The formulation and testing of a Chinese boarding school diet with special reference and application to a Chinese school feeding program
by Wan-Cheng Chang

A THESIS Submitted to the Graduate Faculty In partial fulfillment of the requirements for the degree of Master of Science in Home Kconomioe at Montana State College
Montana State University
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Abstract:
In this study three different diets — a formulated Chinese boarding school diet, a Chinese rural diet, and a diet known to be nutritionally adequate (Sherman's diet B) which served as a control — were prepared and tested on experimental rats. Evaluations and comparisons were made on the growth promoting property of these diets on experimental animals through a seven weeks period.

The formulated Chinese boarding school diet contained various kinds of raw and cooked vegetables, fresh fruits and seats. Powdered milk and whole wheat were added in order to make this diet more nutritionally adequate than the Chinese boarding school diet ordinarily used. Rats fed on this diet showed an average gain of 131 grams in seven weeks compared to 132 grass average gain of the rats receiving Sherman's diet B. This diet is nutritionally adequate for the growth of experimental rats since it contains about two and one-half times more ascorbic acid than is recommended by the National Research Council; thus, it is assumed to be nutritionally adequate also for the growth of human beings.

The Chinese rural diet was tested and found to be nutritionally inadequate for the growth of rate. An average gain of 74 grams resulted in seven weeks. The most glaring defects of this rural diet are that it contains only about 3/4 of the amount of protein, 1/4 of the calcium, 1/5 of vitamin A and 1/3 of riboflavin recommended by the American National Research Council. This experiment indicated one of the possible reasons for the great incidence of malnutrition among the Chinese people.

A study of two Montana School lunch programs was made. The important features are summarised and their applications are made to a feeding pro-gram in a Chinese boarding school. The following ideas have been incorporated in such a program; 1. Lunchroom supervisions by a Home Economist or a Dietician is preferred.

2. Educational posters are an important means of fitting the feeding program into the educational system.

3. A well planned and arranged lunchroom and kitchen are necessary in order to obtain satisfactory results. A floor plan has been devised and is included in this thesis.

THE FORMULATION AND TESTING OF A CHINESE BOARDING SCHOOL DIET WITH SPECIAL REFERENCE AND APPLICATION TO A CHINESE SCHOOL FEEDING PROGRAM

by

WAN-CHENG CHANG

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at

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ABSTRACT

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A study of two Montana School lunch programs was made. The important features are summarized and their applications are made to a feeding program in a Chinese boarding school. The following ideas have been incorporated in such a program:

1. Lunchroom supervisions by a Home Economist or a Dietician is preferred.

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INTRODUCTION

Only a few studies have been made on the chemical analysis of Chinese foods and diets. Blasdale (5), 1899, Chen (8), 1936, Lo (19), 1935, Read (26), 1946, and Harris, Wang et al (12), 1949, have furnished most of the information, but knowledge of the adequacy of these foods in human dietaries is far from being complete.

Jaffa (15) reported the first investigation among the diets of Chinese in California in 1901. He found that in the daily California Chinese diet, 1/3 of the total nutrients, 1/3 of the total protein, and 3/4 of the total carbohydrates were supplied by rice. J. H. Liu (18), 1944, a physician in the Peiping Medical School in China, stated that the dietary habits of the Chinese in North China are different from those in South China. The food habits of people in the east are different from the people in the west.

Despite these differences, approximately 75 per cent to 80 per cent of the Chinese population are vegetarians from economic circumstances rather than choice. The rural Chinese diet is composed of cereal eaten with vegetables. Meat protein is consumed in extremely small amounts, and used only for special occasions. Milk is not readily available, and the average Chinese family can not afford to purchase it. Dr. Hou (13), 1949, in a review of nutritional diseases in China, stated that a large scale dairy industry is not practicable in China. In the thickly populated areas pasture land is not available, and all cereals have to be consumed by human beings. In a few thinly populated areas such an industry might be inaugurated, but the costs of transportation and refrigeration facilities would

make the price of milk prohibitive.

According to Dr. Hou (13), the incidence of various types of nutritional diseases in China differ from place to place. He attributes most of these variations to the dietary practices. In the rice-eating regions in central and southern China, the incidence of beriberi is high, while in the north, where the people have wheat as the main cereal in the diet, the incidence of beriberi is low. Vitamin A deficiency is common in both north and south.

Bonnell's study (6), 1948, showed that the dietary habits and the nutritional status of many school children in China are far from ideal. She also reported that the school children in China revealed a caloric intake 30 per cent below the normal, and a low intake of protein and calcium. The average body weight is below normal. Symptoms of bone deformities are common. The physical examinations showed 80 per cent to be anemic; 50 per cent had marked evidence of ascorbic acid, vitamin B_1, and riboflavin deficiencies. About 57 per cent had scabies, 48 per cent had ring worm of scalp, and about 80 per cent suffered from dysentery, 71 per cent suffered from conjunctivities, 40 per cent had active tuberculosis and 11 per cent suffered from malaria.

Previous studies on the nutritional status of children in the United States (Abbott and Ahman (1), 1930, Roberts (28), 1927, and Roberts (29), 1935) indicated that an adequate nutritional diet is important for the growing child. Both Abbott and Ahman (1), in a nutritional study of the white school children in Florida, and Roberts (28), in his study of the

growth of underweight children, found that malnutrition of children can be improved by changing the present diets to adequate ones. The importance of the school lunch program in American schools as a factor in improving the nutritional status of the children has been proved by Abbott et al (2), 1946. These investigators found that a school lunch program offered an effective means of raising the nutritional status of rural school children from a pronounced clinical deficiency to a condition of sufficiency. Thus, a school lunch program is a factor which will contribute to the general health and growth of children; it might be a necessary part of the school program in China.

The committee on Food and Nutrition of the National Research Council of the United States has utilized the results of many dietary studies in preparing a table of recommended daily allowances. It shows the daily requirements of men, women, and children for some of the nutrients which are considered as essential. Bowes and Church (7), 1946, have compiled valuable data from authoritative sources on the food values of the commonly used foods in terms of unit serving. They also have supplied such data on cooked foods and have summarized important principles of preparation related to the nutritive factors in foods. The use of this material is of great value to dietary technicians and school lunch nutritionists.

