FATS AND OILS IN COOKERY

SOURCES AND CLASSES

Fats are derived from both the animal and the vegetable kingdoms. A few decades ago, the former source was the chief one used by the people of this country, but of late years the latter has been drawn upon more extensively. The chief animal fats used as food are cream, butter, lard, and suet. The common vegetable fats are olive, cottonseed, corn, and nut oils; there are on the market, also, compounds of animal and vegetable fats and some products, such as Crisco, made by treating an oil with hydrogen. In the home, other fats, such as beef and bacon drippings and chicken fat, are obtained by the cooking of meats. These, if carefully saved and judiciously used, will lower considerably the cost of fat in the household.

As in other food supplies, the accessibility determines the amount of any kind to be used, and the fact will always remain that the available and the cheapest foods are the ones which will be employed. It would be foolish to counsel the woman with plenty of fresh cream and butter at her immediate command to purchase olive oil at one dollar per quart. It is equally foolish to recommend cream at fifty cents per quart to the undernourished factory girl. Each consumer must study the possibilities and limitations of her own source of supply, and must act accordingly.

CHEMICAL AND PHYSICAL PROPERTIES

All fats and oils are composed of the elements carbon, hydrogen, and oxygen. These elements are combined in such a way as to form compounds of glycerin and fatty acids called *glycerids*. That is to say, all fats and oils contain glycerin, but the fatty acid may differ, and upon the acid depends the melting point and other distinguishing characteristics of the compound. The compound is called a fat if its melting point is so high as to make it solid at ordinary temperature, and an oil if its melting point is so low as to make it liquid at ordinary room temperature. The three most important fatty acids are palmitic, stearic, and oleic. The first two are much alike, both the acids and the fats in which they predominate being hard substances of high melting point, said chemically to be saturated. Vegetable fats and oils

contain more palmitic than stearic acid, while the contrary is true of fats and oils of animal origin. Oleic acid and the oils in which it predominates are quite different. Their melting point is low and they are chemically unsaturated. The hard tallow of beef and mutton contains glycerin combined with large amounts of stearic acid, some palmitic, and relatively little oleic. Lard contains a larger proportion of oleic acid compounds. Olive oil is almost entirely a glycerid of oleic acid.

It has been found possible to change some oils into solid fats and to harden fats which were already solid by heating the oil under pressure with hydrogen, in the presence of a catalyst, such as nickel. The unsaturated fats, which are soft, take up hydrogen to form saturated fats, which are less soft. These hydrogenized fats are coming to be more and more commonly used, and new forms under varied names are appearing constantly on the market.

In the presence of moisture, fats become rancid on exposure to air, or warmth and light. This rancidity is developed by a process of oxidation and hydrolysis, and generally develops more readily in oils than in solid fats.

Fats have different melting points, ranging from the oils which are liquid at ordinary temperatures and solidify below 0° C. to mutton fat, one of the hardest, having a melting point of 49°–50° C. High heat causes smoking. This is due to decomposition, altho some decomposition may occur at a lower temperature. A list of fats, with their smoking temperatures, is given below. The tests were made on one cup of fat in a small saucepan, six inches in diameter.

TABLE 1.—SMOKING TEMPERATURES OF FATS

Kind of fat	Smoking temperature
	degrees Centigrade
Cottonseed oil (Wesson)	225
Snowdrift	223
Crisco	217
Chicken fat	210
Corn oil (Mazola)	208
Lard	175
Olive oil	156
Bacon fat	145
Suet	117

Katherine Blunt and Clara Feeney[1] found the smoking temperature of a fat to vary according to the amount of surface exposed, the

[1]Journal of Home Economics, Vol. VII, No. 10, p. 535.

amount of free acid, and the amount of foreign material present, such as particles of food or crumbs. The above smoking temperatures will, then, vary according to the size and shape of the utensil used, being lower for a wider pan and higher for a more narrow one, as in the former case the surface exposure is greater. They would also be lowered by rancidity or repeated use of the fat, which means increased free acid, or by the presence of foreign particles. However, under similar conditions, the relation of the temperatures should remain unchanged.

