

## ARTIFICIAL ENRICHMENT OF WHITE RICE AS A SOLUTION TO ENDEMIC BERIBERI

### I. PRELIMINARY REPORT OF FIELD TRIALS <sup>1</sup>

JUAN SALCEDO, JR.,<sup>2</sup> ALFONSO PEDROCHE,<sup>3</sup> ELPIDIO C.  
PANGANIBAN<sup>4</sup> AND JOSE F. DE LEON<sup>5</sup>

*U. S. Public Health Service and Department of Health of the  
Republic of the Philippines, Manila*

(Received for publication February 18, 1949)

A complete beriberi survey in Bataan Province has been reported (Salcedo et al., '48) showing an incidence of symptoms of that disease in 12.77% of 12,400 people who were clinically examined. This survey was undertaken in contemplation of the introduction of artificially enriched rice in all municipalities on the Manila Bay side of the Province (68,000 people). This was inaugurated October 1, 1948, after the installation of machinery for quantitative mixing of "premix" with rice at each of 21 rice mills in the area. Labor and depreciation on this machinery, it is estimated, will add \$0.0008

<sup>1</sup> This study has been made possible by a grant from the Williams-Waterman Fund Committee of the Research Corporation, New York City, to the Department of Health of the Republic of the Philippines. The "premix" was donated by Hoffmann-LaRoche, Inc., Nutley, New Jersey, U.S.A. Equipment and supplies were authorized from funds allocated to the U. S. Public Health Service Rehabilitation Program in the Philippines in connection with the Philippine Rehabilitation Act of 1946 of the 79th Congress of the United States of America.

Read before the monthly meeting of the Manila Medical Society, March 8, 1949.

<sup>2</sup> Director of Field Operations, U. S. Public Health Service in the Philippines. and Director, Institute of Nutrition, Republic of the Philippines.

<sup>3</sup> Medical Supervisor, Welfareville Institutions, Social Welfare Commission, Republic of the Philippines.

<sup>4</sup> Major, Medical Corps, Office of the Surgeon General, Headquarters National Defense Forces, Republic of the Philippines.

<sup>5</sup> Rice Mill Engineering Consultant employed under a grant from the Williams-Waterman Fund.

per ganta (5 pounds) to the cost of rice. During the three months up to January 1, 1949, the enriched rice has proved acceptable to the population. The survey is to be repeated later to determine any change in incidence or in mortality from beriberi.

#### MATERIALS AND METHODS

Previous to the introduction of artificially enriched rice in Bataan Province, it was considered necessary to conduct preliminary field feeding trials to determine its "acceptability" in so far as color, taste, odor, palatability, and digestibility are concerned, as well as to determine any possible beneficial effects on general health and on existing peripheral neuritis and other symptoms of thiamine deficiency among the subjects tested. This was necessary in view of the disappointing experiences local public health officials had previously encountered with the introduction of brown rice, under-milled rice and certain varieties of parboiled rice. In the experiments cited below, as well as in the large-scale enrichment of rice being conducted in Bataan Province, we have used rice grains impregnated with thiamine, niacin and iron pyrophosphate, known as "premix," in such concentrations that when one part by weight of this "premix" is mixed with 200 parts by weight of white, polished rice (Furter et al., '46) the final mixture (now known as enriched rice) as delivered contains per pound 2.0 mg of thiamine, 15 mg of niacin, and 13 mg of iron. The nutrients to be used in a Philippine national enrichment program will be determined later, taking into consideration the results of present and future studies.

#### RESULTS AND OBSERVATIONS

Three sets of observations were made: I, among government employees; II, among children housed and fed in the Welfareville Institutions of the Social Welfare Commission; and III, among personnel of the Armed Forces of the Philippines.

*I. Government employees*

A single 5-lb. trial quantity of enriched rice was given to each of 284 government employees and their respective families totalling, including the employees, 2,188 persons. All of these individuals consumed the enriched rice as a part of their usual daily menus and reported uniformly that it was found satisfactory and acceptable in all instances.

