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# The Energy and the Protein Content of Edible Food Waste and Mixed Meals in Sorority and Fraternity Houses

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# The Energy and the Protein Content of Edible Food Waste and Mixed Meals in Sorority and Fraternity Houses

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The earliest method of studying the food needs of a group of individuals was to determine the energy content of the total food purchased during a given period, with due correction for the energy value of the wasted food. The caloric value of the food was determined indirectly by computation from standard tables or directly by sampling and analysis, usually chemical. It is relatively easy to compute the total caloric value of 100 pounds of flour or a given weight of corn meal or rice, but extremely difficult to estimate from standard tables the fuel value of a mixed meal of vegetables and meat, particularly when cooked, since the standard tables deal very seldom with cooked foods. The accurate sampling, weighing, and analysis of each of the food materials consumed by a group likewise necessitate a great deal of labor, and the problem of how to handle the wasted food is most perplexing. Another method has been to place in a container at each mealtime an amount of food equivalent to that eaten by the average person in a group, so that at the end of a given time the total food thus accumulated would be representative of that supplied to each individual. An aliquot sample of this mixture is then analyzed, but from the total energy content as thus determined must be deducted the caloric value of the food left uneaten on the plate at each meal. This second method of study has an advantage over the first in that all kitchen refuse, which enters into the calculated energy value of the food purchased, is thus eliminated and only the food as served is taken into consideration. In general the food as served represents the edible portion of the food, although not infrequently some meats and vegetables, such as corn on the cob and asparagus, must necessarily be served with certain parts that cannot be eaten and for which allowance must be made in any energy calculations.

No one problem has troubled students of dietetics more than the accurate measurement and the analysis of waste foods. Few studies of waste have been reported, but it is apparent from what few have been made[1] that the obstacles in collecting the waste, the confusion in distinguishing between kitchen refuse and table waste or between inedible and edible waste, and the difficulties in determining the energy and the protein content are great. Waste in dietary studies has two entirely separate interests. If one wishes to know the true energy and the true protein intake of a group of individuals per day, obviously one must take into consideration the waste. From the standpoint of physiology, knowledge of the true food intake is essential in determining the dietary needs of any one group, such as a group of workers. From the economic standpoint likewise such knowledge is of value. Although the necessity of accounting for waste may not seem so apparent at the present day, because of the bumper crops and the over-production of certain foods, nevertheless the reduced incomes of a great many people today are only partly offset by the increased purchasing power of the wage, and perhaps at no time in the history of the United States has waste food been of any greater economic importance than now. The cost of waste food is especially to be emphasized in those institutions in which household economics are taught, where students are brought daily into contact with problems concerning the energy value of food ingredients and the relationship between prepared and rejected foods.

## PLAN OF RESEARCH

In the earlier dietary studies elaborate calculations from standard tables, complicated chemical analyses, or time-consuming combustions with the bomb calorimeter were necessary to establish the energy content of purchased and prepared foods and of food waste. In the last decade, however, it has been demonstrated that students of dietetics and household economics can determine the caloric value of individual foods and food mixtures accurately and with simplicity by the use of the oxy-calorimeter developed at the Nutrition Laboratory.[2] Advantage was, therefore, taken in a cooperative research carried out by the Nutrition Laboratory of the Carnegie Institution of Washington and the University of New Hampshire (some of the results of which have been already published[3]) to determine the energy content of the edible food wasted by groups of college students. The college group was considered ideal for the study, since so many observations in the field of dietetics have already been made with similar groups. If it is feasible to prepare for

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[1] Richards, E. H., and M. Talbot, Food as a factor in student life, Dept. Social Sci., Univ. Chicago, 1894, (cited by E. Hawley; see reference below); Atwater, W. O., U. S. Dept. Agric., Office Expt. Sta., Bull. 21, 1895, p. 162; Gephart, F. C., Boston Med. and Surg. Journ., 1917, **176**, p. 17; MacLeod, A. L., and M. A. Griggs, Journ. Home Econom., 1918, **10**, p. 97; Murlin, J. R., and F. M. Hildebrandt, Am. Journ. Physiol., 1919, **49**, p. 531; Dickins, D., Mississippi Agric. Expt. Sta., Bull. 245, 1927, and Bull. 254, 1928; Searle, G. N., and R. M. Arnold, Journ. Home Econom., 1928, **20**, p. 84; Hawley, E., A study of the food consumed at St. Paul's School, privately printed by St. Paul's School, Concord, New Hampshire, 1928.

[2] Benedict, F. G., and E. L. Fox, Indus. and Eng. Chem., 1925, **17**, p.912; ibid., Journ. Biol. Chem., 1925, **66**, p. 783; Benedict, F. G., Abderhalden's Handb. d. biolog. Arbeitsmethoden, 1929, Abt. IV, Teil 13, p. 51.

[3] Benedict, F. G., and A. G. Farr, Univ. New Hampshire, Agric. Expt. Sta., Bull. 242, 1929.

analysis a composite, aliquot sample of the food eaten by a group of individuals, it is equally as simple to prepare a composite, aliquot sample of the total waste collected during any definite period of time, and the oxy-calorimeter makes it possible to determine the actual caloric value of such a mixed mass of waste readily and accurately.

From our earlier study[1] it was found that if the air-dry weight of a mixture of foods were known, the multiplication of this air-dry weight in grams by the *round* number 5 gives with astonishing accuracy the true caloric value of the food. Indeed, this factor has been recommended for the use of physicians and dietitians in hospitals as a rapid means of calculating accurately the energy value not only of simple foods of well-known composition in a mixed diet, but likewise of the most complicated culinary mixtures. If some such factor could also be established for the caloric value of the edible food waste per gram of air-dry weight, the problem of correction for table waste in dietary studies of groups of individuals would be greatly simplified. Since waste as a whole should normally represent only a relatively small fraction of the total food served, it is obvious that a fairly large error in the factor used for computing the caloric value of waste per gram of air-dry weight could be permitted without seriously affecting the calculation of the actual energy intake. It was believed that combustions made with the oxy-calorimeter of various samples of plate scrapings taken from the ordinary college table might establish a caloric value of the air-dry matter of edible food waste that would be applicable in dietary studies in practically all cases where groups of individuals are eating under the same conditions. Arrangements were therefore made with one fraternity house and two sorority houses at the University of New Hampshire to collect the waste of edible material, to prepare air-dry samples of the same, and determine their heats of combustion with the oxy-calorimeter. By edible material is meant food deprived of its ordinary refuse, such as fruit skins, fruit stones, and meat bones. If visible amounts of fat were served and the fat was not relished by the individual and left uneaten, this was considered as unused edible material. Edible waste that could be scraped off the serving dishes and the cooking utensils was likewise included, but not the inedible kitchen refuse. Consequently all our combustions of waste dealt with the unused edible food, both that in the kitchen and that in the dining room.

In addition to the combustions of samples of food waste, the energy values for a number of mixed meals and a number of so-called "extra foods" were also obtained. To give some hint as to the amount of protein in these waste foods and mixed meals, the nitrogen content was determined by the Kjeldahl process. No effort was made, however, to apportion the calories from protein, fat, and carbohydrate. Comparisons were made between the energy and the protein content of the food served and of the edible waste, in order to calculate what percentage of the energy and the protein in the total food served was discarded un-

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[1] Benedict and Farr, loc. cit.

eaten. The uniformity in the sampling of mixed meals was controlled by combustions on two samples of the same meal collected in separate containers. Although undoubtedly a certain degree of approximation entered into the planning of this research, nevertheless the various factors studied do logically dovetail together and present a more complete picture than would be the case if any one factor alone had been studied.

The fraternity and the sorority dining rooms in which the food samples were collected were in well-ordered college houses where special attention was given to the study of supply and waste, to caloric values, and the economics of the proper preparation of food. We are deeply appreciative of the courtesies extended by the committees responsible for these houses, in permitting these observations to be made.

## THE OXY-CALORIMETER, ITS MODIFICATIONS AND ITS USE

An effort to develop an instrument of simple construction that could be used for measuring accurately the energy value of foods, excreta, and organic compounds in general, and that might in many instances supplant the expensive and complicated bomb calorimeter has resulted in the oxy-calorimeter. Since the laboratory at the New Hampshire Agricultural Experiment Station has made extensive use of the oxy-calorimeter, since the experience there gained has indicated the advantage of making certain modifications for the betterment of the apparatus, and since it is desired to stress the practical use of this instrument, it has seemed fitting to restate in this report the fundamental principle underlying the oxy-calorimeter, to give a short description of the modifications that have been made in it, and to discuss briefly its use. In the original detailed description of all its technical niceties, emphasis was laid upon the importance of adjusting the final temperature of the apparatus so that it would be the same as the initial temperature.[1] In the description of the somewhat less accurate form,[2] designed primarily for use with existing models of respiration apparatus and suggested chiefly for the study of the energy values of foods and excreta, the question of temperature control was not emphasized, for it was believed that the error inherent in the sampling of most mixed foods and excreta would be much larger than the probable error arising from less perfect control of the temperature of the apparatus. In a subsequent German description[3] of the apparatus the temperature control, although mentioned, was by no means adequately stressed. Later experience[4] has shown that the temperature control is not only desirable but practically imperative, and it is the

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[1] Benedict, F. G., and E. L. Fox, Indus. and Eng. Chem., 1925, **17**, p. 912. A slightly modified form was briefly described by us in a previous bulletin. (Univ. New Hampshire, Agric. Expt. Sta., Bull. 242, 1929).

[2] Benedict, F. G., and E. L. Fox, Journ. Biol. Chem., 1925, **66**, p. 783.

[3] Benedict, F. G., Abderhalden's Handb. d. biolog. Arbeitsmethoden, 1929, Abt. IV, Teil 13, p. 51.

[4] Dr. J. M. Petřik (Professor of Physiology at the Masaryk University at Brno, Czechoslovakia) spent several months at the Nutrition Laboratory in 1930 as a visiting Fellow of the Rockefeller Foundation, and made many observations with the oxy-calorimeter, which led to the special study of temperature control.

temperature control especially of the oxy-calorimeter that we wish to emphasize in making this brief description of the equipment.

*Principle of the oxy-calorimeter.* In the oxy-calorimeter a weighed portion, usually 2 grams, of air-dry material is burned in a confined atmosphere rich in oxygen. The carbon dioxide produced by this combustion is absorbed by ventilating the combustion chamber and accessory parts with a rotary blower and forcing the gases of combustion through soda-lime to absorb the carbon dioxide. The air, now carbon-dioxide free but still rich in oxygen, is returned to the combustion chamber, passing by a connection to a spirometer, which has a capacity of about 6 liters. As a result of the combustion there is a notable reduction in the volume of oxygen. This reduction in volume is immediately apparent in the lowered level of the spirometer bell. By reading the level of this bell before and after the combustion one can obtain a measure of the reduction in the volume of air in the closed system, which is a measure of the apparent volume of oxygen consumed. Approximately one liter of oxygen is absorbed in the combustion of each gram of dry substance of ordinary mixed foods. Precise calculations with corrections for barometric pressure, tension of aqueous vapor and, above all, temperature give the true contraction in the volume of oxygen at 0°C. (dry) and 760 mm. absorbed in the combustion of the weight of the substance used. Since the caloric value of a liter of oxygen is known to be not far from 5 calories when mixed foods are burned, the energy content of the substance under consideration can be readily computed.

The main parts of the oxy-calorimeter in the form as ordinarily used consist of a combustion chamber, a ventilating device, a vessel for absorbing carbon dioxide, and an expansion chamber. Strictly speaking, this latter should be called a contraction chamber, for we are dealing with a closed volume of oxygen, and provision for contraction as a result of the process of combustion must be made. Although usually the contraction chamber is a spirometer, in the effort to have the principle of the oxy-calorimeter applicable in as many laboratories as possible the combustion chamber and the ventilating device have been adapted to other types of respiration apparatus, such as the student respiration apparatus[1] and the field respiration apparatus,[2] in both of which models the expansion chamber is formed by a thin rubber bathing-cap attached over a container in which the soda-lime is placed.

