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In cooperation with U. S. Department of Agriculture.
DEEP FAT FRYING AT HIGH ALTITUDES

By Emma J. ThiesSEN

INTRODUCTION

Frying, as a method of cooking, has been in use since the days of the early Romans. It is a popular method of cooking at the present time. Many doughnuts, commercial and home made, are consumed annually in our country. Saratoga chips, French fried and shoestring potatoes are perhaps even more popular fried products.

HISTORY AND LITERATURE

A review of the literature shows that much of the research on deep fat frying dates back to the period of 1916-1921. Since that time the sciences and technology of fats have continuously undergone improvement, so that today there are available for use better and more varied cooking fats, (1)*.

A survey of experimental testing shows little agreement as to the best temperatures to be used in frying. Actual frying temperatures with a range from 350 to 410 degrees Fahrenheit have been recommended for Saratoga chips and French fried potatoes (2, 3), and for doughnuts a range from 350 to 390 degrees has been recognized, (4, 5, 6). Temperatures ranging from 347 to 410 degrees have been recommended for fritters and 365 to 401 degrees for croquettes.

Conflicting data were found in regard to causes for varying amounts of fat absorbed in fried foods. It has been reported that there was less absorption with potato chips cooked at the higher temperatures of 374 than at 338 degrees, (7). On the other hand, other investigators specify that higher frying temperatures increase fat absorption in dough, (8). Still others report there are definite temperatures for different types of fat, when absorption is least and texture optimum, (9). Rich doughnuts absorb more fat than those from less rich formulas. The

*The numbers in parentheses refer to numbers in the "literature cited" at the end of this bulletin.
absorption increases when larger amounts of sugar and fat are added to the dough.

The fitness of fats for cooking after a long series of frying is important for health as well as from an economical viewpoint. Although considerable deterioration has occurred upon re-use, there seems to be little relationship between these chemical changes and the flavor of the product cooked therein. The iodine number is lowered, the percentage of free fatty acids increased, and the smoking point decreased, \(7, 8, 10, 11\).

Formerly, fried foods were considered highly indigestible, but present knowledge indicates that properly fried foods can be digested without difficulty by the normal individual, \(12\). In an experimental study on human subjects in the Physiological Chemistry Department of Yale University, the fats, carbohydrates, and protein of doughnuts replaced equivalent quantities of these nutrients in the basal ration. When six doughnuts were eaten daily, for six consecutive days, the fat made up 50 per cent of the total fat intake, which apparently did not adversely affect either the digestibility of the nutrients of the diet or the retention of calcium or phosphorus. No untoward effects on the health of the subjects were observed, \(12\). The way the frying was done and the nature of the food fried influenced considerably the amount of fat and irritating decomposition products in the food, and hence the digestibility \(13\).

It has long been recognized among nutritional physiologists that fats or foods rich in fat leave the stomach more slowly than carbohydrates or proteins, a fact explaining the “staying” qualities of foods such as fatty meats, doughnuts, and pastry. Such foods, which give a feeling of satiety following their consumption, should not be consumed in addition to a meal of ordinary proportions, \(9, 12\).
STATEMENT OF PROBLEM

It has been the purpose of this study to determine the best methods of preparing fried foods at high altitudes and some of the factors affecting their quality and palatability.

The study has been divided into two parts. The first has to do with frying Saratoga chips, French fried potatoes, and croquettes. Temperatures for frying, as well as various other factors affecting quality, are included. The second part takes up the frying of dough mixtures, the absorption of fat in doughnuts, and the best temperatures to use in frying doughs. The desirability of different types of fat for deep-fat frying has been compared and modifications of formulae for doughnuts at an altitude of 7,200 feet made.

Fried foods can be well or poorly prepared in the home just as baked goods can be made very good or practically inedible according to the method of preparation. Properly fried foods are usually described as products with a crusty golden brown surface and a thoroughly cooked interior with no superfluous fat.

MATERIALS AND METHODS

Fats Used in Cooking. Corn and cottonseed oil, three grades of leaf lard, and two kinds of hydrogenated fat were tested. They were used in eight and sixteen pound lots. No fresh fat was added to the lots for frying doughs, since the deterioration upon re-use was measured from time to time.

Utensils for Cooking. The frying utensils were heavy cast-iron and aluminum. The heavy metal was not so easily damaged by heat and helped to keep the temperature of the fat constant during the frying period. The temperatures were tested by chemical thermometers. Thermometers of other types proved more satisfactory for household tests, since they were not so easily broken. Deep fat frying thermometers can usually be obtained through local dealers for about $2.00. They should register as high as 500 degrees.

A new type of frying pan with a safety ring and attached thermometer proved advantageous for small amounts of food, because only two pounds of fat were required for successful frying.
Precautions in Deep Fat Frying. Fat catches fire readily and should be handled very carefully. The kettles in Figure 1 are large enough so that the fat does not spatter on the stove during cooking. If the kettle has a long handle, care should be taken that the handle does not protrude into the room where there is danger of knocking against it. The small pan in Figure 1 has a safety ring which guards against spattering. This inner ring of metal with vents at the bottom also acts as a breakwater, so that the fat boils over into the rest of the pan, from where it can seep back into the center.

