A COMPARISON OF SOFT AND HARD LARDS FOR DEEP FAT FRYING IN RESPECT TO PHYSICAL AND CHEMICAL PROPERTIES AND THE PALATABILITY OF THE FRIED PRODUCTS

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INTRODUCTION

The following work was done to determine the possible use of soft lard as a deep frying fat. The fat is produced in Virginia from hogs which are fed peanuts; in other parts of the United States other feeds, like soybeans, produce the same type of fat. With increased emphasis on peanut production during the current crisis, peanuts may well become a staple feed for hogs making the soft pork problem even more serious. Because the fat contains a large proportion of unsaturated fatty acids it is softer than lard from corn or tankage fed hogs and never becomes very hard even at refrigerator temperatures. Because of this characteristic it is unattractive in appearance and not a marketable commodity. The hog producers, therefore, suffer a financial loss, for even if it is sold it brings a much lower price per pound than the hard lard.

It was believed that if the fat were studied and possible uses for it investigated regardless of its appearance, a demand could be made for the product and hog producers would not need to suffer the price differential which now exists between the hard and soft fats.

The work presented here is the results of frying doughnuts and croquettes in soft and hard lards.

REVIEW OF LITERATURE

The United States Government refers to its "soft pork problem" in perplexed terms. The problem has been recognized in the United States at least since 1916. Before that it was causing concern in Canada in 1895; in 1885 investigations in European countries were instigated and developed. In 1895 Canadian packers became alarmed at the amount of pork, graded soft which was entering trade channels. Investigations were begun which brought conclusive evidence that the feed was the determining factor causing soft pork (12).

Here is, undoubtedly, an excellent place in which to define terms. Soft pork is not a familiar term in many parts of the United States, not even in the "soft pork area". Unless one is a producer or packer of pork he may be totally unaware of the soft pork situation.

"Soft" is a descriptive term applied to the carcasses of hogs which do not chill firm after being placed for 48 hours in a cooler at a temperature of 32° to 35° F. Carcasses of hogs are placed in coolers to harden immediately after slaughter. If the fat and meat is hard and white and not greasy to touch, it is graded, by trained meat men, as hard and commands the quoted market price for hogs. If it is not hard, but rather in a liquid state, becomes easily misshapen, is difficult to slice, and grayish in appearance, it is graded in degree as its softness is noticeable. There are five grades: hard, medium hard, medium soft, soft, oily.

The lard is the most objectionably soft part of the animal; the hams, the least so. This is explained by the fact that the ham contains a small amount of fat and it is the degree of firmness of the fat which determines

the firmness of the entire carcass. Lard graded soft or oily is not solid but liquid even at a temperature as low as 32° F. Sausages do not hold their shape when made from soft pork, bacon is difficult to slice and the loins are shapeless.

The first record in experiment station files dealing with the problem is from Texas in 1918 pertaining specifically to the softening properties of rice bran in hog rations. The problem was for many years recognized as typically southern, noticeable in areas where peanuts and mast were fed to hogs. But in the past decade, since soybeans have become such an important leguminous crop in the cornbelt regions, Iowa, Illinois, and Oklahoma, the meat packers in the northern markets have become increasingly aware of soft pork in northern sales.

Now that the situation is national in scope, the producers, the packers, the retailers, and the consumers in all sections of the country are vitally involved. The producers first are concerned because on the hog market there is discrimination against the soft pork and a resultant financial loss to the producer. In 1918 in Texas the packers first docked half a cent for soft pork, then one, then one and one-half cents, then two cents. Now the dockage ranges from two to five cents in the hog markets of the United States.

This dockage for soft pork can amount to a considerable sum which is a loss to the industry as a whole (1). In one packing house alone, $100,000 was the total dockage in one year. This must be considered a loss borne by the producers of that region (12). One can figure dockage in any area with the current local prices of pork. For instance, the price of hogs in Virginia was $12.40 per one hundred pounds on April 15,

1942. An average slaughter weight is 225 pounds. The hog should bring the producer $27.90, but if it proves to be soft and the dockage is two cents he must sacrifice $4.50 on the one hog alone; if he had fifty hogs to sell, the loss amounts to $225.00 which is obviously a loss to be considered.

If the soft hogs could be detected before they are slaughtered, much difficulty could be overcome, but it is not until the carcass is chilled that determinations can be made as to its firmness. In an attempt to remedy the whole situation, packers have been buying hogs which they suspected of being soft "subject to test". That is, the producer is not paid for his product until the carcass has been chilled for 48 hours, then graded, then paid accordingly. This is not satisfactory to either producer or packer. The producer dislikes waiting for his money and as the hogs are graded by packers there are times when he feels the judge's scores are unfair and in such cases he has no recourse. Though in fairness to packers, such difficulties have many times been solved, agreeable to both sides (12); but too many times there is dissatisfaction. Nor is the packer entirely pleased when often he finds soft pork among the hogs which he did not purchase "subject to test". The packer must rely upon the word of the producer to truthfully state the content of the rations he fed his hogs.

Another method endeavoring to be fair to both parties is to designate certain areas as "soft pork areas" and to automatically dock hogs from those specified districts. This is, of course, a hardship to the southern states, especially in the peanut section since it is known that peanuts produce soft pork but nothing definite is known about other

feeds. This is unfair to a southern producer who does not feed his hogs softening rations but because he is in the "soft pork area" he can not command full market price.

Thus, the problem affects the packer, indirectly, because it affects the producer. But it also affects him alone. It is difficult to handle the hams, bacons and loins of soft pork because they are greasy and shapeless. The shrinkage of soft hams and bacons is a considerable factor although experiments over a three-year period indicate that the correlation between shrinkage and rations is not as great as was first thought in earlier investigations.

The retailer is concerned because his wares present an unattractive appearance to his customer for the reasons previously stated. The customer finds the meats unattractive and will not buy them, though after final cooking a difference between hard and soft pork cannot readily be detected (25). The fact, then, that the average customer will not purchase soft pork is the ultimate reason for the soft pork problem. Only in areas where soft pork is produced is it used with satisfaction by the housewife.

In 1925 the United States Department of Agriculture decided to do something about the increasingly momentous problem. The work previously done was unorganized and pointless. The decision of the Department of Agriculture was to formulate plans for cooperative research among several interested state experiment stations with the United States Department of Agriculture, the Bureau of Animal Industry and the American Institute of Meat Packers. The individual states were to go ahead during the year carrying out plans outlined by the Washington office. Then every year

representatives of each station would assemble in conference to pool the data and information gleaned and to present their conclusions to those interested. Most of the first year was spent in organization, plans and financial arrangements. In 1926 the first bulletin (1407) was issued and in 1928 the second (1492) was printed as reports of progress for the early years. Individual station reports from that time to 1941 add to and change the original information.

A permanent committee of three, representing the three cooperating agencies was named to judge all the experimental hogs which were sent from the various states to the Experiment Station at Beltsville, Maryland, for slaughter and grading. The states which were a part of the Cooperative Study are Alabama, Arkansas, Indiana, Kentucky, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee and Texas. Especially notable were the studies from North Carolina.

The problems which presented themselves for solution then and for the future were (2):

1. What is the softening effect of peanuts, rice bran, chufas, mast, alfalfa and soybean oil meal?
2. In what proportions can soybeans be used and still produce hard fat?
3. What relation do brewers rice, sweet potatoes, barley, blackstrap molasses, buttermilk, wheat middlings, cottonseed meal have to hardening qualities?
4. What place have soybeans as a supplement to corn for fattening hogs when the beans are grown with corn and are hogged down?
5. What effect does the addition of minerals have on softening?

6. What influence does initial weight, that is, the weight of the young pigs when softening begins, have on the firmness of the carcass?
7. Does the rate of gain in weight have any effect on final grade?
8. Does the length of time of the softening period or that of the hardening period have any relation to firmness?
9. Are type, sex, breed, thrift, or parasitic infestation variable in production of hard pork?
10. Does the feed of the dam have any effect on the fat of the offspring?
11. What is the relative shrinkage of hard to soft pork?

These questions have been considered and conclusions to some degree of certainty have been reached in the years following the first research up to the present time.

If these feeds do not serve their intended purpose of producing a marketable product, one might well ask why their use is continued. According to authorities (2) these are the answers:

1. The softening feeds are peculiarly adapted to the soils and climates where they are raised.
2. They fit well into crop rotations and farming systems.
3. They are leguminous; thus, soil improvers.
4. They have high feeding values.
5. They can be grazed or hogged down thus eliminating harvesting costs.
6. The milled or by-products are inexpensive to process and to purchase in the territory where they are raised.

7. The by-products have satisfactory feeding qualities when properly used.

The paramount question then is how to use these feeds taking advantage of their good qualities and eliminating the bad. A farmer in order to make the best possible use of these economical feeds must know the answers to these points: (1) relative softening effect of various feeds, (2) the influence of the stage of maturity of the hog on the effect of softening feeds, and (3) the influence of total gain on the softening effect.

The answers to these questions, as shall be seen from the ensuing discussion, are known and are available to the hog breeder.

The Denmark investigators (12) early ascribe the undesirable softness to certain feeds in the hog rations. It seems an accepted fact, however, that most of the soft pork in Canada in 1895 was from immature and unfinished hogs. Soft fat contains more unsaturated fatty acids than does hard fat. The principle acids in firm fat are palmitic and stearic; in soft fat they are oleic, linoleic, linolenic, and a small amount of arachidonic (10). When a pig is young and fattening it demands large amounts of fats, but the fats in the feeds supply the necessary amount needed by a small pig. But with increase in size of the pig the fat content of the feed is not sufficient to meet the demands of the increased size so the body transforms the carbohydrates and if necessary the proteins of the feed into stored fat. This synthesized fat is firm. When the ration contains so much fat in itself that it is not necessary for the animal to synthesize fat from carbohydrate the feed fat is laid down unchanged. It can be recognized in these animals that the body fat is

similar chemically and physically to the ingested fat and is soft, medium soft, or oily depending on the nature of the fat in the feed. The conclusions may be drawn that the character of the fat depends, first, on the kind and amount of the fat ingested and, second, on the amounts of other nutrients, i.e., protein and carbohydrates, in relation to the fat in the feed.

