SHELF LIFE EXTENSION OF MAPLE CREAM

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Introduction

Maple cream, a value-added product, is manufactured from pure maple syrup by additional concentration by evaporation, quick cooling, stirring and then packaging at room temperature. Nothing is added to the pure maple syrup to make the maple cream product although the industry name implies there is cream in it. The finished product is light colored, smooth creamy textured, that is used on toast, bagels, muffins, pancakes, etc. From the marketing point of view, it is an all natural product comprised mainly of sugars but it also has other important nutrients such as amino acids, proteins, organic acids, minerals (calcium and potassium being the most prevalent) and trace levels of vitamins (Koelling and Heiligmann, 1996).

During production, the maple syrup is heated to high temperatures (234 to 236°F), which eliminates all pathogenic microorganisms, but the subsequent steps involved rapid cooling to produce the fine crystals and filling at room temperature, all in an open environment where the maple cream is re-contaminated. At the high levels of sugar concentration of the cream, the pathogens can not grow but the spoilage microorganisms, reportedly molds and yeast, can slowly grow and spoil the product. That is why the cream is sold under refrigeration, limiting the marketing potential for the product.

Pure maple cream has a shelf life of less than one month if stored at room temperature. The maple cream may mold and physically separate into its maple syrup component during this period. The current product requires refrigeration to achieve an acceptable shelf life of 6 months. This requirement significantly reduces marketability, distribution and availability of the product to the consumer. The storage and handling requirements also increase the final cost to the consumer. As a result, production, consumption and farmer profit is limited.

Project Goals

Our goal was to develop a process to attain 6 months shelf life at room temperature. One major limitation is that pure maple cream requires packaging at room temperature and therefore can be contaminated with microorganisms present in the environment. To limit the molding problem that occurs on the surface, we evaluated packaging under UV exposure, adding calcium carbonate as a processing aid and flushing the headspace with nitrogen, carbon dioxide and steam. In addition, we studied the standardization of the maple syrup to optimal sugar composition prior to cream preparation in order to minimize the physical separation during the product shelf-life. We evaluated the various proposed processes utilizing farmer capable equipment and applying accelerated shelf life testing techniques to prove the proposed preservation concepts.

METHODOLOGY

Mold spoilage: To address the mold problem, various techniques were investigated that included:

1. Addition of a food preservative (potassium sorbate) at low concentrations;
2. Ultraviolet light decontamination of product surface & closure before closing- 5 min exposure;
3. Flame sterilization of product surface before closing using a bunsen burner;
4. Steaming of product headspace to create an anaerobic environment at closing using a cappuccino machine;
5. Carbon dioxide headspace flushing by applying gas directly from a cylinder at low pressure;
6. Nitrogen gas headspace flushing by gas directly from the cylinder at low pressure and;
7. Addition of 400 ppm sodium bicarbonate to the cream to generate carbon dioxide gas on the headspace of the closed container.

The incidence of mold spoilage in maple cream is relatively low and to more accurately assess the effectiveness of the various treatments, mold from spoiled maple cream samples was collected, cultured and used as an inoculum to the various maple creams treated with the various treatments. A consistent inoculum of vegetative mold was added to each of the treatments. As a control, maple cream prepared under the same conditions was inoculated with the same level of vegetative mold spores. This procedure assured that all the samples were contaminated with mold to enable the evaluation of the various treatments.

A total of ten 8-ounce containers filled with freshly produced maple cream were used for each treatment. The mold was added to the jar and mixed with sterile mixing tools and then the various treatments were applied. For the potassium sorbate treatment, the mold was added after the addition of the preservative. An initial level of the mold spores was determined by plating onto acidified Potato Dextrose Agar (pH 3.5). The samples were placed at 86°F (30°C) and visually observed for mold growth on the surface without opening to avoid secondary contamination or destroying the treatment conditions. The incubation temperature is an accelerated shelf life study that results in a double of the actual holding time at room temperature 70°F (20°C). The samples were examined after 1 and 2 months of holding at 86°F (30°C). Observation of mold growth on the surface indicated a "positive" result and the number of positive mold samples for each treatment was recorded.

In a smaller trial, we also added a small amount of salt to the maple cream samples to determine whether this would produce a more stable product over time. Salt concentrations of 0.1, 0.25, 0.5% were added to the samples.

