A STUDY OF THE CULINARY PROPERTIES OF PEANUT OIL FOR DEEP-FAT FRYING

By

Nell Gray Grim

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Approved:

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Course Advisor

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Head of Department

____
Dean of Agriculture

____
Chairman, Graduate Committee

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TABLE OF CONTENTS

LIST OF TABLES

A STUDY OF THE CULINARY PROPERTIES OF PEANUT OIL FOR DEEP-FAT FRYING

INTRODUCTION

It is thought that the peanut (Arachis hypogoea) originated in South America as peanuts have been found in the ancient burial graves in Peru. From South America they were carried to Africa and then to the United States with the slaves who came from Africa. It has been stated that when peanuts were placed in the hold of an old ship with the slaves, the slaves were in excellent physical condition on arrival for there was no beriberi.

The peanut is perhaps the most important oil-bearing seed that is grown and its value as a source of oil has long been recognized. The Dutch buy peanuts from many countries and bring them to Rotterdam, where they crush them into oil and meal, and barter these products to other countries. Much of their oil was formerly imported into the United States for here the peanut as a source of oil was not realized. Until a few years ago less than 8 percent of the crop was crushed for oil. However, 40 percent of the crop was used for oil in 1940.

The "cake" or meal which is left after the oil has been expressed makes an excellent feed for cattle and is used as such to a great extent, particularly in Germany.

During the first World War there was a great demand for peanut oil and today the need is felt again. It is stated in the Peanut Journal and Nut World (21) that peanut oil imports from foreign countries in the first six months of the 1940-1941 season decreased about 17 percent from the total reached during the same period of the previous years. Today the Secretary of Agriculture has called upon the peanut farmers of the nation to greatly expand their peanut acreage for the production of oil during the coming year. The goal for 1942 is 3,400,000 acres for peanut oil and 1,600,000 acres for edible use. In 1940 only one fourth of the crop or 200,000 tons of peanuts was used for oil. From each ton of peanuts approximately 600 pounds of oil can be obtained.

Peanut oil is used in the United States mainly as an adulterant of or as a substitute for olive oil. It is so excellent in quality that most people cannot detect the difference. Peanut oil is mixed with nearly all the olive oil that comes from the United States.

Peanut oil can replace, in part at least, the approximate 10,000,000 pounds of coconut oil that until now has been imported into the country for roasting peanuts, making soap and other uses.

Since peanut production has been greatly increased for edible oil, and since so little research has been done on the culinary properties of the oil, a study of these properties seemed advisable. The primary purpose of this experiment was to study the palatability of potato chips, shoe string potatoes and French fried potatoes when fried in peanut oil as compared with those fried in cottonseed oil. The absorption of the oil by the products fried in peanut oil was compared with those fried in cottonseed oil. The changes in the two oils during repeated fryings was compared. These changes were measured by the smoking point, free acidity, and rancidity changes of the oils. Since the oils for this experiment could not be produced under experimental conditions, certain constants were measured in order to know about the qualities of the oils. These included the iodine number, saponification number, free acidity, smoking point and the resistance of the oils to rancidity changes.

REVIEW OF LITERATURE

Peanuts:

The peanut crop is of much greater importance than is commonly understood. It grows well in the warmer parts of the temperate zone and these regions produce the bulk of the world crop. Prescott and Proctor (23) stated that the peanut grows best in the tropics, but its cultivation there has not been highly developed. In the United States,North Carolina, Georgia, Virginia and Alabama are the leading peanut producing states, but the production does not sufficiently meet the demands of the public. Thousands of pounds have been imported yearly from China and Japan. India, Senjil and China all rank ahead of the United States in the production of peanuts.

The Manufacture of Peanut Oil:

The major portion of the peanut crop is now used for the production of peanut oil. Prescott and Proctor (23) state that in the United States oil is usually secured by pressing the crushed seed with hydraulic presses. Sometimes the nuts are shelled, ground up very finely and cooked in a steam-jacketed cooker before they are put into the presses. Then the crude oil is filtered, refined and deodorized in a manner similar to the refinement of cottonseed oil. The crude oil is refined by a process using caustic soda, which is followed by bleaching and deodorizing. The bleaching is carried out by the use of Fuller's earth, sometimes aided by activated charcoal. For the deodorization the general principles of heating and distillation under pressure are used to distill off the undesirable impurities causing odors. This deodorization process may be done by blowing superheated steam through the oil which is heated in a vacuum kettle.

According to a publication by the United States Department of Agriculture (29), there are three types of peanut oil found on the American market; namely, virgin oil, crude oil and refined or neutralized oil. The virgin oil is the oil secured when the shells and skins are removed before pressing, and the first crushing is done without heat. Virgin peanut oil is not used to as great an extent in the United States as the other two types, but is used extensively in France. It has a characteristic nutty flavor and can be used for salad or cooking purposes without refining. The crude oil is the oil pressed from the nuts after heating, and may be secured from the second or third pressing. The refined or neutralized oil is that secured from the crude oil by the refining and deodorizing processes discussed in the preceding paragraph.

The Uses of Peanut Oil:

Peanut oil has a definite place in our food economy as an ingredient of shortenings, salad oil, oleomargarine, mayonnaise and oil for deep-fat frying of chicken, fish, doughnuts, potato chips and other foods as stated in the Peanut Journal and Nut World (21). The industrial uses of peanut oil include its being used as a textile lubricant and an ingredient of soap, shaving cream, hair lotion and sunburn lotion. In the field of pharmacy and medicine it is used as a carrier of adrenalin and also as a substitute for olive oil, the supply of which is so uncertain at present. Peanut oil may be used in the manufacture of nitroglycerine and explosives.

Chemical Properties of Peanut and Cottonseed Oils:

Smoking point: Today the culinary properties of peanut oil are being realized to a great extent in the Eastern United States. The qualities which peanut oil has make it desirable for use in the cooking of foods. The smoking point, that is, the lowest temperature at which the oil decomposes sufficiently to produce smoke, is high in comparison with other commonly used cooking fats. Blunt and Feeney (4) found that the smoking point of their No. 1 peanut oil was 149° C and their No. 2 oil was 162° C. The smoking point of cottonseed oil was 233° C. However, in a more recent publication (24) the smoking point of the peanut oil was stated to be 230° to 243° C. This difference in reported smoking points is thought to be due to the different types of oils found on the market. The oil used by Blunt and Feeney as stated in the former reference (4) was possibly a virgin or crude oil, while the oil referred to in the latter reference was possibly a refined oil. Then too the smoking point of the oil may have been influenced by the impurities in the oil and the surface of the oil exposed.

Saponification Number: The saponification number of peanut oil was given by the National Peanut Council (20) as 186.6 to 188.4. Holde and Mueller (10) reported the saponification number of peanut oil as 189 to 194, and that of cottonseed oil as 191 to 198. This number was defined as the number of milligrams of potassium hydroxide which is used by the saponification of one gram of fat. This test is often used to distinguish between various natural fats since it indicates the length of the fatty acid chain. The method of manufacture of the oil, and the variety of peanuts used in making the oil may influence this number. There are many varieties of peanuts used in the United States for the production of oil. The Virginia variety and the Spanish variety are the two of greatest importance.

Iodine Number: The iodine number of peanut oil was given by the National Peanut Council (21) as 89 to 96. Holde and Mueller (11) reported the iodine number of peanut oil as 86 to 98 and that of cottonseed oil as 102 to 111. Jamieson (13) reported from his study of oils, that refined cottonseed oil has an iodine number ranging from 103 to 115. Fulmer and Manchester (9) showed by their experiment that the decrease of iodine value for cottonseed oil was hastened when the oils were heated above 180° C. The iodine number of an oil indicates the class to which it belongs. Oils having an iodine number below 100 may be considered as non-drying oils. Iodine numbers from 100 to 130 indicate semi-drying oils, and those above 130 drying oils. Peanut oil was, therefore, a non-drying oil and cottonseed oil a semi-drying oil. Other semi-drying oils and fats as given by Lowe (17) are wheat, oats, rice, rye, Brazilnut, raisin seed, peach kernel, cherry kernel, apricot kernel and many others which have an iodine number between 100 and 130. The iodine number varies directly with the degree of unsaturation of the oil since the iodine is absorbed by the double bonds of the unsaturated fatty acids found in the oil. Jamieson (13) reported from his investigation that the Spanish peanut oil contained 77 percent of unsaturated fatty acids and 21 percent of the saturated acids. The Virginia peanut oil contained 82.2 percent of unsaturated fatty acids and 17.1 percent of saturated acids. Hilditch and others at Liverpool University (10) have stated that peanut oil contained 82 percent of unsaturated acids and 18 percent of saturated acids. Thus, it might be expected that iodine numbers of peanut oil will vary with the variety of the peanuts used.

Free Fatty Acid Value: It is almost impossible to state an exact free fatty acid number for peanut oil because of the various factors which influence these constants, such as, variety of the peanut used for oil, the type of peanut oils on the market, storage, and the time that elapses between manufacture and utilization.

