

Manufacture of Concentrated Milk and Honey Products^a

G. P. WALTON,^b AND JONATHAN W. WHITE, JR.,
Eastern Regional Research Laboratory^c

AND

B. H. WEBB, C. F. HUFNAGEL, AND A. H. STEVENS,
Bureau of Dairy Industry, Agricultural Research Administration, United States Department of Agriculture

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Concentrated milk and honey products of good storage stability were prepared including honey-sweetened condensed milks, evaporated milk fortified with honey, and dried honey-skim milk with 40 percent honey solids and 60 percent skim milk solids. Methods of manufacture and properties of the products are described.

INTRODUCTION

Milk and honey blend readily to form mixtures that appeal in flavor and palatability to many people. Mixtures of milk and honey are high in energy value and there is evidence that the normal honey acids may exert a favorable effect on the digestibility of the milk proteins (5, 7, 9).

Schlutz and Knott (9) found honey to be of unusual value when used as the carbohydrate component of infant diets. Honey was among the best of the carbohydrates with respect to the speed with which the sugars were assimilated, and it was the best carbohydrate with respect to the length of time a moderately high level of blood sugar was maintained. Also, the inclusion of honey in the diet was found "to have a definite beneficial influence upon the retention of calcium by young infants" (4).

Because of the unique food value of both milk and honey, and also because both products are produced in surplus quantities at times, the cooperative experiments reported herein were undertaken to devise methods of preparing mixtures of milk and honey which would be suitable for use in the manufacture of other foods. Earlier studies (1) by the Bureau of Dairy Industry had shown the possibility of combining milk and honey in a number of products. Emphasis was placed on the preparation of concentrated milk and honey products, since such products would provide a means of introducing the flavor and nutritive value of these ingredients into other foods with a minimum of processing losses.

As a result of these cooperative experiments, methods have been devised for preparing three types of concentrated products from milk and honey: (1) honey-sweetened condensed milk, (2) honey-evaporated milk, and (3) dried honey and milk mixtures. The manufacturing work was carried out on a pilot plant scale

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^b Retired December 31, 1949.

^c One of the laboratories of the Bureau of Agricultural and Industrial Chemistry, Agricultural Research Administration, United States Department of Agriculture.

using the experimental equipment available in the Dairy Products Research Laboratory of the Bureau of Dairy Industry.

The sweetened condensed and evaporated mixtures, which are made with whole milk, are considered especially useful in infant diets and in other special diets. The dried mixtures, which are made with skim milk, should be useful in food manufacture, especially to commercial and retail bakers, as a component of prepared dry mixes for baking, in fortified modified milk powders and concentrates, and in cocoa, beverage, dessert, and ice-cream mixes. It should also be useful in confectionery.

EXPERIMENTAL METHODS AND RESULTS

Honey-Sweetened Condensed Milk. Comparative batches of sweetened condensed milk were made with sugar and with honey as the preserving agents. Representative results are shown in Table 1. The honey-sweetened milks were high in honey flavor and, when proper manufacturing methods were used, the flavor was quite stable.

Thickening to the point of gelation (about 600 poises) during storage is a common defect in sweetened condensed milk. When the product is prepared from milk that has developed some acidity, the tendency toward thickening is increased. Batches made with normal honey thickened rapidly, but when the acidity of the honey was partially neutralized (batches 2 and 4 of Table 1) the tendency to thicken was greatly retarded.

Neutralization of the honey was done carefully, since over-neutralization was detrimental to the honey flavor. Pure, finely powdered calcium carbonate and tri-sodium phosphate proved to be the best agents for partially neutralizing the active acidity of the honey. The honey was diluted to a 60-percent sirup, an aqueous mixture or solution of the neutralizing agent was added, and the honey was then pasteurized to destroy the enzymes that produce objectionable changes in condensed milk during storage.

Since it is well known that dextrose in sweetened condensed milk promotes thickening, an abnormal increase in the viscosities of the honey-sweetened samples was expected. The difference in the viscosities developed by milks that contain honey and sugar is shown in Figure 1.

Milk subjected to high-temperature short-time forewarming before it is concentrated produces a sweetened condensed milk of lower viscosity than when normal forewarming treatment at a temperature below 200° F. (93° C.) is used (15). In Table 1 and Figure 1, comparison of the batches of milk forewarmed at 180° and 240° F. (82° and 116° C.) shows that the higher temperature retarded thickening in both the control and honey-sweetened samples.

