Refining, Bleaching and Hydrogenating Meat Fats

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ABSTRACT

Meat fats are most often steam refined. This has been the accepted practice for at least 35 years. Meat fats are caustic refined for a few specialized products. The caustic refining conditions differ from those used for vegetable oils primarily in the amount of mixing used after the addition of caustic.

Bleaching of meat fats is accomplished easily. Most meat fats are light in color and require clarification more than bleaching. The green color of tallows containing large amounts of chlorophyll is easily removed with activated earth.

Meat fats are hydrogenated to develop the SFI curves needed for various products and also are hydrogenated to saturation for use as plasticizing agents. The hydrogenation of lard and tallow is not as complicated as that of most vegetable oils, because the original fat is more saturated and the reaction has fewer possible routes to follow.

INTRODUCTION

It seems to me that this is a rather historic occasion. The American Oil Chemists' Society holds world conferences and annual meetings, and the processing of meat fats is rarely or ever mentioned. Of course, there are good reasons for this. First, meat fats are a by-product of the packing industry and their production is directly related to meat production rather than the need that may exist for these products. Second, the high degree of saturation of these products has not made them gain in popularity for use in consumer products. Last, but not least, this high degree of saturation has limited the processing possibilities and consequently the research that has been done on these products.

Meat fats, i.e., lard and tallow, are reasonably uniform raw materials. The consistency varies somewhat from season to season but these variations present no real or serious operating problems. The characteristics also vary depending on the method of rendering used. In discussing the effects of the raw material variations, I will attempt to compare the processing steps with those used for vegetable oils in the hope that this will serve to illustrate the relative ease with which meat fats are processed.

REFINING

Traditionally the method used to refine meat fats has been what we now call physical refining. The two main impurities in meat fats are proteins carried over from the rendering process and free fatty acids. Before physical refining, or deodorization, to remove the free fatty acids, it is necessary to remove the proteinaceous materials. This is easily done by adding small amounts of diatomaceous earth and/or bleaching clay followed by filtration. Activated carbon also has been used for this clarification step, but the cost is higher than using filter aids and it is not as popular. This preparation for physical refining is really a clarification procedure. Once clarified, the clean dry fat is ready for physical refining, i.e., deodorization.

This preparation for physical refining obviously requires less care and operating controls than the preparation normally used for soybean oil. With soybean oil I would expect that proper preparation for physical refining would include a closely controlled pre-treatment with an acid to hydrate the beta lipoids and complex the metal salts followed by a carefully controlled water degumming step. The loss of gums and oil in this degumming operation represents a significant oil loss. The loss of lard or tallow in the clarification operation is only the amount entrained with the bleach clay and filter aids. Really, the only difficulty experienced clarifying lards or tallows is the sliming over of the filter caused by the proteins. This can be controlled by proper choice of filter aids.

An alternate method of preparing the lard or tallow for physical refining is to water wash the fat with about 10% water. The purpose of the water washing is to remove the proteins in the product. Water washing to remove the protein is not as widely practiced as filtration. Not only does water washing require extra centrifuge capacity, but since the lard or tallow is bleached anyway prior to deodorization, the protein is most advantageously removed in the filtration step.

There is a case in which meat fats are caustic refined. A market exists for undeodorized tallow for the french frying of potatoes. To produce this product, good quality fresh tallow is caustic refined, double water washed and vacuum dryed. This product is not bleached, has a free fatty acid of about 0.05% and has the characteristic fresh tallow flavor. The refining conditions used are unlike those used for cottonseed oil and soybean oil in that no static mixers are used. Too much mixing causes emulsification and since there are no gums to hydrate, the sole purpose of the addition of caustic is to neutralize the fatty acids. No bleach clays are used to ensure no foreign flavors are added to the product, and since the fresh tallow flavor is desired the product is not deodorized.

Tallow used in french frying operations is not the only meat fat which is not deodorized. Lard, used in operations such as pie making, where the flavor may be desirable, often is mixed with diatomaceous earth and filtered with no further processing.

BLEACHING

Lards and tallows which have not been abused normally require little bleaching. An exception to this rule is tallow which is green because of its high chlorophyll content. Since tallow contains so little red and yellow coloration, the greenish color of the tallow is readily apparent when the tallow is received. The chlorophyll is readily removed with acid activated bleaching earth. This is a special bleaching operation not normally performed.

This is contrasted with soybean oil in which the green color becomes visually obvious only after the red and yellow coloration is removed. Soybean oil always should be subjected to a bleach sufficient to remove soaps, oxidation products and impurities which would later affect the stability of the oil.

