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A STUDY OF THE FROTHING CAPACITY OF WHOLE MILK- 1. A MARKET SURVEY OF CONVENTIONAL AND ORGANIC MILKS, 2. THE EFFECT OF CLEAN IN PLACE (CIP) CLEANING SOLUTIONS

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ABSTRACT

Gourmet coffee drink consumption is on the rise (NCAUSA 2013). With most of these coffee drinks including milk and/or milk foam, an emphasis on producing quality foam is of high importance. Recent complaints have been received on the failure of milk to foam to expectations of the coffee house (Randolph & Associates 2013). Identifying the source of this failure could enable the milk industry to provide higher foam quality milk to meet the growing needs of coffee houses.

A two-part study on the frothing capacity of milk was carried out to investigate potential variations in the market place and to determine the effect of residual cleaning agents used on equipment in the dairy processing industry. For the first part of this study, five different brands of locally available whole bovine milk were compared for their ability to produce quality foam using steam injection from a commercial espresso coffee machine. The effects of common alkaline, acid, and defoaming cleaning products used in high-temperature short-time pasteurization processing plants in CIP (clean-in-place) cleaning method were evaluated in the second phase of this study.

Five different brands of whole milk, two of these certified organic, were frothed using steam injection and evaluated based on three variables- steam froth value (SFV), foam volume (FV), and % dissipation. Each sample was frothed five times with three replications, using a different sell by date with each replication.

Results for the market survey study indicate there were no differences in SFV, FV, or % dissipation in the brands used when compared to each other. However, when the data collected for organic milks were compared to the data from the conventional
milks, there was a significance difference (p<0.05) between SFV, FV, and % dissipation. The organic milks produced lower quality foam as measured by all three variables.

In the second part of this study whole milk was used with the addition of a cleaner solution, or water at an addition rate of 1% and 5% for the second phase. There were a total of 12 treatments and a control. The same three variables were analyzed in the cleaning solution study.

This study comparing the cleaners to a control (no solution added) show that there were significant differences with the addition of water at 5%, alkaline at 1% and 5%, defoamer at 1% and 5%, alkaline+defoamer at 1% and 5%, and acid+defoamer at 1% and 5% (p<0.05) for SFV. The treatments of water at 1% addition and acid cleaner solution at 1% and at 5% addition rates were not significantly different for SFV. When comparing the rates within the solutions, the water solution and the alkaline+defoamer were significantly different (p<0.05). In general, the results for foam volume closely resemble the SFV, with no differences (p>0.05) in water at 1%, and both acid addition rates of 1% and 5% when compared to the control. For % dissipation, solutions that differed from the control (p<0.05) were alkaline+defoamer at 1% rate, water at 5%, and acid+defoamer at both 1% and 5% additions. Results from this study demonstrate that cleaning solutions that may end up in milk at abusive levels may be a source of poor frothing characteristics in whole milk.
DEDICATION

I dedicate this thesis to my family. They have fully supported (financially and emotionally) my academic goals, and provided encouragement along the way. To my daughter, Ansleigh, thank you for your patience and teaching me to slow down and enjoy those precious moments in life.
ACKNOWLEDGMENTS

Without the help of many this road would have been much more difficult. I am forever thankful to all who have assisted me in this pursuit. My committee members, Dr. McGregor, Dr. Northcutt, and Dr. Whiteside, have provided support, guidance, and encouragement throughout the years. I would like to thank Dr. McGregor for the constant positive attitude and making this journey possible for me. Dr. Northcutt has always been able to provide helpful tips as well as a good laugh. Dr. Whiteside has provided patience in teaching me how to use equipment in packaging and always driving me to be as knowledgeable as possible about my field.

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CHAPTER ONE

REVIEW OF MILK, FOAMS, AND CLEANERS

Demand for Milk Froth

Currently, the 2013 survey from the National Coffee Association on drinking trends, found that 83% of American adults say they drink coffee, up five percent from 2012 (NCAUSA 2013). The gourmet coffee consumption category, which can simply be a specialty coffee blend or an espresso based beverage, rose over the last year, with one third of the US population reporting consuming a gourmet coffee each day (NCASUSA 2013). Espresso based beverages include (frozen, iced, or hot): espressos, lattes, macchiatos, mochas, and cappuccinos. Within this category, a majority of these beverages incorporate milk in their recipe. With coffee consumption continually on the rise, it has brought with it a growing demand for the dairy industry to produce milk to meet their coffee drink accompaniment needs.