*Liberation of heat.* Obviously when a dry substance is burned in pure or nearly pure oxygen there is a tremendous liberation of heat in the combustion chamber. Most of this heat is dissipated as the air passes from the combustion chamber to the carbon-dioxide absorbing vessel, but here again a considerable amount of heat is developed by the chemical reaction taking place in the absorption of carbon dioxide by

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[1] Benedict, F. G., and C. G. Benedict, Boston Med. and Surg. Journ., 1923, **188**, p. 567; ibid., Skand. Arch. f. Physiol., 1923, **44**, p. 87.

[2] Benedict, F. G., Boston Med. and Surg. Journ., 1927, **197**, p. 1161; ibid., Chinese Journ. Physiol., Report Series No. 1, 1928, p. 39; ibid., Abderhalden's Handb. d. biolog. Arbeitsmethoden, 1929, Abt. IV, Teil 13, p. 1.

the alkali, usually soda-lime. The mass of soda-lime, the mass of the container, and particularly the poor heat-conducting qualities of the glass bottle originally used in the oxy-calorimeter resulted in a very sluggish temperature adjustment after the combustion ceased. The return of the air temperature to its initial point was in part aided, especially under the temperature conditions prevailing in the laboratory during the winter-time, by passing air from the combustion chamber through a metallic U-tube dipped in ice water. When summer temperatures prevailed, this cooling device was found inadequate and direct cooling of the soda-lime container became necessary. With imperfect temperature adjustment the

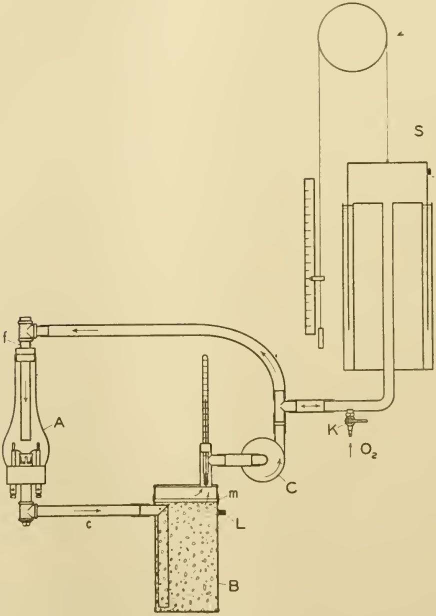

*Fig. 1. The spirometer type of oxy-calorimeter.*

A, combustion chamber; c, tube conducting air from base of combustion chamber to metal soda-lime can, B; L, lug for suspension of soda-lime container over a reservoir of cold water; m, rubber band to hold cover of can, B, securely in place; C, blower; S, spirometer; K, petcock for introduction of oxygen; f, tube leading into combustion chamber.

apparatus may still be used, and indeed was used by us in our research, by applying a correction factor in the calculations, determined by the standardization of the apparatus with a known weight of pure sugar.[1] It is far better to avoid the use of this correction factor by bringing the whole circulating air system to the same temperature at the end of the combustion as it was at the beginning. This is done by cooling the soda-lime container either by external application of ice or cold water or by imbedding a copper cooling coil in the soda-lime.

## THE SPIROMETER TYPE OF OXY-CALORIMETER

The spirometer type of oxy-calorimeter has been more commonly used than any of the other types. It is illustrated in its modified form in Figure 1. The combustion chamber, A, has its base in a brass water seal. The air is withdrawn from the combustion chamber by the blower,[2] C, being conducted from the base of the combustion chamber through the tube, c, by a metal-to-metal contact into a tube leading to the base of the metallic vessel, B, which contains soda-lime. The carbon dioxide is absorbed from the air as it passes up through the soda-lime, and the carbon-dioxide free, oxygen-rich air leaves the container through a tube at the top. In this tube a thermometer is inserted, the temperature of which is very important. The air withdrawn from the soda-lime container is returned by the blower, C, directly to the combustion chamber. As it returns, it passes by a T-connection leading to the spirometer, S. If external cooling is provided for the metallic vessel, B, the temperature of the thermometer can be controlled at will. The copper can, B. is suspended so that a reservoir of cracked ice or water can be raised under it from below and the can immersed to any desired depth. The top of the can, B, is secured by a stout rubber band, m, which can be easily taken off for removal of soda-lime or for refilling. To aid in suspending the soda-lime can, a lug, L, is soldered at one side. The vessel can be easily suspended by attaching a wire over this lug and around the entrance tube, or a wide fork fastened to a retort stand can be used for the suspension. After a little experience in adjusting the level of the cold water, the temperature of the thermometer can be rapidly regulated with little danger of overcooling.

The cooling device for the copper can, described above, has made it possible to simplify the tube leading from the combustion chamber. Thus, the metallic U-tube recommended in the original description of the apparatus may be replaced by the straight tube shown in Figure 1, which makes a direct connection with the soda-lime can. After the combustion has ceased, the lamp chimney, A, and the tube, c, are very hot,

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[1] In the control tests carried out in the development of the oxy-calorimeter pure sugar from the Bureau of Standards was employed. We have found that practically any form of granulated sugar can be used with equal success. Unless the sugar is obviously caked with moisture, the amount of water in the sugar will not affect the results. Drying the sugar in a desiccator overnight is a good precaution.

[2] The rate of ventilation is between 20 and 30 liters per minute, controllable by an external resistance in series with the electric blower, or by a pinch clamp on the rubber tube leaving the blower.

and considerable heat is developed in the can, B. Local cooling of the heat-resisting, Pyrex glass chimney is obtained by applying directly to it a cloth wet with ice water, and not infrequently a piece of wet cheesecloth is likewise wrapped around the tube to dissipate some of the heat. When the thermometer indicates that the temperature of the system at the end of the combustion is the same as at the beginning, the cooling bath is lowered and the apparatus may be stated to be in temperature equilibrium. Theoretically, all portions of the closed circuit should have precisely the same temperature at the end as at the beginning of the combustion. One thermometer alone is used, however, and except for the soda-lime container, the other parts of the apparatus are cooled only until they appear to the hand to have the initial temperature. The largest volume of air is that in the soda-lime can and in the spirometer. The spirometer undergoes practically no changes in temperature. Any changes in temperature of the soda-lime are indicated by the thermometer.

*Method of combustion.* The substance to be studied is brought to an air-dry condition, and a sample of it is carefully weighed and placed in a small nickel capsule supported in the base of the combustion chamber. A fine iron wire is looped across two rods sticking up through the base of the chamber, at the bottom ends of which are two binding posts connecting with the electric current. The central part of this wire loop rests upon the food sample. The spirometer bell is pushed to its lowest level, the lamp chimney is closed at the top, a cork is inserted with a one-hole stopper through which the tube, f, passes, and a cork is inserted in the brass tee above it. Oxygen from a cylinder is first bubbled through water to saturate it and then admitted into the system through the petcock, K, and the spirometer bell rises. One should then remove the cork just above the tube, f, pinch together the rubber tube between the blower and the top of the lamp chimney, and press down on the spirometer bell with the hand in order to displace the air in the system with nearly pure oxygen. Finally, the cork is put in place in the brass tee, and the spirometer is filled to a level that will permit the contraction of at least 3 liters. After the blower has been running for a moment, it is stopped and the temperature and the level of the spirometer are recorded, as well as the barometric pressure. The blower is again started, and the substance in the capsule is burned by electric ignition of the iron wire. A piece of fine mesh, brass wire gauze, about 15 cm. square, rolled in cylindrical form but open on one side, may be snapped around the glass lamp chimney, if desired. This will reduce the brilliancy of the combustion so that the operator need not wear colored glasses. The combustion usually proceeds at a fairly regular rate, but if it is too vigorous, one can reduce it by compressing slightly the rubber tube conducting the air to the lamp chimney from the tee-tube connection to the spirometer. One should not obstruct the passage of air between the base of the combustion chamber and the spirometer, because otherwise air may be sucked in or blown out of the water seal during a poorly regulated combustion. Although the flame of the combustion may impinge on the surface of the glass chimney without danger, a visible deposit of carbon is undesirable, and especially toward the end of the combustion the carrying of bits or flakes of unburned carbon out of the chamber by the air current must be avoided. The spirometer, S, should be carefully counterpoised, and one should occasionally wipe the inside and the outside of the bell with a lightly oiled rag, to minimize the adherence of water to the metal.

The essential features of this modification of the spirometer type of oxy-calorimeter are, therefore, the simplification of the combustion chamber, particularly the base and the metallic tube below it, the substitution of a metallic soda-lime container for the glass container, and the provision for external cooling of this container. With these modifications, if care is exercised in keeping the initial and the final temperatures of the closed system the same, extraordinarily uniform results can be obtained in the various combustions, and the precision claimed for the original model can not only be secured but with less difficulty.

With the spirometer type of oxy-calorimeter provided with the cooling device for accurate temperature control, as described in the preceding pages, the calculation of the result of a combustion may be expressed by the formula:

$$V_{(0^\circ \text{ C., dry; 760 mm.})} = \frac{(L \times K \times M) - 5}{W}$$

in which V is the volume of oxygen consumed in the combustion of one gram of an air-dry food, this volume being expressed in cubic centimeters and reduced to 0°C. (dry) and 760 mm. pressure; W is the air-dry weight of the substance in grams; L is the change in level of the spirometer bell expressed in millimeters; K is the apparent volume of the bell in cubic centimeters per millimeter of its length (usually not far from 21 c.c.); M is the factor for reduction of the apparent volume to standard conditions of temperature and pressure. This factor M is based upon the prevailing barometric pressure and the average temperature of the spirometer and is found by referring to the standard tables published by Carpenter,[1] the air in the apparatus being considered completely saturated. The minus correction of 5 represents the cubic centimeters of oxygen consumed by the ignition of the iron wire. This reduced volume of oxygen consumed per gram of air-dry matter must be corrected for the amount of nitrogen liberated per gram of air-dry substance during the combustion. Since the percentage of nitrogen in the food sample under consideration is determined by the Kjeldahl method and since it is known that one milligram of nitrogen occupies 0.8 c.c. under standard conditions of temperature and pressure, one can readily compute the total volume of nitrogen liberated in the combustion of one gram of the air-dry substance. The reduced volume of oxygen per gram of air-dry material should be increased by this volume of nitrogen liberated, and this result, converted from cubic centimeters to liters,

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[1] Carpenter, T. M., Carnegie Inst. Wash. Pub. No. 303A, 1924, tables 7 and 8, pp. 39 to 70.

should be multiplied by 4.825, the caloric value of a liter of oxygen when mixed foods are burned, or by 4.7, the caloric value when decidedly fatty food samples are burned. This step gives the calories per gram of air-dry matter. The total energy content of the substance is obtained by multiplying by the total air-dry weight. The total protein content is computed from the determined nitrogen percentage and the air-drv weight of the substance, on the assumption that one gram of nitrogen equals 6.25 grams of protein.

## THE SIMPLER FORM OF OXY-CALORIMETER

The spirometer type of oxy-calorimeter is recommended for general use, but if it is not available, the combustion chamber and the blower can be attached to some of the other forms of respiration apparatus in use in many laboratories and clinics. The principle of the oxy-calorimeter is, therefore, easily employed for the combustion of foods and excreta so frequently desired in hospital and dietetic laboratories. One such adaptation is shown in Figure 2, in which the combustion chamber, A, and the blower, C, have been attached to a modified form of the student respiration apparatus,[1] and a cooling device has been provided so that the temperature is as well controlled with this type of oxy-calorimeter as with the spirometer type. In this apparatus a large mass of soda-lime is contained in the metallic can, B, and in place of the spirometer the expansion or contraction chamber is provided by a light, pure gum bathing-cap, b, fastened to the top of the can, B. The blower, C, and the combustion chamber, A, are the same as those shown in Figure 1.

