The Journal of the American Oil Chemists' Society

Volume 29 DECEMBER, 1952 No. 12

A Shortening Consistometer

L. CLARDY, W. D. POHLE, and V. C. MEHLENBACHER, Swift and Company, Chicago, Illinois

SOME of the most critical performance factors of plastic fats are related to the properties commonly referred to as consistency and plasticity. The spreadability of butter and margarine and the bake-shop performance of shortenings are typical examples of important functional properties which are dependent to some extent on these properties. Consistency is generally assumed to be a combination of those effects which tend to give the impression of resistance. Plasticity relates to the capacity of substances for being molded. The properties of plasticity and consistency as they pertain to fats are complicated by the many factors which combine to produce the end-effects. Bailey (1) has listed some of these as:

a) Ratio of liquid to solid portion.
b) Number of nuclei formed during crystallization.
c) Size to which the crystals grow.
d) Rigidity of the crystal portion.
e) Viscosity of the liquid portion.

Since consistency and plasticity of fats are interrelated, it is difficult to measure one without respect to the other. The item we are most concerned with in this paper is consistency, and the method being submitted is designed for that purpose. Hereinafter we will drop reference to plasticity with the understanding that this property is not completely disassociated in the procedure of measurement being presented.

The factors which enter into the characteristics of consistency are not capable of independent measurement with methods now available. However this is relatively unimportant. What is needed is a procedure which will yield duplicable results, of sufficient sensitivity so as to permit making a practical discrimination between samples of different degrees of consistency. In spite of the need there is little uniformity and no standardization of consistency-measuring methods. This situation was well described by Rich (2) a few years ago when he reviewed the methods then in common use. The situation has not changed significantly since that time.

Probably the first method used to evaluate the consistency of shortening was that of thrusting a finger into the product or squeezing a sample of the product within the hand. The impression of firmness thus gained was associated with firmness, body, or consistency. Results of such tests cannot be assigned any reliable numerical value. They are entirely subjective and depend upon psychological reactions. Surprisingly enough, methods such as these have not yet been altogether replaced by more objective tests.

Needle penetrometers, of one type or another, are sometimes used as consistency-measuring devices. These have the advantage of being applicable to small samples which can be rapidly solidified and thus yield results rather promptly. It should be noted that the consistency of fats so solidified may not necessarily check with the consistency of the same fats after they have been chilled and filled in the manner of shortening. Chilling and the subsequent tempering conditions exert a significant influence on the final consistency. Needle type penetrometers have several disadvantages:

a) They are not convenient for the measurement of bulk shortening in large containers.
b) They have a limited range of applicability, being definitely unsatisfactory for soft or hard products.
c) They lack sensitivity.

Another instrument in not uncommon use for measuring the consistency of fats is the ASTM grease penetrometer. In using this instrument, a portion of the product must be removed from the original package for testing unless the sample happens to be a small package. This is undesirable because anything that disturbs the orientation of the crystal structure, whether this be by mechanical means or change of temperature, has an effect on consistency. Fats are thixotropic, and thus the consistency decreases as product is worked, or otherwise deformed. A comparison was made between the instrument to be herein described and the ASTM instrument. (ASTM Method D 217-48). The results are shown in Table I.

TABLE I
Relationship Between Consistometer Readings and A.S.T.M. Penetrometer Readings

Consistometer Reading	A.S.T.M. Penetrometer Reading
10	225
20	205
30	188
40	173
50	158
60	143
70	129
80	117
90	109
100	102
110	96
120	90
130	85
140	80
150	76
160	72
170	68
180	64

Among the instruments and methods mentioned by Rich in his review of consistency-testing instruments was one originally designed by Bloom (3). The device to be described in this paper is that tester with certain modifications.

The consistometer is a device which indicates the relative pressure necessary to force the product

