Note on the Relative Effects of Monoglycerides on the Gelatinization of Wheat Starch[1]

R. W. LONGLEY[2] and B. S. MILLER, General Mills, Inc., Minneapolis, Minnesota 55427

It has been reported that polar surfactants react with amylose to form complexes, thereby altering the physical properties of starch paste. There is some dispute, however, whether the formation of an amylose complex is solely responsible for the effect of surfactant on the rate of starch gelatinization or whether other factors are involved (1).

Although it has been established that surfactants differ in their relative effectiveness to complex with starch, the reasons for this difference are not clearly understood. Osman et al. (2) reported that the effectiveness of those compounds containing a single hydrocarbon chain (as measured by their ability to reduce the iodine affinity of amylose) appears to be related to the percentage of the hydrocarbon portion of the molecule.

The purpose of this study was to investigate the relative effectiveness of a homologous series of saturated monoglycerides to retard gelatinization of soft wheat starch as measured by a light-transmission technique.

METHODS

The monoglycerides used in this study (glyceryl monobutyrate, -laurate, -myristate, -palmitate, -stearate, and -arachidate) were synthesized according to the method of Hartman (3) in which the isopropylidene derivative of glycerol was made prior to esterification with the appropriate fatty acid. The purity of all compounds was determined by thin-layer and gas chromatography and in all cases was found to be higher than 95%. Soluble carbohydrates were determined by an anthrone method (4).

A light-transmission technique was used to measure the changes which starch granules underwent while being heated in excess water. The method used (employing a gelatinizing chamber which contained 300 cc. of liquid) was similar to that of Cook and Axtmayer (5) but was modified to record temperature and transmittance simultaneously. Heating was controlled to give a temperature rise of 2°C. per min.

The light-transmission curves for a starch concentration of 300 mg. per 300 ml. of water were similar to those reported by Beckord and Sandstedt (6). The initial transmittance value was 25 to 30% and there was a straight-line relation between starch concentration and log transmittance. The variation in light transmission was ±1.5%.

When a monoglyceride was not readily dispersible in water at room temperature, it was mixed with water in a predetermined ratio and heated to 56°C. to produce a

[1]Journal Series No. 544.

[2]Present address: Mead Johnson, Evansville, Indiana 47721.

uniform dispersion. A measured amount of this dispersion was added to a starch suspension maintained at 53°C. The temperature of this aqueous starch and monoglyceride mixture was held constant for a short time to establish equilibrium before the gelatinization process was initiated.

RESULTS AND DISCUSSION

The effect of different monoglycerides (used at a concentration of 10 mg. per 300 mg. of starch) on percent transmittance is illustrated in Fig. 1. There was no significant effect on transmittance when the fatty acid chain was below 12 carbon atoms in length. However, the transmittance was practically constant from 65° to 95°C. when glyceryl monoarachidate was used and from 70° to 85°C. when glyceryl monopalmitate was added. The former, even at concentrations as low as 2 mg. per 300 mg. of starch, was effective in reducing transmittance (Fig. 2). Lower concentrations of glyceryl monomyristate and glyceryl monopalmitate were not as effective as the same concentration of glyceryl monoarachidate but still gave lower transmittance values than the control (without monoglyceride).

To relate transmittance data presented in Fig. 1 to the degree of gelatinization of starch, 2-ml. aliquots were removed from the gelatinizing chamber and centrifuged. The supernatant solution was analyzed for soluble carbohydrates using anthrone (4). The results of this analysis for the control and for the samples containing glyceryl monobutyrate and glyceryl monoarachidate are summarized in Table I. The addition of glyceryl monoarachidate resulted in a reduction in the concentration of soluble carbohydrates in the supernatant solution. Incorporation of glyceryl monostearate and glyceryl monopalmitate had a similar but smaller effect (not shown), whereas glyceryl monobutyrate showed no significant effect in reducing the concentration of soluble carbohydrates. The effectiveness of glyceryl

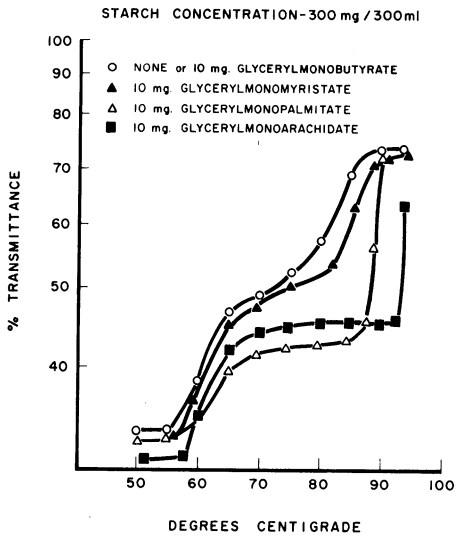

Fig. 1. Effect of different monoglycerides on the gelatinization of wheat starch.

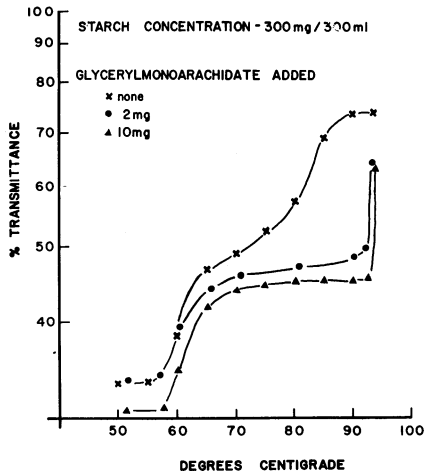

Fig. 2. Effect of different concentrations of glyceryl monoarachidate on the gelatinization of wheat starch.

monostearate was in this respect intermediate between that of glyceryl monopalmitate and glyceryl monoarachidate.

