EVALUATION OF MILK CARAMELS CONTAINING HYDROLYZED LACTOSE

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ABSTRACT

Several properties of milk caramels containing either hydrolyzed lactose (HL), hydrolyzed sweet whey (HSW), or invert sugar were evaluated. Control caramels containing none of these humectants were also evaluated. Caramels containing 5 and 10% invert sugar or 86% HL had comparable hot spread indices, properties of reducing sugar crystallization during storage, and taste and texture panel acceptabilities. However, caramels made with invert sugar were more compressible than those made with HL. On extended storage, both types of caramels resisted moisture losses at 25 and 40% relative humidities, which was predictable from their equilibrium relative humidities (ERH). Caramels made with 5 and 10% hydrolyzed lactose (90%) as HSW were inferior with respect to taste, texture and compressibility but had superior humectant properties as well as the property of reducing sugar crystallization rates. Although their initial taste and texture panel acceptabilities were good, control caramels had the highest ERH and dried out the most in storage at low humidities, causing excessive sugar crystallization. This study shows excellent caramels can be made containing 5 or 10% HL.

INTRODUCTION

SINCE THE SUPPLY of cheese whey (Groves, 1972) is projected to increase in the United States and profitable utilization is still a challenge, continued whey and whey component utilization research is needed. Webb (1966) showed that, with proper formula modifications, cheese whey can be used in fudge and caramels. Alikonis (1972) reported on the making of caramels employing cheese whey and soy protein.

Although sugar prices are now moderately low and stable, their instability and upward spiralling in 1974–1975 stimulated interest in alternative lower priced sugar systems, particularly for their high-level use in caramel manufacture. Lactose, or milk sugar, constitutes about 50% of the solids of skim milk and 66–75% of the solids of cheese whey. It is readily crystallized from whey in the hydrate form, but its low solubility and sweetening power limit its utilization. However, it can be readily hydrolyzed to the sweeter and more soluble glucose and galactose. This paper reports an evaluation of hydrolyzed lactose (HL) sirups and their capacity to control sucrose crystallization in stored caramels.

MATERIALS & METHODS

Ingredients

Lactose used for hydrolysis was obtained from a commercial source as the hydrate and was 99.8% pure. The milk caramel ingredients were as follows: One lot of commercial sweetened condensed whole milk of 50% carbohydrate, 9% fat, and 7% protein; Durkees brand Paramount C hard fat; 42% DE corn sirup solids; Nulomoline brand invert sugar; and Centrophil L Lecithin (Central Soya). Unsatled butter of 86% milk fat was used as a source of fat.

Equipment

The cooking equipment was fabricated from a Hobart C-10 mixer equipped with a 3-qt mixing bowl (Fig. 1). The mixer was welded onto a 6-in. open frame stant. A Dormeyer DF 2 BU French Fry Cooker (mounted on a lift jack) containing glycerol was used for cooking the caramel. A specially constructed paddle with Teflon scraping blades was used to scrape the inside of the bowl continuously during cooking. This was attached to a tapered rotating shaft in a fixed position. A flat paddle attached to a dual rotating shaft also mixed the batter during cooking.

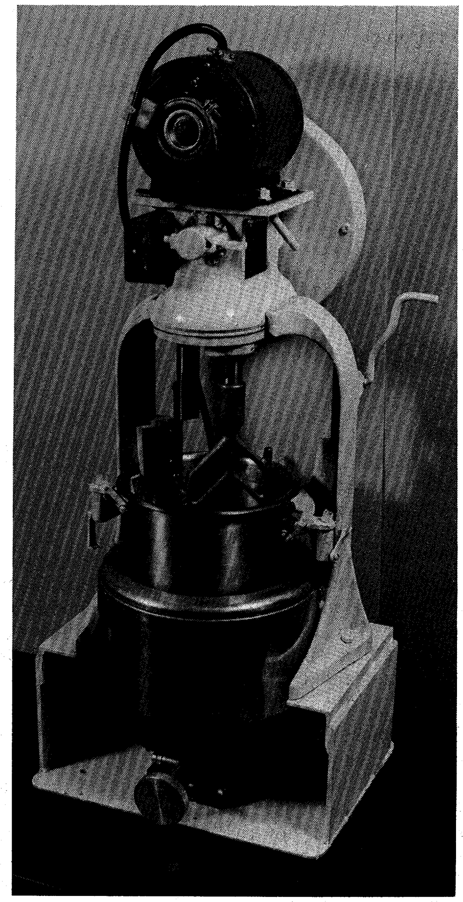

Fig. 1—Mixer caramel candy.