Some results of the work done by Blunt and Feeney follow.

Kind of fat	Smoking temperature in evaporating dish	Free acid, as oleic
	degrees Centigrade	*percent*
Cottonseed oil (Wesson)	233	0.07
Snowdrift	232	0.06
Crisco	231	0.13
Leaf lard	221	0.15
Butter fat	208	0.28
Leaf lard (heated 5 hours)	207	0.34
Bulk lard	194	0.51
A much used lard	190	0.61
Olive oil	175	0.92

It may be seen readily that, while the temperatures in the two tables are not the same, nevertheless relatively they fall in the same order. The differences are to be explained by the fact that a larger and wider utensil was used in the first case than in the second; consequently, smoking began at a lower temperature. This range in smoking temperatures shows that the old time test of fat for frying, "smoking hot," does not give the same temperature for all fats; hence, other tests must be relied upon. The characteristics of a good fat for a frying medium are: first, a high smoking temperature; second, the smoke should increase slowly; and, third, the smoke should not be irritating in character. The first smoke from olive oil, for example, is not irritating and it increases very gradually, so that at 300°C. it is by no means as disagreeable as is lard which starts to smoke at a higher temperature. The objections to fats which smoke readily are the irritating odor and the impaired quality of the fat for further frying. Smoking is an indication of decomposition, and the fat which decomposes most on heating can be used the fewest number of times. From this last standpoint, the cottonseed products are especially desirable as a medium for frying.

VALUE AS FOOD

Fats and oils are of value in the diet chiefly because for a given weight they yield more energy than do any of the other foodstuffs. One gram of carbohydrate or of protein yields four calories of energy in the form of heat, but one gram of fat yields nine calories. For this reason, fats are of especial value to the manual laborer, to the person who works out-of-doors in cold weather, and to the thin or anemic person who has no reserve of fat in his own body. Some of the fats and oils, because of their greater degree of absorption from the digestive tract, are of greater value in giving energy than are others. Fats having low melting points have been found to be more completely assimilated than those having high melting points.[1] Therefore, olive or Wesson Oil and butter, which have low melting points, are to be chosen as foods that will be well absorbed, and hence the ones from which the greatest fuel value will be obtained. Another factor which influences the digestion of a fat is the degree of its emulsification. Only emulsified fats are digested to any appreciable extent in the stomach, and the finer the emulsification the greater is the rapidity of digestion and absorption in the duodenum and, often, the greater is the completeness of utilization. Fats of milk and of egg are examples of this fine emulsification.

Some people cannot digest large amounts of fat. This foodstuff delays the emptying of the stomach, retards the secretion of the hydrochloric acid, and also promotes regurgitation thru the pylorus into the stomach, thus neutralizing the acid that is present there. All of these may occur when foods are fried or sautéd so as to absorb large amounts of fat, or when much fat is mixed thru the food as in very rich pastry. The retardation, in turn, gives an opportunity for bacterial action in the interior of the food mass, resulting in a loss of food to the body and also in the production of gases and even of poisonous substances. This is the explanation of much of the indigestion of which people complain after eating foods rich in fat. One other cause of difficulty in the digestion of fried foods is that the fat is frequently overheated during cooking and is thus decomposed into substances of an irritating character. For these reasons, pastry and fried foods do not belong in the child's diet nor in that of the person with a weak digestion. Neither should they be eaten frequently nor in large amounts by anyone.

[1]Langworthy and Holmes, "Digestibility of Some Animal Fats." U. S. Department of Agriculture, Bulletin 310, p. 21.
H. C. Sherman, "Food Products." p. 389.

Osborne and Mendel and also McCollum and Davis[1] have been making observations on the influence of natural fats upon growth. They have found that butter fat is valuable, not only because of the fuel value which it has, but also because it contains certain growth promoting constituents, not found in all fats. Beef fat also supplies these substances, but in a smaller amount. Egg yolk fat and cod-liver oil, too, belong in this list, but lard, almond, cottonseed, and olive oils, altho valuable foods, so far as known at present do not contain these special constituents. It is evident, then, that rich milk, cream, butter, eggs, fat beef, and cod-liver oil are of especial value in growth and also in cases of malnutrition.