During the course of studies with concentrated monoglyceride systems, an opalescence was noted when monoglyceride was added to a solution of amylose. This suggested the possibility that the decrease in soluble carbohydrates (Table I) and the decrease in transmittancy produced by the addition of certain long-chain monoglycerides to a starch suspension might be due to the reaction of the added monoglyceride with amylose leached from the starch granule. The striking effects of glyceryl monoarachidate on transmittancy (Fig. 2) suggested a means for testing this theory. If the reaction occurred only outside the starch granule, the addition of glyceryl monoarachidate, after the release of soluble carbohydrate from the granule, would cause the transmittancy to decrease to approximately the same level as that obtained when the monoglyceride was added before the gelatinization process was initiated. Stated differently, if the decreased transmittancy were due

TABLE I. EFFECT OF MONOGLYCERIDES ON RELEASE OF SOLUBLE CARBOHYDRATES FROM GELATINIZING SOFT WHEAT STARCH GRANULES[a]

	Control		GMB[b] Added		GMA[c] Added	
Temperature	Soluble CHO mg./300 ml.	Percent of Total Solids %	Soluble CHO mg./300 ml.	Percent of Total Solids %	Soluble CHO mg./300 ml.	Percent of Total Solids %
60°C.	6.9	2.2	6.5	2.1	2.3	0.7
70°C.	9.9	3.1	9.1	2.9	6.1	2.1
80°C.	20.6	6.5	19.7	6.4	10.6	3.8
90°C.	53.4	18.0	57.4	19.4	14.5	5.4

[a]Initial concentration is 300 mg. of starch per 300 ml.

[b]Glyceryl monobutyrate, 30 mg.

[c]Glyceryl monoarachidate, 30 mg.

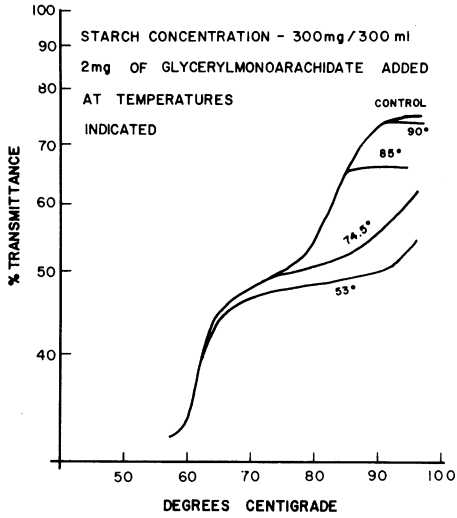

Fig. 3. Effect of glyceryl monoarachidate on starch gelatinization when the former is added to a starch suspension which was preheated to different temperatures.

only to extracellular reaction of amylose with the monoglyceride, then the time of addition of the lipid should have no effect on the final value. On the other hand, if the reaction site were only or mainly inside the starch granule, then the time of addition of the monoglyceride should be very important because of the insolubilization of the amylose still inside the granule and its resultant effect on the absorbance of the granule. Figure 3 points to the latter proposition, since the addition of glyceryl monoarachidate to preheated starch suspensions retards the increase in transmittance with increasing temperature but does not reduce the transmittance values to the level of those given by the sample to which monoglyceride was added below the gelatinization temperature. The widening difference between the transmittance temperature curves in Fig. 3 indicates that the greater the preheat-treatment of starch in water, the less effective is the monoglyceride in reducing the degree of starch gelatinization. This may possibly be due to variations in the relative amounts of water and monoglyceride absorbed by the starch granules as affected by variations in the time of addition of monoglyceride.

SUMMARY

Monoglycerides derived from long-chain fatty acids affect the gelatinization of starch, possibly through a reaction occurring within the swelling granules or through a reduced rate of water absorption by the monoglyceride-treated starch. The effect of this reaction is dependent on the length of the side chain and the concentration of the monoglyceride. The greater the preheat-treatment of starch in water before the addition of monoglyceride, the less effective the monoglyceride is in reducing the degree of gelatinization of starch.

Literature Cited

1. OSMAN, ELIZABETH M. Starch in the food industry. In: Starch Chemistry and Technology 2: 163 (1967).
2. OSMAN, ELIZABETH M., LEITH, SANDRA J., and FLES, MELITA. Complexes of amylose with surfactants. Cereal Chem. 38: 449 (1961).
3. HARTMAN, L. Preparation of alpha monoglycerides by a modified isopropylidene glycerol method. Chem. Ind. (London) 711 (1960).
4. CARROLL, N. V., LONGLEY, R. W., and ROE, J. H. The determination of glycogen in liver and muscle by use of anthrone reagent. J. Biol. Chem. 220: 583 (1956).
5. COOK, D. H., and AXTMAYER, J. H. Determining the gelatinization temperature of starches. A photoelectric method. Ind. Eng. Chem. (Anal. Ed.) 9: 226 (1937).
6. BECKORD, O. C., and SANDSTEDT, R. M. Starch gelatinization studies. Simplified equipment for the study of starch gelatinization by means of light transmission. Cereal Chem. 24: 250 (1947).

[Received June 4, 1970. Accepted September 18, 1970]