought that the current fee was inadequate and that they should be paid more. The specific answers by all of the fourteen responding millers are as follows:

(1)	The current fee (125 ฿ case) is adequate.	(3 respondents)
(2)	The fee should be higher.	(4 respondents)
(3)	The fee should be from 150 to 160 b/case.	(2 respondents)
(4)	The fee should be 200 ฿ case.	(1 respondent)
(5)	The fee should be 250 ฿ case.	(1 respondent)
(6)	The fee should be 300 to 400 ฿ case.	(1 respondent)
(7)	Don't know.	(2 respondents)

The millers were then asked the reasons for their partipation in the pilot project. A variety of responses were given by the seventeen responding millers, most of whom expressed a high degree of social consciousness and a desire to help the villagers. The millers also exhibited a great respect for the authority and contribution of doctors; many of the project personnel were doctors, nurses, and medical technicians and this appears to have been an influential factor in persuading both millers and villagers to participate in the program. The millers outlined the following specific reasons for their involvement in the pilot project.

(1)	The doctors asked us to help (the doctors are helping us so we should give something in return; the doctors are helping the villagers).	(11 responses)
(2)	The fortification benefits the villagers. (It improves the health of the old people and children; reduces fevers; improves eye diseases; and relieves pain.)	(8 responses)
(3)	The project personnel asked us to participate.	(3 responses)
(4)	The fortification was supposed to help people, but now the people don't want to receive it.	(2 responses)
(5)	The payments are useful.	(1 response)
(6)	Don't know; the former mill owner initiated the fortification.	(1 response)

Finally, the millers were asked whether they thought the other millers who were not included in the pilot program would "mind" participating in an expanded fortification program. Only three of the millers thought that other millers might mind or would mind, while five respondents thought the other millers would not mind, and four said the others wouldn't mind if the program were better explained to both the villagers and the millers. One miller said that other millers would probably participate if the majority of millers chose to become involved in a program, and three millers had no opinion.

Summary

The decentralized nature of the rural milling system may initially seem to present logistical problems of management and control for a fortification intervention. However, the two key elements are present - target group coverage and miller's cooperation. Therefore, in the design of a fortification program the alternative of a decentralized milling system should not be overlooked for rural areas. However, urban residents, because of their reliance on the commercial market, could best be reached by the retail network.

Wholesale/Retail

Most of the wholesale rice activities in the Kingdom are conducted by the rice mills that engage in trade. Only in the very largest Changwat capitals and in Bangkok are there non-rice milling firms that specialize in rice wholesaling, and there are only a few such firms. At times, a few additional individuals or firms will engage in speculative holding of stocks, disposing of them either to exporters or to retailers. Recently, during the 1973 rice "crises," the government got involved in rice wholesaling through the Public Warehouse Organization.

Milled rice retailing is engaged in by tens of thousands of individuals and firms scattered throughout the Kingdom. The largest concentrations of course, are in large urban areas, especially in Bangkok. Only very small rice mills sell at retail, the rest prefer to sell at wholesale only. In small villages, at least one general shop will also carry rice at retail for non-rice producers in the community, as well as for rice farmers who do not produce enough or are unable to retain enough rice for their family consumption.

Most urban residents, particularly the low income families, (less than 3,000 bolts annually) purchase rice in the reduced price shops (Slom Survey, 1972). The urban residents could effectively be reached by a centralized processing fortification system using the reduced price shops as an outlet for the fortified rice.

Barrier III: Technology

The technology for development of a fortificant that can be added to a food product has been perfected and does not present a barrier to fortification projects. Technology problems, where they do exist, would be expected to occur in the fortifying process, especially in a large decentralized milling network.

The purpose of rice milling is to process the paddy rice from the form it is in after harvest and threshing into a form in which human beings can consume it. Milling, therefore, adds form utility to the product. The impervious covering of the kernal of paddy rice, called the husk, is composed mainly of silica and is not digestable, and therefore has to be removed before the kernal is available as human food. Underneath the husk are several more layers of material, called bran, covering the kernal. The bran layers are digestible and high in protein content. The outer layer is called coarse bran and the inner layer is called fine bran. These two bran products are separated in some milling systems and not in others, and each bran product has a different price. The kernal with only the husk removed, but the bran layers still remaining, is called brown rice or cargo rice generally, but in Thailand is sometimes referred to, especially in urban areas, as "prison rice," because prison inmates are fed the cheapest food available, which is undermilled rice. This reflects the taste preference of Thai people in general for highly milled rice, in which not only is all of the bran removed, but the kernal is also whitened. Technically, this operation can be called polishing only if a leather polisher is used. In Thailand, emery stone is used, so the operation is called "whitening." As the husk and bran layers are removed, and the rice is whitened, some of the kernals break. In general, the more highly milled and whitened the rice, the higher the breakage rate. Breakage rates, or proportion of brokens is also affected by the variety of rice, weather at harvest time, and the drying technique and practices followed. Among the rice consuming countries known to the authors, Thailand has probably the most detailed classifications of grades of rice based primarily on the proportion of each category of

rice; category referring specifically to length of grain. Length of grain is defined in terms of proportion of a whole long grain kernal.

