

EFFECT OF TYPE OF FAT ON STARCH PASTES CONTAINING GLYCEROL MONOSTEARATE¹

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ABSTRACT

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Studies with a Brabender Amylograph® showed that various types of oils had little or no effect on the viscosity of waxy maize pastes. Addition of various oils to starch-water-glycerol monostearate mixtures showed a characteristic viscosity peak at approximately 56° C during cooling of the gelatinized slurry.

The height of the cooling-curve peak was inversely related to the combined *trans* unsaturated fatty acid and saturated fatty acid content of the oil. These effects were apparently owing to the rate of crystallization of the saturated monoglyceride from the various types of oils at 56° C.

Considerable work has been reported on the effects of various lipids on starch gelatinization (1,2,3,4) and the combined effect of fats and surfactants (*e.g.*, monoglycerides) on starch cooking (5,6,7). Saturated monoglycerides have been shown to retard starch gelatinization by reacting within swelling granules or by reducing the rate of water absorption (8).

Increasing the concentration of triglycerides was found to progressively reduce the peak viscosity of corn starch (5). Surfactants added to starch-water-fat mixtures increased the temperature of pasting and altered the shape of the cooling curve. The effect of fat type on the shape of the cooling curve was not reported.

Starch-based foods containing surfactants usually also contain fats. In this study the Brabender Amylograph was used to study the combined effect of lipid-monoglyceride on starch gelatinization. Particular attention was given to the shape of the viscosity curve during cooling after gelatinization.

MATERIALS AND METHODS

The glycerol monostearate was obtained from a single lot of commercially available 90%-distilled monoglyceride (Eastman Chem. Prod. Inc., Kingsport, Tenn.). The starch was commercially available waxy maize starch (A. E. Staley Mfg. Co., Decatur, Ill.). The fats were refined and deodorized peanut oil, hydrogenated soybean oil (59.7, 85.7 I.V.), a solvent-fractionated vegetable oil, coconut oil (1.0, 8.5 I.V.), and palm kernel oil.

Slurries were prepared using 7% starch in distilled water. The total volume was maintained at 445 ml and the ratio of starch to water held constant. The starch slurries were heated to 45° C in a water bath prior to addition of the oil (3.4%). The glycerol monostearate was added to the oil. The viscosity was determined on a Brabender Amylograph (75 rpm, 700 cm-g cartridge). The slurries were heated from 50° to 95° C, held 10 min at 95° C, and cooled to 50° C. All oils used had melting points below 50° C.

¹The delay in accepting this paper was caused by the loss of the manuscript in the mail.

²Presently at A. E. Staley Mfg. Co., Decatur, Ill.

RESULTS AND DISCUSSION

The viscosity curves of the waxy maize starch and waxy maize starch-water-glycerol monostearate slurries are presented in Fig. 1. The monoglyceride increased the temperature of maximum viscosity as previously reported (5), and exhibited a characteristic viscosity peak at approximately 56°C during the cooling cycle. Addition of various types of oils to a starch slurry showed little or no effect on the maximum viscosity during the heating or cooling cycle.

The type of oil added to starch glycerol monostearate slurries showed only minor differences in the maximum hot-paste viscosity (Table I). All oils decreased the maximum viscosity approximately 180 BU. Upon cooling the monoester-starch-oil slurries to 50°C, a viscosity increase occurred at

TABLE I
Effects of Various Oils on the Maximum Viscosity of 7%
Waxy Maize Starch Pastes with or without Glycerol Monostearate

Additive	Temperature of Max. Viscosity °C	Viscosity BU
Control	77	710
0.27% Glycerol monostearate (GMS)	80	910
Peanut oil	76	740
Coconut oil (1.0 I.V.)	77	720
Solvent-fractionated domestic oil	77	720
Peanut oil + 0.27% GMS	77	740
Solvent-fractionated domestic oil + 0.27% GMS	78	740
Coconut oil (1.0 I.V.) + 0.27% GMS	77	740