*II. Welfareville institutions—enriched rice observations*

Two hundred eighty-seven children of both sexes and of different ages, ranging from three years to 18 years, were served enriched rice starting April 1, 1948. Another group of 287 children of similar sex and age distribution was served with the same amount of white milled rice, without "premix." The children in both groups each consumed daily 200 to 250 gm of rice in addition to the other components of their diet which, however, was generally deficient in thiamine when judged with respect to recommended daily allowances. Both groups were in fairly good health and showed no symptoms of thiamine deficiency at the start of or during the experiment. In Bataan Province it was found that clinical beriberi in children from two to 15 years of age is rare (Salcedo et al., '48). Before the project began, the children under observation were physically examined and their heights and weights were taken. Hemoglobin values and red cell counts were taken on 30 children in each group. On July 1, 1948, the same examinations were repeated to determine the effects of enriched rice on their health and nutrition.

*Results of observations three months after the start of the experiment —*

1. Average increase in height of the children: For the control group (no enriched rice given), 0.63 cm; for the group served with enriched rice, 0.79 cm.

2. The per cent of each group who increased in height by specified amounts is given in table 1.

3. Average gain in weight: For the control group (no enriched rice given), 0.62 kg; for the group served with enriched rice, 0.77 kg.

4. The per cent of each group who gained specified amounts in weight is given in table 2.

Comments. From the above data it may be inferred that the children served with enriched rice for a period of three months had increased in height and gained in weight more than those that were not served with enriched rice.

The above observations were continued for an additional period of 5 months, or a total of 8 months from the start, on 520 children, 260 serving as the experimental group (fed with enriched rice) and an equal number being used as controls.

TABLE 1

| GROUPS UNDER OBSERVATION            | NO IN-<br>CREASE | INCREASE IN HEIGHT BETWEEN: |              |              |              |
|-------------------------------------|------------------|-----------------------------|--------------|--------------|--------------|
|                                     |                  | 0.1-<br>1 cm                | 1.1-<br>2 cm | 2.1-<br>3 cm | 3.1-<br>4 cm |
| 1. Group served with enriched rice  | %<br>7.66        | %<br>66.50                  | %<br>24.00   | %<br>1.84    | %<br>0       |
| 2. Control group (no enriched rice) | 11.84            | 63.76                       | 22.64        | 1.76         | 0            |

TABLE 2

| GROUPS UNDER OBSERVATION            | NO<br>GAIN | GAIN IN WEIGHT BETWEEN: |              |              |              |
|-------------------------------------|------------|-------------------------|--------------|--------------|--------------|
|                                     |            | 0.1-<br>1 kg            | 1.1-<br>2 kg | 2.1-<br>3 kg | 3.1-<br>4 kg |
| 1. Group served with enriched rice  | %<br>9.90  | %<br>63.36              | %<br>21.78   | %<br>4.45    | %<br>0.51    |
| 2. Control group (no enriched rice) | 9.42       | 76.63                   | 11.43        | 2.52         | 0            |

Twenty-seven children from each group had to be dropped due to transfers and discharges from the institutions.

*Results of observations at end of eight months —*

1. Average increase in height of the children: for the control group (no enriched rice), 2.27 cm; for the group served with enriched rice, 2.34 cm.

2. The per cent of each group who increased in height by specified amounts is given in table 3.

3. Average gain in weight of the children: For the control group (no enriched rice), 1.43 kg; for the group served with enriched rice, 1.91 kg.

4. The per cent of each group who gained specified amounts in weight is given in table 4.

5. Average increase in hemoglobin %: For the control group (no enriched rice), 7.33%; for the group served with enriched rice, 13.83%.

6. Average increase in red cell count: For the control group (no enriched rice), 431,000 red cells; for the group served with enriched rice, 667,000 red cells.

Comments. From the above data it may be inferred that the children served with enriched rice for a period of 8 months had increased in height and gained in weight slightly more than those that were served with ordinary rice. It may

TABLE 3

| GROUPS UNDER OBSERVATION            | NO INCREASE | INCREASE IN HEIGHT BETWEEN: |          |          |          |
|-------------------------------------|-------------|-----------------------------|----------|----------|----------|
|                                     |             | 0.1-1 cm                    | 1.1-2 cm | 2.1-3 cm | 3.1-5 cm |
| 1. Control group (no enriched rice) | 4.61        | 15.76                       | 24.23    | 27.69    | 27.71    |
| 2. Group served with enriched rice  | 2.30        | 17.69                       | 21.15    | 30.38    | 28.48    |