The amount of free fatty acid found in some oils was greater than in other oils. The enzyme, lipase, or boiling the oil with alkali will cause hydrolysis which causes oils to split into glycerol and fatty acids. In cooking foods that contain water, such as potatoes, the free fatty acids are increased. When oil is heated in the presence of moisture, some hydrolysis occurs giving off glycerol and free fatty acids. Blunt and Feeney (4) found that oils having the lowest smoking points had the highest percentage of free fatty acids. They decided that the smoking temperature of the fat is closely dependent upon the acidity. In Davies' (6) classification of rancidity he stated that rancidity was brought about by the action of lipase enzymes which by hydrolysis split the fat into glycerol and fatty acids. Davies (6) also stated that free fatty acids may be given off by a high hydrogen-ion concentration in contact with the oil. Many investigators stated that fats were known to show an increase in acidity during use (4, 9, 19, 29). Fulmer and Manchester (9) found a temperature below 220° C produced little change in the free fatty acid content. Between 220° and 240° C the percentage of free fatty acid was more than doubled when the oil was heated for 10 minutes. When the oil was heated 30 minutes there was 4 times as much free fatty acid as was present in the oil originally. When the cottonseed oil was heated at 270° C for 10 minutes and for 30 minutes, the free acid content was 9 and 15 times as great, respectively, as the original amount.

Rancidity: Homemakers speak of rancidity of their fats and oil when they develop a disagreeable odor and flavor, but in the oil industry rancidity is restricted to the oxidative changes in fats and oils. Davies (6) classified rancidity as acid, oxidative and ketonic while Triebold's (27) classification was hydrolytic, oxidative and ketonic. The hydrolytic or acid rancidity of

Davies (6) was brought about by the action of lipase enzymes which by hydrolysis split the fat into glycerol and fatty acid. Since lipase enzymes were destroyed by heat, this type of rancidity was found in products which were not heated to a high enough temperature to destroy the enzymes. Oxidative rancidity occurred when oxygen was taken up, which was necessary before appreciable rancidity could be noticed. This period of oxygen uptake was known as the inductive period. This period varied with different fats and oils. After the inductive period a prooxidant speeded up the oxidation while antioxidants slowed down the process. In the ketonic rancidity Davies (6) thought that fat spoilage was caused by mold which attacked the short chain saturated fatty acids and produced products which caused disagreeable ffavors. This rancidity was confined to butter and coconut oil because of their content of short chained acids.

Cooking Experiments Using Peanut Oil:

There have been few cooking experiments using peanut oil as a deep frying medium. King and others (15) found in their experiment with potato chips that the palatability tests, based largely upon desirability of flavor, showed that oils were preferable to lards. Those potato chips fried in peanut oil ranked highest, with those in cottonseed oil second, yet, statistically the difference was not significant. King (15) also found that potato chips fried in oil, and especially those oils stored in a refrigerator, kept fresh longer.

It is interesting to note in the extensive investigations of Langworthy and Holmes (16), who experimented on human beings using over 20 animal fats and about 40 different vegetable fats, that peanut oil had a digestibility of 98.3 percent, which was the highest of the vegetable oils studied. The digestibility of the fats and oils was calculated by subtracting the amount of fat found excreted in the feces from the total amount ingested.

General Facts Concerning Deep-Fat Frying:

The most important precaution in deep-fat frying is the controlling of the factors that cause the break-down of the fats. When fat is heated, decomposition takes place unless overheating is prevented. When fats are heated to their smoking temperatures during cooking, hydrolysis and dehydration of fat take place. These chemical changes produce by-products of acrolein and fatty acids. The free fatty acids hasten further decomposition which lowers the smoking point. MacLeod and Nason (18) have stated that a fat which will decompose at a temperature below or near 180° C would soon be objectionable for frying because of the formation of fatty acids, acrolein and other possible decomposition products. To control decomposition due to heating at or above the smoking point, it is desirable to have as little as possible of the surface of the oil exposed to the air and to keep finely divided substances such as flour or particles of food from the oil. The temperature at which the oil is stored will also lower the smoking point. When oils are left in heated or warm places, rancidity will develop, producing free fatty acids, which in turn hasten the decomposition of the oil. It is advisable to store oils at about 4° to 5° C.

In deep-fat frying the products are more desirable if a small amount of fat is absorbed. The chief factors governing the amount of fat which will be absorbed by the food during cooking are: the time of cooking, the temperature of the cooking fat, the total surface area of the food exposed, and the composition and nature of the food. It has been stated that the longer the food is cooked, the greater the fat absorption. There are exceptions to this. When food is cooked at high temperatures, coagulated material or a hardened crust may prevent greater fat absorption with longer cooking. When there is a large amount of fat in meats such as chicken and pork chops, there is a loss of fat during cooking. There is also a loss of fat or a small amount of absorption of fat when higher cooking temperatures are used. The greater the surface for a given weight of material, the greater the area over which fat may be absorbed. A smooth surface will not absorb as much fat as a rough surface. Large amounts of flour on the surfaces of food for frying will increase the fat absorbed. Food such as doughnuts which contain sugar, fat, liquid, egg, flour and baking powder may show a wide variation in the amounts of fat absorbed, even when the length of time of cooking and the amount of surface area was kept as near standardized as possible. This was due to the characteristic of the dough which was altered by mechanical treatment.

Holmes and Lang (12) reported from their investigation that the least fat absorption in foods was in the vegetable fats. Thus, vegetable fats was preferred for deep-fat frying when a small amount of fat absorption was desired.

<u>The Storage of Potatoes:</u>

In the making of potato chips, shoe string potatoes and French fried potatoes, the quality of the product is affected by the kind and treatment of the potato as well as the frying method. Potatoes which have been stored at a temperature a few degrees above the freezing point tend to be high in their sugar content. When potatoes contain a large amount of sugar, the surface of the potato in frying becomes brown readily before the rest of the potato is cooked. If the potato is left in the oil until it is cooked, the surface of the potato will become very dark and have a caramelized flavor. Sweetman (25) stated as a result of her study, that the sugar content of potatoes had a controlling influence on the color and flavor of the chips made from them. In her later experiment (25) she found that chips made from potatoes were affected in two ways; namely, they had a sweet, off flavor and they developed a dark brown, uneven color during frying. The color was objectionable when the sugar content of the potato was high. Butler (5) found that in potatoes which had been stored below 10° C, the sugaf increased rapidly as the storage temperature approached 0° C. Appleman (1) found that in potatoes kept at 20°C, the sugar and starch content remained practically constant for a period of two months. In further work he found that potatoes stored at 5.6° C had 4 times as much sugar as those stored at 0° C. The starch content of these potatoes was found to decrease from 14 to 12.5 percent as the temperature decreased. In another study by Appleman (2) he found that the percentage of sucrose in immature potatoes decreased during storage so that by the end of the rest period, it was practically the same in all lots regardless of the degree of immaturity at the time of storage. The percentage of reducing sugar in the potato during storage was very small when calculated on the basis of moisture content at the time of digging. The ripening and maturing of potatoes will continue during storage so that by the end of the rest period, the immature potatoes responded as potatoes allowed to mature on the vine if both were stored under the same condition.

The sugar accumulated by potatoes during cold storage may be reverted back to starch by placing them at room temperature. Butler (5) recommended that potatoes be removed from low temperature storage for a week or two weeks and left at a temperature of 20° C before they are suitable for frying. Appleman (2) has shown that potatoes removed from low temperature storage and placed for a week or two weeks at 20° C will lose four-fifths of their sugar content, while those placed at 7.22 to 10° C will require 3 to 4 weeks to produce the same results.

Selecting a Panel of Judges:

In the scoring of food products judges with sensitive acuity of taste are desirable. Taste is the sensation received when solutions pass over certain areas, especially those on the tongue and soft palate. Taste organs are also found on the epiglottis and larnyx. These areas contain taste buds which are made up of nerve cells. When a solution passes over the buds, the nerve fibers carry the stimulus to the brain. Colloidal solutions cannot stimulate the taste sensations. It is thought that sweet taste is well developed at the tip of the tongue and the bitter taste is sensed at the back of the tongue.

As has been summarized by King (14) many investigators have tried to determine the delicacy of the sense of taste. To do this a small definite portion of a sour, salty, sweet or bitter solution was placed on the tongue at a definite, moderate temperature. The lowest concentration of the solution that produced taste was called the taste threshold.

Food manufacturers have often wished for sensitive tasters to detect flaws in the taste of food and have selected judges according to their taste threshold. The following table arranged by King (14) shows the different thresholds of taste of the 4 primary tastes that have been reported when the above method was used.

Substances	Parker (Several Sources) Mol. per l.	Blakeslee (21 Individuals) Mol. per l.	Crocker & Henderson (21 Individuals) Mol. per l.
Sodium Chloride	.040	.0214 to .0854	.030
Sucrose	.020	- - - - - -	.020
Saccharine	- - -	.00007 to .00055	- - -
Hydrochloric Acid	.0025	.0078 to .0622	- - -
Tartaric Acid	- - -	- - - - - -	.00125
Quinine Hydrochloride	.00004	.0004 to .006	- - -
Caffeine	- - -	- - - - - -	.0002

King (14) studied the taste thresholds for the four substances of 64 individuals, 35 women and 29 men. She found the following rage of thresholds:

Salt - - - - - - - - .0008M to .2048M

Sweet - - - - - - - .0004M to .1024M

Sour - - - - - - - - .0002M to .0128M

Bitter - - - - - - - .0002M to .0128M

Blakeslee (3), who has done considerable work in the taste threshold of individuals, found not only a wide difference among individuals but a difference in acuity of taste of any one individual from day to day and during the day. The variation in taste thresholds for one individual was less than that between individuals. The reason for this was unknown. Many investigators have observed that the sensitivity varies according to the substance used. A person who is very sensitive to bitter taste in one substance may be unable to detect the bitter taste in another substance. It is said that in order to get the best flavor, it was necessary to have all 4 taste sensations in correct proportion to bring out the delicacy of the natural aromas.