Honey-sweetened condensed milk may be manufactured by adding 22½ pounds of honey to 100 pounds of milk. The milk should be forewarmed at 240° F. (116° C.) for 30 seconds and drawn into the vacuum pan. The honey should be partially neutralized to pH 5.8 and pasteurized at 170° F. (77° C.) for 20 minutes, then drawn into the vacuum pan following the milk. After concentration to about 72 percent solids (sugar ratio >60; see footnote e, Table 1), the product should be cooled and agitated to crystallize the lactose, using the normal treat-

TABLE 1

Characteristics of Sweetened Condensed Milks Made With Sugar and with Honey, When the Forewarming Temperature was 180° or 240° F.^a

Sample No.	Carbohydrate added	Forewarming conditions		Composition of finished product					Physical characteristics			Storage time required to develop viscosity of 600 poises		
		Temp.	Time	Total solids	Fat	Honey sugars	Sucrose	Sugar ratio ^e	Reaction	Refractive index	Viscosity at 86° F after 1 day	60° F. [†]	70° F. [†]	86° F.
		° F.	Min.	%	%	%	%	%	pH	n _D ²⁰	Poises	Days	Days	Days
1	Sugar	180	10	72.5	12.0	None	42.1	60.5	6.30	1.4623	83	265	131	44
2	Honey	180	10	71.1	12.4	39.8	None	57.9	6.00	1.4602	154	73	36	12
3	Sugar	240	0.5	72.6	12.0	None	42.2	60.7	6.21	1.4636	17	1,200	610	196
4	Honey	240	0.5	72.0	12.5	40.3	None	59.0	6.00	1.4623	17	465	232	76

^a Each batch was made with 100 pounds of milk and 22.6 pounds of honey or 18 pounds of sugar. The honey contained 15.67 percent moisture and was a blend of 2 parts sweet clover and 1 part California white sage. The reaction of the honey was pH 3.8 and it contained the equivalent of 13.1 ml. of normal acid per kilogram. Before the honey was added to the forewarmed milk it was nearly neutralized by the addition in solution of 2.312 grams of Na₃PO₄ · 12 H₂O per kilogram of honey. The honey was then pasteurized at 170° for 20 minutes.

^e Sugar ratio = $\frac{\text{sugar}}{\text{sugar} + \text{water}} \times 100$. [†] Calculated values.

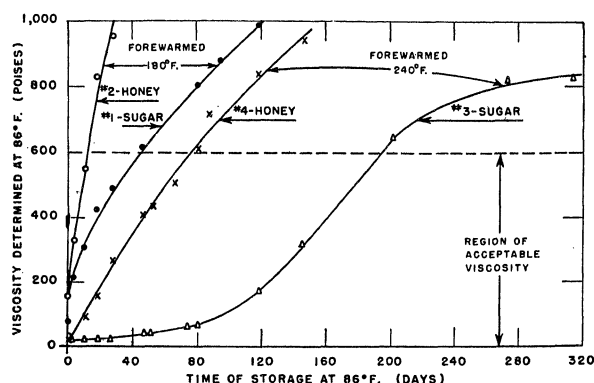


FIG. 1. The effect of forewarming milk to 180° F. (No. 1 and No. 2) and to 240° F. (No. 3 and No. 4) upon the storage viscosity of sweetened condensed milks made with sugar (No. 1 and No. 3) and with honey (No. 2 and No. 4).

ment for sweetened condensed milk. Honey-sweetened condensed milk should be packaged in airtight containers to retard mold growth. When it is held below 70° F. (21° C.) it will remain in satisfactory condition for 5 to 6 months. It should be emphasized that the viscosity of sweetened condensed milk increases logarithmically with increases in storage temperature and arithmetically with increases in storage time (16).

Several batches of honey-sweetened condensed milk were manufactured by following a process described by Ramsdell and Webb (8) for sugar-sweetened condensed whey. Honey and whey were condensed together to produce a concentrated mixture containing 38.5 percent each of honey and whey solids. The reaction of the mixtures was about pH 5.36. Neutralization of the honey was not necessary. Concentrated honey-whey mixtures showed good storage stability, since they contained no casein. Casein is the milk constituent largely responsible for thickening of sweetened condensed milk. Honey-sweetened condensed whey would be useful in food manufacture where concentrated forms of whey and honey are needed.

Honey-Evaporated Milk. Canned, evaporated milks, modified for infant feeding by inclusion of various carbohydrates, have attained some commercial importance.

The composition and characteristics of some evaporated milks made with various quantities of added honey are shown in Table 2. The quantity of honey added to the milk had a marked effect on the viscosity of the milk after sterilization. Neutralization of the honey before it was added to the concentrated milk appeared to be unnecessary for the milks used in this experiment. Partial neutralization of the honey might be helpful in the case of milks of unusually low heat-stability. However, stabilization of milk samples 1-6 in Table 2, with the usual disodium phosphate, was a more effective method of adjusting the heat stability than by neutralizing the honey.