The water activity of all the samples was measured to determine if a low number was achieved. This value indicates the amount of free water (water not bound to compounds) that is available for microbial growth. The water activity of a food is not the same thing as its moisture content. Although moist foods are likely to have greater water activity than are dry foods, this is not always so; in fact a variety of foods may have exactly the same moisture content and yet have quite different water activities. A reduced water activity will result in better shelf-life as the mold will not grow or grow very slowly. The water activity scale extends from 0 (total dryness) to 1.0 (pure water) but most foods have a water activity level in the range of 0.2 for very dry foods to 0.99 for moist fresh foods. For a food to have a useful shelf life without relying on refrigerated storage or preservatives, it is necessary to control either its acidity level (pH) or the level of water activity (aw) or a suitable combination of the two. This can effectively increase the product's stability and make it possible to predict its shelf life under known ambient storage conditions. Food can be made safe to store by lowering the water activity to below 0.85, which will not allow pathogens to grow. To render a product shelf stable at room temperature, the water activity should be 0.6 or lower, although most molds cease to grow or slow down at water activity levels below 0.8 (Worobo and Padilla-Zakour, 1999). Maple cream has a water activity of 0.8 to 0.85 and therefore it is a safe product but allows the growth of mold.

Physical separation problem: To address the physical separation the amount of invert sugar present in the maple syrup was studied. The concept was based on the honey cream, which is stable without refrigeration (Morse, 1983). To convert the sugar in the maple syrup (sucrose) to invert sugars (a mixture of glucose and fructose) an enzyme called invertase was used. This enzyme is commercially available for use by the confectionery and baking industry (DSM Food Specialties, USA). This is considered a processing aid and does not need to be declared on the product label. We added 0.1 to 0.25% enzyme solution to a batch of maple syrup, mixed well and then maintained the syrup at 120 °F (50°C) for 24-48 hrs. in a regular oven. The degree of inversion was monitored using the simple and inexpensive urine sugar test (Clinitest tablets by Bayer).

Small percentages of the inverted syrup solution were added to the maple syrup to be used for boiling to determine the optimum level. The inverted syrup was then boiled to concentrate to approximately 85°Brix (235 to 240°F). The syrup was then rapidly cooled to temperatures below 50°F. For creaming purpose, a potter's wheel type stirring machine was used. Stirring was stopped when the cream lost its shiny appearance and developed a dull flat look. The cream was then transferred to 6 oz. glass jars and stored. Samples with added inverted syrup were compared to the standard cream prepared by heating the syrup to a temperature of 22 to 24 °F above the boiling point of water.

Results

The results are presented in two sections to address the spoilage (mold) problem first followed by the physical separation into liquid and solid layers in the second section.

Mold problem

Initial studies with all the treatments clearly indicated that only potassium sorbate and carbon dioxide provided promising treatments to control the growth of mold. These two treatments were further investigated to determine effective control levels of potassium sorbate and longer carbon dioxide headspace flushing. Three different levels of potassium sorbate commonly used on food products were used (250, 500 and 1000 ppm) with freshly prepared maple cream and subsequently inoculated with the same maple cream mold spoilage organism. The samples were then incubated at 86°F (30°C) for 2 months which is equivalent to 4 months at room temperature. The results of this study further indicated that carbon dioxide headspace flushing provided no protection against mold spoilage resulting in 100% spoilage of all samples. In case of samples with potassium sorbate added, no spoilage was observed at the levels used (Table 1). The maple cream samples containing the various levels of potassium sorbate were evaluated for their organoleptic qualities. No differences were noted in 250 or 500 ppm but an off-flavor was detected with the 1000 ppm potassium sorbate maple cream samples.

Table 1. Microbiological results from maple cream samples inoculated with mold.

Treatment	Number of samples with surface mold
Control	10/10
CO_2 headspace flushing	10/10
250 ppm potassium sorbate	0/10
500 ppm potassium sorbate	0/10
1000 ppm potassium sorbate	0/10

In summary, potassium sorbate even at low levels of 250 ppm was identified as a potential treatment to provide protection for up to 4 months against mold spoilage associated with maple cream product. To assure a 6-month shelf-life at room temperature, a level of 500 ppm is recommended (further testing confirmed the need for 500 ppm).

Physical Separation

Maple cream samples were produced by adding different concentrations of inverted maple syrup to each batch. The syrup was concentrated to about 85°Brix before the cooling step. Summary of preliminary trials is shown in Table 2.