Although the can, B, is constructed of copper, it has been found impracticable to cool it by external devices. Hence a simple method of internal cooling is recommended. A coil of soft copper tubing (4 mm. internal diameter, 6 mm. external diameter, and about 1½ meters long) is placed in the bottom of the can. Both ends of this coil pass out through the rubber stopper, E, fitted into a thimble soldered into the base of the can a little to one side of the air pipe connecting with the pipe, c. The can is about two-thirds filled with soda-lime, and a thermometer is inserted through a side opening, with its bulb just above the top of the soda-lime. To this side opening is attached an upright, H, which supports a clamp and a small plate, d, used as an index of the degree of distention of the bathing-cap, b.

The weighed, air-dry substance and the ignition wire are placed in the combustion chamber, but before beginning the combustion oxygen is supplied through a petcock at the bottom of the can. The apparatus is filled with oxygen until the small button, e, on top of the bathing-cap, b, just comes in contact with the plate, d. The oxygen is then forced through the system by removing the cork in the tee at the top of the lamp chimney and depressing the bathing-cap with the hand.

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[1] Benedict, F. G., and C. G. Benedict, Boston Med. and Surg. Journ., 1923, 188, p. 567; ibid., Skand. Arch. f. Physiol., 1923, 44, p. 87.

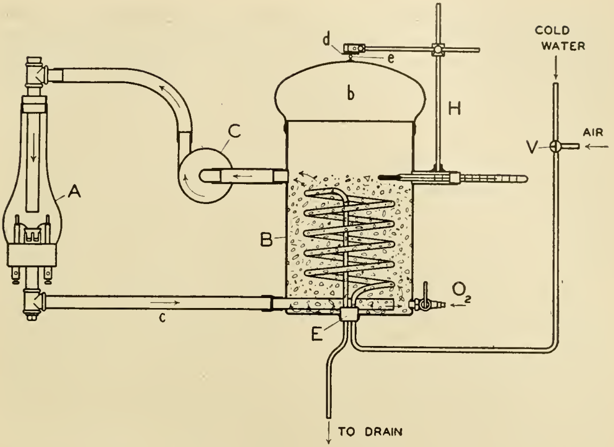

*Fig. 2. A simple form of oxy-calorimeter.*

A, combustion chamber; c, tube conducting air from base of combustion chamber into soda-lime container, B; C, blower; b, rubber bathing-cap with button, e; H, upright with cross arm supporting plate, d; E, 2-hole stopper through which pass the two ends of the copper cooling coil; V, valve to control entrance of water or air into cooling coil; $O_2$, petcock through which oxygen is introduced into the apparatus.

The can is filled with oxygen a second time, the rubber cork is replaced in the tee, and the blower is set in motion. When equilibrium is established, that is, when the button, e, on the bathing-cap just comes in contact with the plate, d, the food substance is ignited.

To cool the can a supply of cold water, either from the tap in winter-time or from a reservoir containing ice water, is allowed to flow into the copper coil embedded in the soda-lime. The amount of water passing through this coil can be controlled by a pinchcock, but at the beginning of the combustion the apparatus is brought into equilibrium by running the blower without having any cold water in the cooling pipe. As a result of the electrical ignition, there is momentarily a considerable expansion of the air in the system by the heat developed. Provision must, accordingly, be made to avoid undue distention of the rubber cap during the combustion. At the beginning of the experiment, therefore, when the apparatus has been brought into temperature equilibrium and the rubber bathing-cap is distended so that the button, e, just comes in contact with the plate, d, a pump (which is used subsequently to measure the oxygen consumption) is connected to the petcock at the base of the can, B, and one complete pumpful (about 370 c.c.) of the oxygenated air is withdrawn from the system. This allows the bathing-cap to fall so that at the moment of combustion, when there is a temporary increase in the volume due to the heat developed, there is no undue expansion of the rubber cap. As the combustion proceeds, the bathing-cap, after its initial rise, begins to sink and at the end of the combustion has fallen considerably. Cold water is then passed through the cooling pipe to bring the temperature of the apparatus to its initial level. When the temperature has again reached equilibrium, the cold water in the cooling pipe should be removed, as otherwise it would result in overcooling the apparatus. The valve, V, is, therefore, turned in the proper direction so that air can enter the pipe, and the cold water is rapidly siphoned out of the cooling pipe.

When temperature equilibrium has been established, a sufficient amount of moist air must be introduced into the apparatus to bring the bathing-cap back to its original level. This includes the introduction of the amount temporarily withdrawn to provide for the expansion of the cap. Indeed, the amount withdrawn is usually replaced immediately after the combustion begins, when there is no obvious tension on the cap. The volume of air introduced can be measured by means of a spirometer or a wet gas meter, but it is far simpler to use a pump such as that employed in the Nutrition Laboratory, which has played an important role in the development of the student and the field respiration apparatus.[1] This pump is a simple hand pump which delivers almost exactly 370 c.c. of air with each complete stroke. The number of whole pumpfuls introduced and the fraction of a pumpful to bring the button on the bathing-cap to its original position give a measure of the total apparent volume of oxygen absorbed during the combustion.

In the original student respiration apparatus dry air was introduced by the pump into the can, to note how much oxygen had been consumed by the subject. More recently we have found that moist air is preferable and simplifies the calculations. If continued, repeated combustions are to be made, the oxygen absorbed from the closed system may be replaced by oxygen which has previously been stored in a football bladder. The football bladder is attached to the nozzle of an oxygen cylinder and filled with oxygen. The pump is then connected with this bladder, oxygen is drawn into the pump, and with proper turning of the 3-way petcock at the base of the soda-lime container as many pumpfuls or fractions of a pumpful of oxygen as are necessary may be rapidly delivered into the apparatus. A few centimeters of water in the rubber bag insure complete saturation of the oxygen.

The calculation of the oxygen absorbed during the combustion is based upon the number of full pump strokes and any fraction of a stroke required to bring the bathing-cap back to its original position,[2] the volume of a complete pumpful (about 370 c.c.), the volume per

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[1] See footnotes 1 and 2 on p. 7 of this report.

[2] Not including the pumpful withdrawn temporarily to prevent undue expansion of the bathing-cap at the moment of combustion and subsequently returned to the apparatus.

millimeter length of stroke[1], the temperature of the barrel of the pump (which should not be touched with the hand), the prevailing atmospheric pressure, and the assumption that the gas is completely saturated with water vapor. The calculation may be expressed by the formula:

$$V = \frac{(L \times K \times M) - 5}{W}$$

in which all the factors except L and K are the same as those described for the formula on page 11. L is the total length of the full strokes and any fraction of a stroke made with the pump, expressed in millimeters and obtained by multiplying the length of the pump stroke in millimeters (as a rule precisely 200 mm.) by the total number of pump strokes.[2] K is the number of cubic centimeters represented by each millimeter length of stroke, based upon the internal diameter of the pump. Since moist oxygen is introduced into the system, the factor M is derived from Carpenter's standard tables[3] for reduction of saturated volumes, based upon the average temperature of the pump barrel and the observed barometric pressure. The correction for nitrogen liberated during the combustion is the same as explained on page 11.

In one of the earlier descriptions of the oxy-calorimeter[4] it was stated that the combustion chamber could likewise be attached to the forms of respiration apparatus having the soda-lime container inside the spirometer. We now question the advisability of using such forms of respiration apparatus for this purpose, since internal or external cooling of these apparatus is impracticable. Combustions with such a set-up will, however, give approximate energy values, and these types of respiration apparatus may be used with reasonable accuracy if a correction factor is established by a standardization test with pure sugar.

## METHOD OF SAMPLING

The sampling of edible waste of mixed meals and of individual meals was carried out in the same manner as outlined in our earlier report.[5] In so far as possible all the edible waste of food that had been prepared to serve at the table was collected. This collection did not include kitchen refuse, inedible portions that would not be served on the table, and uneaten foods such as butter that could subsequently be used in cooking. It did, however, include both plate scrapings and the edible waste of the cooked foods discarded in the kitchen. The plates returned to the kitchen and the kitchen utensils were carefully scraped, but undoubtedly a small amount of food material adhered to the plates and to some of the cooking dishes and was not removed. Our calcula-

[1] Computed from the length of the piston stroke, 200 mm., and the internal diameter of the pump, usually about 48.5 mm.; corresponding to a volume of 1.848 c. c. per mm. length of stroke.

[2] Not including the pumpful withdrawn temporarily to prevent undue expansion of the bathing-cap at the moment of combustion and subsequently returned to the apparatus.

[3] Carpenter, T. M., **loc. cit.**

[4] Benedict, F. G., and E. L. Fox, Journ. Biol. Chem., 1925, **66**, p. 783.

[5] Benedict and Farr, **loc. cit.**

tions of the amounts of total waste are, therefore, somewhat smaller than the true amounts. The edible waste, as thus collected, was placed in a previously weighed container. When single or mixed meals were to be studied, an exact duplicate of the meal or meals eaten by the individual was placed in the weighed container. These samples of meals included all foods eaten except bread, butter, and the beverage served, which was usually tea, coffee, milk, or cocoa. This mixture was then dried at a temperature not above that of boiling water until it became seemingly dry. In the case of fatty mixtures, stirring with a previously weighed knife or rod was necessary during the drying process. When the material had practically ceased to lose weight, it was allowed to stand in the air of the room for several days until moisture equilibrium with the room air was established and the weight of the material remained approximately constant. This so-called "air-dry" material was used in all the combustions with the oxy-calorimeter, and hence all the derived energy calculations have been based upon weights of air-dry material. The exact quantity of water contained in the different air-dry samples is not known, but for our special purpose this knowledge is not necessary. In general, the moisture content was probably between 5 and 10 per cent.

## DISCUSSION OF RESULTS

In the tables to be discussed in the following pages we have given the sample number, a general description of the nature of the food analyzed, the air-dry weight of the sample, the total protein content in grams, the energy content per gram of air-dry matter, and the total calories in the sample. The energy values were obtained as explained in our earlier report.[1] Thus, the measured volume of oxygen consumed per gram of air-dry matter was reduced to standard conditions of temperature and pressure and corrected for the amount of nitrogen liberated per gram of air-dry matter during the combustion. This corrected oxygen value was then multiplied in most instances by the factor 4.825, the caloric value of a liter of oxygen when mixed foods are burned. At times excessively fat samples were burned. These will be specially commented upon in the tables. So far as the accuracy of the above calculations is concerned, the exact composition of the material burned plays no role, however, except when residues of an obviously fatty nature are found. In these instances we have felt it more justifiable to employ the factor 4.7 to represent the caloric value of a liter of oxygen, rather than the conventional value of 4.825 used for all mixed foods.

## STUDY OF EDIBLE WASTE IN A FRATERNITY HOUSE

In Table 1 are presented the results of analyses of edible waste collected at a fraternity house during a period of seven days. Samples were collected at each meal and brought to the laboratory daily for analysis. The foods listed in the second column represent those recognizable portions of food included in the samples. No attempt was

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[1] Benedict and Farr, **loc. cit.**

made to determine the relative amounts of each food ingredient contained in the sample, and the items are listed in Table 1 only to show the variety of foods included in the waste. Samples 749 and 750 each contained a small amount of food prepared for previous meals but not eaten, and discarded from the kitchen. Samples 751, 754, 755, and 757 were distinctly kitchen waste, that is, portions of food that had neither been served nor utilized in "left overs". All the other samples represent only the plate scrapings of served foods.