PURPOSE

The purpose of this study consists of two parts:

I. In view of the recognized deficiencies of Chinese school diets, an

attempt was made to formulate a more nearly nutritionally adequate diet for the use in boarding schools in China. The diet was formulated with particular regard to the habits of the Chinese people, and was tested on experimental animals.

II. A study of the operation of the school lunch program in two Montana schools was made in order that a similar program may be developed for the Chinese schools.

EXPERIMENTAL PROCEDURE

Three different types of diets were evaluated in the first part of this study: the Chinese boarding school diet, the Chinese rural diet, and a control diet (Sherman's diet B). These diets were prepared and fed to 18 white albino rats of known history especially reared for use in feeding experiments. The young were 28 days old at the beginning of this experiment. A comparison of the growth-promoting value of the three different diets was determined by the general growth condition of these experimental animals over a seven-weeks period.

The boarding school diet ordinarily used in southern China consists of a fairly large amount of rice and a limited selection of various kinds of vegetables and meats. It is lacking in raw vegetables and fresh fruits; milk is consistently absent. The diet is noticeably deficient in many recognized food nutrients, such as complete protein, calcium, phosphorus, vitamin A, thiamine, and riboflavin. In this study, improvements were made on this diet in order to make it nutritionally adequate for growth.

In this improved Chinese boarding school diet formulated for this study, all the foods were selected in this country which were known to be available in China, or which could be duplicated in China by selecting the kinds from the same botanical family. The foods that were selected supplied adequate nutrients and variety for a day's meals. The nutritive value of this diet was calculated according to the table of Bowes and Church (7).

The improvements which were made in this diet are listed as the following:

1. A wider selection of vegetables and meats.
2. Addition of raw vegetables and fresh fruits to the diet in order to supply an additional amount of vitamins and minerals.
3. Addition of whole wheat as a supplement to the breakfast cereal.
4. Decrease in the amount of rice consumed daily.
5. Use of powdered milk to supply a source of complete protein and additional calcium and phosphorus for the growing child.
6. The diet was planned to meet the food requirements recommended by the National Research Council. (See data tabulated in table II and IV).

The computed food values and food compositions of this improved Chinese boarding school diet are shown in table II. It presents the total amount of foods which should be consumed by a 12-15 year old child for 6 days. A 6-days period was chosen because in Chinese boarding schools the children go home over Sundays. The menus of this improved diet are listed

in table I.

Because of the incidence of malnutrition among the majority of the Chinese school children, a commonly used Chinese rural diet was listed and analysed in order to evaluate and to compare the growth-promoting property of this diet with the newly formulated Chinese boarding school diet upon the growth condition of the experimental rats. This common rural diet of Chinese consisted of a large amount of rice. Vegetables are limited in both kinds and quantities, and only a very small amount of meat in the form of pork was used. The food values and food compositions of the Chinese rural diet are tabulated in table IV. The total amount of food included is the quantity normally consumed by a 12-15 year old child for 6 days in China.

In order to test the growth-promoting value of the Chinese boarding school diet and the Chinese rural diet, a well known control diet (Sherman's diet B) was selected. This diet produces normal growth in experimental rats; therefore, it served as a positive control in this experiment. Sherman's diet B seemed appropriate since it contained two food substances which appeared to be desirable for incorporation into the Chinese boarding school diet. These are whole wheat and powdered milk. Sherman's diet B (32) is composed of:

1/3 whole powdered milk

2/3 whole wheat

2 per cent of the weight of whole wheat added as salt

The whole wheat was finely ground in the laboratory. Commercially

produced whole powdered milk (Klim whole powdered milk) was purchased in a local store. Salt was added for taste and flavor.

All the food materials which were used in this study were purchased in Bozeman, Montana, retail stores. The foods selected from the local markets could be duplicated in the Chinese markets. Several kinds of vegetables such as water bamboo, bamboo shoot, Chinese cabbage, gourds, lettuce stem, mung bean and mustard root are not found in the local markets in Montana, but foods which belong to same botanical family as those grown in China were selected for use in this study to replace the above non-available kinds of vegetables. According to Cooper's report (9), 1947, and Read (26), 1946, on Shanghai foods, Chinese cabbage has substantially the same nutritive value as the cabbage grown in this country. Certain kinds of soy bean products which are commonly used in China but are not available in Montana were omitted. They are namely: soy bean curd, soy bean sprouts, soy bean curd sheet, soy bean cheese and soy bean clot milk. Instead of using these soy bean products, dried whole soy beans were used in these two tested Chinese diets.

The preparation and cooking were done in the laboratory of the Home Economics Department of Montana State College. Foods were prepared immediately on delivery. All the food preparation and cooking was done according to the Chinese cooking method as it is described below.

Rice was cooked in twice its volume of water. The rice was placed in cold or warm water and cooked until quite dry. It was cooked first at a high temperature until it reached the boiling stage and then a low tempera-

ture was applied. Rice gruel was cooked in the same way as the rice, but more water was used. This gruel is served as a breakfast cereal in the southern Chinese diet. Very often a small amount of sweet potatoes or ham is cooked with the gruel in order to give a better flavor and variety in the day's meals.

Vegetables were cut into $\frac{1}{4}$ inch cubes in order to facilitate the rat feeding purpose. It was fried with a small amount of vegetable oil, after which a small amount of water was added and the whole was steamed during the last few minutes of the cooking period. The green vegetables were not over-cooked and they retained their fresh green color. Turnips and carrots were cooked without removing the skins. Fresh vegetables and raw fruits were also cut into small pieces as described in the above.

Meats were chopped into pieces which were similar to those of the vegetables. They were fried and steamed with the various kinds of vegetables.