Foods, such as potatoes, which were soaked in water, were dried between towels before placing in the fat, since a mixture of water and hot fat readily boils over and catches fire.

The fat was watched carefully during the entire period of heating.

Care of Fats Between Cooking Periods. The frying fats were strained through a double thickness of cheese cloth into tin containers. The containers had tight covers which made them air-tight or practically so. They were stored at 40 to 50 degrees in the intervals when not in use.
EXPERIMENTAL DATA

PART 1. FRYING POTATOES AND CROQUETTES

Saratoga Chips

Preparation. Medium sized tubers were selected. They were peeled by hand and sliced with a mechanical slicer about 1/16 inch in thickness. The slices were covered with water to prevent discoloration. If wilted, they were allowed to soak in cold water several hours before cooking.

Several potato varieties were tested, including those high in starch as well as those with a low starch content.

Changes in Reducing Sugars of Potatoes During Storage and Effect on Quality of Chips. The amount of reducing sugars in the potato determined the color of Saratoga chips and French fried potatoes to a large extent.

The causes for the changes in the sugar content of tubers have been investigated by plant physiologists, who have outlined three processes continually going on in the stored tubers which are concerned with the transformation and disappearance of starch and sugar. These processes are (a) respiration, which consumes sugar by converting it into carbon dioxide and water; (b) conversion of starch into sugar by enzymes; and (c) the process which may again convert the sugar back into starch, (14).

Considerable sugar accumulated in the tubers during a period of long storage at low temperatures. The temperature of the storage cellar usually registered from 38 to 42 degrees throughout the winter months, but lower temperatures were at times unavoidable during the rigorous Wyoming winters. The accumulation of sugar in the tubers was very rapid when storage temperatures were around 32 to 34 degrees.

Potatoes which had accumulated considerable sugar were again made palatable by removing to warmer temperatures.

The lessening of reducing sugars in tubers stored at temperatures of 50 to 60 degrees was followed by the Peacock Brunstetter color test. The test is comparatively simple and may be used by manufacturers of potato chips to select potatoes with low sugar.
content, as well as to determine when they have been stored at the warmer temperature for an adequate time to reduce the sugar sufficiently for good chips. The test is as follows:

One cubic centimeter of a saturated aqueous solution of picric acid (prepared by dissolving an excess of picric-acid crystals in boiling water) is placed in a test tube; one cubic centimeter of a 20 per cent sodium carbonate solution is then added and a potato cylinder is placed in the tube with the mixed solution. This cylinder, which is three-sixteenths of an inch in diameter and one inch long measured from the skin, can be cut with a cork borer. After the contents are shaken, the test tube is held for one minute over the flame of an alcohol lamp, and then placed in a rack to cool. (15).

A color reaction takes place which will vary from pale yellow to dark brown as the percentage of sugar in the potato sample increases. In working with Bliss Triumphs in this laboratory it was found that a color darker than a deep orange indicated that the sugar content was too high for making the most satisfactory chips. When the color was mahogany red or darker, the sugar content was so high that parts of the chip became too brown before the remainder was completely cooked. A manufacturer of potato chips can easily learn to use this test by comparing the color reaction of sample potatoes with the chips they produce.

The sugar in potatoes is largely controllable by the temperature of storage. In this laboratory it was found that potatoes stored for several months in a cellar at 34 to 42 degrees were too high in sugar to make satisfactory chips. However, after they were transferred to storage at 50 to 60 degrees, the sugar gradually became less, and by the end of one to two months they made chips of high quality.

Storage for a period of three to five months at the warmer temperature resulted in withered, sprouted, and off flavored potatoes. Chips made from such tubers were poor in flavor and flinty in texture.

When stored under similar conditions, Cobblers and Early Ohios usually accumulated less sugar than the Bliss and made better chips. All storage cellars should be provided with thermo-
meters in order that variations in temperature may be closely watched during the winter months.

It is advisable to remove small lots of potatoes from the storage cellar from time to time during the winter and store them at warmer temperatures for household use. The warm storage will insure mealier and better flavored baked and boiled potatoes as well as more attractively browned chips and French fried potatoes. The basements of most homes, when the temperature averages around 50 to 60 degrees, provide an excellent place for warmer storage.

Quality of Old Potatoes for Chips. Chemical tests indicated the total sugar in several varieties of old potatoes was too high for good chips and was often considerably higher than in fall tubers from the same lot, even though the temperature of the storage cellar during the spring averaged around 40 to 50 degrees. The Bliss Triumphs usually accumulated more sugar than the Irish Cobblers, Early Ohios, White Pearl, or Russet potatoes.

Temperatures for Frying Potato Chips. The initial temperature to which the fat was heated for frying depended upon the number of slices added at one time as well as their temperature. The drop in the temperature of the fat upon the addition of cold wet slices was often around 50 to 70 degrees. The initial temperature of the fat should be high enough to cover the average drop for the lot being cooked in order that the fat may quickly regain a desirable operating temperature. The operating temperatures were best at 350 to 360 degrees. Potatoes with considerable sugar required somewhat lower temperatures to prevent too deep browning.