TABLE 1.—*Analyses of edible waste at a fraternity house during a period of seven days*

| Sample No. | Foods in sample | Air-dry weight | Protein in sample | Calories | |
|---|---|---|---|---|---|
| | | | | Total in sample | Per gm. air-dry matter |
| | | gm. | gm. | | |
| 740 | Cereal, coffee, toast | 124 | 17.8 | 615 | 5.0 |
| 741 | Bread, meat, pudding, vegetables | 519 | 105. | 2,820 | 5.4 |
| 742 | Baked beans, salt pork, cake | 473 | 49.9 | 2,570 | 5.4 |
| 743 | Bread, coffee, meat, salt pork, vegetables | 166 | 49.3 | [1] 1,080 | [1] 6.5 |
| 744 | Breads, milk | 191 | 18.3 | 870 | 4.6 |
| 745 | Toast, beans, salt pork | 217 | 28.0 | 1,200 | 5.5 |
| 746 | Bread, meat, potato, pudding | 514 | 71.3 | 2,490 | 4.9 |
| 747 | Biscuit, potato | 80 | 13.3 | 426 | 5.3 |
| 748 | Bread, coffee, meat, vegetables, pie | 493 | 111. | 2,860 | 5.8 |
| 749 | Cereal, toast, pudding | 313 | 38.5 | 1,380 | 4.4 |
| 750 | Cereal, bread, salad, corn fritter | 329 | 32.8 | 1,570 | 4.8 |
| 751A | Meat, Indian pudding, white sauce | 802 | 161. | 4,600 | 5.7 |
| 751B Fat | | 107 | 0.3 | [1] 1,000 | [1] 9.3 |
| 752 | Bread, meat, potato, spaghetti | 636 | 130. | 3,390 | 5.3 |
| 753 | Toast | 55 | 5.7 | 257 | 4.6 |
| 754 | Kidney beans | 95 | 18.0 | 429 | 4.5 |
| 755 | Spaghetti with tomato | 113 | 14.1 | 453 | 4.0 |
| 757 | Creamed chipped beef | 170 | 56.1 | 963 | 5.7 |
| 756 | Bread, pudding, creamed chipped beef, vegetables | 670 | 108. | 3,220 | 4.8 |
| 758 | Lettuce, meat, potato, pie | 764 | 181. | 4,090 | 5.4 |
| 759 | Lettuce, cakes, bread | 246 | 16.8 | 1,100 | 4.5 |
| 760 | Bread, meat, vegetables | 510 | 106. | 2,690 | 5.3 |
| 761 | Bread, coffee | 138 | 16.3 | 740 | 5.4 |
| 762 | Meat, rice, tomato, potato, pie | 700 | 103. | 3,240 | 4.6 |
| 763 | Fish, pineapple, potato, tomato | 435 | 115. | 2,100 | 4.8 |
| Total | | ... | 1,570. | 46,200 | ... |
| Average | | ... | ..... | ...... | [2] 5.0 |

[1] Visible fat in sample; hence caloric value of a liter of oxygen estimated as 4.7 instead of 4.825 cals. as in case of other samples.

[2] Not including Samples 743 and 751B.

Meals at the fraternity house were prepared by a cook and served from the kitchen. During this period of seven days, 94 breakfasts, 164 dinners, and 156 suppers, or a total of 414 meals were served. Four or five of the men ate breakfast at some restaurant, and a few others regularly went without breakfast. The total waste per man per day can, therefore, not be computed, but only the average waste per meal. Since 414 meals were eaten and the total amount of food wasted contained 1570 grams of protein and 46,200 calories, the average energy content of the edible waste per meal would be 112 calories and the average protein content 3.8 grams. In this particular study no samples of the meals as served were obtained. An inventory was, however, made of all the food supplies purchased and used at the fraternity house during this week. This inventory included any kitchen refuse and table waste. Calculation from standard tables of food values shows that the food listed in this inventory as purchased and used during the week contained approximately 430,000 calories and 16,000 grams of protein. The edible waste of the prepared food, therefore, contained about 11 per cent of the energy and 10 per cent of the protein of the purchased food.

The energy per gram of air-dry matter in the various samples listed in Table 1 is fairly uniform. A considerable amount of salt pork was included in Sample 743, and the energy content per gram of air-dry matter was high, 6.5 calories. During the time that Sample 751 was being dried, a large amount of fat rose to the surface and prevented further evaporation. This was removed and analyzed as a separate sample (751B). There were in this sample 107 grams of visible fat, nearly one-eighth of the entire weight, that could be skimmed off and analyzed separately, and the energy value of this fat was 9.3 calories per gram. When the caloric value per gram of air-dry weight is found by actual combustion to be materially above 5, therefore, it is logical to reason that there is an excessive amount of fat present in the edible waste. The energy values of the other samples range only from 4.0 to 5.8 calories per gram of air-dry matter. The average value, if Samples 743 and 751B are excepted, is 5.0 calories. If the two fat samples were included, without weighting in proportion to the actual weight of the air-dry matter, the average would be raised to 5.3 calories. From the study at this particular fraternity house, therefore, it may be inferred that the caloric value per gram of air-dry matter of the average edible waste from mixed foods is 5.0 calories.

## STUDY OF EDIBLE WASTE AND OF MIXED MEALS IN SORORITY HOUSE S-1

In one of the two sorority houses where observations were made and which we are calling House S-1 for purposes of reference, fourteen young women and a house mother ate regularly. Meals were prepared by a student instead of a professional cook, and the food was placed on the table in serving dishes, each girl helping herself to a variable quantity as suited her particular preference. Unused portions were left in the pantry for between-meal lunches. The edible waste at House S-1 was collected for a period of two weeks. The girls were asked to save not only plate scrapings but also edible cooked food that remained in the cooking or serving dishes and that would ordinarily be discarded. Because of the economical use of "left overs" for cooking and for lunches between meals, little was included, however, in the collection of waste except plate scrapings. The results of the analyses of the various samples obtained during the two-week period are given in Table 2. With the exception of Sample 726, which contained tough meat and some pudding, the waste samples represented only plate scrapings. Any waste not included in the samples would be the small amounts remaining on cooking dishes or discarded with refuse in the process of preparation. Butter left on the table was used in cooking. Fruit skins and other inedible waste were not included in the samples, except in the case of baked potato skins. As baked potatoes were served frequently, the skins were brought to the laboratory in order that any appreciable amounts of edible potato might be dried with the samples.

Table 2.—*Analyses of edible waste at Sorority House S-1 during a period of two weeks*

| Sample No. | Foods in sample | Air-dry weight | Protein in sample | Calories | |
|---|---|---|---|---|---|
| | | | | Total in sample | Per gm. air-dry matter |
| | | gm. | gm. | | |
| 700 | Apple sauce, chowder, meat, potato, toast | 190 | 31.4 | 951 | 5.0 |
| 704 | Meat, prunes, potato, pudding, salad, relish, coffee | 316 | 33.9 | 1,750 | 5.5 |
| 707 | Bread, chowder, potato | 226 | 26.4 | 967 | 4.3 |
| 712 | Bread, macaroni, potato, pudding, tomato | 204 | 31.8 | 898 | 4.4 |
| 716 | Potato, miscellaneous | 315 | 57.3 | 1,760 | 5.6 |
| 720 | Bread, fat from meat, macaroni, spinach, potato | 136 | 20.0 | 737 | 5.4 |
| 723 | Pudding, miscellaneous | 131 | 10.3 | 541 | 4.2 |
| 726 | Beef, muffins, pudding | 553 | 160.0 | 3,020 | 5.5 |
| 729 | Muffins, prunes, rice | 145 | 14.7 | 683 | 4.7 |
| 731 | Meat, potato | 266 | 111.0 | 1,250 | 4.7 |
| 734 | Bread, rice | 206 | 34.6 | 1,030 | 5.0 |
| 737 | Breads, stew | 192 | 31.2 | 963 | 5.0 |
| Total | | ... | 563. | 14,550 | ... |
| Average | | ... | ..... | ...... | 4.9 |

During the fourteen days when waste samples were collected, 201 breakfasts, 176 lunches, and 184 dinners, or a total of 561 meals were served. On the two Sundays no lunch was served, dinner being in the afternoon. The students were expected to help themselves to anything in the pantry during the evening. On one evening a banquet was held outside the house for which no samples were obtained. As can be seen from Table 2, during these 561 meals a total of 563 grams of protein and 14,550 calories were wasted. This corresponds to a waste per meal of 1 gram of protein and 26 calories. Calculation of the total energy and the total protein content of the food purchased and used at House S-1, according to an inventory made during this two-week period, gave approximate values of 440,000 calories and 14,000 grams of protein. This inventory included any kitchen refuse and table waste but did not include the sample meals taken to the laboratory for analysis. The total amount of prepared food that was wasted, therefore, represented only 3 per cent of the energy content and 4 per cent of the protein content of the purchased food served. From these data it would appear as if there was much less waste of food by the young women in House S-1 than by the young men in the fraternity house. This is perhaps explained by the fact that this particular group of women was a small, newly organized group who were trying to keep the expenses of their house at a minimum. Moreover, they were free to eat left-over foods found in the pantry and had less spending money to buy sweets and other extra foods than some of the other groups of students.

The average factor, 4.9, for the calories per gram of air-dry matter in the edible waste at Sorority House S-1 is nearly identical with that found for the waste at the fraternity house.

At House S-1 duplicate, composite samples were obtained of the lunches and dinners served on most of the days during the same two-week period when waste samples were secured. The lunch and dinner for each day were placed in a weighed container and dried together. A duplicate lunch and dinner for the same day were dried in a second container. The samples were saved by a student who worked in the kitchen and waited on table, and were in her estimation representative of the average helpings of the various foods taken by any one girl from the different serving dishes. The results are given in Table 3. Sample 702 contained two lunches, and Sample 703 two dinners, due to error. Samples 714 and 715 on January 18 each contained one lunch only. No dinner samples could be obtained on that day because of unexpected guests. No samples were collected on January 17 and 19 for the same reason. Samples 738 and 739 each represent one dinner only, since January 26 was a Sunday and no lunch was served on Sunday. The results of the analyses on January 18 and 26 have not been included in averaging the data for the protein and the caloric content of the combined lunch and dinner samples. These meal samples included bread but no butter or beverage. Breakfasts at House S-1 consisted simply of fruit, coffee, muffins, and butter. Prepared cereal was kept in the pantry, but was rarely requested. Little milk was consumed as a beverage at any meal. This study shows that, on the ten days when both lunch and dinner samples were secured on the same day (that is, excluding January 18 and 26), these young women obtained on the average in their lunch and dinner each day 44 grams of protein and 1200 calories per person, exclusive of butter and beverage. These amounts might have been increased by second helpings, no records of which were kept. Absence of samples for the breakfast makes comparison with the data regarding the total waste difficult. The calories per gram of air-dry matter in the lunches and dinners averaged 4.7.

