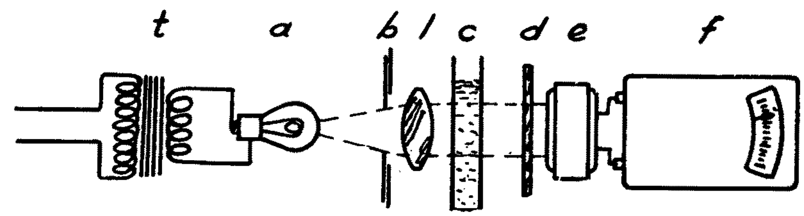

FIGURE FOUR

Eq. 2 reduces to

$$I = Io\, e^{-(c_1 x + c_2 t)y} \qquad (3)$$

where Io is the full scale deflection of the galvanometer when the distilled water or standard solvent is interposed in the light path, and I is the reading of the galvanometer when the sample is placed in the light path. Taking the logarithm of both sides of Eq. 3

$$\log_e I - \log_e Io = \log_e (I/Io = -(c_1 x + c_2 t)y \qquad (4)$$

Solving Eq. 4 for x and introducing a constant c in converting to logarithms of base 10

$$x = -\frac{c}{c_1 y} \log (I/Io - \frac{c_2 t}{c_1} \qquad (5)$$

If the turbidity of the solution, t, is negligible, and the absorption cell thickness, y, is constant, Eq. 5 reduces to the simple form of Eq. 1 in which galvanometer readings replace light intensities. That is,

$$x = -K \log (I/Io) \qquad (6)$$

In the experiments here reported red Lovibond numbers replace the values of solution concentration, x, and changes in other hues of the oil are comparable to the turbidity term, t. That a factor corresponding to the turbidity term, t, is present in the oil samples seems clear in view of the fact that straight line relations are not obtained when Photelometer readings are plotted on a logarithmic scale against red Lovibond numbers.

In conclusion, it may be pointed out that these preliminary experiments show that the standard absorption cell has the proper thickness and the general design of the Photelometer is suitable for obtaining a fairly wide spread of readings on oil samples. In one set of experiments it appears that the Photelometer indicated correctly the Lovibond numbers of certain samples of oil. Although the ultimate success of the Photelometer in specifying colors of oil cannot at this time be predicted, the promising results thus far obtained give reason to believe that the principles embodied in the instrument are fundamentally sound and adaptable to color measurement. The fact that different observers can agree on the Photelometer reading for a given oil sample to a fraction of a division, and the simple technique required to operate the device is worthy of note. The writer ventures the opinion that it might be possible to calibrate the Photelometer to specify colors satisfactorily, but in doing so it might be necessary, and, perhaps, desirable to completely eliminate from consideration the Lovibond standards. Whether this procedure would be desirable from the standpoint of the oil industry the writer is not in position to render an opinion.

The writer expresses appreciation for the cooperation and for the assistance of Dr. Richardson and Mr. Andrews of the Procter & Gamble Co., Mr. Irwin of Swift & Co. and members of his committee, and for the privilege of bringing these experiments to your attention.

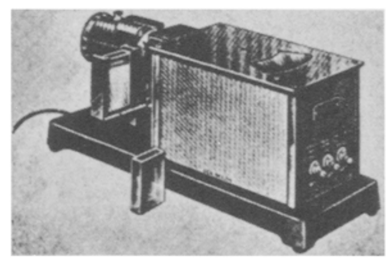

FIGURE FIVE

THE DIETARY VALUE OF FATS

By PAUL E. HOWE, BUREAU OF ANIMAL INDUSTRY

A Paper Delivered Before the 1934 Fall Meeting, A.O.C.S.

The practical problems of dietetics are not concerned so much with food values as with the preparation and service of food, in a manner to make it acceptable. Nutritive values of foods are the background upon which meals are planned. The intrinsic nutritional value of food receives less attention on the part of the average ultimate consumer than its palatability. In a competitive market with two foods of equal value that one which succeeds in creating interest will be more generally used. It is true that certain individuals need to be concerned with the nutritive value of foods, particularly the housewife or the dietetian who plans meals and the physician who prescribes specific diets. Undoubtedly some individuals do consciously consume certain foods for their specific nutritional value but the number is probably comparatively small.