Fats vary in their cost. Often a less expensive fat answers the purpose as well as a more expensive one, and the question may be worth asking, "Are we paying too high for flavor?" The following table shows the prices (May, 1917) for some common fats.

TABLE 2.—PRICES OF SOME COMMON FATS

Name of fat	Price per pound
	May, 1917
Olive oil	
4 ounce or ¼ pint bottle	$1.20
8 ounce or ½ pint can	.60
16 ounce or 1 pint can	.55
32 ounce or 1 quart can	.50
Butter	.52
Oleomargarine	.25
Crisco	.35
Cottonseed oil (Wesson)	.29
Lard	.30
Home rendered lard (purchased at 18 cents per pound exclusive of fuel)	.21
Home rendered lard + gas	.22

The table shows not only the range in prices, but also the advisability of buying oils in the can rather than in bottles, especially when the bottles are small in size. The can is of additional advantage, as it shuts out the light, and light is a potent factor in the production of rancidity. The differences in price of olive oil according to quantity purchased are illustrative of similar differences to be found in purchasing most foods. The home rendered lard may be more or less expensive than an equally good grade of commercial lard according to the cost of fuel and the value of the housewife's time.

[1] Journal of Biological Chemistry, Vol. XVI, p. 423; Vol. XVII, p. 401; Vol. XX, pp. 379, 641; Vol. XXI, p. 179; Vol. XXIII, p. 231

The initial cost of a fat is not the only point to be noted. When used for shortening, a larger amount of one may be required than of another. As butter is only 85 percent fat while lard, oils, and Crisco are 100 percent, less of these is required than of butter. Again, in frying, more of some fats is absorbed than of others. In cooking doughnuts, different fats were found to be absorbed according to the following order: olive oil (least), Wesson Oil, Crisco, lard, lard and suet (most). More important still, from the standpoint of economy, is the question, "Which fat can be used the greatest number of times?" This use depends primarily upon the decomposition temperatures. In general, such fats as lard or lard and suet, which give off most smoke at frying temperatures, can be used a smaller number of times than can those giving off less smoke, as Crisco or the oils. The care in heating and the method of clarifying employed by the housewife also help to determine the number of times the fat can be used. Fat once overheated until it smokes excessively can never be used as long as can the same fat not so overheated. However, Wesson Oil or Crisco do not give off this heavy smoke until a very high temperature is reached, but lard decomposes so rapidly on slight overheating that much care is required to prevent it.

The economy of substituting less expensive fats for those high priced luxuries can easily be seen. For example, one cup of mayonnaise dressing made of olive oil bought by the quart costs 27 cents, whereas if made of cottonseed oil, one cup costs 11.25 cents. Again, the substitution of one cup of oleomargarine for one cup of butter in a cake gave practically identical results and reduced the cost by 8.5 cents. Partial substitution of Crisco might profitably have reduced it still further. In some cases, fats cannot be substituted thus, but often the question of substitution becomes merely one of flavor and must be determined according to one's taste and pocketbook.

USES IN COOKERY

Fats are used in cookery for three general purposes: first, to flavor or to enrich foods, as in cooked salad dressing and white sauce, or as an emulsion in French dressing or mayonnaise; second, as a medium for browning and cooking in sautéing or frying; and third, as a shortening agent in flour mixtures. From the fats available, the housewife must select one which imparts an agreeable flavor and a good texture for her purpose.