Many things may influence one's sensitivity of taste. King (14) stated in her report that in Komuri's experiment on taste he reported that in the reaction of the sense of taste there was a temperature coefficient which functioned below 20° C and above 30° C. The sensitivity increases from 10° to 20° C and slightly diminishes between 30° and 50° C. King (14) stated that the time of day influenced taste sensitivity. The most desirable times to test sensitivity of taste were from two to three hours after meals. Many tasters inhaled the odor of a food through the mouth, believing that a more accurate record of flavor was made. In doing this the taste sensation was recorded by the taste buds along with the odor, therefore, it was not advisable for judges to score food in the same room in which the food was cooked.

METHODS AND MATERIALS USED

<u>General Plan of the Experiment:</u>

In the present experiment potato chips, shoe string potatoes and French fried potatoes were fried in peanut oil and in cottonseed oil to determine the effect of the oil on the palatability of the products. Twelve replicate fryings of each product were made in each oil so that the data could be analyzed statistically. The following comparisons were made of the two oils: (1) the palatability of the fried products in respect to appearance, texture and taste; (2) the rancidity of the two oils after each frying; (3) the acidity of the two oils after each frying; (4) the smoking points of the two oils after each frying; and (5) the amount of oil absorbed by the products during each frying.

Since the oils for this experiment could not be produced under experimental conditions, tests were run on the oils prior to the frying experiments to determine the smoking points, saponification numbers, iodine numbers, free acidity, and the resistance of the oils to rancidity at room temperature and at an oven temperature of 100° C.

Materials Used:

Oils: The peanut oil used in the experiment was made from the Virginia variety of peanut. The peanuts were shelled, ground up very finely and cooked in a steam-jacketed cooker before they were put in the presses. The crude oil obtained from the presses was filtered, refined and deodorized.

The cottonseed oil was made from seeds that were cleaned, delintered, ground up very finely and heated before they were sent to be pressed. The crude oil was then filtered, refined, bleached and deodorized. These oils were purchased and placed in storage at a temperature of 4.4° C and amounts of oil were taken from storage as needed.

Potatoes: The potatoes were early Irish Cobblers, sound, medium sized and southern grown. They were stored at the lowest possible temperature of a refrigerator which was about 4° C until 7 days before frying. They were then removed to room temperature which allowed the reversion of sugar to starch. The amount of sugar present in the potatoes at the time of frying was indicated by the picric acid test. In this test one ml. of a saturated aqueous solution of picric acid and one ml. of 20 percent sodium carbonate, were placed in a test tube. Into this mixture was placed a cylinder of potatoes cut from the center of the tuber with a cork borer. This cylinrical sample had a diameter of 3/16 of an inch and was one inch in length. The test tube was shaken well, held one minute over the flame of an alcohol lamp and then placed on a rack to cool. The amount of sugar was indicated by a color chart. When a test produced a yellow color there was a small amount of sugar in the potato. Orange color indicated that the potato contained the amount of sugar that would make a desirable product when fried at 185° C or below. The production of an English red color indicated that the potato contained the amount of sugar that would make a desirable product when fried at 163° C. A Morocco red indicated that the potato contained the amount of sugar that would make a desirable product when fried at 132° C. A garnet brown indicated that the potato contained an amount of sugar which made it undesirable for frying. In this experiment all the potatoes used produced a deep orange color, thus yielding a desirable product when fried at 175° C.

Equipment: All the frying was done in two 5-quart heavy iron kettles weighing 3.713 kg. and 3.217 kg. The kettles were 10.5 inches in diameter at the top, 9 inches in diameter at the bottom, and 4 inches deep. A wire frying basket was used to hold the products. A centigrade thermometer was placed in an iron thermometer stand and placed in the kettle of oil. The potato chips and shoe string potatoes were cut with a potato slicer and shoe string cutter attachments of a dough mixer.* The French fries were cut with a type of French fry cutter.*

Chemical Methods Used:

Smoking Points: The method of determining the smoking temperature in this experiment was to heat the fat on an electric unit in a No. 4 evaporating dish, with the upper surface of the oil having a diameter of about 6 cm. A thermometer was suspended in the center of the oil and the oil was stirred with it to keep it evenly heated. The temperature at which the first

*Dough mixer type P-12. No. 53587. The Read Machine Company, Inc., York, Pennsylvania.

*Montgomery Ward Model, Montgomery Ward, Baltimore, Maryland.

slight fumes were visible over the liquid was considered the smoking point. The smoking points of two replicate samples were averaged. This method was similar to the method used by Blunt and Feeney (4) in their investigation of smoking points of fats and oils.

Saponification Number: To find the saponification numbers of the oils, about 2 gms. of oil were accurately weighed into a 250-300 ml. Erlenmeyer flask and 25 ml. of alcoholic NaOH solution was pipetted into the flask with a definite time for draining the pipette. The alcoholic NaOH solution was prepared by using 10 gms. of pure NaOH dissolved in 250 cc. of 95 percent ethyl alcohol. The solution was allowed to settle over night and the clear solution was then decanted into another bottle. It was not necessary to standardize this solution. The flask with the oil and NaOH solution was connected with an air condenser and boiled until the oil was completely saponified. This was cooled and titrated with 0.5N HCL, using phenolthalein as an indicator. A 25 ml. aliquot of alcoholic NaOH solution was titrated with the 0.5N HCL solution. From the difference in the titration of this 25 ml. aliquot and the titration value of the sample after saponification, the saponification number of the oil was found. The 0.5N HCL solution was standardized against sodium carbonate in the usual manner. The saponification number is expressed as the number of milligrams of KOH required to saponify one gm. of fat or oil.

Iodine Number: The reported number of peanut oil was discussed briefly in the review of literature but the exact method (7) in this study will now be considered. In testing the oils for their degree of unsaturation, it was first necessary to weigh a 250 ml. Erlenmeyer flask to the second decimal place and add approximately 3 gms. of oil. The amount of fat added should be known to the accuracy of 0.01 gram. To the flask 10 ml. of chloroform and 25 ml. of Hanus solution were added. This mixture was stoppered, put in a dark place for 30 minutes, and shaken occasionally. After the absorption period had elapsed, 15 ml. of 10 percent potassium iodine with about 100 ml. of water was added. To obtain the degree of unsaturation, the excess iodine, which was dissolved in the layer of chloroform at the bottom was titrated with 0.IN sodium thiosulphate solution until the iodine solution changed to a faint yellow. At this point a few cubic centimeters of one percent starch solution was added which turned the solution blue. The titration with thiosulphate solution was continued until the blue color disappeared. A blank of 15 ml. of 10 percent potassium iodide and 25 ml. of Hanus solution was titrated in the same manner with the sodium thiosulphate solution. The difference in the titration of the blank and the sample indicated the amount of iodine which had been absorbed by the oil. Since one cubic centimeter of 0.IN thiosulphate solution is equivalent to 0.0127 gms. of iodine, the number of grams of iodine absorbed by the oil was calculated. This was expressed as the number of grams of iodine absorbed by 100 grams of oil.

Acidity Values: The method of determining the acid values in this experiment of peanut oil and cottonseed oil, two samples of approximately 10 gms. each were taken. These samples of oil were weighed to the nearest .001 gm. They were placed in Erlenmeyer flasks with 30 ml. of neutral alcohol, (neutralized until pink by the use of phenolthalien as the indicator). The flask were placed in a hot water bath and shaken well until the pink color disappeared. The solutions were titrated with a standard solution of 0.1N NaOH. From these titrations the acidity was calculated and reported as the amount in ml. of 0.1N NaOH required to neutralize one gram of oil.

Resistance to Rancidity: In testing peanut oil and cottonseed oil for their resistance to rancidity the Kries test was used. In this test a 2 ml. portion of oil was dissolved in 2 ml. of one percent phloroglucinol ~~iodine~~ in ether. To this was added 2 ml. of commercial hydrochloric acid and the tube was well shaken. The depth of the pink color produced indicated the degree of change in the oil. To have a more definite value of the change in color a table has been compiled by rating the degree of rancidity that occurred in cottonseed oil put into an Erlenmeyer flask and placed in an oven at 100° C for varying lengths of time. Samples of oil were taken at 30 minutes intervals for 330 minutes. The noted changes in color among the samples were given a different value. One plus represented a slightly rancid oil and 5 plusses a very rancid oil. This last value was obtained by using a very rancid oil.

Number of minutes at 100° C	Values Given
Minutes	
60	-
120	+
180	++
240	+++
330	++++
Very rancid oil	+++++

In finding the resistance to rancidity of peanut oil and cottonseed oil at 100° C over a period of time, 150 gms. of each of the oils was placed in an Erlenmeyer flask and put in an oven at 100° C. Samples of the oils were taken at 30 minute intervals for a period of 330 minutes. The degree of rancidity was measured by the Kries test. To find the degree of rancidity developed at room temperature 150 gm. samples of peanut oil and cottonseed oils were placed in tin baking powder cans and stored. This oil had an exposed surface of 5.5 cm. diameter. The Kries test was run on the oils at weekly intervals to find the degree of rancidity.

Testing for a Panel of Judges and the Judging Procedure:

In testing for a panel of judges, solutions of sour, salt, sweet and bitter were made, based on the threshold ranges of these substances as found by previous workers and compiled by King (14). These solutions were made by dissolving hydrochloric acid, sucrose, sodium chloride and quinine sulphate in tap water since distilled water has a flat taste to most people, and would interfere with the taste thresholds. These solutions were made in the following concentrations:

No. of solutions of the series	HCL Molarity	Sucrose Molarity	NaCl Molarity	Quinine Sulphate Molarity
1	.0016	.0016	.0016	.0000035
2	.0032	.0032	.0032	.000007
3	.0064	.0064	.0064	.000014
4	.0128	.0128	.0128	.000025
5	.0256	.0256	.0256	.00005
6	.0512	.0512	.0512	.00010
7				.00020

The No. 1 solutions of all the series were below the thresholds of taste of the judges.