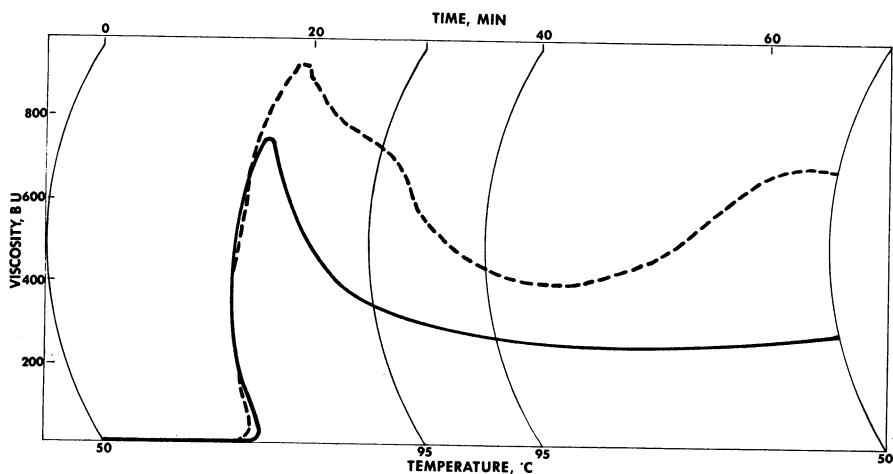


Fig. 1. Amylograph viscosity curves of 7% waxy maize starch paste with (- -) and without (—) 0.27% glycerol monostearate.

approximately 56°C and its magnitude was dependent on the type of oil (Fig. 2).

The fatty acid composition of the various oils is presented in Table II. The nearly saturated oils exhibited a near absence of the viscosity increase whereas the most unsaturated oils had the highest increase in viscosity. The saturated oils contained predominantly lauric acid. Saturated oils of longer chain length were not used because their melting points (65° to 70°C) were higher than the temperature of peak viscosity during the cooling cycle (54° to 56°C).

Partially hydrogenated vegetable oils showed an intermediate effect on the

TABLE II
Fatty Acid Composition of the Various Types of Oils

	Solvent-		Coconut Oil	Coconut Oil	Palm Kernel	Soybean Oil	Soybean Oil
	Peanut Oil	Fractionated Oil	(8.5 I.V.)	(1.0 I.V.)	Oil (0 I.V.)	(85.7 I.V.)	(59.7 I.V.)
^a C 6:0			0.8	0.7	0.2		
C 8:0			8.7	8.5	4.1		
C 10:0			6.4	6.4	3.9		
C 12:0			47.0	47.4	49.1		
C 14:0	0.1		17.6	17.3	14.7	0.1	0.1
C 16:0	11.6	16.2	8.4	8.5	8.0	10.7	10.8
C 18:0	3.1	17.1	2.5	9.8	17.5	4.9	22.4
C 18:1	46.5	63.3	6.3	1.0	1.2	67.9	62.9
C 18:2	31.4	1.3	1.5	0.1	1.0	14.5	3.0
C 18:3	1.5					0.8	0.1
C 20:0					0.3	0.5	0.3
C 22:0	3.0					0.2	0.2
% Trans	0	45.0	0	0	0	33.9	34.9

^aIndicates carbon number and number of double bonds present.

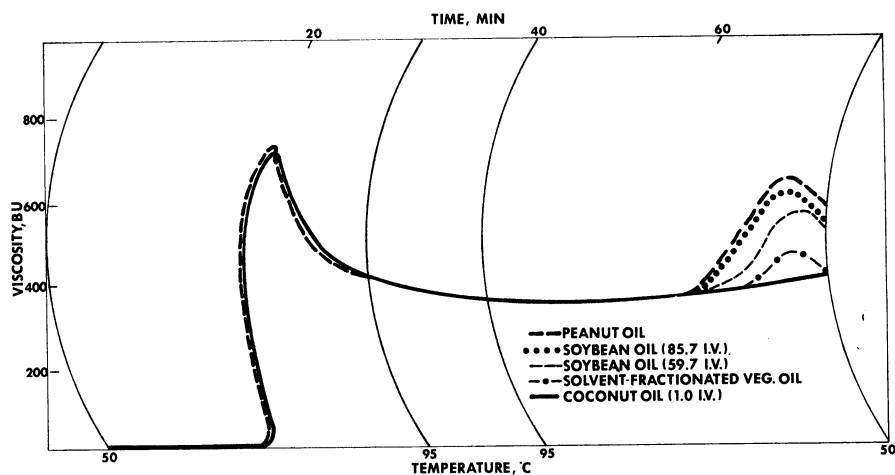


Fig. 2. Effect of various oils on amylograph viscosity curve of 7% waxy maize starch pastes containing 0.54% glycerol monostearate.

cooling curve peak. Two oils with similar iodine values, an indication of the degree of unsaturation, exhibited a considerable difference in their repression of the cooling-curve viscosity peak. Osman and Dix (5) reported that a hydrogenated oil, with an iodine value of 38, affected starch-paste viscosity. The hydrogenated oils used in this study had higher iodine values. However, the iodine value does not fully characterize hydrogenated oils (9). Various degrees of selectivity can occur during hydrogenation that are primarily catalyst-dependent. Isomerization of unsaturated fatty acids from the *cis* to the *trans* configuration can occur dependent on hydrogenation conditions (temperature, pressure, etc.). *Trans* unsaturated fatty acids possess a linear configuration as opposed to the angular *cis* form and they behave sterically similar to fully saturated acids, but have a lower melting point. An inverse relation (regression coefficient = 0.995) was found between the combined *trans* fatty acid and saturated fatty acid content of the oils (Table II) and the magnitude of the cooling-curve viscosity peak.