Preparative methods

Sirup Preparation. HL sirups were prepared by heating a 0.016N HCl solution containing 28.5% lactose hydrate for 4 hr at 121°C. Eighty-six percent hydrolysis was obtained. The sirup was decolorized with 1% charcoal and concentrated in vacuo to 59.5% total solids (Ramsdell and Webb, 1945). Portions of the sirup were neutralized to pH 5.6 (I) and pH 4.9 (II).

HL sweet whey. This material was prepared by the Dairy Foods Nutrition Laboratory at Beltsville, MD, with the addition of 0.3g *Saccharomyces lactis* lactase (Enzyme Development Corporation, New York, NY) per liter of milk. After incubation for 2 hr at 30°C, the milk was pasteurized at 77°C for 15 sec. Cheddar cheese was prepared from the HL milk and the whey was drained, pasteurized, and concentrated in vacuo to 65% total solids. Ninety percent of the lactose was hydrolyzed. The whey was stored frozen to prevent decomposition.

Caramel preparation. The milk caramel formula used is shown in Table 1. With each formula a 2000g portion was weighed out. After melting the hard fat and adding the other ingredients, the contents were stirred and brought to 55–60°C in a hot water bath to minimize the

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Table 1—Caramel formula

Ingredient	% Total solids	Parts
Sweetened condensed whole milk (SCM)	72	1000 (825)[a]
Corn sirup (42DE)	78	600
Sugar	100	200
Hard fat (Paramount C)	100	100
Humectant (5 or 10%)		
Invert sugar or	78	100
		200
Hydrolyzed sirup or	60	130[b]
		260[c]
Hydrolyzed sweet whey	65	160[a]
		320
Salt		4
Lecithin		3
Vanilla extract		8

[a] Protein in whey equivalent to that in 175 parts of SCM. Formula supplemented with 73 extra parts sugar, 16 parts butterfat and 17 parts lactose. Control caramel—no humectant.
[b] Sirup I
[c] Sirup II

Table 2—Evaluation of caramels made with 5% humectant

Type	Control[a]	Sirup I[b]	Invert[b]	Hydrolyzed[a] sweet whey
Mix moisture[c]	24.1	23.6	22.5	24.5
Min cooking time	22½	21¾	20½	23
% caramel moisture	9.22	9.07	9.04	8.89
Color[d]	0	2	1	1.5
Hot spread cm^2/g[e]	1.08b	1.02b	1.03	1.41a
Taste panel scores[e]				
	7.12bc	7.93a	7.43ab	6.43c
	7.21a	7.75a	7.50a	7.21a

[a] Represents averages of one batch of caramels—duplicate panel evaluations on different days
[b] Represents averages of two batches of caramels—single panel evaluations of each batch on different days
[c] Calculated
[d] Higher numerical value = darker color.
[e] Common letters—not significantly different (NSD) across at the 5% confidence level. No significance should necessarily be attached to letters of taste panel scores in vertical columns. One evaluation per batch (exception noted above in 1) as described in Methods.

temperature drop in the cooker. The cooker containing glycerol at 166°C was raised into contact with the bowl containing the pre-tempered candy batter and the mixer was started. The candy was cooked to a medium firm ball as judged exclusively by a stick test (118–119°C by thermometer). The cooker was then lowered and vanilla flavoring was added, the mixture was briefly stirred, the flat paddle was taken our, five portions were quickly removed with a ½-cup ladle, poured into greased and tared 8-in. diameter cake pans, and allowed to cool about 5 min. The radii of five circles of caramel batter were then measured. The circles of caramel were then weighed, removed, tightly rolled in a jellyroll fashion, molded by hand into a long rectangular-type piece, and cut across to form squares of caramels, which were then wrapped in moisture barrier Handi-Wrap.