The test period was set three hours after meals since King (14) reported in her experiment that Komuro stated this time as one of the desired times for testing thresholds of taste. The solutions were given at room temperature because the highest sensitivity was obtained at this temperature.

Five subjects were given this test. They were told the solutions would taste sour, salt, sweet, and bitter. Before taking the test the mouth was thoroughly rinsed with water. A sample of 5 ml. of the No. 1 solution was poured into a glass, put into the mouth and rolled around so that it would reach the back of the tongue. The solution was discarded and the taste recorded. The mouth was again rinsed with water and after a lapse of two minutes the No. 2 solution of the same substance was tasted. A clean glass was used for each solution. This procedure continued until each judge identified the substance. This was repeated for each of the 4 substances. The thresholds of taste of the 5 judges were compiled and the three with the most sensitive taste were selected as judges.

In scoring potato chips, shoe string potatoes and French fried potatoes a score card for each of the products was used (See Appendix). Potato chips and shoe string potatoes were scored when they were cold in a different room from the one in which they were made. The scoring took place two hours after meal time. French fried potatoes were scored while they were hot. No comments were made by the judges about the products during the process of scoring.

Cooking Test:

Cooking Methods: In making potato chips the potatoes were washed and the blemishes removed. The chips were sliced with a mechanical slicer to the thickness of one to 1.5 mm. A sample of 226.8 grams of these chips was soaked for 30 minutes in cold running tap water. The slices were laid out separately between two layers of cotton dish toweling and patted until the surface water was absorbed by the toweling. The drying process lasted about five minutes. The chips were weighed and wrapped in wax paper until fried. A third of the sample which contained 14 slices was dropped into hot oil at an initial temperature of 175° C and fried 210 seconds, lifted out, drained, placed on wax paper and weighed. Three fryings were necessary to fry the sample. There was a temperature drop of 5° C when the potato chips were dropped into the oil. Therefore the frying temperature was 170° C. In the frying of potato chips 2.5 kg. of each of the oils was used. These oils were cooled and strained after the second, fourth, sixth, eighth and tenth frying and stored for 12 hours at about 4° C.

For shoe strings, the potatoes were washed and the blemishes removed. The shoe strings were cut with a mechanical cutter to the thickness of one-eighth inch. The length of the strings depended on the size of the potato. A sample of 226.8 gms. of shoe strings were soaked for 30 minutes in cold running tap water. The strings were laid between two layers of cotton dish toweling and patted until the surface water was absorbed. The drying process lasted about five minutes. The shoe strings were weighed and wrapped in wax paper until fried. One-half of the potatoes was dropped into hot oil, at an initial temperature of 175° C and cooked for 200 seconds, lifted out, drained, placed on wax paper and weighed. There was a 10° C drop in temperature when the shoe strings were dropped into the oil: Therefore, the frying temperature was 165° C. In frying the shoe string potatoes 2.5 kg. of each oil was used. These oils were cooled and strained after the second, fourth, sixth, eighth and tenth frying and stored for twelve hours at about 4° C.

In making French fried potatoes the potatoes were peeled and cut with a mechanical cutter to the thickness of three-eights of an inch. The length of the French fried potatoes depended on the size of the potatoes. A sample of 226.8 gms. of French fries was cut and placed to soak for 30 minutes in cold running tap water. The French fries were laid out separately between two layers of cotton dish toweling, and patted until the surface water was absorbed by the toweling. The whole drying process lasted about five minutes. The French fries were weighed and wrapped in wax paper until fried. The whole sample of French fries was dropped into hot oil at an initial temperature of 175° C and cooked 720 seconds, lifted out, drained, placed on wax paper, and weighed. Since there was a drop of 5° C in the temperature of the oil when the French fries were dropped into the oils, the frying temperature was 170° C. In frying the French fried potatoes 2.5 kgs. of each oil was used. The oils were cooled and strained after the third, sixth and ninth frying and stored for 12 hours at about 4° C.

Rancidity Test of the Two Oils on Repeated Fryings:

The oils were tested for rancidity after each frying by the Kries test. Two samples from each lot of oil were taken for the test and the values were averaged. The rancidity was expressed in plusses as heretofore described.

Acidity Test of the Two Oils on Repeated Fryings:

The oils were tested for acidity after each frying of potato chips, shoe string potatoes and French fried potatoes. Two samples from each lot of oil were taken for the test and the values averaged. The method previously described for the determination of acidity values was used.

Smoking Point of the Two Oils on Repeated Fryings:

A sample of each oil was taken after every frying for the determination of its smoking point. The method previously described for the determination of smoking point was used.

Absorption of the Two Oils on Repeated Fryings:

The amount of oil absorbed when potato chips, shoe string potatoes, and French fried potatoes were fried in peanut oil and cottonseed oil was based on the loss of kettle weight during each frying. The kettle, oil, basket and thermometer were weighed before and after each frying on a Torsion balance. The difference between weights gave the amounts of oil absorbed by 226.8 gms. of the raw potatoes.

Statistical Methods:

The statistical method used in the analysis of the experimental data was Fisher's (8) "t" test or standard error. This test studied the significance of the difference between two means. The basis of comparison included all the variability within the two groups compared. The formula used was $t = \bar{d}\,\frac{\sqrt{N-1}}{\sigma d}$. For each value of "t" calculated by the formula, the corresponding P value was found. If the value for P was .05 or less, the difference was considered significant, and if it was .01 or less, highly significant. These values represent the commonly used 5 percent and one percent levels of significance, respectively. The 5 percent level of significance means that in only 5 cases in 100 could such a difference be due to errors of random sampling. The one percent level, of course, indicates that the difference could be due to random sampling errors only one time out of 100.

RESULTS AND DISCUSSION OF RESULTS

Chemical Constants of the Two Oils:

Table 1. Chemical and Physical Constants of the Peanut Oil and Cottonseed Oil Used in the Experiment

	Smoking Points °C	Saponification No. Mgs. KOH per one gm. oil	Iodine No. Gm. I_2 per 100 gm. oil	Acidity CC. 0.1N NaOH per gm. oil
Peanut Oil	242	194	92	.01530
Cottonseed Oil	240	191	105	.01530

Smoking Points: It is shown in Table 1 that the smoking points of the peanut oil and the cottonseed oil used in this experiment were 242° C and 240° C, respectively. It was considered that this difference in the smoking points of the two oils was insignificant. The smoking point of the peanut oil used in the present experiment was within the range reported by the National Peanut Council (21), namely 230° - 243° C. In comparison with the smoking points given by Blunt and Feeney (4) of 142° C for their peanut oil No. 1 and 162° C for their peanut oil No. 2, the smoking point of the oil used in the present experiment was 100° C and 80° C higher, respectively.

Blunt and Feeney (4) reported the smoking point of cottonseed oil to be 233° C which is 7° lower than that of the cottonseed oil used in this experiment. These results suggest that smoking points may be influenced by the variety of seeds used in making the oils and the methods of refining. Both oils used in the present experiment can be considered to have good smoking points for deep-fat frying.

Saponification Numbers: The saponification numbers of the peanut oil and the cottonseed oil used in this experiment were 194 and 191, respectively (Table 1). These saponification numbers agree with the saponification numbers reported by Holde and Mueller (11) who gave 189 to 194 for peanut oil and 191 to 198 for cottonseed oil. The saponification number of the peanut oil in the present experiment was greater than the range of saponification numbers given by the National Peanut Association (21) which was 186.6 to 188.4. As mentioned before, however, the saponification number may vary with the variety of peanuts used since the number is a measure of the length of the fatty acid chains.

Iodine Numbers: The iodine numbers of the peanut oil and cottonseed oil used in the present experiment were 92 and 105, respectively (Table 1). These values correspond to those compiled by Holde and Muller (11) who gave 86 to 98 for peanut oil and 102 to 111 for cottonseed oil. The National Peanut Council (21) reported that the iodine number of peanut oil was 89 to 96. Therefore, the peanut oil and the cottonseed oil used in this experiment had iodine numbers similar to those reported in the literature. These numbers definitely place peanut oil in the non-drying group of oils and cottonseed oil in the semi-drying group.

Acidity Values: The acidity values of the same variety differ greatly because of the various types of oil on the market, the process used in making them and their storage before utilization. However, in the present experiment the acidity values for the two oils were the same, .01530 (Table 1). Since this amount of free acidity found in the two oils was very insignificant, it is reasonable to believe that the peanut oil and the cottonseed oil were both fresh when received.

From these results of the chemical constants of the two oils it can be stated that the peanut oil and the cottonseed oil were similar in smoking points, saponification numbers and free acidity, the latter value being of an insignificant magnitude for both oils. The iodine number was definitely higher for cottonseed oil than for peanut oil which placed the former in the semi-drying class and the latter in the non-drying class. All constants agreed well with those which have been reported by other investigators. From these constants it was realized that the oils to be used in the experiment were fresh and had good smoking points for deep-fat frying.