The time for cooking ranged from 4 to 5 minutes, which in turn depended upon the thickness of the slices. A small hand potato slicer made it possible to secure thinner slices than with the ordinary practice of hand slicing. Crisper chips resulted from the thinner slices.

It was difficult to evaluate the various data on the best frying temperatures for Saratoga chips at low altitudes and to establish a satisfactory norm for comparison since temperatures from
350 to 410 degrees were listed as desirable for frying chips at sea level. The upper limits were not satisfactory at an altitude of 7,200 feet. Frying temperatures of 400 to 410 degrees produced over-brown, almost burned chips which were frequently not cooked through. This was true with oil as a frying medium as well as lard and was more pronounced with re-used fats. Lowering the temperatures prevented too deep browning.

No frying tests were made with these potatoes at low altitudes. It was evident, however, that the highest of the lea-level deep-fat frying temperatures could not be used satisfactorily at an altitude of 7,200 feet. A probable explanation may be that since moisture fries out of the food more speedily at higher elevations, the intrinsic heat would rise more rapidly in the food to the end that, at the same temperature and other things being equal, a darker brown product would result. (1).

**French Fried Potatoes**

*Preparation.* French fried potatoes differ from Saratoga chips in that they are cut in larger pieces. A medium sized potato in these tests was usually cut lengthwise in eighths. A larger tuber was cut into twelve strips. The quality was impaired unless they were served immediately when cooked. If this was impossible, they were fried until tender but not brown, drained on absorbent paper and placed in the hot fat for browning a few minutes before serving.

*Temperatures for Frying French Fried Potatoes.* The thickness of the pieces necessitated lower frying temperatures than were used for chips. An operating temperature around 330 degrees F. for ten to twelve minutes was satisfactory for French fried potatoes if the tubers were low in sugar. Temperatures of 280 to 290 degrees gave more satisfactory results with potatoes high in sugar. As with chips, this product was best made from tubers high in starch and low in sugar. Good fried potatoes are usually obtained from a variety that is mealy when baked or boiled. This may be used as a guide by the housewife in selecting potatoes for frying.
Shoestring Potatoes

Shoestring potatoes differ from French fried potatoes in that they are cut in thin strips. The ones used in these tests were two inches in length and one-fourth inch in thickness. Temperatures for frying were similar to those listed for Saratoga chips.

Relative Value of Different Fats for Frying Potatoes

Oils were given the preference as a frying medium for potatoes. Chips cooked in oil were brighter, clearer, and glossier in appearance than those cooked in lard. Quality differences using various fats as frying mediums were more evident with potatoes than with doughs. The flavor of chips cooked in oils was preferred by the majority of the judges.

Croquettes

Croquettes are usually made of meat, vegetables, or rice, seasoned and held together with egg or thick white sauce. The mixture, which is shaped and rolled in crumbs and egg, is fried in deep fat. The ingredients in the mixture are usually cooked. It is then only necessary that the croquettes be browned in the hot fat. If the ingredients are uncooked, the time for frying must be lengthened.

Temperatures for Frying

The operating temperatures were best at 360 to 365 degrees F., for one to two minutes. High temperatures of 390 to 400 degrees produced very dark brown croquettes with a rather tough and hard egg coating. The frying fats also smoked badly at the high temperatures, particularly the re-used fats. The fat absorption of the croquettes seemed to vary only slightly at the different temperatures noted above. The advantages seem to be with moderately high temperatures for frying.
PART II. FRYING DOUGH MIXTURES

Doughnuts

Relative Value of Different Fats for Frying Doughnuts.*

The frying life of lard, corn oil, cottonseed oil, and a hydrogenated fat were compared when used for cooking doughnuts. These fats, with the exception of corn oil, were secured from the manufacturers with a partial chemical analysis of each lot.

Three lots of lard which are commonly found on the market were tested; namely, Grade I, smooth leaf lard; Grade II, smooth leaf lard; and a leaf lard of grainy consistency.

Eight pounds was the initial amount of lard and hydrogenated fat used for the 12-hour, and 16 pounds for the 18-hour series of frying tests. The oils were used in one-gallon lots for the 12-hour and in two-gallon lots for the 18-hour tests. The larger amount of fat would not be used for household frying but only for large-quantity cooking.

The smoking points of unused fats at a high altitude of 7,200 feet were approximately the same as at sea level. A smoke box was utilized to secure the smoking point and the method described by the American Oil Chemists Society proved the most satisfactory (17). The thin atmosphere made it very difficult to see the smoke by the method of heating the fat in open evaporating dishes (18). The smoking point was lowered from 50 to 70 degrees in the re-used oils and hydrogenated fats. The decrease was less for lard during similar periods of frying.

All fats deteriorated upon re-use. The free fatty acids increased, and the iodine number and smoking point were lowered. The rate of deterioration varied little with different fats.

Storing either used or unused lard in a cool place and keeping it tightly covered helped to prevent rancidity. Unused lard stored in a tight tin container at 70 to 75 degrees for six months developed more acid than lard from the same lot stored at 50 to 60 degrees for this period of time. There was little difference in the acidity of unused corn oil stored at these different temperatures for six months. A home-rendered lard, which became ran-

*A part of this material has been published in Food Research and may be referred to for a more detailed study. (19).
cid shortly after it was made, probably due to insufficient heating, had a high acid content. Off flavors were evident in foods in which this lard was used. Attempts to recondition the rancid fat were unsuccessful.