Soybean oil is properly bleached to remove these impurities and not to reduce color since refined, water washed, dried and deodorized soybean oil normally has a color of less than I.O.R.

Properly bleached soybean oil will not show the greenish discoloration after all processing including deodorization is completed because a proper bleaching step removes the chlorophyll. In short, lards and tallows require less bleaching to less carefully controlled standards than do soybean oil and most other vegetable oils.

I would like to point out that the bleaching operation on meat fats is the clarification step for physical refining. There is no separate pretreatment for physical refining or deodorization as must be done for vegetable oils.

Saturated		**Soybean Oil**	**Lard**	**Tallow**
C - 14		0.2	1.5	3.0
C - 16		10.2	23.6	24.2
C - 18		3.7	14.2	17.2
C - 20			1.0	0.1
	Total	14.1	40.3	44.5
Mono-Unsaturated				
C 16:1		0.1	2.8	3.6
C 18:1		22.8	44.2	44.9
	Total	22.9	47.0	48.5
Poly Unsaturated				
Linoleic		53.7	10.7	3.4
Linolenic		8.6	0.4	1.0
	Total	62.3	11.1	4.4

FIG. 1. Fatty acid composition of soybean oil, lard and tallow.

Batch vacuum bleaching vessels are well suited to bleaching meat fats because these vessels can be used to dry wet product. Also, these vessels can be used as continuous bleachers. The initial charge is pumped into the bleacher with full vacuum on the vessel. The product is heated to about 210 F, and then the bleaching clay and filter aid are added. After about 10 minutes of mixing, the product is pumped through the filter and recirculated to the bleacher. When clarity is achieved the product is diverted to the finished product tank.

Fresh product is pumped into the bleacher at the same rate the bleached product is pumped out. Bleach clay and filter aid are added at a proportioned rate to keep the percentage of bleaching clay constant in the bleach vessel. Since the primary purpose of the operation is clarification, retention time is of little consequence.

HYDROGENATION

The hydrogenation of meat fats is a relatively simple matter compared to the hydrogenation of a highly polyunsaturated oil such as soybean oil. To understand why meat fat hydrogenation is a relatively simple matter it is only necessary to examine the fatty acid composition of lard and tallow compared to that of soybean oil. Typical data are presented in Figure 1.

From this fatty acid composition data it is apparent that the polyunsaturated acid content of soy oil is about six times that of lard and about 15 times that of tallow. With so little polyunsaturation it is obvious that with anything less than perfect selectivity hydrogenation will immediately affect the mono unsaturated acids and will form considerable quantities of saturated acids.

At this point we also should consider that in hydrogenation of lard to produce margarine stocks the iodine value is lowered only about 10 units. When tallow is brush hydrogenated, the iodine value is lowered only a few units. There is not enough exotherm generated to really change the selectivity of the hydrogenation reaction above that available with plant steam. In other words, if plant steam pressure allows you to heat the batch to 330 F before hydrogenation, then about 330 F is your effective hydrogenation temperature. Contrast this with soybean or corn oil in which the oil often is lowered about 65 iodine values for some of the hard margarine stocks. As the temperature rises, the pressure can be lowered to further increase hydrogenation selectivity.

When lard is to be hydrogenated to meet a required SFI limit, or tallow is brush hydrogenated, it normally is done with .01 or .02% nickel at 300-350 F and at about 15 pounds hydrogen pressure. When these fats are hydrogenated to make hardstocks the pressure used is 60-100 psi, and the heat of reaction is allowed to increase the reaction temperature to 400-450 F.

Hydrogenation control of hardstocks or "titer" stocks normally is done with a "quick titer" determination since the official titer determination is too time consuming for hydrogenation control. In a quick titer determination, a thermometer is dipped into the test sample and then rotated between the fingers until the fat on the thermometer bulb clouds. The temperature is read at this point and a constant added to obtain the quick titer. This is the same procedure normally used for hydrogenation of vegetable oil hardstocks.

After hydrogenation meat fats must be postbleached to remove trace nickel. This is the same procedure used with vegetable oils.

As meat fats are hydrogenated, the SFI slope of the hydrogenated meat fat initially remains the same as the original meat fat, and as hydrogenation continues the SFI slope flattens out. As soybean oil which is used to represent polyunsaturated oils is hydrogenated, the SFI slope steepens until the iodine value approaches about 60 (depending on hydrogenation conditions) and then it flattens out.

Figure 2 shows the change in SFI of lard during hydrogenation at constant hydrogenation conditions. The conditions used were .02 nickel, 330 F and 15 psig. While this was a pilot plant hydrogenation, the conditions were chosen because they represented our typical plant hydrogenation conditions.