In the extensive experiment sponsored by the United States Department of Agriculture it can be well understood that the correct interpretation of the data collected by the various experiment stations would depend in considerable measure on the scores of the judges at Beltsville. To eliminate, to some degree, errors in subjective judgments, the fat constants, iodine number, refractive index and melting points, were determined and correlated with the judges' scores. Number values were given to the descriptive grade: hard-1, medium hard-3, medium soft-4, soft-6, oily-8 (2). The dispersion of the numbers allows for slight differences within the grade.

A higher correlation was found to exist between refractive index and judges' grades than between iodine number or melting point and judges' grades (3). Thus, the refractive index is the routine constant used in the cooperative studies. The United States standards for refractive index and iodine number of fats of varying degrees of hardness are the following:

REFRACTIVE INDEX AND IODINE NUMBER

Grade	Refractive Index	Iodine Number
hard	1.4597 and below	66.9 and below
medium hard	1.4598 to 1.4601	67.0 to 70.4
medium soft	1.4602 to 1.4605	70.5 to 72.9
soft	1.4606 to 1.4618	73.0 to 83.4
oily	1.4619 and above	83.5 and above

The correlating (5) of fat constants with judges' scores gives reliability to the tests. Committee grades and constants do not always agree but the variation is ascribed to slight variations of unsaturation of the fat within one grade. Another certain method of determining the degree of softness is to analyse for the exact quantities of fatty acids present. The acids in soft fat, oleic and linoleic, vary in amounts as softening increases or diminishes. There is a pronounced rise of linoleic acid as softening increases. The fat of hogs fed soybeans contains nearly equal quantities of oleic and linoleic acid whereas hogs fed brewers' rice have a body fat which is high in oleic but low in linoleic acid content.

Another objective test used very recently for measuring softness of fat (1941) is the penetrometer (16). The penetration in millimeters during 15 seconds of a needle 0.15 inches in diameter and weighing 255.62 grams into a chilled carcass determines the degree of hardness of the fat. The penetrometer readings for lards of varying degrees of hardness are as follows:

PENETROMETER READINGS

Grade	mm.
hard	2.1 or less
medium hard	2.2 to 3.3
medium soft	3.4 to 4.8
soft	4.9 to 7.0
oily	7.1 or more

The correlation of these readings with committee grades or with refractive index is very high, over 0.9.

The degree of hardness of the lards depends on many factors other than the quality of the fats in the feeds. Hostetler and coworkers in 1938 summarized these factors regarding peanut rations (17):

1. There is a high correlation between the actual amount of oil ingested and the softness. A consumption of as little as 10 pounds of fat may cause softness.
2. If the hog consumes over one hundred pounds of starch a hardening is noticed.
3. A ration high in carbohydrate and low in fat produces firm fat.
4. The importance of initial weight is less than the importance of the actual amount of oil consumed.
5. The weight at the start of the hardening period is more important than the gain in weight after the hardening period is begun.
6. Next to the weight of the animal at the beginning of the hardening period, the amount of starch consumed is important.

7. Oil should be fed only to young pigs; at a weight of 80 to 85 pounds they should be placed on a hardening ration.
8. Pigs of one hundred pounds or more should not be fed peanuts.
9. Cotton seed meal added to the corn ration increases the hardening qualities of corn but does not influence the softening effect of peanuts.
10. When hogs are started on softening ration at 35 to 60 pounds and kept on these feeds to 75 to 85 pounds, then fed on a hardening ration containing 13 per cent cotton seed meal until they weigh 225 pounds they will kill firm.
11. The gain in weight in the hardening period should be 3.5 times the weight gain in the softening period.
12. Pigs weighing 35 to 45 pounds should not consume more than 100 pounds of peanuts and 60-pound pigs should consume less than 90 pounds.
13. The starch intake during the hardening period should exceed the oil intake in the softening period at least by 6.6 times.

Hostetler (18) made further studies on the soft pork problem in relation to soybeans as a softening feed. Fifty-one hogs were divided into three lots and fed rations with different proportions of soybeans. It was found that the greater the proportion of soybeans fed, the smaller were the gains in weight of the hogs. Thus, the time required to reach a given weight is greater as the percentage of soybeans in the feed is increased. Pertinent to this problem, Robison (28) used soybeans from which the oil had been removed as feeding rations. It required four more days for hogs to be ready to market than hogs on tankage, and the hogs consumed

five pounds more feed per 100 pounds of weight. There is general agreement that more feed is required per 100-pound gain in weight when softening feeds rather than hardening feeds are used.

Hostetler concluded from his work that soybeans can be fed to hogs without appreciably lowering the quality of the pork. The soybeans can be used if they are fed to pigs of an initial weight of 40 to 60 pounds, then finished on a corn and tankage ration containing 13 per cent cotton seed meal, until they weigh 225 pounds. The carcass will then chill firm just as did the peanut fed hogs. The oil intake must be limited to 28 to 40 pounds per pig. The starch in the corn was the hardening agent and the amount of starch must be 6.6 times that of the oil intake.

Another question which needed solving was whether the feeds of the dam affected the offspring. Martin (22) developed nine gilts on rice polish. He found that rice polish could be fed during pregnancy and the fat of the offspring was not affected. Also the rice polish could be fed three weeks after the weanling stage without affecting the fat. Thus, a solution of the problem would be to use the softening feeds to maintain the breeding herd.

In summary, these are methods of meeting the soft pork problem:

1. Start softening feeds at a weight not greater than 61 pounds, and change to hardening rations at a weight not over 90 pounds. A hardening ration containing 13 per cent cotton seed meal is best. The economy of this method depends entirely on the price of softening feeds. It is further affected by the facts that feed consumption is increased and weight gain decreased when softening feeds are fed.

2. Softening feeds can be used to maintain the breeding herd.
3. Softening feeds can be used in the rations of weanlings for three weeks.
4. The by-products of softening feeds from which the oil has been extracted can be used, advantageously.

It may be seen from this review that feeding softening feeds successfully is difficult and that soft pork will result in a great many cases regardless of care. The purpose of this thesis is to approach the subject from the standpoint of the use of the soft lard produced. If uses for the lard could be found, a consumer demand would be created.

Stevenson and Kincaid[1] at Virginia Polytechnic Institute found that the lard made an excellent pastry. They suggested that further work using soft lard as a shortening should not be done except with lard from hogs fed under experimentally controlled conditions, but that work on deep-fat frying was needed.

Since no work has been done using soft lard as a deep frying fat, the present work is concerned with a comparison of the physical and chemical properties of the soft and hard lards when used for deep fat frying. The palatability of doughnuts and croquettes fried in these lards are studied.

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[1] Stevenson, Gladys and Kincaid, Virginia. Experiments with Pastry Using Soft Lard. Unpublished.

EXPERIMENTAL WORK

Purpose of the Experiment

The aims of this study were to compare soft lard with hard lard in respect to these items: (1) the physical and chemical constants of the lards in respect to iodine number, smoking points, and melting points, (2) the keeping qualities or resistance to rancidity of the lard which would determine the marketing possibilities, (3) the value of the lards as a fat for deep frying of doughnuts and croquettes, (4) the changes in acidity and rancidity which occur in the fats during repeated fryings, and (5) the amount of fat which is absorbed into the food during frying.

Materials Used

Source of the Fats

The soft lard used throughout the entire period was obtained from Smithfield, Virginia, where the hog rations are predominantly peanuts. The lard was not produced under experimental conditions, but was the kind produced by the average hog raiser in that region. It was graded soft as it came from the market. The cost was six cents a pound in comparison to ten cents a pound for hard lard.

The hard lard was purchased from a local grocer. It was a brand much used in the southeastern part of Virginia.

In order to know better the exact degree of softness or hardness of these fats, several chemical and physical constants were determined; namely, iodine number, smoking point and melting point.

Chemical and Physical Properties of the Fats

Iodine Number:

The iodine number was determined by the Hanus Method (2). The average iodine number (Table I) for the hard lard was 56.15, for the soft lard 79.68.

According to the United States standards (3), previously discussed, which were set up for the judging of pork products, the iodine number for hard lard fell at 66.9 and below. For soft lard it was 73.0 to 83.4. Values for medium hard and medium soft lards fell between these two values and the value for oily was 85.4 and over. Thus, the lard used in this experiment, having an iodine number of 56.15, was definitely hard and that having an iodine number of 79.68 was graded soft by the criterion of iodine number.

A high iodine number is an indication of the presence of unsaturated fatty acids, such as linoleic, linolenic, and arachidonic (9) which occur in varying amounts in soft lard. Work (31) has been done to show that these fats are essential to the normal nutrition of experimental animals. There are some indications that these acids may be necessary in human nutrition.

Smoking Point:

The smoking point for the hard lard was 215° C. while that for the soft lard was 225° C. King (20) found that the fats, such as soft lard, with the greatest number of unsaturated fatty acids had the highest smoking points, which made them superior fats for deep frying.

Blunt and Feeny (27) placed the temperature at which leaf lard decomposed between 214° C. and 232° C. Thus, the two lards in the

Table 1. Iodine Number, Smoking Point and Melting Point of the Hard and Soft Lards Used in the Experiment

Trial No.	Iodine Number		Smoking Point		Melting Point	
	Hard	Soft	Hard	Soft	Hard	Soft
1	65.96	93.37	213° C.	225° C.	64° F.	45° F.
2	64.74	89.67	213° C.	225° C.	68° F.	42° F.
3	61.33	81.74			66° F.	45° F.
4	79.92	80.11			68° F.	
5	55.84	77.94				
6	60.01	73.01				
7	45.35	70.00				
8	46.08	73.25				
9	39.10					
10	42.22					
Average	56.15	79.68	213° C.	225° C.	67° F.	44° F.

present experiment had smoking points within the range of temperature for leaf lard. Blunt and Feeny also gave the smoking temperature for oils from 222° C. to 232° C. According to King (20) the oils, those fats containing the most unsaturated fatty acids, provided the best frying medium. Because of this, soft lard would make an excellent deep fat frying medium because it had a high smoking point which indicates a slow rate of fat decomposition with its resultant acrid odors and disagreeable flavors.

