THE CALORIC AND PROTEIN VALUES OF SOME COMMONLY EATEN FOOD MIXTURES AS DETERMINED BY DIRECT ANALYSIS

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THESIS

This is to certify that the

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AS
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By

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I. INTRODUCTION

Endeavors throughout time have been directed toward improving man's life situation in relation to health. Man has attempted to find the best environmental conditions in which to live, and in order to do that he has attempted to uncover the facts about the composition of the material things of which his surroundings are composed. He attempts to supply the body with what it required through the proper use of food. And, it has been important to ascertain the composition of the human body in order to help determine its requirements. Only through the knowledge of the composition of the foods consumed by humans can the nutritionist, the dietitian, those in the medical profession, the welfare worker, and the teacher instruct others in choosing the foods which will encourage optimal nutritional status for individuals as well as for populations.

A.

For this reason, food composition has been studied by many persons. During the first half of the nineteenth century work in the field of food analysis was sporadic. Later in the century, Liebig's development of knowledge and methods of organic chemistry made it possible for more systematic investigations of the composition of food materials. In 1872, when Atwater returned from study of agricultural scientific advancement in Germany, he was convinced that the people of the United States had a need for more information about food composition. The available tables had been compiled for foods consumed by Germans, and they were not applicable in many instances to foods consumed in America. And so, it was through Atwater's efforts that the first extensive compilation of American foods was prepared. This work was published by the United States Department of Agriculture as Office of Experiment Stations Bulletin 28 under the title, "The Chemical Composition of American Food Materials". Although the 4,000 analyses of American food materials included in this table proved to be extremely useful to professional people in the fields of nutrition and medicine, Atwater realized that these tables would have to be revised at some future date. He states this in the first publication and the 1899 revision of the U. S. D. A. Bulletin 28:

> This table is intended to replace previous ones, and to serve as a standard for reference until it shall, in its turn, be replaced by a larger and more complete compilation.

Additional analyses continued to be made on foods which Atwater had not included. Through the efforts of Chatfield and Adams the "Proximate Composition of American Food Materials" was published as U. S. D. A. Circular No. 549 in 1940. This table contained some of Atwater's results as well as the results of many other investigations in an attempt to provide a more complete table to supplant Atwater's Bulletin 28. Advancement in research concerning vitamin and mineral values provided more information about the composition of foods which we find incorporated in a newer food table, the U. S. D. A. Miscellaneous Publication No. 572, "Tables of Food Values in Terms of Eleven Nutrients".

Almost all of the workers in this field since Atwater included the figures from his analyses in their tables. However, for convenience the information was presented in several different ways. For example, some authors expressed nutritive values per pound, others, per gram of each food product. Comparison of the value of foods with recommended allowances was developed into a share system of food values by Mary Swartz Rose.

B.

In our society today, we have become accustomed to cafeterias, diners, and places where "short orders" are served. At these places food mixtures are sold and many of them have become a part of the normal diet and are accepted as standard items. With the ever increasing number of persons eating all their meals, or at least one meal of the day, "out" because of the business stress of today's society, there is a need to know the common restaurant practice for the preparation of these items. As this situation developed over the years, it became increasingly apparent that the nutritive values for food mixtures were desirable for convenience in calculating diets of today. In some food tables the authors have used a recipe method, in which the value of each ingredient was known and the total value of the ingredients was taken as the nutritive value of the food mixture. Ellen H. Richards was among the first workers to set up a table of food values for food mixtures calculated from recipes.

Benedict and Farr working at the New Hampshire Agricultural Experiment Station analyzed some food mixtures commonly eaten in a college community. Food mixtures such as sandwiches, cookies, candy bars, many flavors of ice cream, and pies of various kinds were analyzed for energy value and protein content. The results of this work were published in 1929. Although this work is quite complete in its coverage of foods eaten by the students, some popular items were not included. A hamburger on a bun, a malted milk are common items today which were not among the foods analyzed by Benedict and Farr.

It was the purpose of this study to determine the energy value and protein content of certain popular food mixtures as served to patrons in the cafeterias and drugstores in a college community. This study is limited to laboratory analyses of commercial servings of foods for which there is little information in the literature: a hamburger on a bun, a malted milk, and a bowl of chili con carne.

II. REVIEW OF LITERATURE

Until 1896 tables of food values were concerned with foods consumed by Europeans, particularly Germans, for the work up until that time had been done in European and German laboratories. In America we had no such tables for American foods and we were forced to rely upon such works as those compilations of food materials generally consumed by the Germans. Atwater, having seen the workings of the German organization for scientific study of German agriculture, became increasingly interested in developing agricultural science in the United States, particularly in the field of food composition.

One of the beneficial outcomes of Atwater's endeavors was Bulletin 28. This bulletin was comprised of many investigations carried on both at the Storrs, Connecticut Agricultural Experiment Station and at other laboratories and experiment stations in the country. It included compilations of analyses made by Professor Atwater and his associates, by the Division of Chemistry of the U. S. D. A., and by other investigations and miscellaneous sources. It was from collating all this scattered information that the results of 4,000 analyses were recorded in tabular form to make up the "Chemical Composition of American Food Materials".

The figures recorded for the nutritive values of foods cannot be taken as accurate, indisputable facts. In bulletin 28, the maximum and minimum values of the composition of American food materials were recorded as well as the average values. Atwater and his co-workers had collected more than one value for almost all of the foods included in the tables. However, little mention was made in subsequent tables of the maximum and minimum values. There were differences in the values obtained because each food as it is grown has inherent differences from another supposedly just like it, and also, because the accuracy of the figures as recorded are dependent upon man's technical skill used in making the analyses.

Little additional work was done to improve upon or increase the information grouped together by Atwater. However, as investigations in vitamin and mineral content of foods increased, some of the results were tabulated and added to the information provided in Bulletin 28.

