EFFECT OF A BREADED PRODUCT ON THE FRYING LIFE OF THREE TYPES OF FAT

by

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INTRODUCTION

Deep fat frying is a widely accepted method of food preparation in food services. A great variety of fats, processed for frying, are available to institutional buyers. These may be animal, vegetable, or a combination of animal and vegetable fats. Since manufacturers can produce suitable fats for frying from a variety of raw materials, those are used which are economically advantageous at a particular time. Depending upon processing, fats may be categorized on the basis of condition at room temperature, as solid, semi-liquid, or liquid.

Institutional food buyers may have difficulty in evaluating these products. The decision of which fat to purchase may be based on frying life, ease of use, cost, and/or palatability.

Deteriorative changes in the fat with resulting transfer of undesirable characteristics to food may cause variability in length of use. A survey of 34 food services revealed that frying fats were changed as frequently as every other day to as infrequently as every 45 days.

Factors which may affect the life of fat include temperature of fat or food, presence of foreign particles that accumulate during frying, presence of salt and spices, amount of exposed surface area, fat turnover, and cleanliness of fryer.

Although several techniques have been proposed to increase life of fat, no simple criteria have been developed to assist the food service worker with the decision of when to dispose of the fat.

Based on this need a project has been underway at Kansas State University to establish guidelines which may be used by food service personnel in the selection and care of fats used for frying. Studies have been completed on effect of method of care and type of fat on the frying life of fat used in food services. The purpose of this investigation was to study the effect of a breaded product on the frying life of 3 types of fat used in food services.

LITERATURE REVIEW

Composition of Fats

Chemical. The most widely accepted classification of lipids is that proposed by Bloor (1943, p. 1). Simple lipids, esters of fatty acids and various alcohols, are glycerides. Found in both animal and vegetable matter, fat, one of the simple lipids, is referred to as a triglyceride because it is an ester of alcohol and 3 molecules of fatty acids.

Source. Animal fats commonly used for frying in food services are those from beef and pork; whereas vegetable fats for this purpose are prepared from cottonseed, soybean, corn, and peanuts, according to Griswold (1962, p. 251).

Growing and market conditions affect amount and kind of fat from these sources processed in a given year. The layman frequently categorizes fats according to source and/or consistency at room temperature.

Consistency. Griswold (1962, p. 259) stated that the melting point of oil is below room temperature, while that of fat is above room temperature because of the fatty acid radicals contained. Fat has a higher percentage of saturated glycerides than does oil, which in turn possesses more unsaturated glycerides than does fat.

During hydrogenation, unsaturated fatty acids add hydrogen at the double bonds, thus becoming more saturated. Depending on completeness of hydrogenation and whether or not some oil or soft fat is mixed with the product, Lowe (1955, p. 521) reported that the resulting fat may have varying degrees of hardness and plasticity. An opaque, pourable fat developed by Andre and Going (1957) consists of a liquid glyceride vehicle, and in stable suspension, from 2 to 10% of finely divided, fully saturated glycerides.

Processed fats made from vegetable sources are higher in total unsaturated fatty acids than those made from animal and vegetable fats according to Goddard and Goodall (1959). Wide variations in the fatty acid composition of processed fats is found.

Factors Affecting Frying Life of Fat

Many factors affect frying life of fat. Some of these relate to the fat itself, some to the manner of handling the fat, and some to the nature of the food cooked in it.

Free Fatty Acid Content. According to Lowe (1955, p. 522) some free and uncombined fatty acids and glycerol are usually found in fats and oils. The amount of free fatty acids is greater in some fats and oils than in others. Fats may be hydrolyzed during heating in the presence of moisture, into fatty acids and glycerol. Morgan and Cozens (1919) found that fat showed consistent increase in free fatty acids when a standard dough was cooked for 3 minutes. Heating the fat alone for the same period did not cause as rapid an increase.

Food with high water content, like potatoes, when cooked in fat, increased the free fatty acid content more than food with a smaller water content, like doughnuts, reported Lowe et al. (1940). On the other hand, Bennion and Hanning (1956b) compared changes in lard by frying potatoes or fritter batter and found that frying fritters caused a greater degree of decomposition as shown by a more pronounced increase in free fatty acids than did potatoes.

Lowe et al. (1958) investigated the free fatty acid content of 20 fats initially and after use. Initial free fatty acid content was lowest in oils, slightly higher in shortenings, and highest in lards. Free fatty acid content of all fats increased during heating and cooking of doughnuts. The increase in free fatty acids tended to be greater in fats with a low initial content.

When the free fatty acid content reached 2.0%, Porter *et al.* (1932) found an objectionable flavor was noticeable in doughnuts. In 3 projects of widely different nature analyzed by Hall *et al.* (1962a), initial development of free fatty acids was attended by increased flavor scores for the fat. Development of fat acidity by nutritional depletion, feeding wheat to pigs, and deep frying of potatoes demonstrated a simultaneous increase of flavor scores and acidity of the fat up to a point.

Whether or not liberated free fatty acids had any serious effect on flavor, Lea (1961) reported, depended on chain length. When fatty acids with 12 or fewer carbon atoms were present in quantity, liberation of fatty acids by enzyme action could cause soapy or rancid "off" flavors.

Smoke Point. When fats are heated to a temperature characteristic of the fat, smoke is given off. Griswold (1962, p. 258) stated that this thin, bluish smoke is undesirable because it imparts a disagreeable flavor to the food, as well as makes cooking unpleasant. Smoke point depends on the nature of the fat, manner of use, and testing method.

Blunt and Feeney (1915) first observed that fat with high free fatty acid content had low smoke point. This finding was confirmed by Lantz and Carlin (1938) and Lowe *et al*. (1940). Fat as a class had a higher smoke point than oils, according to Vail and Hilton (1943). Hydrogenated vegetable fats showed higher smoke points than animal fats. In testing frying fats for commercial use, Block (1951) observed that hydrogenated fats maintained the higher smoke point for a longer period than vegetable oils. Although vegetable oil and continuous process lards had substantially higher initial smoke points than other fats tested by Bennion and Hanning (1956b), the differences between them were appreciably narrowed by the end of frying.

Smoke point for a particular fat was lowered when exposed surface area of the fat was increased noted Blunt and Feeney (1915). Lowe *et al*. (1940) credited the presence of finely divided foreign particles which accumulate during frying with lowering the smoke point. Because of these particles, smoke point was lowered to a greater extent after frying doughnuts than after frying potato chips, even though free fatty acid content of the fat in which chips were fried was higher.

Addition of monoglycerides to lards lowered the smoke point observed Bennion and Hanning (1956b). Griswold (1962, p. 263) explained that emulsifiers (mono- and diglycerides) lower the smoke points of frying fats. A significant negative correlation between smoke point temperature and free fatty acid values suggested to Zabik (1962) the validity of both tests for determining progressive deterioration of fat subjected to repeated heating.

Rancidity. Deuel (1951, p. 281) stated that the chief form of degradation in fats is referred to as rancidity. The reactions involved in producing rancidity may be hydrolytic or oxidative in character and may originate from enzymatic activity or from spontaneous atmospheric oxidation. Oxidative rancidity is more important in foods than is hydrolytic rancidity according to Griswold (1962, p. 268).

Oxidative Rancidity. Oxidation takes place at the unsaturated linkage, Deuel (1951, p. 281) explained. Oxygen is required for this reaction, and the rate of development is increased by light, moisture, and heat. Certain metals and their oxides greatly hasten the onset of rancidity by what is believed to be a catalytic action.

Blanck (1955) summarized the oxidative reaction as a complex one involving free radicals, chain reaction, and resonance. During the course of the reaction, hyperperoxides, aldehydes, ketones, and free fatty acids shorter than those originally present are formed.

Presence of oxygen was shown by Rock and Roth (1964) to be a necessary condition for deterioration of frying qualities of a fat at frying temperatures. Rate of change of frying characteristics was directly proportional to degree of exposure of fat surface to oxygen.

Reversion, as defined by Lowe (1955, p. 525) is a flavor deterioration originating with less oxidation than is required to produce oxidative rancidity. Reversion is a problem in products made from oils containing high proportions of unsaturated fatty acids such as soybean and linseed oils. If the proportion of soybean oil is below 25 to 35%, Daubert and O'Connell (1953) reported detectable reversion ordinarily does not occur. Lowe (1955, p. 530) stated that products made from cottonseed and peanut oils present no reversion problems.

Oxidation of fat is accelerated by increase in temperature and concentration of the reactants, oxygen, and saturated free fatty acids, according to Griswold (1962, p. 270). Addition of a trace of rancid fat greatly hastens the development of rancidity in fresh fat.