Since rats have a tendency to pick up certain foods from the diet and discard other large particles, all the foods which belonged to the same diet were mixed thoroughly and made into a homogeneous mixture in an electric mixer. The mixed foods were weighed and packed individually into small freezing containers of 210 grams per box, and stored in a deep freezer. Since it has been demonstrated by Diehl (11), 1945, that foods can remain in a deep freezer for from 6-12 months without altering their nutritive values, the foods used in this experiment were kept in the deep freezer and removed as needed throughout the 7 weeks experimental period.

Eighteen albino rats were supplied from the breeding colony of the Home Economics Research Department of the Montana Experimental Station. They were of known parentage and controlled nutritional background, highly satisfactory for use as experimental animals. The rats were all alike with respect to age, size and weight as it was possible to obtain. They were distributed evenly into three groups, each group consisting of three males and three females. The rats were placed in individual cages and fed one of the experimental diets at regular intervals throughout a seven weeks feeding period.

Fifteen minutes per day of ultra-violet light was given to the rats as a source of vitamin D in order to duplicate the condition in southern China where sunshine is always available.

The wasted food from each rat was weighed and kept separately, and was dried at normal room temperature in order to estimate the actual amount of food consumed by each animal. Records are tabulated in table V.

At the end of the seven weeks experimental period, the rats on the Chinese boarding school diet and the rats on Sherman's diet B were placed in the breeding colony. The rats which were receiving the Chinese rural diet had grown so poorly the author felt that perhaps some supplements might be added to improve their growth condition. Schweigert (30), 1949, and Coates (9), 1950, found that the Animal Protein Factor is essential for normal growth of rats and had suggested 30 mcg as the daily requirement. Since the Chinese rural diet was conspicuously deficient in protein, it was believed that the addition of Animal Protein Factor would be informa-

tive. Accordingly Animal Protein Factor in the quantity recommended (30 mcg daily) was added to the diet in the form of a concentrate produced by Charles Pfizer and Co., Inc., Brooklyn, New York. This supplement was fed to the rats on the rural Chinese diet for three weeks following the first seven weeks experimental period.

Since no significant improvement in growth rate was noted at the end of the above three weeks supplemental feeding, the diet was further supplemented by the addition of powdered whole milk. It was added in the amount equal to 20 per cent of the total average caloric intake of the consumed diet. The animals in this group were now receiving the supplements of Animal Protein Factor and powdered milk in addition to the original Chinese rural diet. This was continued for another three weeks, but there was still no increase in growth curve (see figure 3). This is explained in the result and discussion section of this article.

Protein analysis of the three tested diets were made by the grain laboratory of the Montana State College. The results are tabulated below the tables of the food values and food compositions of the various diets (see table II and IV).

The moisture determinations of the two tested Chinese diets were made according to the method recommended by the Association of Official Agricultural Chemists (3), 1945. The results are also given at the bottom of the tables of food values and food compositions of the different diets (table II and IV).

Observations of two Montana school lunch programs were made for the

second part of this study in order to find the features applicable to a Chinese boarding school. An observation form and tabulation of results is attached. This form was developed by the author for this study.

DISCUSSION OF RESULTS

A review of the following studies indicated that the method of food preparation and cooking effect the vitamin and mineral contents of the vegetables. Munsell (22), 1948, found that steaming and the use of less water during cooking prevented the loss of vitamins and minerals from vegetables. Peterson (25), 1925, stated that the loss of vitamins and minerals from vegetables is least when vegetables are steamed. A great loss of vitamins and minerals occurs when vegetables are boiled in an excessive amount of water. Berry (4), 1912, reported the losses from boiling spinach are about 50 per cent, the losses from boiling cabbage are about 30 per cent, and the losses from boiling carrots are about 15 per cent of the original contents. Noble and Worthington (23), 1948, found that cutting the vegetables into small pieces, such as coarsely shredded, cubed, and frenched, increased the loss of ascorbic acid. Oliver (24), 1941, stated that green vegetables should be boiled as quickly as possible and cooked at a shorter time, using a minimum amount of water to reduce the cooking losses.

It is indeed fortunate that the Chinese have cooked their vegetables in a particular way for many years by using a small amount of fat and water, and have cooked certain vegetables without removing the skins, thus

SCHOOL LUNCH PROGRAM OBSERVATIONS

		Schools I	Schools II
1.	The supervisor is a Home Economics teacher.....	no	yes
2.	Is the supervisor considered as a member of school staff.....	no	yes
3.	Type of menu used.....	Menu type A	
4.	Government subsidy.....	yes	yes
5.	Costs related to total budget		
	Food cost per year.....	57%	71%
	Labor cost per year.....	25%	20%
	Utility cost per year.....	18%	9%
	Unit cost per pupil per lunch.....	26¢	26¢
	Food cost per pupil per lunch.....	20¢	20¢
6.	Operation		
	Number of pupils in the school.....	560	280
	Number of pupils who go home for lunch daily.....	260	100
	Number of pupils who eat a complete lunch at school daily.....	300	180
	Number of teachers who eat a complete lunch at school daily.....	10	20
	The total food served is from 1/3 to 1/2 of the child's daily needs.....	yes	yes
7.	The school lunchrooms were inspected annually....	yes	yes
8.	Size and space of the kitchen varies in relation to the number of pupils served.....	yes	yes
	Size of kitchen in relation to the number of workers and number of students served.....	*1W/60S	1W/60S
9.	Kitchen equipment		
	Stoves.....	2 double ranges	4 single ranges
	Refrigerators.....	2	2
	Sinks.....	2	2
	Cooking utensils.....	sufficient	

*W = worker; S = student

preventing the loss of vitamins and minerals. Work done by Hsi Hsuan Yu (14), 1939, has confirmed the fact that this method of cooking used by the Chinese does conserve the nutrients in vegetables. Lowe's experimental work (20), 1949, showed that vegetables such as carrots, turnips and potatoes cooked with their skins on lose less minerals and vitamins than pared vegetables.