For additional information concerning the proximate principles Chatfield and McLaughlin (1928) and Chatfield and Adams (1931) compiled original data on the proximate composition of fruits and vegetables which were tabulated into new summary tables. In 1940 a similar table for all foods was published and this work, "Proximate Composition of American Food Materials", by Chatfield and Adams, included the information in the tables by Chatfield which were just mentioned.

The table most recent in development, as far as expansion and revision of Atwater's data is concerned, is the U. S. D. A. Misc. Publ. No. 572, "Tables of Food Composition in Terms of Eleven Nutrients". It includes not only the proximate principles, but also vitamin and mineral values for food materials. Elvehjem (1946) has recorded a brief history of the evolution of this table. He states that in 1942 the Food and Nutrition Board was requested by the Office of the Quartermaster General to establish a committee to "assemble, coordinate, and appraise data on food composition for the War Department". A committee on Food Composition undertook the first problem of compiling a table listing the proximate, mineral, and vitamin values of some 250 foods, and hence, made use of information "... from data reported in the literature and in part from unpublished data made available through many sources"... (U. S. D. A., Misc. Publ., No. 572). Information adding to current knowledge was provided "... from the research of the State agricultural experiment stations and from Federal, commercial, and other laboratories that have carried out analyses through special arrangements with the National Research Council" (U. S. D. A., Misc. Publ. No. 572). This table is relatively complete, but it contains few cooked foods or food mixtures.

Since the publication of Bulletin 28, many tables of food composition have been published and are in use. There are tables by:

Richards - The Dietary Computer

Locke - Food Values

Rose - A Laboratory Handbook for Dietetics

Bowes and Church - Food Values of Portions Commonly Used

Bridges - Food and Beverage Analysis

Taylor - Food Values in Shares and Weights

Bradley - Tables of Food Values

Donelson & Leichsenring - Food Composition Table for Short Method of Dietary Analysis

Boyd, Eads, Sandstead - Food Value Tables for Calculation of Diet Records

and also tables found in the Appendices of textbooks on foods and nutrition by such authors as Bogert, Pattee, Rose, and Sherman.

These tables either in part or in entirety are dependent upon values from the following three compilations of original data:

Atwater - Chemical Composition of American Food Materials, U. S. D. A., O. E. S., Bulletin 28, 1896 (Rev. 1899 and 1906)

Chatfield and Adams - Proximate Composition of American Food Materials, U. S. D. A. Circular No. 549, June 1940.

Bureau of Human Nutrition and Home Economics - Tables of Food Composition in Terms of Eleven Nutrients - U. S. D. A. Misc. Publ. No. 572.

From these listings it can be seen that a very few compilations of original data are the references and standards for many tables of food values used for general public and professional use.

The tables mentioned above are mainly concerned with single foods or food mixtures whose values have been calculated from the ingredients. Direct analyses of food mixtures have been made by few investigators.

McCance and Widdowson (1940) working at the University of Cambridge determined food values for British foods. Food mixtures were considered. The recipes for the various dishes were chosen, the ingredients were weighed and mixed together according to the directions. These mixtures were weighed before cooking, and then again when they were ready for consumption. Instead of analysing these prepared mixtures, the food values were calculated from the composition of the listed ingredients and the change in weight in cooking. Only the fried foods were analysed.

Benedict and Farr (1929) in this country conducted research over a period of two years to secure data regarding the energy and the protein value (1) of several individual foods, such as breads, pastry, soups, sandwiches, salads, desserts, ice creams, and candies; (2) of the total meal -

breakfast, dinner, and supper; and (3) of the total food consumed per day by an individual. These workers chose to take their samples from three types of eating places; the commercial restaurant, the college cafeteria, and the drugstore. They referred to the foods such as candies and ice creams as "extra foods". The authors felt that the use of these co-called "extra foods" was widespread in this country, and that their results were representative of the energy values of many of the present-day, somewhat standardized food mixtures.

Fuel value is one of the measures made of foods. It is referred to as heat of combustion, energy, or caloric value of foods. Calorimetry is used and it has been defined as "the theory and practice of making measurements of quantities of heat" (Worthing, 1948). The unit of measure is the large calorie, which is the amount of heat required to raise one kilogram of pure water one degree centigrade when the pressure is one atmosphere, and temperature 15° C.

Caloric values for food materials are obtained through the use of two types of equipment, the oxy-calorimeter and the bomb calorimeter. The latter instrument is used in obtaining the physical caloric values of foods and constituents of foods. The physical caloric values of the constituents (protein, fat, and carbohydrate) were the basis of both Rubner's and Atwater's calculations for the physiological fuel value of foods.

Rubner's "standard values" have been widely used throughout the world in determining the average fuel value of a mixed diet. He reasoned that the heat value of one gram of protein would be 4.1 calories in such a diet. This figure is an average of the physiological caloric values for the calculated protein content of a mixed diet as follows: casein, 4.4, organic substances of meat, 4.233, and vegetable proteins, 3.96. For the heat value of fat in a mixed diet Rubner considered 9.3 calories per gram to be correct. He reckoned this from an average of Stohmann's caloric values for olive oil (9.384 cal./gm.), animal fat (9.372 cal./gm.), and butter fat (9.179 cal./gm.). Heat values had been determined by Stohmann and Rubner for various carbohydrates (dextrose, milk sugar, cane sugar, and starch). Rubner felt that starch was of predominant importance in the average diet, and, therefore, he assigned the value of 4.1 to carbohydrate heat value in foods. (Lusk, 1909). These values are best used if applied to a mixed diet. (Maynard, 1944).

