The Physical Requirements of a Margarine Fat

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IT is desirable that a margarine arrive at the customer's home on a hot summer day after travelling through Texas heat and still maintain the shape of a neat quarter-pound print. After the margarine has been lying around on the table in a hot kitchen for three or four hours, it will be placed in the deep freeze. Then at some odd hour when the margarine has reached a temperature of zero degrees Fahrenheit, someone will bring it out and try to spread it on a brittle cracker. Naturally it must spread smoothly. When it is eaten, it must melt quickly in the mouth. It must not leave the tongue with the feeling that it is coated with paraffin wax or cold cream. At the same time there must be no sandiness to it or remind one of axle grease.

And now let us go back to the margarine factory for a moment. This product has to be packaged. It is molded in a machine to form a quarter-pound print. This print is pushed into a piece of parchment wrapping paper at a rapid pace. If the margarine is not hard enough at this point, it will be any man's guess where the margarine stops and the paper begins. The print must remain hard enough even when there are minor variations in the refrigeration supply to the Votator. The extreme case is when the factory people expect the prints to remain hard when the refrigeration is off altogether.

Of course, all of this is an exaggerated portrayal of what might be expected of a margarine. As a matter of fact, overemphasis on one extreme will require a certain amount of neglect in other directions. However it appears that the physical properties in a margarine fat which come into play in every case here are related to the melting and crystallizing characteristics of the fat. Although physical characteristics can cover everything from color to refractive index, the present discussion will be limited to those characteristics in connection with melting and crystallization.

It is possible to divide these characteristics roughly into two classes. The first includes those characteristics which are more evident only after the fat has been plasticized and which are dependent in part on the plasticizing process. In the other class are those characteristics which might be said to be inherent in the oil and, although they affect the plasticizing process, are not necessarily dependent upon it. It is difficult to draw a sharp line of distinction between these two classes hence any division is more for convenience rather than a clear-cut differentiation. With this in mind let us discuss those characteristics which are more evident after plasticizing.

A plastic fat consists of a dispersion of crystalline fat in liquid fat. This involves a state of equilibrium which may or may not be stable at a given temperature. As the temperature falls or rises, more solid material will form or melt as the case might be.

The size of the particles of solid fat seems to affect the plasticity of the fat. A fat in which the solids are present in the form of large unconnected crystals may be sloppy at a given temperature whereas if the same proportion of solid fat is present at that temperature in the form of very fine crystals, the fat may behave as a solid and will resist a deforming stress until that stress reaches a critical value. In the first case the fat was a fluid aggregate, and in the second it was a plastic material.

At a higher temperature of perhaps 83°F. a table margarine in the form of a quarter-pound print should maintain its shape under the stress of its own weight. At about 88°F. it may deform to a certain extent, but the oil should not separate and run out of the print. This is a requirement, naturally, for the summer months. To maintain its shape at 83°F. the margarine fat should have around 10% solid fat although this varies according to the kind of fat.

The corollary to this lies at the other end of the temperature scale. This is that it is desirable that the margarine spread easily at refrigerator temperatures. Hence at 45°F. only a mild applied deforming stress should be necessary to cause the margarine to break down and flow. Again the percentage of solid fat present will influence this characteristic. In the so-called "spreadable" type of margarine oils this may be in the neighborhood of 32%. Here again the percentage of solid fat necessary will vary with the kind of fat.

The two preceding characteristics had to do directly with plasticity. The next classification is related to plasticity, but it is a characteristic of the plastic material and does not directly affect its plasticity. There are several characteristics involved, but they can all come under the general heading of texture.

In butter technology texture is considered in the same light as "body." However body, as it is considered here, would also include spreadability and structural stability. The last characteristics are measurable in terms of deforming stress while texture is a factor which can be judged more satisfactorily by appearance and touch in the opinion of the writer.

ABOUT the worst defect in texture is graininess. Graininess in margarine occurs in the form of relatively large crystals of hard fat. These may have been present in the oil before it was plasticized, or it may occur after plasticizing. The first type is due to holding the oil for a certain length of time at a critical temperature which will allow the hard fat to grain out. The other type of graininess happens when finished margarine is overheated and then cooled slowly so that the hard fat is again allowed to grain in large crystals. It might be of interest to note that the first type of grain is visible under a polarizing microscope as smooth elongated crystals while the grains in margarine overheated in the field generally appear as fan-shaped crystals.

Graininess seems to be more prevalent with some oils than with others. In our experience soya oil shows more of a tendency toward this than cotton oil. The sharp melting hydrogenated oils seem to grain more easily than wide plastic range hydrogenated oils. Even within these categories proper hydrogenation and blending practice can reduce the tendency toward graininess.

Another defect in texture is oiliness. Oiliness or greasiness goes along with lack of body. It is characterized by an oily sheen on the surface of the margarine and the feel of greasiness in the mouth. The wide plastic range fats seem to be more oily than the sharp melting fats. Here again proper hydrogenation and blending practice can overcome this deficiency. Graining out can cause oiliness to some degree in that the graining process will liberate a certain amount of liquid oil from the solid fat dispersion.

And now let us discuss what the writer chooses to call inherent characteristics. For margarine to be packaged efficiently in automatic machinery the fat must be capable of being plasticized to a certain initial firmness. This firmness must be achieved by the time the margarine has passed through the Votator process. There are factors in processing which can overcome in part a deficiency in this regard. However there are practical limits beyond which efficiency is impaired to an impossible degree.

In general, a wide plastic range fat is more deficient in printability than the sharper melting fats. However a 76 coconut oil blend hardened with fully hydrogenated soya or cotton oil stock can be difficult to print even though it melts sharply. In this case the trouble may be that this blend crystallizes so rapidly that it interferes with the operation of the Votator apparatus.