The percentage of free acid in a used fat has been considered a fairly reliable measure of the extent of its breaking down and imparting poor flavors to foods. Porter, Michaelis, and Shay reported an objectionable flavor in doughnuts with two per cent acid in the frying medium (16). This was considerably higher than the acid in the re-used fats in these experiments in which the highest amount was 0.75 per cent for lard.

The discoloration in re-used lard and hydrogenated fat apparently had little effect upon the flavor of the foods cooked therein. In the case of lard, the distinctive lard flavor was less pronounced in doughnuts after this fat had been re-used several times. The reasons for this have not been determined.

Whether the above fats, after 12 to 18 hours of use, had deteriorated to the extent that the products cooked therein would be unsafe for human consumption is a matter for further investigation. The judges suffered no apparent ill effects, as a result of eating the doughnuts cooked in the re-used fats in this series of tests.

Absorption of Fat in Doughnuts and Factors Affecting It.
The absorption of lard, hydrogenated fat, corn and cottonseed oil in doughnuts was approximately the same. The fat was determined by ether extraction on duplicate samples and averaged about 21 per cent in doughnuts made from a mix containing 75 per cent hard wheat flour and 25 per cent cake flour. When the formula was modified to include equal proportions of soft and hard wheat flour, the total fat averaged from 28 to 30 per cent, or approximately one tablespoon of fat to each doughnut. When the scraps of dough from the first cutting were re-rolled, there was about 3 per cent less fat in each doughnut. With a second re-roll, the absorption was 4 per cent less. More handling of the dough lessened absorption but also toughened the doughnut. Doughnuts from the second re-roll were inferior in quality to the others.
Doughnuts cooked at a temperature of 385 to 390 degrees absorbed 2 per cent more fat than those cooked at 350 to 355 degrees, either in corn oil or hydrogenated fat. Although no large cracks were apparent, the surface seemed somewhat rougher in doughnuts cooked at the high temperature. Other things being equal, frying at comparatively low temperatures usually results in more absorption of fat (7).

Commercial doughnuts dropped from a doughnut machine varied only slightly, one from another, in fat content. The average was 21.6 per cent. A second lot dropped from a pastry tube varied considerably in size and shape and likewise in fat. A small one contained 17.2 per cent, whereas a second, which was larger and thicker, contained 20.4 per cent.

It was further noted that when the fat was increased in the recipe, more was absorbed in the doughnut, and that increasing the sugar in the formula resulted in increased fat absorption.

As scored by the majority of the judges, the doughnuts with 28 to 30 per cent fat rated higher in palatability than those with 18 to 20 per cent. Most homemade doughnuts carry from 25 to 30 per cent fat, considerably more than the commercial average (10, 20). Of this about 5 per cent is usually in the mix itself and the average absorption about 20 to 25 per cent.

A comparatively high fat content of 28 to 30 per cent, seemed desirable for palatable doughnuts but might be questioned from the health standpoint. Foods rich in fat must be considered as to speed of digestion, comfort during digestion, and completeness of digestion.

**Scoring for Palatability**

The judging was done by a panel consisting of trained home economists which was supplemented from time to time by other men and women. In the first ratings a standard of perfection was agreed upon for the various products.

Three or more samples were rated at the same time in order that comparisons might be made of one sample with another as well as with the standard product. Samples were prepared so that variables were eliminated in so far as possible.
In comparing the palatability of different types of fat for frying, doughnuts were cut from the same mix and from the first roll of the dough. They were fried in each of the four frying fats being tested, simultaneously, so that the flavor of one fat might be compared with another. A similar technique was used in comparing fresh and re-used fats for frying mediums, also the desirability of high and low temperatures on the quality of the product.

The score card was so arranged that the judges could indicate their ratings for the different samples on a single sheet and specify the type of fat they thought was used for frying each sample.

Modification of Doughnut Formulae at High Altitudes

Doughnuts made from most sea level recipes were very poor and frequently cracked when fried at an altitude of 7,200 feet. There was often a high fat absorption which was usually an indication of a too rich dough, and frequently they were hard and brown. To remedy some of these difficulties, the leavening and fat were usually reduced and a certain proportion of hard wheat flour was used. In richer formulae it was also necessary to reduce the sugar. The temperatures for cooking were lowered.

The type of flour undoubtedly influenced the eating quality to a great extent. There was a tendency for doughnuts to crack and soak up grease when cake flour was used 100 per cent. The proportion of 50 per cent cake flour and 50 per cent hard wheat flour gave a tender product with a normal absorption of fat and less tendency to crack. Hard wheat flour used 100 per cent toughened the doughnuts.

The optimum amount of sugar that could be added depended upon the strength of the flour. It was possible to use larger proportions with hard wheat flour in the mix. Sugar made the doughnuts more tender and gave them a good flavor. Hence as large a proportion as possible was added.

Shortening was used in small amounts since too much weakened the structure resulting in a high fat absorption with frequent cracking of the doughnuts. Egg yolks made a tender
doughnut, but if used to excess they produced one which was too short and cracked open. An excessive amount of whole eggs produced a tough doughnut.

