Food Science and Technology Notes

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FUNCTIONS OF GUMS USED IN ICE CREAM ARE STUDIED

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A number of gums such as carboxymethylecellulose (CMC), carrageenin, locust bean gum and alginates are commonly used in ice cream as stabilizers. Their functions are to reduce the amount of free water in the mix, insure that the ice crystals formed on freezing are small and prevent the growth of already formed ice crystals on warming and refreezing. To accomplish these functions, a stabilizer may take up water as water of hydration, produce a gel structure throughout the mix, or react with certain milk constituents to form water absorbing substances. Each gum has characteristic properties of its own which are of value to the ice cream maker.

The most widely utilized source of carrageenin is Irish moss (Chondrus crispus and Gigartina stallata). The gum is a strongly charged, sulfate containing polyelectrolyte which is unique in its ability to react with milk proteins. It produces marked increased in viscosity when used in very low concentrations.

CMC is commonly used in the dairy industry in the form of its more soluble salt, sodium carboxymethylcellulose. It may be manufactured by reacting sodium monochloroacetate with alkali cellulose. When used alone, CMC causes whey separation in the mix but this can be prevented by the addition of a small quantity of Irish moss. It has excellent water absorptive properties.

Algin is produced from kelp which grows on both the Atlantic and Pacific coasts. It is usually marketed in one of its more soluble forms such as -odium alginate or an organic ester of alginic acid. Alginates produce high, immediate viscosities at relatively low concentrations.

Locust bean gum is prepared from the de-hulled bean or endosperm of the carob bean tree, which is grown principally in the Mediterranean area. It is a complex carbohydrate polymer of galactose and mannose. It is generally used in conjunction with Irish moss extracts or prevent whey separation.

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Effects of Heat Treatment

A study was made to determine the effect of heat treatment on the viscosity of a number of systems containing these gums. The heating was done in a Mallory small tube heat exchanger as described previously in the December 21 issue of ICE CREAM WORLD. The gums were used at the following levels, expressed as percent of gum in the water portion of the system:

Carrageenin (roller dried Irish moss extract), 0.04 percent; CMC (high viscosity, coarse powder, with 70 percent of glucopyranose units substituted), 0.16 percent; locust bean gum (regular commercial product), 0.14 percent; and algin (commercial product, Dariloid XL, high strength), 0.373 percent.

Systems containing milk fat were preheated to 140 degrees F, and the gums were incorporated just before homogenization. In the absence of fat, the gums, with the exception of algin, were incorporated at room temperature and the systems were not homogenized. Algin required preheating to 120 degrees F. The gums were sprinkled on the surface with vigorous agitation continued for at least 15 minutes to effect solution. Viscosities were determined at 40 degrees F by means of a Hoppler viscosimeter after reducing the apparent viscosity by passage through a hand emulsifier. Results are shown in Tables 1 to 8.

Both CMC and locust bean gum containing milk systems exhibited syneresis (wheying off). The extent of syneresis decreased as the temperature to which the system was heated increased. In the case of CMC containing systems, practically no wheying off was observed when a heating temperature of 290 and 305 degrees F was employed.

No strong evidence was found on degradation of the gums by heat treatment in aqueous solution, and, conversely, increasing heat treatment did not improve the effectiveness of the gums. Only locust bean gum solutions had a higher viscosity following progressively increasing heat treatment, possibly due to better solubility at elevated temperatures. Carboxymethylcellulose solutions, on the other hand, showed slight decreases in viscosity following increasing heat treatment, but the small magnitude of the change makes it of doubtful significance.

Nearly all milk systems containing gums exhibited greater increases in viscosity as a result of previous heat treatment than would have been anticipated from consideration of the same systems without gums (see December 21 issue of ICE CREAM WORLD), and the viscosities of the aqueous solutions of the gums. This would indicate that an inter-action was taking place between the gums and the milk constituents. In some cases, the extent of the inter-action was increased by more intense heat treatment.

Milk salts had a depressing effect on the viscosity of the systems containing CMC, carrageenin, and locust bean gum at all temperatures studied. It is to be noted that the viscosities of CMC containing skimmilk and whole milk systems were actually lower than those of the aqueous solution of CMC. This, apparently, anomalous behavior can be attributed to the effect of milk salts.

The milk systems containing carrageenin showed considerable evidence of inter-action with milk proteins. Since this effect was not observed in the sodium caseinate suspension, there is an indication that this is a reaction of a specific colloidal system of the proteins. The reaction was found to be dependent on the degree of heat treatment which the system received.