The storage stability of evaporated milks that contained honey was excellent, except for changes in color. The color of

the samples that contained honey darkened more rapidly than did that of the controls.

Since the proportion of honey to milk solids was much lower in the evaporated than in the sweetened condensed samples, there was less honey flavor in the evaporated milks. Some of the heat sensitive components of the honey flavor may have been lost in the sterilization treatment to which the evaporated milks were subjected.

Viscosity of the milk and size of the fat globules largely determine the degree of separation that will occur in evaporated milks held in storage at constant temperature. Samples shown in Table 2 that contained honey were of a higher viscosity than the controls (no honey) and showed less fat separation during storage. Milks 5 and 6 (Table 2) containing the quantity of milk solids normal in evaporated milk plus 8 percent honey had a very heavy body and these were remarkably stable during storage.

These experiments on honey-flavored evaporated milk suggest the possibility of preparing a sterile honey-flavored beverage milk having somewhat lower milk solids content than evaporated milk. Such a product might be patterned after a recently described caramel-flavored sterilized milk which contained about 22 percent total solids (14).

Dried Honey-Milk Mixtures

Honey technologists have long recognized that a dehydrated honey would be useful in food manufacture. A moisture-free honey is especially adapted to the preparation of packaged dry mixes and to the production of confections. The heat treatment required to boil off undesired water in candy manufacture is injurious to delicate honey flavors. The preparation of a satisfactory dried honey has thus far been found impossible because of the high levulose content of honey. Accordingly, part of the work of this project was directed toward production of a dried honey-milk mixture. Whole milk was used in some of the experiments and with it products of excellent flavor were produced. But the whole milk-honey mixtures have the same package requirements as dried whole milk. Gas packing is needed to retard rapid development of a tallowy flavor. Since food manufacturers can find convenient sources of milk fat, emphasis was placed on the development of dried honey-skim milk mixtures.

Different ratios of honey and skim milk were spray dried in a Gray-Jenson type unit having a 9-foot-diameter drying cone. Results of some typical experiments are presented in Table 3. Optimum conditions were obtained when the honey-skim milk solids ratio was not greater than 40:60 and when the solids content of the sprayed mixture did not exceed 40 percent. With the experimental drying equipment that was available, it was not possible to dry satisfactorily a mixture of equal parts of honey and skim milk solids.

TABLE 2
Characteristics of Evaporated Milks Made With and Without Honey^a

Sample No.	Reaction of honey	Composition of finished product				Physical characteristics of finished product						
		Total solids	Milk solids not fat	Fat	Honey solids	Heat stability at 240° F.	Reaction after sterilization	Viscosity at 86° F. during storage at 86° F.			Fat separation at 86° F.	
								1 day	100 days	1 year	100 days	1 year
	pH	%	%	%	%	Min.	pH	c.p.	c.p.	c.p.		
1	.....	26.0	18.0	8.0	0	23	6.08	33	15	41	Moderate	Heavy
2	4.31	28.0	18.0	8.0	2	18	6.02	69	21	37	Slight	Moderate
3	4.31	30.0	18.0	8.0	4	16	5.99	124	43	62	None	Light
4	4.31	32.0	18.0	8.0	6	14	5.97	276	158	201	None	Slight
5	4.31	34.0	18.0	8.0	8	13	5.90	352	330	315	None	None
6	5.35	34.0	18.0	8.0	8	14	5.88	242	220	242	None	None
7	.....	26.4	18.3	8.1	0	35	6.18	25	14	32	Slight	Heavy
8	3.66	32.0	16.6	7.4	8	33	6.09	49	37	45	Slight	Light
9	5.79	32.0	16.6	7.4	8	33	6.09	26	20	18	Slight	Moderate
10	4.31	32.0	16.6	7.4	8	33	6.03	53	34	45	Slight	Light
11	5.35	32.0	16.6	7.4	8	33	6.04	41	25	25	Slight	Moderate

^a Samples 1-6 were prepared in April from the same milk and tupelo honey. Samples 7-11 were prepared in May from another milk. Samples 8 and 9 contained fireweed honey, while samples 10 and 11 were made with the tupelo honey. The honeys used in samples 6, 9, 10, and 11 were neutralized to the indicated reaction. All honey samples were pasteurized and added to the milks after forewarming. Each batch of milk was forewarmed to 203° F. for 10 minutes before concentration, homogenized at 2,500 pounds pressure after concentration, and sterilized in cans at 240° 15 minutes. Viscosities greater than 100 c.p. indicate formation of a "liver" or gel structure during sterilization. Samples 1-6 were heat stabilized by the addition of 20 ounces of Na₂HPO₄ per 1,000 pounds of evaporated milk.

