Maple Cream Shelf Life Extension Project

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Project Goals:

Pure maple cream, a maple syrup value-added product 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.

Our goal is to develop a process to attain 6 month 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 propose to evaluate packaging under UV exposure, adding calcium carbonate as a processing aid and flushing the headspace with nitrogen, carbon dioxide and steam. In addition, we will study 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 will evaluate the various processes utilizing farmer capable equipment and applying accelerated shelf life testing techniques to prove one or more of the proposed preservation concepts.

What did we do:

We evaluated the various proposed processes utilizing farmer capable equipment and applying accelerated shelf life testing techniques to prove the proposed preservation concepts.

Maple cream 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 a light colored, smooth creamy textured, that is used on toast, bagels, muffins, pancakes, etc. It is a product that has no equal in terms of taste, texture or color. The texture is similar to a smooth peanut butter. 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.

During production, the maple syrup is heated to high temperatures (234 to 236°F) which eliminats 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.

Project 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.

Mold Spoilage

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

1. Food preservatives (potassium sorbate)
2. Ultraviolet light decontamination of surface & closure – 5 min exposure
3. Flame sterilization of product surface – using a bunsen burner
4. Steaming of headspace to create an anaerobic environment – using a capucchino machine
5. Carbon dioxide headspace flushing – gas directly from a cylinder at low pressure
6. Nitrogen gas headspace flushing – gas directly from the cylinder at low pressure
7. Addition of sodium bicarbonate to generate a carbon dioxide headspace in the container – 400 ppm llevel

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.

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 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 (20°C). The samples were examined after 1 and 2 months of holding at 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.

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 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 30°C for 2 months which is equivalent to 4 months at room temperature. The results of this further study clearly indicated that carbon dioxide headspace flushing provided no protection against mold spoilage resulting in 100% spoilage of all samples. However, all levels of potassium sorbate (250, 500 & 1000 ppm) showed no evidence of mold spoilage for all maple cream samples. Since 250 ppm was the lowest level of potassium sorbate used in this study and showed no evidence of mold spoilage, lower levels may provide sufficient protection but this requires additional verification outside of the scope of this project. 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 denoted with the 1000 ppm potassium sorbate maple cream samples.

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.

Physical Separation:

To address the physical separation the amount of invert sugar present in the maple syrup was studied. Typically maple syrup has 0 to 2% invert sugar and the literature cites an optimal level of 0.5-2% invert to make the cream. A small amount of invert provides a smooth texture but higher concentrations were assumed to prevent the crystallization process necessary to make the cream.

Our approach was to study the effect of higher levels of invert, under controlled conditions, to make a more stable product that would not separate at room temperature for 6 months. The concept was based on the honey cream, which is stable without refrigeration. The sugars in honey are mainly glucose and fructose, i.e., invert sugar.

To convert the sugar in the maple syrup (sucrose) to invert (a mixture of glucose and fructose) an enzyme called invertase was used. This enzyme is available commercially for use by the confectionery and baking industry. An enzyme is considered a processing aid and does not need to be declared in the product label. The process to invert the maple syrup requires the addition of 0.1 to 0.25% enzyme solution (is sold liquid), mixing well and then maintaining the syrup at 50°C for 24-48 hrs. A regular oven can be used for this step. The degree of inversion is monitored using the simple and inexpensive urine sugar test (Clinitest tablets by Bayer), which can be bought over the counter at drug stores.

The first step was to prepare 100% invert syrup, that is, the enzyme was added to the syrup and all the sucrose was converted into the simple sugars glucose and fructose. The inverted syrup was then boiled to concentrate to approximately 85°Brix (235 to 240°F) and creamed. The product had good consistency, darker color than the maple cream and a very sweet taste (similar to honey) and was rated unacceptable. The strategy was then to add small percentages of invert syrup to regular maple syrup to establish the level that could provide stability with an acceptable flavor and consistency.

Summary of trials with different levels of invert is shown in Table 1.

Table 1. Evaluation of maple cream samples produced with varying levels of inverted maple syrup – production date 10/20/2002 – stored at room temperature.

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

From the first tests, 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 2. Evaluation of maple cream samples produced with varying levels of inverted maple syrup – production date 10/30/2002 – 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, 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 3. Evaluation of maple cream samples produced with varying levels of inverted maple syrup – production date 2/1/2003 – 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
50	Separation

From these preliminary results, we concluded that a 5-10% level 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 4. Shelf-life study of maple cream samples produced with 10% inverted syrup and 250 ppm potassium sorbate – batch made on 2/11/03

Evaluation after 2 months

Treatment	Storage temperature	Surface mold	Separation % volume/volume Syrup/Cream	°Brix	Water Activity (Aw)
Control 1	Room temperature	Mold	20	84.6	0.81
Control 2	Room temperature	No mold	21	84.6	0.79
Control 3	Room temperature	Mold	20.5	85.9	0.81
Control 4	Room temperature	No mold	22	83.8	0.82
Invert 1	Room temperature	No mold	5	83.5	0.77
Invert 2	Room temperature	No mold	5	84.3	0.78
Invert 3	Room temperature	Mold	6	85.0	0.73
Invert 4	Room temperature	Mold	5.5	82.4	0.75
Control 1	30°C	No mold	38	86.4	0.80
Control 2	30°C	No mold	37	84.1	0.78
Invert 1	30°C	No mold	14	83.8	0.75
Invert 2	30°C	No mold	16	83.1	0.73

At this point in the discussion a description of the water activity metric is explained.