The data presented here are not intended to imply that viscosity measurements represent the only or even the best test for evaluating the properties of gums used in ice cream. It would be highly desirable to study the bound water content or the size of ice crystals formed under controlled conditions.

Such tests should be developed as they would offer a more direct measurement of a gum's performance potential in ice cream. On the other hand, viscosity measurements also furnish useful information, particularly where they indicate changes as a result of variations in technological processes. A thorough study of the results presented in this paper and their implications should lead to a better understanding of the functions of gums in ice cream.

Table 1.
Effect of heat treatment on the viscosity of water suspension of gums.

Gum	Viscosity following heat treatment to (°F) 200	230	260	275	290	305
	(centipoises)					
Carrageenin	3.7	3.7	3.8	3.7	3.8	3.8
CMC	14.4	14.0	14.1	14.1	13.9	14.0
Locust Bean Gum	7.5	8.4	8.4	8.6	8.0	-
Algin	3.3	3.3	3.3	3.3	3.3	3.3

Table 2.
Effect of heat treatment on viscosity of 15% sucrose solution containing gums.

Gum	Viscosity following heat treatment to (°F) 200	230	260	275	290	305
	(centipoises)					
Carrageenin	7.5	6.8	7.0	6.5	6.7	6.4
CMC	21.8	22.2	22.5	22.0	22.6	20.9
Locust Bean Gum	10.3	11.3	12.4	12.9	12.9	13.3
Algin	6.0	5.9	5.9	6.0	5.9	5.9

Table 3.
Effect of heat treatment on the viscosity of skimmilk containing gums.

Gum	Viscosity following heat treatment to (°F) 200	230	260	275	290	305
	(centipoises)					
Carrageenin	4.8	5.6	7.4	8.8	10.4	10.5
CMC	10.6	11.5	11.9	12.0	12.1	12.6
Locust Bean Gum	14.0	13.8	14.2	14.8	15.4	15.6
Algin	9.9	10.2	10.1	10.4	10.6	11.0

Table 4.
Effect of heat treatment on the viscosity of whole milk containing gums.

Gum	Viscosity following heat treatment to (°F) 200	230	260	275	290	305
	(centipoises)					
Carrageenin	6.6	6.7	8.7	11.2	12.7	13.3
CMC	12.7	12.8	13.3	14.7	14.3	13.8
Locust Bean Gum	13.9	14.3	14.7	15.6	16.6	17.0
Algin	13.4	13.6	13.1	14.2	14.4	15.5

Table 5.
Effect of heat treatment on the viscosity of a simulated solution of milk salts containing gums.

Gum	Viscosity following heat treatment to (°F) 200	230	260	275	290	305
	(centipoises)					
Carrageenin	2.5	2.5	2.4	2.5	2.5	2.5
CMC	9.6	10.2	10.0	10.4	10.2	10.4
Locust Bean Gum	6.4	7.4	7.3	8.1	7.6	7.6
Algin	3.4	3.4	3.3	3.3	3.2	3.2

Table 6.
Effect of heat treatment on the viscosity of a sodium caseinate suspension containing gums.

Gum	Viscosity following heat treatment to (°F) 200	230	260	275	290	305
	(centipoises)					
Carrageenin	5.2	5.1	5.1	5.0	5.1	5.1
CMC	11.7	12.4	12.3	12.3	12.2	12.3
Locust Bean Gum	11.9	13.6	13.4	14.9	14.5	15.0
Algin	5.7	5.9	5.8	5.8	5.8	5.7

Table 7.
Effect of heat treatment on the viscosity of an ice milk mix[(1)] containing gums.

Gum	Viscosity following heat treatment to (°F) 200	230	260	275	290	305
	(centipoises)					
Carrageenin	19.4	20.6	35.6	59.7	49.9	47.5
CMC	37.8	37.8	43.0	56.4	54.4	57.3
Locust Bean Gum	31.6	32.2	39.5	48.5	53.0	51.4
Algin	39.0	40.0	58.0	64.2	69.3	68.5

(1) 5% fat, 14% serum solids, 12% sucrose and 6% high enzyme converted corn syrup.

Table 8.
Effect of heat treatment on the viscosity of an ice cream mix[(1)] containing gums.

Gum	Viscosity following heat treatment to (°F) 200	230	260	275	290	305
	(centipoises)					
Carrageenin	22.6	26.6	28.4	64.5	47.0	46.9
CMC	44.6	47.9	49.0	59.3	53.9	52.8
Locust Bean Gum	39.1	40.4	45.3	55.4	51.3	52.3
Algin	67.4	64.7	71.8	67.1	79.4	80.0

[(1)] 12% fat, 11% serum solids, and 15% sucrose