It was noted that keeping the mix comparatively soft aided in preventing cracks. If the dough was too soft, however, it absorbed large amounts of fat. The addition of mashed potatoes tended to lessen the fat absorption and produce doughnuts with better keeping qualities. Dipping in a glaze prevented rapid staling. Reheating in the oven just before serving freshened the doughnuts.

Temperatures for Frying Doughnuts. To prevent too deep browning the temperatures for frying were lowered from those which were usually recommended at sea level. The temperatures tested for frying ranged from 350 to 400 degrees. Doughnuts cooked at 350 degrees for three minutes were a golden brown color; 365 degrees for two minutes, a deep brown color; and 390 degrees for one and one-half minutes produced a very dark brown doughnut. This effect was more pronounced with re-used than with fresh fats. Such high temperatures as 385 to 390 degrees often advocated at sea level, were not satisfactory at an altitude of 7,200 feet. These refer to the operating temperatures. The drop in the temperature of the frying fat upon the addition of four doughnuts usually averaged from three to four degrees depending upon the coldness of the dough. The initial temperature of the fat would therefore need to be very little higher than the operating temperature.

The doughnuts were lighter in texture when fried at the lower temperatures of the above series.

Fritters

Fritters are drop batters to which fruit or vegetables are added. They are much thinner in consistency than doughnuts and their behavior while cooking varied considerably from the stiffer doughs.

Formula Modifications. A survey of recipes revealed many different formulae which varied chiefly in their proportions of
baking powder, sugar, and fat. In an analysis of twenty low altitude household formulae for fritters, counting flour 100 per cent, these ingredients showed the following range in proportions: Sugar 0 to 46 per cent, fat 0 to 9 per cent, baking powder 1.7 to 7 per cent.

In the less rich formulae in which all bread flour was used the fritters tended to be tough. Their texture and tenderness improved greatly when part of the bread flour was replaced with cake flour. Lessening the sugar, fat, and baking powder in the rich formulae also improved the product.

Batters which were comparatively stiff produced fritters of a nicer texture than the thinner mixtures. Care was taken not to toughen the fritters by over-mixing.

Temperatures for Cooking. Desirable frying temperatures for fritters at 7,200 feet ranged from 360 to 370 degrees F., for 3 to 4 minutes which depended in some measure upon the composition of the batter and the size of the fritter. Frying temperatures listed as desirable in various cook books at sea level ranged from 347 to 410 degrees for 2 to 3 minutes.

It was evident in these frying tests that cover batters or fritters with no sugar in the mixture did not have a golden brown color at any of the above frying temperatures. Some sugar in the recipe was essential for an attractively browned crust. As with doughnuts, the texture was more desirable at moderately high frying temperatures.

Absorption of Fat. Fritters which contained no fat or sugar or very small amounts of these, absorbed less fat, but they tended to be tough and less palatable than those from richer formulae.

Fritters made from thin batter had a less desirable texture and absorbed more fat than ones made from thicker mixtures.

The size of the fritter also had an effect upon fat absorption. Small fritters dropped from a teaspoon were more desirable in texture and absorbed less fat than large fritters dropped from a tablespoon. The small fritters usually turned themselves after the first minute of frying as well as several times during the cooking period. It was necessary, however, to turn the larger fritters and cook them for a longer period.
Practical Application

As a result of the experimental tests on dough mixtures, a number of high altitude recipes have been formulated. All of the recipes listed here have given good results when made under standard conditions at an altitude of 7,200 feet.

It must be remembered that the best recipes may be spoiled by poor technique and poor ingredients. Fresh ingredients, accurate level measurements, measuring the flour after it has been sifted once, and careful mixing are most essential. The ingredients before mixing should be allowed to stand in the kitchen until they are approximately the temperature of the room. The dough can be handled to better advantage when kept in a covered bowl about twenty minutes before rolling out. The handling of the dough may be further simplified by the use of a canvas cover for the molding board and a stockinet cover for the rolling pin. These sets may be purchased in kitchen furnishing departments.

If a large number of doughnuts are cut at one time, they should be covered with a clean dry towel, with a slightly moist one placed over it, to prevent the surface of the dough from crustling.

Flour is a variable factor, since bread flour made from hard wheat absorbs more moisture than all purpose or cake flour made from soft wheat. Flour that is very dry also requires more liquid. It may, therefore, be necessary to make slight changes in the proportions of flour in the following recipes. The dough for all the cake doughnut recipes should be of medium softness and approximately the consistency of a rolled cooky dough.