Caramel quality evaluation methods

Spread. Spread of caramels was calculated in cm^2/g. The area in cm^2 was calculated from the radii of the circle or ellipse of poured caramel. Higher spread indices are associated with less desirable caramels.

Compression. Samples of hot caramel batter were placed in 2-in. diameter greased aluminum moisture dishes of 0.65-in. thickness. The dish and contents were cooled, wrapped, and stored 24 hr at 25°C. The compression drop (in inches) in 1 min was then measured with a Scott compression tester on duplicate 1-in. squares of caramel taken from the dish.

Taste and texture. Using the ERRC panel room taste facilities, each batch of caramels was evaluated for both taste and texture on a nine point hedonic scale preference test (Peryam and Pilgrim, 1957) by a panel of 13–16 judges. The judges, consisting of men and women employees of ERRC, although not experienced in evaluating caramels, had previous experience in taste panel evaluation of a variety of food products. The panel reproduced taste results for two samples within an average of 0.42 hedonic units between days and 0.10 units for texture scores. These averages were often time less than flavor score differences and most of the time less than texture score differences between samples of different formulations.

Color. Several caramels were selected, arbitrarily given scores of zero (light tan) to seven (dark brown), and mounted. When not used, the standards were stored at 6°C.

Equilibrium relative humidity (ERH). ERH values were determined at 23°C employing about 500 ml of 40.2, 42.4 and 45.2% H_2SO_4 solutions in sealed bell jars to obtain 56.5, 51.5, and 45.8% relative humidities (Landroch and Proctor, 1951). Between 13–17g samples of caramels were weighed on the analytical balance initially and after 1 and 2 days holding. Weight changes were calculated on the basis of a constant weight of caramel.

Storage of caramels. Triplicate samples of unwrapped caramels weighing from 13.5000–14.5000g were stored up to 6 months at 23°C in a 40% constant humidity room and in desiccator jars at 25% R.H. and weighed periodically. Weight loss was expressed on a percentage basis. Wrapped caramels were also stored at 23°C to observe the rate of sugar crystallization.

Analytical methods

Extent of hydrolysis. The extent of lactose hydrolysis in sugar solutions was measured by the procedure of (Tauber and Kleiner, 1932) for the determination of monosaccharides in the presence of lactose.

Moisture. The moisture content of caramels was determined by first weighing accurately 1.000g of caramel into tared aluminum moisture dishes. The sample was then dried to constant weight for 4–6 hr at 80°C at 28.5 in. vacuum. A standard deviation of ±0.062% moisture was obtained with duplicate weighings of caramels.

Total solids. The total solids (T.S.) of sirups were determined from refractive index (RI) measurements at 27°C. It was found that reliable T.S. values could be obtained when readings at this temperature were converted to the corresponding percent T.S. on the International Scale for sucrose solutions at 20°C. This was substantiated by toluene moisture determinations of solids in the sirups.

Statistical methods

Significance of differences in compression values was determined by the analysis of variance. Hot spread values were analyzed statistically using the formula

$$SD = \frac{2s\sqrt{a}}{\sqrt{n}}$$

where SD = significant differences; s = standard deviation; a = numerical rank apart in the array of data; and n = number of replications. The standard deviation for the above was estimated from ranges (Snedecor, 1959). Results on taste and texture were statistically analyzed by analysis of variance programmed on the ERRC computer.