Schultz et al. (1962, p. 39) reported that light, especially ultraviolet rays, speeds up oxidation, probably by furnishing energy for formation of free radicals. Other accelerators of oxidation that are important in relation to food fats include various metals, metal salts, and organic compounds of metals; and oxidative enzymes, such as lipoxidases.

That dry sodium chloride and sodium chloride solution at high concentrations behaved as a pro-oxidant in fat oxidation was ascertained by Chang and Watts (1950). Later research described by Marbrouk and Dugan (1960) indicated that common salt showed an important accelerating effect on lipid oxidation in food systems apparently because of an activating influence on pro-oxidants already present. Salt seemed to have no direct effect on lipid oxidation. Hall et al. (1962b) reported on the controversial relation between sodium chloride and oxidation of unsaturated fats.

Compounds that delay rancidity may be present naturally in the fat, or it may be added. These substances prevent the development of rancidity by donating the labile hydrogen required to form a hydroperoxide which would otherwise be taken from another fatty acid with the formation of a free radical, suggested Bate-Smith and Morris (1952). The chain reaction is broken by the antioxidant, which is oxidized in the process.

Griswold (1962, p. 268) reported that vegetable fats take up oxygen more slowly and are therefore less likely to become rancid than animal fats. Since this is due to natural antioxidants in the vegetable fats, antioxidants have been added during manufacture of many animal fats. Because of the use of antioxidants, Carlin et al. (1954) stated that rancidity is no longer a great problem.

Development of rancidity may be measured chemically by determining the peroxide value which is the amount of peroxide present per 1000 g of fat according to Lowe (1955, p. 521). Concentration and purification of peroxides has been one of the most difficult steps in the elucidation of fat autoxidation. Schultz et al. (1962, p. 51) reported that peroxides decompose easily into a multitude of secondary reaction products.

Higher peroxide numbers were recorded by Bennion and Hanning (1956b) for frying potatoes than for frying fritters. Lowe _et al_. (1940) observed an increase in peroxide number as doughnuts were fried. However, Chang _et al_. (1952) found that peroxide numbers of lard used for frying doughnuts decreased to negligible values after 40 minutes of frying. In the Bennion and Hanning study (1956b), the second batch of fritters represented 32 minutes of frying time, and peroxide values were low in all fats at that period. Presence of an antioxidant exerted some effect on peroxide values, but none on smoke point or free fatty acid content.

Hydrolytic Rancidity. Griswold (1962, p. 273) indicated that in hydrolytic rancidity, fat is hydrolyzed by the fat-splitting enzyme, lipase, to glycerol and fatty acids. Since heat destroys lipase, hydrolytic rancidity can be prevented by suitable heat treatment.

Nature of the Food. Amount of water in food, presence of finely divided foreign particles in the fat, and ingredients in the food to be fried, all have an effect on the life of fat. Temperature of the food to be fried also is believed to affect the life of fat although no studies were found to support this.

After cooking doughnuts and potato chips in different samples of the same fat, comparative changes reported by Lowe _et al_. (1940) were: (a) free fatty acid content was higher after frying potato chips; (b) smoke point was lowered more after frying doughnuts; (c) if a fat smoked during use, it smoked sooner and more profusely when frying doughnuts; and (d) fats discolored to a greater extent after frying doughnuts, even though the free fatty acid content of the fat in which the chips were fried was higher.

Bennion and Hanning (1956a) compared effects of cooking fritter batter and frying potatoes in lard. Frying fritters caused a greater degree of decomposition than did potatoes as shown by a more pronounced increase of free fatty acids and decrease in smoke point. Peroxide values remained at lower levels with fritters. In determining the effect of fritter ingredients on decomposition of lard, baking powder, milk, and eggs appeared to be the ingredients in the batter exerting the greatest influence on decomposition.

Lard and cottonseed oil were compared by Stasch and Kilgore (1962) for frying potatoes and chicken. Greater degradation of fat as measured by increased free fatty acids occurred when potatoes were fried than when the same fats were used to fry chicken.

Color. Carlin *et al*. (1954) stated that highly bleached, almost water-white products are manufactured for frying purposes. However, evidence has not been found to indicate that absence of color pigments improves frying properties. Dark colors are developed in the fat after several hours of use. Lard colored to a greater extent with doughnuts than with potato chips, observed Lowe *et al*. (1940).

Color changes in lards and combination fats used in frying a fritter batter were similar for both types of fat according to work reported by Bennion and Hanning (1956c). Changes involved a marked decrease in color lightness and in development of reds and yellows. When 20 fats were compared by Lowe *et al.* (1958), all darkened, some more than others. No relationship appeared to exist between darkening and free fatty acid content nor source of fat.

Frying Temperature. Chemical changes that occur in a specific triglyceride molecule are dependent on at least 4 factors: (a) length of time exposed to heat, (b) temperature, (c) presence of accelerators of oxidation, and (d) structure of the triglyceride, according to Schultz *et al.* (1962, p. 294). Lowe *et al.* (1940) reported that when doughnuts were cooked at 3 temperatures, changes in smoke point, free fatty acid content, and peroxide value were more rapid at 200° C than at 185° C, and in turn more rapid at 185° than at 170° C.

Hydrolysis of a frying fat takes 2½ times as long at 365° F as it does at 392° F stated Bates (1952). Quammen (1955) advised frying at the lowest temperature compatible with desired color and doneness of food.

Method of Care. To prolong usable life of fat, Arenson (1950) recommended filtering fat between fryings to remove foreign matter, whereas Block (1951) favored filtering frying fat after every 1 to 2 hr of use. Arenson (1950) suggested that the original volume of fat be maintained to increase the frying life. Addition of fresh fat each time the fat was used to replace that lost during the previous cooking was recommended by Stasch and Kilgore (1962) for dilution of chemical changes.

Important factors in storage of fats were summarized by Lowe (1955, p. 530) as exclusion of light and circulating air and low temperature. Rust and Harrison (1960) found that frying life was lengthened by filtering after use, refrigerated storage, and by placing in a clean fryer after each use. Frying life was improved further by replacing 20% of the original weight after each use instead of replacing the amount used during an 8 hr frying period. For efficient frying, Quammen (1955) proposed complete turnover in 10 hr. Smallest practical quantity of fat should be used that would fry the amount of food required.

Purchasing of Frying Fats for Food Services

Selection of frying fat, regardless of product to be cooked, was considered of prime importance by Block (1951). An ideal frying fat was described as one that was flavorless, odorless, colorless, liquid or plastic at 20° C, resistant to foaming, and had a high smoke point. Arenson (1950) agreed with this description, but pointed out that no one fat had all these desirable characteristics.

Choice of fat for frying in food services may be made on the basis of frying life, ease of use, or palatability. Little research has been done at a food service level;

most work reported involved family-size or industrial studies.

Length of Life. Great variability exists in the length of time fats are used. Manufacturers of fats and fryers sometimes make conflicting recommendations, but in general, suggest that fat should be discarded as soon as it bubbles excessively before food is added or when gummy film collects on the frying basket or heating elements. The operator of a fryer is advised to taste the fat once a day to ascertain if objectional flavors are present (Anon., 1964).

According to Bennion and Hanning (1956b), palatability judges could not consistently distinguish between flavor or odor of fritters fried in fresh or greatly used fat. This was in general accord with findings of Thiessen (1939) who reported that reheating and reuse of fat up to 12 hr did not affect flavor or quality of product cooked in it.

Stasch and Kilgore (1962) surmised that since foaming increased markedly and color development was quite severe after 20 hr of heating, the maximum practical time of use for all fats was between 10 and 20 hr of heating.

If basic concern is the nutritutional aspect of saturated and unsaturated fatty acids, Fleishman *et al*. (1963) recommended that saving and reusing oils in cooking did not appear to be advisable, since second heating caused additional hydrolysis and oxidation of oil. However, Stasch and Kilgore (1962) pointed out that regardless of type of fat used, large amounts of fat showed less chemical change during heating than did small amounts. Prolonged heating resulted in considerably greater saturation. If a particular type of fat is chosen because of content of unsaturated fatty acids, each time a fat is reused, it becomes less unsaturated. However, even after heating, vegetable oil remained more unsaturated than other fats tested. Length of heating time influenced chemical changes in fats to a greater degree than type of fat or kind of frying container (Stasch and Kilgore, 1962).