Table 2. Evaluation of maple cream samples produced with varying levels of inverted maple syrup and stored at room temperature.

% Inverted syrup	Observations
0 (control)	Very grainy, large crystals
10	Good consistency, good sweetness and little grain
20	A bit grainier, some crystals
50	Good consistency, very sweet (too sweet)

From the first tests (Table 2), it was clear that an invert level lower than 30% was necessary to maintain the typical maple cream flavor. A second round of tests was run to narrow down the concentration of invert syrup required.

Table 3. Evaluation of maple cream samples produced with varying levels of inverted maple syrup and stored at room temperature.

% Inverted syrup	Observations
0 (control)	Grainy with crystals
15	Little separation, grainy
20	Little separation, grainy
25	Grainy, significant separation
30	Grainy, significant separation

From these trials (Table 3), it was concluded that the procedure to make the cream had to be carefully controlled, as the texture was not consistent from one test to another. After further practicing and standardization another test was run.

Table 4. Evaluation of maple cream samples produced with varying levels of inverted maple syrup and stored at room temperature.

% Inverted syrup	Observations
0 (control)	Grainy, separation
5	No separation, good consistency
10	No separation, good consistency
15	Separation
20	Separation
25	Separation
30	Separation

From the results shown in Table 4, we concluded that a 5-10% level of inverted syrup was best. We proceeded to perform a shelf-life study with 10% inverted syrup and potassium sorbate added to assess the long-term stability of the maple creams.

Table 5. Shelf-life study of maple cream samples produced with 10% inverted syrup and 250 ppm potassium sorbate, evaluated at 2 and 6 months.

Treatment	Storage Temperature	°Brix	Water Activity (a_w)	Observed Surface Mold	Separation % vol/vol Syrup/Cream
Control 1	Room temp.	84.6	0.81-0.82	Mold (2 mo.) Mold (6 mo.)	20% (2 mo.) 23% (6 Mo.)
Control 2	Room temp.	84.6	0.79-0.81	No mold (2 mo.) No mold (6 mo.)	21% (2 mo.) 25% (6 mo.)
Control 3	Room temp.	85.9	0.81-0.82	Mold (2 mo.) Mold (6 mo.)	20.5% (2 mo.) 23% (2 mo.)
Control 4	Room temp.	83.8	0.81-0.82	No mold (2 mo.) No mold (6 mo.)	22% (2 mo.) 25.5% (6 mo.)
Invert 1	Room temp.	83.5	0.77-0.79	No mold (2 mo.) No mold (6 mo.)	5% (2 mo.) 12% (6 mo.)
Invert 2	Room temp.	84.3	0.78-0.79	No mold (2 mo.) Mold (6 mo.)	5% (2 mo.) 11% (6 mo.)
Invert 3	Room temp.	85.0	0.73-0.78	Mold (2 mo.) Mold (6 mo.)	6% (2 mo.) 12% (6 mo.)
Invert 4	Room temp.	82.4	0.75-0.78	Mold (2 mo.) Mold (6 mo.)	5.5% (2 mo.) 11% (6 mo.)
Control 1	86°F (30°C)	86.4	0.80-0.82	No mold (2 mo.) No mold (6 mo.)	21% (2 mo.) 23% (6 mo.)
Control 2	86°F (30°C)	84.1	0.78-.82	No mold (2 mo.) No mold (6 mo.)	20.5% (2 mo.) 22% (6 mo.)
Invert 1	86°F (30°C)	83.8	0.75-0.78	No mold (2 mo.) No mold (6 mo.)	8% (2 mo.) 12% (6 mo.)
Invert 2	86°F (30°C)	83.1	0.73-0.78	No mold (2 mo.) No mold (6 mo.)	9% (2 mo.) 13% (6 mo.)

The results in Table 5 show that the samples with invert syrup had slightly lower water activities but was not sufficient to impede the growth of mold, even with the addition of potassium sorbate at 250 ppm. Select molds and yeast are capable of growing at very low water activities (aw = 0.60-0.70) and are called osmotolerant. The mold isolated from maple cream falls under this category. In all cases, the control samples were of hard texture and very low spreadability due to the additional concentration to achieve 85°Brix. The samples with 10% inverted syrup had a creamy texture and were easily spreadable. The amount of separation was significantly reduced by the use of invert syrup as after 6 months, the invert samples had 12% or less of separation compared to 25% for the control samples.