The following fats were tested recently in cooking experiments conducted in these laboratories: olive oil, Mazola, Wesson Oil, chicken fat, butter, oleomargarine, Snowdrift, lard, Crisco, suet, and bacon drippings. The flavor obtained is the first consideration. Olive oil gives, in all cases except in fried foods, a very pronounced and characteristic flavor. This, for salad dressing, constitutes its chief recommendation. Mazola, a corn oil, gives a flavor only a little less strong, but it is often not detected unless used in large amounts. Wesson Oil is practically tasteless. Chicken fat has its own distinctive but mild flavor unless tried out at a high temperature; in doughs and batters its use is ordinarily not evident. As an enriching or shortening agent, butter is generally used and directions for the substitution of other fats are concerned largely with methods of approximating the flavor and texture secured with butter. Oleomargarine, if of good quality and purchased of a reliable firm, may be used for the same purposes as butter, in all sorts of cooking, and it is difficult to detect even in mildly seasoned sauces. Snowdrift is a very white fat but one which easily becomes rancid. In these tests it was never satisfactory because of the strong, disagreeable flavor. Lard and Crisco, altho differing in source and smoking points, give somewhat similar results as shortening agents. Lard can almost always be recognized by a peculiar characteristic sensation in the mouth. Crisco gives somewhat the same sensation in the mouth as lard but to a lesser degree. It ordinarily has little flavor, altho after long standing it may become strong. Suet has a very limited use because it can practically always be tasted and its hardness gives an unpleasant texture. Bacon drippings are strong flavored, but are not for that reason necessarily useless. They should, however, be restricted to sautéing of those foods in which the added flavor is not objectionable. The consistency of cooked salad dressings and of mayonnaise, the color secured in sautéing or deep-fat frying, the texture of muffins, cakes, and pastry, vary somewhat with the kind of fat used, and these variations will be discussed later.

COOKED SALAD DRESSING

Recipes for cooked salad dressing usually call for butter or perhaps for olive oil, but cheaper fats may be substituted. Wesson Oil or oleomargarine can easily be used, but the taste of Mazola is immediately apparent and its presence must depend upon whether or not one likes the flavor it gives. Crisco and lard are possible altho the discriminating person detects them easily. Chicken and bacon fats

are quite noticeable, but may be a desirable addition with a vegetable or a meat salad. Suet is disagreeable. The consistency varies so little with the different fats as to be quite unimportant; so the selection of the fat depends upon the flavor imparted. In other words, any one of several common fats may be used for cooked salad dressings, especially if the combination is carefully considered. If, however, cooked salad dressing is made in large quantities and used from time to time for different salads, butter, oleomargarine, or Wesson Oil is best because of the flavor.

FRENCH AND MAYONNAISE DRESSINGS

For French dressing, olive oil is generally recommended but Wesson Oil or Mazola may be used. The difference between a dressing made with olive oil and one made entirely of Wesson Oil is the absence of the distinctive olive flavor rather than any added taste. Substituting Wesson for one-half the olive oil enables one to secure the flavor of the more expensive product and at the same time to lower the cost considerably. The presence of Mazola is very evident unless the dressing contains at least one part of vinegar to three of oil, so that for those who do not like a very tart dressing, Wesson gives the best results.

For mayonnaise dressing, Wesson is a better substitute for olive oil than Mazola, for the flavor of Mazola is not sufficiently disguised by the smaller proportion of other ingredients. Chicken fat, especially the more oily portion, can be utilized, altho the flavor is evident. If one does not have an oil at hand, mayonnaise dressing may be made with washed and melted butter, oleomargarine, or melted Crisco; half oil and half washed or unsalted butter give an especially well-flavored dressing of good consistency.

WHITE SAUCE

White sauce can be made easily with fats other than butter if the purpose for which it is to be used is kept in mind. For example, with finnan haddie the flavor of the partly smoked fish is so pronounced that almost any fat can be used in the sauce without being detected; with creamed meats, the use of drippings is sometimes a desirable addition. Since white sauce is served hot and the proportion of fat is small, no variation in consistency is apparent.