Fats and oils have a unique place in the dietary because of their ability to impart flavor, especially richness of flavor, to change texture, and to add attractiveness. For example take the shortening value of fats in such baked products as pastries, cakes, crackers and breads. The richness of meat is due largely to the fat that is laid down in and around the muscles. In frying, whether it be pan frying or deep fat frying, fats and oils aid in the browning of foods and impart flavor and improved appearance, for instance the improved flavor of fried mush and french fried potatoes over ordinary mush and boiled potatoes. Fats and oils are added directly to foods to impart richness or smoothness and attractiveness. Examples of this phase of the use of fats are mayonnaise dressing, salad dressings, cream, butter and oleomargarine and in cooking in general. It is apparent, therefore, that fats play a very important role in improving the attractiveness of foods and in assisting to stimulate the consumption of foods that have little flavor or lack richness.

The intrinsic nutritive value of fats and oils is chiefly as a source of energy. Some fats carry sufficient quantities of vitamins to be useful in increasing the vitamin content of the diet. Certain of the fish oils are important as sources of vitamins D and A. Recent evidence indicates that there are essential unsaturated fatty acids which the body is unable to synthesize, and must, therefore, be supplied in the diet. The vitamin content of oils of fish as well as that of butter and body fats depends upon the nature of the diet ingested by the animal from which they are derived. When sold as an avowed source of vitamins A or D the potency of the product should be determined and declared. Vitamin-rich fats and oils are not the only sources of these vitamins, since they may also be obtained from vegetables or indirectly from the sunlight but they constitute a convenient source, especially for medicinal purposes. Any addition to the diet, however, that will contribute to an increase in the vitamin content of the diet is important in attaining the "abundant health," characterized by Sherman.

Experiments on rats using highly purified diets of casein and sucrose with the addition of vitamins and salts have established the fact that certain fatty acids, linoleic or linolic ($C_{17}H_{31}COOH$) and linolenic acid ($C_{17}H_{29}COOH$) are essential to well-being and these acids must be supplied in the diet since warm-blooded animals are, apparently unable to synthesize them.

The effect of a lack of the essential fatty acids is shown in various ways. Rats cease to grow after attaining about 25 per cent of the weight of adequately fed rats; the hind feet become rough and scaly, excessive dandruff occurs on the back followed by the loss of hair and skin lesions; reproduction is adversely affected; successful gestation is not possible; lactation is not normal; males become sterile; the testes become small and watery; kidney lesions occur; and there is an increased consumption of water accompanied by decreased excretion of urine. The condition can be cured or prevented by the addition of fats containing the higher unsaturated acids, particularly linoleic and linolenic acids. Fats which are very effective in this respect are lard, vegetable oils, and cod-liver oil. Butter and butter or lard substitutes were found to have little or no value as sources of these unsaturated acids. It is possible that butter from cows fed considerable quantities of unsaturated acids or butter or lard substitutes made from such oils will be useful. Purified methyl esters of the essential fatty acids are effective.

As far as man is concerned it is probable that with the exception of very one-sided diets, including predominately milk diets, there is little practical danger that the average individual will not obtain sufficient linoleic or linolenic acid for his needs. There is some indication that infants on a straight milk diet may occasionally suffer from a lack of the essential fatty acids.

The digestion, absorption, and utilization of fats and oils are phases of the use of foods that always attract attention. Considerations are not so much with regard to absolute digestibility as with the ease of digestion (which is difficult to characterize) and with the effect of fats and oils on the digestibility of other foods.

The stomach is not essentially concerned with the digestion of fats. In it the fats are softened or melted and a certain amount of hydrolysis of glycerides takes place. This hydrolysis results from the action of gastric or pancreatic lipase and bile regurgitated from the small intestines. Practically no fat absorption takes place from the stomach. Evidence is, however, divided as to whether or not it is possible for fat to be absorbed in the stomach.