Melting Point:

The melting point (Table 1) for hard lard was 67° F. or about room temperature. That for soft lard was 44° F., or a temperature within the range of the household refrigerator. That fact indicated that the soft lard would be liquid, not solid, even though it were stored in the refrigerator.

Among average housewives there is a general misconception that lard, because it is an animal fat, is difficult to digest. This is an erroneous belief since the length of time of digestion of a fat depends on the amount of fat digested and to some extent on its melting point. It has been found (24) that fats with low melting points are more completely digested and absorbed than those with higher melting points. Since soft lard had a melting point considerably below that of other lards, one would assume that it would be to some degree more completely digested and absorbed than the hard lards.

Thus, because soft lard was found to be rich in unsaturated fatty acids which may be nutritionally essential to the human body and because it had a low melting point which makes it to some degree more completely digested than more saturated fats, it is an excellent cooking fat.

Because of its high smoking point and consequent slower rate of decomposition, there is further reason for its adaptability for use in deep frying.

Keeping Quality or Resistance to Rancidity of the Fats

Resistance to rancidity of the soft and hard lards was determined by the Kreis test for rancidity. For this determination the fat was dissolved in phloroglucional in ether. When hydrochloric acid was added to the mixture in a test tube, a faint pink ring formed if the fat had become rancid.

A two gram sample of each of the two fats was put into a cylindrical bottle with a surface one and one-fourth inches in diameter exposed to the air. Two samples of each fat were kept at room temperature (about 20° C.) and at oven temperature (100° C.). The test was made on each sample stored at 100° C. at intervals of one hour until the lards became rancid. Weekly tests were made on the lard at room temperature until the fats became rancid.

The results obtained (Table 2) after one hour in the oven at 100° C. showed that neither the hard nor the soft lard was rancid. After five hours the hard lard was slightly rancid but the soft lard showed no change. After six hours the hard lard was quite rancid and the soft lard was becoming rancid. At the end of seven days both lards were very rancid.

At one hour, five hours, and six hours at 20° C. (room temperature) neither lard was rancid. After six weeks at that same temperature, the hard lard was quite rancid and the soft lard was showing slight change. Thus, from these data it is shown that at 100° C. the soft lard was more resistant to rancidity than the hard lard. This finding agrees with work

Table 2. Resistance of Hard and Soft Lards to Rancidity at 100° C. and at 20° C. as Indicated by the Kreis Test

Period of Time	Changes at 100° C.		Changes at 20° C.	
	Hard	Soft	Hard	Soft
1 hour	no change	no change	no change	no change
5 hours	slight change	no change	no change	no change
6 hours	pronounced change	slight change	no change	no change
7 days	pronounced change	pronounced change		
6 weeks			pronounced change	slight change

done by Stevenson who also found that soft lard showed greater resistance to rancidity than did the hard lard.

Methods of Procedure

General Plan of the Experiment

The hard and soft lards were compared for their deep frying qualities by using them for frying four series of products. Series I consisted of doughnuts fried in soft lard compared to those fried in hard lard. It was thought [1] if the soft lard could also be used as the shortening in the doughnuts that it would have greater usefulness in doughnut manufacture. In Series II all the doughnuts were fried in soft fat but half of them contained hard fat as a shortening and the other half soft fat. Series III was studied to determine whether the greasiness, color, flavor, and aroma of the doughnuts fried in soft fat might be improved by using a higher temperature. Two temperatures were therefore used, 375° F. and 365° F. The soft fat was the frying medium.

To know what effect the soft lard would have on salmon croquettes, a pre-cooked product which fried for a shorter time than doughnuts, Series IV was made. The hard lard and the soft lard were used as the deep frying fats at a temperature of 390° F.

Three judges who had taken the taste test scored the products. After each frying, the acid number, rancidity test, and amount of fat absorbed were determined.

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[1] Stevenson, Gladys. Personal communication.

Each series of fried products comprised twelve replicates, so that a sufficient number of samples was available to apply the Fisher t test to the differences of the two means. This test reveals to what extent the difference may result from errors of random sampling. The P values corresponding to t, obtained from Trolear (30), were used at the five per cent and one per cent levels; that is, if the value of P was found to be 0.05 or less the difference between means was considered significant since there would be only five chances in 100 that the difference could arise from errors of random sampling. If the value for P were 0.01 or less the difference between means was considered very significant since there was only one chance in 100 that the difference was due to errors of random sampling. The formula for t is $\frac{\bar{d}\sqrt{n-1}}{\sqrt{\frac{\Sigma d^2}{n} - \bar{d}^2}}$ where d equals the difference between two comparable values in the fried series compared.

Obtaining a Panel of Judges

For the purpose of obtaining the best possible panel of judges to score the products, a taste test was given to a group of 10 people. The taste test measures the threshold of sensitivity of a person to a particular substance. Because the sense of taste is such an indefinite variable dependent upon the temperature of the food, physical sensitivity of an individual's taste mechanism, odors present, food prejudices, habits of smoking and time of eating, it has been thought necessary to have some objective form of discovering the taste thresholds of specific judges in order to know the reliability of the scores which they give to the

products of the experiment. Thus, the taste test was developed for the four basic tastes of salt, sweet, sour and bitter.

Observations on taste sensitivity (19) have been made by Blakeslee (1932), Fox (1931), Snyder (1931), and Lovene and Anderson (1931). Blakeslee found that out of 238 persons tested 32.2 per cent were taste blind, that is, they could not detect a bitter taste. Fox, using p-ethoxyphenyl-carbamide, found 40 per cent of the persons tested to be non-tasters. Snyder found 31.5 per cent to fall in the non-tasting group.

Mee (1934) says "when we have a rational standard upon which to base a scale of taste and the personal elements can be eliminated we still have to discover the relationship between the arrangement of the groups in the molecule of the compound and its taste before any comprehensive thing can be drawn up".

King (19) in 1937 in selecting judges to score bread in an experiment found that some persons could not detect slight differences in taste. Before continuing the bread judging a decision was made to test the taste acuity of persons selected. For the four tastes, salt, sweet, sour and bitter she used sodium chloride, sucrose, lactic acid and caffeine. Dilute solutions in terms of molarity were made up in distilled water. Each successive solution was twice the molarity of the preceding one. The temperature of the solutions was 25° C. Koumro (19) in 1921, after studying the temperature coefficient in relation to taste sensitivity, found that the coefficient functions below 20° C. and above 30° C. and that sensitivity increases from 10° C. and above 30° C. to 50° C.

Taste is dependent on many variables peculiar to an individual. In order to know the persons judged, King gave first a questionnaire in which

such questions were asked as: Do you have a cold? Do you dislike bread? Do you smoke? How long since you have eaten? All these factors have a bearing on one's taste sensitivity.

King tested 96 individuals. These people assembled in a room free from odors. A five cubic centimeter portion of the solution was given to the individual judge for each test. The test followed the last meal by three or four hours. No clue was given as to the order in which the solutions were given. Between each taste the mouth was rinsed with distilled water.

The principles of the above test were followed in the present study. Ten persons were selected. The substances used were sodium chloride, sucrose, hydrochloric acid, and quinine.

The range of dilution for salt was .0008M to .2048M, for acid .0002M to .1024M, for sucrose .0004M to .1024M, and for quinine .0002M to .0128M. The solutions were kept at 20° C. The score card of King was adapted for this test. Those persons to be tested were assembled at 10:00 A. M. in order to rule out the effects of hunger or satiety. The room was devoid of foreign odors. Specific directions for the judges were on the scoring sheet. The score card is here presented:

SCORE CARD FOR TASTE SENSITIVITY

Name:

Date:

Procedure: Rinse the mouth with distilled water. Take a mouthful of the solution handed to you. Taste it. Don't swallow it. Rinse mouth before each test. Wait two minutes between each test.

Code for indicating taste sensation:

0 - No taste
1 - Very faint
2 - Faint
3 - Easily noticeable
4 - Slightly noticeable
5 - Very strong

Solution	1	2	3	4	5	6	7	8
A								
B								
C								
D								

It may be seen from Table 3 that the most dilute solution detected for salt was .0032M with one of the ten persons noting it. Eight persons tasted salt between the range of .0064M and .0512M. One person did not detect any taste until a concentration of .1024M was reached.

One person tasted sour at .0004M, five persons tasted it between .0008M and .0064M and four persons at .0128M.

Sweet was tasted by two persons at .0004M, seven persons tasted it between .0016M and .0512M and one person at .1024M.

All ten persons tasted bitter at .0002M.

Table 3. Range of Taste Thresholds for Salt, Sour, Sweet and Bitter, of Ten People, and the Number of People With the Lowest, Medium and Highest Thresholds

Substance Used	Lowest Taste Thresholds		Medium Taste Thresholds			Highest Taste Thresholds	
	Molarity of Solutions	No. of Judges	Average Molarity	Range of Molarity	No. of Judges	Molarity of Solutions	No. of Judges
Salt (Na Cl)	.0032M	1	.0128M	.0064 - .0512M	8	.1024M	1
Sour (H Cl)	.0004M	1	.0016M	.0008 - .0064M	5	.0128M	4
Sweet (Sucrose)	.0004M	2	.0064M	.0016 - .0512M	7	.1024M	1
Bitter (Quinine)	.0002M	10	.0016M	.0004 - .0064M	0	.0128M	0

Table 4 shows the comparison of these thresholds with those which were found by King.

Because the number of persons tested in the present study was small and because the tastes for sour and bitter were hydrochloric acid and quinine instead of lactic acid and caffeine, used by King, no absolute comparison can be made.