In general, there are approximately seven possible steps in the process of rice milling. In some of the most elementary technologies, some of the steps are omitted or passed over. Advanced or "modern" technologies include all seven steps. The steps are:

(1) Placing the paddy into the milling machine.

(2) Removing the husk from kernal and then from milling machine.

(3) Separating husk and coarse bran from brown rice.

(4) Removing fine bran (whitening) from kernal and from the milling machine.

(5) Separating fine bran from white rice.

(6) Separating head rice from broken rice, and separating head and broken rice into various grades of each.

(7) Removing head and broken rice from the milling machine.

Devices or elements used to perform these steps can be divided into:

(1) Husking devices

(2) Whitening devices

(3) Separating devices

(4) Source of power

This scheme of seven steps and four elements can be used to describe any milling process. For example, the ancient and traditional method of hand pounding paddy rice includes:

(1) Mortar and pestle for husking.

(2) No whitening.

(3) Bamboo tray for winnowing.

(4) Human being for power.

The feasibility of adding equipment for fortification at the local mill was investigated as part of the Pilot Project Millers Survey (Mock, 1975). One of the concerns was that machinery needed in order to add the fortificant would disrupt the small-scale operation of village mills. It is generally stated that adding supplemental equipment to a mill system is easier in a more complex operation. The millers were asked about technical difficulties in the fortifying process.

In the Thai pilot project, small simple fortification feeders were developed and constructed locally for about $50 each. These were installed in the small mills of 22 villages which were selected because of the cooperative attitude of the village officials and the millers. For the customers desiring to have all or a portion of their rice fortified, the feeders could be simply and quickly attached to the driveshaft of the milling machines and thus, always function at the same rate of speed as the machine itself. For customers not desiring fortification, the feeder could be easily detached from the mill. Each feeder was examined by project personnel once a week and quality control checks were made regularly, but the feeders continued to function effectively throughout the duration of the project to assure their participation in the program and to compensate them for any time expended or additional costs, the millers were paid 125 ฿ ($6.25) for each case (25 kg) of RFGs dispersed, which is the equivalent of 0.32 ฿ (1.6 cents) for each bushel basket of paddy which was fortified during milling. The granules were delivered regularly to each mill by project personnel. Most of small drums containing the fortificants were stored in the mills; the drums were generally stacked in one corner of the mill enclosures, most of which are small bamboo structures with dirt floors.

The millers were first asked whether the fortification operations had caused them to incur any additional costs. The millers noted only three specific factors which they felt had increased their costs or their workload. First, two of the millers thought that the attachment of the feeders to the milling machines caused the machines to utilize a small quantity of extra fuel, although other millers were certain that there had been no increase in their fuel costs. The second factor, noted by five millers, was that the operation of the feeders considerably increased the load on their machines' engines and thought that this extra load harmed the engines and caused more rapid depreciation than would otherwise occur. The

third item mentioned by the millers was extra time and effort required to measure out the fortificants and to supervise the feeder operations. However, the millers themselves could easily perform these functions, and thus, did not have to hire any additional labor. Aside from these three factors there were no additional costs incurred by the millers as a result of the fortification program.

Despite the operational inconveniences cited, 17 of the 21 millers specifically stated they would still be willing to participate in the fortification effort if it were to help the villages. The one problem that has been identified for the small village mill using their current system is a lower recovery rate

Barrier IV: Consumer Acceptability

In order to obtain information about the attitudes of the participants in the Thai pilot project towards the fortification granules and towards the overall program, forty-five villagers were interviewed in 20 of the 22 villages where the fortification was being conducted (Mock, 1975). In addition, twenty of the participating millers in these villages were also interviewed about their perception of their customer's attitudes towards the fortificants and the program. The respondents were first questioned about whether they like or dislike the fortification granules and about their appraisal of the fortificant characteristics -- its odor, taste, color, and texture, and the problems involved in soaking and cooking rice which has been fortified. The respondents were then asked their opinion concerning the ways in which the fortification granules should be improved in order to increase consumer acceptability of the fortificants. The next group of questions involved the reasons for the villagers' participation in the program - why they and others participate, who consumes the granules, the reasons why some villagers stop participating, why others stop and then resume their participation, and finally, their attitude towards the day care centers which were being operated in some of the villages.

The responses to these questions often varied noticeably, according to specific content of the fortificant granules being dispensed in the particular village. In some villages, the granules contained lysine and threonine, as well as vitamins, iron, and riboflavin; these granules are known as RFG 1. Nine of the eleven villages distributing these granules were interviewed in the survey. The second

type of fortificant granules, RFG 2, contained only vitamins, iron and riboflavin; all of the five villages dispensing this fortificant were visited. The third type of granule, RFG 3, was a placebo; these were distributed in six villages, all of which were visited in the survey. Because of the distinct differences in the characteristics of these granules and in the consumers' attitudes towards them, the responses to most of the questions are subdivided according to the type of fortificant distributed in the particular village where the interview was being conducted.