RESULTS & DISCUSSION

HYDROLYZED LACTOSE (HL), hydrolyzed sweet whey (HSW), invert sugar or control caramels containing no humectant were prepared and evaluated using the caramel formula shown in Table 1. Five and 10% additions of humectants (basis of 78% solids) were added to the caramel mixes. Seventy-five percent of whey solids were carbohydrate. When whey was added, the sweetened condensed whole milk was reduced in the caramel formula by the same protein level as was added with 5% whey. However, the formula was supplemented with sugar, butterfat, and lactose to compensate for the amounts lacking due to the reduction in sweetened, condensed milk. No reduction of sweetened condensed milk or supplementation of sugar, butterfat, and lactose was made when the caramel was formulated with 10% hydrolyzed whey, thus producing a caramel with higher carbohydrate and protein compared to the caramel with 5% whey. The caramels made with 5% invert sugar of HL siryp I were not significantly different in the critical indices of taste and hot spread (Table 2). The caramels containing hydrolyzed sweet whey had the

Table 6—Average loss of moisture of caramels (5% humectants) stored 6 months at 40% relative humidity at 23°C

Sample	% Original moisture	% Moisture loss[a]
Control	9.22	1.40a
5% Sirup I	9.09	1.02b
5% Invert	8.80	0.83b
5% hydrolyzed whey	8.89	0.57c

[a] Common letters—not significantly different (NSD) at the 5% confidence level.

Table 7—Average loss of moisture of caramels (10% humectants) stored 6 months at 40 and 25% relative humidities at 23°C

Sample	% Original moisture	% Moisture loss[a] at	
		40% RH	25% RH
Control	8.85	0.98a	1.82a
10% Sirup II	8.99	0.72b	0.86b
10% Invert	8.80	0.62c	0.85b
10% Hydrolyzed whey	8.80	0.52d	0.78b

[a] Common letters—not significantly different (NSD) at the 5% confidence level for each % RH.

lactose. Sirups can be prepared by enzymatic hydrolysis of lactose (Guy, 1976) and should offer alternative means of preparing hydrolyzed lactose.

REFERENCES

Alikonis, J.J. 1972. Whey solids increasing use in confections. Proceedings of Whey Products Conference, Chicago, IL, June 14—15, 1972. ERRL Publication 3779.

Groves, F. 1972. An economic analysis of whey utilization. Proceedings of Whey Products Conference, Chicago, IL, June 14—15, 1972. ERRL Pulbication 3779.

Guy, E.J. 1976. Preparation and properties of hydrolyzed-lactose sirups. 71st Amer. Diary Sci. Asso. Meeting, Raleigh, NC, June 20—23, 1976.

Landrock, A.H. and Proctor, B.E. 1951. A new graphical interpretation method for obtaining humidity equilibrium data with special reference to its role in food packaging systems. Food Technol. 5: 332.

Peryam, D.R. and Pilgrim, F.J. 1957. Hedonic scale method for measuring food references. Food Technol. 11(9): 9.

Ramsdell, G.A. and Webb, B.H. 1945. Acid hydrolysis of lactose and preparation of hydrolyzed lactose sirup. J. Dariy Sci. 24: 677.

Snedecor, G.W. 1959. "Statistical Methods," 5th ed. Iowa State College Press, Ames, IA.

Tauber, H. and Kleiner, I.S. 1932. A method for the determination of monosaccharides in the presence of disaccharides and its application to blood analysis. J. Biol. Chem. 99: 249.

Webb, B.H. 1966. Whey—A low cost dairy product for use in candy. J. Dairy Sci. 49: 1310.

Ms received 8/8/77; revised 10/20/77; accepted 10/25/77.

Acknowledgment is given to F.B. Talley and J. Clark of the Engineering & Development Laboratory, Eastern Regional Research Center, for conducting organoleptic evaluations of the caramels.

Reference to brand or firm name does not constitute endorsement by the U.S. Department of Agriculture over others of a similar nature not mentioned.