*Uniformity in duplicate sampling.* On nine of the days listed in Table 3 duplicate samples, representing a combination of lunch and dinner, were secured. A comparison may, therefore, be made of the analyses of these duplicate samples to determine whether there was uniformity in the sampling. Comparison of the total energy and the total protein content in the duplicate samples on these nine days can be made by inspection of the detailed data in the fifth and seventh columns of Table 3, but for convenience these values have been summarized in Table 4. One sees that on the whole the duplicate samples had much the same energy and protein content. In only a few instances do the values for duplicate samples differ appreciably. Thus, on January 21 the protein content was 50.8 and 43.3 grams, respectively, in the two samples and the energy content 1250 and 1190 calories; that is, the

TABLE 3.—*Analyses of combined samples of lunch and dinner at Sorority House S-1 during same two weeks when waste samples were collected*

| Sample No.[1] | Date | Foods in combined lunch and dinner | Air-dry weight | Protein |  | Calories |  |  |
|---|---|---|---|---|---|---|---|---|
|  |  |  |  | In each sample | Average of duplicate samples | In each sample | Average of duplicate samples | Per gram air-dry weight |
|  |  |  | gm. | gm. | gm. |  |  |  |
| [2] 702 | Jan. 13 | Hash, bread, custard pudding | 135 | [2] 15.1 | 25.4 | [2] 733 | 1,210 | 5.4 |
| [3] 703 |  | Pressed ham, apple sauce, potato, bread, orange tapioca pudding | 118 | [3] 10.3 |  | [3] 474 |  | 4.0 |
| 705 | Jan. 14 | Scrambled egg with ham, creamed potato, whole wheat bread, rice pudding. Corned beef, potato, salad, whole wheat bread, peaches | 270 | 51.4 | 51.1 | 1,260 | 1,260 | 4.7 |
| 706 |  | Duplicate of sample 705 | 265 | 50.8 |  | 1,250 |  | 4.7 |
| 708 | Jan. 15 | Corn chowder, bread, apple pan dowdy. Hash, baked potato, carrots, whole wheat bread, pear sauce, cookie | 252 | 35.2 | 36.2 | 1,160 | 1,180 | 4.6 |
| 709 |  | Duplicate of Sample 708 | 264 | 37.2 |  | 1,200 |  | 4.6 |
| 710 | Jan. 16 | Creamed asparagus on toast, chocolate bread pudding. Salmon loaf, potato, bread, peas, gingerbread | 220 | 41.4 | 41.4 | 978 | 1,000 | 4.5 |
| 711 |  | Duplicate of Sample 710 | 232 | 41.4 |  | 1,030 |  | 4.4 |
| [4] 714 | Jan. 18 | Salmon loaf, whole wheat bread, chocolate cornstarch pudding | 123 | [4] 42.7 | [6] 40.7 | [4] 606 | [6] 590 | 4.9 |
| [4] 715 |  | Duplicate of Sample 714 | 115 | [4] 38.6 |  | [4] 573 |  | 5.0 |
| 718 | Jan. 20 | Macaroni, tomato, cheese, whole wheat bread, peach custard. Ham, potato, spinach, jelly tart | 221 | 38.5 | 37.7 | 1,010 | 976 | 4.6 |
| 719 |  | Duplicate of Sample 718 | 209 | 36.8 |  | 942 |  | 4.5 |
| 721 | Jan. 21 | Creamed salmon on toast, peas, rice pudding. Hash, potato, string beans, celery, bread, cookies | 255 | 50.8 | 47.1 | 1,250 | 1,220 | 4.9 |
| 722 |  | Duplicate of Sample 721 | 251 | 43.3 |  | 1,190 |  | 4.7 |
| 724 | Jan. 22 | Bacon, creamed potato, bread, pudding. Roast beef, baked potato, mixed vegetables, bread, fruit cup | 232 | 49.1 | 53.5 | 1,150 | 1,250 | 4.9 |
| 725 |  | Duplicate of Sample 724 | 254 | 57.8 |  | 1,340 |  | 5.3 |
| 727 | Jan. 23 | Rice with tomato and bacon, bread, coffee cornstarch pudding. Lamb, baked potato, lima beans, whole wheat bread, sliced peaches | 257 | 53.3 | 53.0 | 1,220 | 1,200 | 4.7 |
| 728 |  | Duplicate of Sample 727 | 252 | 52.6 |  | 1,180 |  | 4.7 |
| 732 | Jan. 24 | Cole slaw, bread, chocolate bread pudding. Pot roast, vegetable, gravy, baked potato, bread, gingerbread | 260 | 48.9 | 49.7 | 1,290 | 1,300 | 5.0 |
| 733 |  | Duplicate of Sample 732 | 264 | 50.4 |  | 1,300 |  | 4.9 |
| 735 | Jan. 25 | Stew of vegetables and meat, whole wheat bread, loganberry shortcake. Baked beans, brown bread, cake | 311 | 45.2 | 45.5 | 1,400 | 1,440 | 4.5 |
| 736 |  | Duplicate of Sample 735 | 320 | 45.7 |  | 1,470 |  | 4.6 |
| [5] 738 | Jan. 26 | Meat, squash, potato, whole wheat bread, fruit jelly, custard sauce | 106 | [5] 23.4 | [6] 22.8 | [5] 507 | [6] 469 | 4.8 |
| [5] 739 |  | Duplicate of sample 738 | 92 | [5] 22.2 |  | [5] 430 |  | 4.7 |
| ...... | ......... | Average | ... | ..... | [6] 44.1 | ..... | [6] 1,200 | 4.7 |

[1] Each sample included one lunch and one dinner, unless otherwise stated.
[2] This sample included two lunches, and no dinner.
[3] This sample included two dinners and no lunch.
[4] Sample of one lunch only. Dinner sample could not be obtained because of guests.
[5] Sample of one dinner only. No lunch served, because of Sunday.
[6] Samples on January 18 and 26 not included in average.

TABLE 4.—*Comparison of analyses of duplicate samples of lunch and dinner at Sorority House S-1*

| Sample Nos. | Date | Calories | | Protein (gm.) | |
|---|---|---|---|---|---|
| | | Sample 1 | Sample 2 | Sample 1 | Sample 2 |
| 705 and 706 | Jan. 14 | 1,260 | 1,250 | 51.4 | 50.8 |
| 708 and 709 | Jan. 15 | 1,160 | 1,200 | 35.2 | 37.2 |
| 710 and 711 | Jan. 16 | 978 | 1,030 | 41.4 | 41.4 |
| 718 and 719 | Jan. 20 | 1,010 | 942 | 38.5 | 36.8 |
| 721 and 722 | Jan. 21 | 1,250 | 1,190 | 50.8 | 43.3 |
| 724 and 725 | Jan. 22 | 1,150 | 1,340 | 49.1 | 57.8 |
| 727 and 728 | Jan. 23 | 1,220 | 1,180 | 53.3 | 52.6 |
| 732 and 733 | Jan. 24 | 1,290 | 1,300 | 48.9 | 50.4 |
| 735 and 736 | Jan. 25 | 1,400 | 1,470 | 45.2 | 45.7 |
| Average | ...... | 1,190 | 1,210 | 46.0 | 46.2 |

values were larger for the first than for the second sample. On January 22 the reverse is true, the protein and the energy values being lower for the first than for the second sample. However, although on these two dates the duplicate samples varied as much as 15 per cent in their protein and energy content, in general the energy and the protein values agree satisfactorily. The average energy values are 1190 and 1210 calories and the average protein values 46.0 and 46.2 grams for the first and the second samples, respectively, indicating that the sampling was remarkably uniform.

## STUDY OF MIXED MEALS AND OF EDIBLE WASTE IN SORORITY HOUSE S-2

In the second sorority house, S-2, the experimental procedure was altered somewhat so that the food value of each meal, lunch and dinner, could be obtained separately. Duplicate samples of the lunches and dinners served at this sorority house were collected every day for nearly a month. One lunch and one dinner each day were dried separately. Second samples of lunch and dinner were combined and analyzed together. In a sense, therefore, the data secured on the combined samples serve as a check on the analyses of the separate samples. In Table 5 are reported the results for the separate meals, the first sample on any given day representing the lunch and the second the dinner. In Table 6 are given the data for the combined samples, and hence there is but one sample number for each day. Butter and beverage were not included in these meal samples. Record of the food consumption of four individuals at this sorority house showed that they did not always eat bread with these meals. Therefore, no bread was dried in the samples except for the brown bread in the dinners on May 4, 11, and 18. But before the samples were ground, a weighed amount of analyzed whole wheat bread (the equivalent of one slice) was added to each sample except those containing brown bread. Because of this procedure the food value of the meals *with* breadstuff has been determined, and the caloric values of the air-dry material, as reported in Tables 5 and 6, may be considered comparable to those of the meals from House S-1 (in which

TABLE 5.—*Analyses of separate samples of lunch and dinner at Sorority House S-2*

| Sample No.[1] | Date | Foods in lunch or dinner [2] | Air-dry weight | PROTEIN | | CALORIES | | |
|---|---|---|---|---|---|---|---|---|
| | | | | In each sample | Total in two meals | In each sample | Total in two meals | Per gram air-dry matter |
| | | | gm. | gm. | gm. | | | |
| 501 | Apr. 29 | Asparagus on toast, creamed potato, apricots, cookie | 102 | 11.6 | 42.5 | 441 | 1,140 | 4.3 |
| 502 | | Hamburg, tomato sauce, potato, peas, chocolate pudding | 146 | 30.9 | | 700 | | 4.8 |
| 509 | Apr. 30 | Tongue, scalloped potato, doughnut, cheese | 105 | 15.7 | 33.0 | 528 | 890 | 5.0 |
| 510 | | Ham, potato, spinach, pineapple | 92.5 | 17.3 | | 362 | | 3.9 |
| 516 | May 1 | Crabmeat and potato salad with lettuce and mayonnaise, bread pudding with whipped cream | 128 | 24.8 | 42.3 | 646 | 1,380 | 5.1 |
| 517 | | Lamb, potato, string beans, cucumber salad, steamed pudding | 143 | 17.5 | | 737 | | 5.2 |
| 526 | May 2 | Chicken pie with vegetables, cottage pudding | 112 | 12.3 | 26.8 | 529 | 996 | 4.7 |
| 527 | | Minced lamb on toast, pear, cheese and nut salad | 85.5 | 14.5 | | 467 | | 5.5 |
| 530 | May 3 | Corn chowder, pickles, crackers, peaches, frosted cake | 159 | 13.4 | 46.0 | 640 | 1,420 | 4.0 |
| 531 | | Salmon, lemon sauce, potato, tomatoes, strawberry shortcake | 158 | 32.6 | | 780 | | 4.9 |
| 535 | May 4 | Tomato and egg salad, fried potatoes, caramel pudding | 94.4 | 12.5 | 38.4 | 484 | 1,780 | 5.1 |
| 536 | | Baked beans, brown bread, frankfurts, orange layer cake | 261 | 25.9 | | 1,300 | | 5.0 |
| [3] 538 | May 5 | Swiss steak, parsley potatoes, beets, tapioca cream | 83.8 | 18.2 | ... | 381 | ... | 4.6 |
| 541 | May 6 | Creamed salmon and peas on crackers, butterscotch pudding | 116 | 18.5 | 38.8 | 540 | 1,110 | 4.7 |
| 542 | | Casserole of beef and vegetables, potato, rice pudding | 128 | 20.3 | | 570 | | 4.4 |
| 545 | May 7 | Potato salad, baked beans, orange tapioca | 120 | 13.3 | 24.3 | 521 | 1,230 | 4.4 |
| 546 | | Carrots, string beans, dandelion greens, beets, potato, mince pie | 159 | 11.0 | | 712 | | 4.5 |
| 553 | May 8 | Spaghetti, beef and vegetable casserole, pineapple, cheese and nut salad | 96.9 | 14.5 | 34.2 | 448 | 1,180 | 4.6 |
| 554 | | Sausage, tomatoes, baked potatoes, bread pudding | 166 | 19.7 | | 739 | | 4.5 |
| 557 | May 9 | Frankfurts in tomato sauce, creamed potato, peach, cake | 132 | 16.3 | 39.7 | 651 | 1,280 | 4.9 |
| 558 | | Lamb, lima beans, potato, asparagus on toast, strawberry shortcake | 137 | 23.4 | | 629 | | 4.6 |
| 563 | May 10 | Creamed crabmeat on toast, pear and nut salad | 93.9 | 16.8 | 54.2 | 464 | 1,250 | 5.0 |
| 564 | | Fried halibut, tartar sauce, potato, peas, chocolate pudding | 160 | 37.4 | | 790 | | 5.0 |