The "Atwater System", on which all studies made in the United States since 1900 were based (Morey, 1936 - 37), involves consideration of losses in digestion. Atwater (1895) also felt that we should consider the physiological value of the diet rather than the physical. From 185 dietary studies made on different peoples in different areas of the United

States, Atwater summarized the data and classified the foods consumed into various groups. For each group, such as dairy products, cereals, legumes, etc., he calculated the percentage of protein, fat, and carbohydrate. The average figures obtained"... were taken to represent the relative proportions of total food and total nutrients supplied by the different food groups in the 'average diet'." (Maynard, 1944). He next determined the heats of combustion of various proteins, fats, and carbohydrates. From these data he averaged the values for the different groups and found the following findings:

Of Total Food	Heat of Combustion per gram
Protein	5.65
Fat	9.40
Carbohydrate	4.15

From the summarized data of 97 digestion experiments with mixed diets and of others with single foodstuffs, Atwater arrived "at the average coefficients of availability (digestibility) for the nutrients of the different food groups and for the average mixed diet, ...". (Maynard, 1944). The figures were listed as the Proportion of Total Nutrient Actually Available: protein, 92; fats, 95; and carbohydrates 97,(Storrs, Connecticut Agri. Exper. Sta., 1899). The product of the latter figures and the respective heats of combustion per gram gives the total energy available per gram of nutrient. In the case of protein, Atwater found 1.25 calories per gram of protein was lost in urea and, therefore, should be subtracted from the product. Atwater finally "... arrived at the overall [caloric] values we now use, namely: protein 4, fat 9 (rounded off from 8.9) and carbohydrates 4" (Maynard, 1944).

Maynard (1944) makes a noteworthy statement in regard to the use of the Atwater system:

> It should be noted that the Atwater factors, 4-9-4, as arrived at by the procedure indicated in the table, apply stricly only to the diets in which the kinds and proportions of foods are similar to those of his averaged mixed diet.

Also issuing this same precaution was the FAO Committee on Caloric Conversion Factors and Food Composition Tables who, in 1947, said they could find no evidence that Atwater's data, properly used, were not reliable. Merrill and Watts (1948) discussed the use of this system in their paper on the "Physiologic Energy Value of Wheat".

In reviewing the methods used to obtain energy values, mention was made above of the oxy-calorimeter and the bomb calorimeter. Benedict (1929) was one of the more important workers using the former piece of equipment. He believed the use of it was a "simple technique" than making chemical analyses of foods, or operating a bomb calorimeter.

Morey (1936 - 37) in referring to work done by Benedict, points out that the values obtained by him with the oxy-calorimeter, were very similar to those which might be obtained if Rubner's factors had been used, since the oxygen used in the calculation has already been corrected for physiological losses.

The bomb calorimeter is another instrument long in use for energy value determinations. Concerning the use of it, Sherman (1944) says: "As the result of years of most painstaking research it was found: ... that with the bomb calorimeter the energy or fuel values of foods can be measured with great precision;...". Since the bomb is considered accurate, it seems to be one of the best pieces of eqiupment to use in determining the fuel value of single foods and food mixtures.

All protein values found in food composition tables to date are calculated from the nitrogen content of food, which has been determined through the use of some variation of the Kjeldahl method. Atkinson in 1893 refers to "... the principal nutrients - nitrogen, starch, and fat-", which seems to be a more accurate way of referring to the composition of food materials, in respect to protein at least. The nitrogen content is determined by analysis, whereas, the protein value is calculated by applying a factor to the nitrogen value.

The need for accurate protein conversion factors has been recognized for many years. Atwater used the factor 6.25 in obtaining the protein value of almost all the foods included in his food composition table. In the Twelfth Annual Report of the Storrs, Connecticut Agricultural Experiment Station, Atwater makes it clear that there are varying percentages of nitrogen in certain proteins. However, he believed that the factor 6.25 covered all common animal foods, including milk.

This way of calculating protein values depends on two assumptions, neither of which are wholly correct. One is that all nitrogen in food materials is in the form of protein nitrogen. There are some nitrogenous substances in food materials which are not proteins, nor related to proteins. The second fallacious assumption is that all proteins contain 16 percent nitrogen. The proteins of cereal grains and milk have been found to contain different percentages of nitrogen than the proteins of meat and eggs. Wheat flour, for example, is made from the endosperm of the wheat kernel. It is used in the making of bread and rolls. The principal proteins of the endosperm are gliadin and glutenin. Gliadin contains 17.6 percent nitrogen, and glutenin, 17.5 percent nitrogen. For an average we find the endosperm protein contains 17.55 percent nitrogen which gives the factor 5.7 ($100 \div 17.55 = 5.698$ or 5.7). Most of the proteins isolated from meat and eggs contain 16 percent nitrogen, so that the factor 6.25 seems to be reasonable for calculating the protein content of foods of animal tissue. The factor 6.38 for calculating the protein content of milk has been in general use for some time. The principal proteins of milk are casein and lactalbumin and an average of the percent nitrogen in each of these two proteins is 15.65 percent producing the factor 6.38.(Jones, 1941).

The use of these factors for their respective foods should yield more accurate results in calculating the protein content of these foods than the all-inclusive use of 6.25. However, even though these factors help give us more accurate results than an indiscriminate use of 6.25, they are not perfect factors because available data are not sufficiently complete to formulate such factors.

Up to this point there has been discussion of the methods used in obtaining caloric and protein values in the food composition tables. It has been seen that there are certain limitations in accuracy placed on all figures recorded in the tables. These limitations hinge on man's technical skill and interpretation of data.

The foods we accept as common foods of our day and which are included in this investigation are a hamburger on a bun, a malted milk, and chili con carne. The first mention of any of these foods that we find in the food tables is in 1917. At this time Locke published his book of Food Values and among those listed is included malted milk whose nutritive value as listed was obtained by totaling the value of the ingredients. The next mention of any of these foods is of hamburg steak listed as "beef, broiled" in Rose's Laboratory Handbook for Dietetics, 1929. Bridges lists chili con carne in his "Table of Nutritive and Caloric Value of Foods" published in 1935. The value of this food product also was calculated from its ingredients, but the recipe was not included in the reference. In 1942 two tables were published. One by Bradley which included values for chocolate malted milk, chili con carne, and hamburger, and one by Taylor which included chocolate malted milk and hamburger, whose values were calculated from the ingredients of the recipe. Bowes and Church, in 1944, published their Food Values of Portions Commonly Used which included values for "chocolate malted milk shake". The latest table, published in 1947, by Boyd, Eads, and Sandstead included nutritive values, calculated from ingredients, for all three food mixtures: malted milk, hamburger on bun, and chili con carne. It is not known from the information printed in these tables how many recipes were used in obtaining the nutritive values. In some cases the ingredients of the recipes used to obtain the food values are not published with the tables although they may be readily available on request.