TABLE 4

| GROUPS UNDER OBSERVATION           | DECREASED IN WEIGHT | NO GAIN IN WEIGHT | GAIN IN WEIGHT BETWEEN: |          |          |          |
|------------------------------------|---------------------|-------------------|-------------------------|----------|----------|----------|
|                                    |                     |                   | 0.1-1 kg                | 1.1-2 kg | 2.1-3 kg | 3.1-5 kg |
| 1. Control group                   | 8.84                | 4.23              | 28.45                   | 33.07    | 16.53    | 8.88     |
| 2. Group served with enriched rice | 5.00                | 0.76              | 24.23                   | 34.61    | 16.53    | 18.87    |

also be noted that more children among those served with enriched rice increased in height, from two to 5 cm, and gained in weight, from two to 5 kg. Fewer children among those served with enriched rice decreased in weight or gained no weight. It was also observed that enriched rice did not produce any unfavorable reactions among the children served with it.

### III. Enriched rice feeding of Armed Forces personnel

A clinical survey for beriberi was conducted among the personnel of certain units of the Armed Forces of the Philippines late in September, 1947, and repeated in July, 1948, as noted in table 5.

Enriched rice was issued to units 1 and 2 (table 5) and un-enriched white rice to unit 3 from January 1 to mid-July, 1948. In addition, enriched rice was issued to 800 enlisted men of the First Infantry Training Battalion and to 150 civilian employees of the Ordnance Center. Thus, a total of 1,416 persons of the military establishment consumed enriched rice and were questioned and observed as to its acceptability and its effects. Clinical observations, however, were substantially confined to the personnel listed in table 5.

The use of enriched rice was not maintained consistently at the Ordnance Center, and in all three groups there was

TABLE 5  
*Experimental and control groups in armed forces*

| UNIT                              | SEPT. 1947 |   | JULY 1948 |   | WEIGHTS <sup>1</sup>    |                        |
|-----------------------------------|------------|---|-----------|---|-------------------------|------------------------|
|                                   | Total men  | No. with B <sub>1</sub> deficiency symptoms | Total men | No. with B <sub>1</sub> deficiency symptoms | In-creased (0.5-14 lb.) | De-creased (0.5-9 lb.) |
| 1. Signal Service Bn. (exptl.)    | 130        | 21  | 93        | 0   | 60                      | 15                     |
| 2. Ordnance Center (exptl.)       | 220        | 67  | 143       | 25 <sup>2</sup>                             | 51                      | 81                     |
| 3. Engineer Service Bn. (control) | 116        | 13  | 83        | 30  | 40                      | 27                     |

<sup>1</sup> Weight changes are recorded only for those men who remained in the units throughout the period of experiment.

<sup>2</sup> Sixteen cases of this group had no symptoms during the first survey.

considerable movement of men to other camps. These disturbing factors interfered with the conduct of a rigorously controlled experiment, but certain of the results appear to be of interest.

*Findings.* A monthly check was made on all the men receiving the enriched rice, as to any reactions to it. All stated that there was no change in taste, color or palatability. There was a mild odor reminiscent of tikitiki. There was no increase in the incidence of gastrointestinal symptoms in the daily sick call. No untoward by-effects were attributed by the men to the enriched rice. All the men of both experimental and con-

trol groups were given the other components of their usual daily diets.

#### DISCUSSION

The Signal Service Battalion is a unit which showed the typical reaction due to constant feeding of enriched rice for 6 months, with general improvement in the physical appearance of the men. Sixty-five per cent of the men gained in weight, while 17% lost in weight. All of those with signs or symptoms of peripheral neuritis failed to show or complain of any further manifestations of this symptom-complex. Contrast this with a unit having a big work load, much movement of personnel, and irregular feeding with enriched rice, at the Ordnance Center. In this group there were 30% who increased in weight, 55% who lost in weight. Those cases which previously showed mild symptoms and signs were relieved but, although there was a big reduction in those with one or two signs or symptoms, 16 formerly showing no symptoms had developed symptoms of peripheral neuritis after 6 months. These 16 were among personnel who had been transferred to and from other ordnance units and those on cash rations permitting them to eat outside. Considering that their messes were practically identical with those of the Signal Battalion the different results indicate the effects of neglected use of enriched rice. The results shown in the Engineer Service Battalion (controls) indicated health improvement directly attributable to improved diet (caloric increase), but the increase in the number of cases with one or two signs or symptoms of polyneuritis indicated that the quality, at least the thiamine intake, was still subnormal. Contrast this with results in the Signal Service Battalion, where all cases with symptoms improved.