TABLE III
Time for Crystallization of the Monoglyceride from Various Oils

Oil	Crystallization Time min
Peanut oil	0.75
Soybean oil (85.7 I.V.)	2.75
Soybean oil (59.7 I.V.)	2.75
Solvent-fractionated oil	3.0
Coconut oil	7.0
Palm kernel oil	7.0

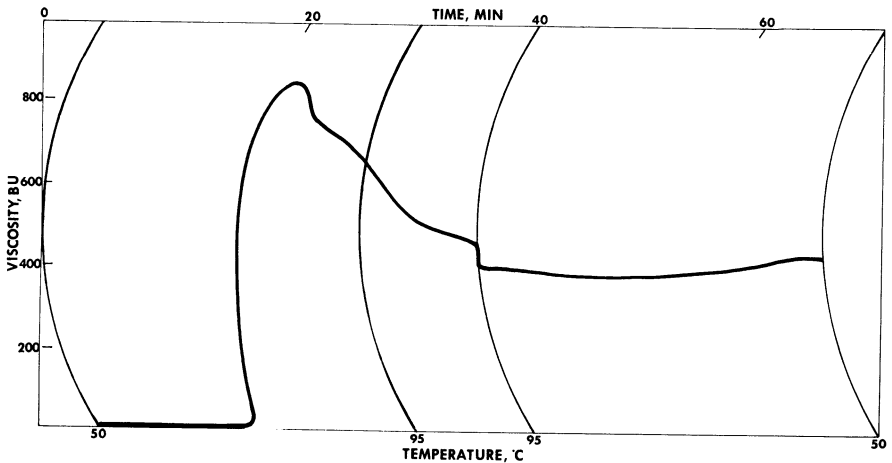


Fig. 3. Effect of addition of solvent-fractionated vegetable oil on amylograph viscosity curve of 7% waxy maize starch paste containing 0.27% glycerol monostearate after heating to 95°C.

The effect of oil type on the cooling-curve viscosity of starch monoglyceride slurries could result from either a preferential oil absorption by the starch excluding the monoglyceride, or differences in the availability of the monoglyceride because of preferential association with particular oils. If a preferential oil-starch absorption occurred, addition of a fully saturated or high *trans* oil to a fully complexed starch monoglyceride slurry should have no cooling-curve viscosity effect on the complexed starch monoester slurry. The addition at 95°C of a solvent-fractionated oil (45% *trans*) showed nearly complete repression of the cooling-curve viscosity peak (Fig. 3), indicating nonpreferential oil absorption by the starch.

The effect of oil type on the availability of the saturated monoglyceride was related to the time required for the monoglyceride to crystallize from the oil upon cooling from 95° to 56°C (Table III). Further work is required, however, to establish the effect of closely related oil types on the crystallization rate of monoesters from oils and on the solubility of saturated monoesters in various oils.

Literature Cited

1. GRAY, V. M., and SCHOCK, T. J. Effects of surfactants and fatty adjuncts on the swelling and solubilization of granular starches. *Stärke* 14: 239 (1962).
2. YASUMATSU, K., and MORITAKA, S. Changes of characteristics of starch during gelatinization in the presence or absence of fatty acid. *J. Food Sci.* 29: 198 (1964).
3. MEDCALF, D. G., YOUNGS, V. L., and GILLES, K. A. Wheat starches. II. Effect of polar and nonpolar lipid fractions on pasting characteristics. *Cereal Chem.* 45: 88 (1968).
4. LEACH, H. W. Gelatinization of starch. In: *Starch: Chemistry and technology*, ed. by R. L. Whistler and E. F. Paschall, Vol. 1. Academic Press: New York (1965).
5. OSMAN, E. M., and DIX, M. R. Effects of fats and nonionic surface-active agents on starch pastes. *Cereal Chem.* 37: 464 (1960).
6. YASUNAGA, T., BUSHUK, W., and IRVINE, G. N. Gelatinization of starch during bread-baking. *Cereal Chem.* 45: 269 (1968).
7. JACKSON, G. R., and LANDFRIED, B. W. The effect of various glycerides on the baking properties of starch doughs. *Cereal Chem.* 42: 323 (1965).
8. LONGLEY, R. W., and MILLER, B. S. Note of the relative effects of monoglycerides on the gelatinization of wheat starch. *Cereal Chem.* 48: 81 (1971).
9. SWERN, D. *Bailey's industrial oil and fat products* (3rd ed.). Interscience: New York (1964).

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