SAUTÉING

In sautéing, a golden brown color and a good flavor are the desired ends. The color usually depends upon the temperature and the time

of cooking, but it is sometimes heightened by the discoloration of the fat. Starch and sugar brown so easily that flour mixtures or meats rolled in bread crumbs acquire a good color whether the fat contributes to it or not, but some vegetables brown with such difficulty that a fat of low smoking point, as suet or drippings, gives a better appearance. Altho often recommended, butter burns so easily that, when it is used, it is difficult to avoid a very uneven color and often an unpleasant flavor. Better results are obtained with butter as well as with suet and drippings if some other fat of high smoking point, like Crisco or Wesson Oil, be substituted in part. Olive oil and Mazola give characteristic flavors which may or may not be liked. Wesson Oil is practically tasteless, and consequently can be very generally used. Moreover, because of its high smoking point, there is little danger of scorching. Chicken fat, bacon, or other drippings often add an agreeable flavor to meats or vegetables, but they must be selected with care to avoid unpleasant combinations. Lard and Crisco are so nearly tasteless that like Wesson Oil they find wide use. Suet, because of its flavor and the unpleasant sensation left in the mouth when it cools even a little, is better used in small quantities or with other fats.

DEEP-FAT FRYING

In deep-fat frying, an even brown color and a pleasant flavor, with the minimum of fat absorption, make a good product. The color depends upon the character of the food and of the fat, but more especially upon the temperature and the time of cooking. The flavor varies with the fat used, altho the differences are much less than one might expect. For example, even Mazola and chicken fat give little taste to doughnuts and none at all to French fried potatoes sprinkled with salt. While strongly flavored fats need not always be discarded, those with little flavor are safest for general use. The smoking point of fats also determines the quality of the finished product, for when fats smoke, decomposition is taking place at a rather rapid rate, producing an unpleasant flavor. Moreover, fats which have become discolored by decomposition do not produce as even a color in frying. Consequently, lard which is used "smoking hot" is less satisfactory than Crisco, Mazola, or Wesson Oil, which give no smoke at any ordinary cooking temperature. (See Table 1, page 4.) The high smoking point of chicken fat makes it especially desirable for frying, but it is not often obtained in the ordinary home in quantity sufficient for that purpose. Moreover, chicken fat is very much the best butter substitute for shortening and should be reserved for that purpose.

Greasiness is somewhat dependent upon the kind of fat used but much more dependent upon the food to be cooked and the temperature employed. Rich doughs and batters become more grease soaked in frying than those containing less shortening, and foods cooked at too low a temperature absorb a large amount of fat because the protecting coating is formed less quickly than at a higher temperature and because the material stays in the fat for a longer time. Doughnuts made without shortening absorb much less fat than those in which shortening is used. Because at least a small amount of fat is taken up in frying, a fat with little flavor and a high smoking point is best for general use. Of the fats used, Wesson Oil and Crisco fulfil the conditions best.

SHORTENING

DOUGHS AND BATTERS

With doughs and batters, the kind of fat to be used varies with the amount required, for with the possible exception of butter, no one fat gives a uniformly good texture and flavor in all mixtures. Since differences produced in texture are neither marked nor important except in cakes and rich muffins, the choice in mixtures containing little fat is governed by flavor. In griddle cakes, any fat except olive oil can be used, but the griddle should be greased with one having little flavor. For muffins, butter gives the best flavor and the greatest tenderness, but oleomargarine or chicken fat produces an almost identical product. Crisco, lard, or Wesson Oil gives good results provided a little extra salt is added; of the three, lard is the most easily detected. Mazola is too apparent to be desirable, and drippings and suet are so strongly flavored as to be impossible. For biscuits, the same fats may be used as for muffins except that the failure to increase the salt is more serious and that Crisco seems to produce a somewhat coarser texture. For the richer shortcake mixture, a fat with little flavor, like Crisco, lard, or Wesson Oil, is best with the exception of chicken fat. For both biscuit and shortcake, to secure the best texture, oils when used should be mixed with the liquid rather than with the flour.

CAKES

With the exception of pastry, cake is the richest mixture used. For that reason, care is needed in the selection of the fat, but since the flavor is often disguised by extracts, spices, or chocolate, a comparatively large number of fats are possible.