Milk’s ability to produce the desired foam for the gourmet coffees is of great importance. Huppertz (2010) states, “… the recently emerging exponential growth in the consumption of cappuccino-style beverages has led to a re-emergence in the scientific study of foaming properties of milk.” Milk foam has previously been studied in depth to determine how to prevent foam for processing and packaging purposes; however, with certain coffee drink’s desirable “frothy top”, the need for further research into the “…process parameters driving froth quality” is an ongoing topic (Silvia and others 2008). Personal communications from Randolph and Associates and dairy extension
professionals has brought more recent concerns from coffeehouses concerning milk and it’s occasional poor frothing performance (2013).

**Milk Composition**

Milk is comprised of a highly complex matrix of five basic components. The component in the largest quantity is water. Water comprises 87% of the milk matrix with the other 13% being total solids. The total solids can be further characterized as follows, fat (3.9%), proteins (3.4%), lactose (4.8%), and minerals (0.8%) (Bylund 2003).

Analyses of each component, beginning with fat, shows that fat exists as an oil in water emulsion in milk. Fat is the largest particle in milk, with an average fat globule size of 3 um, and a density that is much lower than the other components. The lower density of the fat is what allows the fat to rise to the top when raw milk is left to stand. In today's milk processing it is common practice for the milk to pass through a homogenizer, causing the fat globules to decrease in size to approximately 0.8 um (Muir 1998). At this size, the fat globules do not rise as quickly, providing a better dispersion of the fat globules and overall better consistency. The structure of the fat globule is also complex. The fat that is in milk is predominately made up of mixed-triglycerides. Triglycerides are a structure in which glycerol is the main backbone and three fatty acids are attached to glycerol through ester linkages. Fatty acids are hydrocarbon chains with an acid group on one end of the chain and a methyl group on the other end of the chain. Fatty acids differ in the number of carbons in the chain as well as the number of bonds (single or double) between these carbons. The differences between their chains are what cause each fatty acid to behave differently. Triglycerides can have three different fatty acids
attached to the glycerol backbone or three of the same fatty acid attached to glycerol. Myristic, palmitic, stearic, and oleic acids are the four most common fatty acids found in milk (Bylund 2003).

Lactose is the most abundant constituent of the total solids in milk, and is the only carbohydrate in milk and is only found in milk. It is a disaccharide of galactose and glucose providing the slight sweet taste of milk (Muir 1998). Lactose also allows milk to be easily fermented with the introduction to certain bacteria, giving the bacteria a good substrate to metabolize. Lactose is also a reducing sugar which undergoes a highly complex reaction known as the Maillard reaction when heated to high temperatures. This reaction is also responsible for the change in color when milk is heated (Hotrum and others 2010).

While milk has numerous different types of proteins, they fall into two main categories: caseins and whey proteins. Caseins are the dominant class of proteins in milk, contributing to 80% of the overall milk proteins. The caseins are subdivided into four principal caseins- the alpha\(_{s1}\) (\(\alpha_{s1}\)), alpha\(_{s2}\) (\(\alpha_{s2}\)), beta (\(\beta\)), and kappa (\(\kappa\)) (O’Regan 2009). Casein proteins have the ability to group into micelle structures and are comprised of submicelle units. Kappa casein keeps the micelle structures from grouping together due to its hydrophilic parts. Introducing certain enzymes or acid into the system it will cause the caseins to precipitate. This is important in formulation of other dairy products. If the caseins are allowed to aggregate and form curds, the whey proteins will remain in solution (Bylund 2003). Whey proteins are the second major group of proteins found in milk. There are two main whey proteins, \(\alpha\)-lactalbumin and \(\beta\)-lactoglobulin.
α-lactalbumin aids in the synthesis of lactose and is found in all mammalian milk (Bylund 2003). The whey proteins are classified as globular in shape and when introduced to heat they will denature. Heat denaturation causes these proteins to unfold, allowing them the ability to bind with other molecules. The heat denaturation of β-lactoglobulin gives milk the “cooked” flavor from release of hydrogen sulfide when milk is heated over to temperatures over 60°C. This is due to the number of cysteine amino acids, which contain a reduced sulfur group (Patton 1969).