Consumer Attitudes Towards the Characteristics of the Fortificant Granules

The villagers were first asked whether they liked or disliked the fortificant granules, and the millers were also asked to evaluate whether most of their customers liked or disliked the fortificant. Most (57 percent) of the villagers responded that they disliked the granule, and almost all of the millers said that most of their customers did not like the fortificants. The RFG 1 was the most disliked type of granule; 14 of 18 villagers (78 percent) and all nine millers in the RFG 1 villages gave negative appraisals of the granules. The RFG 3 was clearly the most acceptable granule; two-thirds of the consumer respondents (8 out of 12 individuals) and three of four millers interviewed in these villages indicated that they liked the granule. The complete breakdown of responses given to this question are summarized in Table 9.20.

Table 9.20

Consumer and Miller Evaluations of the Overall Acceptability of the Granules

Response to the question: Do you/your customers like or dislike the granules.

	"Like" the granules				"Dislike" the granules			
	RFG1	RFG2	RFG3	Total	RFG1	RFG2	RFG3	Total
Villager responses.	4	6	8	18	14	6	4	24
Miller evaluation of most villagers attitudes.	–	–	3	3	9	5	1	15

The responses to the first question are not only useful in indicating consumer attitudes towards the different types of granules, but the generally positive reactions towards the placebo, RFG 3, suggests that the villagers are not opposed to having a foreign substance mixed into their food, as long as the specific characteristics of the substance are not displeasing. A more thorough approach to determining acceptability would entail blind taste tests as done in the Guatemala case study.

The villagers and millers elaborated their views in the second section of questions, in which they were asked what specifically they liked or disliked about the characteristics of the granules -- the odor, taste, color, texture, soaking properties, and cooking characteristics. The responses to these questions are summarized in Tables 9.21 - 9.23. As Table 9.21 illustrates, 24 of the villagers (57 percent) complained of an unpleasant, drug-like or sickening odor, and fourteen of the millers said that their customers dislike the odor of the granules. Almost all of the respondents in RFG 1 villages andmost of the people receiving RFG 2 complained about the odor; while most of the inhabitants of the villages receiving placebos had no reaction to the granules' odor or said they smelled good, two consumers of placebos did complain about their objectionable odor. It is also important to note that some of the people who like the granules complained about the unpleasant odor, but still find the fortificants acceptable. One woman explained that although she dislikes the odor, her family consumes the granules because of their benefit. Another woman said that she refused to ruin her rice with the bad-smelling RFG 1 granules, but she takes the granules home in a small bag, soaks them, and consumes them like pills in order to receive the beneficial effect.

Table 9.21

Consumer and Miller Evaluations of the Odor of the Granules

Percent	Opinions of Villagers Who Liked the Granules				Opinions of Villagers Who Disliked the Granules				
	RFG 1	RFG 2	RFG 3	Total	RFG 1	RFG 2	RFG 3	Total	Grand Total
Villager Responses									
1. The granules have a bad smell.					11	3	1	15	15
2. The granules smell like a medicine or drug.	2	2	1	5	1	2		3	8
3. The granules used to smell like a drug but smells ok now.		1		1					1
4. The granules have a sickening smell (feels dizzy).					1			1	1
5. The granules smell good.		1	3	4					4
6. No reaction	2	1	5	8	1	1	3	5	13
Total				18				24	42
Miller Evaluation									
1. Most customers think that the granules have an unpleasant odor.					9	5		14	
2. Most customers have no reaction.			3	3			1	1	

Table 9.22

Consumer and Miller Evaluations of the Taste of the Granules

Percent	Opinions of Villagers Who Liked the Granules				Opinions of Villagers Who Disliked the Granules				
	RFG 1	RFG 2	RFG 3	Total	RFG 1	RFG 2	RFG 3	Total	Grand Total
Villager Responses									
1. The granules taste like a drug taste.		1	1	2	5		1	6	8
2. The granule taste like a drug or medicine.					1		1	2	2
3. The granules have a bad taste.						1		1	1
4. The granules have a sickening taste (vomited after eating).					1			1	1
5. The granules taste good.	2	1	3	6		1	1	2	8
6. The granules are sweet tasting.			1	1					1
7. No reaction.	2	4	3	9	7	4	1	12	21
Total				18				24	
Miller Evaluation									
1. Most customers think the granules have a bad/bitter taste.					8	1		9	9
2. Most customers have no reaction.			3	3	1	4	1	6	9
Total				3					18

Table 9.23

Consumer and Miller Evaluations of the Texture of the Granules

Percent	Opinions of Villagers Who Liked the Granules				Opinions of Villagers Who Disliked the Granules				Grand Total
	RFG 1	RFG 2	RFG 3	Total	RFG 1	RFG 2	RFG 3	Total	
Villager Responses									
1. The granules are too hard.	2	5	4	11	5	3	3		11
2. The granules are too soft.	2			2	2		1		3
3. The granules have a normal rice texture.			3	3					
4. No reaction.		1	1	2	9	1			10
Total				18					24
Miller Evaluation									
1. The granules are too hard.			1	1	5	4	1	10	11
2. The granules are too soft.					1			1	1
3. No reaction			2	2	3	1		4	6
Total				3				15	18

The consumers' and Millers' evaluations of the taste of the granules are presented in Table 9.22. Exactly half of both the villagers and Millers responses indicated that there was no reaction to the taste of the granules and thus the taste was considered 'normal' and acceptable. Some of the villagers, including those who like and dislike the granules even said that they tasted good or sweet. However two of the respondents who liked the fortificants and ten (42 percent) of those who disliked the granules complained about the bitter, bad or sickening taste. Most of these complainants lived in RFG 1 villages and a few lived in RFG 2 villages; in addition, three people receiving the placebos found the taste objectionable.