A six days' menu of the improved Chinese boarding school diet is listed in table I. Table II shows the food values and food compositions of the improved Chinese boarding school diet. Figures given represent the average amount for a child from 12-15 years of age for a period of six days. It is noted that various kinds of vegetables, fruits and meats were used. Raw vegetables and fresh fruits were used to supply a source of vitamins and minerals. The recommended daily allowance of ascorbic acid was provided by the addition of citrus fruit and raw tomatoes. A sufficient amount of vitamin A was contributed by green and yellow vegetables such as broccoli, carrots, green peas, green pepper, string beans, and spinach, which are good sources of vitamin A. In fact, these greens contain much more vitamin A in one serving than is needed for the total daily allowance.

Green vegetables are known as "protective foods." However, there are some important nutritional differences between certain kinds of greens. According to Wittwer's report (35), 1947, greens of the mustard family, such as mustard and turnip greens, have a much higher percentage of available calcium than those of the goose family greens such as spinach, swiss

Table I. The Improved Chinese Boarding School Menu for 6 Days.

Date	Breakfast	Lunch	Supper
Mon.	Boiled egg. Wheat gruel with sweet potato. Milk Sugar	Potato with beef. String beans. Raw carrots. Rice. Milk. Sugar.	Turnip with pork. Green peas. Green pepper with beef. Rice. Fresh apple.
Tues.	Rice gruel with ham. Milk. Sugar.	Soy beans. Broccoli with beef. Turnips. Rice. Milk. Sugar.	Beets. Liver with spinach. Raw tomato. Fresh orange. Rice.
Wed.	Cooked egg. Wheat gruel with sweet potato. Milk. Sugar.	Corn. Potato with beef. Cabbage with pork. Rice. Milk. Sugar.	Turnips with pork. Ham with celery. Rice. Peach.
Thurs.	Rice gruel with ham. Milk. Sugar.	Cauliflower. Onion with beef. Squash. Rice. Milk. Sugar.	String beans. Green pepper with pork. Cabbage. Rice. Fresh apple.
Fri.	Cooked egg. Wheat gruel with sweet potato. Milk. Sugar.	Peanuts. Broccoli with beef. Raw carrots. Rice. Milk. Sugar.	Fish, broiled. Cauliflower with pork. Raw tomato. Rice. Pear.
Sat.	Rice gruel with ham. Milk. Sugar.	Soy beans with veal. Cabbage. Raw cucumbers. Rice. Milk. Sugar.	Potatoes. Celery with beef. Green peas. Rice. Fresh orange.

Table II. Food Values and Food Compositions of the Improved Chinese Boarding School Diet for a Period of 6 Days.

Food	Weight gm.	Calories	Protein gm.	Calcium gm.	Iron gm.	Vitamin A I.U.	Thiamine mcg.	Riboflavin mcg.	Niacin mg.	Vitamin C mg.	Vitamin D I.U.
Rice, white	1500	5250	115	0.2	10	----	750	450	21	----	----
Rice for gruel	180	630	13.8	0.02	1.2	----	90	54	2.5	----	----
Wheat for gruel	360	1320	42.0	0.13	13.2	----	1620	468	16.5	----	----
Milk, powdered	340	1686	87.7	3.18	2.0	4740	1020	4964	2.3	20	----
Egg, cooked (3)	150	237	19.2	0.08	4.2	1710	156	483	0.15	----	135
Apple, fresh	200	128	0.6	0.01	0.6	180	80	40	0.40	10	----
Orange, fresh	200	100	1.8	0.06	0.8	380	160	60	0.40	98	----
Peach, canned (water pack)	100	30	0.5	0.01	0.4	450	10	20	0.70	4	----
Pear, canned (water pack)	100	35	0.3	0.01	0.2	----	10	20	0.10	2	----
Oil, peanut	390	3514	----	----	----	----	----	----	----	----	----
Beef, loin, cooked	339	993	57.3	0.03	8.5	----	339	440	15.59	----	----
Fish, white, cooked	113	169	25.8	0.03	1.5	----	102	102	4.75	----	----
Ham, cooked	226	655	47.9	0.03	6.3	----	2260	452	11.3	----	----
Liver, beef, cooked	113	235	26.60	0.02	7.6	14000	226	4068	17.86	----	22
Pork, cooked	283	839	62.6	0.05	9.6	----	2381	499	10.14	----	----
Veal, cooked	50	80	9.8	0.01	1.5	----	90	140	3.21	----	----
Sugar, white	60	280	----	----	----	----	----	----	----	----	----
Broccoli, cooked	226	83	7.4	0.29	2.9	7910	203	475	2.03	266	----
Beet, red, cooked	113	44	1.1	0.02	0.7	23	11	34	0.11	6	----
Carrots, raw	226	101	2.7	0.09	1.8	27120	158	135	1.13	14	----

Table II (continued)

Food	Weight	Calories	Protein	Calcium	Iron	Vitamin A	Thiamine	Riboflavin	Niacin	Vitamin C	Vitamin D
Celery, cooked	226	49	3.1	0.11	1.3	23	68	90	0.67	18	----
Cucumber, raw	113	18	0.9	0.01	0.5	----	46	103	0.23	9	----
Cabbage, cooked	339	98	4.7	0.16	1.7	271	237	203	1.0	176	----
Corn, cooked	113	122	4.1	0.01	0.6	220	169	158	1.58	14	----
Cauliflower, cooked	226	70	5.4	0.05	2.6	201	224	246	1.34	153	----
Onion, cooked	113	55	1.6	0.04	0.6	56	34	23	0.11	10	----
Peas, cooked	226	228	15.1	0.05	4.3	1536	813	406	4.7	58	----
Pepper, green, cooked	226	65	2.7	0.03	0.9	1423	158	90	0.9	271	----
Peanut, cooked	105	623	28	0.08	2.1	----	315	168	17	----	----
Potato, white, cooked	339	288	6.8	0.04	2.3	68	335	128	3.7	37	----
Sweet potato, cooked	226	282	4.1	0.08	1.6	11300	226	136	1.6	50	----
String beans, cooked	226	94	5.4	0.14	2.5	1423	180	226	1.4	20	----
Soy bean, dried, cooked	226	787	78.8	0.51	18.0	247	2565	697	4.7	----	----
Spinach, cooked	113	28	2.6	++++	3.4	10644	135	271	0.8	67	----
Squash, cooked	113	21	0.7	0.02	0.5	293	45	56	1.2	19	----
Turnips, green	339	118	3.7	0.12	1.01	----	118	172	1.01	54	----
Tomato, raw	200	46	2.0	0.02	1.2	2200	120	80	1.2	46	----
Total	8851	19401	691.8	5.73	118.1	86418	15454	16157	153.31	1422	157
Daily Average	1475	3234	115.3	0.955	19.7	14403	+ 2576 (2.58 mg)	+ 2693 (2.69 mg)	25.6	237	26
National Research Council recommendation for boys and girls of 12-15 yrs.		2600-3200	80-85	1.3-1.4	15	5000	1.3-1.4 mg	2.0 mg	13-15	80-90	----