A Comparison of the Resistance to Rancidity of the Two Oils:

At oven temperature, 100° C, both the peanut oil and the cottonseed oil began to develop rancidity after 120 minutes (Table 2). At 180 minutes the rancidity value was + for the peanut oil but ++ for the cottonseed oil. From this time until the end of the test, 350 minutes, the cottonseed oil increased in rancidity faster than the peanut oil. At room temperature, no rancidity was noted in either oil until 9 weeks had elapsed. Over the period of this test, 11 weeks, there was no apparent difference between the two oils in their rancidity changes. From these results, it would seem that peanut oil is somewhat more resistant to rancidity changes than cottonseed oil since the former became rancid more slowly than the latter at a temperature which accelerated the reaction. If time had allowed, it is expected that the same relation between the two oils would have been obtained at room temperature.

Table 2. Rancidity Changes of Peanut Oil and Cottonseed Oil Kept at 100° C and Room Temperatures as Indicated by the Kreis Test

Oven Temperature			Room Temperature		
Time Minutes	Peanut Oil plusses*	Cottonseed Oil plusses	Time Weeks	Peanut Oil plusses	Cottonseed Oil plusses
60	-	-	1	-	-
120	+	+	2	-	-
150	+	+	3	-	-
180	+	++	4	-	-
210	++	+++	5	-	-
240	++	+++	6	-	-
270	++	+++	7	-	-
300	++	+++	8	-	-
350	+++	++++	9	+	+
			11	++	++

* Plusses
1. A faint pink
2. Very light pink
3. Light pink
4. Pink
5. Dark pink

Table 3. The Taste Thresholds for Sour, Sweet, Salt and Bitter of the Three Judges Selected for Judging the Products

Judges Number	Sour	Sweet	Salt	Bitter
	molarity	molarity	molarity	molarity
1	.0032	.0128	.0032	.000025
2	.0032	.0032	.0064	.000050
3	.0032	.0256	.0032	.000025
Range	.0032	.0032-.0256	.0032-.0064	.000025-.00005

Testing for a Panel of Judges:

In the taste test given to the judges, 4 solutions, hydrochloric acid, sodium chloride, sucrose and quinine sulphate, were tested. Among the 5 judges there was no taste blindness since all were able to identify the substances at some concentration given for tasting. Out of the 5 persons tested the 3 whose taste thresholds were most consistent and sensitive were chosen for judges. Their thresholds are given in Table 3. The taste thresholds of the judges in the present experiment all fell within the range of the thresholds reported by King (14) with the exception of the thresholds for bitter. It was found that the thresholds for sour in the present experiment were .0032M while King's judges ranged from .0002M to .0128M. The salt thresholds of the judges were found to be .0032M to .0064M while these of King's subjects were .0008M to .2048M. The sweet threshold was .0032M to .0250M while those found by King were .004M to .102M. The bitter thresholds of the judges were .000025M to .00005M while those of King's judges were .0002M to .0128M. It is thought that the difference in the bitter thresholds was caused by the difference in the bitterness of quinine sulphate used in the present experiment and quinine hydrochloride used by King.

<u>Results of the Cooking Tests:</u>

The Palatability of Potato Chips: Potato chips fried in peanut oil and in cottonseed oil for 12 consecutive fryings were compared in respect to appearance, texture and flavor. The potato chips fried in peanut oil were judged significantly higher for shape, tenderness and brittleness than those fried in cottonseed oil (Table 4). The P values for shape, tenderness and brittleness were .0336, .0014 and .0036, respectively. Thus the difference in shape was significant since P was below the 5 percent level and the differences in tenderness and brittleness were highly significant since P had values below the one percent level. The difference in shape of potato chips fried in the two oils was unexpected. A possible explanation may be that the chips were scored for their curliness as well as for size and contour of the chip, factors which are determined by the size and shape of the potato. This suggests that potato chips were curlier when fried in peanut oil than when fried in cottonseed oil. It is interesting that tenderness and brittleness, both of which factors depend on the shortening value of a fat or oil, were judged higher in potato chips fried in peanut oil than those fried in cottonseed oil. In the present experiment taste, color, oiliness and aroma were not significantly different for potato chips fried in peanut oil and those fried in cottonseed oil since the P values were all above the 5-percent level. King (15) reported that potato chips fried in peanut oil were scored higher in taste than those fried in other fats and oils, but she could not prove statistically that the difference was significant.

The total scores of potato chips fried in peanut oil and in cottonseed oil show that as a whole the chips were much better when fried in peanut oil since the P value of the difference in the mean total scores was .003, a highly significant difference. The average total score for potato chips fried in peanut oil was 91.33 while those fried in cottonseed oil scored only 85.70 (Table 7)

From these results, it would seem that peanut oil gave a more desirable potato chip than cottonseed oil since the scores for shape, tenderness and brittleness were all judged significantly higher for those fried in peanut oil and the total scores were much higher for the chips fried in peanut oil than those fried in cottonseed oil.

The Palatability of Shoe String Potatoes: Shoe string potatoes when fried in peanut oil and cottonseed oil for 12 consecutive fryings were compared in respect to appearance, texture and flavor (Table 5). In only one factor, that of taste, were the shoe string potatoes fried in the two oils significantly different. Shoe string potatoes fried in peanut oil had an average score for taste of 9.03 while those fried in cottonseed oil scored only 8.51. The value for P for the difference was .0482. The score for brittleness was much higher for shoe string potatoes fried in peanut oil but the value for P, .0818, did not reach the 5-percent level. However, this result might indicate a preference for peanut oil in this respect and a larger sample might have made the difference significant. The scores for color, shape, tenderness, oiliness and aroma of the shoe string potatoes fried in peanut oil and in cottonseed oil were not significantly different.

The total scores of shoe string potatoes fried in peanut oil and in cottonseed oil show that as a whole the shoe strings were better when fried in peanut oil since P was .097, a difference that almost reaches the 5-percent level of significance. The average score forshoe string potatoes fried in peanut oil was 80.64 and for those fried in cottonseed oil, only 77.09 (Table 7).

From these results, it would seem that peanut oil gave more desirable shoe string potatoes than cottonseed oil since the total score, the scores for taste and possibly for brittleness were significantly higher for those fried in peanut oil.

The Palatability of French Fried Potatoes: French fried potatoes when fried in peanut oil and cottonseed oil for 12 consecutive fryings were compared in respect to appearance, texture and flavor. The aroma of the French fried potatoes was found to be significantly higher for those fried in peanut oil, since the value for P was .003 (Table 6). The fact that French fried potatoes were scored while they were hot leads to the suggestion that cottonseed oil had a more disagreeable and penetrating odor when hot than when cold since the difference in aroma between the two oils was not significant when potato chips and shoe string potatoes were scored cold. The difference in taste of the French fried potatoes fried in the two oils approached the 5-percent level of significance since the value for P was .0576. Again peanut oil gave the more desirable taste. It will be remembered that taste was also judged higher for shoe string potatoes fried in peanut oil than those fried in cottonseed oil since the value for P was .0482. The score for color, shape, tenderness, brittleness and oiliness of the French fried potatoes fried in peanut oil and cottonseed oil were not significantly different. The total scores of French fried potatoes fried in peanut oil and in cottonseed oil showed that those fried in peanut oil had a higher total score, 87.80 than those fried in cottonseed oil, 85.14 (Table 7). However, this difference was not significant since P, .1356, was above the 5-percent level.

From these results it is suggested that peanut oil gave a more desirable aroma and possibly taste to French fried potatoes than cottonseed oil, but the difference between the two products as a whole was not as great as for potato chips and shoe string potatoes fried in the two oils since the value for P for the difference in total scores was only .1356.

In the frying of potato chips, shoe string potatoes and French fried potatoes in peanut oil and cottonseed oil the type of oil did not seem to affect any of the products in color and in oiliness since the P values for these factors were all above the 5-percent level (Table 8). In only one case, that of potato chips, was there a difference in shape and in this case peanut oil was judged to give a significantly higher score. One might expect the scores for tenderness and brittleness to differ with the type of oil used but only in the case of potato chips were there significant differences in these two factors. In both factors, the products fired in peanut oil scored significantly higher. The shoe string potatoes fried in peanut oil scored considerably higher in brittleness than those fried in cottonseed oil but the difference did not quite reach the 5-percent level of significance. However this value would indicate a possible difference in brittleness. In general, peanut oil seemed to give higher values for the aroma and taste of the products than cottonseed oil. The P values for taste show that both shoe string potatoes and French fried potatoes fried in peanut oil had a better taste than those fried in cottonseed oil. In one case, that of French fried potatoes, there was a significant difference in aroma and in this case peanut oil was judged significantly higher. However, taste in the

Table 4. Average Scores (3 judges) of Potato Chips Fried in Peanut Oil and Cottonseed Oil