High Altitude Doughnut Recipes

1. Plain Cake Doughnuts

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 cup milk</td>
<td>2 1/4 cups cake flour</td>
</tr>
<tr>
<td>1 cup sugar</td>
<td>2 1/4 cups bread flour</td>
</tr>
<tr>
<td>3 tsp. fat</td>
<td>3 tsp. baking powder</td>
</tr>
<tr>
<td>3 egg yolks</td>
<td>1 1/2 tsp. salt</td>
</tr>
<tr>
<td>1 whole egg</td>
<td>1 tsp. nutmeg</td>
</tr>
<tr>
<td></td>
<td>1/2 tsp. cinnamon</td>
</tr>
</tbody>
</table>

( Makes 3 dozen)
Beat eggs until light with Dover egg beater; beat in sugar gradually; add melted fat. Reserve \( \frac{1}{2} \) cup flour. Sift the rest of the flour, baking powder, salt, and spices together twice. Add to the first mixture in four additions alternately with the milk, starting and ending with the dry ingredients. The amount of flour will vary somewhat with the kind and dryness. Add as much of the reserved flour as is needed. Do not over mix. The dough should be of a medium soft consistency that can be rolled without sticking to the board. Let stand in a covered bowl 20 minutes. Knead slightly by placing on a floured board. Fold the dough over several times. Roll out about half of the dough at a time to one-third inch in thickness. Cut with a doughnut cutter. Fry at 350 to 355 degrees for 3 minutes. Do not attempt to cook more than four at one time. Turn after the first 1½ minutes of cooking. Drain. Roll in either granulated or powdered sugar or dip in a glaze.

**Variations—Chocolate Doughnuts.**

Substitute one-half cup cocoa for one-half cup flour in the plain cake doughnut recipe.

2. **Potato Glazed Doughnuts**

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 cup hot riced potatoes</td>
<td>1( \frac{1}{8} ) cups cake flour</td>
</tr>
<tr>
<td>3 tsp. butter</td>
<td>1( \frac{1}{8} ) cups bread flour</td>
</tr>
<tr>
<td>1 egg yolk</td>
<td>2 tsp. baking powder</td>
</tr>
<tr>
<td>1 whole egg</td>
<td>1( \frac{1}{2} ) tsp. salt</td>
</tr>
<tr>
<td>1 cup sugar</td>
<td>1 tsp. mace or nutmeg</td>
</tr>
</tbody>
</table>

(Makes about 1½ dozen doughnuts)

Measure out all ingredients. Add butter to hot riced potatoes and beat until melted. Cool until lukewarm; add unbeaten eggs and sugar. Beat well. Reserve one-half cup of flour. Sift the rest of the flour, baking powder, salt, and spices together twice. Add all at once to the first mixture and mix until well blended, add a part of the reserved flour or more if needed. The moisture in the potato makes the addition of liquid unnecessary and varies with the type of potato. Enough flour should be added to make this dough the consistency of a soft cooky dough. Let dough stand in a covered bowl 20 minutes. Roll out one-third inch in thickness. Cut in rings and fry at 350 to 355 degrees as with the plain doughnuts. Dip in a glaze or roll in sugar.
3. Sour Cream Ice Box Doughnuts.

2 cups cake flour  
2 cups bread flour  
1/2 tsp. baking powder  
1/2 tsp. soda  
1/2 tsp. nutmeg  
1/2 tsp. cinnamon

1 tsp. salt  
1 tsp. thick sour cream (scant)  
1/4 tsp. sour milk  
1 egg yolk  
1 whole egg  
1 cup sugar

(Makes about 3 dozen)

Beat eggs until light, beat in sugar, add cream. Add sifted dry ingredients alternately with milk as with the plain cake doughnuts. The dough should be the consistency of a soft cooky dough. Place dough in a covered vessel or glass jar with a tight lid. Store in the ice-box. Dough may be kept about a week and doughnuts fried as desired. Roll slightly thinner than ordinary doughnuts. Proceed as in the recipe for plain cake doughnuts for frying.

4. Devil's Food Doughnuts.

1 1/2 sq. chocolate,  
1 tsp. butter  
1 cup hot riced potatoes  
1 yolk  
1 cup sugar  
2 tbsp. chopped nuts

(1 1/2 oz.)  
1 tsp. vanilla  
1 cup cake flour  
1 cup bread flour  
1/2 tsp. baking powder  
1/2 tsp. soda  
1 tsp. salt

(Makes about 1 1/2 dozen)

Measure out all ingredients before starting to mix. Add butter to the hot riced potatoes. Stir until melted. Cool until lukewarm, mix in unbeaten eggs one at a time. Add sugar and beat well. Add melted chocolate and flavoring, then grated orange rind and nuts. Reserve one-half cup flour. Sift the remainder of the flour together with the baking powder, soda, and salt twice. Add to the first mixture, with as much of the reserved flour as is needed. Dough should be of medium stiffness. Let stand in covered bowl 20 minutes. Place on lightly floured board and knead slightly by folding over several times. Roll dough to one-third inch in thickness. Cut out doughnuts and fry at 350 to 355 degrees for 3 minutes. Turn after the first
I½ minutes of cooking. Drain on brown paper and dip in chocolate frosting. Note directions for dipping under frosting.

Note: These doughnuts are a nice party doughnut. They are quite rich hence measurements must be level or doughnuts will crack. Should this occur, fold the dough over several times and reroll.