+ 1 mcg equals 1/1000 mg. These changes are made in order to be able to compare the value with the National Research Council's recommendation.
++ Protein analysis of this diet - 16.3%
+++ Moisture content of this diet - 68.4%
++++ Calcium is present but not available.

chard, and beet greens. The differences are due to the oxalic acid content in the goose family greens. Oxalic acid combines with the dietary calcium, and the latter is excreted as an insoluble calcium salt. For this reason, care was taken not to include too many goose family greens in the tested diets. On the other hand, these foods have not been entirely excluded because they contain a high percentage of vitamin A and iron.

Meats of different kinds are included in the Chinese boarding school diet in order to help to provide the most commonly deficient constituents thiamine, riboflavin, niacin and protein. The dietary iron is derived from egg, liver, meat and vegetables in the diet under consideration.

Milk and soy bean helped to supply protein, calcium, phosphorus, iron, thiamine, riboflavin and niacin. Cooper (9), 1947, reported that dry soy beans contain 35 per cent protein, 0.23 per cent calcium, and 0.59 per cent phosphorus. Kennedy (17), 1941, in a study of the relative economy of nutrients in a serving of some commonly used foods, found that milk is a rich and cheap source of calcium and phosphorus. Both milk and egg are good sources of "complete proteins," essential to growth and life (31). Richard's report (27), 1947, indicated that a small addition of milk or milk products improved the nutritive value of an average diet. Powdered milk was used in this study because it is more available in China than fresh milk.

A substantial amount of thiamine, riboflavin and niacin were furnished by whole wheat grain as served in a breakfast cereal, gruel form. Rice not only provides calories and bulk but when it is consumed as a main cereal

in China, it is also a fair source of thiamine, riboflavin, niacin and iron.

Table III shows the menus for six days. Table IV shows the food values and food compositions of the Chinese rural diet. A significantly low amount of protein, calcium, phosphorus and iron is noticed. This results from the limited use of the various kinds and amounts of meat, vegetable, milk and eggs. A low intake of thiamine, riboflavin and niacin is also indicated due to the use of rice as the main cereal in the diet. A low vitamin A and ascorbic acid intake is brought about by the limited selection of vegetables, and the lack of raw vegetables and fresh fruits in the diet. The deficiencies in this diet indicate that a diet can not be made complete and satisfactory unless a variety of foods is used.

Figure 1 shows the general physical condition of the rats fed the different diets. The rats fed the Chinese boarding school diet and those fed Sherman's diet B have grown strong, big, and appear normal. However, rats fed the Chinese rural diet were weak and small but no physical deformity was noticed.

Figure 2 shows that the growth rate of the rats on the Chinese boarding school diet is similar to that of the rats receiving Sherman's diet B throughout the seven weeks of the experimental period. The rats which were fed the Chinese boarding school diet made an average gain of 131 grams in seven weeks compared to 132 grams for those fed the Sherman's diet B. The rats fed the Chinese rural diet acted nervous and irritable. They disliked the food which was given to them every day. About 1/3 of the food

Table III. The Chinese Rural Diet Menus for 6 Days.

Date	Breakfast	Lunch	Supper
Mon.	Cabbage. Rice.	Cabbage. String beans. Rice.	Turnips. String Beans. Rice.
Tues.	String beans. Rice.	Turnips. Squash. Rice.	Turnips. Squash. Rice.
Wed.	Soy beans. Rice.	Potato. Cabbage. Rice.	Potato. Cabbage. Rice.
Thurs.	Cabbage. Rice.	Turnips. String beans. Rice.	Turnips. String beans. Rice.
Fri.	Potato. Rice.	Cabbage. Beets. Rice.	Cabbage. Potato. Rice.
Sat.	Turnips. Rice.	Squash. Turnips. Rice.	Squash. Soy beans with pork. Rice.

Table IV. Food Values and Food Compositions of the Chinese Rural Diet for a Period of 6 Days.

Food	Weight gm.	Calories	Protein gm.	Calcium gm.	Iron mg.	Vitamin A I.U.	Thiamine meg.	Riboflavin meg.	Niacin mg.	Vitamin C mg.	Vitamin D I.U.
Rice, white	3000	10500	230	0.3	20		1500	900	42	----	----
Oil, peanut	233	2079	----	----	----	----	----	----	----	----	----
Pork, cooked	113	323	24.1	0.02	3.7	----	916	192	3.9	----	----
Cabbage, cooked	792	71	11.2	0.36	3.6	634	544	475	2.4	411	----
Beet, red, cooked	113	44	1.1	0.02	0.7	23	11	34	0.11	6	----
Potato, white, cooked	452	384	9.0	0.05	3.2	90	447	172	4.5	49	----
Squash, cooked	452	85	2.7	0.07	1.8	1175	180	226	4.5	76	----
Soy beans, dried, cooked	226	787	78.8	0.51	18.0	247	2565	697	4.7	----	----
String bean, cooked	565	237	13.6	0.37	5.6	3559	452	565	3.4	107	----
Turnips, white, cooked	792	277	7.9	0.27	2.4	----	277	403	2.4	128	----
Total	6738	14787	378.4	1.97	59.0	5728	6892	3664	67.9	777	----
Daily Average	1123	2465	63.1	0.33	9.8	955	+ 1148 (1.15 mg)	+ 611 (0.6 mg)	11.3	129	----
National Research Council recommendation for boys and girls, 12-15 yrs.		2600-3200	80-85	1.3-1.4	15	5000	1.3-1.5	2.0	13-15	80-90	----

+ 1 mcg equals 1/1000 mg. These changes are made in order to compare the value with the National Research Council's recommendation.