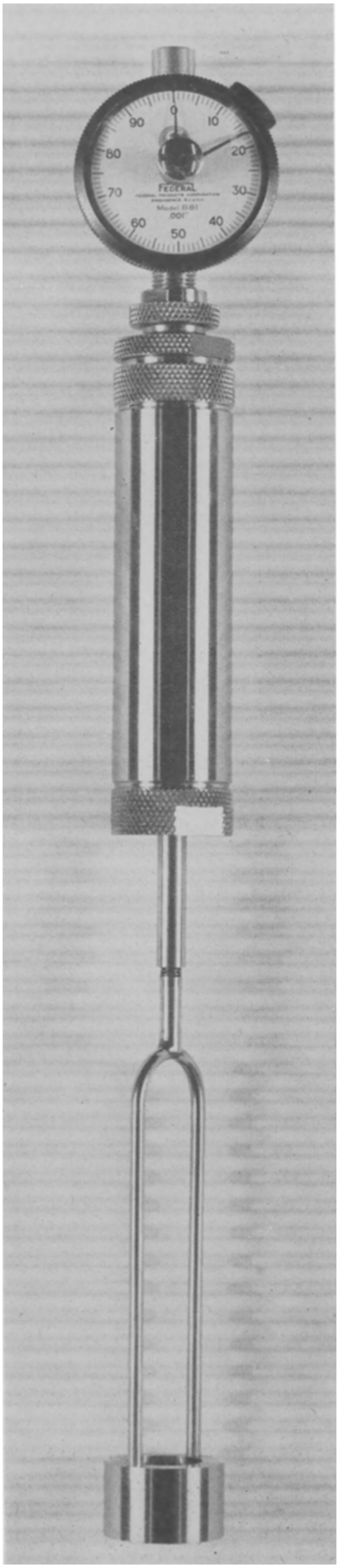

FIG. 1

through an opening in the end of a plunger. This instrument is illustrated in Figure 1. It consists of a barrel, a displacement gauge, and a plunger. The plunger consists of a supporting yoke, at one end of which is a small cylinder. The inside of this cylinder has the shape of the frustum of a cone so that as the sample passes through this opening, deformation is caused. A spring contained in the barrel is so dimensioned and wound that a compression of 0.020 inches per pound is obtained with a minimum of end-effect. The displacement gauge is graduated in 0.001 inches with a scale reading from 0 to 100 and a maximum reading indicator. A nut is located under the gauge for the purpose of adjusting the sensitivity so as to obtain a scale deflection of approximately 20 divisions per pound of force applied at the end of the plunger. This instrument may be applied by hand or may be motor-driven (see Figure 2). The latter eliminates the personal factor and such variations as might occur due to manual application.

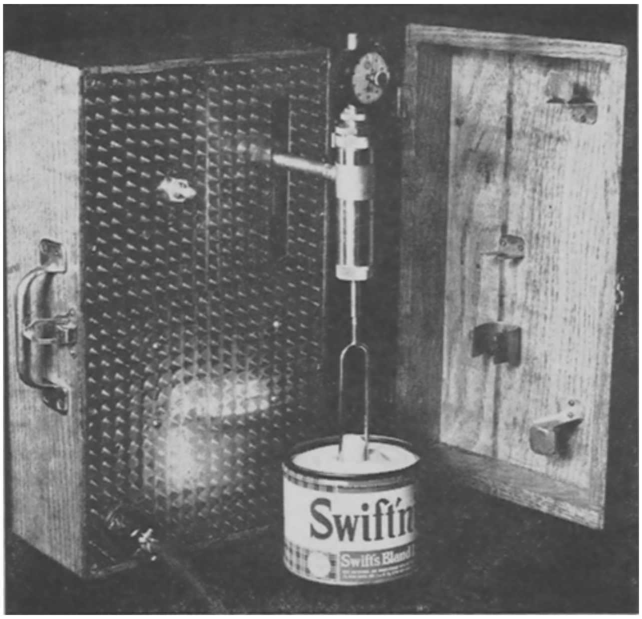

FIG. 2

Method for Measuring Consistency

Calibration. Place a 1-lb. weight on the right-hand pan of a Torsion-type balance and then release the pans. Grasp the consistometer firmly and hold vertically over the center of the left balance pan. Set maximum reading hand to zero and then press the plunger against the pan with a constant speed ($1\frac{1}{2}$-inch depression per 30 seconds). When the balance comes to zero, quickly remove the pressure and read the figure on the dial coinciding with the maximum hand. Repeat the test using 2-, 3-, and 4-lb. weights. If the instrument is in adjustment the scale readings and balance will bear the relation to each other shown in the following table.