When questioned about their reaction to the color of the granules the villagers in the RFG 1 and 2 villages noted the yellow color (caused by the riboflavin), no one indicated that the color caused them to avoid accepting the fortification. Only one woman said that the color caused her to dislike the granules, but she said that her family consumes them anyway, because of their benefit. Almost all of the Millers thought that most of their customers dislike the yellow color of the RFG 1 and 2 granules. Several of the consumers of the placebos also complained about their 'black' (less than pure white) color; like the Tunisian consumers these Thai villagers seemed to be extremely sensitive to subtle shades of color in their grain products.

The villagers and millers were questioned next about their reaction to the texture of the granules. Throughout the duration of the pilot project this had been an issue about which the villagers had continually complained and as a result several modifications had been made in the preparation of the granules. The reactions of the respondents, who were interviewed in early 1974, are summarized in Table 9.23. As the data shows over half of the villagers and Millers, including both those who liked and disliked the granules, complained that the granules still have an objectionably hard texture. However a large proportion of the respondents had no particular reaction to the texture. This factor, plus the high proportion of people who liked the granules yet still complained about their texture being too hard or too soft suggests that the texture of the fortificants was no longer an important issue in determining the behavior of the consumers.

The last two characteristics which the villagers were asked to evaluate were the problems encountered in the soaking and cooking of the fortified rice. Only two of the villagers complained that the granules require more soaking time, and

four respondents including two who liked the granules, mentioned that the fortified rice was more time consuming to prepare. In addition, two of the Millers emphasized that the granules required more cooking time, but said that this did not cause their customers to refuse to accept the fortification.

After villagers and Millers had evaluated the characteristics of the granules used in the pilot fortification project, the respondents, were asked to describe how the fortificants should be improved so as to increase consumer acceptability and consumption. Their suggestions are outlined in Table 9.24. As the data illustrates, the most frequent comment was that the yellow color of the granules should be removed; 30 percent of the respondents made this suggestion. The issue of odor was almost as important to the respondents as the color issue; over 27 percent of the respondents advised that the bad or medicinal odor should be removed in order to increase consumer acceptability. The third major issue which was mentioned was the texture; 24 percent of the respondents suggested that the granules should be made softer. Only 7 percent of the respondents thought that the taste needed improvement and eight villagers, 9 percent of the total sample, said that the granules used in the pilot project were acceptable and needed no specific changes.

Consumer Participation in the Fortification Program

As the previous section reveals, many Thai villagers in the pilot project region were highly critical of various characteristics of the fortificant granules. However in spite of their adamant opinions, it is critical to note that almost all of the villagers interviewed were participating in the fortification program, despite their dissatisfaction with the odor, taste, color, or texture of the granules. Although undoubtedly some villagers who were not included in the limited sample may have stopped their participation in the program because of the characteristics of the granules, it is also clear that consumer dissatisfaction with these characteristics, however strongly felt, does not necessarily cause a sharp reduction in program participation.

Of the forty five villagers interviewed randomly in the pilot project villages, forty reported that either their children or their entire family were still consuming the fortified granules. Only five of the respondents said that they had halted their participation in the program. Three people explained that they could

Table 9.24

Consumer and Miller Suggestions as to How the Fortified Granules Should be Improved

Percent	Villager Suggestions				Miller Suggestions				Grand Total
	RFG 1	RFG 2	RFG 3	Total	RFG 1	RFG 2	RFG 3	Total	
1. Remove the bad/medicinal odor.	12	7	1	20	3	1		4	24
2. Remove the yellow color; make the granules white.	13	7		20	2	5		7	27
3. Improve the texture: make the granules softer.	3	7	4	14	2	3	2	7	21
4. Remove the bitter taste; make it taste like normal rice.	2			2	4			4	6
5. No changes are necessary; the granules are acceptable as they are.	2	2	4	8					8
6. No suggestions.	1		1	2					2
Total				66				22	88

no longer tolerate the odor of the granules, one person said that the hard texture was too unpleasant, and one villager said that her family stopped because they could see no positive benefits to their health. One other woman also admitted that her family detests the fortificants and would like to forego eating them but have continued their participation so that their children can attend the day care center.

Thirty four of the villagers interviewed who are participating in the program (85 percent of the participants) reported that their entire family consumed the fortified rice. In addition, in two families the mother and the children participated in the program.