**Milk Processing**

Once milk has been received from the dairy farm and transported to the processing facility via milk tank trucks, it is held in silo tanks. From here the cream is separated from raw milk leaving only skimmed milk (Gunsing and others 2009). Before entering heat treatment, the fat is standardized, “…to give the milk a defined, guaranteed fat content.” (Bylund 2003). According to the standard identity, whole milk must contain at least 3.25 % milk fat, Reduced Fat must contain 2% milk fat, Low-fat must contain 1%, and skim must contain less than 0.5% milk fat as stated by the USDA in the Code of Federal Regulations (USDA 2013). Milk is then homogenized, which reduces the fat globule size, allowing it to distribute more evenly throughout the milk and providing overall more consistent texture. Now the milk is ready for the heat treatment known as pasteurization.

Pasteurization of milk is used to kill pathogenic bacteria. This also allows milk to “…enhance its shelf life by removing 95% of all the contaminating organisms” (Chandan 2008). The “Grade A Pasteurized Milk Ordinance” by FDA’s Department of Human and
Health Services, states that the minimum time temperature requirements for legal high-temperature short-time pasteurization as 15 seconds at a temperature of 72°C (USFDA 2009). Pasteurization is defined as, “…the process of heating every particle of milk or milk product, in properly designed and operated equipment…” to at least the minimum time temperature requirement (FDA 2011). Post pasteurization, milk is cooled back to 4°C to minimize any possible growth of microorganisms that could cause spoilage or health concerns (Jones and Harper 1976). Post-pasteurization milk may be bottled and packed for shipment. Fluid milk that has been HTST pasteurized will have a shelf life of 14-28 days (Boor 2001). Most conventional milk has been HTST processed, and considered to have this shelf life. (This is a very generalized overview of milk processing; many factors can affect the processing flow depending on the desired final product.)

**Organic Milk**

Organic milk must be certified organic under the National Organic Program in the United States Department of Agriculture – Agricultural Market Service before being able to bare the USDA Organic seal (USDA-AMS). While there is limited research claiming that organic milk differs compositionally from conventional milk, overall the two milks do not vary from a nutritional standpoint. The difference lies in the livestock handling procedures for dairy cattle as outlined by the USDA. Organic dairy farms feed their livestock 60-100% forage diets, while conventional dairy farms feed a concentrated feed (Harstad and Steinshamn 2010). “The USDA organic seal verifies that producers met animal health and welfare standards, did not use antibiotics or growth hormones, used
100% organic feed, and provided animals with access to the outdoors.” (USDA-AMS 2013). The majority of organic milks are ultra pasteurized, this heats the milk to a higher temperature than traditional HTST pasteurization.

“Ultra-pasteurized, when used to describe a dairy product means that such products shall have been thermally processed at or above 280°F for at least two seconds, either before or after packaging to produce a product which has an extended shelf life under refrigerated conditions.” (21CFR Part 131.110, 2013.)

Due to the different farming practices and higher feed expense for organic dairies, organic milk typically cost more per gallon than conventionally produced milk. The idea of a longer shelf life for some consumers is a way to offset the additional cost. Ultra pasteurized milk for some consumers, however, is less preferred. The added heat treatment and increase in protein denaturation at this temperature causes a stronger cooked flavor to the milk, and has not been widely accepted by consumers (Clare and others 2005). Levy and McGregor previously studied the heat processing method on three factors associated with milk foam evaluation. From the three variables analyzed, steam froth value (SFV), percent dissipation as well as foam volume, there were no differences between the two processing methods and their ability to produce quality foam (1998).

**Food Foams**

Foams in foods exist in a wide range of food products from bread, beer, ice cream, cereals, specialty coffee drinks, and countless others. McGee (1984) defines foam as “… a portion of liquid mass that holds its shape”. Three different processes can
generate aerated foods. The first process is by mechanical action such as shaking or whipping in which “… the liquid is actively forced around external gas..” (Campbell and Mougeot 1999). The second process is the opposite of the first process whereby gas is forced through the liquid, and is called sparging. The third process happens within the food matrix itself, either chemical or biological by applying heat and/or pressure, is called in situ (Campbell and Mougeot 1999). The stability of aerated foods varies greatly from minutes, like with a cappuccino, to possibly years, as seen with frozen ice cream.