Weights	Limits for Gauge Pointer Reading
1 lb.	19 ± 1.5
2 lb.	40 ± 1.5
3 lb.	60 ± 1.5
4 lb.	80 ± 1.5

TABLE II

Comparison of Hand and Motor Driven Consistometer Results

Sample	Hand-Operated Consistometer				Motor-Driven Consistometer			
	A	B	C	D	A	B	C	D
Can 1	53	42	....	161	54	40	....	154
	54	42	....	150	57	41	....	149
	56	43	....	150	55	39	....	151
Can 2	53	41	34	162	54	49	42	156
	50	41	37	146	58	46	41	147
	54	40	36	148	54	49	46	164
	52	44	39	151	56	47	46	158
Can 3	55	39	42	139	59	45	42	171
	57	41	43	128	61	47	42	175
	55	41	41	148	59	46	43	169
	53	38	45	140	57	48	43	164
Can 4	55	40	43	143	61	47	43	147
	56	42	42	144	58	47	42	150
	58	43	38	147	58	44	44	155
	57	39	42	156	61	44	45	158
Standard deviation	1.6	1.6	2.0	7.0	1.7	1.5	1.8	5.2

Procedure. Hold the sample at the specified temperature long enough for it to come to equilibrium at that temperature. This is usually a minimum of 24 hours, but it depends on the size of the sample. Grasp the instrument firmly and hold at right angles to the surface of the sample. If there is a light crust on the surface, this may be removed with a spatula. With a constant application of pressure, force the plunger slowly (1½-inch depression in 30 seconds) into the sample until the maximum pointer is practically stationary or until the core of sample forced through the ring of the plunger is about 1½ inches long. The figure on the dial coinciding with the maximum reading hand is the consistency.

The following data are an indication of the performance of the consistometer. These data were obtained by making hand- and motor-driven tests on several different samples representing a range in consistency.

The foregoing data represent various types of shortenings. There was no significant difference between the two instruments. The coefficient of variation calculated for the above data is 3.8%, from which the standard deviation for any range of consistency may be estimated. The coefficient of variation equals $\sigma/\bar{x}$ when σ equals the standard deviation and $\bar{x}$ equals the mean.

The consistometer, which has been described, provides a means of obtaining numerical measurements of the consistency of fats. It is applicable to shortening and other plastic products such as margarine and butter. Results are reliable over a range of from 20 to 170 on the scale. This extends from products which are very soft to those which are very firm. The method is simple and very rapid. An important advantage of this instrument is that it is small and light in weight so that it may be applied directly to the original container whether this container be a 1-lb. package or a 50-lb. drum. In fact, it is a relatively easy matter to go through an entire stock in a short time checking individual packages. The instrument and method are therefore particularly suitable for production control purposes.

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[Received May 1, 1952]

Component Fatty Acids of Indian Shark Liver Oils

S. P. PATHAK, C. V. AGARWAL, and S. S. MATHUR, Department of Industrial Chemistry, Benares Hindu University, Benares, India

LIVER oils from several varieties of sharks have been studied by a number of investigators, notably from Japan (Tsujimoto and co-workers, for example). The data for most of them are however of semi-quantitative nature, and the fatty acid compositions of only a few are available in some details. The composition of the liver oil of the shark *(Carcharius gangeticus)*, reported by Tsujimoto (9), is of special interest in being unusually rich in saturated (mainly palmitic) acids (nearly 50% of the total fatty acids).

The present investigation was undertaken to study the fatty acid compositions of the liver oils of Indian sharks *(Galeocerdo rayneri)*, one of which was from the Arabian Sea and the other from the Bay of Bengal. These oils proved to belong to Tsujimoto's fourth group (10) of Elasmobranch fish liver oils in having high (ca. 40%) saturated acid contents. Oils of this group are very rare indeed, and the liver oil of this species of sharks appears to be the third instance of this peculiar group. The present study is probably the first detailed analysis of an oil of this group where an efficient modern fractionating column has been employed.

Experimental

A sample of refined oil from the liver of a shark *(Galeocerdo rayneri)*, from the Arabian Sea, was kindly supplied to us by the Director of Fisheries, Bombay, and is referred to as No. 1 shark liver oil.

Another sample of the liver oil of the same species of shark, caught in the Bay of Bengal, was kindly sent to us by U. S. Kini, manager, Government Oil Factory, Kozhikode, Calicut, Madras, and will be named as No. 2 shark liver oil.

Liver Oil of Shark No. 1 (Arabian Sea). The oil deposited 5.8% of phosphatides on keeping in 10 volumes of acetone solution at about 0°C. for 4 weeks. The glyceride portion (220.6 g.) was added in minimum quantity (45.0 g.) of potassium hydroxide in 1,100 c.c. alcohol (95%) and heated for one hour on water bath after which about 700 c.c. of alcohol was distilled off. This precaution was taken to keep the highly unsaturated acids from undergoing isomeric rearrangement. It is preferable to risk the chance of slightly incomplete conversion of the whole fat into fatty acids rather than to incur rearrangement of some of the highly unsaturated components. The unsaponifiable matter was extracted with ether from