These respondents offered four explanations for the adult's consumption of the fortificants: (1) it was less time consuming and bothersome to cook all of the families rice together, without separating it (six responses); (2) the adults participation acted as an example for the children and encouraged them to eat the fortified rice (six responses); (3) all of the rice was milled together (three responses); and (4) the adults perceived a positive effect on their own health after consuming the granules (two responses). In only three of the forty participating families interviewed was the consumption of the granules restricted to the children alone. It is clear from this data that if the designated target group were defined to include only the young children, the children's families would need better instruction in the separation of the childrens rice at the point of milling, and in the cooking of separate portions for children, which is accomplished simply by placing the childrens' portions first in the bottom of the cooking pot. With the yellow color, the fortified rice is easily visible after cooking and can be spooned out separately from the unfortified rice. Even if the yellow color were removed from the granules, the rice could probably still be cooked in one pot in this fashion, although the size of the cooked portions to be served to the children would have to be roughly estimated. Furthermore, it might be impossible in some families to serve rice only to the children, if the example of the parents participation serves as a strong motivating factor for the children.

The forty villagers who reported that they participated in the fortification program were then asked to explain the reasons for their participation. All of the individuals interviewed were also asked why they thought other people participated; this question was asked in the hopes of obtaining more honest responses from some villagers who might feel freer to explain frankly the reasons for other peoples' behavior than their own. Finally the Millers were also asked to explain

their view of the reasons for their customers participation in the program. The responses to these three questions are presented in Tables 9.25 - 9.27. As the comments in these tables illustrate, the main reasons for participation, as explained by the villagers and the millers, are the expected and perceived medical benefits to both the adults and the children who consume the granules. In each group of explanations, the great majority of the responses concerned these medical and health benefits. The explanations also reflected a great respect for the advice of medical personnel, a factor which could be extremely useful in encouraging support in for an expanded fortification program.

Table 9.25

Villagers' Explanations of Their Reasons for Participation in the Pilot Fortification Project

1. The doctors suggested that they participate in order to improve their health and the health of the children (16 responses).
2. The fortification is beneficial for the health of all of the consumers. (Some villagers were certain that the granules had cured various illnesses such as rheumatism, arthritis, mouth and eye diseases, and muscle pains.) (8 responses)
3. The fortification is beneficial for the childrens health, makes them stronger (5 responses).
4. The granules are added at the mill; no other reason (4 responses).
5. The majority of the people are participating; it is good to follow the majority (2 responses).
6. The workers at the child care center persuaded them to participate (1 response).
7. The children like the granules (1 response).
8. The children must participate in order to attend the center (1 response).

Table 9.26

Villagers' Explanations of Other Peoples Reasons for Participating in the Pilot Fortification Project

1. The doctors asked them to participate in the program in order to improve their health and the health of their children (10 responses).
2. The majority of the people are participating and the others want to follow the majority (8 responses).
3. The fortification is beneficial for the childrens' health (4 responses).
4. Others participate so that their children can attend the day care center, where the children must eat fortified rice (1 response).
5. Adults participate to serve as an example to their children (1 response).
6. The children like the granules (1 response).
7. Don't know other peoples reasons (14 responses).

Table 9.27

Millers' Explanation of the Villagers' Reasons for Participating in the Pilot Fortification Project

1. The fortification is beneficial for the health of adults, cures rheumatism, aches, and muscle pains (7 responses).
2. The fortification is beneficial for the health of the children (6 responses).
3. The doctors asked them to participate (5 responses).
4. The children must eat the granules in order to attend the day care center. The day care center is good for the parents; enables parents to work (2 responses).
5. The doctors force them all to participate by visiting the mill to see if the granules are being distributed (1 response).
6. The millers participate in order to set a good example for the villagers (1 response).

Although the villagers and millers displayed a high degree of interest in the expected and perceived medical and health effects of the pilot fortification program, the stimulation of consumer acceptance by promising or predicting any of these benefits must be done in an extremely cautious manner. In Thailand many of the villagers were impatient to see visible benefits within a short time period. In many of the interview responses about various other issues, the villagers expressed concern and even extreme dissatisfaction with the lack of visible health or medical benefits, and their reluctance to continue further participation in the program unless such effects could be seen within a few months or at least a few years. In addition, three of the five millers who reported decreased customer acceptance of the granules in 1973-4 as compared with the year before attributed this decrease to the customers inability to see any health or medical benefits from their participation. Therefore in the education programs for the participants in any future fortification programs, there should be explicit, careful explanations of the exact benefits which can be expected. It must be emphasized that many of these benefits might not be visible to the participants or the parents of the children participating, similarly, the participants must be led to understand that some of the benefits will not be gained in a short period of time but can only be achieved after several or many years participation in a fortification program.

Barrier V: Intervention Economics

The final issue to be addressed is one of economics; two separate questions need to be answered: "What is the cost of the fortification program?" and equally important "Who shall pay?"

The cost components of a fortification program include -- the fortificant, program logistics, control and cooperation costs. The fortificant cost is the major component of overall cost.

The following economic analysis has been developed from information gathered from interviews with millers and consumers in 20 of the 22 villages that participated in the pilot fortification effort in Thailand (Mock, 1975).

The Millers Appraisal of Consumer Willingness to Pay for Fortification

In order to gain an impression of the possible willingness of consumers to pay for part or all of the costs of fortification, the millers who implemented the program for four years during the pilot project were questioned in detail about customer reaction to the fortification. The millers were considered to be knowledgeable about the attitudes of their customers, who either refused or accepted the millers offer of fortification each time the customers brought their rice to be milled. Much of the information obtained from the miller interviews was included in the previous section which discussed consumer acceptability in the pilot project region. However one of the specific questions posed to the millers concerns the consumers' willingness to pay for fortification; the millers were asked whether they thought that their customers would pay an unspecified amount to receive the fortification and why their customers would or would not be willing to make any payments.