5. Whole Wheat Orange Doughnuts.

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 cup hot riced potatoes</td>
<td>4 tbsp. sour milk</td>
</tr>
<tr>
<td>3 tsp. butter</td>
<td>1 cup cake flour</td>
</tr>
<tr>
<td>1 whole egg</td>
<td>1 cup bread flour</td>
</tr>
<tr>
<td>1 yolk</td>
<td>6 tbsp. fine whole wheat flour</td>
</tr>
<tr>
<td>½ cup brown sugar</td>
<td>¼ tsp. salt</td>
</tr>
<tr>
<td>½ cup white sugar</td>
<td>½ tsp. soda</td>
</tr>
<tr>
<td>2 tbsp. grated orange rind</td>
<td>½ tsp. baking powder</td>
</tr>
<tr>
<td>3 tbsp. chopped nuts</td>
<td></td>
</tr>
</tbody>
</table>

(Makes about 2 dozen doughnuts)

Measure out all ingredients. Add fat to hot riced potatoes, stir until melted, and cool until lukewarm. Add unbeaten eggs and beat well. Mix in sugar. Add dry ingredients alternately with milk in three additions. The dough should be of a soft cooky dough consistency. Add additional flour if necessary. Let stand in covered bowl 20 minutes. Roll out and fry according to the method for plain doughnuts. Roll in sugar in which grated orange rind has been added, or dip in plain or chocolate frosting.


<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>¾ cup scalded milk</td>
<td>½ tsp. salt</td>
</tr>
<tr>
<td>½ cake compressed yeast</td>
<td>1 egg</td>
</tr>
<tr>
<td>dissolved in</td>
<td>1 tsp. nutmeg</td>
</tr>
<tr>
<td>¼ cup lukewarm water</td>
<td>¾ cups bread flour</td>
</tr>
<tr>
<td>¼ cup sugar</td>
<td></td>
</tr>
<tr>
<td>½ tbsp. fat</td>
<td></td>
</tr>
</tbody>
</table>

Scald the milk and pour over sugar, fat, spice, and salt. Cool to lukewarm and add beaten egg. Dissolve the yeast in the lukewarm water and add to the above mixture. Add flour to make a medium soft dough. Knead as with bread. Grease top of dough and place in a covered vessel. Let rise in a moderately warm place (80 to 83 degrees) until double in bulk which will
require about 1½ hours. Punch down and let rise again. Roll out on a floured board one-half inch in thickness. Cut with doughnut cutter. Place on floured board, cover with clean towel, let rise for an hour or until quite light. Fry at 350 to 355 degrees for 3 to 4 minutes, depending upon the thickness of the dough. Place in frying fat with raised side down. These doughnuts may be served plain or dipped in the plain glaze or thin white frosting. They may be freshened by reheating in the oven just before serving.

Variations—The dough may be made in different shapes as:

Fried Knots—Roll dough one-half inch thick. Cut in strips one inch by four inches. Measure accurately. Tie each strip in a knot and cover with a clean towel. Let rise until very light. Fry at 350 to 355 degrees for 4 to 5 minutes as with the plain yeast doughnuts. Dip in a gelatin glaze. Serve hot.

Raised Jelly Doughnuts—Roll dough very thin (one-eighth inch) and cut in three-inch rounds. Cover with a clean towel. Let rise one-half hour. Place on one round a teaspoonful of tart jelly or orange marmalade. In place of the jelly, an apple filling made from chopped apple, raisins, cinnamon, and nuts may be used. Moisten the edges and place another round on top, sealing the edges well. Let rise until quite light. Place in frying fat with raised side down. Fry at 350 to 355 degrees for about 4 minutes. Roll in a mixture of sugar and cinnamon or dip in the plain gelatin glaze. Serve hot.

7. Fritter Batter with Fruit.

1 cup bread flour ½ tsp. salt
½ cup cake flour 1 egg
1¼ tsp. baking powder 1 tbsp. fat
3 tbsp. sugar ¾ cup milk
¾ cup finely chopped fruit

Mix and sift flour, baking powder, sugar, and salt. Beat the egg until light and to it add the milk and melted fat. Add to the dry mixture. Add the chopped fruit. Pineapple or apples are usually preferred. Drop the batter by teaspoonsfuls into deep fat which has been heated to 360 to 365 degrees, first dipping the
spoon in the hot fat. Cook 3 to 4 minutes depending on the size of the fritters. Turn after the first minute of cooking, if they do not turn themselves. Re-turn once. Drain on brown paper. Serve with a sauce or syrup.

Glazes for Doughnuts

1. Plain Gelatin Glaze.

\[
\begin{align*}
\frac{1}{2} \text{ cup water} & \quad \frac{1}{2} \text{ tsp. cream of tartar} \\
1\frac{1}{2} \text{ tsp. white corn syrup} & \quad 1\frac{1}{4} \text{ cups sugar}
\end{align*}
\]

Mix the above ingredients and boil ONLY two minutes. If boiled longer the glaze may become sticky. Pour hot over 1½ tsp. plain gelatine that has been soaked in 1 tbsp. cold water for five minutes. Cool mixture to about 120 degrees or lukewarm. Dip the warm doughnuts quickly in and out of the glaze. Place on a wire cake rack or preferably suspend on a glass rod to allow excess to drip off. Place paper underneath to catch drip.