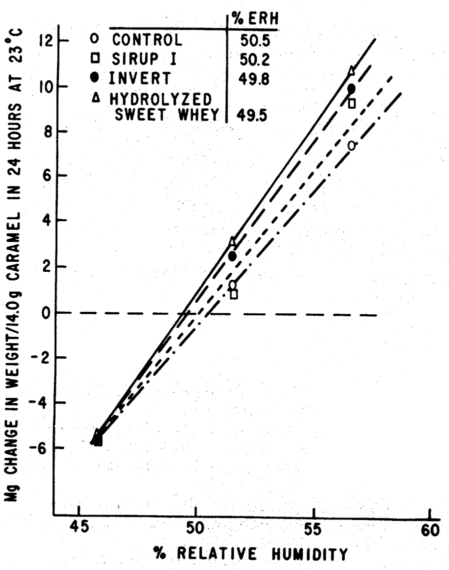

Fig. 4—Percent equilibrium relative humidity (ERH) at 23°C for 24 hours of caramels containing 5% humectants.

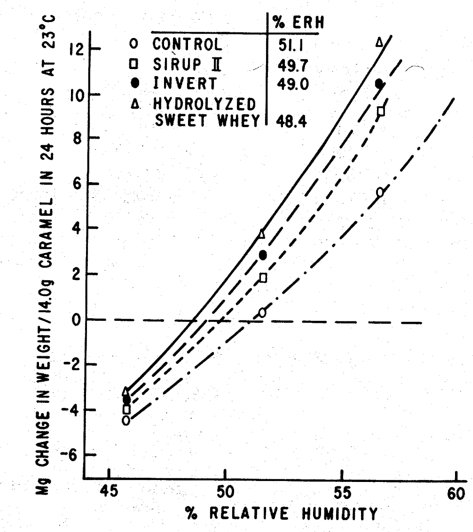

Fig. 5—Percent ERH at 23°C for 24 hours of caramels (lot I) containing 10% humectants.

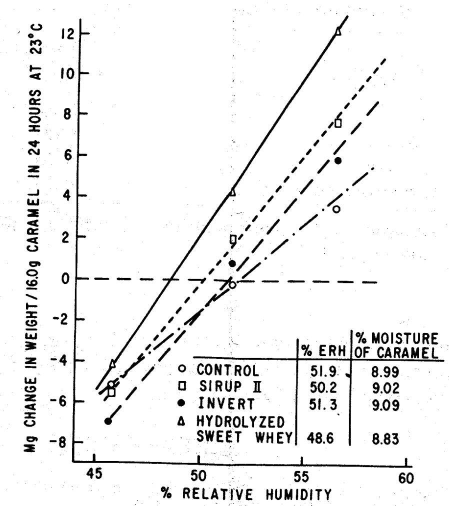

Fig. 6—Percent ERH at 23°C for 24 hours of caramels (lot II) containing 10% humectants. Moistures—control, 8.99%; invert, 9.09%; sirup II, 9.02%; hydrolyzed sweet whey, 8.83%.

the caramel with invert sugar was softer than either the control or the HL caramel.

Caramels containing humectants had a lower percentage ERH than the controls, and those with hydrolyzed sweet whey had the lowest percent ERH (Fig. 4 and 5). These same caramels were stored at 40% and 25% RH for up to 6 months at 23°C and showed predictable patterns with respect to moisture loss. Control caramels lost significanly more moisture than the others (Table 6 and 7). The caramels containing hydrolyzed whey lost the least moisture at 40% relative humidity. The fact that caramels with invert sugar lost slightly less moisture than caramels containing HL may be attributed to lower initial moistures. At relatively comparable moisture levels, the caramels with hydrolyzed lactose had even lower ERH than those containing invert sugar (Fig. 6). The effect of extended storage on these caramels was not determined.

All caramels containing humectants had less sugar crystallization in the surface areas of the rolled layers than the controls after storage for 2½ to 3 months at 23°C. The effect of crystallization is readily visible when the caramels are cut (white area, Fig. 7 and 8). The caramels varied in moisture from 8.80–9.28%. The control caramel in Figure 7 (9.22% moisture) and the control caramel in Figure 8 (8.85% moisture) had large amounts of crystallized sugar and indicated that crystallization of sugar is independent of moisture content in the range studied. Seventy-fold magnification of the cut surface revealed small aggregates of nonumiform type of crystals. Scrapings of this material melted at 170–178°C, near the melting point range of sucrose.