Description of Water activity in food

Water in food, which is not bound to food molecules, can support the growth of bacteria, yeasts and moulds (fungi). The term water activity (a_w) refers to this unbound water.
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.

Measuring water activity (a_w)

The water activity scale extends from 0 (bone dry) 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. Water activity is in practice usually measured as equilibrium relative humidity (ERH).
The water activity (a_w) represents the ratio of the water vapour pressure of the food to the water vapour pressure of pure water under the same conditions and it is expressed as a fraction. If we multiply this ratio by 100, we obtain the equilibrium relative humidity (ERH) that the foodstuff would produce if enclosed with air in a sealed container at constant temperature. Thus a food with a water activity (a_w) of 0.7 would produce an ERH of 70%.

Predicting Food Spoilage

Water activity (a_w) has its most useful application in predicting the growth of bacteria, yeasts and moulds. For a food to have a useful shelf life without relying on refrigerated storage, it is necessary to control either its acidity level (pH) or the level of water activity (a_w) 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 a point that will not allow pathogens to grow in it. Many foods can be successfully stored at room temperature by proper control of their water activity (a_w). Most moulds cease to grow at a water activity level below about 0.8.

Evaluation after 6 months

Treatment	Storage temperature	Surface mold	Separation % volume/volume	°Brix	Water Activity Aw
Control 1	Room temperature	Mold	23	86.2	0.82
Control 2	Room temperature	No mold	25	86.5	0.81
Control 3	Room temperature	No mold	23	87.5	0.82
Control 4	Room temperature	No mold	25.5	86.5	0.81
Invert 1	Room temperature	No mold	12	85.4	0.79
Invert 2	Room temperature	Mold	11	84.5	0.79
Invert 3	Room temperature	No mold	12	85.3	0.78
Invert 4	Room temperature	Mold	11	84.1	0.78
Control 1	30°C	No mold	23	86.2	0.82
Control 2	30°C	No mold	22	86.4	0.82
Invert 1	30°C	No mold	12	84.6	0.78
Invert 2	30°C	No mold	13	84.3	0.78

In all cases, the control samples were of hard texture and very low spreadability. The samples with 10% inverted syrup had a creamy texture and were easily spreadable

The addition of inverted syrup decreased the separation problem significantly and we decided to continue with more trials to improve the process.

We decided to see if the addition of a small amount of salt could help with a more stable product over time. Maple cream samples with 5 and 10% inverted syrup plus 0.25, 0.5, 1 and 2% salt were prepared. Salt concentrations of 0.5% and above were considered unacceptable due to salty taste.

Table 5. Evaluation of maple cream samples produced with low levels of inverted maple syrup and added salt – production dates 2/12-25/2003 – stored at room temperature for 6 months

% inverted syrup	Initial Observations	Separation and mold after 6 months
5 (3 replicates)	Creamy texture, little separation	Minimal separation – no mold
10 (3 replicates)	No separation, creamy texture	No separation – no mold
10 + 0.1% salt (3replicates)	Creamy, little separation, hint of salty taste	No separation – no mold
10 + 0.25% salt (3 replicates)	Less creamy, no separation, a bit salty	No separation – no mold

The use of salt did not seem to offer additional benefits. Another shelf-life test was run to confirm results and to compare the effect with the addition of potassium sorbate.

Table 6. Evaluation of maple cream samples produced with low levels of inverted syrup, salt and potassium sorbate - batches made 3/31-4/10, 2003 – stored at room temperature for 6 months

Treatment (2 replicates)	**Separation and mold after 6 months**	**Texture**	**Taste/other**
5% inverted syrup	No separation No mold	spreadable	Typical
5% inv + 0.1% NaCl	No separation No mold	spreadable	Hint of salt Acceptable
5% inv + 250 ppm sorbate	No separation No mold	spreadable	Typical
5% inv + 0.1% NaCl + 250 ppm sorbate	No separation No mold	spreadable	Hint of salt Acceptable
10% inverted syrup	No separation No mold	creamy and spreadable	Typical
10% inv + 0.1% NaCl	No separation No mold	grainy	Hint of salt Acceptable
10% inv + 250 ppm sorbate	No separation No mold	grainy	Typical
10% inv + 0.1% NaCl + 250 ppm sorbate	No separation No mold	spreadable	Hint of salt Acceptable

We measured the water activity of the samples to determine if a low number was achieved. A reduced water activity will result in better shelf-life as the mold will not grow or grow very slowly. All the samples had water activities from 0.71 to 0.74, a bit lower than in previous trials. This level is not enough to guarantee absence of mold and therefore the use of sorbate is recommended, even though we did not observed any mold in the final trial. The use of salt is optional as there was no observed benefit.

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.

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 unique equipment. The use of an enzyme to increase the invert sugar content cost is approximately $.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. Where changes are made to the standard process to produce the extended shelf life maple cream they 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 22 to 24 degrees F above the boiling point of water. Remember to establish 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 stage and just prior to cooling stage. Potassium sorbate is available at most wine kit producing locations. 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. ...."