Fats have a very definite effect on gastric secretion and the rate of passage of food from the stomach. When added to test meals, fats have been found to cause a decrease in acid production in about 50 per cent of the cases studied. In some cases after a temporary cessation of stomach activity there was a marked stimulation of secretion. There is also evidence in the literature which indicates on the contrary that fat does not cause a decreased acidity or flow of gastric juice. There is also evidence that the decreased gastric secretion following fat ingestion is not due to the action of fat on the stomach but to a factor present in the intestinal mucosa.

The effect of fat is to retard the rate of passage of food from the stomach. When fed individually carbohydrates pass most rapidly from the stomach, proteins next, and fats the slowest. Combinations of food tend to be evacuated at the rate characteristic of the food having the slowest rate. The nature of the fat seems to influence the rate of passage of the food, the harder fats requiring a longer time to leave the stomach than the soft fats. The rate of passage of food from the stomach varies with individuals, some stomachs normally evacuate more rapidly than others. Likewise there is a difference in susceptibility to an excessive fat intake among individuals. The effect of fat on gastric motility is well illustrated by the study of the emptying time of potatoes prepared in various ways. For dogs, boiled potatoes passed out most rapidly (about 3 hours). French fried potatoes with 7 per cent fat or pan fried potatoes with 12.5 per cent fat slightly longer, 4-5 hours. When 37.5 per cent fat was added to boiled potatoes there was a distinct delay of about 3 hours over the boiled potatoes. In men and women there was no difference in the rate of passage of boiled and fried potatoes—but there was a delay of about 1½ hours when 37.5 per cent fat was added to the boiled potatoes. A delay in passage of food is not always a disadvantage. It is conceivable that a longer retention of food in the stomach with the increased opportunity for gastric digestion may facilitate the ultimate digestion of food in the intestines. A slower rate of passage of food may under some conditions be a benefit to intestinal digestion. There are indications that fats mixed with foods facilitate digestion of starchy foods and vegetables rather than interfere with it.

The determination of the extent of absorption of fat, or its digestibility, in a quantitative sense is complicated by the excretion of lipids into the intestines and their loss in the feces. A determination of the digestibility of fat involves a correction for metabolic fat. Some of the difficulties involved in the determination of the digestibility of fats are illustrated by the extensive series of determinations of the digestibility of fats of various kinds conducted by Langworthy and Holmes. In these studies the metabolic fat was assumed to be the fat excreted in the feces on the basal diet. The apparent utilization of fat of the basal diet was 62, 63, 34 and 53 per cent for the four subjects studied. The metabolic fat was obtained by subtracting from the fat resulting from the basal diet, 5 per cent of the weight of milk-fat ingested and 10 per cent of the fat from the wheat products. This procedure gave 6.84, 7.70, 16.02, and 9.00 per cent or an average of 9.89 per cent of metabolic fat in the water-free feces. The effect of correcting for metabolic fat was to increase the apparent digestibility of the various fats studied, an average of about 3 per cent. The range of digestibility within any series for the soft fats and oils is approximately 5 per cent, while for the harder fats, beef, mutton and cocoa butter it was 15 per cent. In a set of 16 fats studied the upper limit of the uncorrected digestibility was between 95 and 98 per cent with three exceptions, mutton fat 88.2, cocoa butter 94.2 and egg yolk 92.1. In this work the percentage digestibility tended to decrease with an increase in melting point. This point is best illustrated with the results on hydrogenated corn, cottonseed and peanut oils or blends of these oils and the hydrogenated product. The results showed a progressive decrease in digestibility with increasing melting point. It has been shown in another study that a moderate increase of roughage does not cause as much of an increase in fat as it does of nitrogen in the feces. There were considerable differences in the extent of digestibility for the various individuals in the above results, furthermore, the same individual with a low digestibility contributed two results to the average in some cases.

These details indicate not only the difficulties involved in determining the digestibility of fats but also the extent of variability of the determined values.