++ Protein analysis of this diet - 8.9%.

+++ Moisture content of this diet - 66.4%.

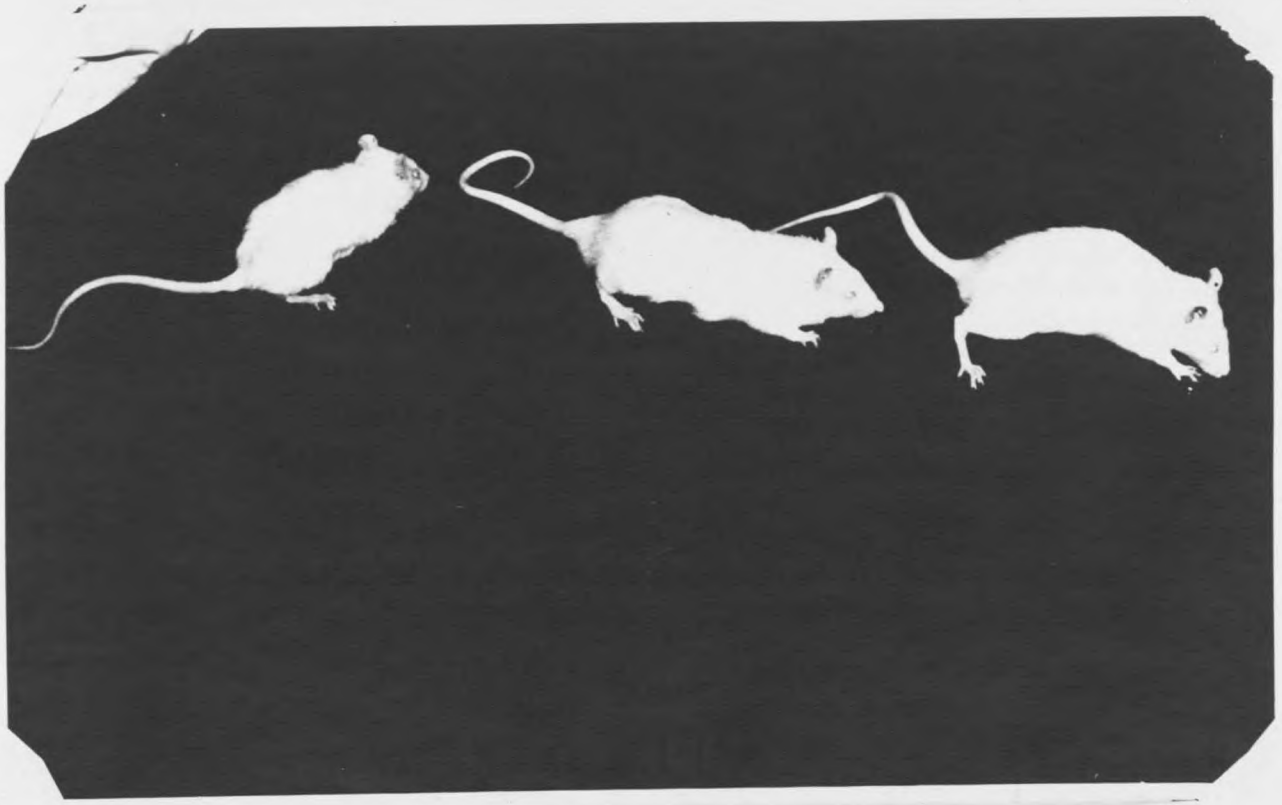

Figure 1. General physical condition of three groups of rats fed with; Chinese rural diet, Chinese boarding school diet, and Sherman's diet B, as they appear from left to right in the picture.