The recipes, which were printed with the tables, are as follows:

For Locke's figures: Malted Milk

1 heaping tbsp. malted milk
7/8 cup milk

For Bradley's figures:

Malted Milk

3/4 c. milk
2 T. chocolate sauce
1 T. malted milk
1/3 cup ice cream (2 small scoops)

Chili Con Carne
1 can kidney beans
1 lb. ground beef
1 onion
1 t. fat
1 c. cooked rice

For figures from Bowes and Church:

Chocolate Malted Milk Shake
6 - 8 oz. milk
1 - 1 1/2 oz. chocolate syrup
2 oz. ice cream
(from regulation soda fountain recipes)

The nutritive values of the foods as recorded in the tables are summarized as follows:

Measures	Total Grams	Protein Grams	Fuel Value Calories	Source of Information
Malted Milk:				
1 cup	-	9.71	221	Locke
1 1/2 c.	300	10.8	405	Bradley
10 oz. glass	379	13.8	460	Taylor
10 oz. glass	360	13.7	480	Bowes & Church
1 cup	-	8.1	287	Boyd, et al.
Hamburger:				
2 1/2" diam., 7/8" thick	57	(55 Cal. from protein)	100	Rose
1 of 3 1/4"X3"X1/4"	25	8.5	140	Bradley
1 cake, 2 3/4" diam. 7/8" thick	88	20.7	150	Taylor
1 hamburger and bun (commercial)	-	11.5	228	Boyd, et al.
Chili Con Carne:				
1/2 cup	100	13.3	115	Bridges
1/2 cup	136	17.7	275	Bradley
1 cup	-	21.1	366	Boyd, et al.

Through the years there has been a paucity of information gathered on these particular foods, and because of the various methods used in calculating fuel and protein values, there has been divergence in the information as printed in different tables of food composition.

III. EXPERIMENTAL PROCEDURE

A hamburger on a bun, a malted milk, and a serving of chili con carne were purchased from five popular commercial eating establishments in the East Lansing area. These establishments are accustomed to selling orders to take out and it was a simple matter to collect samples representative of the foods as served to the general public.

Preparation for Analysis. As each food mixture was received in the laboratory, the total portion was weighed and prepared for analysis. Each purchase was blended with water in a Waring Blendor. With the exception of the malted milks, the food mixtures were transferred quantitatively to large glass trays in which they were air dried at room temperature with the use of an electric fan. Then the foods were ground to a fine homogeneous mixture, and weighed on a torsion balance. Half the dried weight of each sample was wrapped in cellophane (with a pharmaceutical wrap) and stored in a dessicator. This half of each dried sample was set aside and used later for the determination of caloric values. The remaining half of each sample, for determining nitrogen content, was stored in approximately 1 N hydrochloric acid.

The malted milk is a type of food mixture that is not successfully dried in the same manner as the other foods studied. Attempts to air dry it at room temperature produced a gum-like consistency which was much too difficult to work with. It was not possible to get all of this gummy substance from the trays; nor was it possible to grind it to a homogeneous mixture. Therefore, each entire purchase of malted milk in the fluid state was weighed and divided by weight into two parts. One half was acidified for nitrogen determinations, and the other half was used for heat combustion determinations.

The most suitable procedure to follow in preparing the malted milk for combustion was that of drying weighed portions of the material sufficiently for ignition. This was carried out by drying the malted milk directly in the ignition pan of the bomb calorimeter. (Detailed directions for the preparation of dried samples of hamburger, hamburger bun, malted milk, and chili con carne are included in the Appendix.)

<u>Methods of Analysis</u>. 1. The caloric value (or heat combustion) of each food mixture was determined in the Emerson Fuel Calorimeter following the method described by Mahin (1932).

2. The protein values were determined according to the macro-Kjeldahl method. Three replications were made of each analysis.

IV. RESULTS AND DISCUSSION

The average fuel value, as determined by the bomb calorimeter uncorrected for physiological losses, was 115 calories for a hamburger, 179 calories for a bun, (making a total of 294 calories for the combination), 518 calories for the malted milk, and 349 calories for chili con carne. These values are expressed in Table I.

However, plainly observable from the literature is the fact that the physical fuel value of foods is higher than the physiological fuel value of the human body, and it is the available energy value of foods which concerns us. It was necessary, therefore, to calculate the physiological fuel values. For the calculation of the values for the foods in this study figures determined by Atwater are used and we are dependent upon the accuracy and validity of his work. From his experiments on availability and digestibility of food materials in the human body, he found there were varying coefficients of digestibility of protein, fat, and carbohydrate. Fat and carbohydrate are believed to be oxidised completely by the body, whereas, the protein is not. From the nitrogen found to be present in the excreted end-products of digestion, it was calculated that 1.25 calories, from every gram of protein ingested, were not utilized by the human body.

Table 1.