Table 4 shows that the greatest sensitivity was for the bitter taste. The range was much lower in the present work than in King's. This might be partially explained by the fact that quinine was used instead of caffeine. The least sensitivity was shown for salt, evidenced both by the present work and that of King. The thresholds for sour and sweet usually fell somewhere between bitter and salt.

The threshold limits of Westerberg fall within those of King but for one instance, that of sweet. The thresholds for this taste were much higher than those given by King.

Among these ten persons tested, greater sensitivity was seen among the older women, though age variation was not great. The taste test appeared to be discriminatory, at least in the present experiment, since a person who had a low threshold for one taste had a low threshold for all tastes. Those with medium or high thresholds for one taste were consistently that for all tastes.

The greatest acuity was found in two women who worked with foods and did a great deal of judging. The least sensitive person was a man who smoked a pipe a great deal.

The test served its purpose of discriminating the excellent from the poor judges. The three judges selected were chosen accordingly except

Table 4. Comparison of Taste Thresholds Obtained by King and Those Obtained by Westerberg for the Tastes of Salt, Sour, Sweet and Bitter

Solution	Lowest Threshold		Medium Threshold		Highest Threshold	
	King	Westerberg	King	Westerberg	King	Westerberg
Salt	.0008M	.0032M	.0128 - .0256M	.0064 - .0512M	.2048M	.1024M
Sour	.0002M	.0004M	.0128M	.0008 - .0064M	.1024M	.0128M
Sweet	.0004M	.0004M	.0016M	.0016 - .0512M	.0128M	.1024M
Bitter	.0002M	.0002M	.0032M	.0002M	.0128M	.0002M

for the one man judge. It was thought wise to have one male judge to score doughnuts because of the universal preference of men for that food.

It was believed that the results of the taste test were an important factor in obtaining reliable scores for the products of the experiment.

Judging Procedure

Judging was done at ten o'clock each morning. The judges were assembled so that the products could be judged immediately after cooking.

The score card consisted of two parts (See Appendix I). Part A was a card on which a detailed description of each factor appeared. This score card was used for every series throughout the experiment. The numerical range within which each degree of perfection might fall was listed opposite the description.

Part B was a smaller card on which the eight factors and the perfect score were listed. Space was allowed for the score to be written by the judges on the card as they scored each item.

Cooking of Doughnuts

Three series of doughnuts were made. In Series I the doughnuts were fried in hard and soft lards at 365° F. Hard lard was used for shortening. In Series II the fryings were made in soft lard at 365° F. but hard and soft lards were used as shortening. In Series III soft lard was used for frying and hard lard for shortening but two different frying temperatures were used, 375° F. and 365° F. The following recipe was used.

Ingredients	Weight (gms)	Measure
Sugar	100.0	1/2 C.
Fat	12.5	1 T.
Egg	48.0	1
Milk	122.0	1/2 C.
Flour	308.0	2 3/4 C.
	(minus) 22.8 (used for kneading doughnuts)	
Baking Powder	7.4	1 T.
Cinnamon	.25	1/4 t.
Nutmeg	.25	1/4 t.
Salt	6.0	1 t.

The egg was beaten with a rotary beater for ten revolutions, then one-half the sugar was added and beaten twenty times. After the last addition of sugar the mixture was beaten 40 times. The melted fat was stirred in the mixture with a wooden spoon for fifteen strokes. The milk and flour, sifted with the baking powder, salt and spices, were added alternately, in three equal divisions, each addition being gently stirred with a spoon for 60 strokes. The mixture was placed in the refrigerator for ten minutes, then tossed on a floured board on which cleats were fastened to assure even thickness for rolling and cutting. One hundred strokes were used to knead and incorporate the 22.8 grams of flour kept out of the batter for that purpose. The dough was cut into eleven doughnuts, one-fourth inch thick, and allowed to stand 20 minutes before frying. The doughnuts were placed in a wire basket and fried at 365° F., except in Series III where the two frying temperatures were compared. The doughnuts were fried three minutes. A stop watch was used to determine the time. The doughnuts were turned immediately when they rose to the surface and again in 60 seconds. The fat in the kettle averaged about 1505 grams.

All the doughnuts were removed at the same time and drained on paper towelling. They were judged immediately.

Cooking of Croquettes

Series IV was a series of twelve replicates of salmon croquettes which were fried in soft and hard lards.

The following is the recipe and method for salmon croquettes:

Ingredients	Measure	Weight (gms)
Flour	3 T.	21.0
Milk	1 C.	244.0
Butter	3 T.	37.5
Salmon	2 C.	.....
Egg	....	.....
Bread Crumbs	....	.....

The butter was melted and the flour was combined with it. The milk was added slowly, then cooked five minutes. The flaked salmon was added and the mixture allowed to cool before forming croquettes. The croquettes (33.7 grams of the mixture) were rolled in egg, then dry bread crumbs, then egg and crumbs again. They were then weighed and placed in a wire basket and fried at 390° F. for one minute. They were judged immediately.

Determination of Free Fatty Acid Content and Resistance to Rancidity

Fat from each kettle, after each frying, was taken to determine the free fatty acid content of each fat. The fat was dissolved in neutral alcohol prepared with phenolpthalein. Ten to fifteen grams of the fat was weighed on a Harvard trip balance and 50 cc. of the alcohol was added to it. It was then warmed and titrated with a standardized solution of 0.1N NaOH. The acid number is expressed as the amount of 0.1N NaOH

that would be taken up by 100 grams of the fat.

A two cubic centimeter portion of the fat was used to test the rancidity of the fat by the Kreis test (already described). This was done for each of the twelve fryings for each lard in Series I.

Determination of Fat Absorption

The kettle and the fat were weighed on a torsion balance before each frying. The products to be fried were weighed before frying. After frying, the kettle and the fat were again weighed and the difference in weight was calculated as fat absorption in grams.

DISCUSSION OF RESULTS

Series I

Significance of Judges' Scores

The average scores of the three judges for the factors of color, greasiness, flavor and aroma and total ratings of the twelve fryings of doughnuts fried in hard and soft lards are given in Table 5. Ten points, as indicated by the score card, were given for perfection in eight factors, color, shape, grain, lightness, moistness, tenderness, greasiness and flavor and aroma. Only color, greasiness, flavor and aroma and total ratings were statistically analyzed by the t test, as it was thought they would be the factors most influenced by the deep frying medium.

In only one case were the doughnuts which were fried in soft lard scored higher than those fried in hard lard. The average score for color was 8.7 for those fried in soft lard, and 8.5 for those fried in the hard fat. This difference was statistically insignificant since t was 1.07 and the P value was only 0.29.

The mean for greasiness was 7.9 for the doughnuts fried in hard lard and 7.5 for those fried in the soft fat. This is a significant difference as t is 4.00 and the P value is .0018. For flavor and aroma the mean for the doughnuts fried in hard fat was 8.6 and for those fried in soft fat 8.4. This difference is insignificant as t is 1.06 and the P value is 0.29.

The difference in the total ratings for this series of doughnuts approached significance when the five per cent level of significance is used. The mean for the total scores of the doughnuts fried in hard fat was 68.5 and for the doughnuts fried in soft fat 67.8. The t value is

Table 5. Judges' Scores [1] for Color, Greasiness, Flavor and Aroma and Total Ratings [2] of Doughnuts Fried in Soft Lard and Hard Lard [3]. (Averages of Three Judges)

Sample	Color		Greasiness		Flavor and Aroma		Total Ratings	
No.	Hard	Soft	Hard	Soft	Hard	Soft	Hard	Soft
1	8.0	9.3	8.6	8.0	8.6	9.0	68.1	69.9
2	8.0	9.0	8.3	8.3	9.0	8.0	65.1	65.1
3	8.3	8.3	8.0	7.3	8.0	8.3	65.9	65.4
4	8.5	8.3	7.5	7.0	9.0	9.3	68.3	67.4
5	9.6	9.5	8.3	8.3	9.0	9.3	73.6	72.6
6	7.6	7.8	6.0	6.0	7.3	8.1	63.9	63.9
7	8.3	8.8	8.0	7.6	8.6	7.8	68.2	68.7
8	8.6	9.0	7.6	6.6	8.6	8.0	69.5	67.8
9	9.0	8.6	8.0	7.0	9.0	8.0	71.3	67.2
10	8.8	8.3	7.6	7.5	9.0	8.3	69.0	67.1
11	8.3	8.6	8.3	8.1	9.0	8.3	69.6	68.9
12	9.0	8.6	8.8	8.0	8.3	8.6	69.9	68.1
Mean	8.5	8.7	7.9	7.5	8.6	8.4	68.5	67.8
t...	1.07		4.00		1.06		1.88	
P...	.29		.0018		.29		0.09	

(1) Perfect score for each factor = 10.
(2) Perfect total score = 80.
(3) This series will be referred to in the text as Series I.

1.88 and the value of P is 0.09.

The averages of the judges' scores for shape, grain, lightness, moistness, and tenderness (Table 6) were practically the same for the two series of doughnuts. The scores were not statistically analyzed by the t test because it was thought that these factors would not be primarily affected by the character of the fat used in deep frying. A perfect score for each factor was ten.

As shown by the mean for shape of the doughnuts fried in soft lard and by the mean of the doughnuts fried in hard lard, which was 8.6 for each, there was no difference in respect to shape of the doughnuts fried in either lard. The mean for grain of the doughnuts fried in hard lard was 8.7 which was very little different from the mean of the doughnuts fried in soft lard which was 8.5. The average for lightness of the doughnuts fried in soft lard was 8.4 and for the doughnuts fried in hard lard 8.5, which indicated very little difference between the two lards. Again, the doughnuts fried in each lard had identical means for the factor of moistness, which was 8.9. For tenderness there was a slight difference; the doughnuts which were fried in hard lard had an average of 8.7 and the doughnuts fried in soft lard had an average of 8.9. It could be seen from the above averages that the factors other than greasiness were not significantly different for either the doughnuts fried in hard lard or those fried in soft lard.