The use of salt was investigated to evaluate if additional stability could be achieved by adding very small amounts to the cream. Results are presented in

Table 6. Concentrations above 0.1% were not considered acceptable due to salty taste. The use of salt did not seem to offer advantages but a more complete study was performed to confirm the results. The samples prepared with inverted syrup were very stable as no mold was observed and minimal separation occurred.

Table 6. Evaluation of maple cream samples produced with low levels of inverted maple syrup and added salt and stored at room temperature for 6 months

% Inverted Syrup	Initial Observations	Separation and Mold after 6 months
5% (3 replicates)	Creamy texture, little separation 84.4°Brix, 0.68 Aw	Minimal separation - no mold
10% (3 replicates)	No separation, creamy texture 81.8°Brix, 0.76 Aw	No separation - no mold
10% + 0.1% salt (3 replicates)	Creamy, no separation, hint of salty taste 83°Brix, 0.72 Aw	No separation - no mold
10% + 0.25% salt (3 replicates)	Less creamy, no separation, a bit salty 83°Brix, 0.70 Aw	No separation - no mold

Table 7 shows the final shelf-life study conducted using 5 and 10% invert syrup for cream preparation. The study also evaluated the use of salt and potassium sorbate.

Table 7. Evaluation of maple cream samples produced with low levels of inverted syrup, salt and potassium sorbate and stored at room temperature for 6 months

Treatment (2 replicates)	Separation and Mold after 6 months	Texture °Brix, A_w	Taste/other
5% inverted syrup	No separation No mold	Spreadable 80.4°Brix, 0.76 Aw	Typical
5% inv + 0.1% salt	No separation No mold	Spreadable 80.2°Brix, 0.76 Aw	Hint of Salt Acceptable
5% inv + 250 ppm sorbate	No separation No mold	Spreadable 80.0°Brix, 0.72 Aw	Typical
5% inv + 0.1% salt + 250 ppm sorbate	No separation No mold	Spreadable 80.0°Brix, 0.72 Aw	Hint of Salt Acceptable
10% inverted syrup	No separation No mold	Creamy & spreadable 80.4°Brix, 0.74 Aw	Typical
10% inv + 0.1% salt	No separation No mold	Little grainy 85.2°Brix, 0.54 Aw	Hint of Salt Acceptable
10% inv + 250 ppm sorbat	No separation No mold	Little grainy 82.7°Brix, 0.62 Aw	Typical Typical
10% inv + 0.1% salt	No separation No mold	Spreadable 82.3°Brix, 0.71 Aw	Hint of Salt Acceptable

From all the shelf-life studies, we concluded that the potassium sorbate at 250 ppm might not be 100% effective as some surface mold was observed sporadically (very small amounts) and the 500 ppm is therefore recommended. The separation problem was minimized by the use of 10% inverted syrup given an acceptable product with good consistency and very little or no separation. After 6 months, the samples remained stable and in good condition. Careful control of the process will be necessary as in some cases the maple cream samples were a bit grainy, most likely due to over concentration of the syrup.

It is also recommended that the maple cream jars be labeled "Best if used by . . ." dated 6 months after production and "Refrigerate after opening" to allow the consumer to keep the product for longer periods of time.

Estimated Revenue Increase to Maple Syrup Farmers

It is estimated a room temperature shelf life of six months would benefit the Northeast Maple Syrup Industry by a $1.6 million yearly increase in revenue. (Note: Total Northeast USA Maple Syrup revenue for the year 2000 is $28.2 million. This represents approximately 20% of North American production.). The estimate was calculated with the following assumptions: Retail value of maple syrup $28 per gallon, retail value of maple cream $60 per equivalent gallon (based on syrup), maple syrup producers normally dedicate 5-10% of their syrup to maple cream manufacture. If we assume that currently 5% is dedicated to maple cream then $28.2 million x 0.05 = $1.4 million as maple syrup which is equivalent to $3 million as maple cream, i.e., a net increase of $1.6 million. If by developing good manufacturing practices for the production of shelf-stable maple cream we can increase production and market to 10% (conservative value) then an extra $1.6 million revenue will go to the producers.

Economic Findings

The addition of potassium sorbate will increase the cost of the product less than $0.01 per pound of finished product and does not require any specialized equipment. The use of an enzyme to increase the invert sugar content cost is approximately $0.05 per pound of finished product and utilizes equipment already on a typical maple syrup farm, i.e.: kitchen oven or crock pot. Total cost is expected to be less than $0.10 per pound of finished product and will not require any equipment not already available on a typical maple syrup farm.