It is thus evident that practically all fats that are used in the human dietary are well utilized. When it is considered that the average intake of fat is from 60 to 100 grams per day a small difference in actual digestibility is not of great significance. Langworthy when discussing beef fats states "With the possible exception of ox marrow fat, all the beef fats are very completely digested and are well tolerated by the human body." The utilization of fat will be affected by the quantity of fat ingested. It is, however, important to know the differences that have been observed when handling unusual dietary requirements.

A study of digestibility is further complicated by the fact that an ether extract of feces contains considerable non-saponifiable material; for oleo oil 43 per cent, of which about 24 per cent was insoluble material carried through with the ether extract and the remainder consisted largely of coprosterol. There is considerable evidence that under ordinary conditions of feeding the absolute quantity of fecal fat is relatively low, the nature of fat is independent of fat ingested and shows a marked similarity to the composition of the blood fat, i. e., the fecal lipids represent in part the excretion of fat into the digestive tract. The feces also contain a certain amount of fat in the form of soap. The quantity of soaps in certain samples of feces in the experiments of Langworthy and Holmes was so small that a correction would not affect the percentage digestibility appreciably, being less than one per cent. With a high fat intake and the ingestion of lipids which cannot be absorbed or are not readily absorbed the character of the fecal fat will, however, take on some of the characteristics of the ingested material. Disturbances of fat digestion such as lowered pancreatic activity or excretion of bile, result in an increased excretion of fat.

Rancid fats are held to cause digestive disturbances. Two types of "rancidity" must be recognized in considering the effect of rancid fats on digestive activity. These are oxidative rancidity and the presence of free fatty acids. The effect of rancidity may be the direct result of changes in the fat or they may follow the action of the rancid fat on the food, e. g., the destruction of one or more vitamins. It has been found that under restricted conditions fatty acids are utilized less efficiently than fats which contain glycerol. In the presence of traces of vitamin A, acids of lower molecular weight have been found to be more useful than those of higher weight, except in the case of oleoic acid which was utilized more completely than stearic acid. With an adequate amount of vitamin A, however, similar results were obtained for fatty acids alone and in combination with glycerol. Fatty acids when fed require a higher intake of vitamin A. That partially oxidized fats do not have the same nutritive value as neutral fat was presented to your organization last year by Dr. Dorothy Whipple. She very carefully left open the question as to the immediate effect of rancid fat, whether it was a specific effect, loss of essential fatty acids or the destruction of vitamins. Rancid margarine has been found to cause a definite rise in acidity of the gastric juice and a shortening of the secretion time in the stomach and a hastening of the emptying time.

Extreme rancidity of fat in the diet is not an important practical problem since such fats are not particularly palatable and are not likely to be consumed in large amounts. No evidence has been produced showing the effect of heat upon rancid fats used in cooking. In a demonstration of palatability of cakes made with lard without flavoring, a cake made with rancid lard could not be detected or in most cases distinguished from cakes made with butter or fresh lard. On the other hand rancid or aged lard can be detected in biscuits.

Emulsification and digestion of fats proceed actively in the intestines. Digestion results particularly from the action of the lipases of the pancreatic juice and the intestinal juice. The presence of bile acids along with soaps aids in the emulsification of fat and the solution of fatty acids and possibly directly aid their absorption. It may also increase the permeability of the epithelial cells. Fats are hydrolyzed to glycerol and fatty acids. The preponderance of evidence is to the effect that it is the glycerol and free fatty acids or soap that pass through the cell membranes into the epithelium and not unhydrolyzed fat. The fat fragments are built up into fat in the epithelial cells in which they may be temporarily stored or passed on to the lacteals and then through the thoracic duct to the blood stream. There is evidence, although disputed, that fat also passes to a less extent directly from the epithelial cells into the blood stream. The phospholipid, lecithin, is concerned in the transport of fat in the body. With an increase of fat in the blood stream there is an increase in lecithin and also cholesterol. Aside from the temporary increase of fat in the blood such as during fat absorption or the rapid mobilization of fat from the fat depots is is believed that lecithin is a major factor in the transport of fat to and from the issues.