Table 6. Judges' Scores (1) for Factors Not Thought to be Primarily Affected by the Character of the Fat, i.e., Shape, Grain, Lightness, Moistness, and Tenderness of Doughnuts Fried in Soft and Hard Lards (2).

(Averages of Three Judges)

Sample	Shape		Grain		Lightness		Moistness		Tenderness	
No.	Hard	Soft	Hard	Soft	Hard	Soft	Hard	Soft	Hard	Soft
1	9.0	8.0	8.3	9.0	8.0	8.6	9.0	9.0	8.3	9.0
2	8.6	7.3	7.3	7.6	7.0	8.0	8.6	8.6	8.3	8.3
3	8.0	8.3	8.0	8.0	8.0	7.6	9.0	8.6	8.6	9.0
4	8.0	8.6	9.0	8.6	8.3	8.3	9.0	9.0	9.0	8.3
5	9.5	9.0	9.6	9.1	8.8	8.8	9.3	9.3	9.5	9.3
6	7.3	7.0	9.3	8.6	9.0	7.8	9.1	9.3	8.3	9.3
7	8.3	8.8	9.1	9.0	8.3	8.6	8.8	9.1	8.8	9.0
8	8.6	8.6	9.5	9.0	9.0	8.3	8.6	8.8	9.0	9.5
9	9.0	8.8	9.3	9.1	8.8	7.6	9.1	9.8	9.1	9.3
10	9.0	9.0	8.6	8.0	8.6	8.6	8.6	9.1	8.8	8.3
11	9.3	9.1	8.0	8.1	9.1	9.3	9.1	8.6	8.5	8.8
12	9.1	9.0	8.6	8.1	9.1	8.3	9.0	9.0	8.0	8.5
Mean	8.6	8.5	8.7	8.5	8.5	8.4	8.9	8.9	8.7	8.9

(1) Perfect score for each factor = 10.
(2) Series I.

Significance of Acid Number

In this series the acid number (Table 7) of the hard lard was higher than that of the soft lard. The average for the hard lard was 14.66 and for the soft lard 12.53. The value for t was 0.13 and the P value was greater than 0.56, when the t test was calculated on the basis of change between consecutive samples of each lard. When t was calculated on the basis of actual values of the two lards the value for t was 0.63 and the P value was 0.56.

Thus, it was shown that even at as high a temperature as 365° F. the soft lard was hydrolyzed or broken down into glycerol and fatty acids no faster than the hard lard. The lard was kept for only four days, during the frying of the twelve replicates. If during frying, the fat is kept at a constant temperature below its smoking point the rate of decomposition of any fat is not as great as when care is not taken.

Fulmer and Manchester (20) in their studies state that below 220° C. there is little change in free fatty acid content. And Woodruff and Blunt (20) found little change in acidity during cooking. King (20) found a smaller increase in free fatty acid content in oils than in lards.

Thus, for the ordinary use of fats in deep frying where they are not kept over a long period of time, hydrolysis of the fat or increased fatty acid content is not an important factor when the soft lard is compared to the hard lard.

Resistance to Rancidity

In Table 7 the change in rancidity which occurred in the fats during frying were indicated by +, ++, and +++, as the degree of rancidity increased. Both lards showed a slight change after the first frying, then

Table 7. Fat Absorption (1), Acid Number, and Resistance to Rancidity (2) of Hard and Soft Lards in Which the Doughnuts Were Fried. (Series I)

Sample No.	Fat Absorption		Acid Number		Resistance to Rancidity	
	Fried in Hard	Fried in Soft	Hard	Soft	Hard	Soft
1	46	42	20.61	.....	/	/
2	36	49	9.81	6.84	//	//
3	49	44	17.35	9.77	///	///
4	34	36	12.29	10.53	///	///
5	31	38	14.08	1.02	///	///
6	36	41	11.46	9.90	///	///
7	44	45	14.16	11.79	///	///
8	39	36	20.70	13.08	///	///
9	44	31	1.33	18.91	///	///
10	46	46	17.22	21.98	///	///
11	40	36	21.09	19.46	///	///
12	33	32	18.14	19.78	///	///
Mean	39	39	14.66	12.53		
t...	<.00		.13(a)	.63(b)		
P...	>.56		>.56	.56		

(1) Fat absorbed by 115 gms. of batter.
(2) Resistance to rancidity as indicated by the Kreis test.
/ Indicates a faint color change.
// Indicates a greater change.
/// Indicates a pronounced color change.
(a) This "t" test was calculated on the difference between each two consecutive samples in respect to acid number.
(b) This "t" test was calculated on the difference in acid number of hard and soft lard.

greater change after the second frying and the greatest rancidity after the third fryings. They remained constant, as could be determined by the Kreis test, for the following nine fryings.

When the lards were used for cooking at a temperature of 365° F., any difference in the tendency of one lard to become rancid before the other lard was not detected. It was shown in the preliminary Kreis tests on the two lards that the hard lard became rancid before the soft both at 20° F. and at 100° F. During the frying no differences could be seen. The lard was used for only four days and stored at refrigerator temperature overnight. Rancidity could not be detected organoleptically in either fat.

Fat Absorbed by the Doughnuts

The actual amount of fat in grams absorbed by the 115 grams of doughnut batter in both hard lard and soft lard was the same. Thirty-nine grams of lard were absorbed by both lards. Obviously, the value for t was 0.00 and the value for P greater than 0.56.

It will be remembered from the previous discussion that the score for greasiness of the doughnuts fried in soft lard was 7.5 while that for doughnuts fried in the hard fat was 7.9. This was a significant difference as the value for t was 4.00 and the P value was .0018. In this case the judges have shown a decided preference for the doughnuts fried in the hard fat because they were less greasy. However, the data for fat absorption indicated that the actual fat absorbed by the doughnuts fried in the two fats was the same.

Langmuir (21) states that unsaturated fatty acids cover a larger surface area than saturated ones. Thus, since soft lard has a high

proportion of linolenic acid, an acid with three unsaturated double bonds, this fat would cover more surface area and impart the characteristic oiliness or greasiness which was noted by the judges when they scored the doughnuts which were fried in soft lard lower than those fried in hard lard. This characteristic is responsible for the increased shortening value of the fats which contain large amounts of unsaturated fatty acids.

In summary, the difference between the means of the total ratings of the doughnuts which were fried in hard lard compared with those fried in soft fat almost approaches significance. This is due to the fact that the difference between the means for greasiness was very significant, that even though values for other factors showed no significance, the value for greasiness was reflected in the total ratings.

The doughnuts fried in soft fat were consistently scored lower for greasiness than those fried in hard fat. As shown by the fat absorption data, the greasiness was not due to the grams of fat absorbed but rather to the unsaturated fatty acid content of soft fat which lessens surface tension and increases shortening value of the fat.

In respect to resistance to rancidity, free acidity, and fat absorption, there was no difference between the hard lard and the soft lard.

Series II

Significance of Judges' Scores

A greater amount of shortening in a doughnut (21) increases the fat absorption during the frying period. In Series I it was indicated that the soft lard has a higher shortening value than the hard lard. Therefore,

Series II (Table 8) was studied to note what effect the soft lard would have, used as shortening in the doughnuts fried in the soft lard. The series consisted of twelve replicates of doughnuts containing hard lard and fried in soft lard and twelve replicates of doughnuts containing soft lard and fried in soft lard.

Color, greasiness, flavor and aroma and total ratings were analyzed by the t test. In this series the mean for color of the doughnuts containing hard lard was 8.1 and for the doughnuts containing soft lard 8.2. The value for t was 0.58 and the P value was greater than 0.56 which indicated an insignificant difference. There was an insignificant difference between the judges' scores for greasiness of this series. The mean of the doughnuts containing hard lard was 6.8 and the mean for the doughnuts containing soft lard was 6.7. The value for t was 0.91 and the P value was 0.38 which was statistically insignificant.

Here it could be seen that the kind of fat which was used in the doughnuts had no affect on the greasiness of the fried product.

The mean for flavor and aroma of the doughnuts containing hard lard was 7.3 and that for doughnuts containing soft lard was 7.4. The value for t was 0.42 with a P value greater than 0.56 which was statistically insignificant.

The average for total ratings of the doughnuts containing hard fat was 62.9 and for the doughnuts containing soft fat 63.7. The value for t was 1.11 and the P value was 0.29, which is insignificant.

Shape, grain, lightness, moistness, and tenderness were not analyzed for t. For shape, (Table 9) the doughnuts containing hard lard had a mean of 7.8 and the doughnuts containing soft lard had a mean of 8.1; for grain,

Table 8. Judges' Scores (1) for Color, Greasiness, Flavor and Aroma and Total Ratings (2) of Doughnuts Fried in Soft Lard Using the Hard and Soft Lards for Shortening (3) (Averages of Three Judges)

Sample	Color		Greasiness		Flavor and Aroma		Total Ratings	
No.	Hard	Soft	Hard	Soft	Hard	Soft	Hard	Soft
1	7.3	8.0	5.6	6.0	7.0	7.1	58.3	63.5
2	6.6	8.6	5.3	5.3	6.6	7.0	60.6	63.0
3	8.6	9.0	6.0	4.6	6.3	6.3	60.0	58.9
4	8.0	9.0	7.0	6.0	7.0	7.3	60.0	63.6
5	8.3	7.6	6.3	6.5	7.0	7.8	62.9	63.4
6	8.5	8.0	6.0	6.3	6.6	7.1	62.6	62.6
7	8.1	7.6	7.5	7.5	7.5	7.0	65.9	64.6
8	8.3	8.1	7.6	7.3	7.0	7.0	63.4	64.6
9	8.5	8.6	8.5	6.3	8.0	8.5	66.6	68.6
10	7.8	8.0	8.1	7.5	9.1	8.1	66.0	63.7
11	8.3	7.8	7.0	7.3	8.0	8.0	66.1	64.7
12	7.6	8.6	7.0	7.3	7.8	7.6	61.8	64.8
Mean	8.1	8.2	6.6	6.7	7.3	7.4	62.9	63.7
t...	.53		.91		.42		1.11	
P...	.56		.38		.56		.29	

(1) Perfect score for each factor = 10.
(2) Perfect total score = 80.
(3) This series will be referred to in the text as Series II.