Number of Fryings	Appearance				Texture				Flavor					
	Color		Shape		Tenderness		Brittleness		Taste		Oiliness		Aroma	
	Peanut	Cottonseed	Peanut	Cottonseed	Peanut	Cottonseed	Peanut	Cottonseed	Peanut	Cottonseed	Peanut	Cottonseed	Peanut	Cottonseed
1	9.33	9.33	9.00	9.00	19.00	18.33	19.33	19.33	10.00	9.00	17.67	17.67	10.00	8.33
2	11.67	6.67	9.33	8.00	18.67	16.33	19.33	16.33	10.00	9.00	16.33	17.67	10.00	10.00
3	7.33	8.33	10.00	10.00	18.33	17.67	19.00	16.00	9.33	10.00	16.67	17.00	9.00	10.00
4	8.67	8.33	10.00	10.00	19.33	19.00	19.33	18.67	10.00	10.00	17.33	18.67	9.33	10.00
5	8.33	8.67	10.00	8.67	20.00	18.67	19.33	19.00	10.00	9.33	18.67	18.00	10.00	10.00
6	6.00	9.67	10.00	10.00	19.67	18.67	19.67	19.33	10.00	9.67	17.00	17.33	10.00	10.00
7	9.33	7.33	9.33	9.67	18.33	13.33	19.00	14.00	10.00	9.33	18.33	19.00	10.00	9.00
8	10.00	8.67	9.67	9.33	19.33	19.00	19.00	18.66	10.00	10.00	19.00	18.33	10.00	10.00
9	8.33	7.00	10.00	10.00	19.67	18.67	19.00	19.00	9.00	7.67	17.00	17.00	10.00	9.00
10	8.33	7.00	9.33	8.67	18.00	14.67	18.33	14.67	10.00	10.00	17.33	17.33	10.00	10.00
11	7.67	5.33	9.33	8.67	15.67	12.00	17.00	11.67	7.67	9.00	17.33	16.67	9.33	10.00
12	6.33	6.33	8.00	7.67	15.00	11.00	15.00	10.33	8.67	8.00	15.67	10.00	8.00	10.00
Mean	8.44	7.72	9.50	9.22	18.42	16.45	18.61	16.41	9.53	9.23	17.36	17.03	9.64	9.69
Possible score	10.00	10.00	10.00	10.00	20.00	20.00	20.00	20.00	10.00	10.00	20.00	20.00	10.00	10.00
t.	1.19		2.39		4.14		3.57		1.43		.57		-.18	
P.	.2532		.0336		.0014		.0036		.1868		>.5596		>.5596	

Table. 5 Average Scores (3 judges) of Shoe String Potatoes Fried in Peanut Oil and Cottonseed Oil

Number of Fryings	Appearance: Color, Peanut	Appearance: Color, Cottonseed	Appearance: Shape, Peanut	Appearance: Shape, Cottonseed	Texture: Tenderness, Peanut	Texture: Tenderness, Cottonseed	Texture: Brittleness, Peanut	Texture: Brittleness, Cottonseed	Flavor: Taste, Peanut	Flavor: Taste, Cottonseed	Flavor: Oiliness, Peanut	Flavor: Oiliness, Cottonseed	Aroma, Peanut	Aroma, Cottonseed
1	9.00	8.33	8.67	8.67	19.00	19.00	19.00	18.67	10.00	9.67	20.00	20.00	10.00	10.00
2	8.67	9.33	9.00	10.00	18.00	19.33	19.00	19.67	10.00	10.00	20.00	20.00	10.00	10.00
3	10.00	7.67	8.33	9.00	18.00	18.00	15.67	15.67	10.00	10.00	20.00	20.00	10.00	10.00
4	8.33	8.33	8.67	8.33	17.33	17.33	18.67	17.00	10.00	10.00	18.00	18.67	10.00	10.00
5	9.67	10.00	9.67	9.67	16.67	18.33	17.33	18.67	10.00	10.00	18.67	19.00	9.33	10.00
6	7.33	7.00	8.67	8.33	15.67	13.67	16.33	13.00	9.67	9.67	19.33	16.00	9.33	8.67
7	7.33	8.67	8.67	9.00	15.33	14.33	14.67	15.33	9.33	9.67	19.33	19.33	9.67	9.67
8	7.33	4.00	10.00	9.00	14.00	8.00	9.67	6.00	7.67	6.00	16.00	18.67	9.67	9.00
9	7.33	6.67	10.00	9.00	16.67	13.33	17.67	13.33	10.00	9.67	15.67	18.00	9.67	9.00
10	7.00	7.00	8.33	8.67	13.00	7.67	13.00	7.00	9.00	7.00	17.00	15.00	9.00	8.33
11	8.33	5.67	7.67	8.00	5.33	6.67	4.67	6.67	7.33	5.33	12.00	14.00	7.33	8.00
12	5.33	5.33	7.00	7.00	4.67	6.00	5.33	3.67	5.67	5.33	9.00	8.00	5.00	4.33
Mean	7.97	7.33	8.72	8.72	14.47	13.47	14.23	12.89	9.03	8.51	17.08	17.22	9.08	8.92
Possible score	10.00	10.00	10.00	10.00	20.00	20.00	20.00	20.00	10.00	10.00	20.00	20.00	10.00	10.00
t.	1.57		.00035		1.31		1.88		2.18		-.28		1.18	
P.	.1356		>.5596		.2180		.0818		.0482		>.5596		.2534	

Table 6. Average Scores (3 judges) of French Fried Potatoes Fried in Peanut Oil and Cottonseed Oil

Number of Fryings	Appearance				Texture				Flavor				Aroma	
	Color		Shape		Tenderness		Brittleness		Taste		Oiliness			
	Peanut	Cottonseed	Peanut	Cottonseed	Peanut	Cottonseed	Peanut	Cottonseed	Peanut	Cottonseed	Peanut	Cottonseed	Peanut	Cottonseed
1	8.33	9.00	10.00	10.00	19.67	18.67	18.33	18.67	10.00	9.33	19.67	19.00	10.00	10.00
2	9.67	9.67	10.00	10.00	20.00	17.67	19.67	18.00	10.00	4.00 ×	18.00	18.00	10.00	10.00
3	8.67	8.67	10.00	10.00	19.00	19.33	18.67	18.33	10.00	9.33	18.00	17.67	10.00	10.00
4	8.33	8.00	10.00	10.00	18.33	18.00	19.00	17.67	9.67	9.67	18.33	17.00	9.67	9.33
5	7.33	7.67	9.67	10.00	17.67	18.33	17.00	17.33	9.33	9.67	18.00	17.33	10.00	9.00
6	8.33	6.00	10.00	10.00	17.00	17.67	17.33	16.67	9.33	7.00	17.67	17.00	9.33	7.67
7	6.33	9.00	9.33	10.00	18.33	18.00	16.67	17.67	9.33	9.67	17.33	17.67	9.33	9.33
8	8.00	8.00	9.33	10.00	17.67	17.67	17.67	17.00	9.33	8.00	15.00	18.00	9.00	8.00
9	7.00	8.00	10.00	10.00	17.00	17.00	16.33	16.33	9.00	8.33	17.33	16.00	9.67	9.00
10	4.00	5.67	10.00	10.00	17.00	17.33	16.00	16.67	9.33	8.67	17.33	17.00	8.00	7.00
11	4.00	7.67	10.00	10.00	16.67	18.00	17.00	16.67	6.00	6.67	17.00	15.67	5.00	4.33
12	6.00	4.67	10.00	10.00	17.00	14.33	14.67	11.33	8.00	5.67	15.67	12.00	7.00	4.33
Mean	7.16	7.67	9.86	10.00	17.94	17.67	17.36	16.86	9.11	8.00	17.44	16.86	8.92	8.08
Possible score	10.00	10.00	10.00	10.00	20.00	20.00	20.00	20.00	10.00	10.00	20.00	20.00	10.00	10.00
t.	-1.05		-.19		.84		1.45		2.12		1.33		3.73	
P.	.2531		>.5596		.4392		.1868		.0576		.2180		.0030	

Table 7. Total Scores (3 judges) of Potato Chips, Shoe String Potatoes and French Fried Potatoes Fried in Peanut Oil and Cotton Seed Oil

Number of Fryings	Potato Chips		Shoe String Potatoes		French Fried Potatoes	
	Peanut oil	Cottonseed oil	Peanut oil	Cottonseed oil	Peanut oil	Cottonseed oil
1	94.33	90.99	95.67	94.34	96.00	94.67
2	95.33	84.00	94.67	98.33	97.34	87.34
3	89.66	89.00	92.00	90.34	94.34	92.33
4	93.99	94.67	91.00	89.66	93.33	89.67
5	96.33	92.33	91.34	95.67	89.00	89.33
6	92.34	94.67	86.33	76.34	88.99	82.01
7	94.32	81.66	84.33	86.00	86.65	91.34
8	97.00	93.99	74.34	60.67	86.00	86.67
9	93.00	88.34	87.01	79.00	86.33	84.66
10	91.32	82.34	76.33	60.67	81.66	82.34
11	84.00	73.34	52.66	54.34	75.67	79.01
12	76.67	63.33	42.00	39.66	78.34	62.33
Mean	91.33	85.72	80.64	77.09	87.80	85.14
Possible Score	100.00	100.00	100.00	100.00	100.00	100.00
t.	3.71		1.85		1.57	
P.	.003		.097		.1356	

Table 8. A Summary of the Significance of the Differences in the Factors of Palatability of Potato Chips, Shoe String Potatoes and French Fried Potatoes Fried in Cottonseed Oil and in Peanut Oil as Expressed in Terms of the "t" Value and "P" Value

Products	Appearance				Texture				Taste							
	Color		Shape		Tenderness		Brittleness		Taste		Oiliness		Aroma		Totals	
	t	P	t	P	t	P	t	P	t	P	t	P	t	P	t	P
Potato Chips	1.19	.2532	2.39	.0336	4.14	.0014	3.57	.0036	1.43	.1868	.57	.5596	.18	.5596	3.71	.003
Shoe String Potatoes	1.57	.1356	.00035	.5596	1.31	.2180	1.88	.0818	2.18	.0482	-.28	.5596	1.18	.2534	1.85	.097
French Fried Potatoes	-1.05	.2531	-.19	.5596	.84	.4392	1.45	.1868	2.12	.0576	1.33	.2180	3.73	.003	1.57	.1356

case of French fried potatoes had the value for P of .0567 which was just above the 5-percent level of significance.