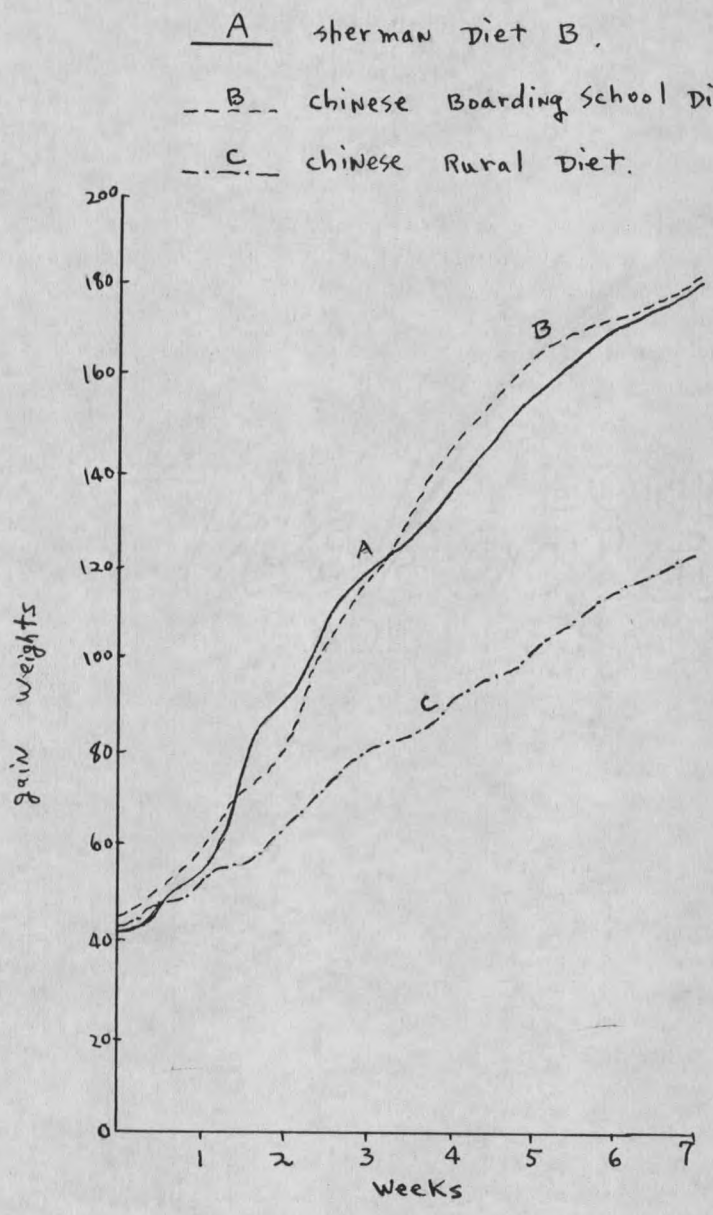

Figure 2. Average growth rate of three groups of rats over a seven weeks experimental period receiving; A- Sherman's diet B, B- Chinese boarding school diet, C- Chinese rural diet.

was wasted. The growth rate in figure 2 shows that the rats on this Chinese rural diet gained only 74 grams through the seven weeks experimental period. This gain is about 1/2 of the weights gained by the other two groups of rats in the same length of time. The more detailed explanation is listed in table V.

In table V is listed the individual records of each rat which was used in this experiment. The table shows the initial weight of the rats at the beginning of the experimental period, the food consumed by each rat, the final weight at the end of the seven weeks experimental period, the average gain in weight of each rat, and the average gain in weight per gram of food consumed by each rat. The food consumed is reported on "dry" basis so that a comparison can be made between the three tested diets. The average gain per gram of food consumed was 0.291 gram for the group of rats on Sherman's diet B, 0.323 gram for the rats on the Chinese boarding school diet, and 0.186 gram for the rats receiving the Chinese rural diet.

The average food consumed by each group was calculated on the dry basis. The average food consumed for the rats on Sherman's diet B was 450.6 grams, compared with 404.3 grams for the rats on the Chinese boarding school diet and 374.8 grams for the rats on the Chinese rural diet. This clearly indicates that the rats on the Chinese boarding school diet consumed approximately 10 per cent less than the rats on Sherman's diet B but they showed substantially the same average gain in body weight. Thus it is assumed that there was more efficient utilization of the food ingested by the rats on the Chinese boarding school diet than by the rats on

Table V. Individual Growth Records of Rats Fed with Three Tested Diets.

Rats	Sex	Average Body Weight (gm.) Initial	Final	Gain	Deviation	Food Consumption (gm.) Food Wasted	Food Consumed	Gain/gm. of Body Weight
Group I, on Sherman's diet B.								
No. 1	female	45	172	127	- 5	0	423	0.300
No. 2	"	40	149	109	-23	0	431	0.253
No. 3	"	41	148	107	+25	0	435	0.246
No. 4	male	43	188	145	+13	0	423	0.342
No. 5	"	44	216	172	+40	0	517	0.332
No. 6	"	41	170	129	- 3	0	475	0.271
Average		42	174	132		0	450.6	0.291
Group II, on Chinese Boarding School Diet.								
No. 7	female	44	144	100	-31	159	332	0.304
No. 8	"	44	175	131	0	73	418	0.313
No. 9	"	44	174	130	- 1	62	429	0.303
No. 10	male	46	162	116	-15	107	384	0.302
No. 11	"	42	187	145	+13	76	415	0.349
No. 12	"	45	209	164	+33	43	448	0.366
Average		44	175	131		86.6	404.3	0.323
Group III, on Chinese Rural Diet.								
No. 13	female	43	113	70	- 4	160	362	0.192
No. 14	"	45	117	72	- 2	164	358	0.201
No. 15	"	42	103	61	-13	153	369	0.166
No. 16	male	45	135	90	+16	76	446	0.201
No. 17	"	47	127	80	+ 6	144	378	0.211
No. 18	"	45	114	69	- 5	186	336	0.145
Average		45	119	74		147.1	374.8	0.186

the Chinese boarding school diet than by the rats on Sherman's diet B. It should be remembered that the Chinese boarding school diet and the Chinese rural diet were cooked, and the Sherman's diet B was raw, uncooked. It is probable that cooking increased the digestibility of the foods. Evidence was observed to substantiate this view during the experimental period, for the feces of the rats on the Sherman's diet B obviously showed a yellow color instead of the normal black color. The former indicates the presence of undigested foods.

Since the rats which were fed the Chinese rural diet were supplemented with Animal Protein Factor and powdered milk, increased growth rate over that which was obtained on the Chinese rural diet was expected according to Coates (9), 1950, and Schweiger (30), 1949. It was surprising to find that there was no increase in the growth rate of these rats after six weeks of supplemental feeding (see figure 3). This may be due to the fact that these rats had evidently passed their active growing period corresponding to adolescence in children; therefore, no conclusion can be drawn from these supplemental feedings. According to Johnston (16), 1949, and Stuart (34), 1949, growth in all dimensions begins to accelerate and continues to a maximum peak of gain during the adolescent period of both boys and girls, and is followed by a marked reduction in rate of growth. Since the growth rate during adolescence is at a maximum therefore, the food requirements should be furnished at a maximum during that time.

Protein analysis of the three tested diets were made by the grain laboratory of the Montana State College. The results showed that the

__A__ chinese Rural Diet + animal protien Factor.

_.B._ chinese Rural Diet + animal protien Factor + powdered milk.