Table 9. Judges' Scores (1) for Factors Not Thought to be Primarily Affected by the Character of the Fat, i.e., Shape, Grain, Lightness, Moistness, and Tenderness of Doughnuts Fried in Soft Lard Using Hard Lard And Soft Lard for Shortening (2). (Averages of Three Judges)

Sample	Shape		Grain		Lightness		Moistness		Tenderness	
No.	Hard	Soft	Hard	Soft	Hard	Soft	Hard	Soft	Hard	Soft
1	7.0	7.6	8.3	8.3	7.0	8.3	8.3	9.0	7.8	9.0
2	8.1	8.3	8.6	8.6	7.6	8.0	8.3	8.6	7.8	8.6
3	7.3	8.6	8.3	8.0	7.6	7.1	8.3	8.0	7.6	7.3
4	7.0	8.3	8.3	8.6	7.6	7.8	7.6	8.5	7.5	8.5
5	8.0	7.6	9.0	9.0	7.5	7.8	8.8	9.0	8.0	8.1
6	8.8	7.6	8.6	8.8	7.5	7.8	8.3	8.5	8.1	8.5
7	8.5	8.0	9.3	8.6	8.1	7.6	8.6	8.0	8.3	8.6
8	7.6	8.5	8.5	9.1	7.6	8.0	8.3	8.3	8.5	8.3
9	7.6	9.1	9.0	8.5	8.5	8.6	8.3	8.6	8.8	8.6
10	7.5	7.6	8.3	8.5	8.6	8.1	8.1	8.1	8.5	7.8
11	9.0	7.6	8.6	8.3	8.3	8.3	8.6	8.6	8.3	8.3
12	7.0	8.3	8.5	9.0	8.0	7.6	8.1	8.3	7.8	8.1
Mean	7.8	8.1	8.6	8.7	7.8	7.9	8.3	8.4	8.1	8.3

(1) Perfect score for each factor = 10.
(2) Series II.

the doughnuts containing hard lard had a mean of 8.6 and the doughnuts containing soft lard had a mean of 8.7; for lightness, the doughnuts containing hard lard had a mean of 7.8 and the doughnuts containing soft lard had an average of 7.9; for moistness, the doughnuts shortened with hard lard had a mean of 8.3 and the doughnuts containing soft lard had a mean of 8.4; and for tenderness, the mean for the doughnuts containing hard lard was 8.1 and the mean for the doughnuts containing soft lard was 8.3. The perfect score was ten.

Thus, though soft lard had a higher shortening value than hard lard the amount of shortening used in the doughnuts was so small that the fat absorption of the doughnut, or its greasiness, was not affected.

Fat Absorbed by the Doughnuts

The fat absorption (Table 10) in grams in Series II for the doughnuts containing hard lard was 60 grams and for the soft lard 62 grams. The value for t was 0.56 and the P value is greater than 0.56.

To summarize, it may be said that using the soft lard as shortening in the doughnuts made products which were not significantly different from the products in which hard lard was used as the shortening when both doughnuts were fried in soft lard at a temperature of 365° F. Greasiness was not augmented by the use of the soft lard within the doughnuts. No differences were noted in any of the other qualities of the doughnuts. And the fat absorption was the same in the two products.

From these data it can be seen that soft lard may be used as a shortening and as the deep frying medium for doughnuts without increasing the fat absorption or decreasing the palatability of the doughnuts.

Table 10. Fat Absorption [1] of Doughnuts Containing Hard Lard and Soft Lard But Fried in Soft Lard. (Series II)

Sample No.	Fat Absorption	
	Containing Hard Lard	Containing Soft Lard
1	66	77
2	68	61
3	69	59
4	46	57
5	64	58
6	59	55
7	70	68
8	59	58
9	70	55
10	50	70
11	50	51
12	49	51
Mean	60	62
C...	.56	
P...	>.56	

(1) Fat absorption for 115 gms. batter.

Series III

Significance of Judges' Scores

The doughnuts of Series I and II were fried at a temperature of 365° F., the temperature given by Lowe (21). It was thought desirable to know what effect an increase of temperature would have on the color, greasiness, palatability, fat absorption and fat breakdown of the soft fat. Twelve replicates of doughnuts were fried in soft lard using hard lard as shortening at a temperature of 365° F. and twelve replicates were fried at 375° F. The scores (Table 11) for color, greasiness, flavor and aroma, and the total ratings were analyzed by the t test.

In this series in only one case was the doughnut fried at 365° F. scored higher than the doughnut fried at 375° F. This was for color. The mean for the doughnuts fried at 375° F. was 7.1 and for the doughnuts fried at 365° F. 7.7. The value for t was 1.21 and P value 0.25. This is statistically insignificant. The doughnuts fried at 365° F. were much greasier than those fried at 375° F. The mean for the doughnuts fried at 375° F. was 7.2 and the mean for the doughnuts fried at 365° F. was 6.6. The value for t was 4.46 and the P value was .0008 which is statistically significant. The higher temperature of the soft lard produced a doughnut which was much less greasy to the touch than the doughnuts fried at the lower temperature. The mean for flavor and aroma of the doughnuts fried at 375° F. was 7.7 and the mean for the doughnuts fried at 365° F. was 7.2. The t was 1.91 and the P value was 0.08. The P value using the five per cent level approached significance, which indicated that the flavor of the doughnuts fried at a temperature of 375° F. was somewhat

Table 11. Judges' Scores for Factors (1) of Color, Greasiness, Flavor and Aroma and Total Ratings (2) of Doughnuts Fried in Soft Lard at Temperatures of 375° F. and 365° F. (3) (Averages of Three Judges).

Sample No.	Color		Greasiness		Flavor and Aroma		Total Rating	
	Fried at 375° F.	Fried at 365° F.	Fried at 375° F.	Fried at 365° F.	Fried at 375° F.	Fried at 365° F.	Fried at 375° F.	Fried at 365° F.
1	9.0	7.6	6.6	6.3	8.0	8.0	60.8	58.7
2	5.0	9.3	7.6	6.6	8.6	8.0	55.8	63.2
3	7.0	7.3	8.3	7.3	8.6	8.1	60.4	60.2
4	7.1	8.3	6.3	6.1	6.6	7.5	54.9	56.0
5	8.3	8.5	7.6	7.0	8.0	7.1	58.5	58.3
6	6.0	6.0	7.0	7.0	7.0	7.3	54.7	55.5
7	6.6	8.0	7.0	6.5	7.8	6.0	59.4	55.3
8	6.3	7.0	7.3	6.3	8.0	6.0	59.5	54.6
9	6.3	6.3	7.3	6.3	8.3	6.3	59.6	53.1
10	7.8	7.6	6.5	6.0	6.3	6.6	54.1	54.0
11	7.6	8.0	7.6	7.0	7.6	8.0	58.3	58.1
12	8.6	8.3	7.0	7.0	8.0	7.6	59.6	59.2
Mean	7.1	7.7	7.2	6.6	7.7	7.2	58.0	57.2
t...	1.21		4.46		1.91		.66	
P...	.25		.0008		.08		.48	

(1) Perfect score for each factor = 10.
(2) Perfect total score = 80.
(3) This series will be referred to in text as Series III.

better than those fried at 365° F.

The total rating of the doughnuts did not show a significant difference. The mean for those fried at 375° F. was 58.0 and for the doughnuts fried at 365° F. it was 57.2. The t value is 0.66 and the P value is 0.48 which is not significant.

The scores (Table 12) for the factors of shape, grain, lightness, moistness and tenderness were not analyzed by the t test as it was thought that they would not be primarily affected by the temperature of the deep frying fat. The mean for shape of the doughnuts fried at 375° F. was 7.2, that for the doughnuts fried at 365° F. was 7.4; the average for grain of the doughnuts fried at 375° F. was 7.4 and the average for the doughnuts fried at 365° F. was 6.7; for lightness of the doughnuts fried at 375° F. the mean was 7.0 and for the doughnuts fried at 365° F. was 7.0; the average for moistness of the doughnuts fried at 375° F. was 7.2 and that for those fried at 365° F. was 7.4; and for tenderness of the doughnuts fried at 375° F. the average was 7.2 and that for the doughnuts fried at 365° F. was 7.2.

Thus, it can be seen that when doughnuts were fried in soft lard at a temperature of 375° F. a better product was made than when the doughnuts were fried in soft lard at 365° F. The doughnuts fried at the higher temperature were significantly less greasy than those fried at 365° F. Other factors were not significantly different when the two temperatures were compared using soft fat for frying with hard lard as the shortening.

Table 12. Judges' Scores (1) for Factors Not Thought to be Primarily Affected by the Character of the Fat, i.e., Shape, Grain, Lightness, Moistness, and Tenderness of Doughnuts Fried in Soft Fat at Temperatures of 375° F. and 365° F. (2)

(Averages of Three Judges)

Sample No.	Shape		Grain		Lightness		Moistness		Tenderness	
	Fried at 375°	Fried at 365°	Fried at 375°	Fried at 365°	Fried at 375°	Fried at 365°	Fried at 375°	Fried at 365°	Fried at 375°	Fried at 365°
1	8.8	7.3	7.6	7.6	7.6	6.6	6.6	7.3	6.6	8.0
2	6.5	9.0	7.5	7.5	5.6	7.6	8.0	7.6	7.0	7.6
3	6.6	6.6	7.3	6.3	7.3	8.0	7.3	8.3	8.0	8.3
4	7.1	8.3	7.3	6.6	7.3	7.0	6.6	6.1	6.6	6.1
5	7.6	8.3	7.3	7.3	6.3	7.0	7.1	6.8	6.3	6.3
6	6.6	6.6	7.0	7.3	7.0	7.0	7.1	7.3	7.0	7.0
7	7.0	8.3	8.1	6.3	7.8	6.6	7.3	7.0	7.8	6.6
8	7.0	7.1	8.1	6.3	7.6	6.6	7.6	8.3	7.6	7.0
9	6.3	6.6	7.8	6.0	7.6	7.0	7.3	8.0	7.6	6.6
10	7.3	7.3	6.6	6.6	6.0	5.8	7.3	7.6	6.3	6.6
11	7.3	7.0	7.3	6.0	7.0	7.5	7.3	6.8	7.6	7.8
12	8.0	6.6	6.6	6.3	7.0	7.3	6.6	6.0	7.8	8.1
Mean	7.2	7.4	7.4	6.7	7.0	7.0	7.2	7.4	7.2	7.2

(1) Perfect score for each factor = 10.
(2) Series III.