One way of estimating the printability of a fat is by its congealing temperature or congeal point. However it is our experience that a wide plastic range fat will require a somewhat higher congeal point than a sharper melting fat for equivalent printability under the same plasticizing conditions.

In the case of hydrogenated soya oils the congeal point will occur at that temperature where there is about 11% solid fat present.

Congeal point as a measure of printability does not seem to apply to a highly thixotropic fat such as lard. All plastic fats are thixotropic to a degree, but the lengths of time necessary for recovery from this action vary. Too rapid recovery can make it difficult to force the product through the plasticizing system whereas a very slow recovery can interfere with packaging.

Melting point is important in that a fat which has too high a melting point will have a tendency to coat the mouth. Too high a melting point will also make the margarine seem pasty or even "chewy."

In the long plastic range fats the melting point can be somewhat higher than body temperature if the solids content at that temperature is not more than about 2½%; with a sharp melting fat the melting point should be several degrees lower. The reason for this lies mostly in the slope of the solids content-temperature curve in the region near the melting point. For a wide plastic range fat the slope will be relatively flat, and the solids content curve can extend somewhat beyond body temperature even though the solids content at that temperature is relatively low. For a sharp melting fat the slope will be relatively steep, and therefore the opposite result will occur.

THE tests used to evaluate the characteristics outlined here can be classified according to their applications. For the plasticized product there are slump tests, penetrometer or consistometer tests, and certain qualitative tests. On the original oil there is the dilatometer test for estimating solids content at different temperatures. There are the Wiley and capillary tube melting points and the congeal point.

These tests are all well known so that a detailed discussion is unnecessary. However it would be well to emphasize that they are all empirical to some degree. This includes the simplified dilatometry which is most generally used.

The unfortunate thing about empirical tests is that, unless the tests are standardized, confusion reigns. Except for the Wiley and capillary tube melting points, none of these tests are too well standardized.

The value of a good test method is that it can express a desired characteristic in terms of an exact requirement. However it can be seen from the foregoing discussion on the characteristics of margarine fat that no one characteristic can be used as the basis for a complete specification. Hence more than one test is necessary when the total requirement is considered.

There should be full realization of what the limitations of a test are. Hence the A.S.T.M. penetrometer readings on a margarine with good spreadability can be the same as those on a margarine which is lumpy. Other examples probably could be mentioned.

If all fats upon being plasticized produced the same-sized crystals and if the liquid portions of these plasticized fats had identical viscosities, solids content data would cover just about everything. This, of course, is not the case. Solids content data are very useful in comparing two fats like soya oils which were hydrogenated in a like manner. However if a soya oil and a lard are compared, the lard generally will be considerably softer, given the same solids content and equivalent plasticizing.

In summarizing this discussion, it might be said that certain qualities of a finished margarine are dependent on the physical characteristics of the fat used in that margarine. Accordingly the requirements imposed on the fat used should be based on these characteristics. However the limitations of the tests used should be recognized.

Obviously, existing test methods should be improved whereever possible and new ones developed. When a test has proved itself useful, standardization should follow.

Critical evaluation of margarine fats can do nothing but lead to better margarine and foster the industry.

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New Members

Active

Herbert Barnes, resident chemist, General Mills Inc., Minneapolis, Minn.
Robert B. Barrett, laboratory director, Klenzade Products Inc., Beloit, Wis.
James G. Bradford, chief chemist, The Cudahy Packing Company, Memphis, Tenn.
Jean B. Carden Jr., assistant scientist, Kraft Foods Company, Glenview, Ill.
Earl G. Hammond, assistant professor, Iowa State College, Ames, Ia.
Richard J. Hanzlik, laboratory supervisor, Armour and Company, La Grange, Ill.
William Harlan Hill, research chemist, A. E. Staley Manufacturing Company, Decatur, Ill.
Russell H. Maas, research project engineer, Oscar Mayer and Company, Madison, Wis.
Robert John Meyer, research project chemist, Standard Oil Company, Whiting, Ind.
Herbert W. Schubert, assistant chief chemist, Armour and Company, North Bergen, N. J.
Edward L. Spencer, chemist, Emery Industries Inc., Cincinnati, Ohio
Charles S. Steiner, head, industrial oils research, Swift and Company, Hammond, Ind.
Tod John Stewart, chemist, Schulze-Burch Company, Chicago, Ill.
H. Vacit Tumer, production chemist, Turyag Oil and By-Products Company, A. O. Izmar, Turkey
Kenneth N. Warner, senior chemist, Emery Industries Inc., Cincinnati, Ohio
Charles W. Williams Jr., chemist, Sharon Laboratory Service, Denison, Tex.
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Blase T. Messina, food engineer, Armour and Company, Chicago, Ill.
William J. O'Connell, vice president, HumKo Company, Trendex Division, Memphis, Tenn.

Corporate Associate

Atlas Refinery Inc., 142 Lockwood street, Newark, N. J.

Correction

We are guilty of what has turned out to be an obvious error. The April advertisement of the Girdler Company featuring the new Chicago plant of Southern Cotton Oil Company mentions that hydrogen is used in their Wesson Oil and Snowdrift. It should have referred only to Snowdrift.

In spite of all the precautions to avoid errors such as this, there seems to be an exception which makes the rule. The error was caught by the Girdler people, but not until the April issue had come off the press.

GRISWOLD-ESHLEMAN COMPANY
by L. R. CANFIELD

The appointments of C. L. Peterson as divisional vice president of the Brown Instruments Division of MINNEAPOLIS-HONEYWELL REGULATOR COMPANY, New York City, and O. B. Wilson as general sales manager have been announced.