Some Remarks Illustrating the Importance of Knowing the Structure of Oil and Fat Triglycerides

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IN the table (I) have noted down a few analyses of cottonseed oil, cottonseed winter oil stearine, cottonseed winter oil, as well as some analyses of compounded vegetable shortening, and finally a few analyses of partly hydrogenated cottonseed oil of the shortening type.

By comparing the analyses it can readily be seen that winter oil stearine of an iodine number about the same as compounded vegetable shortening has a higher titre but much lower melting point than the shortening. It may further be seen that a partly hydrogenated shortening of about the same titre as compounded shortening has a much lower melting point and much lower idodine number.

It is common knowledge that by mixing about 8-10% of 58-60 titre hydrogenated cottonseed oil with cottonseed oil and chilling on a roll, a vegetable shortening is made which has a very high melting point, about 48°. This, notwithstanding that the percentage of saturated fats in this compound is only 5-6% more than the percentages contained in cottonseed oil or the amount of solid fats 5½-6½% more than in cottonseed oil.

TABLE 1

ANALYSIS

	Iodine Value	Titer	Melting Point	Sat'd Acids %	Isoleic Acid %	Oleic Acid %	Linoleic Acid %
Cottonseed Oil	109.8	....	....	25.0	....	23.0	51.9 K
C. S. O. Winter Oil	113.3	....	....	22.1	....	25.0	52.9 K
C. S. O. Winter Oil Stearine	94.0	45.0	28.0	37.0	....	17.5	45.6 K
C. S. O. Winter Oil (Wesson)	87.1	44.9	27.6	38.0	....	(— 62.0 —)	
C. S. O. Winter Oil Stearine	94.0	38 0	25.0	33.0	....	26.0	41.0 L
C. S. O. Compounded Vegetable Shortening	93.0	37.5	45.3	32.4	2.4	25.6	40.6 L
C. S. O. Compounded Vegetable Shortening	93.6	36.2	47.0	30.0	3.4	28.7	38.6 L
C. S. O. Part. Hyd. Vegetable Shortening	64.3	36.1	37.2	28 2	15.8	52.7	3.4 L
C. S. O. Part. Hyd. Vegetable Shortening	69.9	36.1	36.5	23.9	11.8	58.6	5.7 L
C. S. O. Part. Hyd. Vegetable Shortening	67.5	37.5	38.8	32.2	10.4	46.2	1.1 L
		Fully Saturated Acids %		Saturated Acids %		Unsaturated Acids %	
Mutton Tallow (Hilditch)		26.0		59.7		40.3	
Cacao Butter (Hilditch)		2.5		58.8		41.2	

K indicates Kaufmann method.
L indicates Lead-Ether method.
Analysis from former Portsmouth Cotton Oil Refining Corporation unless indicated.

The cottonseed winter oil stearine, as mentioned in the table, contains around 15% more saturated fat than cottonseed oil and still has the low melting point of around 28° C.

Compared with the compounded shortening, it is striking, that the partially hydrogenated vegetable oil shortening has a much lower melting point, notwithstanding that in one of the cases mentioned in the table the percentage of saturated acids is about the same as in the compounded vegetable shortening and in all the cases of partially hydrogenated vegetable oil shortening shown in the table the percentage of solid fatty acid is much higher than in the compounded vegetable shortening and, notwithstanding that the iodine number is about 28 less than that of the compounded shortening.

Those few examples plainly show that the usual analysis of shortening or fat will not suffice to explain their physical characteristic.

The trouble with our fat analyses has been and is that so many refer to the fatty acids instead of the triglycerides. German and Japanese scientists have for some time past made some progress toward the qualitative determination of the various glycerides but it is only since Prof. Hilditch of the University of Liverpool and his co-workers' development of their methods to analyze the glycerides that the constitution of the oil and fat glycerides has become known to us and we thereby have been able to find some explanation for conditions which previously have appeared so inconsistent.

We now know that in cottonseed oil probably no tripalmetin nor tristearine exist and only 1% of fully saturated glycerides and as the presence of fully saturated glycerides, palmetin or stearin, have a great tendency to increase the melting point of a fat it can readily be understood why an addition of 8-10% of high titre hydrogenated cottonseed oil is able to raise the melting point of an oil, liquid at ordinary temperature even at 0°, to about 47° C. and thereby make possible a shortening, when on the other hand an increase from around 23% to 38% in the percentage of saturated fatty acids as mixed triglycerides in winter oil stearine as compared with normal cottonseed oil only raises the melting point to 28° C.

In this connection it may be interesting to point out that in making cottonseed winter oil in a yield of around 80% in some cases when analyses were made the percentage of saturated acids only decreases with around 25% and the oleic acid increases with 2% and linoleic increases with 1% as compared with cottonseed oil from which it was made. It would therefore seem that when chilling cottonseed oil for making winter oil, probably primarily those glycerides crystallize out, which contain either two palmetic acid radicals and one oleic or linoleic acid radicals; or one palmetic acid and two oleic acid radicals, etc. There possibly are only a limited number of such triglycerides and that may explain why the freezing of cottonseed oil has to be done so very carefully. If the chilling is not done right the yield not only becomes very poor but the standing quality of winter oil is usually much lowered because the crystallization and thereby the separation does not take place properly.