**Milk Foam**

Milk foam is a colloidal dispersion with gas as the dispersed phase and the liquid as the continuous phase (Murano 2003). Described by Levy as, “… mostly air and is characterized by high viscosity, low density, high surface area and high surface energy.” (2003). The foam produced by milk is short lived and intended to be produced directly before consumption. Milk foam quality can be evaluated several different ways. Common terms within recent literature, four different analyses stand out. The first being the overall overrun of the milk, this is described as how much the milk expanded due to the air incorporated. Levy (2003) use the term Steam Froth Value (SFV) when describing the overrun of the milk. The second term is foam volume (FV). Knowing the time at which this measurement was taken is an important factor, for Levy (2003) the measurement was taken after minutes of dissipation, Kamath (2008) uses this measurement directly post frothing and uses the term foamability. Silvia and others (2008) use volume of foam and measure at specified increments. Foam stability, is the ability of the foam to maintain its structure over a specified amount of time or given
conditions (Huppertz 2010). Levy (2003) uses % dissipation while others (Kamath 2008) use the half life of the foam to define the foam stability. The last visual evaluation of milk foam is the imaging of the air bubble size (Huppertz 2010). For coffee houses the ideal foam would have small bubble size and consistent stability.

Proteins in milk allow milk to create foam when introduced to forced air and heat. Specifically, the globular whey protein β-lactoglobulin, is mainly responsible for milk’s ability to entrap the air bubbles and create the foam matrix (Kailaspathy 2009). As heat and or mechanical agitation are introduced into the system, the protein unravels exposing its previously entangled hydrophobic end to the introduced air bubble causing an increase in strength of the of the air bubble. Kamath and others (2011) sum up the interaction as follows: “… temperature determines the physical phenomena such as foamability of milk and stability of milk foam by altering the protein composition and protein-protein interactions at the air-liquid interface of milk foams” (2011). Once the foam has been created in milk, the matrix is only considered to be metastable, meaning it is not permanent (Murano 2003). Milk foamed coffee drinks, once made by the barista, are intended to be consumed immediately and are given a consumption time of 10-15 minutes (Huppertz 2010).

Foam destabilizes by three different processes- coalescence, disproportion, and drainage. Campbell and Mougeot (1999) define the stability of the bubbles within the foam and explains the three methods of destabilization. The first process is coalescence of the bubbles. Coalescence occurs when two bubbles merge together and create a larger air bubble, decreasing the amount of bubbles but increasing in the size of one individual
air bubble. Viscosity is directly related to bubble coalescence. The higher the viscosity the less likely coalescence will occur which correlates to the fat content of the milk. The second process is disproportionation of gas bubbles. In this process, the smaller air bubbles have higher gas pressure and thus slowly diffuse to the larger gas bubble causing the smaller bubbles to become smaller and the larger bubbles to grow in size. The third process that affects stability is drainage. Drainage pulls the liquid portion down causing the thinning of the film, reducing the interfacial tension causing coalescence of the bubbles and/or bubble rupture (Damodaran 2005). Over time the drainage finally causes deformation of the bubbles (Huppertz 2010).

**Steam Injection**

Few studies have been conducted on steam injection of foam formation. This process is preferred over mechanical agitation due to its quick results as well as the positive effects from increasing the temperature of the liquid using the steam method. “This method, unlike mechanical agitation, induces a steep increase in the milk temperature, which is expected to have a significant effect on protein conformation.” (Silva and others 2008). Steam injection is completed by forcing air into the milk through a nozzle that has a perforated surface (Huppertz 2010). The steam injection method is used by baristas in coffeehouses to create the milk foam.

**Plant Cleaning and Sanitation**

Milk processing equipment must be cleaned to maintain product safety. To maintain plant productivity a cleaning process known as CIP, or clean-in-place, is often used to decrease labor and maintain productivity. CIP cleaning is just as effective as
dismantling and manual cleaning (Marriott 1999). Since the equipment in CIP does not need to be dismantled and reassembled, the plant is able to increase productivity due to less down time for cleaning and sanitation (Anderson 2007). Anderson (2007) reported that CIP is an effective process, “…using time, temperature, chemical concentration, and mechanical action to achieve satisfactory performance on a repeatable basis.” Table 1.1 shows the typical operations and function of cleaners in the typical cycle for CIP systems.