The poorer taste and texture qualities of caramels containing lactose-hydrolyzed whey was unexpected and probably due to the whey protein and salts added. These caramels did show excellent humectant properties and ability to retard crystallization of sucrose undoubtedly due to their hydrolyzed

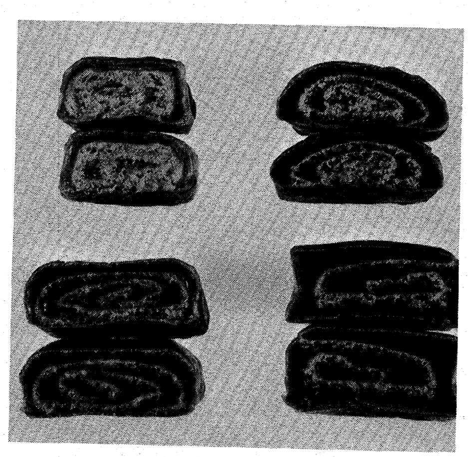

Fig. 7—Effect of 2½ months storage of caramels containing 5% humectants on the crystallization of sugar. Moistures: 2 control (upper left) 9.22%; invert (lower left) 9.28%; hydrolyzed sweet whey (upper right) 8.89%; and sirup I (lower right) 9.05%.

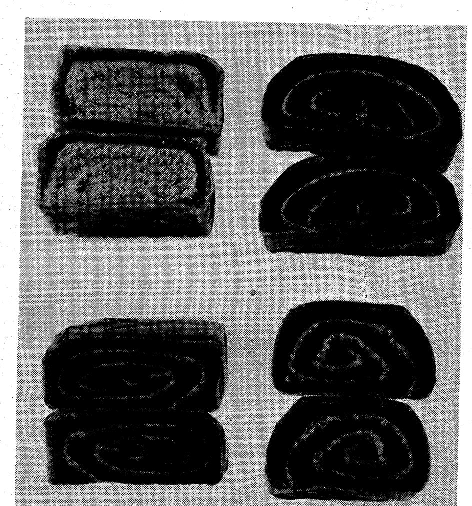

Fig. 8—Effect of 3 months storage of caramels containing 10% humectants on sugar crystallization. Moistures: 2 control (upper left) 8.85%; invert (lower left) 8.80%; hydrolyzed sweet whey (upper right) 8.80%; and sirup II (lower right) 8.99%.

Table 3—Average evaluations[a] of two batches of caramels made with 10% humectants

Type	Control	Sirup II	Invert	Hydrolyzed sweet whey
% Mix Moisture[b]	24.1	24.7	22.5	24.3
Min cooking time	22¾	24½	21½	25
% caramel moisture	8.93	9.01	8.94	8.82
Color[c]	1	3.5	2.5	3.5
Hot spread in cm^2/g[d]	1.05c	1.15b	1.17b	1.24a
Taste panel scores[d]	7.33a	7.13a	7.36a	5.82b

[a] One evaluation per batch as described under methods
[b] Calculated
[c] Higher numerical value = darker color.
[d] Common letters—not significantly different (NSD) at the 5% confidence level.

Table 4—Hedonic texture scores vs % moisture and compression values of caramels containing 5% humectants

Sample	Batch No.	% Moisture	Texture scores[a] Trial 1	Texture scores[a] Trial 2	Inches compression drop in 1 min[a]
Control	1	9.22	7.35a	7.25a	0.352d
Sirup I	1	9.05	7.42a		0.361c
	2	9.09		7.00a	0.360c
Invert	1	9.28	7.57a		0.394a
	2	8.80		6.93a	0.370b
Hydrolyzed sweet whey	1	8.89	6.07b	5.97b	0.331e

[a] Common letters—not significantly different (NSD) at the 5% confidence level in one line. No significance should necessarily be attached to superscripts of texture scores between trials.

significantly highest hot spread index and the lowest average taste acceptability (significantly lower in one instance). The cooking times were directly related to the mix moistures. All humectants intensified the color of the caramels.