Fats are stored in fat depots, or adipose tissue, such as under the skin, around the various organs, in the omentum and mesentary, and in the connective tissue around the muscles. The relation of the diet to the character of the fat deposited in the body has been the subject of study for many years. It has received marked attention, however, during recent years, chiefly in relation to the production of soft lard and fat in the carcasses of swine fed on oil bearing seeds, also because of the increased interest in the problem of fat metabolism.

The fat deposited in animal tissues arises from two sources, that formed in the animal itself from carbohydrate or in unusual conditions from the protein and from ingested fat. The fat of various species of animals is more or less characteristic. Since the nature of the fat ingested and possibly other conditions affect the character of the fat deposited it is probable that the characteristic fat of an animal is the fat deposited when the maximum amount of fat is formed from carbohydrate on a ration as fat free as is consistent with adequate nutrition. Otherwise in defining the normal fat of an animal it would be necessary to characterize it as fat resulting from the usual or a specific ration.

The fat deposited by a hog when fed a ration of brewers' rice and tankage, very low in fat, contained 57 percent of unsaturated acids of which 55.9 per cent was oleic acid, a small quantity of linoleic acid, no linolenic acid and a trace of arachadonic acid. The saturated acids constituted 38.6 percent, of which palmitic acid comprised 25.2 percent and stearic acid about half as much, 11.6 percent. The lard resulting from feeding corn was rather similar to that obtained from the brewers' rice except that it contained 6.7 percent linoleic acid and was in consequence slightly softer. Lard from hogs fed peanuts contained more linoleic and linolenic and less stearic and palmitic acids. Lard from soybeans contained less oleic acid and more linoleic acid than brewers' rice lard. It also contained linoleic acid. The changes in the character of the lard followed in general the characteristics of the plant oils on which the swine were fed. It is interesting that while the percentage of palmitic and stearic acids changed somewhat the ratio remains approximately the same, two of palmitic acid to one of stearic acid.

The effect of cottonseed oil in the ration is interesting. It has been found that when 4 percent or more of the total fat content of the ration fed swine is peanuts or soybean oil, the lard obtained tends to be soft. The softness increases with increasing quantities of these fats ingested. When 4 percent of the fat content was cottonseed oil, however, the resulting lard was hard, whereas the same percent of peanut soybean or corn oil gave medium soft lards. While the explanation of the cause of these differences is not known it has been suggested that it is due to the presence of an isomer or isomers of the unsaturated acids, particularly oleic acid presents in cottonseed oil and that these isomers are readily transformed into stearic acid. As the amount of cottonseed oil is increased in the ration to 8 and 12 percent the lards become softer. The fatty acids obtained upon separation indicate that as the amount of ingested oil is increased there is an increase in the iodine number, a decrease in the percentage of oleic acid and of both saturated acids and an increase in linoleic acid. It would appear that swine are able to saturate a part of the unsaturated acids when limited amounts of cottonseed oil are fed, but that as the quantity of the oil increases they are unable to keep pace with the influx of acids and that considerable amounts pass on unchanged to the fat depots.

In the various studies of the effect of ingested fat on the composition of adipose tissue the fat deposited is usually modified to a certain extent. These changes are possibly the result of the utilization of some of the fatty acids, the formation of fat from carbohydrates and simultaneous deposition or the modification of some of the ingested fat by desaturation or saturation. It is obvious that the greater the consumption of fat the more likely it is that the deposited fat will take on the characeristics of the ingested fat.

Environmental conditions or the portion of the body in which the fat is deposited apparently affect the nature of the fat deposited. There is the well-known experiment of Henriques and Hansen in which swine were kept at a temperature of 30 to 35° C. and 0° C.; one of the animals kept at 0° C. was protected by a sheepskin coat while the other was without protection. The outer layer of fat in the animal without protection had a higher iodine number than the fat of the protected animal or of the one kept at a higher temperature. Studies of the various layers of fat in swine have shown that the fat in the outer layer between the skin and the "streak" had a higher iodine number than the fat between the "streak" and the body or the kidney fat characterized by a somewhat greater amount of oleic acid, and a correspondingly less quantity of palmitic and stearic acids. While temperature has been assigned as the possible explanation of this difference there is some question as to the correctness of the assumption since some animals with relatively high body temperatures have characteristic fats which are very soft or oily. Investigations with rats have not confirmed the results obtained with swine. The difficulty may be due to the fact that rats do not possess the ability to form and lay down fat as readily as swine, or possibly to the protection of a heavy coat of hair. Rats also tend to deposit fat in more localized areas than swine.