One of the characteristics of a good cake is tenderness. The influence of the mixing upon tenderness is well known, but variations due to the kind of fat used are often not sufficiently emphasized. The most tender cake is obtained with butter. This does not mean that a good cake cannot be made with other fats but merely that if two cakes are made from the same recipe and with the same method of mixing, one with butter and the second with some other fat, the one in which butter has been used seems the more tender. The nearest approach to the texture of a butter cake is obtained with chicken fat or oleomargarine. Contrary to what one might expect from the results with chicken fat, oils do not produce good cake. The cake seems dry and breadlike, while if more fat is added, it becomes greasy, and if more liquid, coarse. Since butter is 85 percent fat and lard and Crisco, 100 percent, in substituting either for butter, to secure the same richness, the quantity should be reduced about one-eighth. Increasing the liquid slightly to allow for the moisture of the butter improves the texture. The amount of beating is, however, the most important factor, for beating increases the tenderness and the apparent richness of any cake. A butter cake made with the minimum of beating may be tender, but one with Crisco is dry and lacking in richness if beaten too little. To secure the best possible texture in substituting Crisco or lard for butter, the amount of fat should be decreased one-eighth, the liquid should be slightly increased, and care should be taken to beat the cake well.

Butter gives not only the best texture but the best flavor also, and if it is used at all in baking, it should be for cake. The best substitute, from the standpoint both of flavor and texture, is oleomargarine or chicken fat with increased salt, and, as has been said before, the best use for the limited amount of chicken fat usually obtained in the home, is as a butter substitute in cakes. For a white cake, where it is desired to avoid all color, Crisco is the best shortening agent, if the precautions noted in the discussion of texture in cakes are observed. Lard tho often used, is more easily detected than Crisco and hence is less satisfactory. It can, however, be used safely with spices or any strong flavoring extract. Snowdrift, altho very white, is very apparent and unpleasant in flavor even in spice cake. The oils are not desirable because of the texture produced.

PASTRY

For plain pie crust, lard gives the tenderest and flakiest product. A good crust can be secured with oils if they are properly handled but a mealy rather than a flaky texture is the result. Not more than one part of oil to four of flour should be used, and care should be taken to mix the oil and flour only slightly. Otherwise so little water can be added that the pie crust is very difficult to handle and crumbles to pieces when baked. Chicken fat gives a good crust but it should be handled like the oils. Butter produces a crust of delicious flavor for those who are willing to pay the price, but the texture is no better than with lard and often not so good. Sour cream when used in somewhat larger proportion than the oils requires a little soda to neutralize the acid, but gives a very good quality of crust and one tasting much like a butter crust. No water can be used, as there is sufficient liquid in the cream. Oleomargarine gives a crust almost impossible to detect from one made with butter. A crust made with Crisco closely resembles one made with lard. Suet does not give a good texture and both suet and drippings are too strongly flavored to be desirable.

SUMMARY

The problem of the housewife in the use of fats and oils in cookery is largely one of understanding the possibilities and limitations of her particular supply, and of using that supply as economically as possible. This involves an understanding of the possible substitutions of one fat for another, with some knowledge of their comparative costs. The following table shows the possible uses of the ordinary fats.

TABLE 3.—SUMMARY OF USES OF EASILY OBTAINABLE FATS

Kinds of fat	Flavor	Uses
Olive oil	Strong	Uncooked salad dressings
Wesson Oil	Slight	Deep-fat frying, salad dressings, shortening except cakes
Mazola	Fairly strong	Deep-fat frying
Chicken fat	Mild	Shortening, especially cakes
Butter	Mild	Shortening, except of plain pastry
Lard	Mild	Shortening, especially of plain pastry
Snowdrift	Often strong	Frequently too strong for use
Crisco	Slight	Sautéing, deep-fat frying, shortening
Suet	Strong	Sautéing
Bacon fat	Very strong	Sautéing
Oleomargarine	Mild	Same as butter

COOKING TEMPERATURES

USES OF THE THERMOMETER

No factor in the preparation of food so largely determines the results as does heat. Upon its proper application depends the texture and quality of a product and also the development of the finer flavors. Exact results can be obtained only by the use of accurate methods, and the thermometer furnishes the only really accurate method of determining the degree of heat that is being applied. Satisfactory results may be produced by the use of good judgment only, but good judgment requires repeated observation, training, and skill, is acquired slowly, and is dependable only after years of experience. Judgment, developed by experience, enables one to tell the time of day by the sun, but a watch is much more easily used and is a more accurate gage.