Caramels made with 10% invert or hydrolyzed lactose sirup II were not significantly different in taste and hot spread (Table 3). The caramel made with hydrolyzed whey had both a significantly higher hot spread and lower taste acceptability than the other caramels. The 10% levels of added humectants significantly increased the hot spread index over that of the control with no humectant. The slightly darker color of the caramels made with HL sirup compared to that of the caramels containing invert sugar was undoubtedly caused by the longer cooking times necessitated by the higher moisture of these mixes. Mixes containing either invert sugar of HL sirup at 24.7% total solids yielded nearly comparable colors when heated for equivalent times (Fig. 2). Compression values for the higher moisture caramels were significantly higher than for those of lower moisture when the differences were 0.10% or more (Table 4 and 5). The caramels containing invert sugar were softest by the compression test although they did not have panel texture scores significantly different from those of the controls or those containing 5% HL sirup. The caramels containing 10% HL or control caramels did have lower average panel texture scores than those containing 10% invert sugar which were not consistently significantly different. However, caramels with hydrolyzed whey had significantly lower panel texture ratings and compression values.

Table 5—Hedonic texture scores vs % moisture and compression values of two batches of caramels containing 10% humectants

Sample	% Moisture	Texture scores[a] Batch 1	Texture scores[a] Batch 2	Inches compression drop in 1 min[a]
Control	8.99	7.11ab		0.356c
	8.86		6.57b	0.320d
Sirup II	9.03	6.82b		0.387b
	8.94		7.07ab	0.350c
Invert	9.09	7.70a		0.420a
	8.80		7.57a	0.385b
Hydrolyzed sweet whey	8.83	5.29c		0.335cd
	8.80		4.50c	0.320d

[a] Common letters—not significantly different (NSD) at the 5% confidence level in one line. No significance should necessarily be attached to texture scores between batches.

Figure 3 shows the effects of moisture content on compression values of caramels made with 10% invert sugar, 10% HL, and control caramels. In this experiment caramels were made with invert sugar or hydrolyzed lactose at 24.7% T.S. Duplicate samples were removed at timed intervals after cooking and placed in two inch diameter mositure dishes. The next day compression readings and moisture analyses were obtained on the wrapped caramels. At any one moisture level,

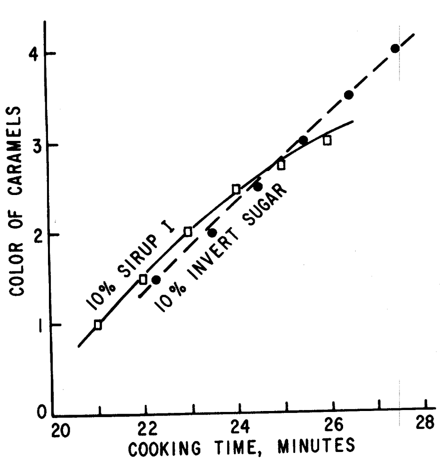

Fig. 2—Effect of cooking time on the color of caramels containing either invert sugar or hydrolyzed lactose sirup.

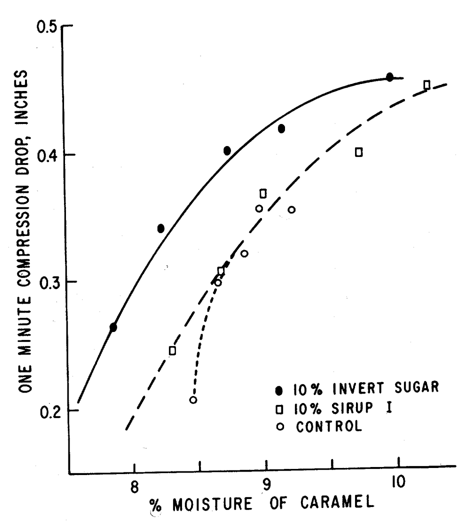

Fig. 3—Effect of moisture on the compression of caramels.