FUEL VALUES OF HAMBURGER, BUN, CHILI CON CARNE, AND CHOCOLATE MALTED MILK.
(Bomb Calorimeter Determinations Uncorrected for Physiological Losses)

Food Product	Eating Estab.	Weight, A.P.*	Food, Dry	Food, A.P.	Fuel Value per Serving
		Grams	Cal./gm.	Cal./gm	Calories
Malted Milk	A	298.1		1.59	474
	B	310.2		1.69	524
	C	276.7		1.84	510
	D	314.4		1.31	411
	E	331.5		2.03	673
	Av.	306.2		1.69	518
	s			0.75	
Hamburger	A	46.1	6.63	3.13	144
	B	42.0	6.73	3.27	137
	C	31.1	6.51	3.23	100
	D	30.2	6.69	3.29	99
	E	29.6	6.58	3.12	92
	Av.	35.8	6.63	3.21	115
	s			0.05	
Bun	A	49.5	4.70	3.49	170
	B	48.5	5.05	3.77	183
	C	51.7	4.93	3.44	178
	D	47.3	4.78	3.58	169
	E	52.0	5.09	3.71	193
	Av.	49.8	4.91	3.60	179
	s			0.18	
Chili	A	264.0	5.60	1.30	343
	B	372.2	4.87	0.90	337
	C	335.2	5.16	1.33	441
	D	412.5	4.77	0.95	392
	E	267.9	4.90	1.06	284
	Av.	330.4	5.06	1.11	359
	s			0.20	

* As Purchased.

In this study the physical energy and protein values were determined. Therefore, to calculate the physiological caloric value, it was necessary to determine first the physical fuel value from the protein (Table II, column 1) and by difference obtain the number of calories provided by the combined fat and carbohydrate of the food (Table II, column 2). Atwater's correction factors may now be applied. The physiological calories from protein are obtained by applying the proper factors to the known protein content of the food (Table II, column 3). The physiological calories from the combined fat and carbohydrate constituents are calculated by the application of a known factor to the physical calories per serving from these constituents (Table II, column 4). By adding figures in column 3 with those in column 4, the total available calories per serving of each food item are obtained. These values are shown in column 5 of Table II.

The coefficient of digestibility for fat is 95% and for carbohydrate is 97%. Since these are so similar, an average of these two figures of 96% was used which precludes the necessity for determining both of these constituents of food materials. The application of 96% to the physical calories provided by the fat and carbohydrates of the food gives the total calories available or physiological fuel value from these constituents.

Table II.

PHYSIOLOGICAL FUEL VALUES OF HAMBURGER, BUN, CHILI CON CARNE, AND CHOCOLATE MALTED MILK[1].

Food Product	Eating Estab.	Weight A.P.	Uncorrected Fuel Value from Protein[2]	Uncorrected Fuel Value from Fat and CHO	Available Fuel Value Protein[3]	Available Fuel Value Fat and CHO	Available Fuel Value per Serving
		Grams	Cal.	Cal.	Cal.	Cal.	Cal.
Malted Milk	A	298.1	74	400	56	384	440
	B	310.2	69	455	52	437	489
	C	276.7	65	445	49	427	476
	D	314.4	79	331	60	318	378
	E	331.5	75	598	56	574	631
	Av.	306.2	72	446	54	428	483
(Range from Literature							221-480)
Hamburger	A	46.1	67	78	50	74	125
	B	42.0	62	75	47	72	119
	C	31.1	46	54	35	52	87
	D	30.2	45	54	34	52	86
	E	29.6	46	46	35	44	79
	Av.	35.8	53	61	40	59	99
(Range from Literature							100-305)
Bun	A	49.5	25	145	16	140	155
	B	48.5	23	159	15	153	168
	C	51.7	24	154	15	148	163
	D	47.3	23	146	15	140	155
	E	52.0	25	168	16	161	177
	Av.	49.8	24	155	15	148	164
Chili	A	264.0	93	250	61	240	301
	B	372.2	88	248	58	238	296
	C	335.2	123	318	81	305	386
	D	412.5	116	276	76	265	341
	E	267.9	87	197	57	189	246
	Av.	330.4	102	258	67	248	314
(Range from Literature							115-366)

1 Calculated by Atwater's Method.

2 Obtained by multiplying protein grams per serving (Table III) by the factors: 5.65 for malted milk and hamburger, 5.80 for the bun, and 5.68 for chili con carne.

3 Factors used to obtain available calories from protein: 4.25 for malted milk and hamburger, 3.70 for the bun, and 3.73 for chili con carne.

The coefficient of digestibility of protein of meat and dairy products if 97%, of cereals 85%, and of legumes 78% (Atwater and Bryant, 1899). For every gram of protein from meat and dairy products Atwater found there were 5.65 physical calories; for every gram of cereal product 5.80 calories; and for legumes 5.70 calories. (It appears that the average figure 5.68 might be used for chili since it is a mixture of meat and legumes.) The factors 5.65, 5.80, and 5.68 are used to obtain the figures recorded in Column I Table II. Now, the additional factor of 1.25 must be applied. Therefore, to obtain the available energy value per gram of protein, 1.25 is subtracted from the product of 5.65, 5.80, and 5.68 and the respective coefficients of digestibility. To obtain the available calories from the proteins of the hamburger and the malted milk 4.25 calories per gram of protein was used, of a bun 3.70 cal./gm., and of the chili 3.73 cal./gm.. The value 3.73 cal./gm. used for chili is an average of 3.20 for legumes and 4.25 for meats since chili is a combination of the two. These factors 4.25, 3.70, and 3.73 were used in calculating the figures in column 3 of Table II.

The averages of the total physiological fuel value, calculated by the procedure described above, were 99 calories for a hamburger, 164 calories for a bun (making a total of 263 calories for a hamburger on a bun), 483 calories for a malted milk, and 314 calories for a serving of chili con carne.

The figures for the physiological fuel value of these foods are included in column 5 of Table II.

As can be noted from Table I the food portions differ in size. For ease in comparing the caloric value of a food product from one establishment with those of other establishments, calories per gram of serving as purchased were calculated. The average value for the malted milk was 1.69 cal./gm. with a standard deviation 0.75. The average for the hamburger was 3.21 cal./gm. with a standard deviation 0.05. The average for the bun was 3.60 cal./gm. and the standard deviation, 0.18. The average value for the chili was 1.11 cal./gm. and the standard deviation, 0.20. All the recorded values in calories per gram for malted milk, bun, and chili con carne fell within the range of the respective standard deviations. The values in calories per gram of hamburger fell well within the range of two standard deviations and those which were outside the range of one standard deviation, were very close to the limits of the range. The caloric values per gram are within relatively narrow ranges for the respective foods. This indicates that there is not too much variation in the formulas used by the different establishments.