A study by Rust and Harrison (1960), conforming with food service practices, investigated effect of method of care on length of life of a vegetable fat processed for frying. Life was greatest for that fat which was filtered, placed in a clean fryer insert, refrigerated between fryings, and had a 20% replacement for each 8 hr of use. However, if cost were to be considered, a 20% replacement resulted in a complete turnover every 5 frying periods; whereas when only fat was replaced that was used (approximately 7%), a complete turnover resulted every 14 to 15 periods.

Ease of Use. No work has been reported on ease of use of fats of different consistencies. Pourable fats are obviously easy to handle since they are packed in containers small enough to lift and pour directly into the fryer. Solid fats with high melting points may be hard, particularly if refrigerated, and pack with difficulty into fryers (Anon., 1964).

Palatability. Nine fats were investigated by King *et al*. (1936) regarding palatability. Oils were found to be preferred to lards, with peanut oil being most desirable. Melnick (1955) agreed that peanut oil was most acceptable, but commented that its use was limited because of short supply and high price. When fritters were fried in lard, cottonseed oil, peanut oil, and 2 blends of lard with other fats, palatability judges did not consistently prefer one fat above another by flavor or odor scores according to work reported by Bennion and Hanning (1956b).

Stasch and Kilgore (1962) investigated assumptions of homemakers that use of vegetable oil and use of iron frying pans resulted in fried food with better flavor. The experimental results obtained provided some justification for these assumptions. Carbonyl compounds are flavor components of fats and fried foods. Of all fats studied, vegetable oil contained the greatest amount of carbonyl compounds after heating. Of all pans used, iron resulted in the highest concentration of carbonyl compounds in the fat.

EXPERIMENTAL METHODS

Preliminary Work

Preliminary work was necessary (1) to develop the formula for rice croquettes to be used for breading and (2) to standardize techniques of preparation, frying, and testing.

Formula for Rice Croquettes. Rice croquettes were prepared with a thick white sauce and converted long-grain rice. The sauce was made using a mix adapted from one developed and tested by Woodhams (1961). For the present study, ingredients included all-purpose flour, hydrogenated vegetable shortening, butter, salt, and non-fat dry milk. Required amounts of salt and water were established. Salt was combined with dry ingredients at time of mixing. Preparation methods recommended by the processor were used to cook the rice. A rice croquette of high quality contains rice with sufficient white sauce to yield a product of creamy consistency yet retaining its shape during breading, frying, and serving. Various proportions of white sauce and cooked rice were combined before an acceptable product was obtained.

Techniques in Preparation and Testing. Procedures for preparation of rice croquettes and breading, as well as for palatability tests were standardized. Work simplification techniques were used in developing croquette shaping and crumbing processes.

Accuracy of thermostatic controls and temperature fluctuation of fat in the deep fat fryers were checked. Fifteen min were allowed for the temperature of the fat to be raised from room temperature to 350° F.

Scorecards were developed and tested (Appendix A). The palatability panel was familiarized with the scorecards at 2 practice periods. Instruction sheets for the panel may be found in Appendix A.

Statistical Design and Methods of Analysis

The study consisted of 2 parts. Part I was designed to evaluate palatability factors of color, shape, odor, texture, flavor, and internal temperature of the breaded product, and color of samples of each fat. Weight loss of fat, as well as weight loss of one batch of croquettes, selected at random, was also determined. Part II was designed to analyze chemical changes occurring in fat by determining free fatty acid and peroxide values of each fat. Approximately one-third of Part I was completed when Part II was begun. Both parts of the study were completed simultaneously.

In Part I, 54 croquettes, 6 batches of 9 each, were fried in each of 3 fats for 100 6-hr periods. Fats investigated were: fat A, hydrogenated vegetable fat; fat B, hydrogenated blend of animal and vegetable fats; and fat C, semi-liquid vegetable fat. Determination of which batch for testing and which batch for weighing was done initially by drawing numbered beans from a jar. Batch 2 was selected for organoleptic testing while batch 5 was chosen for weighing.

The statistical design was a randomized complete block of the 3 fats in 3 fryers. Drawing of numbered beans from a jar was also used to determine into which fryer each fat was placed for each frying period. The same design was used for presentation on the plate of the 3 croquettes prepared in the 3 fats to the judges at each frying period (Table 1). Position of fat in fryers and croquette on plates was

Table 1. Statistical design for fat-fryer position and croquette-plate position.

Frying period	Fryer-plate position	Fat	Frying period	Fryer-plate position	Fat
3	1	A	54	1	A
	2	C		2	B
	3	B		3	C
6	1	B	57	1	C
	2	C		2	A
	3	A		3	B
9	1	A	60	1	B
	2	C		2	A
	3	B		3	C
12	1	B	63	1	C
	2	C		2	A
	3	A		3	B
15	1	B	66	1	B
	2	C		2	A
	3	A		3	C
18	1	A	69	1	C
	2	C		2	B
	3	B		3	A
21	1	C	72	1	A
	2	A		2	B
	3	B		3	C
24	1	B	75	1	C
	2	A		2	B
	3	C		3	A
27	1	B	78	1	A
	2	C		2	C
	3	A		3	B
30	1	C	81	1	C
	2	B		2	B
	3	A		3	A
33	1	C	84	1	B
	2	B		2	A
	3	A		3	C
36	1	C	87	1	A
	2	B		2	C
	3	A		3	B
39	1	B	90	1	B
	2	C		2	A
	3	A		3	C
42	1	A	93	1	B
	2	B		2	C
	3	C		3	A
45	1	C	96	1	C
	2	A		2	A
	3	B		3	B
48	1	A	99	1	B
	2	C		2	A
	3	B		3	C
51	1	C			
	2	A			
	3	B			

designated by numbers 1, 2, and 3. Color of samples of fat was visually evaluated on completion of the experiment.

In Part II, samples of each fat taken at the end of each frying period were frozen and held at -20° F until analyzed for free fatty acid and peroxide numbers for every period. After a trend became apparent, samples from every third frying period were evaluated for the remainder of the investigation upon the recommendation of the chemical analysis laboratory and the statistician.

Data collected were subjected to analysis of variance to determine the effect of using 3 fats on: palatability factors of color, odor, texture, and flavor of croquettes; free fatty acid and peroxide numbers; and color of used fat. Regression of percentage of weight loss for fat per frying period and one croquette with each fat were ascertained. Where appropriate, least significant differences were established on the data.

Procurement and Storage of Ingredients

Procurement. All ingredients, except milk, eggs, butter, and day-old bread for crumbs were obtained in sufficient quantity for the entire experiment. Care was taken to obtain fat, flour, salt, and rice processed in the same batch.

Hydrogenated vegetable fat and hydrogenated blend of animal and vegetable fats were packed in 110-lb cans. The pourable vegetable fat was secured in 5-qt cans, packed 6 to the case. Instant non-fat milk was purchased in vacuum-sealed cans, packed 6 to the case. Each can contained $4\frac{1}{2}$ lb of dry milk. All-purpose flour was procured in 50-lb bags, salt in 5-lb bags, and rice in 100-lb bags.

Milk, eggs, butter, and day-old bread were purchased locally as needed. Tap water was used to prepare the white sauce and cook the rice.

Storage. The 3 fats for frying were stored in a walk-in refrigerator at a temperature of 35-40° F until time for use, when they were moved to the laboratory and held at room temperature. All-purpose flour, rice, and salt in covered containers and non-fat milk in sealed cans were stored in the laboratory. Hydrogenated shortening used in the white sauce mix was kept in the original container in the walk-in refrigerator at 35-40° F.

Preparation of Mix and Croquettes

Preparation of Mix. White sauce mix formula and procedure developed by Woodhams (1961) were used (Table 2). The mix was placed in 1-gal. jars, covered with metal lids, and stored at 35-40° F until needed. Sufficient mix was made in advance to prepare croquettes for 4 frying periods.

Preparation of Rice Croquettes. The formula for the rice croquettes is given in Table 3. Rice and white sauce were prepared in an electronically controlled 14-qt electric

Table 2. Formula for thick white sauce mix.

Ingredients	Weight g	lb	oz
Flour, all-purpose	1361	3	
Shortening, hydrogenated vegetable	2041	4	8
Butter	2041	4	8
Salt	168		6
Milk, non-fat dry	4082	21	6
Yield:		4 gal. (approximate)	

Table 3. Formula for rice croquettes.

Ingredients	Weight g	lb	oz
To prepare rice:			
Water	7224	16	
Salt	96		3.5
Rice	2381	5	4
To prepare white sauce:			
Water	5450	12	
White sauce mix	2409	5	5
To bread croquettes:			
Milk	625	1	6
Eggs	386		14
Bread crumbs	800	1	12
Yield:		162 croquettes	

trunnion kettle. A balloon-type wire whip was used to stir the sauce.