Housewives employ many little devices which show their need of a definite measure for temperature. Thus a bit of flour or bread is browned in the oven, a small preliminary cake is baked, or a piece of bread is browned in hot fat in "forty counts" before frying croquettes or in "sixty counts" before frying doughnuts. The woman who uses gas learns to light the burner a definite time before putting her bread to bake, and then turns the flame off one-half or one-third. All of these devices show an attempt to obtain exact methods of applying heat.

The chemical thermometers give very accurate results. They do, however, have the serious drawback of being easily broken and of requiring a hole in the top or side of the oven for their insertion. The mercury bulb should be as near as possible to the food being cooked, since the temperature at the top or at the side of the oven is not the same as in the center. If the thermometer is inserted thru the side, just below the grate, the bulb is then immediately below the food being cooked. These chemical thermometers can be had ranging from the six-inch 100° C. thermometers, which may be inserted in a roast, up to those registering 300° C. and recording as high temperatures as are ever used in cookery.

Thermometers on stands, which may be placed beside the bread or cake in the oven and which are less easily broken, may also be had in the Fahrenheit scale. These are sufficiently sensitive for ordinary purposes, as they record the temperature to within ten degrees of the chemical thermometer. They are especially satisfactory when used with an oven having a glass door. When used in a coal range and placed

directly on the bottom of the oven, a temperature of approximately 85° F. lower than the required gas oven temperature should be used because of the difference in the course of the heat in the two stoves.

Stove manufacturers are recognizing the value of a heat gage and are putting thermometers on the outside of their ovens. Such thermometers are of considerable value and aid greatly in determining the temperature. Heretofore we have sought, in our laboratories, to record chiefly the temperature in the center of the oven, and have not relied to any extent upon thermometers which register the heat elsewhere. Since these thermometers on the outside seem to be most practicable and most easily observed, we may, with profit, learn to use a slightly different set of temperatures based on their records. Starting with those temperatures taken at the center of the oven, we must make allowance for the fact that the outside thermometer will record the heat more slowly, and will register a temperature of about 50° F. lower than the thermometer in the center.

The table on the opposite page shows the range of temperatures applicable in the preparation of foods, as worked out in these laboratories.

DISCUSSION OF TEMPERATURE TABLE

Water is frozen at 0° C., but fruit ices or ice creams freeze at a lower temperature. Substances in solution lower the freezing point, and the more concentrated the solution, the lower the temperature required to freeze it. Thus, a mixture may be prepared containing so much pulp and sugar that it is almost impossible, by ordinary methods, to freeze it. Under such circumstances, the remedy lies in diluting the mixture and adding more salt to the crushed ice. Three parts of ice to one part of salt ordinarily gives a sufficiently low temperature for freezing ices and ice creams, but adding more salt produces a still lower temperature.

Water simmers before it boils. Tiny bubbles rise and break under the surface of the water, and some form about the edges of the pan. When water boils, however, the surface is completely agitated. Above sea level, the boiling point may be reached at 98° C. or 99° C. or lower, according to the altitude. Simmering temperature is used in the cooking of meat stews and of so called "boiled" meats.

The boiling point of a sugar solution is higher than that of water, as substances in solution raise the boiling point. The temperatures given in the preceding table should be lowered 1° C. for every degree below 100° C. found as the boiling point of water. If the boiling point is 99° C., then fondant frosting is best at 112° C., etc. Most satisfac-