2. Plain White Frosting

\[
\begin{align*}
2 \text{ cups powdered sugar} & \quad 1 \text{ tsp. vanilla} \\
2 \text{ egg whites}
\end{align*}
\]

Blend the above ingredients and mix until smooth. The consistency will vary with the size of the eggs and should be of medium thickness. Test the consistency by dipping several doughnuts. Thin with a small amount of top milk if necessary. Place the mixture in a small and rather deep vessel. Dip doughnuts before they have entirely cooled. Suspend on a rod until frosting has set. Place waxed paper underneath to catch the drip which may be scraped up and reused. Decorettes, coconuts, or nuts may be sprinkled over the frosting before it has entirely set. If the frosting is to be spread, it may be somewhat thicker.

3. Chocolate Frosting.

Add one square melted chocolate to the plain white frosting. The chocolate stiffens the mixture and one teaspoon or more of top milk may be used to thin the frosting for dipping. A desirable consistency can be determined by dipping several doughnuts. Proceed as above with plain frosting.
Cooking Periods and Temperatures

Satisfactory temperatures for deep fat frying described in the fore part of this bulletin are summarized in the following table.

**TABLE I.**

Deep-Fat Frying Temperatures at High Altitudes

<table>
<thead>
<tr>
<th>Food</th>
<th>Temperature of fat (Degrees Fahrenheit)</th>
<th>Operating temperatures</th>
<th>Cooking Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Croquettes</td>
<td>360-365</td>
<td></td>
<td>1- 2</td>
</tr>
<tr>
<td>Doughnuts</td>
<td>350-355</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Fritters</td>
<td>360-370</td>
<td></td>
<td>3- 4</td>
</tr>
<tr>
<td>Timbale cases</td>
<td>355-360</td>
<td></td>
<td>1- 2</td>
</tr>
<tr>
<td>French Fried Potatoes</td>
<td>330-340</td>
<td>280-290 (If high in sugar)</td>
<td>10-12</td>
</tr>
<tr>
<td>Potato Chips</td>
<td>350-360</td>
<td></td>
<td>4- 5</td>
</tr>
<tr>
<td>Shoestring Potatoes</td>
<td>350-360</td>
<td></td>
<td>4- 5</td>
</tr>
<tr>
<td>Fish, (Fillet of sole, etc.)</td>
<td>365-370</td>
<td></td>
<td>6- 7</td>
</tr>
<tr>
<td>Scallops</td>
<td>360-365</td>
<td></td>
<td>3- 5</td>
</tr>
</tbody>
</table>

Note: The initial temperature to which the fat is heated should be high enough to cover the average drop for the food being cooked in order to quickly regain the desirable operating temperature listed above.
SUMMARY AND CONCLUSIONS

1. The best temperatures for deep fat frying at high altitudes were below those usually recommended at sea level in order to prevent too deep coloring while the food was cooking. The browning was more pronounced with re-used fats.

2. The temperature for frying potato chips varied with the amount of sugar in the potatoes. When the sugar content was high, the frying temperatures were lowered. The accumulation of reducing sugar in potatoes was rapid with low storage temperatures of 32 to 34 degrees F. Removal of the whole potatoes from cold to warm temperatures for a month or more resulted in an improvement in the color and quality of Saratoga chips and French fried potatoes.

3. Good doughnuts and fritters can be made with each of the frying mediums tested. Judges could rarely identify the frying fat from the flavor of the product cooked therein with the exception of lard. The cheaper grade of lard was the only fat pronounced undesirable in doughnuts. Oils rated higher than the solid fats for frying potato chips.

4. Fats can be used over and over for deep-fat frying if they were not heated to extremely high temperatures and are strained through cheese cloth after each frying, cooled, covered closely, and stored in a cold place. Off flavors in doughnuts cooked in fat so treated were not evident until the frying fats had been re-used 12 hours or more.

5. To obtain good cake doughnuts free from cracks and with a normal fat absorption at an altitude of 7,200 feet, it was necessary to modify most sea-level recipes. In rich formulae, fat was reduced as well as the leavening. A certain proportion of hard wheat flour in the mix resulted in less fat absorption and made it possible to use more sugar.

6. Cake doughnuts, to be rated of good quality, carried 20 per cent or more fat. Those with 25 to 30 per cent scored higher in palatability than those with 20 per cent fat.
7. The absorption of fat was approximately the same with four different frying mediums, using the same formula and frying temperatures.

8. Fat absorption in doughnuts increased with larger proportions of soft wheat flour in the mix. With more handling the dough absorbed less fat, but the doughnuts were not as tender.

ACKNOWLEDGMENTS

The author is indebted to Doctor W. Lee Lewis of the American Institute of Meat Packers for suggestions and criticisms in carrying on this study of dough mixture; to the chemists of various manufacturing plants for samples of fats and chemical analyses; to Franklin Hepner for chemical determinations; also to Evelyn Roberts and Glessa Tucker, graduate home economics students, for preliminary work in the frying tests.

LITERATURE CITED


The following publications of the Wyoming Experiment Station may be had upon request: (Revised list, February, 1940).

**ANNUAL REPORTS—**
19th to 49th, inclusive (1908-9 to 1938-39, except 21st and 22nd.)

**INDEX BULLETINS—**
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No. **CIRCULARS—**

No. **BULLETINS—**
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234. The Cellar Wintering of Bees.
236. Hybrid Corn Adaptation Trials in Wyoming in 1939.