Following the processor's recommendations, rice was cooked by heating 7224 g water and 96 g salt to approximately 95° C and then adding 2381 g rice. After reaching the simmering point, the rice was allowed to cook for 23 min. It was then poured into a 20-qt mixing bowl.

For the preparation of the white sauce, 5450 g water was heated in the trunnion kettle. When the temperature of the water reached approximately 90° C, 2409 g of mix was added to the water and stirred for 90 sec. The mixture was cooked for 5 min with occasional stirring. The white sauce was poured over the rice, mixed thoroughly, and allowed to stand at room temperature for approximately one hr. Using a No. 12 dipper, the croquette mixture was dipped on 3 aluminum foil-lined bun pans and yielded a total of 162 croquettes. After covering with towels, the croquettes were stored overnight in the walk-in refrigerator at 35-40° F. At the beginning of the frying period the following day, the croquettes were shaped, using polyethylene gloves. A mixture of 625 g milk and 386 g eggs was used in which to dip the croquettes, after which they were rolled in 800 g dry bread crumbs.

Frying Procedure

Three 15-lb electric fryers of the same model were used in the investigation. Initially 15 lb of each fat was placed in the randomly selected fryers. At the completion of the frying period, each of the fats was filtered through 4 thicknesses of cheese cloth into a clean fryer insert, weighed, 200 g removed for testing, and stored at room temperature. That which was removed for testing was stored at -20° F until analyzed. At the beginning of each subsequent frying period, sufficient fresh fat was added to replace the frying loss plus the 200 g removed for testing.

One frying period was 6 hr. The fats were preheated to 200° F and held at this temperature for $1\frac{1}{2}$ hr. Fifteen min were allowed for the temperature of the fats to be raised to 350° F. The frying portion of the period required $1\frac{1}{4}$ hr. During this time, 6 batches were cooked in each of the fryers for 4 min each with 10 min between batches. The thermostats were turned back to 200° F and held at this temperature for 3 hr.

Batch 5 was randomly selected to be weighed. Batch weight of the croquettes fried in each fat was recorded before and after cooking. From this measurement average individual croquette weights were established. Percentage weight loss of each fat at each frying period was calculated. Also, percentage weight loss was determined for batch 5 and for an average individual croquette cooked in each fat at each period. Grams of fat required to fry one croquette were computed.

Testing Procedures

Organoleptic Testing. Batch 2 was randomly selected to be evaluated by the palatability panel. After this batch was cooked, judges were given 3 croquettes, one fried in each of the 3 fats. Position number of the croquettes on the marked plate corresponded to the fryer number as determined by the statistical design of the experiment (Table 1). Instructions for the palatability panel are given in Appendix A.

Using a descriptive numerical scorecard (Appendix A), judges assessed samples for color, shape, odor, texture, flavor, and internal temperature. Scores ranged from 4 points for a highly acceptable product to zero for an unacceptable one.

Color of Fat. At the completion of the study, 100 g samples of each fat from every third frying period were arranged consecutively and evaluated by the judges who had served on the palatability panel. The rating sheet used is found in Appendix A. Scores ranged from 4 for a white or colorless fat to zero for a very dark brown fat.

Chemical Testing. At each period 2 100-g samples of each fat were frozen and held at -20° F until analyzed. Free fatty acid numbers were determined as described by Jacobs (1958, p. 385) and expressed as mg KOH/g of fat.

Peroxide numbers were determined by the Wheeler method (1932) and expressed as ml 0.002N thiosulfate/g of fat.

RESULTS AND DISCUSSION

The investigation was terminated at the end of 100 frying periods or 600 hr of use for each type of fat. When the same fats were used by Hemphill and Roach (1963), palatability scores for potatoes gave little evidence that the fats were reaching the terminal point of use at the end of 600 frying hr.

Frying Life. At the end of 100 frying periods, all fats were still usable as judged by criteria of behavior of fat and palatability scores given to the breaded rice croquettes. Using fat A of the present study, Rust and Harrison (1960) found that fat bubbled excessively and failed to brown potatoes at the end of from 168 to 504 hours depending upon method of care used; palatability scores declined to zero.

Fat Used Per Serving. Significant differences were not apparent among the 3 fats for g of fat used to fry one croquette as noted in Table 4. Fat A, hydrogenated vegetable fat, required a mean of 6.55 g; fat B, hydrogenated blend of animal and vegetable fats, used 6.76 g; and fat C, semiliquid vegetable fat, required 6.76 g. Detailed data are given in Appendix B, Table 8.

Frying Losses and Fat Turnover. Percentage average frying loss for one croquette indicated no significant differences discernable among the 3 fats. Average loss for croquettes fried in fat A was 7.2%; fat B, 7.1%; and fat C, 7.2% (Table 4). Among the 3 fats, significant differences in percentage fat frying losses were not found. Percentage mean loss ranged from 5.3 for fat B to 5.2 for fat C. Fat turnover was approximately 5% for all fats (Table 4). In establishing method of care used for subsequent work, Rust and Harrison (1960) using the same method of care, found average fat turnover to be 6.9% when using fat A to fry potatoes; Hemphill and Roach (1963) found it to be 6.7% for fats A and B and 7.2% for fat C.

Fat Cost. On the basis of per pound cost of fat current at the time of this study (fat A, $0.2275; fat B, $0.1925; and fat C, $0.2617), the cost of fat to fry one croquette was least for fat B and greatest for fat C. Cost of fat per croquette was: A, $0.0033; B, $0.0029; and C, $0.0038. A total of 5,400 croquettes was fried in each fat or 16,200 croquettes in all fats. Total cost of fat used for each type was: A, $17.73; B, $15.48; and C, $20.69 (Table 4).

Table 4. Mean values for g of fat to fry one croquette, percentage fat and croquette frying losses, and cost of fat.

Fat	Fat to fry one croquette, g	Fat frying loss, %	Croquette frying loss, %	Fat cost per serving	Total cost of fat
A[1]	6.55	5.179	7.175	$0.0033	$17.734
B[1]	6.76	5.275	7.135	0.0029	15.484
C[1]	6.65	5.145	7.167	0.0038	20.685

A[1] - hydrogenated vegetable fat.
B[1] - hydrogenated blend of animal and vegetable fats.
C[1] - semi-liquid vegetable fat.

Palatability of Croquettes. Seven judges scored croquettes fried in each fat at each period for color, shape, odor, texture, flavor, and internal temperature using a 5-point scale ranging from 4, most acceptable, to zero, least acceptable (Appendix A). Although data for shape and internal temperature were collected, these factors apparently were not affected by type of frying fats. Throughout the experiment, croquette shape was consistently rated 4 and internal temperature was affected only by length of time lapsing after removal from fryer until judging.

Color. Significant differences were not found in color of croquette crust ascribed to type of fat. Average color score for croquettes fried in fat A was 2.679; B, 2.870; and C, 2.764 (Table 5). In general, color scores for croquettes declined as frying periods progressed (Figure 1).

Odor. Odor scores for croquettes attributable to type of fat were significantly different between fats A and C, B and C, but not A and B (Table 5). Average odor score for croquettes prepared in fat A was 2.758; B, 2.709; and C, 1.648. Odor scores at periods 3 and 99 ranged from 3.7 to 1.8 for croquettes fried in fat A, 3.5 to 2.0 for those in B, and 3.2 to 0.3 for those in C (Appendix B, Table 9). Odor scores for croquettes prepared in fat C were consistently lower than for those in fats A and B as illustrated in Figure 1. Palatability judges commented on an "off" or fishy odor for fat C.