TABLE OF TEMPERATURES

Process	Degrees Centigrade	Degrees Fahrenheit
Freezing of fruit ices (temperature of medium)	−5 to −8	23 to 18
Freezing of water	0	32
Whipping of cream	3 to 10	37 to 50
Butter-making	15 to 16	60
Raising of bread (temperature of room)	26 to 40	79 to 104
Cheese-making	37 to 60 (Depends upon acidity)	98.6 to 140
Coagulation of albumin	Begins 56; completes 71	133 to 160
Simmering of water	82 to 99	180 to 210
Soft custards	82 to 84	179 to 183
Double boiler, top part	89 to 94	192 to 201
Boiling water at sea level	100	212
Jellies (boiling point of water 100° C.)	103	185
Sugar cookery (boiling point of water 100° C.)		
Fondant	113	235
Fudge frosting, boiled	111	232
1 egg white to 1 cup sugar	113 to 115	235 to 239
2 egg whites to 1 cup sugar	117	243
1 egg white to 1 cup of dark brown sugar	125	257
1 egg white to ¾ cup of dark brown sugar, ¼ cup white	122	252
[1]Roasting of meat		
Temperature of oven		
First 15 minutes	250	450
Remainder of time	175	347
Temperature of meat interior		
Rare done	46.5 to 60	115.7 to 140
Medium	60 to 70	140 to 158
Well done	70 to 80	158 to 176
Deep-fat frying. Temperature of fat for		
Uncooked foods	175 to 190	347 to 374
Cooked foods	185 to 205	365 to 401
Cold, wet, uncooked foods	190 to 195	374 to 383
Baking. Temperature of center of oven for		
Sponge cakes	175 to 190	347 to 374
Angel food cakes	150 to 170	302 to 338
Soufflés (surrounded by water)	200	392
Bread	180 to 220	356 to 428
Butter cakes		
Loaf	190	374
Layer	210	410
Muffins	220 to 235	428 to 455
Parkerhouse rolls	235	455
Baked potatoes	235	455
Baking powder biscuit	235 to 240	455 to 464
Popovers	235 to 200	455 to 392
[2]Pastry	240	464

[1]Elizabeth Sprague and H. C. Grindley, "A Precise Method of Roasting Beef," University of Illinois Bulletin, Vol. IV, No. 19.

[2]Elizabeth Sprague, "Studies of Methods in Food Preparation," Journal of Home Economics, Vol. III, No. 5, p. 446.

tory results have been obtained in sugar cookery on rainy days by first taking the temperature of boiling water and then raising the temperature for the cooking of the sugar solution to accord. The lower temperatures given produce a softer frosting which requires more beating and hardens more slowly. The addition of egg white to a frosting or a candy will, it may be noted, raise the required temperature for the syrup. The larger amount of egg is often desirable as it makes a frosting which spreads easily and which keeps soft on the inside. The presence of caramel raises the temperature to which sugar solutions should be cooked. Thus the soft ball test for dark brown sugar, which contains a considerable amount of caramel, is 119° C. instead of 113° C., as for white sugar. This applies in the making of boiled frostings, when dark brown sugar is used. The temperature required rises in accordance with the proportion of this sugar substituted.

Cream whips best at 5° C., especially if it is not very thick. If the temperature is as high as 15° C. or 16° C., the butter-making point is reached and a little overbeating gives a granular appearance and continued beating may produce butter. The proper temperature in the making of butter causes it to form much more readily and to give a larger bulk with a better color and consistency.

The best quality of cottage cheese is made when the curd is separated from the whey by means of the sun's heat or at a temperature of 37° C., in a double boiler. However, the milk must be fairly acid to separate at this temperature; otherwise, it may be necessary to use a higher one. In any case, a double boiler should be used, and the temperature never allowed to go much above 70° C., as the curd will then toughen.

Since eggs contain much albumin, the egg can be completely coagulated, even made firm, at a temperature of 71° C. or 72° C. At this temperature, the egg white is not made tough and rubbery as at higher temperatures. Hard cooked eggs are much more tender if cooked for forty-five minutes at 75° C. than if boiled for ten minutes. Likewise, soft cooked eggs are much better if cooked for five to ten minutes at about 75° C., than if boiled for three minutes. Approximately this temperature is obtained when eggs are put into boiling water and allowed to stand, with the heat turned off.

Soft custards are thickened by means of egg and, on overcooking, curdle because the protein of the egg toughens and shrinks. The changes take place very rapidly, so that much care is required in the testing. The presence of egg white lowers the curdling point; thus a custard made from egg whites curdles at 83° C., one made from whole egg at 83.5° C., and one made from yolks at 84.5° C. The optimum