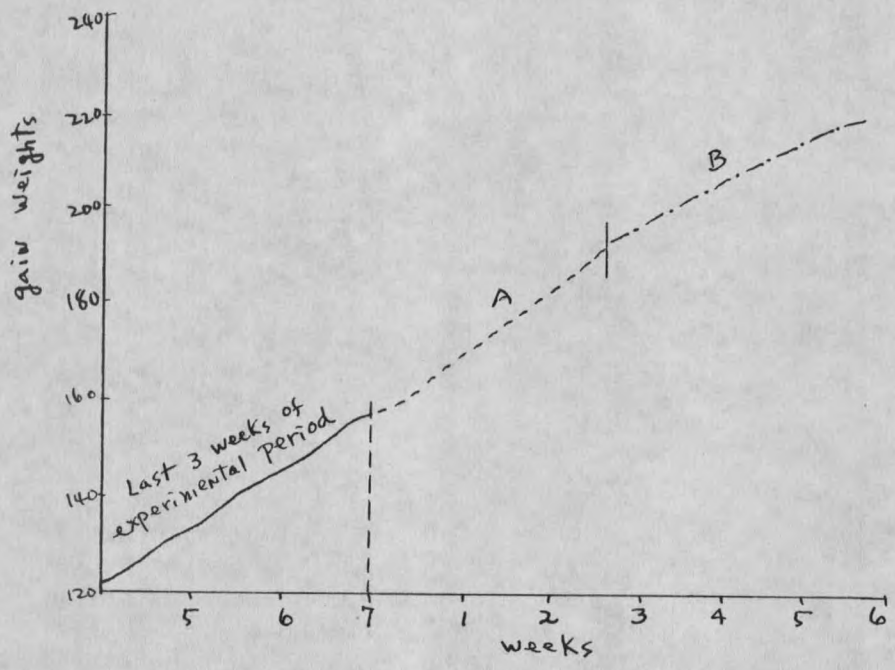

Figure 3. Average growth rate of rats receiving Chinese rural diet and supplemented with; A- animal protein factor, B- animal protein factor plus powdered milk.

Sherman's diet B contained 16.4 per cent protein, the Chinese boarding school diet contained 16.3 per cent protein, and the Chinese rural diet contained only 8.9 per cent protein.

Moisture contents were determined for the two tested Chinese diets. The Chinese boarding school diet consisted of less rice and an increased amount of fresh fruits and raw vegetables; it showed a moisture content of 68.4 per cent. The Chinese rural diet containing more rice and less amount of vegetables had a moisture content of 66.4 per cent.

The above study has demonstrated that the diet formulated for a Chinese boarding school is adequate for the growth of young rats and is therefore presumably adequate for the growth of human beings. In China, a student attending a boarding school will remain in the school for six days of each week and take all the meals at the school during that time. In America, students normally attend the public school for five days of each week and receive only one meal at the school. It is supplied by the school lunch program.

In view of Abbott et al's work (2) on the effectiveness of the school lunch in improving the nutritional status of rural school children, it was believed that a study of the equipment and methods used in America would be helpful in conducting the meal service in a Chinese boarding school.

THE SCHOOL LUNCH PROGRAM

Today the school lunch program has become a focal point for the development of good health habits in many American schools but the

emphasized objectives are different in various schools. In reviewing the two school lunch programs which have been observed, one of them received a certain amount of supervision from the home economics teacher in the school, while the other did not. The first emphasized the idea of fitting the school cafeteria into the educational scheme; the latter neglected to consider the school lunch program as a medium of education.

According to the report from the United States Department of Education (33), 1947, the important objectives and values of a school lunch program are as follows:

1. To serve the food needed by the children in an appetizing manner and in such a way to preserve the greatest possible amount of food value.
2. To teach the children to eat the foods which they need.
3. To serve foods needed by children for proper physical and mental development.
4. To improve the general health of school children and youth.
5. To develop desirable food habits.
6. To develop an appreciation and understanding of the type of foods necessary to meet the nutritional needs of children, youth, and adults.
7. To develop an appreciation of the importance of cleanliness in selecting, storing, preparing, and serving of foods.

8. To provide a pleasant social atmosphere where simple table etiquette is practiced.

It was observed that the menus served in these two school lunch programs belong to the school lunch menu type A, which is a complete lunch. It furnishes 1/3 to 1/2 of the day's total nutritive requirements. It consists of one serving of meat or meat substitutes, one serving of vegetable, bread, butter, milk or chocolate milk, and a simple dessert. Menus used in these school cafeterias are planned by the home economics teacher or by the school lunch manager. They are planned one week in advance of the delivery of foods and supplies. Menus are checked by the Federal school lunch program committee.

The school lunch programs which have been observed are receiving aid from the Federal Government. This Federal aid consists of 6 cents per pupil per meal plus a certain amount of surplus canned, dried, and processed foods.

In these two school lunch programs, the school lunch budget was divided into: 57-71 per cent for foods, 20-25 per cent for labor, and 9-18 per cent for utilities.

Lunchrooms observed are connected with the kitchens or located adjacent to the kitchens. They are decorated in various ways; one of them used the educational posters, the other used attractive and colorful pictures. The size of the lunchrooms are proportional to the number of students served.

After observing the floor space provided and the arrangement of equip-

ment in the two school lunch programs, and consulting the recommendation of the United States Department of Agriculture, School Lunch Division, on the subject (21), a floor plan for a school lunchroom with indicated basic equipments was designed for use in China (figure 4).

The plan assumes that an average classroom would be converted to this usage. This average classroom is 22'0" by 37'6". It is divided into a 9'0" by 22'0" space for kitchen and storage room and a 22'0" by 28'6" space for the use of serving and dining.

According to the report from the United States Department of Agriculture, Division of School Lunch Program, by Morris (21), 1946, it is recommended that a 10 to 15 square feet space is required for each child. The above space therefore is sufficient for 42 to 62 students. However, it is believed that a greater number could be served in this lunchroom in China because the food served in China is simpler than American foods, and it requires a smaller space for serving.

In this floor plan in figure 4, the entrance is planned to be near the serving counter, and the exit is placed to be convenient to the soiled dish table and the washing sinks. At the food service area, all the activities which are related to the food preparation are concentrated in one location in order to gain satisfactory results. In order to have the food served hot, the counter is located and arranged for the convenience to workers in the kitchen and to students coming to the lunchroom. In a small kitchen like the one in this plan, no steam or hot units are necessary because all the plates are dished up directly from the range which is placed near one