**Table 1.1 Typical Cycle for CIP System**

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<tr>
<td>1. Preliminary rinse (hot or cold water)</td>
<td>Remove gross soil</td>
</tr>
<tr>
<td>2. Detergent wash</td>
<td>Remove residual soil</td>
</tr>
<tr>
<td>3. Rinse</td>
<td>Remove cleaning compounds</td>
</tr>
<tr>
<td>4. Sanitization</td>
<td>Destroy residual microorganisms</td>
</tr>
<tr>
<td>5. Final rinse (optional, according to sanitizer use)</td>
<td>Remove CIP solutions and sanitizers</td>
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(Source: Marriott 1999 p.174)

With the chemicals being automatically diluted and dispensed into the line with CIP, care must be taken to ensure the correct dilutions rates are added. It is recommended that the rates be checked bi-weekly to ensure accuracy (Schmidt 2003).

Water plays a very important role in plant cleaning and sanitation. Water quality cannot be overlooked and water sources must be periodically tested for safety. Rinsing is an integral part in the cleaning sequence, with two main rinse cycles, a pre-rinse, and a post-rinse (Carsberg 2003). Post production, the pre-rinse cycle should begin immediately, removing as much soil as possible and running until the water being flushed returns clean (Bylund 2003). Since milk deposits cannot be removed from the processing lines with water alone, chemicals must be used in conjunction with water. “Protein rich deposits are mainly removed by alkaline cleaning solutions and mineral scale by acidic
solutions.” (Christian and Fryer, 2003). Dairy processing plants run the CIP process at least once a day (van Asselt and te Giffel, 2009).

Previous focus in the processing plant has been placed on decreasing foam for bottle filling as well as the possibility of a wet sealing surface caused by foam (Gamboa and Barraquio, 2012).

Cleaners

In milk processing plants different cleaners are used based on several factors but key factors are: effectiveness on the type of soil present, the surface material, and cleaning process method in place (Tact Wins). Using one single chemical cleaner is not plausible, due to their different mode of action. Implementation of a proper cleaning/sanitation program that is made specific for the sequence of the cleaners used as well as the processing facility is necessary for safe milk production (Holah and Thorpe 2009). There are many different types of cleaners; however, the two common cleaners used in food processing, specifically dairy processing, are alkaline and acid-based chemicals (Tact Wins). Often, a third chemical, a surfactant is added to aid the detergent. Surfactants form micelles around soil allowing it to be removed from surfaces by water. Alkaline detergents act on organic soil and acids act on inorganic soil (Tact Wins). Heating of milk (through the pasteurization process) causes the denaturation of proteins (organic), as well as precipitation of the salts (inorganic) onto surfaces making it more difficult to clean than cold processed milk (Tamime and Robinson 1999). The cleaners are combined with high quality water at the recommended ratio to create a cleaning
solution. Cleaning solutions need to be prepared fresh to avoid microbial growth in the diluted stage, preferable within 48 hours of expected usage time (Ray 2001).

Alkaline cleaners are described as those having a pH range of 7-14. The alkaline cleaner is typically circulated and then followed by an acid (Bylund 2003). The purpose of the alkaline cleaner is to breakdown the protein deposits along with solubilizing fats (Ray 2001). Acid cleaners have pH range < 7.0. The main focus of the acid cleaner is to work on the surface of the equipment rather than the soil particles (Marriott 1999). Acids also aid in reducing the alkalinity from the previous alkaline cleaner which contains corrosive properties (Tact Wins).

It is often common practice to add a defoamer when foam formation occurs during the cleaning process. Surfactants, get their name from combining the words “surface active agent” (Tact Wins). Surfactants reduce the surface tension of water, enabling the cleaner to work more effectively on the surface being cleaned as well as the soil (Bylund 2003 and Marriott 1999). Defoamers function by attaching to the air bubble and ultimately cause the bubble to collapse and rupture from either coalescence of the bubbles, or weakening and destroying the bubble lamellae (Pelton and Flaherty 2003).

The goal for this research was to determine if there is a difference in whole milk frothing capacity between locally available milk brands including certified organic milk. The second part of this research project focuses on the potential effects that CIP cleaning solutions could have on the frothing capacity of whole milk.
Literature Cited:


CHAPTER TWO
MARKET SURVEY OF ORGANIC AND CONVENTIONAL MILKS

Abstract

Five different brands of whole milk, two of these being organic, were frothed using steam injection and evaluated based on three variables: steam froth value (SFV), foam volume (FV), and percent dissipation (%D). Each brand was frothed five times during three replications, using a different milk sell by date with each replication. Differences (p<0.05) in frothing were seen only when organic milks were compared to conventional milks. Organic milk produced lower quality foam as measured by SFV, FV and %D.