Seventeen millers were asked these questions. One miller said he did not know the answer and one said he thought the customers would pay if the fortification were better promoted with an extensive advertising ('propoganda') campaign. However, fifteen of the seventeen millers said that in their opinion the customers would not be willing to pay anything; several millers were extremely adamant in expressing this view. The reasons given by the millers can be divided into three main categories. First, the millers cited the unpleasant characteristics of the RFG granules as a major reason for the probable lack of consumer willingness to pay for fortification. Six millers said that many people refuse to accept the fortificants because of these characteristics; the millers reasoned that if these people would not accept fortification free of cost, they certainly would not be willing to pay for the fortification. Four of the millers specifically mentioned the odor of the granules, the yellow color, and the cooling characteristics (excessive softness after cooling and yellow discoloration of surrounding rice grains) as the main reasons why the villagers would be unwilling to pay for the program. One miller said that she had even attempted to induce customers to accept the fortificants by effectively paying them. She gave reduced prices to any customers willing to have their grain fortified and was thus passing on some of their own payments for participation to her customers. However she reported that her policy had produced little effect and that even when they were paid most of her customers still refused to accept the fortification.

According to the millers, the second major reason for the unwillingness of customers to pay for fortification is that they simply cannot afford to pay. Four of the seventeen millers said that most villagers are too poor to pay for any of the fortification costs.

The third argument presented by two millers is that many villagers cannot see any clear benefit from fortification and thus would not be willing to pay for participation in the program. Two millers gave this explanation; although one of these mills was dispensing placebos and thus could not be expected to produce any real results, this lack of clear cut benefit from the vitamins and amino acid fortification was a frequent complaint mentioned by numerous respondents in other contexts.

Consumer Evaluation of their own Willingness to Pay for Fortification

Thirty nine residents of villages where fortification was implemented were asked whether they would be willing to pay for fortification, the reasons for their responses, and how much they might be willing to pay. Twelve of the 39 respondents indicated that they would be willing to pay for fortification one villager said that she would pay only if the granules were improved, nineteen gave negative responses to the question, and seven people said that they might be willing to pay for the program.

The villagers who answered affirmatively to the question gave three reasons for their responses. Five people said that the fortification seemed to be beneficial for their health and the health of their children. One respondent said that he would pay because the local doctor supports the program, and another person attributed their willingness to pay to the influence of her brother, who is a firm supporter of this program. The woman who said that she would pay for the granules if they were improved made four specific criticisms. She said that the RFG, which in her village contained amino acids and vitamins, had a bitter taste, a texture which was too hard, a disturbing yellow color and a smell so unpleasant that a friend had vomited after consuming the granules.

The twelve respondents who indicated their willingness to pay for fortification were then asked how much they would consider reasonable to pay. The villagers were offered four different price levels to choose from: (1) (0.25 ฿ ($1.25¢) per kg of rice; (2) (0.50 ฿ (2.5¢) per kg; (3) 0.75 ฿ (3.75¢) per kg; and (4) 1.0 ฿ (5¢) per

kg. Four of the twelve respondents selected the first choice, 0.25 ฿; two people selected the second category, 0.5 ฿; and four individuals indicated they would pay 1.0 ฿. Two respondents ignored the choices offered; one volunteered that she would be willing to pay 1.5 ฿/kg, and the second said he would pay whatever the millers charged to obtain the fortification. The woman who said that she would pay only if the granules were improved indicated that she would pay any price which would be charged for the improved granules.

The nineteen respondents who said that they would not be willing to buy the fortified granules gave three main reasons for their position: (1) the fortification yields no clear benefit to the consumers (8 responses); (2) the granules have unpleasant characteristics, mainly an undesirable smell and taste (5 responses); and (3) the respondent was too poor to pay any money for the fortification (4 responses).

Finally, three of the villagers who responded that they might pay to have their rice fortified explained that they would follow the decision of the majority of the villagers and would participate in any program accepted by the village as a whole. Two people said that they would pay if the price were not too high, one person indicated that she would pay if she had extra money, and one villager said she would buy the granule if she could see more clear cut benefit to her family.

The differences between the villagers responses to these questions and the millers appraisal of the villagers willingness to pay for fortification are striking. While 31 percent of the villagers interviewed (12 of 39 respondents) indicated their willingness to buy the granules only one of seventeen responding millers thought that the villagers would be willing to pay. While there are several possible reasons for these differences, without further interviews it would be impossible to ascertain which responses are more representative of the opinions of the majority of the villagers. Nevertheless, the villagers responses do suggest that despite their criticisms of the grandules and the fortification program, many might in fact be willing to bear part of the costs of the program, if they perceive a benefit.