However, the portion sizes of foods vary as seen in the ranges from these five places. The malted milk ranged from the lowest at 276.7 grams to 331.5 grams, with an average of

306.2 grams. This variation in portion size is reflected in the caloric value per serving which ranged from 378 to 631 calories, with an average of 483 calories. The hamburger varied from 29.6 grams at one place to 46.1 grams at another, with an average of 35.8 grams. The caloric values ranged from 79 to 125 calories, with an average of 99 calories. The bun was relatively constant. The portion sizes ranged from 47.3 to 52.0 grams (average, 49.8 grams). This was also reflected in the caloric values, i. e., 155 to 177 calories (average, 164 calories) per serving. The commercial portions of chili showed a varied range from 264.0 to 412.5 grams (average 330.4 grams). The caloric value per serving spread from 246 to 385 calories (average 314 calories).

In order to determine the protein content of foods, it has been customary to use the nitrogen analysis and to obtain protein values of foods by the application of conversion factors. Through the knowledge of the proteins in the various types of foods and their percentage of nitrogen, certain factors have been calculated for use with different classes of foods. From Jones we find 6.38 to be the protein conversion factor for milk, 5.7 for wheat flour (as in a bun), and 6.25 for foods of animal tissue.

There are limitations to the usage of the protein values derived from the application of protein conversion factors, and more accurate knowledge of the relationship of nitrogen in the composition of various foods needs to be developed. For this reason, it seems somewhat more accurate to record nitrogen analyses of foods as nitrogen values rather than converting to protein content. However, the values in food tables have been commonly expressed as protein values rather than according to their nitrogen content. Therefore, in this study protein content has been determined through the use of the following conversion factors: 6.38 used for malted milk, 6.25 used for hamburger and chili, and 5.7 used for the bun.

After applying the appropriate conversion factors to determine the protein content of the foods, the following averages were found: 9.5 gms./ serving of hamburger, 4.2 gms./ serving of bun (making a total of 13.7 grams protein per serving of a hamburger on a bun), 12.8 gms./ serving of malted milk, and 17.9 gms./ serving of chili con carne. The nitrogen and protein values of these foods are found in Table III.

The nitrogen per 100 grams of each food product as purchased was calculated. The average nitrogen content of the hamburger was 4.25 grams per 100 grams of the food with a standard deviation of 0.12. The average for the bun was 1.46 grams of nitrogen per 100 grams of food with a standard deviation of 0.04. The average for the malted milk was 0.66 grams of nitrogen per 100 grams of the food with a standard deviation of 0.04. The average for the chili con

Table III.

NITROGEN AND CALCULATED PROTEIN CONTENT OF HAMBURGER, BUN, CHILI CON CARNE, AND CHOCOLATE MALTED MILK.

Food Product	Eating Estab.	Weight, A.P.	N per Serving	N per 100 Grams	Pro Per 100 Grams	Pro per Serving
		grams	grams	grams	grams	grams
Malted Milk	A	298.1	2.05	0.69	4.4	13.1
	B	310.2	1.92	0.62	3.9	12.2
	C	276.7	1.80	0.65	4.1	11.5
	D	314.4	2.20	0.70	4.5	14.0
	E	331.5	2.07	0.62	4.0	13.2
	Av.	306.2	2.01	0.66	4.2	12.8
	s			0.04		
Hamburger	A	46.1	1.89	4.11	25.7	11.8
	B	42.0	1.77	4.21	26.3	11.0
	C	31.1	1.31	4.23	24.4	8.2
	D	30.2	1.28	4.24	26.5	8.0
	E	29.6	1.31	4.44	27.7	8.2
	Av.	35.8	1.51	4.25	26.5	9.5
	s			0.12		
Bun	A	49.5	0.75	1.52	8.6	4.3
	B	48.5	0.71	1.46	8.3	4.0
	C	51.7	0.73	1.41	8.0	4.1
	D	47.3	0.70	1.48	8.4	4.0
	E	52.0	0.76	1.45	8.3	4.3
	Av.	49.8	0.73	1.46	8.3	4.2
	s			0.04		
Chili	A	264.0	2.63	1.00	6.2	16.5
	B	372.2	2.49	0.67	4.2	15.6
	C	335.2	3.46	1.03	6.5	21.6
	D	412.5	3.27	0.79	5.0	20.4
	E	267.9	2.46	0.92	5.7	15.3
	Av.	330.4	2.86	0.88	5.5	17.9
	s			0.15		

carne was 0.88 grams of nitrogen per 100 grams of food and the standard deviation was 0.15.

All the values for nitrogen per 100 grams of malted milk fell within the range of one standard deviation. However, all the values for nitrogen per 100 grams of hamburger, bun, and chili con carne did not come within the range of one standard deviation but those values that were without the ranges of one standard deviation were within two standard deviations, and very nearly within one. Again, it is evident that there is relatively close agreement among the formulas used from one place to another. However, the protein per serving varies among the different eating establishments along with variation in portion sizes, noted before.

The protein grams per serving for malted milk varied from 11.5 grams to 14.0 grams (average, 12.8 grams); for hamburger, from 8.0 grams to 11.8 grams (average 9.5 grams); for a bun, from 4.0 grams to 4.3 grams (average, 4.2 grams); for chili con carne, from 15.4 grams to 21.6 grams (average, 17.9 grams). The bun again shows constancy in content by its narrow range in protein per serving from different places.