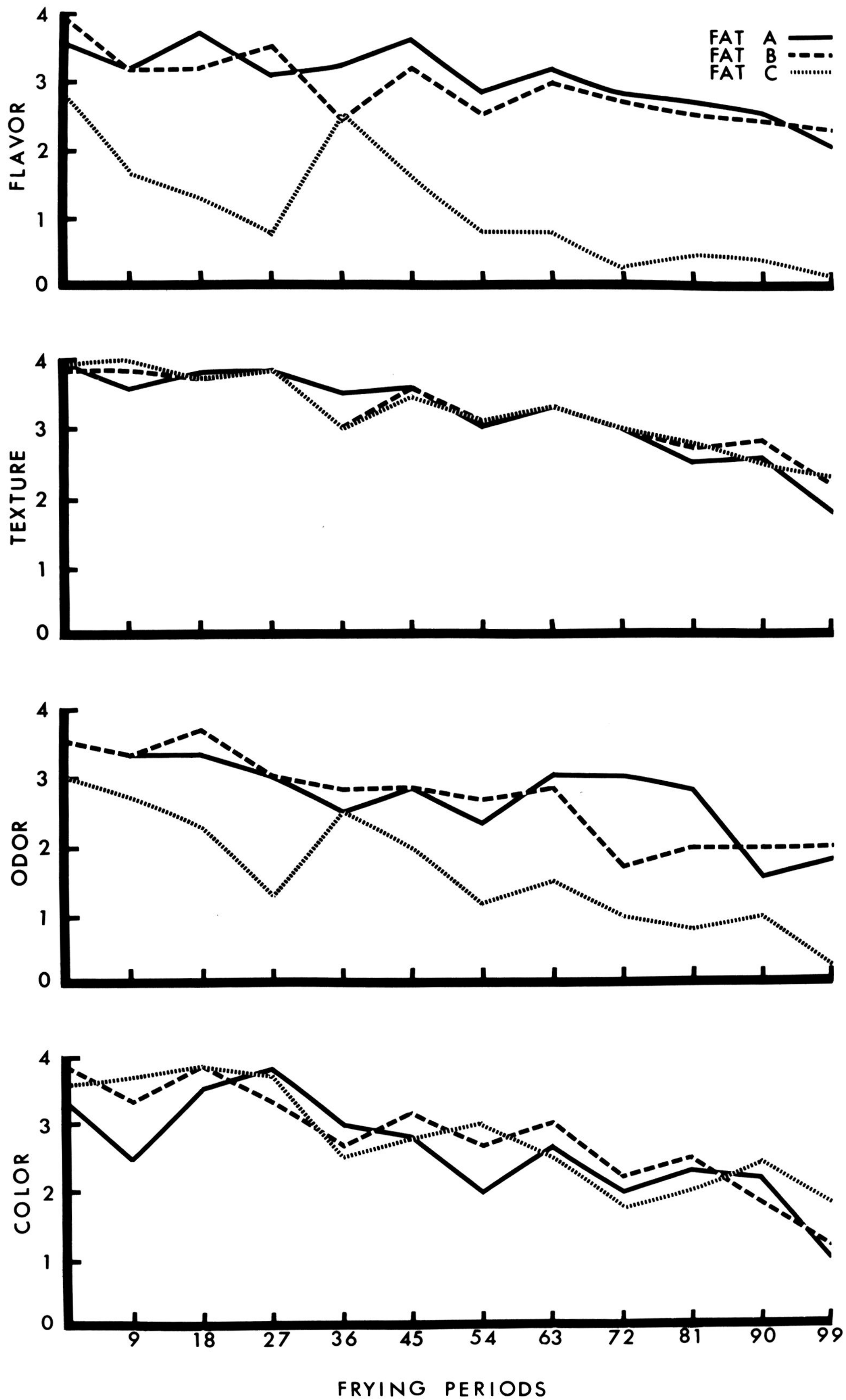

Fig. 1. Curves for palatability scores given a breaded product fried in 3 types of fat.

Texture. Differences in texture of crust of croquette caused by type of fat were not significant. Average texture score for croquettes fried in fat A was 3.203; B, 3.212; and C, 3.133 (Table 5). Texture scores declined gradually with less variation among the fats than other palatability factors as illustrated in Figure 1.

Flavor. Croquette flavor scores related to type of fat varied significantly between fats A and C, B and C, but not A and B (Table 5). Average flavor scores for croquettes prepared in fat A were 3.106; B, 2.979; and C, 1.127. Flavor scores for croquettes at periods 3 and 99 for fat A ranged from 3.8 to 2.1; B, 3.7 to 2.3; and C, 2.0 to 0.2 (Appendix B, Table 10).

Widest fluctuation and variation of any of the palatability factors occurred in flavor scores as illustrated in Figure 1. Flavor and corresponding odor scores for fat C rose sharply at period 36 and declined subsequently. Croquettes prepared in fat C had lower flavor scores than those for A at all times except at period 93 when they were the same, and lower than fat B at all times except at periods 33 and 36 (Appendix B, Table 10). Throughout the investigation palatability judges remarked about an "off" flavor for fat C. Hemphill and Roach (1963) reported a similar observation. However, if the croquettes were eaten with other foods this characteristic might not be apparent.

<u>Color of Fat</u>. Samples of fat were arranged chronologically according to type of fat and scored using a 5-point

scale, ranging from 4 for a white or colorless fat to zero for a dark brown fat. Mean scores for color of fat ranged from highest for fat A, denoting lightest color, to lowest for fat C, indicating darkest color. Mean scores were A, 2.097; B, 1.924; and C, 0.730. Significant differences among all fats were apparent for color scores of samples (Table 5). Detailed data are given in Appendix B, Table 11.

Table 5. Mean values for scores[1] for croquette color, odor, texture, and flavor and color of fat samples.

Fat	Croquette				Fat
	Color	Odor	Texture	Flavor	Color
A[2]	2.679	2.758	3.203	3.106	2.097
B[2]	2.870	2.709 *	3.212	2.979 *	* 1.924 *
C[2]	2.764	* 1.648	3.133	* 1.127	* 0.730
LSD*	ns	.214	ns	.234	.125

1 - scoring range, 4 to 0.
A[2] - hydrogenated vegetable fat.
B[2] - hydrogenated blend of animal and vegetable fats.
C[2] - semi-liquid vegetable fat.
LSD - least significant difference.
* - significant at the 5% level.
ns - nonsignificant.

<u>Free Fatty Acid Values</u>. Significant differences attributable to type of fat were found in mean acid numbers. Mean acid numbers were: fat A, 5.2594; fat B, 4.0743; and fat C, 5.0673 (Table 6).

Free fatty acid values of unused fat of each type were below 0.41 (Appendix B, Table 12). In general, acid numbers for all fats increased gradually, declined slightly, and then continued to increase with some fluctuation (Figure 2). Fat C reached a high point for all fats of 7.315 at period 54. Acid numbers for samples of fat taken at the end of period 99 were for A, 7.018; B, 5.197; and C, 5.709. These figures contrast sharply with acid values at the final periods in the Rust and Harrison study (1960) all of which were more than 23. After cooking potatoes, acid numbers of the same fats observed by Hemphill and Roach (1963) at the corresponding period were: A, 3.918; B, 4.317; and C, 4.299.

Peroxide Values. Significant differences attributable to type of fat were found in mean peroxide values for all fats. Mean peroxide values were: A, 6.8434; B, 9.6095; and C, 8.5696 (Table 6).

Peroxide numbers for unused fats were below one for fats A and B, and slightly above one for fat C (Appendix B, Table 13). Values fluctuated widely, but increased throughout (Figure 2). Peroxide values for samples of fat taken at the end of period 99 were: A, 12.597; B, 19.019; and C, 17.167. Using the same fats to fry potatoes, Hemphill and Roach (1963) found peroxide values at the corresponding period to be: A, 12.893; B, 14.362; and C, 14.481.

Correlation coefficients between scores for palatability factors of color, odor, texture, and flavor, and free fatty acid numbers, peroxide numbers, and scores for color of fat were calculated (Table 7). All coefficients between palatability factors and chemical measurements were negative; and, except