1. Introduction

Consumption of gourmet coffee drinks has dramatically increased in the past few years (NCAUSA 2013). With most of these coffee drinks including milk and/or milk foam, an emphasis on producing high quality foam is of great importance. Recent customer complaints have focused on the failure of milk to foam to expectations of the coffee house (Randolph & Associates 2013). Identifying the source of this failure could enable the milk industry to provide higher foam quality milk to meet the growing needs of coffee houses.

Another growing consumer trend has been the increased production and consumption of organic milk. The Dairy Market News reported that organic whole milk sales were up 11% from the year-to-date comparison in 2012 to 2013 (2013). With consumer trends focused on the use of organic products, coffee houses have responded
with using organic foods. Many coffee houses are beginning to offer organic coffee beans, as well as using organic milk in recipes, leading to the need for more research on organic milk and comparison to conventional milk. Because milk frothing is a key component in the production of coffeehouse drinks, this study was undertaken to determine if there are differences in the frothing quality of organic and conventional milks.

2. Materials and Methods

2.1 Milk Samples:

The milk samples for this experiment were all obtained from local grocery stores. Five brands of whole, high-temperature short-time pasteurized (HTST), homogenized bovine milk was used for the market survey study. Two of the milks used in the market study were organic products. After the milk was purchased, the containers were placed in a cooler for transport to the lab. At the lab, the containers were placed into a 1°C refrigerator until frothing.

Milk containers remained unopened for seven days prior to the stamped sell by date, on this date the milk was then prepared for the frothing procedure.

2.2 Frothing Procedure:

The frothing procedure was adapted from Levy (2003). All frothing was conducted in the same manner. Refrigerated McCormick® commercial red food coloring was added at 0.01 ml to a 7.5 cm diameter graduated cylinder. Whole milk (6°C±1°C) was then measured at 200 ml and added to the graduated cylinder. The cylinder was then placed under the steam tip so that the steam tip was off-center towards the back of the
cylinder (closer to the steamer) and at a slight angle (Figure 2.1). The steamer used in this experiment was an Astoria Single Steamer, Model AL 1 with pressure of 1.10 bar. The steam valve was then opened fully and the cylinder was slowly lowered as the milk began to froth so that the steam tip remained just below the surface of froth. The milk was frothed for a total of 10 seconds. The steam was turned off, temperature recorded and the cylinder was placed on a flat surface. The height of the froth, the liquid volume, and the milk/foam interface were all measured in centimeters at intervals of five seconds, one minute, and at five minutes post frothing. The ruler for measuring was placed so that 0 cm was at the bottom of the liquid directly on the outside of the cylinder (Figure 2.2.) The steam valve was fully opened for 2 seconds prior to frothing each sample to purge the line. After completing one set, which consist of five froth runs, means for the values were calculated. After running one set, the boiler tank of the steamer was refilled to three fourth full and given 15 minutes to come back up to pressure of 1.10 ±0.05 bar. Each treatment was repeated three times with a different code date used for each repetition.
Figure 2.1: View of the position of the steam tip and angle of steam wand.

Figure 2.2: Position of measuring ruler beside cylinder. Close up view of the ruler position at base of cylinder on right.
2.3 Foam Volume:

The foam value was calculated using the method developed by Levy (2003) by taking the foam height after 5 minutes dissipation and subtracting the foam interface. If the foam was not evenly distributed across the beaker, an average height was determined visually.

2.4 Foam Dissipation:

The percent foam dissipation (Levy 2003) was determined by the formula:

\[
\% \text{ dissipation} = \frac{IF - FF_5}{IF - FMI} \times 100
\]

where the initial foam (IF) is foam height 5 seconds after the cylinder was removed from steam, final foam height (FF_5) is foam height after 5 minutes dissipation, final milk interface (FMI) is the final milk/foam interface in the cylinder.

2.5 Steam Froth Value (SFV):

Levy (2003) calculated steam froth value as follows, SFV= 100(TV-LV)/LV, where (TV) is the total volume, and (LV) is the liquid volume. All values in this calculation were measured after 5 minutes of dissipation.
Figure 2.3: Visual of regions within the graduated cylinder.