TABLE 5.—*Analyses of separate samples of lunch and dinner at Sorority House S-2*—(*Continued*)

| Sample No.[1] | Date | Foods in lunch or dinner [2] | Air-dry weight | Protein | | Calories | | |
|---|---|---|---|---|---|---|---|---|
| | | | | In each sample | Total in two meals | In each sample | Total in two meals | Per gram air-dry matter |
| | | | gm. | gm. | gm. | | | |
| 567 | May 11 | Spaghetti with tomato, tapioca pudding | 114 | 13.4 | 51.4 | 506 | 1,520 | 4.5 |
| 568 | | Baked beans, brown bread, corn beef loaf, blueberry pie | 200 | 38.0 | | 1,010 | | 5.0 |
| [3] 569 | May 12 | Pork chops, baked potatoes, string beans, fruit cup | 126 | 23.7 | .... | 637 | ..... | 5.1 |
| 573 | May 13 | Vegetable salad, chocolate pudding | 107 | 12.1 | 36.6 | 499 | 1,300 | 4.7 |
| 574 | | Pot roast, potato, tomatoes, gravy, rice pudding | 153 | 24.5 | | 803 | | 5.3 |
| 580 | May 14 | Goldenrod toast, rhubarb sauce, cake | 115 | 11.7 | 42.9 | 481 | 1,220 | 4.2 |
| 581 | | Swiss steak, baked potato, succotash, strawberry shortcake | 166 | 31.2 | | 734 | | 4.4 |
| 585 | May 15 | Meat loaf, baked beans, creamed potato, pear sauce | 162 | 34.3 | 57.7 | 773 | 1,410 | 4.8 |
| 586 | | Ham, potato, cabbage, banana pie | 130 | 23.4 | | 639 | | 4.9 |
| 590 | May 16 | Shrimp wiggle, jam tarts | 90.0 | 14.3 | 57.5 | 431 | 1,480 | 4.8 |
| 591 | | Lamb, potato, peas, pineapple salad, ice cream | 205 | 43.2 | | 1,050 | | 5.1 |
| 595 | May 17 | Baked mackerel, potatoes, beets, chocolate pudding | 162 | 29.8 | 45.5 | 804 | 1,270 | 5.0 |
| 596 | | Fish hash, cucumber and tomato salad, raspberry jello | 98.5 | 15.7 | | 462 | | 4.7 |
| 598 | May 18 | Crabmeat stew, pear sauce | 78.5 | 13.6 | 54.4 | 369 | 1,320 | 4.7 |
| 599 | | Beans, brown bread, cold meat, cake | 211 | 40.8 | | 951 | | 4.5 |
| [3] 600 | May 19 | Roast veal, lima beans, potato, ice cream | 143 | 38.8 | .... | 694 | ..... | 4.8 |
| 607 | May 20 | Corned beef, scalloped tomatoes, baked beans, fruit cup | 137 | 26.0 | 53.1 | 597 | 1,310 | 4.4 |
| 608 | | Hamburg, potato, spinach, tomato sauce, cottage pudding | 158 | 27.1 | | 714 | | 4.5 |
| 614 | May 21 | Noodle soup, banana salad | 72.6 | 11.9 | 36.5 | 308 | 847 | 4.2 |
| 615 | | Lamb casserole, potato, prune whip | 122 | 24.6 | | 539 | | 4.4 |
| 617 | May 22 | Ham hash, poached egg, butterscotch pudding, cream | 110 | 28.2 | 45.4 | 569 | 1,390 | 5.2 |
| 618 | | Roast pork, potato, gravy, string beans, asparagus salad, strawberry shortcake | 168 | 17.2 | | 819 | | 4.9 |
| 621 | May 23 | Cream of tomato soup, cake, sauce | 169 | 15.1 | 49.1 | 711 | 1,410 | 4.2 |
| 622 | | Corned beef, cabbage, potato, gingerbread with whipped cream | 143 | 34.0 | | 697 | | 4.9 |

TABLE 5.—*Analyses of separate samples of lunch and dinner at Sorority House S-2*—(*Concluded*)

| Sample No.[1] | Date | Foods in lunch or dinner [2] | Air-dry weight | PROTEIN |  | CALORIES |  |  |
|---|---|---|---|---|---|---|---|---|
|  |  |  |  | In each sample | Total in two meals | In each sample | Total in two meals | Per gram air-dry matter |
|  |  |  | gm. | gm. | gm. |  |  |  |
| 625 | May 24 | Creamed salmon with peas on toast, pineapple and cheese salad | 103 | 15.2 | 41.4 | 492 | 1,040 | 4.8 |
| 626 |  | Mackerel, potato. beets, tapioca pudding.................... | 123 | 26.2 |  | 546 |  | 4.5 |
| 628 | May 25 | Vegetable salad, pear sauce, cake......................... | 109 | 7.9 | 27.7 | 464 | 986 | 4.3 |
| 629 |  | Baked beans, orange pudding.............................. | 119 | 19.8 |  | 522 |  | 4.4 |
| [3] 630 | May 26 | Meat loaf, with tomato sauce, potatoes, lima beans, cucumbers, ice cream................................................ | 161 | 31.4 | .... | 815 | ..... | 5.1 |
| Average | ......... | ........................................................ | ..... | .... | 42.5 | ..... | 1,260 | 4.7 |

[1] The first sample on each date represents a lunch and the second a dinner.

[2] One slice of whole wheat bread was included in each sample except Nos. 536, 568, and 599.

[3] Dinner sample. No lunch served as it was Sunday.

bread was included) and to the values reported by us in our first publication.[1]

Inspection of Table 5 indicates that the difference between the amount of food eaten in general at the noon meal or lunch and that at the second meal or dinner is by no means uniform, so far as the air-dry weight, the protein content, and the energy content are concerned. In the majority of cases the values for the lunch are lower than those for the dinner, and yet there are a number of instances, such as on April 30, May 2, and May 17, where the reverse is true. Thus, on May 17 the lunch contained 30 grams of protein and 804 calories, whereas the dinner contained but 16 grams of protein and 462 calories. In such instances the main meal was served at noon, because the cook was to be absent in the afternoon. It is clear that the mere designation of a meal as lunch or dinner does not in itself serve to indicate whether the meal was a light or a heavy one. On the average, in these two meals together these women students received 42.5 grams of protein and 1260

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[1] Benedict and Farr, loc. cit.

TABLE 6.—*Analyses of composite samples of lunch and dinner at Sorority House S-2*

(Duplicates of meals analyzed separately—See Table 5)

| Sample No. | Date | Meals in sample [1] | Air-dry weight | Protein in sample | Calories | |
|---|---|---|---|---|---|---|
| | | | | | Total in sample | Per gm. air-dry matter |
| | | | gm. | gm. | | |
| 500 | Apr. 29 | Lunch and dinner....... | 249 | 41.3 | 1,160 | 4.7 |
| 508 | 30 | Lunch and dinner....... | 185 | 35.0 | 811 | 4.4 |
| 515 | May 1 | Lunch and dinner....... | 239 | 39.6 | 1,150 | 4.8 |
| 525 | 2 | Lunch and dinner....... | 197 | 26.0 | 1,000 | 5.1 |
| 529 | 3 | Lunch and dinner....... | 276 | 39.9 | 1,240 | 4.5 |
| 534 | 4 | Lunch and dinner ...... | 310 | 36.6 | 1,530 | 4.9 |
| 539 | 5 | Dinner [2]............... | 86.9 | 17.9 | 404 | 4.7 |
| 540 | 6 | Lunch and dinner....... | 229 | 41.0 | 1,050 | 4.6 |
| 544 | 7 | Lunch and dinner....... | 272 | 25.3 | 1,180 | 4.3 |
| 552 | 8 | Lunch and dinner....... | 241 | 25.9 | 1,100 | 4.6 |
| 556 | 9 | Lunch and dinner....... | 258 | 41.1 | 1,240 | 4.8 |
| 562 | 10 | Lunch and dinner....... | 244 | 48.7 | 1,170 | 4.8 |
| 566 | 11 | Lunch and dinner....... | 275 | 38.6 | 1,340 | 4.9 |
| 570 | 12 | Dinner [2]............... | 119 | 20.6 | 579 | 4.9 |
| 572 | 13 | Lunch and dinner....... | 248 | 35.2 | 1,190 | 4.8 |
| 579 | 14 | Lunch and dinner....... | 273 | 42.5 | 1,170 | 4.3 |
| 584 | 15 | Lunch and dinner....... | 299 | 58.6 | 1,440 | 4.8 |
| 589 | 16 | Lunch and dinner....... | 283 | 53.3 | 1,340 | 4.7 |
| 594 | 17 | Lunch and dinner....... | 259 | 47.1 | 1,240 | 4.8 |
| 597 | 18 | Lunch and dinner...... | 313 | 50.9 | 1,430 | 4.6 |
| 601 | 19 | Dinner [2]............... | 144 | 35.7 | 690 | 4.8 |
| 606 | 20 | Lunch and dinner....... | 277 | 59.0 | 1,260 | 4.5 |
| 613 | 21 | Lunch and dinner ... | 193 | 36.4 | 852 | 4.4 |
| 616 | 22 | Lunch and dinner....... | 258 | 47.7 | 1,320 | 5.1 |
| 620 | 23 | Lunch and dinner ... .. | 315 | 46.7 | 1,420 | 4.5 |
| 624 | 24 | Lunch and dinner..... | 238 | 46.1 | 1,070 | 4.5 |
| 627 | 25 | Lunch and dinner.... | 233 | 28.2 | 1,060 | 4.6 |
| 631 | 26 | Dinner [2] ............ | 157 | 26.9 | 768 | 4.9 |
| Average | ...... | .................... | ... | [3] 41.3 | [3] 1,200 | 4.7 |

[1] One slice of whole wheat bread was included in each sample before it was ground.
[2] Sunday. No lunch served.
[3] Not including Samples 539, 570, 601, and 631.

TABLE 7.—*Comparison of food intake with food waste of four students at Sorority House S-2*