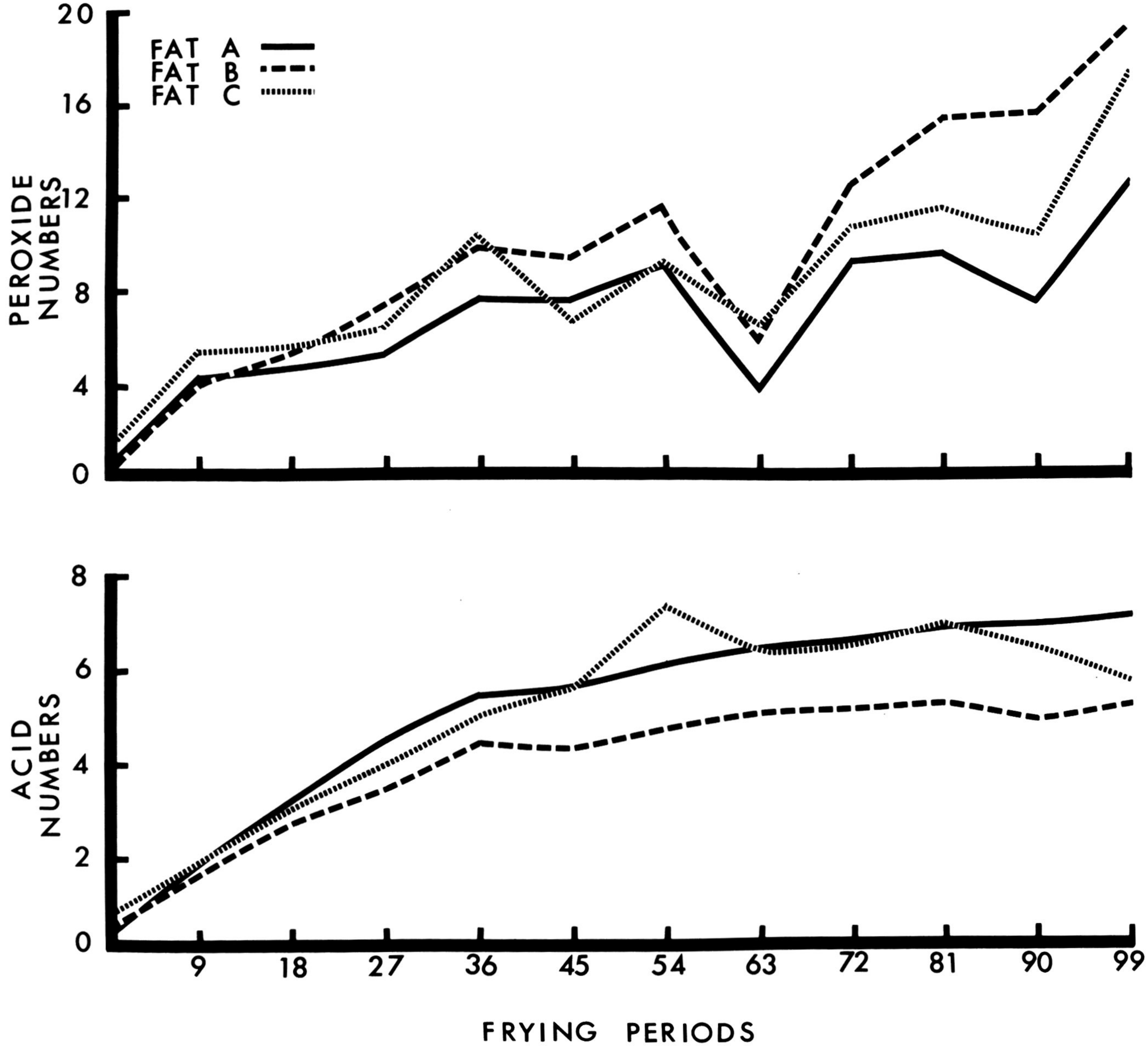

Fig. 2. Curves for free fatty acid and peroxide numbers for 3 types of fat used to fry a breaded product.

between flavor scores and peroxide numbers, all were significant, indicating that, in general, as free fatty acid and peroxide numbers of the fats increased, palatability scores of croquettes decreased. A significant positive correlation was observed between palatability scores of croquettes and color of used fats demonstrating that as fat darkened, palatability scores declined.

Table 6. Mean free fatty acid and peroxide numbers.

Fat	Free fatty acid number, mg KOH/g of fat	Peroxide number, mg 0.002N $Na_2S_2O_3$/g of fat
A[1]	5.2594	6.8434
	*	*
B[1]	4.0743 *	9.6095 *
	*	*
C[1]	5.0673	8.5696
LSD*	.188	.782

A[1] - hydrogenated vegetable fat.
B[1] - hydrogenated blend of animal and vegetable fats.
C[1] - semi-liquid vegetable fat.
LSD - least significant difference.
* - significant at the 5% level.

Table 7. Correlation coefficients.

Palatability factor	Free fatty acid number	Peroxide number	Color of fat
Color	-.69492 *	-.71685 *	.47543 *
Odor	-.60164 *	-.55171 *	.78399 *
Texture	-.70721 *	-.72169 *	.54874 *
Flavor	-.36489 *	-.30926 ns	.76278 *

* - significant at the 5% level.
ns - nonsignificant.

SUMMARY

The purpose of this investigation was to study the effect of a breaded product on the frying life of 3 types of fat used in food services. Fats investigated were: a hydrogenated vegetable fat, a hydrogenated blend of animal and vegetable fats, and a semi-liquid vegetable fat. A randomized complete block of the 3 fats in 3 fryers was used.

Fifty-four rice croquettes (6 batches) were fried in each fat during 100 frying periods of 6 hr each. Palatability factors of croquette color, odor, texture, and flavor, as well as fat color after every third frying period were evaluated. At each frying period weight loss of fat and one croquette were determined. Chemical changes occurring in the fats as shown by free fatty acid and peroxide numbers were measured.

Data collected were subjected to analysis of variance to determine effect of using 3 fats on palatability factors of croquette, free fatty acid and peroxide numbers, and color of used fat. Regression of percentage of weight loss for fat per frying period and one croquette with each fat used were ascertained. Where appropriate, least significant differences were established on the data. Correlation coefficients were determined between palatability factors of croquette color, odor, texture, and flavor, and free fatty acid numbers, peroxide numbers, and color scores of used fat.

All fats were still usable at the end of 100 frying periods (600 hr). Significant differences were not apparent among the 3 fats for g of fat used to fry one croquette or for percentage average weight loss for fat per frying period or for one croquette. An approximate 5% fat turnover resulted for all fats. Cost of fat used per serving was least for hydrogenated blend of fats and greatest for semi-liquid vegetable fat.

Significant differences were not found in color or texture scores of croquette crust attributable to type of fat; whereas croquette odor and flavor scores varied significantly between the hydrogenated vegetable and semi-liquid vegetable fat, hydrogenated blend and semi-liquid fat, but not between the 2 hydrogenated fats. Throughout the investigation, palatability judges remarked about "off" flavor and odor characteristics for the semi-liquid vegetable fat. Widest fluctuation and variation of any of the palatability factors occurred with flavor scores.

All the fats became darker as frying periods progressed. Significant differences were apparent among all fats. The hydrogenated vegetable fat remained lightest in color, whereas the semi-liquid vegetable fat darkened most.

Free fatty acid and peroxide values for all fats indicated significant differences attributable to type of fat. Both values increased with fluctuations as frying periods progressed. For all fats, mean acid number was highest for hydrogenated vegetable fat and lowest for hydrogenated blend of animal and vegetable fats, while mean peroxide number was highest for the hydrogenated blend of fats and lowest for the hydrogenated vegetable fat.

Correlation coefficients between palatability scores for color, odor, texture, and flavor of croquettes and acid and peroxide numbers of fats were negative; and, except between flavor scores and peroxide numbers, all were significant, indicating that, in general, as free fatty acid and peroxide numbers of the fats increased, palatability scores of croquettes decreased. A significant positive correlation was observed between palatability scores of croquettes and color of used fats denoting that as fat darkened, palatability scores declined.

CONCLUSIONS

1. Under the conditions of this study, all fats were still usable at the end of 600 hr, after frying 5,400 breaded rice croquettes in each fat.
2. Among the 3 fats, significant differences were not apparent for g of fat used to fry one croquette, percentage average weight loss of fat per frying period or for one croquette. All fats had an approximate 5% turnover at each frying period.
3. Cost of fat per croquette, as well as total cost, was least for the hydrogenated blend of animal and vegetable fats and greatest for the semi-liquid vegetable fat.

4. All fats darkened with use, the hydrogenated vegetable fat remaining lightest and the semi-liquid vegetable fat becoming darkest. As fats darkened, palatability scores declined.
5. Color and texture scores for crust of croquette did not show differences attributable to type of fat. Odor and flavor scores for croquettes reflected significant differences ascribed to type of fat between the hydrogenated vegetable fat and the semi-liquid fat, the hydrogenated blend of animal and vegetable fats and the semi-liquid vegetable fat, but not the 2 hydrogenated fats. Mean odor and flavor scores were highest for the hydrogenated vegetable fat and lowest for the semi-liquid vegetable fat.
6. Free fatty acid and peroxide numbers increased with fluctuations as frying periods progressed. In general, as these measurements increased, palatability scores declined.