The fact that differences in the composition of fat do occur in different parts of the body may lead to interesting speculations as to why they should exist at all; e.g., they might be due to selective deposition; to selective utilization, if temperature is a factor, although such a condition would assume that the saturated acids were used rather than unsaturated oleic acid; or that there may be a more active interchange of fat in the outer fat layers, or assuming that the synthesis of fat takes place in the fatty tissue, which is not known, external conditions may favor the formation of slightly more unsaturated acids or oppose the formation of saturated acids.

The question of the nature of deposited fat is not one of great importance in the average man. It has important bearings on the explanation of utilization of fat and is of economic importance in the production of animals.

It is difficult to assign a definite value to the amount of fat required for the diet of man or animals. Health is possible on a very low fat intake. The work on essential fatty acids sets a quantitative value on fats. The requirements are very low and probably attained in the average diet without difficulty. Since fats are carriers of the fat-soluble vitamins, on a low fat diet we may be concerned with regard to an adequate supply of vitamins, A and D. These vitamins can be obtained, however, without resorting to specifically fat foods. On the other hand, if it is desired to fortify the diet with vitamins A and D, fatty foods, such as fish oils, are usually selected. It is possible however, to obtain concentrations of these vitamins associated with the minimum quantity of fat.

In the average dietary, fats supply approximately one-third of the total energy. In the so-called standard dietaries the weight of the fat consumed has varied between 50 and 100 gms. per day. The average daily consumption of fats and oils purchased as such in the United States is roughly 63 gms per capita. Some dietaries in the South have shown a consumption of almost twice as much fat. Analyses of food used in certain messes in the Navy and Army show a consumption of approximately 30 gms. of cooking fat and 37 gms. of "edible" fat and oils per man per day.

The various phases of the use of fats that have been discussed represent only a part of the interesting story of the utilization of fat. It is obvious that fats and oils have a very important and unique place in the human dietary. They have the fortunate faculty of increasing our enjoyment of food. In some cases they carry necessary vitamins, and always supply energy in a concentrated form, thus leaving a place for other interesting and important foods.

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A SIMPLE TEST TO DETECT CHLOROPHYLL IN TALLOW

By C. P. LONG and H. B. STEVENSON
THE PROCTER & GAMBLE CO.

Presented Before the 8th Annual Fall Meeting—A.O.C.S.

This paper is directly concerned with the identification of green tallows. Let us consider first what we mean by a green tallow, which term we will use broadly to include all animal fat. The best definition from a soap maker's viewpoint is that a green tallow is a tallow which, when saponified in the normal manner, will produce a finished soap green in color. The raw fat may be noticeably green in color or it may carry sufficient red and yellow coloring matter to completely or partially mask the green so that the color of the fat does not appear to be green. In the kettle often sufficient of the red and yellow coloring is destroyed, changed or removed while very little of the green is lost, so that the resulting soap is green.

For soap making, the objection to the use of green tallows is that soaps made from such tallows appear definitely dull and muddy. This is true even when the green fats are mixed with non-green fats to an extent that the final soap is not definitely green.

The detergent properties of the soap containing green tallow are very little, if any, different than those of the soap made from non-green tallow. The difference is only one of appearance. The appearance of soap, even laundry soap, is very important in the eyes of a critical consuming public and a producing organization zealous to please those consumers.

There is little question but that the green color is mainly due to chlorophyll—probably introduced by contact with offal in rendering. Very little, if any, chlorophyll is normally deposited in the fatty tissues of a plant eating animal. Carotin, the orange-yellow coloring matter of leafy material, and of certain fruits and roots, such as carrots, is to some extent deposited into the fatty tissues.