In all three cases the products fried in peanut oil received higher total scores than those fried in cottonseed oil. In the case of potato chips the difference was highly significant since the value for P was .003 (Table 8). Although the P value for French fried potatoes, .097, was above the 5-percent level of significance, it did approach significance and might be considered to be indicative. The difference in total score of French fried potatoes fried in the two oils was not significant since the value for P was only .1356. From these results, it is suggested that in general peanut oil gives better products in the deep-fat frying of potatoes chips, shoe string potatoes and French fried potatoes than cottonseed oil. It can be concluded from this study that peanut oil gave a more desirable shape, tenderness and brittleness to potatoe chips, a more desirable taste and possibly brittleness to shoe string potatoes and a more desirable aroma and possibly taste to French fried potatoes than cottonseed oil.

Rancidity Changes in the Two Oils:

The rancidity of peanut oil and cottonseed oil was determined by the Kries test after each of the 12 consecutive fryings of potato chips, shoe string potatoes and French fried potatoes. Both peanut oil and cottonseed oil began to develop rancidity in the first frying of potato chips and shoe string potatoes. Peanut oil began to develop rancidity in the second frying of French fried potatoes while cottonseed oil began in the third frying (Table 9). In only one case, that of French fried potatoes, was there a significant difference between the two oils in the development of

Table 9. Rancidity of Peanut Oil and Cottonseed Oil as Determined by the Kreis Test After Each of Twelve Consecutive Fryings of Potato Chips, Shoe String Potatoes and French Fried Potatoes

Number of Fryings	Potato Chips		Shoe String Potatoes		French Fried Potatoes	
	Peanut	Cottonseed	Peanut	Cottonseed	Peanut	Cottonseed
	plusses*		plusses		plusses	
1	1	1	1	1	-	-
2	2	1	1	1	1	-
3	3	2	2	1	1	1
4	3	3	2	1	1	1
5	3	3	2	2	2	2
6	3	3	2	2	2	2
7	3	3	2	2	2	3
8	3	3	3	3	2	3
9	3	3	3	3	2	3
10	4	4	4	4	3	4
11	4	4	4	4	3	4
12	4	4	4	4	3	4
Mean	3.00	2.83	2.50	2.33	1.83	2.25
t.	1.52		1.52		-2.21	
	.1594		.1594		.0402	

* Plusses
1. A faint pink
2. Very light pink
3. Light pink
4. Dark pink

rancidity. The average rancidity of cottonseed oil for the 12 fryings were scored 2.25 plusses while that for peanut oil was only 1.83. The value for P for the difference was .0402.

From these results, it would seem that peanut oil was somewhat more resistant to rancidity changes than cottonseed oil since the former became rancid more rapidly than the latter when the oil was kept hot for longer periods as was necessary in the frying of French fried potatoes. If time had allowed it is expected that the same relations between the two oils would have been obtained for potato chips and shoe string potatoes.

Acidity Changes in the Two Oils:

The peanut oil and cottonseed oil contained the same amount of acidity at the beginning of the experiment which was expressed as .01530 ml. of 0.1N NaOH for one gram of oil. The peanut oil developed significantly more free fatty acids than the cottonseed oil in the 12 consecutive fryings of potato chips, shoe string potatoes and French fried potatoes (Table 10). The P values for the differences were highly significant, .0026, .0012 and .0092 for the potato chips, shoe string potatoes and French fried potatoes, respectively. However, after the twelfth frying of potato chips, shoe string potatoes, and French fried potatoes the cottonseed oil always contained more free fatty acids than the peanut oil. Noting these results, it is believed that if time had allowed cottonseed oil would have developed free fatty acids more rapidly than peanut oil with further use.

The Smoking Point Changes in the Two Oils:

The smoking points of the peanut oil and the cottonseed oil were similar at the beginning of the experiment, 242°C and 240°C, respectively.

Table 10. Free Fatty Acids * of Peanut Oil and Cottonseed Oil After Each of Twelve Consecutive Fryings of Potato Chips, Shoe String Potatoes and French Fried Potatoes

Number of Fryings	Potato Chips		Shoe String Potatoes		French Fried Potatoes	
	Peanut	Cottonseed	Peanut	Cottonseed	Peanut	Cottonseed
	CC. of O. 1N NaOH		CC. of O. 1N NaOH		CC. of O. 1N NaOH	
1	.01537	.01535	.02042	.01530	.01532	.01527
2	.015353	.01535	.02043	.01530	.01533	.01529
3	.01998	.01943	.01039	.01533	.02466	.01533
4	.02049	.01943	.02557	.02042	.02043	.01535
5	.02557	.02045	.02545	.02043	.02045	.01533
6	.02557	.02043	.02551	.02556	.02047	.01531
7	.03064	.02046	.02557	.02552	.02047	.01533
8	.03563	.02553	.02551	.02557	.02044	.01531
9	.03577	.02558	.03065	.02541	.02555	.02559
10	.03575	.02554	.03067	.02555	.02560	.02551
11	.03576	.02553	.03067	.03067	.02553	.02555
12	.03561	.03581	.03063	.03069	.02543	.02546
Mean	.02762	.02241	.02593	.02298	.02164	.01872
t.	3.84		4.15		3.11	
P.	.0026		.0012		.0092	

* Expressed as CC. O. 1N NaOH per gram of fat

Table 11. Smoking Points of Peanut Oil and Cottonseed Oil After Each of Twelve Consecutive Fryings of Potato Chips, Shoe String Potatoes and French Fried Potatoes

Number of Fryings	Potato Chips		Shoe String Potatoes		French Fried Potatoes	
	Peanut	Cottonseed	Peanut	Cottonseed	Peanut	Cottonseed
	°C	°C	°C	°C	°C	°C
1	240	235	235	238	240	238
2	233	235	235	238	235	238
3	230	235	235	238	235	235
4	230	235	235	238	231	235
5	230	235	233	236	230	235
6	230	235	230	235	230	232
7	230	235	228	235	230	232
8	230	235	225	235	230	232
9	230	235	225	230	230	230
10	230	235	225	230	230	230
11	230	210	220	220	230	230
12	230	210	220	220	230	225
Mean	231	232	229	233	232	233
t.	-.24		-6.02		-1.14	
P.	.5596		.0002		.2930	

The difference, 2°C, is not considered significant (Table I). There was a gradual decline in the smoking points of the two oils during the 12 consecutive fryings (Table II). The difference between smoking points of the peanut oil and the cottonseed oil was not significant after each of the 12 consecutive fryings of potato chips and French fried potatoes, since the P value were .5596 and .2930, respectively. In the case of shoe string potatoes, however, the smoking point of the peanut oil upon repeated fryings was significantly lower than that of cottonseed oil since the value of P for the difference was .0002.

From these results it is suggested that the smoking point decreased when the acidity value increased since in the 12 consecutive fryings of potato chips, shoe string potatoes and French fried potatoes, the acidity values of the oils increased and the smoking points decreased (Table 10). In addition, the acidity values of the peanut oil were found to be higher than those of cottonseed oil and the smoking point of this oil was lower, at least in the case of French fried potatoes.

Amounts of Oil Absorbed by the Products Fried in Peanut Oil and Cottonseed Oil:

In the twelve consecutive fryings of shoe string potatoes and French fried potatoes in peanut oil and cottonseed oil, more grams of cottonseed oil were absorbed than of peanut oil (Table 12). However, the difference in amounts of oil absorbed by the shoe string potatoes was not significant since the value of P was only .1148. The difference in the case of French fried potatoes was significant since the value for P was .0482. There was no difference in the oil absorbed by potato chips fried in the two oils. The fact that a significant difference in oil absorption was found in the case of French fried potatoes may be explained by the fact that French fries are not completely dehydrated as are potatoe chips and shoe string potatoes. This may cause a greater variability in the water and fat content and thus the characteristics of the oil might determine the amount of oil absorbed. The oil absorbed, expressed as percentage of the final product, is shown in Table 13. Values for P similar to those shown in Table 12. are obtained since the calculations were made from the same data. Thus, only in French fried potatoes was there a significant different in the percentage of oil in the products fried in the two oils. Peanut oil caused less absorption of the oil than cottonseed. It is interesting to note from Table 13 that potato chips contained 21.66 percent peanut oil while shoe string potatoes and French fried potatoes contained 14.17 and 3.27 percent, respectively. The potato chips when fried in cottonseed oil contained 21.34 percent oil while shoe string potatoes and French fried potatoes contained 15.87 and 4.59 percent, respectively. Thus potato chips are about one-fifth fat while shoe string potatoes contain only 14-15 percent and French fried potatoes only 3-4 percent.