It will be noted that in lowering the iodine value of the lard 10 units to 55 I.V., the SFI increased 9.5 units at 50 F and 9.0 units at 104 F. This means that the SFI slope of the hydrogenated lard is exactly the same as of the original lard. This is a point of some importance. It means that if the hydrogenation end point is overshot, a second batch may be under-hydrogenated and blended with the first to produce a product with exactly the desired SFI. If there

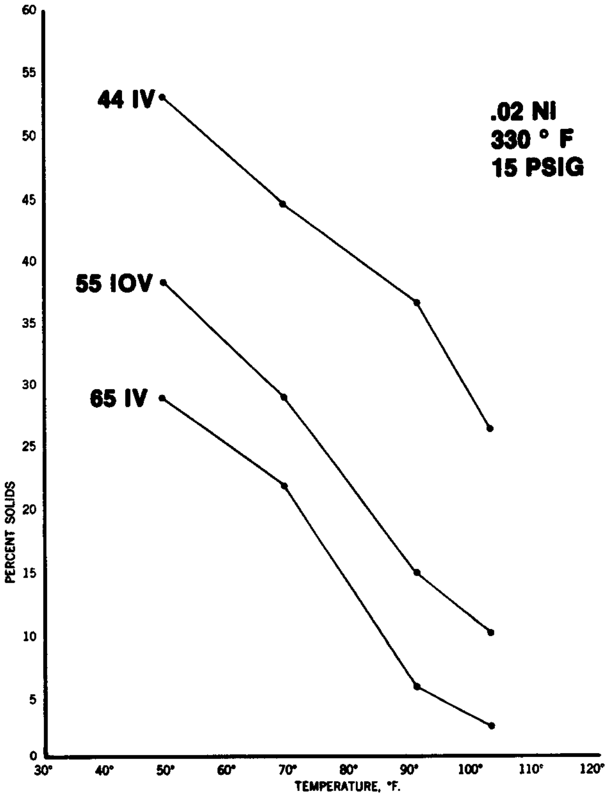

FIG. 2. Hydrogenated lard.

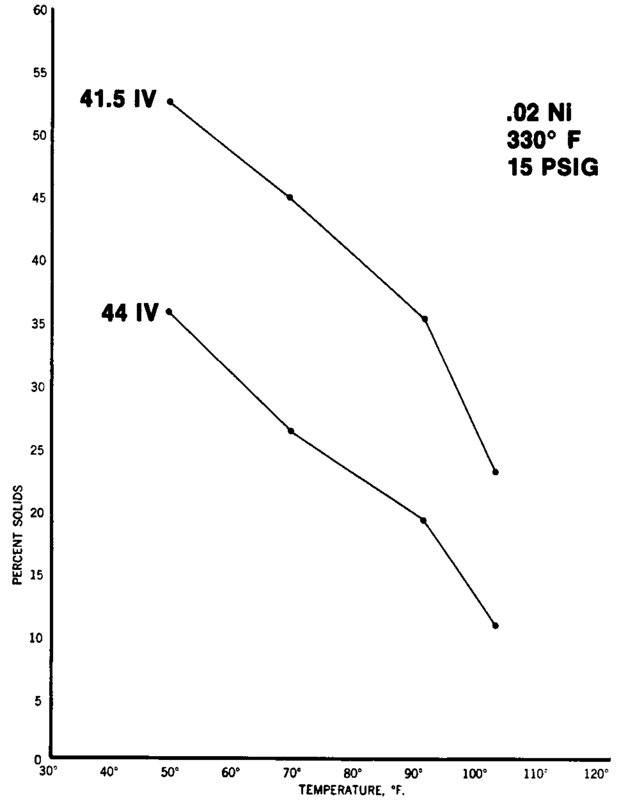

FIG. 3. Hydrogenated tallow.