It seems as if the liquid acids, oleic and especially linoleic, are able to dissolve the saturated solid acids much more easily when they are all combined in the mixed triglycerides than when the same percentage of saturated acids are present but to some extent as fully saturated triglycerides. It also may be that the mixed triglycerides which contain two molecules of linoleic acid and one molecule of palmetic or stearic acid are more apt to retain the saturated acid in solution than the triglycerides containing two oleic acid or one oleic acid and one linoleic acid in addition to the palmetic or stearic acid.

All of you probably have had experience with making compounded shortening using winter oil stearine and you know that you will have to use only a very little less hydrogenated oil in order to give the shortening the desired melting point and consistency than you would by using normal cottonseed oil or even winter oil which naturally shows how little influence the saturated acids have as far as the melting point is concerned when they are present in the shape of mixed triglycerides.

Of course in this connection I do not refer to the hardness which appears at low temperatures and which is an entirely different matter.

It is rather interesting to remember, as Hilditch so clearly has pointed out, the physical difference between mutton tallow and cacao-butter, both of which contain almost the same fatty acids in the same proportions. Mutton fat, however, contains 26% of fully saturated glycerides when on the other hand cacao-butter only 2.5%. Mutton tallow is of a high melting point as compared with cacao butter.

When cottonseed oil is hydrogenated selectively the melting point remains comparatively low until the approaching disappearance of the linoleic acid because no fully saturated glycerides are being formed. On the other hand when the hydrogenation is not carried out selectively, fully saturated triglycerides may be formed or at least saturated acids are formed and the melting point becomes high even at a stage when a still comparatively large percentage of linoleic acid is present.

Of course there are also other factors that govern the melting point of partial hydrogenated oil such as the percentage of isooleic acid, a large percentage of which may depress the melting point but such conditions I have not considered in this connection.

Some tests to determine the latent heat absorbed when melting cottonseed oil shortening of various temperatures were made in the laboratory of Portsmouth Cotton Oil Company during 1930 by M. H. Wall and Mr. Bergh. The tests were carried out in a thermos bottle in similar way as described by Dr. Wesson in "The Cotton Oil Press," 1918. Some of the results I have shown graphically in Table II. The data on which the curves are based are probably only approximately correct but I believe that they are sufficiently interesting to show the relative change which takes place in shortening when the temperatures are changed.

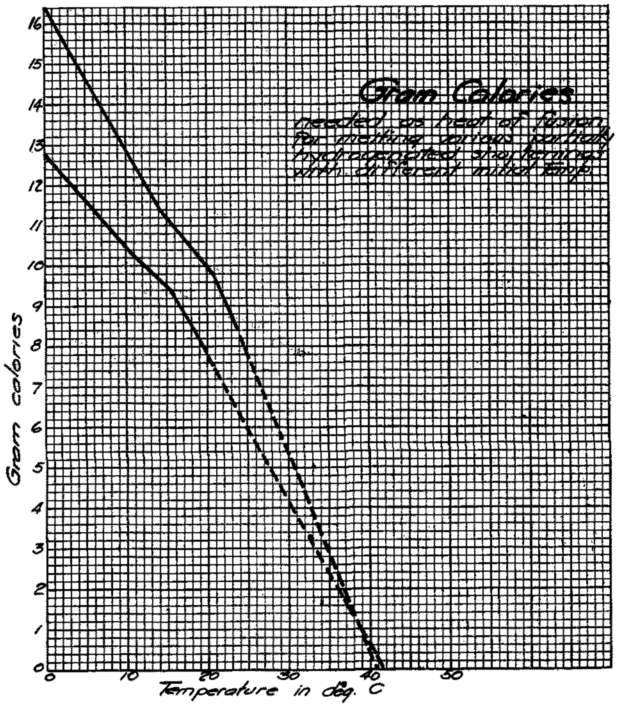

Table II—Showing Data Graphically

It is very obvious from the curves that with changing temperature the physical condition of the shortening not only continuously changes but must change even if the final melting point remains constant. The fact that for a specific shortening the latent heat varies with the temperatures distinctly shows that a certain part of the shortening is present in a melted or solid condition at a certain temperature and that the shortening as such does not remain unchanged when variations in temperature occur even within limits of more or less ordinary temperature. This is rather significant because it proves that the condition of none of the various brands of partly hydrogenated shortening tested and probably no shortening can be uniform so far as consistency is concerned unless the temperature is constant. Even if the same brand all of the time is manufactured with chemically the same composition and otherwise under exactly the same physical or mechanical conditions, the shortening will not appear uniform unless the temperature is kept constant. If we can separate and analyze (I mean analyze the constitution of the glycerides and not the content of the various fatty acid) the various fractions which liquefy at various temperatures we may finally get a clue as to how to make a shortening which will not change its consistency (plasticity) within certain temperature ranges or we may at least be able to considerably improve our present shortenings in this regard.

There is no doubt in my mind that the analysis and the determining of the various percentages of the different fatty acids in compounded and in partly hydrogenated shortening will only to a very limited extent help us to make a shortening of good physical qualities but that on the other hand a complete knowledge of the constitution of glycerides will be a great aid in making a shortening of correct consistency and I therefore believe that the use of the methods for analyzing the constitution of glycerides which have been devised and worked out by Prof. Hilditch and his co-workers in Liverpool will contribute to the greatest progress in the edible oil shortening industry since the introduction of hydrogenation.

GERMANY

Oleo Oil Importation Normal

An increase of 9 per cent in amount and a drop of 13 per cent in value occurred in the importation of oleo oil during the year. Both were considerably below the totals of 1930. Approximately 95 per cent of these imports are from the United States.