Comparison of values in the literature are difficult to make. There are differences in the average portion sizes both by weight and by measure, which cause variation in the nutritive values as recorded. Two factors may be considered responsible for the differences. Size servings are interpreted differently by the authors of food tables. For example, one half cup of chili con carne is considered an average portion size by some workers (Bridges, 1942; Bradley, 1942); whereas, others state one cup as being an average size portion (Boyd, et al., 1947). This would not present too great a problem if the weights for definite measures were the same. For a 10 oz. glass of malted milk, Taylor (1942) records a weight of 379 grams and Bowes and Church (1944) give 360 grams as its weight. Compare these weights with 300 grams of malted milk for 1 1/2 cup scant as recorded by Bradley (1942). The incorporation of air into the mixture in the process of whipping the mixture may account for these discrepancies.

In comparing the results of this study with the figures found in food tables, the caloric values for malted milk in this study are obviously higher than some recorded in the literature. Locke (1911) records 221 calories and 9.7 grams protein for one cup malted milk (containing no ice cream). Boyd, et al. (1947) records 287 calories and 8.1 grams protein for one cup malted milk. If the average values in this study were changed to correspond to one cup measure of malted milk, there would have been approximately 387 calories and 10.2 grams protein which are higher values than those of Locke (1911) or Boyd (1947). The average caloric value per serving of malted milk in this study was practically identical with that recorded by Bowes and Church (1944), (483 calories and 480 calories, respectively). Yet, the weight per serving from Bowes and Church is 360 grams, whereas the weight per serving in this study was 306 grams. It also may be observed that the reports (Taylor, 1942; Bowes and Church, 1944) in which the caloric values per serving were similar to the average of this study, also were similar in protein values. The average amount of protein per serving recorded in the literature was 13.7 - 13.8 grams for a malted milk giving 460 - 480 calories (Taylor, 1942; Bowes and Church, 1944). In this study, the average protein value per serving was 12.8 grams.

For a serving of hamburger it is difficult to determine which is the typical weight for a serving of the food. An average serving was recorded as weighing 57 grams (Rose, 1937), 88 grams (Taylor, 1942) and 25 grams (Bradley, 1942). This last figure is 10 grams lower than the average weight (35.8 grams) found in this study, but it is the closest to the analyzed value of any recorded in the literature. For 25 grams of hamburger, Bradley (1942) records 140 calories and 8.5 grams protein which are extraordinarily high in comparison to the values per weight which others have recorded in the literature (page 19 of the Review of Literature). It is also high in comparison with the value obtained in this study. (NOTE: The values (protein 8.5 grams, fat 11.8 grams, and 140 calories). Bradley records for hamburger, 25 grams, indicate a water content of approximately 20%, and that the hamburger is exceedingly concentrated.) Rose records

100 calories from 57 grams of hamburger and this figure for caloric value seems low for the size serving, in comparison to the 99 calories per 35.8 grams hamburger found in this study. Taylor's figure for size portion (88 grams) seems rather large in comparison to the 35.8 grams found to be the average size hamburger. However, the protein value recorded by her (20.7 grams) is in relative proportion to the size serving according to the protein values (9.5 grams) found in this study for 35.8 grams hamburger. The caloric value, 150 calories for 88 grams, seems low when compared to the 99 calories per 35.8 grams as an average serving in this study.

Boyd, et al. (1947) was the one reference found in the literature to report the combined values for a commercial hamburger and bun. This seems to be a more useful manner of listing this food product, since it is sold and eaten in the combined form. Therefore, if the corresponding caloric and protein values for each hamburger and its bun analyzed in this study are combined, the following value for a hamburger and bun result:

Eating Estab.	Fuel Value Calories	Protein grams
A	280	16.1
B	287	15.0
C	250	12.3
D	241	12.0
E	256	12.5
Av.	263	13.6

In comparing the values from Boyd, et al. (1947) (11.5 grams protein, 228 calories) for a hamburger and bun with the results of this study, it is observed that Boyd's values in the literature are low for both protein and calories.

If the values for one half cup chili con carne recorded in the literature are changed to the values for one cup, an easier comparison can be made between those values and the results of direct analysis carried out in this study. One cup measure is more nearly the measure actually served than one half cup. The range in serving measure in this study was from approximately 1 cup to 1 3/4 cup. If this suggestion is carried out, it will be found that all the caloric values for chili obtained in this study are within the limits (230 - 550 calories) listed in the literature. However, the protein values in this study (15.4 to 21.6 grams) were lower than those in the literature (range, 21.1 to 35.4 grams for one cup chili). The highest protein value (21.6 grams) found for chili in this study was for a serving larger than one cup. The average caloric value (314 calories for an average weight of 330.4 grams) for chili in this study is not too far from the mean of the extremes recorded in the literature.

From the above observations and discussion it would appear that the formulas used by the commercial places studied are relatively standard. The salient difference in food value per serving lies in the fact that portion sizes differ from one establishment to another. Nevertheless, the portion sizes do not vary too greatly, and so, averages from results of direct analysis may be used for the values of commercial food servings within certain areas.

The figures as observed here are representative of the energy and protein values of hamburger, hamburger bun, malted milk, and chili con carne as they are served commercially in East Lansing. These values are applicable to the same food mixtures served in other areas of the country <u>only</u> on the assumption that restaurant practices are similar and that there may be differences, but not great ones.

It would seem that one of the best ways to check on these assumptions is to analyze servings of these foods as they are sold in various areas of the country. Since food composition tables are composed of averages, perhaps tables for use in various sections of the country - southeast, northeast, mid-west, southwest, northwest - would contain more representative average values.

V. SUMMARY AND CONCLUSIONS

Because food tables are relied upon for the calculation of the nutritive value of diets, it is necessary that they be as complete and accurate as possible. Several common food mixtures are not included in many or any food tables. If they are included, the nutritive values were calculated from ingredients rather than by direct analysis. This study was made to provide some information about the proximate principles of certain food mixtures enjoyed by many persons in our society today, particularly college students.