Significance of Acid Number

The acid numbers (Table 13) for the fats used in Series III were 10.87 for the soft lard heated to 375° F. and 9.75 for the soft fat heated to 365° F. The value for t was 0.40 and the value for P was greater than 0.56; therefore, the difference was insignificant.

Thus, the rate of decomposition, in respect to hydrolysis of the soft fat, was no greater between each consecutive frying of doughnuts when a temperature of 375° F. was used than when the fat was heated to 365° F.

Fat Absorbed by the Doughnuts

The grams of lard (Table 13) absorbed by 115 grams of doughnut batter was 41 grams when heated to 375° F. When heated to 365° F. the grams of fat absorbed was 44. The value of t was 1.67 and the P value was 0.11 which, although not significant, was rather high and did indicate that possibly more fat was absorbed by the doughnuts fried at the lower temperature.

Again it was shown that the greasiness of the doughnuts was not caused as much by actual fat absorption as by the characteristic oiliness of the soft fat and the temperature at which the doughnuts were fried.

In summary, it has been shown that when soft fat was heated to 375° F. the products fried in it showed less greasiness than did the doughnuts which were fried at 365° F. It seemed to the experimenter that the color was darker at the higher temperature than the standard for doughnuts which was indicated on the score card but the scores indicated no significant difference. No significant differences were noted for the other factors.

In respect to actual fat absorption of the doughnuts fried at the

Table 13. Fat Absorption (1) and Acid Number of Soft Lard in Which the Doughnuts Were Fried at Temperatures of 375° F. and 365° F. (Series III)

Sample No.	Fat Absorption		Acid Number	
	Fried at 375° F.	Fried at 365° F.	Fried at 375° F.	Fried at 365° F.
1	36	47	8.00	9.79
2	40	41	11.38	9.67
3	36	49	10.45	8.53
4	45	56	16.36	8.13
5	36	38	8.90	10.44
6	39	35	13.97	10.51
7	42	46	11.42	12.39
8	33	41	11.48	8.11
9	37	40	9.97	9.77
10	50	47	7.59	8.62
11	53	49	10.41	10.73
12	47	45	10.59	10.39
Mean	41	44	10.87	9.75
t...	1.67		.40	
P...	.11		>.56	

(1) Fat absorption for 115 gms. batter.

two temperatures, there was no significant difference. As indicated by the acid number, the rate of breakdown of the fat was no greater at a temperature of 375° F. than at the temperature of 365° F.

Summary of Series I, II, and III

When the soft lard was compared to the hard lard for deep frying (Table 14) using hard lard as shortening, the products fried in the soft lard scored significantly lower as to greasiness. Other factors were not markedly different. The greasiness was shown by the fat absorption data, not to be attributable to the actual grams of fat absorbed. The resistance to rancidity and the rate of hydrolysis to glycerol and fatty acids, as indicated by the Kreis test, and the acid number, respectively, showed there to be no difference between the hard and the soft fats.

Using soft lard for deep frying but comparing the hard and soft lard as shortening in the doughnuts, there was found to be no significant difference in the fat absorption by the doughnuts. Even though the fat absorption of doughnuts is affected by the shortening used in the batter the greasiness of this series showed no difference in judges' scores for greasiness or actual fat absorbed between the two fats. The average grams of fat absorbed by the doughnuts containing soft lard was the same as for the doughnuts containing hard lard.

When 375° F. was used as the temperature for frying the doughnuts in soft lard using hard lard for shortening, the greasiness of the products was less than at 365° F. The amount of fat absorbed showed no great difference between the two temperatures. The rate of breakdown of the soft fat was no greater at 375° F. than at 365° F.

Table 14. Summary Table of Significance of Differences Between Means for the Factors [1] of Color, Greasiness, Flavor and Aroma and Total Ratings for Doughnuts Series I, [2] II, [3] and III. [4] (Averages of Three Judges for 12 Samples)

Series I	Fried in Hard	Fried in Soft	"t"	"p"	Significance
Factors:					
Color	8.5	8.7	1.07	.29	Insignificant
Greasiness	7.9	7.5	4.00	.0018	Highly significant
Flavor and Aroma	8.6	8.4	1.06	.29	Insignificant
Total Ratings	68.7	67.6	1.88	.09	Insignificant
Series II	**Containing Hard**	**Containing Soft**	**"t"**	**"p"**	**Significance**
Factors:					
Color	8.1	8.2	.53	>.56	Insignificant
Greasiness	6.8	6.6	.91	.38	Insignificant
Flavor and Aroma	7.3	7.4	.42	>.56	Insignificant
Total Ratings	62.9	65.8	1.11	.29	Insignificant
Series III	**Fried at 375° F.**	**Fried at 365° F.**	**"t"**	**"p"**	**Significance**
Factors:					
Color	7.1	7.7	1.21	.25	Insignificant
Greasiness	7.2	6.6	4.46	.0008	Highly significant
Flavor and Aroma	8.6	7.2	1.91	.08	Insignificant
Total Ratings	57.9	57.2	.66	.48	Insignificant

(1) Perfect score for each factor = 10; total rating = 80.
(2) In this series the doughnuts were fried in hard and soft lards.
(3) In this series the doughnuts were fried in soft lard using hard and soft lards for shortening.
(4) In this series the doughnuts were fried in soft lard at temperatures of 375° F. and 365° F.

Thus, it can be seen that doughnuts fried in soft lard are comparable in almost all respects to those fried in hard lard

When the three series of doughnuts were completed, twenty-five persons were invited to have doughnuts and coffee so that the experimenter might learn the preferences of a larger number of people than his judges represented. One doughnut which was fried in hard lard at 375° F. and one which was fried in soft lard at the same temperature and using hard lard as shortening were served to each individual. A slip of paper was handed to each person on which he was asked to state his preference and his reasons for his preference. Seven of the twenty-five people preferred the soft lard doughnut. The other eighteen persons preferred the doughnuts fried in hard lard. The reasons for the preference expressed in some way by all eighteen who preferred the doughnut fried in hard lard was that the other doughnut was too greasy. This bears out the scorings of the three trained judges that soft lard made a greasier doughnut.

Series IV

Significance of Judges' Scores

Salmon croquettes were deep fried in hard lard and soft lard to determine the adaptability of the soft lard to that type of frying. The color, greasiness, flavor and aroma, and total ratings were statistically analysed by the t test (Table 15). The mean for color of the croquettes fried in hard lard was 8.5 and the mean for the croquettes fried in soft lard 8.2. The value for t is 1.12 and the P value is 0.28, which is statistically insignificant.

The mean for greasiness of the croquettes fried in hard lard is 8.2

Table 15. Judges' Scores [1] for Color, Greasiness, Flavor and Aroma and Total Ratings of Salmon Croquettes Fried in Hard and Soft Lards [2]. (Averages of Three Judges)

Sample	Color		Greasiness		Flavor and Aroma		Total Ratings	
No.	Hard	Soft	Hard	Soft	Hard	Soft	Hard	Soft
1	9.3	7.6	8.1	9.0	8.5	8.6	51.2	50.5
2	9.5	7.6	8.0	9.0	8.6	8.9	51.1	52.1
3	8.5	7.8	8.0	9.1	9.5	9.0	51.6	52.5
4	9.3	9.0	8.6	7.0	9.3	9.0	54.3	48.6
5	7.3	9.0	9.0	9.0	8.8	9.0	51.7	53.3
6	8.6	9.0	9.1	8.0	9.1	9.3	53.4	54.5
7	8.6	8.0	7.6	6.6	8.0	8.6	46.4	44.8
8	8.6	7.3	7.3	7.0	8.6	8.5	48.6	45.0
9	8.0	7.0	7.5	6.6	8.6	8.3	48.2	43.3
10	7.8	8.3	8.5	7.6	9.1	9.3	49.8	50.4
11	8.6	9.0	8.5	8.6	9.0	9.3	52.6	53.7
12	8.1	8.5	8.3	8.1	9.0	9.0	50.3	51.2
Mean	8.5	8.2	8.2	8.0	8.8	8.9	50.5	49.9
t...	1.12		.91		.80		1.14	
P...	.28		.38		.55		.27	

(1) Perfect score = 80.
(2) This series will be referred to in the text as Series IV.

and for croquettes fried in soft lard 8.0. The value for t is 0.91 and the value for P is 0.38, which is insignificant. It would seem that the coating of egg and crumbs of the croquettes prevented the lard from appearing so greasy. In addition, the croquettes were fried at a temperature of 390° F., which is considerably higher than that used for doughnuts. In Series III, where the frying temperature of 365° F. and 375° F. were compared for doughnuts, less greasiness was noted at the higher frying temperature.

The mean score for flavor and aroma of the croquettes fried in hard lard was 8.8 and for the croquettes fried in soft lard, 8.9. The value for t was 0.60 and the value for P was 0.55, which is insignificant. Thus, the soft lard does not give an objectionable flavor and aroma when used as a frying medium for croquettes.

The total perfect score is 60 for croquettes. The total ratings for the croquettes fried in hard lard showed a mean of 50.8 while those fried in soft lard had a total score of 49.9. The value for t was 1.14 and the value for P was 0.27 which was insignificant.

Since there were no significant differences in the judges' scores of croquettes fried in hard lard and those fried in soft lard, it may be stated that for croquettes, a product which is rolled in egg and crumbs, the soft lard is as good a frying medium as the hard lard.