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APPENDIX A

SCORECARD FOR CROQUETTES

SCORECARD FOR CROQUETTES

Name____________________ Date____________ Frying Period____________

	4	3	2	1	0	Scores 1	2	3
External								
1. Color	Even, golden brown.	Uneven, golden brown.	Color varying from light to dark brown.	Dark brown.	Very dark brown, almost burnt, or light and colorless.			
2. Shape	Regular and even.	Slightly irregular.	Somewhat misshapen.	Misshapen.	Very misshapen.			
3. Odor	Pronounced croquette odor.	Pronounced odor of croquette, slight odor of fat.	Moderate odor of croquette, slightly pronounced odor of fat.	Slight odor of croquette, pronounced odor of fat.	Very slight odor of croquette, very pronounced odor of fat.			
4. Texture	Crisp, thin, pleasing.	Fairly crisp and thin.	Somewhat crisp and moderately thin.	Soggy, somewhat grease-soaked, slightly thick.	Very soggy and grease-soaked, thick.			
5. Flavor	Pronounced flavor of rice and milk.	Pronounced flavor of rice and milk, slight flavor of fat.	Pronounced flavor of rice and milk, moderate flavor of fat.	Slight flavor of rice and milk, pronounced flavor of fat.	No flavor of rice and milk, very pronounced flavor of fat.			
Internal								
Temperature at center	Hot	Medium hot	Slightly warm	Cool	Cold			

COMMENTS:

INSTRUCTIONS FOR CROQUETTE TASTE PANEL

1. Tasting will be done in laboratory 152.

2. Water, scorecards, and pencils will be on a cart. Please serve yourself. Plates containing croquettes will be placed at intervals at the north counter in the laboratory.

3. Mark scorecard with name.

4. Rinse mouth with water before tasting and between each sample. Please refrain from eating or drinking for one hour before tasting.

5. Procedure for tasting croquettes:
   a. Observe color, shape, and odor of croquette. Score.
   b. Break croquette open. Indicate internal temperature after tasting center of croquette.
   c. Score crust texture and flavor.
   d. Additional comments are encouraged. Colds and hay fever may affect the senses of taste and smell. These conditions should be noted on scorecard.

6. Place soiled dishes on counter by double sink and scorecards on top of file.

Rating Sheet For Color Evaluation Of Fat Samples

Name______________________________Date_______________Fat_____

Period	4	3	2	1	0
0 (Before use)					
3					
6					
9					
12					
15					
18					
21					
24					
27					
30					
33					
36					
39					
42					
45					
48					
51					
54					
57					
60					
63					
66					
69					
72					
75					
78					
81					
84					
87					
90					
93					
96					
99					

Score 4 white or colorless
3 lightly colored
2 medium lightly colored
1 medium brown
0 dark brown

Please list any other adjectives which describe the appearance of the fat and the period number at which it is apparent.

APPENDIX B

Table 8. Frying losses at every third frying period.

Frying period	Fat frying loss, %			Croquette frying loss, for one, %		
	Fat A	Fat B	Fat C	Fat A	Fat B	Fat C
3	4.91	4.69	4.87	7.01	8.26	7.24
6	5.25	5.63	5.47	6.80	7.37	6.66
9	4.87	5.06	5.02	7.71	6.46	6.59
12	5.68	5.71	5.75	7.09	7.56	7.22
15	5.07	5.49	5.46	6.09	7.16	5.96
18	4.66	4.80	4.81	7.61	6.14	5.94
21	5.13	5.15	4.91	7.02	6.88	7.69
24	5.16	5.15	5.06	4.76	5.19	4.87
27	4.84	5.28	5.05	6.26	7.29	5.96
30	5.06	5.18	5.09	6.55	6.76	6.93
33	5.32	5.76	5.41	6.62	6.86	7.40
36	4.75	5.15	4.55	8.74	9.22	9.33
39	3.93	3.81	3.89	4.91	6.03	5.35
42	5.07	5.41	5.16	9.55	8.71	7.52
45	7.13	5.56	5.21	7.38	7.09	7.45
48	5.29	5.81	5.62	8.74	7.12	8.47
51	5.35	5.63	4.85	6.76	6.28	7.95
54	5.12	5.84	5.57	9.29	7.68	7.67
57	5.65	5.57	5.38	7.52	8.03	9.32
60	5.28	5.22	5.21	6.74	7.96	6.55
63	4.93	5.15	4.58	6.07	6.20	6.74
66	5.22	5.07	5.24	8.16	8.83	5.60
69	5.28	5.15	4.88	6.47	6.76	7.93
72	4.62	4.81	4.62	9.01	5.88	8.63
75	5.28	5.41	4.87	5.86	6.67	6.84
78	5.34	5.68	5.37	8.35	6.46	7.33
81	5.40	5.31	5.18	6.40	6.21	6.47
84	5.03	5.09	5.37	8.07	8.64	7.77
87	4.84	5.40	5.06	7.90	6.27	6.98
90	4.85	5.02	5.00	6.26	7.48	6.65
93	5.51	5.37	5.91	7.24	8.18	7.79
96	5.44	5.29	5.25	6.13	6.09	8.43
99	5.65	5.43	5.60	7.71	7.75	7.29
Average	5.179	5.275	5.145	7.175	7.135	7.167

Table 9. Mean color and odor scores[1] for croquettes cooked in 3 types of fat at every third frying period.

Frying period	Color			Odor		
	Fat A	Fat B	Fat C	Fat A	Fat B	Fat C
3	3.2	3.5	3.7	3.7	3.5	3.2
6	3.3	3.3	3.7	3.5	3.5	2.7
9	2.5	3.3	3.7	3.3	3.3	2.7
12	3.7	3.5	3.2	3.8	3.5	1.5
15	4.0	4.0	4.0	4.0	4.0	1.0
18	3.5	3.8	3.8	3.3	3.7	2.3
21	3.6	3.8	3.6	3.4	3.6	2.6
24	3.8	4.0	3.8	3.4	3.2	2.2
27	3.8	3.3	3.7	3.0	3.0	1.3
30	2.8	3.8	3.0	3.4	2.8	1.4
33	3.0	3.2	2.6	3.4	3.0	2.8
36	3.0	2.7	2.5	2.5	2.8	2.5
39	3.0	2.8	3.2	2.7	2.8	2.5
42	3.3	3.3	3.1	3.0	2.6	1.0
45	2.8	3.2	2.8	2.8	2.8	2.0
48	2.2	3.0	2.0	1.5	2.5	1.5
51	3.0	3.2	3.0	2.8	2.7	2.2
54	2.0	2.7	3.0	2.3	2.7	1.2
57	2.7	2.8	2.5	2.5	2.7	2.3
60	2.3	2.5	2.7	2.3	2.8	1.7
63	2.7	3.0	2.5	3.0	2.8	1.5
66	2.8	2.2	3.0	2.8	2.6	1.4
69	2.2	2.4	2.2	2.2	2.2	1.2
72	2.0	2.2	1.8	3.0	1.7	1.0
75	2.7	2.2	2.0	2.8	2.3	0.8
78	1.8	2.6	2.4	2.4	2.4	1.6
81	2.3	2.5	2.0	2.8	2.0	0.8
84	1.8	1.7	2.5	1.8	2.0	0.8
87	1.3	2.8	2.0	2.2	1.8	0.3
90	2.2	1.8	2.4	1.6	2.0	1.0
93	2.1	2.0	2.0	1.6	2.1	1.4
96	2.0	2.4	1.0	2.4	2.0	0.8
99	1.0	1.2	1.8	1.8	2.0	0.3
Average	2.297	2.870	2.764	2.758	2.709	1.648

[1] - Scoring range, 4 to 0.

Table 10. Mean texture and flavor scores[1] for croquettes cooked in 3 types of fat at every third frying period.

Frying period	Texture			Flavor		
	Fat A	Fat B	Fat C	Fat A	Fat B	Fat C
3	3.8	3.8	3.7	3.8	3.7	2.0
6	3.8	3.8	3.8	3.0	3.3	2.3
9	3.6	3.8	4.0	3.2	3.2	1.7
12	4.0	4.0	4.0	3.5	3.5	1.5
15	4.0	4.0	4.0	4.0	4.0	0.7
18	3.8	3.7	3.7	3.7	3.2	1.3
21	3.6	4.0	3.6	3.4	3.8	1.6
24	3.8	3.8	3.6	3.4	3.4	1.6
27	3.8	3.8	3.8	3.1	3.5	0.8
30	3.0	2.8	3.0	3.6	3.2	0.8
33	3.6	3.6	3.6	3.2	2.3	2.5
36	3.5	3.0	3.0	3.2	2.3	2.5
39	3.7	3.5	3.5	3.3	2.8	2.0
42	3.0	3.1	3.0	2.9	2.9	1.6
45	3.6	3.6	3.4	3.6	3.2	1.6
48	3.2	3.3	2.7	3.0	2.8	0.8
51	3.3	3.2	3.5	2.8	2.5	1.7
54	3.0	3.2	3.2	2.8	2.5	0.8
57	2.7	2.8	2.8	3.2	2.7	2.0
60	3.3	3.3	3.3	3.0	3.3	0.5
63	3.3	3.3	3.3	3.2	3.0	0.8
66	3.4	3.4	3.4	3.4	3.2	0.4
69	3.4	3.2	3.0	3.0	2.8	0.4
72	3.0	3.0	3.0	2.8	2.7	0.3
75	2.7	2.5	2.3	3.5	2.7	0.5
78	2.8	3.0	2.0	3.3	3.2	1.0
81	2.5	2.7	2.8	2.7	2.5	0.5
84	1.8	2.0	2.0	2.8	2.5	0.2
87	3.0	2.5	2.8	2.5	2.5	0.0
90	2.6	2.8	2.4	2.6	2.4	0.4
93	2.7	2.7	2.4	1.7	2.9	1.7
96	2.6	2.6	2.6	3.0	2.8	0.6
99	1.8	2.2	2.3	2.1	2.3	0.2
Average	3.203	3.212	3.133	3.106	2.979	1.127

[1] - Scoring range, 4 to 0.