A chocolate malted milk, a hamburger and bun, and a serving of chili con carne from each of five eating places in a college community were analyzed for caloric value and protein content. The foods were air dried. One half the serving of each food was acidified and used for nitrogen determinations according to the Kjeldahl method. The other half was used for fuel value determinations using the Emerson Fuel Calorimeter, according to the method described by Mahin (1932).

Calculation of the protein content was done by applying the appropriate conversion factors to the nitrogen values determined by analysis. The "Atwater System" was used to compute the fuel value of these foods actually available to the human body.

The values for calories per gram and nitrogen per 100 grams were found to be within relatively narrow ranges for the respective foods. This indicated that there was not too much variation in the formulas used by the different establishments. However, the portion sizes varied from one place to another accounting for the larger differences in food value.

The average caloric value of a malted milk was found to be higher than those recorded in the literature; of a hamburger, higher in comparison with two cases in the literature and lower in a third case; of a hamburger and bun combined, higher when compared with the one analysis recorded in the literature; of a serving of chili, midway between the two extremes recorded in the literature.

The average protein value of a malted milk was found to be comparable to the higher values recorded in the food tables; of a hamburger, about the same as that in the literature; of a hamburger and bun, slightly higher than that of the one instance recorded in the literature; and of chili, lower than the values in the food tables.

Discrepancies in comparing the values of the food mixtures in this study with those in the literature were pointed out. Conceptions of portion sizes varied. Weights for the same measure differed. Recipes used for calculations of nutritive value of food mixtures varied. Many food mixtures popular in the present day are not included in many food composition tables, if they are found in the literature at all.

It seems necessary, then, that further analyses be made to bring the current food tables up to date and clear up a great many discrepancies found therein. These analyses are needed to confirm, discredit, or add more information about nutritive values of foods and food mixtures as they are used today.

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VII. APPENDIX

A. DETAILS OF PROCEDURE USED IN PREPARING DRIED SAMPLES OF HAMBURGER, HAMBURGER BUN, CHOCOLATE MALTED MILK, AND CHILI CON CARNE.

<u>Hamburger</u>. Prepare 3 large glass trays (rinsed with distilled water). Weigh hamburger. Break hamburger into small pieces into a clean Waring Blendor. Add 240 cc. hot distilled water and blend until a homogeneous mixture is obtained. To each third part of the mixture add an additional 100 cc. hot distilled water and pour into glass tray. (The 100 cc. of water may be used to transfer, quantitatively, the mixture into the tray.) Air dry with the use of an electric fan. This may take 3 to 4 hours. When the mixture is dry in the trays, scrape the dried material into a mortar. (A small spatula and rubber scraper are useful for this.) Grind the dried food in a mortar with a pestile. Weigh the dried material. The dried food may be kept successfully if wrapped in cellophane (with a pharmaceutical wrap) and stored in a dessicator.

<u>Bun</u>. One tray is all that is required for this food. Weigh the bun and break it into pieces into the tray. Allow the sample to air dry using an electric fan. This takes about 2 hours. Crush in a mortar with a pestile and grind until the mixture is homogeneous. Weigh the dried food. Wrap in cellophane and store in a dessicator.

. <u>Chili con carne</u>. As many as 7 to 12 trays may be required for a serving of this food mixture. Weigh the sample of chili. Pour it into a clean Waring Blendor and add 100 cc. of hot distilled water. Blend until it is a smooth homogeneous mixture. Pour 50 cc. of the mixture into a pharmacist's graduate and add 50 cc. hot distilled water. Add an additional 100 cc. hot distilled water to this and pour the total of 200 cc. into one tray. The 100 cc. of water may be used to transfer, quantitatively, the mixture into the tray. Do this for as much chili mixture as there is; for as many trays as are necessary. Air dry using an electric fan. This may take 4 to 5 hours. When the mixture is dry, scrape it into a mortar and grind with a pestile. (The scraping process for 4 trays may take as long as 2 hours.) Weigh the dried material. Wrap in cellophane, and store in a dessicator.

. <u>Malted Milk</u>. This type of food mixture is not dried successfully in the same manner as the foods previously mentioned. It forms a gum-like consistency. Therefore, if calorimetry is to be done on this food:

Weigh the malted milk. Fill weighed ignition pan from the calorimeter with malted milk and weigh. Air dry using an electric fan. This may take as long as 4 to 5 hours. Weigh the partially dried sample and fill the pan again with liquid. Air dry. Weigh the dried sample in the pan. Two dryings should be sufficient to obtain a sample large enough to use in the Emerson Fuel Calorimeter. These samples in the small pans may be stored for a short time in a dessicator.

PREPARATION OF PELLETS FOR USE IN THE CALORIMETER.

It has been found that if the substance to be oxidized is reduced in moisture content, and then, if it is pressed into a compact form (such as the shape of a pellet), a more complete combustion of the material is effected. For the particular foods mentioned here the following suggestions are made concerning the formation of these pellets.

A. Hamburger. Use a hand press.

B. Bun. Use the hydraulic press up to a pressure of 800 pounds to 1000 pounds.

C. Chili con carne. Use a hand press.

B. Table IV. RECOVERY OF NITROGEN FROM A STANDARD SOLUTION.

Material	Date	Nitrogen in Sample	Nitrogen Recovered	Percent of Nitrogen Recovered
		grams	grams	
NH_4Cl	5/21/49	.0650	.0629	96.8
		.0650	.0634	97.5
		.0650	.0645	99.2
Average				97.8

Table V. DETERMINATION OF WATER STANDARD FOR CALORIMETER USING BENZOIC ACID.

Results of Tests	Deviations from Mean	Approximate Error of Experiment
Calories	Calories	percent
2567.3	15.0	
2537.1	15.2	
2562.0	9.7	
2544.5	7.8	
2569.5	17.2	
2552.0	0.3	
2538.8	13.5	
2542.5	9.8	
2557.3	5.0	
Average		
2552.3	10.4	
		0.4