| Student and days represented | PROTEIN | | | | | CALORIES | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Served at table | WASTED | | IN EXTRA FOODS | | Served at table | WASTED | | | IN EXTRA FOODS | |
| | | Total | Per cent of protein served | Total | Per cent of total protein eaten | | Total | Per gram of air-dry matter | Per cent of calories served | Total | % of total calories eaten |
| Student 1 | gm. | gm. | | gm. | | | | | | | |
| 5 | 234 | 19.0 | 8 | 38.0 | 15 | 8,470 | 1,110 | 4.9 | 13 | 2,990 | 29 |
| 3 | 150 | 25.8 | 17 | 26.9 | 18 | 5,580 | 1,180 | 4.5 | 21 | 2,260 | 34 |
| 4 | 181 | 21.4 | 12 | 37.8 | 19 | 7,490 | 906 | 4.4 | 12 | 3,280 | 33 |
| 2 | 103 | 13.1 | 13 | 6. | 6 | 3,550 | 584 | 4.4 | 16 | 662 | 18 |
| [1] 3 | 98 | 18.4 | 19 | 8. | 9 | 3,220 | 638 | 5.1 | 20 | 868 | 25 |
| 5 | 253 | 17.3 | 7 | 39.3 | 14 | 8,090 | 814 | 4.9 | 10 | 2,330 | 24 |
| ***Average per day***[5] | 48 | 5.1 | 11 | 7.8 | 15 | 1,746 | 242 | [6] 4.7 | 14 | 606 | 29 |
| Student 2 [2] | | | | | | | | | | | |
| 6 | 201 | 20.4 | 10 | 54. | 23 | 8,360 | 976 | 5.3 | 12 | 2,880 | 28 |
| [3] 6 | 193 | 12.1 | 6 | 46. | 20 | 8,440 | 483 | 4.5 | 6 | 3,050 | 28 |
| [4] 5 | 128 | 35.1 | 27 | 42. | 31 | 4,930 | 803 | 5.0 | 16 | 2,470 | 37 |
| 4 | 146 | 19.3 | 13 | 7.8 | 6 | 5,900 | 582 | 4.8 | 10 | 609 | 10 |
| ***Average per day***[5] | 35 | 4.0 | 11 | 6.2 | 17 | 1,426 | 156 | [6] 4.9 | 11 | 349 | 22 |
| Student 3 | | | | | | | | | | | |
| 3 | 139 | 48.2 | 35 | 7.7 | 8 | 6,210 | 1,190 | 5.8 | 19 | 642 | 11 |
| 4 | 221 | 37.0 | 17 | 33. | 15 | 8,220 | 1,130 | 4.8 | 14 | 1,660 | 19 |
| [3] 4 | 188 | 17.7 | 9 | 2. | 1 | 8,320 | 559 | 4.6 | 7 | 100 | 1 |
| [3] 5 | 324 | 39.4 | 12 | 33. | 10 | 10,990 | 951 | 4.9 | 9 | 2,490 | 20 |
| 4 | 264 | 18.2 | 7 | 11. | 4 | 9,110 | 570 | 4.9 | 6 | 776 | 8 |
| ***Average per day***[5] | 57 | 9.4 | 16 | 4.7 | 9 | 2,140 | 263 | [6] 5.0 | 12 | 280 | 13 |
| Student 4 | | | | | | | | | | | |
| 1 | 66 | 10.6 | 16 | 1.3 | 2 | 2,610 | 436 | 4.3 | 17 | 242 | 10 |
| 1 | 49 | 14.7 | 30 | 6.9 | 17 | 1,970 | 540 | 5.2 | 27 | 761 | 35 |
| 2 | 91 | 33.5 | 37 | 6.0 | 9 | 4,840 | 1,010 | 5.2 | 21 | 479 | 11 |
| 3 | 154 | 31.9 | 21 | 35.0 | 22 | 7,230 | 1,570 | 4.7 | 22 | 1,950 | 26 |
| [3] 3 | 148 | 37.6 | 25 | 2.5 | 2 | 6,400 | 1,040 | 5.3 | 16 | 216 | 4 |
| 2 | 106 | 28.9 | 27 | 4.2 | 5 | 4,710 | 1,000 | 4.7 | 21 | 675 | 15 |
| 1 | 66 | 22.0 | 33 | 2.7 | 6 | 2,390 | 691 | 4.7 | 29 | 296 | 15 |
| 2 | 114 | 36.5 | 32 | 2.1 | 3 | 4,090 | 761 | 5.5 | 19 | 260 | 7 |
| 2 | 115 | 39.6 | 34 | 3.1 | 4 | 4,420 | 953 | 4.9 | 22 | 546 | 14 |
| 1 | 61 | 28.6 | 47 | . . . | . . | 2,490 | 647 | 5.8 | 26 | . . . . | . . |
| 2 | 126 | 12.7 | 10 | 2.0 | 2 | 5,150 | 719 | 5.2 | 14 | 262 | 6 |
| ***Average per day***[5] | 56 | 15.2 | 27 | 3.7 | 8 | 2,347 | 490 | [6] 5.0 | 21 | 322 | 15 |

[1] Breakfast only eaten at house on two of these days; the other meals were eaten away from the house and no record was kept.

[2] No lunches eaten by Student 2 at House S-2.

[3] One dinner eaten away from house, of which no record was obtained.

[4] Two dinners eaten away from house, of which no record was kept.

[5] Not including samples for which a record of some meal is missing.

[6] Arithmetical mean.

calories each. Confirmatory of the earlier study on the caloric value of mixed foods, the average energy value for this entire series of lunches and dinners is 4.7 calories per gram of air-dry matter.

The results of the duplicate but combined samples of lunch and dinner collected at House S-2 on the same days as shown in Table 5 are recorded in Table 6. Although variations in the total protein and the total energy content of the two meals on any given date are to be noted by comparison of Tables 5 and 6, averaging of the data in Table 6 shows precisely the same energy value per gram of air-dry matter, that is, 4.7 calories. The average total protein content is 41.3 grams in one case and 42.5 grams in the other case, an insignificant disagreement. The average total energy content is 1200 calories as compared with 1260 calories. In consideration of the fact that the meals analyzed were mixed meals of widely varying composition, the agreement between the two series of samples is all that could be desired and is excellent justification of the method of sampling and aliquoting. Table 6 confirms the evidence in Table 5 that these young women in House S-2, in presumably the two heavier meals of the day, received on the whole 42 grams of protein and 1230 calories each.

During this particular study at House S-2 individual records were kept by four students of all the various foods eaten both at the table and away from the table, including the amounts of bread, butter, and beverage consumed at each meal, also the breakfasts and second helpings. It has thus been possible to calculate the total energy and the total protein content of the foods served to them at table and of the foods eaten away from table. These calculations have been based, so far as lunches and dinners are concerned, upon the results of the combustions of the lunches and dinners reported in Table 5 which were similar to the meals served to these four students. The breakfasts were not analyzed, but they were light, consisting of fruit, coffee or milk, muffins or toast, and ready-prepared or occasionally cooked cereal. As a rule there was no use of eggs or meat. The calories and protein represented by the breakfasts and the "extra foods" have been estimated from the results given in Tables 8 and 9 of this report, from the data secured in our earlier research,[1] from the data furnished by Rose,[2] and from the values reported by Benedict and Benedict.[3] In addition to these records of food served at table and of "extra foods", a study was made during the same period of the edible food wasted at table by these same four students. All servings that were refused and all plate scrapings were collected each day in separate containers, one for each student, and dried for analysis. These plate scrapings included not only the food wasted at lunch and dinner but that wasted at breakfast. Any food eaten between meals, such as candy, ice cream, or sundaes, was

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[1] Benedict and Farr, loc. cit.

[2] Rose, M. S., Laboratory handbook for dietetics, New York, 3d ed., 1929; ibid., Feeding the family, New York, 1916 and 1925.

[3] Benedict, C. G., and F. G. Benedict, Boston Med. and Surg. Journ., 1918, **179**, p. 153; ibid., 1919, **181**, p. 415.

entirely consumed and there was no waste. The results of this study of food intake and food waste are reported in Table 7.

The data for Student 2 are not strictly comparable with the data for the other students because the food intake and the food wasted in her case do not include the lunch served at House S-2. Student 2 worked in a drug store during the lunch hour and, therefore, had no regular meal at that time. She occasionally had coffee and a sandwich or ice cream at the store and sometimes ate a piece of cake or cookie when she returned to House S-2. These have been included in her food inventory. Her food record is similar to that which might be obtained from students who do not eat breakfast or lunch and replace the uneaten meals with foods obtained from the drug store or candy counter. In the case of the other three students there are also some instances when a meal, particularly dinner, was eaten away from the house and no record was kept of the amount eaten or wasted. The food habits of these four students were typical of any college student having a reasonable amount of spending money and able to cater, to a certain extent, to food dislikes at table by buying food at the drug store between meals. Student 4, as shown by comparison of the individual records of these four students, indulged her food dislikes more than the others by purchasing a greater amount of "extra foods." Hence it is not surprising that her plate waste, with reference to the food served at table, was greater than that of the other students.

The caloric value of the edible waste in the case of these four students is again remarkably close to 5.0 calories per gram of air-dry matter. The average percentage waste per day of the protein served at table (excluding Student 2, who had no regular lunches and whose data, therefore, cannot be compared with the results for the other students) ranged from 11 to 27 per cent with Students 1 and 4, respectively. In the case of Students 1 and 3 this waste of protein was compensated in nearly every instance by the consumption of protein in foods eaten between meals. Student 4, however, in only one instance ate enough protein between meals to make up for that not eaten at table. Of the total protein eaten per day, from 8 to 15 per cent on the average was eaten in the form of "extra foods" (again excluding Student 2). The calories wasted per day ranged, on the average, from 12 to 21 per cent of the total energy in the food served, the largest amount again being wasted by Student 4. The calories obtained per day in the form of "extra foods" amounted to from 13 to 29 per cent of the total daily energy intake.

## EXTRA FOODS

This large waste of both protein and calories in a house in which presumably great care was taken in cooking, in removing obviously inedible material, and in placing before the students well cooked and tastefully displayed foods, is distinctly surprising. It is evident that these waste samples recorded in Table 7 represent normal plate scrapings rejected not only because not relished by the individual, owing to

TABLE 8.—*Analyses of "extra foods" consumed by four students at Sorority House S-2*

| Sample No. | Description of food | Weight as purchased | Protein in sample | Calories | |
|---|---|---|---|---|---|
| | | | | Total in sample | Per gm. air-dry matter |
| | | gm. | gm. | | |
| 512 | Vegetized Wafers (Huston's Whole Wheat). Carton of 25 for 25c. Per wafer | 11.3 | 0.98 | 52.1 | 4.6 |
| 513 | Fudge, 5c. Square of fudge with one nut meat | 69.1 | 2.06 | 260. | 3.8 |
| 514 | Cherry Ripe. 1½ oz. for 5c. Chocolate-coated candy with cocoanut center | 61.4 | 2.44 | 324. | 5.3 |
| 528 | Raspberry Tart. Served at House S-2 | 28.2 | 1.80 | 92.9 | 3.3 |
| 549 | Molasses Chips. 1c each. Chocolate-coated squares, brittle molasses-flavored centers. Per square | 9.9 | 0.59 | 46.5 | 4.7 |
| 551 | Peanuts. 10c bag. Sold in theatre lobby. 2 cups of nuts in shells. Nuts only | 77.0 | 22.5 | 551. | 7.2 |
| 582 | Bob-Whites. 1½ oz. box at 5c. 42 to 44 pieces of chocolate dotted with white balls. Per box | 53.4 | 1.95 | 262. | 4.9 |
| 583 | Chow Mein. 1½ oz. for 5c. A nut bar, no chocolate | 52.4 | 5.92 | 287. | 5.5 |
| 612 | Pop-corn, buttered. 5c bag. Sold in theatre lobby | 31.1 | 2.75 | 174. | 5.6 |
| 641 | Marshmallow Fluff. 12 oz. can for 25c. Used for frosting. Per tablespoonful | 5.8 | 0.10 | 18.5 | 3.2 |
| 642 | Raspberry Jam. 32 oz. jar for 49c. Per tablespoonful | 19.9 | 0.09 | 50.7 | 2.6 |
| 643 | Milky Way. 1¾ oz. for 5c. Chocolate-covered bar, firm center of marshmallow and butterscotch | 76.3 | 3.70 | 318. | 4.2 |
| 644 | Dill pickles. Sixteen pickles in quart jar. Per pickle | 49.4 | 0.29 | 6.21 | 0.13 |
| 647 | Cinnamon toast. 10c per order of 3 slices. Per order | 58.1 | 5.85 | 265. | 4.6 |
| 648 | Brownies. 5c each. A rich cookie | 34.8 | 2.93 | 166. | 4.8 |

her particular food dislikes, but because the amount not eaten was compensated by "extra foods" eaten outside the dining room. A list of some of the "extra foods" consumed by the same four students with whom individual studies of waste were carried out is given in Table 8, together with the results of the analyses of the same. The air-dry weight of the food is not given in this table, but the fresh weight as purchased. It can be seen that the protein content of these foods, except in the case of peanuts, is an almost insignificant factor in the total daily intake. Indeed, these extra foods are for the most part primarily of a carbohydrate nature. The high energy values found for these extra foods listed in Table 8 are in full conformity with the results obtained in the earlier studies of extra foods made by Benedict and Benedict[1] and accentuate the potential source of calories in these foods commonly considered insignificant. Thus, in a 5-cent chocolate-covered bar of candy 300 calories or more can be obtained, and the consumption of one 5-cent chocolate bar might furnish nearly 20 per cent of the entire day's

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[1] Benedict, C. G., and F. G. Benedict, Boston Med. and Surg. Journ., 1918, **179**, p. 153; ibid., 1919, **181**, p. 415.

energy intake. The role that these secondary or extra foods may play is thus great. These foods are often disregarded by dietitians and only too frequently by physicians in summing up the food presumably eaten by their patients. Until the public, including dietitians and physicians, recognize the potentialities for securing an appreciable percentage of the total energy intake in these extra foods, confusion in such calculations is sure to arise. The large percentage of food waste shown by the data in Table 7 is not an indication that the food offered to the students was unpalatable because poorly cooked and unattractively served but is only an index of the food not eaten because of personal likes and dislikes. It is certain that the energy in the food rejected as waste was usually more than compensated by the extra foods consumed. The personal records of the individual students show that this is the case.