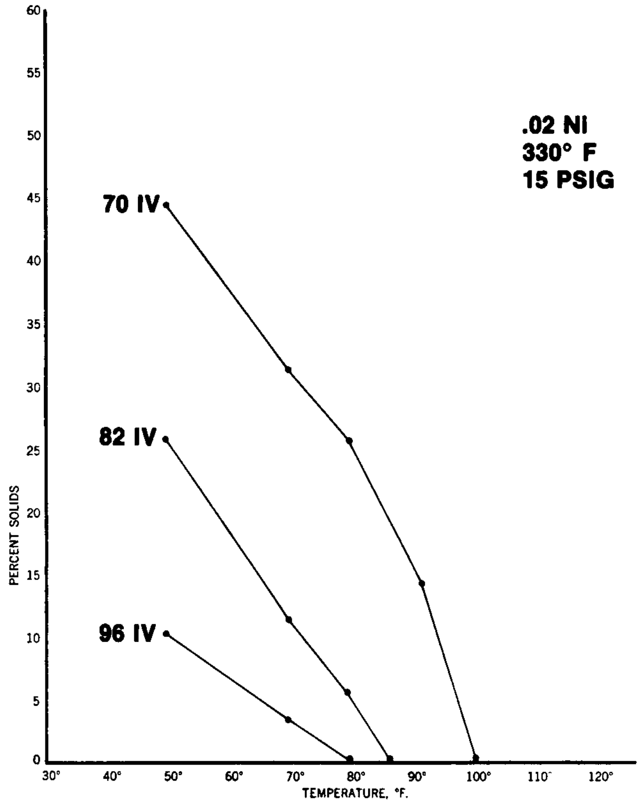

FIG. 4. Hydrogenated soybean oil.

had been considerable change in the slope of the SFI curve, this would not be possible.

Of course, blending a slightly over-hydrogenated batch with an under-hydrogenated batch will not produce quite as good AOM stability as if the whole batch were hydrogenated to the correct end point. Once again, this is not as critical as with highly polyunsaturated oils for two reasons:

- Normally a high percentage of the stability of meat fat products is achieved not through hydrogenation but through antioxidant addition. The same is not true of vegetable oils.
- The stability of very highly unsaturated oils increases dramatically as the linolenic acid content approaches 0% and as the linoleic acid content approaches 0%. As a result the AOM stability increase of vegetable oils through hydrogenation is not in direct proportion to the decrease in iodine value. The blending of hydrogenated vegetable oils of differing iodine values can make a significant difference in AOM stability when compared to a straight hydrogenated oil.

Further examination of this hydrogenation shows that as the iodine value is reduced from 55 I.V. to 48 I.V. the SFI increases 14.5% at 50 F and 16.0 at 104 F. This indicates that the 104 F solid is beginning to rise at a faster rate than the 50 F solids, and the curve is beginning to flatten. Continued hydrogenation would cause further, more rapid increases in the SFI at 104 F until at 10 I.V. or less the SFI curve would be a horizontal line between 50 F and 104 F.

Figure 3 shows a 44 I.V. tallow which has been hydrogenated to 41.5 I.V. The slope of the hydrogenated and unhydrogenated tallow are almost identical. Further hydrogenation would result in a greater increase in the SFI at 104 F than at 50 F with a corresponding flattening of the SFI curve, until at saturation the curve would be horizontal.

Figure 4 represents the hydrogenation of soybean oil at precisely the same conditions used for the tallow and lard previously shown. The temperature was held at 330 F even though the exothermic heat of reaction would have increased the temperature rapidly. The SFI curve shows a sharp increase in steepness as the iodine value is lowered. As the iodine value is lowered from 96 to 82, the SFI increases 15.5% at 50 F and only 8.5% at 104 F.

This increase in slope of the SFI curve was developed at constant hydrogenation conditions. Had the temperature been allowed to increase or the pressure to lower, the slope would have been steeper. Conversely, increasing the pressure would have further flattened the SFI curve.

These SFI curves illustrate some important differences in the hydrogenation control of meat fats and vegetable oils. First, at shortening consistencies, the slope of the SFI curve of hydrogenated tallow or lard is the same as the original tallow or lard. This certainly is not true of vegetable oils which are hydrogenated. Second, when enough data has been collected to predict the SFI increase with a given increase in congeal point or a given reduction in iodine value, a desired hydrogenated lard or hydrogenated tallow SFI can be predicted accurately on either congeal point or iodine value alone.

I would like to give an example of how this simplicity of hydrogenation control can be put to use in plant practice. In 1963 I left a firm which processed both meat fats and vegetable oils but primarily vegetable oils. I went to a firm which processed about 70% meat fats and 30% vegetable oils. In my new position, I was responsible for establishing a formal system of operating specifications and manufacturing standards. Since I was knowledgeable with using SFI as a means of controlling the consistency of vegetable fat margarines and shortenings, I instituted the same control procedures at the new company. When this system had been established at the plant at which I was based, I began to install this system at the company's other plants.

At one of these plants, the quality assurance manager balked at changing his method of consistency control. He had been using congeal points only. He had established separate congeal point data that gave the penetrations he required for lards, tallows and blends of meat and vegetable fats. His consistency control record was outstanding.

The reason this system worked was that there is a definite relationship between the 92 F solids and congeal point. Since the slopes of the individual meat fat curves remain the same (in the range of shortening consistencies), determination of the congeal point effectively determined the entire SFI curve.