Comparison of Fortificant Costs with Consumer Expenditures on Rice and Rice Milling

One method of evaluating the feasibility of allocating the costs of fortification to the recipients is to compare the costs with the recipients' normal expenditures on rice and rice milling. It can generally be assumed that if the additional costs do not significantly increase their normal expenditures, consumers might be able or willing to assume these extra costs. Conversely, if the addition of the fortification costs results in a considerably increased price for rice or rice milling, it is reasonable to assume that most recipients, especially the lower income or subsistence rural population, would not be willing or able to pay for the fortification of their rice. This kind of comparison could be particularly useful to government officials who, in deciding where to allocate costs, could have explicit or implicit guidelines concerning the size of grain and milling price increases which would be tolerated by the consumers and thus which the government might consider politically feasible to allow.

While detailed estimates of the total costs of a fortification program in Thailand are not available, the cost of the fortificants, which represent the large majority of total costs, can be used as a rough indicator of total program costs. In early 1974 the manufacturers of the fortified granules estimated that the price of the granules in 1980 would be $10 per kilo. Since the granules are added to rice at a rate of one percent, the fortification of rice with these granules would cost about $.10 (2฿) per kilo of rice or $.64 (13฿) per bushel of paddy milled (one bushel of paddy = 6.4 kg of rice).

During the research for this project, the millers and residents of 21 of the 29 villages included in the Thai pilot fortification project were interviewed about the prices for paddy and rice in their area during both the winter season, when prices are typically at their lowest level, and during the summer, when prices rise to their highest point. Information was also obtained about the milling fees and the typical grain purchasing patterns of consumers in each village. While this data may not precisely correspond to the exact conditions in all of the other regions of the country, the information can be considered representative of typical rural villages in the northern rice growing regions of Thailand. The data can also be used to roughly evaluate the economic conditions in other regions of the country, although additional data would have to be gathered, particularly in the northeast region, before an expanded fortification program could be implemented.

In order to evaluate the ability of the village consumers to absorb the cost of a fortification program, as represented by the actual fortificant costs, these costs should be compared with the expenditures typically required in the five main ways in which rice is usually obtained and processed: 1) home grown paddy, milled locally in exchange for the bran; 2) home grown paddy, milled locally for a fee; 3) purchased paddy, milled locally in exchange for the bran; 4) purchased paddy, milled locally for a fee; and 5) purchased rice.

Home grown paddy, milled locally in exchange for bran: Some local mills offer their customers the option of foregoing the milling fee and given the miller the bran by-product instead of a fee. In this case, the consumer makes no immediate out-of-pocket expenditures for the paddy, which is home grown, or for the milling. The allocation of the full fortification costs to the consumers would require that they pay 13B ($.64) per bushel of paddy milled. Since the lowest income groups in rural areas, probable target groups of a fortification program, live largely outside the cash economy or have relatively limited cash resources available, the absorption of these new costs would most likely be an impossibility. Those families with relatively more cash available would probably be highly reluctant to assume what appears to them to be significant new costs instead of receiving a seemingly free service.

Home grown paddy, milled locally for a fee: In the northern rural areas near the city of Chiang Mai, where the pilot project was conducted, the operators of the small local mills charge from 0.5-1.25฿ (2.5-6.25¢) per bushel for the milling of paddy. For the families with home grown paddy, the absorption of the full fortification costs would mean price increases of 13B per bushel, with the new fees ranging from 13.5-14.25฿ (68-71¢) per bushel. Again, to the consumers these would appear to be highly dramatic increases, which most poor rural families would not be able to absorb and which other more prosperous families would probably not be willing to cover, because of the relative magnitude of the increases.

Purchased paddy, milled locally in exchange for the bran: In the villages included in the project interview respondents reported that during the winter harvest months a bushel of good quality paddy costs from 12-25฿ ($.60-1.25) per bushel, with an average price quoted of 18.6B ($.93). During the summer and fall when paddy is more scarce the price increases to from 17-34฿ ($.85-1.70), with an average price of about 26.5฿ ($1.33). If the purchased paddy were milled in a

small local mill and the bran were given to the miller in lieu of a milling fee, the addition of the fortification costs would cause the immediate out-of-pocket expenditures for the paddy and milling to rise to an average of 31.6฿ ($1.58) per bushel in winter and 39.5฿ ($1.98) in summer. This represents cost increases of about 70 percent in winter time and about 50 percent in summer. For most low income customers, these increases would probably be prohibitive. However for the poor families who grow most of their own rice supply and purchase paddy only when their home grown stock is depleted, these additional costs would most likely be impossible to absorb.

Purchased paddy, milled locally for a fee: When purchased paddy is milled for a fee, overall costs to the consumer are increased by about .93฿ per bushel the average cost of milling in the pilot project villages. Thus the consumer price for a bushel of paddy and processing increases from an average paddy price of 18.6฿ ($.93) in summer to a total cost of 19.5฿ ($.98), and in winter the average price of paddy, 26.5฿ ($1.33) is increased to 27.4฿ ($1.37). When fortification costs are processing, the total cost to the consumer increases to an average of 32.5฿ ($1.63) in winter and 40.4฿ ($2.02) in winter, increases of 66 percent 47 percent respectively.