TABLE 3
The Effect of Variations in the Solids Content of the Sprayed Mixture and the Temperature of the Drying Air Upon the Drying Properties of Honey-skim Milk Mixtures^b

Sample No.	Solids content of skim milk	Solids content of mixture when sprayed	Honey solids-skim milk solids ratio	Drying air temperatures		Properties of powder
				In	Out	
				° F.	° F.	
1	28	41.9	50:50	260	190	Candied mass, sticky
2	41	55.1	50:50	290	190	Burned, brown
3	36	46.7	40:60	255	195	Sticky, lumpy
4	36	43.4	30:70	250	195	Sticky, few lumps
5	30	34.5	20:80	265	190	Smooth, dry powder
6	30	37.1	30:70	265	190	Smooth, dry powder
7	30	40.4	40:60	265	190	Dry, slight caking
8	24	35.1	40:60	250	190	Smooth, dry, satisfactory
9	20	32.3	50:50	260	195	Sticky, lumpy mass

^b The skim milk was forewarmed at 185° F. for 15 minutes before it was concentrated. The honey, which contained 16 percent moisture, was pasteurized at 160° for 10 minutes and then mixed with the concentrated skim milk. The honey-skim milk mixture was sprayed (at 135° F. and 2,000 lbs. pressure) through a 0.025-inch nozzle at the rate of about 600 lbs. per hour.

A description of the method of spray drying the mixtures is given in a footnote to Table 3. The composition of three experimental powders is given in Table 4. The spray dried powders were highly hygroscopic because of the presence of lactose, dextrose, and levulose in amorphous condition. A more stable powder could be produced, where facilities are available, by drying to about 12 percent moisture and passing the powder through a conditioning unit or rotary tunnel drier where most of the lactose could crystallize. Another possibility would be to prepare a highly concentrated (about 60 percent total solids) honey-sweetened condensed skim milk, allow the lactose to crystallize, and then spray the mixture in a centrifugal spray unit. Furthermore, a powder with a higher ratio of honey to skim milk might be obtained by using one of the above modifications.

Table 5 shows the equilibrium moisture content at several relative humidities for a spray dried honey-skim milk of 42.5:57.5 honey solids-milk solids ratio, and 0.96 percent moisture content as made. The data were determined by the static method used for dried skim milk by Supplee (11) and Henry, Kon, Lea, and White (3). Stokes and Robinson's data (10) were used to relate relative humidity and sulfuric acid concentration. The equilibrium values in Table 5 are those at 68 days,

TABLE 4
Composition of Spray-Dried Milk and Honey Powders (In Part Calculated)

Composition	From skim milk		From whole milk
	Product I	Product II	Product III
	%	%	%
Moisture.....	3.2	1.6	2.5
Total solids.....	96.8	98.4	97.5
From honey.....	19.4	41.3	19.5
From milk.....	77.4	57.1	78.0
Butterfat.....	0.8	0.6	20.0
Milk proteins.....	28.6	21.3	21.4
Sugars, total.....	60.3	68.8	50.4
Lactose (milk sugar).....	41.7	29.7	31.6
Levulose.....	9.2	20.5	9.3
Dextrose.....	8.9	16.7	9.0
Sucrose.....	0.5	1.9	0.5
Ash (mineral matter).....	6.4 ¹	4.7	5.0 ¹
Undetermined.....	0.7	3.0	0.7
pH value, before drying.....	6.2	6.1	6.7
Sweetening effect ²	31.0	55.0	29.0

¹ Includes calcium carbonate added to the honey.

² Calculated sweetening effect of the total sugars in terms of pounds of sucrose (ordinary sugar) per 100 pounds of product.

at which time the rate of change averaged less than 0.02 percent moisture per week.

It appears from the data in Table 5 that the product is not quite as hygroscopic as dried skim milk at relative humidities below 30 percent, but at humidities above this value the honey-skim milk powder is more hygroscopic.

The maximum moisture contents and the equilibrium values are identical up to 30 percent R. H. (5.19 percent H₂O); above this point a decrease in moisture to equilibrium was noted after an initial rapid absorption as shown in the table. This was accompanied by caking of the powder, which is ascribed for dried skim milk by Troy and Sharp (13) to crystallization of lactose hydrate. This "over-shooting" has been reported by many observers in the past. No such decrease in moisture content was noted for the 30 percent R. H. powder, although caking was evident. To insure satisfactory storage stability dried honey-skim milk should be made and held under such conditions that the moisture content of the product does not exceed 3.5-4 percent.