Table 11. Mean scores[1] for visual evaluation of color of 3 types of fat after every third frying period.

Frying period	Fat A	Fat B	Fat C
(Before use) 0	4.0	4.0	3.9
3	3.3	3.6	3.1
6	3.0	3.3	2.6
9	3.0	2.9	2.4
12	3.0	2.0	2.1
15	2.9	2.9	2.1
18	2.8	2.8	1.6
21	2.6	2.5	1.3
24	2.4	2.4	1.3
27	2.1	1.9	1.1
30	2.0	1.8	1.0
33	2.0	1.8	1.0
36	1.9	1.6	0.1
39	1.9	1.6	0.1
42	1.9	1.6	0.1
45	1.9	1.6	0.1
48	1.9	1.6	0.1
51	1.9	1.6	0.1
54	1.9	1.6	0.1
57	1.9	1.6	0.1
60	1.9	1.6	0.7
63	1.9	1.6	0.9
66	1.9	1.6	0.4
69	1.9	1.6	0.3
72	1.9	1.6	0.4
75	1.8	1.6	0.4
78	1.8	1.6	0.3
81	1.8	1.5	0.1
84	1.8	1.5	0.0
87	1.8	1.5	0.0
90	1.8	1.5	0.0
93	1.8	1.5	0.0
96	1.8	1.5	0.0
99	1.8	1.5	0.0
Average	2.097	1.924	0.730

[1] - Scoring range, 4 to 0.

Table 12. Free fatty acid values, expressed as mg potassium hydroxide/g fat, for 3 types of fat after every third frying period.

Frying period	Fat A	Fat B	Fat C
(Before use) 0	.336	.347	.405
3	.675	.694	.578
6	1.100	1.080	1.100
9	1.851	1.562	1.870
12	2.328	1.878	2.460
15	2.741	2.253	2.647
18	3.211	2.666	3.060
21	3.624	2.985	3.492
24	4.168	3.211	3.793
27	4.468	3.361	3.981
30	5.068	4.128	4.454
33	5.241	4.377	4.627
36	5.452	4.454	4.953
39	5.314	4.109	4.972
42	5.394	4.243	5.337
45	5.491	4.243	5.491
48	5.606	4.531	5.875
51	5.740	4.588	6.086
54	6.124	4.742	7.315
57	6.143	4.800	5.932
60	6.336	4.761	6.105
63	6.432	5.068	6.336
66	6.585	4.761	6.124
69	6.619	5.045	6.316
72	6.544	5.068	6.487
75	6.695	5.045	6.676
78	6.581	5.159	6.638
81	6.847	5.235	6.980
84	6.885	5.330	6.961
87	6.965	5.178	6.506
90	6.866	4.893	6.373
93	6.600	4.780	6.145
96	6.847	5.026	5.842
99	7.018	5.197	5.709
Average	5.2594	4.0743	5.0673

Table 13. Peroxide values, expressed as ml 0.002N sodium thiosulfate/g fat, for 3 types of fat after every third frying period.

Frying period	Fat A	Fat B	Fat C
(Before use) 0	.637	.071	1.298
3	4.295	2.384	5.806
6	1.935	3.210	3.304
9	4.390	4.224	5.428
12	1.628	3.446	3.398
15	2.525	4.248	3.257
18	4.673	5.310	5.664
21	3.823	5.924	4.413
24	4.221	6.832	6.783
27	5.246	7.344	6.539
30	5.058	6.558	7.066
33	5.518	7.623	8.325
36	7.696	9.583	10.261
39	6.389	9.559	9.051
42	4.550	4.550	5.276
45	7.091	9.317	6.776
48	8.954	8.954	7.284
51	6.413	5.881	8.685
54	9.024	11.658	9.192
57	9.048	10.344	12.480
60	9.918	11.955	11.856
63	3.913	5.805	6.521
66	5.365	8.250	7.361
69	7.678	10.917	11.140
72	9.106	12.400	10.745
75	10.139	13.634	13.042
78	8.392	13.980	10.745
81	9.573	15.388	11.461
84	8.072	14.400	10.843
87	10.681	16.450	9.806
90	7.383	15.413	10.201
93	8.694	15.783	9.732
96	9.844	16.771	13.190
99	12.597	19.019	17.167
Average	6.8434	9.6095	8.5696

EFFECT OF A BREADED PRODUCT ON
THE FRYING LIFE OF THREE TYPES OF FAT

by

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Deep fat frying is a widely accepted method of food preparation in food services. A great variety of fats, processed for frying, are available to institutional buyers. A need exists to establish guidelines which may be used in selection and care of fats used for frying. The purpose of this investigation was to study the effect of a breaded product on the frying life of 3 types of fat used in food services. Fats investigated were: a hydrogenated vegetable fat, a hydrogenated blend of animal and vegetable fats, and a semi-liquid vegetable fat. A randomized complete block of the 3 fats in 3 fryers was used.

Fifty-four rice croquettes (6 batches) were fried in each fat during 100 frying periods of 6 hr each. Palatability factors of croquette color, odor, texture, and flavor, as well as fat color after every third frying period were evaluated. At each frying period weight loss of fat and one croquette were determined. Chemical changes occurring in the fats as shown by free fatty acid and peroxide numbers were measured.

Data collected were subjected to analysis of variance to determine effect of using 3 fats on palatability factors of croquette, free fatty acid and peroxide numbers, and color of used fat. Regression of percentage of weight loss for fat per frying period and one croquette with each fat used were ascertained. Where appropriate, least significant differences were established on the data. Correlation coefficients were determined between palatability factors of croquette color, odor, texture, and flavor, and free fatty acid numbers, peroxide numbers, and color scores of used fat.

All fats were still usable at the end of 100 frying periods (600 hr). Significant differences were not apparent among the 3 fats for g of fat used to fry one croquette or for percentage average weight loss for fat per frying period or for one croquette. An approximate 5% fat turnover resulted for all fats. Cost of fat per serving was least for hydrogenated blend of fats and greatest for semi-liquid vegetable fat.

Significant differences were not found in color or texture scores of croquette crust attributable to type of fat; whereas croquette odor and flavor scores varied significantly between the hydrogenated vegetable and semi-liquid vegetable fat, hydrogenated blend and semi-liquid fat, but not between the 2 hydrogenated fats. Throughout the investigation, palatability judges remarked about "off" flavor and odor characteristics for the semi-liquid vegetable fat. Widest fluctuation and variation of any of the palatability factors occurred with flavor scores.

All the fats became darker as frying periods progressed. Significant differences were apparent among all fats. The hydrogenated vegetable fat remained lightest in color, whereas the semi-liquid vegetable fat darkened most.

Free fatty acid and peroxide values for all fats indicated significant differences attributable to type of fat.

Both values increased with fluctuations as frying periods progressed. For all fats, mean acid number was highest for hydrogenated vegetable fat and lowest for hydrogenated blend of animal and vegetable fats, while mean peroxide number was highest for the hydrogenated blend of fats and lowest for the hydrogenated vegetable fat.

Correlation coefficients between palatability scores for color, odor, texture, and flavor of croquettes and acid and peroxide numbers of fats were negative; and, except between flavor scores and peroxide numbers, all were significant, indicating that, in general, as free fatty acid and peroxide numbers of the fats increased, palatability scores of croquettes decreased. A significant positive correlation was observed between palatability scores of croquettes and color of used fats denoting that as fat darkened, palatability scores declined.