Purchased rice: Most urban families, and the wealthier and non-farming rural families purchase all or a major part of their rice supply as processed rice, rather than unprocessed paddy. The poorer rural families may also buy processed rice when their home grown stocks are depleted and when local paddy is unavailable or scarce, and therefore extremely expensive. Much of this rice is milled in the large rice mills within each particular region although processed rice is also regularly transferred from more productive regions to the rice deficit areas, which would be the likely targets for a fortification program. Some of this rice is also processed in the small local mills; in addition to providing milling services, some millers also grow or purchase paddy which they process and sell as rice either in their mills or in local market places and retail outlets. In the northern Chiang Mai region, the price of high quality processed rice averages about 3.6฿ (18¢) per kg in winter time and about 4.5฿ (23¢) per kg. in summer while low quality rice is priced at an average of 2.7฿ (13¢) per kg. in winter and 4.0฿ (20¢) per kg in summer. If fortification costs of 2฿ ($.10) per kilo were added to these prices, the winter and summer prices for high quality rice would

increase by 56 percent and 44 percent respectively, while the price of low quality rice would increase by 74 percent in winter and 50 percent in summertime.

In summary, as these various comparisons suggest, allocating the full cost of the fortificants to the consumers would result in price increases which most poor rural consumers would probably be both unwilling and unable to bear. However with these data and information on village incomes and rice consumption, government officials with a view of the political feasibility of small price increases would be better able to evaluate the ability and willingness of villagers to absorb a certain portion of the fortification costs. Of course, the price burden is much smaller for micronutrient fortification.

Summary of Intervention Economics

The costs incurred as a result of the fortification include the fortificant, the fortifying process, control costs and cooperation incentives. By far, the most expensive component of the intervention is the cost of fortificant. However, it is apparent, given the income constraints of the target population in rural areas that only a small part, if any, of the cost of fortification could be absorbed by consumers.

The consumers' reactions to cost were all gathered on rural area residents in the pilot fortification village. No data were gathered on urban residents; however, as stated earlier, the majority of the lowest income urban consumers purchase rice in the government subsidized rice shops. As of June 1977, rice in the government subsidized shops was selling for 60 bolt per 15 kilos of rice compared to 65 bolt for the same quantity in the retail stores. The primary reason for utilizing the government shops is because of the cost savings. If, in fact, the cost of a fortification program was passed onto the urban consumer utilizing government shops, the price differential between subsidized and non-subsidized rice would disappear. The fortification under these circumstances (consumers paying for the service) might even have a negative impact if, because of the price increase, consumers purchased less rice. In short, it does not appear feasible for low income consumers in urban or rural areas to pay all or part of the cost of fortification. The question then becomes can the Thai government afford to underwrite this type of nutrition intervention. For example, in the northeastern area of Thailand there are approximately 8.9 million people including 1.4 million preschoolers (periodic nutrition survey, 1966) survey data indicate that in 1966, adults consumed an average of 511 gms of rice per day. Under the system used in the pilot fortification project, in most cases, the total rice supply of the family was fortified. If this were done in the northeastern area of Thailand, it would result in an overcoverage of 7.5 million persons in order to reach the 1.4 million preschoolers in the area. A more efficient approach would be an attempt to target in on the preschoolers; in Thailand, this could be done through the currently existing day care centers. Use of the centers as delivery systems allows not only efficient coverage but utilizes a network with an established administrative structure. As such, a quality control system could easily be integrated into the day care centers.

However, even if the fortification effort were able to target exclusively on the 1.4 million preschoolers, it is still an expensive venture. For the 1.4 million preschoolers in the northeastern region of Thailand, the cost of fortificant alone is 3.5 million/year. This cost would be dramatically reduced to approximately $27,000/annually if only micro level fortification were proposed.

The costs of the fortifying process are minimal; in the 21 mills surveyed (Mock, 1975) fortification equipment could be supplied generally at $100 or less.

Control costs could also be substantially curtailed by use of already established agencies like day care centers.

Data from the millers' survey (Mock, 1975) provide estimates of the economic incentives needed to cultivate the cooperation of millers; the average fee for millers in the pilot project area was $.025/kg of rice fortified. This $0.25 was 34 percent of the normal million fee of $.0725/kg rice. Although most of the millers indicated that they would expect more reinbursement if the program continued, they also indicated that if the volume of business at the mills increased thereby increasing their total earnings, they would probably continue to accept the same fee.

Summary

Dietary and anthropometric survey data from Thailand have indicated that nutritional deficiencies do exist in a significant proportion of the population. The fortification pilot project described in this chapter was one attempt to address these problems. The technology both for the fortificant and fortifying process is available and can be implemented in a centralized or decentralized system.

The concept that fortification is an "invisible" intervention is not true. Consumers interviewed in the pilot project villages revealed that not only could they distinguish the fortified from unfortified rice but the fortified rice had undesirable taste, odor, color and cooking characteristics. Despite these criticisms of the fortified rice, most consumers also indicated that they were willing to eat the rice if they thought it was beneficial for them and their families.

The major drawback of the fortification project as currently designed is cost. In view of the possibility of caloric insufficiency in the target population, the government might consider micro rather than macro-level fortification. In rural areas, this could easily be done through the currently existing day care centers. In urban areas, micro-fortificants could be added to the rice sold through the government subsidized shops. These shops are used primarily by low income consumers.