A new method for the preparation of a dry honey-skim milk mixture was developed as a result of the experimental work described above. The honey was

TABLE 5

The Effect of Relative Humidity Upon Moisture Content of a Spray-Dried Honey-Skim Milk (Solids Ratio 42.5:57.5) at 25° C.*

Relative humidity	Moisture content ¹		Condition of powder
	Maximum	Equilibrium	
%	%	%	
6.0	1.02	1.02	Free-flowing
10.0	1.42	1.42	"
18.0	2.16	2.16	"
30.0	5.19	5.19	Caked
39.5	7.50	6.48	"
51.7	10.7 ^m	8.73	"
71.1	15.5 ^m	15.07	"
100.0	50.6 ⁿ	.....	.....

* For comparison, the equilibrium values given for spray-dried skim milk by others are: Henry et al. (3); 41% RH-7.5% H₂O; 29% RH-5.0% H₂O; 17.5% RH-3.0% H₂O. Tamsma (12); 50% RH-6.4% H₂O; 40% RH-6.7% H₂O; 30% RH-4.8% H₂O; 20% RH-3.5% H₂O. Davis (2); 60% RH-8.25% H₂O; 40% RH-7.10% H₂O. For honey, Lothrop (6) reports: 70% RH-26.0% H₂O; 60% RH-18.4% H₂O; 50% RH-12.6% H₂O; and 30% RH-8.02% H₂O.

¹ Calculated on "as is" basis.

^m Interpolated.

ⁿ Discarded at 42 days, molded.

mixed with spray dried skim milk that contained amorphous lactose. The non-crystalline lactose as well as the uncrystallized dextrose in the honey, being present in highly supersaturated condition, crystallized. In crystallizing, each molecule of these sugars combined with one molecule of water of crystallization furnished by the honey. As a result of the reduction in free water content, the mixture lost its viscous consistency as well as some of its hygroscopic qualities and acquired a granulated texture. The crystallized product which usually contained less than 10 percent moisture could be further dried on trays or in a rotary tunnel drier.

During experiments with the "dry mix" method, the ratio of honey solids to milk solids was varied but best results were obtained when this ratio was 40:60. No more honey than that needed to produce a 50:50 mixture could be used. Mixing was done at room temperature in a kettle equipped with a double action, scraper-agitator. The honey was drizzled into the powder in fine streams and intimately mixed so that large droplets of honey would not become isolated and surrounded by a powder coating.

This "dry mix" method would be easy to carry out with simple equipment. The raw materials—honey and dried skim milk—could be assembled at any convenient location. Large quantities of the powder could be prepared for storage or sale, or small lots could be made specially for use in specific bakery or candy products.

The honey flavor of the honey-dried skim milk mixtures persisted much longer than did that of the spray dried products. After 4 to 6 months of storage at room temperature, the spray dried mixtures were weak in honey flavor and a stale powder flavor began to appear. After 10 months in storage, the honey-dried skim milk mixtures (dried to 2 percent moisture at the time of manufacture) still showed an attractive honey flavor and only a slight stale milk flavor. It was necessary to package all samples in sealed cans to prevent moisture pickup by the levulose of the honey. Some darkening in color was noticed in all the dry mixtures held at room temperature but this darkening was not considered objectionable until the samples were held at least one year.

SUMMARY

1. Concentrated milk and honey products with good storage stability can be prepared for use in infant or special diets and also for use as a highly condensed or

dried source of milk and honey in the manufacture of dry mixes, confections, bakery goods, and other foods.

2. Sweetened condensed milks made with honey in place of sugar were held for 6 months at 70° F. (21° C.) before objectionable thickening occurred. It was necessary to forewarm the milk, before evaporation, to about 240° F. (116° C.) for ½ minute to retard thickening in storage.

3. Evaporated milk fortified with 8 percent honey solids had adequate heat stability to withstand sterilization. The viscosity of the honey-evaporated milk was greater than the viscosity of normal evaporated milk. Since high viscosity retards phase separation, it is desirable in this product. Except for a darkening in color, the honey-evaporated milk withstood storage for 1 year at 86° F. (30° C.) better than the samples without honey.

4. Dried honey-skin milk mixtures with 40 parts of honey solids to 60 parts of non-fat milk solids were successfully prepared by two different methods: (1) Spray drying, and (2) mechanical mixing of the honey and dried skim milk. Both processes produced excellent products but the mechanically dry-mixed powder maintained a good honey flavor during storage longer than the spray dried product. Both powders were hygroscopic and darkened somewhat during storage.

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