In summary, from refining through hydrogenation, meat fats are easier to process than vegetable oils. While their degree of saturation may limit their usage, this same quality also makes the processing easier than for vegetable oils.

Meat Fat Formulation

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ABSTRACT

Edible usage of meat fats has somewhat declined over the past years. This can be attributed to several factors. First, the advancement of hydrogenation technology has led to the development of highly functional vegetable oil products. Second, there has been an increased emphasis on Kosher products. Third, various questions relating cholesterol to risks of heart disease have generated some marketing concerns over meat fat usage.

Meat fats are still a factor in the edible oils market. U.S. consumption of meat fats in 1976 was 4.1 billion pounds, approximately one billion pounds for edible usage. Because of their triglyceride profiles, they are excellent sources of highly functional products for bakery applications. They have tended to be the "Cadillac" around which hydrogenated vegetable oil products have been developed. In addition, the economics of these products have generated significant savings for end users. Flavor attributes of meat fats have, in other cases, been the reason for their sole usage in certain specific products.

In shortening formulation, meat fats are merely one of many triglyceride sources. They can be blended with any vegetable oil source. They can be subjected to the same processing as other oils in order to modify physical chemical properties such as SFI, melting point, consistency and oxidative stability.

This paper will discuss specific applications where lard and tallow contribute unique functionality. It will then discuss various modifications which can be employed to insure more consistent performance or to customize products to specific applications.

DISCUSSION

Table I compares typical fatty acid compositions of lard and tallow with several common vegetable oil sources. As noted, both products contain substantially high levels of saturated fatty acids and are solid at room temperature. Vegetable oils, excepting palm oil, are high in unsaturated fatty acids and are liquid in nature. Coconut and palm kernel, being "high lauric acid," are solid at room temperature; however, they tend to crystallize into a brittle nonplastic consistency. The solid triglycerides in lard and tallow provide plasticity, which is ideal for functionality in bakery systems. The vegetable oils, soybean and cottonseed, etc., must be hydrogenated to the same degree of saturation to achieve functionality. Formulation must adjust for inherent variations of composition in the animal fats.

LARD

Table II shows typical analytical composition ranges of crude lard. Variations are in iodine number and in the total fatty acid content. These variations are a result of factors relating to diet, climate and the overall structure of the animal. Even with this variation, lard contains a high percentage of medium melting disaturated monounsaturated (GS2U) triglycerides. These triglycerides tend to be largely in a symmetrical arrangement. Hence, the fat crystallizes in the beta form. Uses for lard, therefore, center around applications requiring low structure and high lubricity. The main application is in pie crusts.

TABLE I

Typical Fatty Acid Composition—Common Oil Sources

Fatty acid	Soybean	Cottonseed	Palm	Lard	Tallow	Coconut
Lauric	0.1	0.1	0.1	0.1	0.1	46.5
Myristic	0.1	0.7	1.0	1.4	2.8	19.2
Palmitic	10.2	20.1	42.8	23.6	23.3	9.8
Stearic	3.7	2.6	4.5	14.2	19.4	3.0
Oleic	22.8	19.2	40.5	44.2	42.4	6.9
Linoleic	53.7	55.2	10.1	10.7	2.9	2.2
Linolenic	8.6	0.6	0.2	0.4	0.9	0.0

TABLE II

Variations in Crude Lard[a]

Lard analytical composition	
Iodine number	46 - 70
Saponification number	195 - 202
Titer, C	36 - 42
Wiley melting point, C	46 - 48
Fatty acid composition %	
Myristic	1 - 4
Palmitic	20 - 28
Stearic	5 - 14
Oleic	41 - 51
Linoleic	2 - 15
Linolenic	Tr - 0.1
Arachidonic	0.3- 1.0
Glyceride composition	
Total GS_3	2 - 5
Total GS_2U	25 - 35
Total GSU_2	50 - 60
Total GU_3	10 - 30

[a] Swern et al., *Bailey's Industrial Fats and Oils,* 3rd edition, p. 189.

TABLE III

Functional Characteristics of Pie Shortenings

- Plasticity at refrigerated temperatures
- Loosely bound oil fraction - lubricity
- High solids - flaky texture
- Rapidly melting, rapidly dissolving solids - mouth feel

Table III notes functionality requirements of pie crust shortening. In mixing a pie crust, the shortening is rather loosely mixed into the dough. Overmixing causes the shortening to be absorbed into the dough, creating a tougher pie crust and excessive shrinkage. To control the absorption, mixing is conducted at colder dough temperatures. For adequate rolling and forming, the shortening must have plasticity at refrigerated temperatures. In addition, the