Additional support to our belief that the manner of rendering and the contact with offal during rendering are responsible for green tallows are the facts that tallow from butchers' scrap is not usually green, while the Government "New Deal" pig grease from small pigs, where the whole carcass was rendered, was extremely green. The latter was equally, if not more, intensely green than the so-called "olive oil foots" or "green olive oil," which is made by solvent extraction of the olive pomace after direct pressing. Edible tallows and the lighter colored grades of inedible tallow are not usually green.

Chlorophyll is fat soluble. If fats are brought in contact with material carrying chlorophyll under suitable conditions, some of the chlorophyll will be extracted by the fat. Once the chlorophyll is in the fat, it is not easily removed. The fat may be saponified with caustic soda and pass through the various steps of soap boiling with little, if any, removal of chlorophyll.

The chlorophyll may be removed from the fat by bleaching, but this involves additional handling and expense. It is obvious that if we have two tallows of the same apparent color and otherwise equal, one containing chlorophyll and the other not, that the first is worth less than the second by the cost of the bleaching required to remove the chlorophyll.

The surest test to determine if a tallow will produce green soap is to saponify it alone and note the color of the soap it produces. This involves the killing or saponification change, a strong change, a salt wash and a pitch or settle. The grained soap of the kill and the nigre are in such physical states that usually the green color of a very green tallow is not obvious. The neat soap, especially when solid, very readily indicates variations in greenness. To properly carry out such a soap making test on a small scale requires about two days before the answer is available. Such a slow, cumbersome procedure is hardly applicable to receipt samples of shipments.

It is well known that commercial chlorophylls invariably contain copper. Pure chlorophylls are magnesium compounds equivalent to about 4.5% of magnesium oxide. The magnesium form very easily changes to the corresponding stable copper chlorophyll* so that normally the copper is introduced by processing the chlorophyll extracts in copper equipment. Some manufacturers go a step farther and add copper salts to secure a high content of the copper chlorophyll, since the latter is more intensely green than the magnesium chlorophyll and has more tinctorial power per pound. The intense green of the copper chlorophyll prompted the addition of copper salts to canned peas and other vegetables in the pre-Wiley days.

With the reactions of chlorophyll and copper in mind, we made experiments with a group of tallows of varying green content as known from the color of the neat soaps from them. Using each of these tallows, two series of attempts to change the chlorophyll in them to the copper compound were made. Each tallow was melted and two 2 oz. bottles filled about ⅔ full. To one bottle of each tallow sufficient aqueous solution of copper acetate to give 5-6 p.p.m. of copper was added and thoroughly mixed with the fat. Into the bottles of the second set a coil of clean copper wire was placed. The bottles were then kept at 60° C. for 14 hours.

Those tallows which had produced green neat soaps increased in intensity of greenness in the presence of metallic copper. Those in contact with the copper acetate solution did not give as pronounced results as the metallic copper. Further work was discontinued with the copper acetate solution since copper wire reacted quickly and was easy to apply. Further samples were given the copper treatment as well as made into neat soaps. The results further correlated the copper treated fat color with that of the soap.

Various periods and temperatures of heating were tried. It was found that the maximum intensity of green was reached in 6 hours at 60° C. or in one hour at 110°-115° C. in nearly every case.

At 100° C. about 75 minutes is satisfactory. Under these conditions the color of a non-green fat is not markedly changed.

The test as we usually carry it out is to fill two 2 oz. bottles about ⅔ full of the melted fat. Into one bottle of fat is placed a coil of clean copper wire or a strip of clean copper sheet. This bottle is then placed in an air oven and held at 110°-115° C. for one hour. The first sample is melted and both are chilled quickly in the refrigerator. When crystallization is complete, the fats are examined. The extent to which the solidified tallow has increased in green will indicate the probable color of the soap from it. The test

*The copper compound should properly be called copper pheophytins. The pheophytins are chlorophylls in which the magnesium is replaced by hydrogen. They form a salt with the metal which is very similar to chlorophyll in which the magnesium is replaced by copper. Schertz "Industrial & Engineering Chemistry," Vol. 19 (1927), p. 1152, and "Investigations on Chlorophyll" by Willstätter and Stolz, translated by Schertz and Merz, p. 236.