#### *Deaths from beriberi in Bataan Province*

Preliminary observations on the effect on beriberi mortality in Bataan of the introduction of artificially enriched

rice are indicated in table 6. Conclusions will be drawn after a longer period of observation, and following a beriberi re-survey during 1949.

TABLE 6  
*Deaths from beriberi in Bataan province*  
(From the statistics of the District Health Officer of Bataan)

| ENRICHED RICE AREA <sup>1</sup><br>(7 MUNICIPALITIES)           | OCT. 1-DEC. 31<br>1947 |        | JULY 1-SEPT. 30<br>1948 |        | OCT. 1-DEC. 31<br>1948 |        |
|---|------------------------|--------|-------------------------|--------|------------------------|--------|
|   | Infants                | Adults | Infants                 | Adults | Infants                | Adults |
| 1. Abucay   | 2                      | 3      | 2                       | 0      | 1                      | 0      |
| 2. Balanga  | 12                     | 1      | 6                       | 1      | 2                      | 1      |
| 3. Hermosa  | 8                      | 2      | 5                       | 1      | 0                      | 0      |
| 4. Orion  | 7                      | 1      | 6                       | 0      | 5                      | 0      |
| 5. Pilar  | 2                      | 0      | 0                       | 0      | 0                      | 0      |
| 6. Samal  | 0                      | 0      | 3                       | 0      | 6                      | 0      |
| 7. Orani  | 6                      | 1      | 4                       | 1      | 5                      | 0      |
| Totals  | 37                     | 8      | 26                      | 3      | 19                     | 1      |
| AREA WITH ORDINARY<br>WHITE POLISHED RICE<br>(5 MUNICIPALITIES) |                        |        |                         |        |                        |        |
| 1. Dinalupihan  | 1                      | 1      | 6                       | 1      | 4                      | 1      |
| 2. Bagac  | 1                      | 0      | 2                       | 0      | 1                      | 0      |
| 3. Mariveles  | 0                      | 0      | 0                       | 0      | 0                      | 0      |
| 4. Moron  | 5                      | 0      | 0                       | 1      | 2                      | 2      |
| 5. Limay  | 0                      | 0      | 5                       | 0      | 2                      | 0      |
| Totals  | 7                      | 1      | 13                      | 2      | 9                      | 3      |

<sup>1</sup> Enriched rice simultaneously introduced to all municipalities of this area on October 1, 1948.

#### SUMMARY AND CONCLUSIONS

Preliminary field trials in the Philippines with artificially enriched white rice have been made with a total of almost 3,500 individuals, including government employees and their families, members of the Armed Forces, and the children in government institutions. The results in so far as "acceptability" with reference to color, taste, odor, palatability and digestibility is concerned have been completely satisfactory. Limited observation points to beneficial effects on peripheral neuritis among members of the Armed Forces. The results

of the large-scale feeding of enriched rice in Bataan Province will be published in the future as soon as the studies are completed.

## ACKNOWLEDGMENT

The authors would like to express herein their grateful acknowledgement for the full cooperation, moral support and helpful advice extended to the Project by Brigadier General Howard F. Smith, Assistant Surgeon General, U.S. Public Health Service, and Officer-In-Charge, Philippine Public Health Rehabilitation Program; the Honorable Antonio Vil-larama, Secretary of Health, Republic of the Philippines; Dr. Robert R. Williams, Chairman, Williams-Waterman Fund Committee for the Combat of Dietary Diseases; Hoffmann-La Roche, Inc., of Nutley, New Jersey; The National Rice and Corn Corporation of the Philippines; the medical officers of the various units of the Armed Forces of the Philippines involved in these studies; the Staff of Welfareville Institutions; and by Dr. Isabelo Concepcion, Dr. Francisco O. Santos, and Dr. Arturo B. Rotor, who acted as advisers to the Project.

## REFERENCES

- FURTER, M. F., W. M. LAUTER, E. DERITTER AND S. H. RUBIN 1946 Enrichment of rice with synthetic vitamins and iron. *Ind. Eng. Chem.*, **38**: 486-493.
- SALCEDO, JUAN, JR., E. O. CARRASCO, F. R. JOSE AND R. C. VALENZUELA 1948 Studies on beriberi in an endemic sub-tropical area. *J. Nutrition*, **36**: 561-577.