2.6 Statistical Analysis

Sample means for the market survey were compared for significance using the Tukey multiple comparison procedure for the three response variables, SFV, foam value, and percent dissipation, comparing each brand against each other. Linear contrasts were used to compare the means of the conventional milks to the organic. Using a significance level of 0.05, (95% confidence).
3. Results and Discussion

Analyses of the five different brands of milk indicated no significant differences (p>0.05) for the steam froth value, foam volume, or percent dissipation as seen in Table 2.1. Due to the visual differences in the foams from the two organic milks compared to the three conventional milks, data collected on the organic milks were statistically compared against the conventional milks. Organic milks were significantly different from the conventional milks for all three variables: SFV, FV, and % dissipation, Table 2.2 (p<0.05). Furthermore, the organic milks had a lower overall steam froth value than conventional milk, meaning a lower overrun of the milk when the steam was injected. Organic milks also had a higher percent dissipation than conventional milks. During froth formation, the organic milks had overall larger air bubbles, with more of a “dish soap” appearance than the “wet paint” look of the conventional milk’s froth. The organic milks produced a much larger bubble size when compared to the conventional milk.
Varying milk composition has been noted between organic milk and conventional milk. The amount of whey proteins produced by cows depends strongly on many factors.
factors, including cows’ diet, health, stage of lactation, breed, and time of year.”
(Kuczynska 2011). Certified organic dairy farms must offer at least 60% forage in the cow’s total diet. Harstad and Steinshamn (2010) show that the overall available energy in forage diets is less than concentrated feed. Literature states that when increasing the metabolizable energy by one MJ, stimulates milk protein content by an estimated 0.2-0.3% (Givens 2003). Metabolizable energy is the available energy from the feed, which is measured in Mega Joules (MJ) of metabolizable energy (ME) per kg of dry matter (DM) (Givens 2003). The higher the MJ of ME/kg DM the higher the energy feed. Givens (2003) states that, “…energy value of the majority of forages is generally lower (<11 MJ of ME per kg of DM) than that of concentrated feed (>13 MJ of ME per kg of DM)…”.

Previous work from Levy and McGregor (1998) considered the differences in the processing methods (HTST for conventional and Ultra pasteurized typically used for organic) and found no differences for foam quality between the two processing methods. However, their study did not include the study of certified organic milk, which would include the different farming practices for organic dairy farming.

4. Limitations

Having the same number of organic milk brands, as conventional brands would have been ideal. However, the differences of grouping the samples as conventional against organic was not decided until analyzing the data. One brand of conventional milk was noted as having large visual variability between replications, which could have affected results slightly.
5. Conclusion

While there was no statistical difference when comparing one brand of milk to another, the visual differences that were observed between the three conventional milks as compared to the two organic brands led to a direct comparison of the data. When the data was separated into conventional and organic brands of milk, a significant difference (p<0.05) between steam froth value, foam volume, and percent dissipation when comparing the conventional to organic brands. The organic milks produced lower quality foam as measured by all three variables: SFV, FV and %D.

6. Further Studies

Future research on foams between brands should include samples from different seasons that would include different lactation seasons for cows, as well as more samples. Imaging looking at bubble size, quantity, and source of rupture could bring previously undocumented results and answers. The viscosity of the foams could also be tested using a Bostwick Consistometer to determine if there is a difference in the viscosities of the foams produced from the different brands.
CHAPTER THREE

EFFECT OF CLEAN-IN-PLACE (CIP) CLEANING SOLUTIONS ON THE
FROTHING CAPACITY OF WHOLE MILK

Abstract

The effect of common CIP cleaning solutions on milk frothing ability was evaluated. Residual cleaning and sanitizing solutions are commonly found on commercial milk processing equipment, and these cleaning agents may negatively impact milk frothing. Whole milk was treated by the addition of alkaline, acid, antifoaming CIP solutions, or water at an addition rate of 1% or 5%. A total of 12 treatments and a control were evaluated in this study. The three variables analyzed were steam froth value (SFV), foam volume, and percent dissipation. Each sample was frothed five times with three replications, using a different sell by date with each replication.