Table 12. Amount of Oil in Grams Absorbed by Potato Chips, Shoe String Potatoes and French Fried Potatoes Fried in Cottonseed Oil and Peanut Oil for 12 Consecutive Fryings

Number of Fryings	Potato Chips		Shoe String Potatoes		French Fried Potatoes	
	Peanut	Cottonseed	Peanut	Cottonseed	Peanut	Cottonseed
	gms.	gms.	gms.	gms.	gms.	gms.
1	52	49	40	40	5	5
2	54	43	42	32	2	6
3	46	39	35	32	5	5
4	41	53	32	40	12	10
5	42	42	28	35	5	15
6	46	50	30	33	10	10
7	49	48	38	40	10	15
8	45	47	30	33	5	17
9	50	52	20	40	5	10
10	52	46	29	35	10	10
11	52	47	32	30	10	10
12	63	65	30	42	10	10
Mean	49.33	48.41	30.67	36.00	7.42	10.23
t.	.524	-	1.73		-2.21	
P.	.5596		.1148		.0482	

Table 13. Amounts of Oil, Expressed as Percent, Absorbed by Potato Chips, Shoe String Potatoes and French Fried Potatoes

Number of Fryings	Potato Chips		Shoe String Potatoes		French Fried Potatoes	
	Peanut	Cottonseed	Peanut	Cottonseed	Peanut	Cottonseed
	percent		percent		percent	
1	22.92	21.60	17.63	17.63	2.20	2.20
2	23.80	18.95	18.51	14.10	.88	2.65
3	20.28	17.19	15.43	14.10	2.20	2.20
4	18.07	23.36	14.10	17.63	5.29	4.41
5	18.51	18.51	12.34	15.43	2.20	6.61
6	20.28	22.04	13.22	14.55	4.41	4.41
7	21.60	21.16	16.75	17.63	4.41	6.61
8	19.84	20.72	13.22	14.55	2.20	7.49
9	22.04	22.92	8.81	17.63	2.20	4.41
10	22.92	20.28	12.78	15.43	4.41	4.41
11	22.92	20.72	14.10	13.22	4.41	4.41
12	27.77	28.65	13.12	18.51	4.41	4.41
Mean	21.66	21.34	14.17	15.87	3.27	4.59
t.	.42		-1.73		-2.21	
P.	.5596		.1148	.	.0482	

SUMMARY

1. The chemical constants of peanut oil and cottonseed oil were similar in smoking point, saponification numbers and free acidity, the latter value being of an insignificant magnitude for both oils. The iodine number was definitely higher for cottonseed oil than for peanut oil. From these findings it was realized that the oils used in the experiment were fresh and had good smoking points for deep-fat frying.

2. At 100°C. cottonseed oil developed rancidity faster than peanut oil.

3. The judges were found to have taste thresholds that were consistent and sensitive to sour, salt, sweet and bitter.

4. The following differences in the palatability of potato chips, shoe string potatoes and French fried potatoes were observed when the products were fried in peanut oil and in cottonseed oil:

   a. The color and oiliness of potato chips, shoe string potatoes, and French fried potatoes were not significantly different when the products were fried in peanut oil and in cottonseed oil.

   b. The shape of shoe string potatoes and French fried potatoes was not affected by the oils in which they were fried. However, the shape of potato chips fried in peanut oil was judged significantly higher than those fried in cottonseed oil, the value for P being .0336.

   c. The tenderness of shoe string potatoes and French fried potatoes did not differ when they were fried in the two oils, since the values for P were .2180 and .4392, respectively. However, the potato chips fried in peanut oil were scored higher for tenderness than those fried in cottonseed oil, the value for P being .0014.

d. The brittleness of potato chips and shoe string potatoes fried in peanut oil were scored significantly higher since the values for P were .0036 and .0818, respectively. The value for P for the potatoe chips was highly significant but that for shoe string potatoes only approached the five-percent level of significance. The difference in the brittleness of the crust of French fried potatoes was not significant.

e. The taste of potatoe chips was not affected by the oils in which they were fried since the value for P for the difference was only .1868. However, the taste of the shoe string potatoes fried in peanut oil was judged significantly higher than those fried in cottonseed oil, the value for P being .0482. The value for P, .0576, for the difference in the taste of French fried potatoes cooked in the two oils indicated that the peanut oil gave a better taste than cottonseed oil.

f. The aroma of potato chips and shoe string potatoes was not affected by the oils in which they were fried. However, the aroma of French fried potatoes fried in peanut oil was judged significantly higher than those fried in cottonseed oil, the value for P being .003.

5. Peanut oil and cottonseed oil both began to develop rancidity in the first frying of potato chips and shoe string potatoes. However, peanut oil began to develop rancidity in the second frying of French fried potatoes while cottonseed began in the third frying. In only one case, that of French fried potatoes, was there a significant difference in the rate of development of rancidity in the two oils. In this case, cottonseed oil became rancid faster than peanut oil since the value for P was .0402.

6. The peanut oil developed significantly more free fatty acids than the cottonseed oil in the 12 consecutive fryings of potato chips, shoe string potatoes and French fried potatoes. The P values for the differences were highly significant, .0026, .0012 and .0092. However, after the twelfth frying of potato chips, shoe string potatoes and French fried potatoes the cottonseed oil always contained more free fatty acids than the peanut oil.

7. The smoking points of peanut oil and cottonseed oil were similar at the beginning of the experiment, 242°F and 240°C, respectively. There was a gradual decline in the smoking point of the two oils during the 12 consecutive fryings. The smoking points of the two oils were not significantly different during the frying of potato chips and French fried potatoes. However, the smoking point of peanut oil upon repeated fryings of shoe string potatoes was significantly lower than that of cottonseed oil since the value of P was .0002.

8. In the 12 consecutive fryings of shoe string potatoes and French fried potatoes more cottonseed oil, in terms of grams, was absorbed than peanut oil. However, this difference between the amounts of oil absorbed by shoe string potatoes was not significant since the value of P was only

.1148. The difference in the case of French fried potatoes was significant since the value for P was .0482. There was no difference in the oil absorbed by potato chips.

CONCLUSIONS

The peanut producing states were requested by the Secretary of Agriculture to increase their acreage in peanuts for the production of oil. Virginia is one of the leading states in peanut production. Since peanut oil is used extensively as an edible oil, this work reported in this thesis was a comparison of the culinary qualities of peanut oil with those of cottonseed oil. Cottonseed oil was chosen because it is one of the most used vegetable oils in food preparation.

In general, peanut oil gave a better product in deep-fat frying of potatoe chips, shoe string potatoes and French fried potatoes than cottonseed oil. This difference seemed to be due chiefly to higher scores for tenderness, taste and aroma of the products. The judges preferred the products fried in peanut oil for there was no odor from this oil, while cottonseed oil gave a characteristic odor of cottonseed after about 10 fryings of the products in the oil. When the oils were maintained at elevated temperature for long period of time cottonseed oil developed more rancidity. When the free acidity of the two oils was compared for the 12 replicate fryings of the potato products, it was found that the peanut oil contained significantly more free fatty acids than the cottonseed oil. However, it was noted that after the twelfth frying in every case peanut oil had a lower acid value than cottonseed oil. This fact in addition to the slower development of rancidity of peanut oil, would lead one to believe that peanut oil could be used longer for repeated fryings than cottonseed oil.

APPENDIX

Score Card for Potato Chips

	Score
1. Appearance	
A. Color	
1. Even straw color	8 - 10
2. Slightly uneven straw color	5 - 7
3. a. brown b. pale c. very uneven	0 - 4
B. Shape	
1. Edges curly	8 - 10
2. Edges very curly and overlapped	5 - 7
3. Chips flat and straight	0 - 4
2. Texture	
A. Tenderness	
1. Tender	18 - 20
2. Slightly tender	10 - 17
3. Hard	0 - 9
B. Brittleness	
1. Brittle	18 - 20
2. Slightly brittle	10 - 17
3. Tough	0 - 9
3. Flavor	
A. Taste	
1. Pleasing mild potato flavor	8 - 10
2. Carmalized flavor	5 - 7
3. Burned or raw potato flavor	0 - 4
B. Oiliness	
1. Very little oiliness	18 - 20
2. Slightly oily	10 - 17
3. Very oily or greasy	0 - 9
C. Aroma	
1. Pleasing aroma	8 - 10
2. Slightly pleasing aroma	5 - 7
3. Rancid or burnt aroma	0 - 4
Total - . . .	100

Score Card for Shoe String Potatoes

	Score
1. Appearance	
A. Color	
1. Even straw color	8 - 10
2. Slightly uneven straw color	5 - 7
3. a. brown b. pale c. very brown	0 - 4
B. Shape	
1. Rectangular and straight	8 - 10
2. Slightly rectangular and straight	5 - 7
3. Flat and curly	0 - 4
2. Texture	
A. Tenderness	
1. Tender	18 - 20
2. Slightly tender	10 - 17
3. Hard	0 - 9
B. Brittleness	
1. Brittle	18 - 20
2. Slightly brittle	10 - 17
3. Tough	0 - 9
3. Flavor	
A. Taste	
1. Pleasing mild potato flavor and a pleasing flavor of fat	8 - 10
2. Carmalized flavor	5 - 7
3. a. burned b. raw potato flavor c. off flavor	0 - 4
B. Oiliness	
1. Very little oiliness	18 - 20
2. Slightly oily	10 - 17
3. Very oily and greasy	0 - 9
C. Aroma	
1. Pleasing aroma	8 - 10
2. Slightly pleasing aroma	5 - 7
3. Ransic or burnt aroma	0 - 4
Total	100

Score Card for French Fried Potatoes

	Score
1. Appearence	
A. Color	
1. Even straw color	8 - 10
2. Slightly uneven straw color	5 - 7
3. a. brown b. pale c. very brown	0 - 4
B. Shape	
1. Rectangular and straight	8 - 10
2. Slightly rectangular	5 - 7
3. Flat	0 - 4
2. Texture	
A. Tenderness	
1. A tender mealy inside	18 - 20
2. Slightly tender and mealy inside	10 - 17
3. Hard and firm	0 - 19
B. Brittleness	
1. Brittle outside	18 - 20
2. Slightly brittle outside	10 - 17
3. Tough outside	0 - 9
3. Flavor	
A. Taste	
1. Pleasing taste	8 - 10
2. Slightly pleasing taste	5 - 7
3. a. burnt b. raw potato flavor c. off flavor of oil	0 - 4
B. Oiliness	
1. Very little oiliness	18 - 20
2. Slightly oily	10 - 17
3. Very oily and greasy	0 - 9
C. Aroma	
1. Pleasing aroma	8 - 10
2. Slightly pleasing aroma	5 - 7
3. Rancid or burnt aroma	0 - 4
Total	100

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