Maple Cream Extended Shelf Life Manufacturing Process

The following maple cream manufacturing process is copied from the "North American Maple Syrup Producers Manual", The Ohio State University Extension Bulletin 856, copyright 1996, page 119 with additions to the standard process that is a result of this work. Changes made to the standard process to produce the extended shelf life maple cream are in Italics.

"Maple spread (cream), a fondant-type confection, is prepared by elevating the boiling point of maple syrup to a prescribed level, then rapidly cooling the cooked syrup followed by stirring. This procedure results in the formation of very small crystals, which together have a "peanut butter consistency". Maple spread is a delectable topping for toast, muffins or other similar products. For best results, the syrup from which maple spread is prepared should be U.S. grade A Medium Amber or lighter. However, other grades of syrup can be used if they contain less than 4 percent invert sugar.

. . . Syrup that contains from 0.5 to 2 percent invert sugar will make a fine-textured spread that feels smooth to the tongue. Syrup with from 2 to 4 percent of invert sugar can be made into spread by heating it to 25 degrees F above the boiling point of water (instead of the usual 22 to 24 degrees F). Syrup with more than 4 percent of invert sugar is not suitable for making spread. . . .

However, to prevent separation of maple cream into maple syrup during storage add a small amount of inverted syrup to the syrup which is to be converted to maple cream. This inverted syrup will be made by using an enzyme. The invert syrup is made by adding 0.1% to 0.25% by volume of the enzyme invertase to the pure maple syrup used for making maple cream. For a gallon of syrup to be converted to invert syrup add 1.5 teaspoons of invertase. Invertase is available commercially as it used by the confectionery and baking industry. This mixture is heated to 50 degrees C (120 degrees Fahrenheit) for 24 to 48 hours and then stored under refrigeration. The use of an oven or crock-pot is ideal for this purpose. This invert syrup solution is added to the maple syrup to be used for boiling to the higher temperatures needed to make maple cream.

The invert syrup should represent 10% of the final quantity of syrup to be boiled to the normal temperature required of maple cream. If one is using a one gallon batch size for cream production use 3.5 quarts of regular syrup and one pint of invert syrup mixed prior to boiling.

To prepare maple spread, syrup is heated to a temperature of 24 to 28 degrees F above the boiling point of water. It is important to consider the exact temperature at which water boils on the day maple spread is prepared since boiling temperature depends on atmospheric pressure. As soon as the boiling syrup reaches the desired temperature, it is removed from the heat and rapidly cooled. Rapid cooling is necessary to prevent premature crystallization. Quick cooling is facilitated by transferring the cooked syrup to large shallow pans. Refrigeration units or troughs with circulating cold water in which the pans are placed can be used. For best results, the syrup should be cooled to 50 degrees F or below. It is considered sufficiently cooled when the surface of the cooked syrup is firm to the touch.

Potassium sorbate is added after the boiling and cooling stages. Potassium sorbate is available at most stores that supply materials for wine making. Add potassium sorbate to the concentrated cooled product at the rate of 500 parts per million based on volume. If the cooled product is a result of one gallon of syrup prior to cooking add 0.3 teaspoons of potassium sorbate to the surface of the concentrated syrup.

Following cooling, the chilled syrup is stirred under room-temperature conditions. Stirring can be done by hand or by mechanical stirring machines. Several different types are available commercially or they can be fabricated. While being stirred, the cooled syrup first tends to become more fluid (less stiff), following which it begins to stiffen and show a tendency to "setup". At this point it loses its shiny appearance and develops a dull flat look. When this occurs, the crystallization process is considered complete and the spread can be transferred to appropriate containers. If stirring is stopped too soon, the final product may become somewhat grainy due to the formation of larger crystals. Likewise, if the cooking process did not reach the correct temperature, some separation (presence of liquid syrup on top of the crystallized cream) may occur while in storage.

To hasten the crystallization process, a small amount of "seed" (previously made spread) can be added to the glass-like chilled syrup just before stirring. The addition of 1 teaspoon of seed for each gallon of cooked syrup will provide small particles to serve as nuclei so crystals will form more rapidly. The entire stirring process may require from 1 to 2 hours, depending on the size of the batch, but the use of seed will often shorten the time by half.

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