The factors of shape, crispness and tenderness (Table 16) were not analyzed by the t test. It was thought that they were not affected primarily by the character of the fat for frying. The mean for shape of the croquettes fried in hard lard was 8.5 and for the croquettes fried in soft lard 8.3. For crispness the average for croquettes fried in hard lard was 8.4 and

Table 16. Judges' Scores (1) for Factors Not Thought to be Primarily Affected by the Character of the Fat, i.e., Shape, Crispness and Tenderness of Salmon Croquettes Fried in Hard and Soft Lards. (Averages of Three Judges)

Sample	Shape		Crispness		Tenderness	
No.	Hard	Soft	Hard	Soft	Hard	Soft
1	9.0	8.3	8.3	9.0	8.0	8.0
2	8.3	8.6	8.6	9.3	8.1	8.8
3	8.3	8.5	8.3	9.3	8.0	8.6
4	9.5	8.0	8.6	8.0	9.0	7.6
5	8.0	9.0	9.6	9.0	9.0	8.3
6	8.6	9.3	9.0	9.6	9.0	9.3
7	8.0	7.6	7.1	7.0	7.1	7.0
8	7.8	7.6	8.0	7.8	8.3	7.3
9	8.1	6.8	8.0	7.3	8.0	7.3
10	8.3	8.3	8.0	8.3	8.1	8.6
11	9.1	9.1	8.6	9.1	8.8	8.6
12	8.5	8.3	8.1	8.3	8.3	9.0
Mean	8.5	8.3	8.4	8.5	8.3	8.2

(1) Perfect score for each factor = 10.

for the croquettes fried in soft lard 8.5; and the mean for tenderness of the croquettes fried in hard lard was 8.3 and for the croquettes fried in soft lard 8.2.

Fat Absorbed by the Croquettes

In Table 17 it can be seen that the actual grams of fat absorbed by the croquettes in the two fats were not significantly different. Nine and two-tenths grams of fat were absorbed by the croquettes fried in hard lard and ten grams of fat by the croquettes fried in soft lard.

Thus, the judges' scores for the croquettes and the grams of fat absorbed show that soft fat may be used for frying as well as hard fat.

Table 17. Fat Absorption (1) of Salmon Croquettes Fried in Hard and Soft Lards.

Sample No.	Fat Absorption	
	Hard	Soft
1	16	19
2	7	2
3	6	10
4	15	9
5	9	2
6	3	2
7	8	7
8	3	10
9	7	11
10	14	10
11	20	14
12	4	25
Mean	9.2	10.0
C...	.35	
P...	.45	

(1) Average weight of croquettes = 128.72 gms.

SUMMARY

1. The lards used in the experiment were hard lard and soft lard as determined by the iodine numbers, smoking and melting points. The hard lard had an iodine value of 56.15; it melted at 67° F. and its smoking point was 218° C. The iodine value of the soft lard was 79.68; it melted at 44° F. and its smoking point was 225° C.

2. Doughnuts made with hard lard and fried in soft and hard lards at a temperature of 365° F. showed a very significant difference in the factor of greasiness, those fried in the soft lard being more greasy. The value for t was 4.00 and the P value was .0018. Other factors were insignificant.

3. Doughnuts made with hard and soft lards, fried in soft lard at a temperature of 365° F., showed no significant difference in palatability factors.

4. Doughnuts made with hard lard but fried in soft lard at 375° F. and 365° F. showed a very significant difference in the factor of greasiness; those fried at 365° F. were more greasy. The t value was 4.46 and the P value was .0008. Other factors were not significantly different.

5. Salmon croquettes fried in hard lard and in soft lard showed no significant differences in palatability factors.

CONCLUSIONS

The lards used in the experiment were typical samples of hard and soft lards as determined by the physical and chemical constants, iodine numbers and smoking and melting points.

When doughnuts fried in soft lard were compared to those fried in hard lard at 365° F., the doughnuts were greasy in comparison. Other factors were not significantly different. It was believed from the actual fat absorption data that this greasiness was not attributable to the grams of fat absorbed by the batter, but by a characteristic of the soft fat. Soft lard has a high content of unsaturated fatty acids which decreases the surface tension of the fat and therefore increases the shortening value. Apparent oiliness results from a fat with low surface tension.

When doughnuts were made using soft lard as the deep frying fat and soft lard and hard lard as the shortening, at 365° F. there was no difference in the quality of greasiness between the two. This indicated that the fat within the doughnuts did not affect that quality of the doughnuts to a significant degree. Other factors did not show significant differences when the fats, hard and soft, were compared as shortening in doughnuts and the products were fried in soft lard.

Soft lard was used for frying at two temperatures; they were 375° F. and 365° F. Hard lard was used for shortening. The doughnuts which were fried at 375° F. were less greasy than those fried at 365° F.; the difference for this factor was highly significant. The color of the doughnuts fried at 375° F. seemed somewhat darker than the standard for doughnuts.

The fat absorption showed no significant differences between the doughnuts fried in soft lard at 365° F. and those fried in soft lard at 375° F. The acid number, which indicated the rate of hydrolysis of the fat, did not indicate that hydrolysis occurred any faster in the fat heated to 375° F. than when the soft fat was heated to only 365° F.

The comparison of croquettes which were fried in soft fat with those fried in hard fat indicated that the greasiness so apparent when frying doughnuts was not so marked in croquettes. The croquettes were a pre-cooked mixture rolled in egg and crumbs. Other factors, including color, crispness, tenderness, shape, flavor and aroma, and the fat absorption data indicated that the croquettes which were fried in the soft lard were equally as palatable and desirable as the croquettes fried in hard lard.

The flavor and aroma of the soft fat is distinctive and could be detected by the judges but was never objectionable.

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APPENDIX I

Score Card A for Doughnuts

	Description	Score
COLOR:	Even, golden brown on both sides	8-10
	Lighter or darker, or more uneven than best product	5-7
	Dark, mottled, brown, or light tan on either or both sides	0-4
SHAPE:	Rounded top, symmetrical, and proportional hole, properly round	8-10
	Slightly flat on either or both sides, slightly rough on top side, unsymmetrical	5-7
	Flat, unraised, rough surface, misshapen	0-4
GRAIN:	Small, even air cells, no tunnels	8-10
	Few large air cells, and tunnels	5-7
	Large, unevenly spaced cells, and many tunnels	0-4
LIGHTNESS:	Has the appearance of featherymess, to the touch is light, when broken looks light	8-10
	Looks a little heavy, doesn't give a definite impression of lightness	5-7
	Is very heavy to look at and to handle, and when broken appears soggy	0-4

	Description	Score
MOISTNESS:	When broken does not crumble, moist, remains intact but tender	8-10
	When broken crumbles, when eaten gives a slight impression of dryness	5-7
	When eaten is very dry, and crumbly	0-4
TENDERNESS:	Breaks lightly, with no apparent resistance	8-10
	When broken and eaten seems tough and chewy	5-7
	Is very tough and elastic when broken and eaten	0-4
GREASINESS:	Has no line of fat below crust and does not leave grease on the fingers	8-10
	Has a slight fat ring below crust, slightly greasy to feel	5-7
	Has a deep fat ring, is very greasy to feel, and nauseating to eat	0-4
FLAVOR AND AROMA:	Has a delicate sweet spicy odor and taste, with a sensation of richness	8-10
	Slightly greasy and "doughnutty" with a predominance of fat over spice	5-7
	Pronounced fat, disagreeable to smell and unappetizing to taste	0-4

Score Card B for Doughnuts

NAME: DATE:

CODE NUMBER	TOTAL POINTS
COLOR	10
SHAPE	10
GRAIN	10
LIGHTNESS	10
MOISTNESS	10
TENDERNESS	10
GREASINESS	10
FLAVOR AND AROMA	10

Score card A was used to give the judges a word description of the standard products and variations from the standard. Each quality and variation in the quality is given a numerical rating. This score card remained unchanged throughout the experiment.

Score card B, which was used for the actual scoring of the products made that day, was handed to the individual judge each morning. The date and the identification number for each doughnut was placed on the card before he received it.

APPENDIX II

Score Card A for Salmon Croquettes

	Description	Score
SHAPE:	Carefully formed, no roughness or distortion	10-8
	Slightly irregular and careless appearing, with uneven surface	7-5
	Very irregular, cracked and bumpy	4-0
COLOR:	True, appetising brown, darker than golden; no splotches of burned crumb	10-8
	Lighter or darker than brown, slightly uneven	7-5
	Very much under or over done and uneven	4-0
CRISPNESS:	Nice crunch when broken or bitten	10-8
	Slightly gummy and chewy	7-5
	Very gummy and chewy	4-0

	Description	Score
TENDERNESS:	Breaks at the slightest effort, gives no resistance when bitten, soft interior but not pasty	10-8
	Slightly resistant, interior runny or pasty	7-5
	Very tough and very runny or pasty	4-0
GREASINESS:	No grease line below crust, or excess grease left on fingers	10-8
	Slight grease line below crust, and grease in the interior, greasy to feel	7-5
	Exceedingly greasy to feel and to touch	4-0
FLAVOR AND AROMA:	No flavor of cooking fat in interior, well-heated nicely seasoned sauce, crust has appetizing, nutty flavor	10-8
	Not well heated, slightly objectionable or pronounced flavor to crust	7-5
	Very objectionable flavor and aroma to crust	4-0

Score Card B for Salmon Croquettes

NAME:

DATE:

CODE NUMBER	TOTAL POINTS
SHAPE	10
COLOR	10
CRISPNESS	10
TENDERNESS	10
GREASINESS	10
FLAVOR AND AROMA	10

Score card A was used to give the judges a word description of the standard products and variations from the standard. Each quality and variation in the quality is given a numerical rating. This score card remained unchanged throughout the experiment.

Score card B was used for actual scoring of the products made that day, and was handed to the individual judge each morning. The date and the identification number for each doughnut was placed on the card before he received it.