## ANALYSES OF BREADS AND MISCELLANEOUS FOODS

In Table 9 are given the results of analyses of breads, cereals, muffins, and other miscellaneous foods that were served at Houses S-1 and S-2. Only one quality of milk was purchased at House S-2, the top milk being used for cream and the skimmed milk as a beverage and for cooking. Obviously slices of bread, unless cut by machine, will vary greatly in size, but in general each slice of bread analyzed, whether graham, raisin, white, or whole wheat, contained with surprising uni-

TABLE 9.—*Analyses of breads and miscellaneous foods*

| Sample No. | Food | Air-dry weight | Protein in sample | Calories | |
|---|---|---|---|---|---|
| | | | | Total in sample | Per gm. air-dry weight |
| | | gm. | gm. | | |
| 571 | Bran. Post's bran flakes, slightly over ½ cup in serving | 29.4 | 4.12 | 115. | 3.9 |
| 550 | Bread, graham.[1] Slice 6 mm. thick | 17.5 | 2.33 | 68.1 | 3.9 |
| 521 | Bread, raisin.[1] Slice 6-12 mm. thick | 18.0 | 1.90 | 71.4 | 4.0 |
| 520 | Bread, white.[1] Slice 6-12 mm. thick | 15.5 | 1.98 | 62.5 | 4.0 |
| 634 | Bread, whole wheat. Dried with meal samples | 18.0 | 2.39 | 69.8 | 3.9 |
| 635 | Same as Sample 634 | 17.0 | 2.26 | 69.1 | 4.1 |
| 636 | Same as Sample 634 | 17.5 | 2.36 | 70.6 | 4.0 |
| 559 | Cereal, rolled oats cooked with bran.[1] ½ cup | 22.6 | 3.32 | 86.4 | 3.8 |
| 611 | Cocoa.[1] ⅔ cup | 30.5 | 6.45 | 135. | 4.4 |
| 507 | Cookie, ginger.[1] | 41.6 | 3.20 | 174. | 4.2 |
| 610 | Cream.[1] ¼ cup | 18.1 | 1.83 | [2] 139. | [2] 7.7 |
| 519 | Doughnut [1] | 32.0 | 3.30 | 141. | 4.4 |
| 609 | Milk.[1] Scant cupful | 27.8 | 7.55 | 141. | 5.1 |
| 561 | Puffed rice.[1] ⅝ cup | 9.5 | 0.59 | 35.8 | 3.8 |
| 565 | Rice Krispies.[1] ½ cup | 15.1 | 1.06 | 55.8 | 3.7 |
| 522 | Roll, white [1] | 29.2 | 3.91 | 124. | 4.3 |
| 523 | Muffin, bran [1] | 34.7 | 4.42 | 158. | 4.6 |
| 560 | Muffin, oatmeal [1] | 31.9 | 3.96 | 144. | 4.5 |
| 571 | Muffin, rice [1] | 30.5 | 3.35 | 135. | 4.4 |
| 524 | Muffin, white [1] | 31.3 | 4.23 | 138. | 4.4 |
| 701 | Muffin [3] | 33.3 | 2.95 | 154. | 4.6 |
| 730 | Muffin, whole wheat [3] | 46.5 | 5.75 | 218 | 4.7 |

[1] Served at House S-2.
[2] 4.7 used as the caloric value of a liter of oxygen.
[3] Served at House S-1.

formity not far from 70 calories and about 2 grams of protein. The muffins varied considerably in weight, from 30.5 to 46.5 grams, and the energy content was approximately proportional to the air-dry weight, ranging from 135 to 218 calories. These observations were made to assist in the calculations given in Table 7 of the total energy and protein consumed by Students 1 to 4.

## THE CALORIC VALUE OF AIR-DRY FOOD SAMPLES

The main object of this investigation was not to make a precise study of the total energy intake or the percentage of food energy wasted by any one group of individuals. To be sure, the energy content of several mixed foods and of a few extra foods was determined, as a supplement to our earlier studies. But our chief purpose was to ascertain the average energy value of edible food waste per gram of air-dry material and to compare this value with the average caloric value of any meal of mixed foods, such as lunch or dinner. For convenience in making such a comparison we have summarized in Table 10 the results of our analyses reported in the preceding tables. Thus, the average caloric values per gram of air-dry matter of the lunch and dinner samples listed in Tables 3, 5, and 6, respectively, together with the minimum and maximum values, are summarized in the upper portion of Table 10. The average energy value is in all three instances exactly the same, 4.7 calories, although there is a considerable range between the maximum and the minimum values, depending in large part upon the percentage of fat in the meals. When visible fat is present, obviously the caloric value will be greater. In the middle portion of Table 10 are given the energy

TABLE 10.—*Comparison of energy content of mixed meals with that of edible waste*

| Data from Table No. | Type of sample | Number of samples analyzed | CALORIES PER GRAM OF AIR-DRY WEIGHT | | |
|---|---|---|---|---|---|
| | | | Minimum | Maximum | Average |
| 3 | Lunch and dinner | 24 | 4.0 | 5.4 | 4.7 |
| 5 | Lunch and dinner | 52 | 3.9 | 5.5 | 4.7 |
| 6 | Lunch and dinner | 28 | 4.3 | 5.1 | 4.7 |
| [1] 17 | Breakfast | 26 | 3.6 | 5.1 | 4.3 |
| [1] 18 | Dinner | 71 | 3.7 | 5.7 | 4.7 |
| [1] 19 | Supper | 59 | 3.8 | 5.7 | 4.8 |
| [1] 21 | Total daily meals | 14 | 4.5 | 5.5 | 5.0 |
| 1 | Edible waste without visible fat [2] | 23 | 4.0 | 5.8 | 5.0 |
| 1 | Edible waste with visible fat [3] | 25 | 4.0 | 9.3 | 5.3 |
| 2 | Edible waste without visible fat | 12 | 4.2 | 5.6 | 4.9 |
| 7 | Waste by student 1[4] | 6 | 4.4 | 5.1 | 4.7 |
| 7 | Waste by student 2[4] | 4 | 4.5 | 5.3 | 4.9 |
| 7 | Waste by student 3[4] | 5 | 4.6 | 5.8 | 5.0 |
| 7 | Waste by student 4[4] | 11 | 4.3 | 5.8 | 5.0 |

[1] See Benedict, F. G., and A. G. Farr, Univ. New Hampshire, Agric. Expt. Sta., Bull. 242, 1929.

[2] Not including Samples 743 and 751B.

[3] Including Samples 743 and 751B.

[4] Butter included in some of the waste samples.

values of the mixed meals studied in our earlier research.[1] The average energy content in these instances varies according to the meal of the day, the breakfasts having the lowest value. Since the breakfasts were in large part of a purely carbohydrate nature with a minimum content of fat, this is to be expected. The total daily meals, when analyzed together, had an average caloric value of 5.0 calories, but the meals analyzed separately contained more nearly 4.7 or 4.8 calories per gram of air-dry matter. This is in full conformity with the results shown in the upper portion of Table 10 for the combined lunch and dinner samples. In our earlier report a *round* figure of 5 was suggested as being of practical use in calculating the energy content of mixed meals from the known, air-dry weight in grams. From the results of this present study and a closer inspection of the earlier observations it would appear that in all probability a slightly higher degree of accuracy could be obtained in estimating the energy intake in mixed foods by using the factor 4.7.

In the lower part of Table 10 are given the average values for edible waste derived from the detailed data in Tables 1, 2, and 7. Twenty-three samples of edible waste containing no visible fat had an average value of 5.0 calories per gram of air-dry matter. These samples were collected at the fraternity house. If, with the results for these samples, the data for the two samples (743 and 751B) containing fat are included, the average becomes 5.3 calories. Twelve edible waste samples containing no visible fat, collected at House S-1, had an average energy value of 4.9 calories. The food wasted by Students 1 to 4 at House S-2 varied in energy content from 4.3 to 5.8 calories, but on the average contained 4.9 calories per gram. Since it is to be expected that plate scrapings would consist in large part of residues of mixed meals, with a possible preponderance of fat, it is not surprising that the caloric value of edible waste per gram of air-dry material is on the average so close to the *round* value suggested in our earlier report for mixed meals, namely, 5 calories. It is clear, however, that the presence of a large amount of fat will alter materially the caloric value of edible waste. When large amounts of edible fat are served, are not relished by the person eating the meal, and are left on the plate, obviously the percentage of fat in the plate scrapings will be larger than the percentage of fat in the food served. The chief problem, therefore, in the handling of waste food is the fat.

Our study leads to the conviction that in all future dietetic studies edible waste as such, distinguished from kitchen refuse, should first be air-dried. The air-dry weight in grams should then be multiplied by the factor 5, if the waste sample contains no visible fat. If there is visible fat in the sample and it can be easily skimmed off, it should be removed, its weight determined separately, and the caloric value of this waste fat computed on the basis that each gram is equivalent to 9 calories. This factor of 9 allows for a certain amount of moisture and probably non-fatty material unavoidably included in the removal of the

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[1] Benedict and Farr, loc. cit.

fat. When the visible fat has been removed, the air-dry weight of the rest of the waste should be considered to have an average caloric value of 5 calories per gram. Obviously in the collection of table waste, fruit stones and other unquestionably inedible material that may have been served with the food should not be included. In the majority of cases such inedible refuse would represent but a small percentage of the total day's table waste, but as a degree of refinement in the calculation of the energy value of edible waste such removal is warranted.

## SUMMARY

Samples of mixed meals and edible waste from one fraternity house and two sorority houses were analyzed for their energy and protein content. Modifications made in the oxy-calorimeter for the better control of temperature during combustions are described, and the method of sampling is discussed briefly.

At the fraternity house samples of edible waste from breakfasts, dinners, and suppers were collected for one week. The edible waste per meal contained 112 calories and 3.8 grams of protein, or 11 and 10 per cent, respectively, of the energy and the protein content of the total food served. At one of the sorority houses samples of edible waste from lunches and dinners were collected during a two-week period. On the average per meal this waste contained 26 calories and 1 gram of protein, or 3 and 4 per cent, respectively, of the energy and the protein content of the food served. At the second sorority house samples of mixed meals (lunch and dinner) were collected for nearly a month. At this same house and during the same time the food wasted at breakfast, lunch, and dinner by four different students was collected, and a daily record was kept by each student of the food served her at table and that eaten away from table. From the data thus secured it was found that the amount of waste varied greatly with the individual. Thus, the protein wasted per day at table amounted on the average to from 11 to 27 per cent of the total protein served, and the food energy wasted amounted to from 12 to 21 per cent of the total food energy served at table. This seemingly large waste of really well-prepared and well-served food is undoubtedly explained by the consumption of extra foods which, as our study shows, corresponded to from 13 to 29 per cent of the total energy intake per day.

One hundred and four samples of mixed meals collected at the two sorority houses had an average energy value of 4.7 calories per gram of air-dry weight. One hundred and seventy samples of mixed meals collected in an earlier research in the same college community and including meals at restaurants and cafeterias also had an average energy value per gram of air-dry weight of 4.7 calories. Sixty-three samples of edible waste, collected at the two sorority houses and at the fraternity house, averaged 5.0 calories per gram of air-dry matter. The energy factor for samples containing visible fat was appreciably greater than 5. It is recommended that the energy content of edible table waste (as distinguished from kitchen refuse) can be calculated with reasonable accuracy by multiplying the air-dry weight in grams by the factor 5, if visible fat is not present. If there is visible fat and it can be removed easily, its energy value should be calculated separately by multiplying its weight in grams by the factor 9, and the rest of the waste should then be considered to have an energy content of 5 calories per gram of air-dry matter.