The addition of cleaning solution significantly (p<0.05) reduced the milk’s SFV as compared to the control milk (no cleaning solution). The solutions that were different from the control include: water at 5%, alkaline at 1% and 5%, defoamer at 1% and 5%, alkaline+defoamer at 1% and 5%, and acid+defoamer at 1% and 5%. The treatments of water at 1% addition and acid cleaner solution at 1% and at 5% addition rates had no effect on SFV (p>0.05). When comparing the rates (1% or 5%) within the solutions, the water solution and the alkaline+defoamer were significantly different (p<0.05). In general, the results for foam volume closely resemble the steam froth value, with no differences (p>0.05) in water at 1%, and both acid addition rates of 1% and 5% when compared to the control. For percent dissipation, solutions that differed from the control
(p<0.05) were alkaline+defoamer at 1% rate, water at 5%, and acid+defoamer at both 1% and 5% additions. Results from this study demonstrate that cleaning solutions that may end up in milk at abusive levels could be a source of poor frothing characteristics in whole milk.

1. Introduction

Gourmet coffee drink consumption has increased over the past several years (NCAUSA 2013). With most of these coffee drinks including milk and/or milk foam, there is a significant need to produce high milk foam. Recent complaints have focused on the failure of milk to foam to expectations of the coffee house (Randolph & Associates 2013). Identifying the source of this failure could enable the dairy industry to provide higher foam quality milk to meet the growing needs of coffee houses.

The FDA mandates sanitation of dairy processing equipment. Milk processed using an unsanitary environment is considered to be adulterated and “unfit for human consumption”. Dairy processors must hold up to a high level of cleaning standards to produce a safe and high quality product. This includes having a sanitation program in place along with Good Manufacturing Practices and proper employee training. Sanitation programs vary widely depending on the processing facility, equipment used, products produced, and method of cleaning. CIP (clean-in-place) is the preferred cleaning method for most dairies due to reduced labor and increased productivity (Bylund 2003). CIP also includes the use of certain cleaners and must rely on proper addition rates of these cleaners to the equipment. Care must be taken to ensure this addition rate is correct; not only for the equipment surface, but for the safety and quality of the product processed
immediately after cleaning. Additionally, when high levels of cleaner or sanitizer are used when not necessary, this incurs a loss of dollars associated with chemical usage waste (Marriott 1999). Companies must also be careful with their wastewater discharge levels, as fines can be placed upon the company when levels are too high.

The objective of this study is to determine the effects of antifoaming agents contained in common alkaline, acid, and antifoaming cleaning solutions on the frothing properties of whole milk.

2. Materials and Methods

2.1 Milk Samples

The milk samples were obtained from a local grocery store. After the milk was purchased, the containers were placed in a cooler for transport to the lab. Once in the lab, the containers were placed into a refrigerator set to 1°C until ready for frothing.

2.2 Cleaner Solutions

Three different cleaning solutions were evaluated in this experiment and were chosen based on their use in dairy HTST processing facilities along with the recommendation of an Ecolab® representative. The cleaning solutions that were tested included: an alkaline cleaner (AC-103), an acid cleaner (Red 55-5), and a defoamer (Foam Nox). All solutions were formulated based on the highest recommended usage rate from Ecolab® specification sheet, Table 3.1. Each concentrated cleaner was added to 32 ounces (946.35 ml) of distilled water as seen in Table 3.1 to create a standardized cleaning solution. The solutions were inverted 10 times to mix and placed into the
refrigerator set at 1°C. All standardized cleaning solutions were made the day before adding it to the milk for frothing.

**Table 3.1. Amount of cleaner added to distilled water.**

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Amount Added to (946.35 ml) Water</th>
<th>Highest Recommended Usage per Specification Sheet*</th>
</tr>
</thead>
<tbody>
<tr>
<td>AC-103- Alkaline</td>
<td>14.34 ml</td>
<td>194 oz to 100 gallons water</td>
</tr>
<tr>
<td>Red 55-5-Acid</td>
<td>22.18 ml</td>
<td>3 oz to 1 gallon of water</td>
</tr>
<tr>
<td>Foam Nox- Defoamer</td>
<td>.37 ml</td>
<td>1 oz per 20 gallons of water</td>
</tr>
</tbody>
</table>

*Specification sheets in Appendix A.

**2.3 Sample Preparation**

On the day of running the samples, (7 days prior to sell by date) 1000 ml of milk was poured into a clean unused half-gallon milk container. The stock cleaner solutions that were made up the prior day were individually added to 1000 ml of milk at a rate of 1% (10 ml) or 5% (50 ml). A control (no solution added) as well as a distilled water treatment at 1% and 5% were also frothed. Once the correct percentage of cleaner solution was added to the milk container, the container was sealed and mixed by inverting the container 10 times. The container was then placed back into the refrigerator to equilibrate for 15 minutes. A gentle swirl was given to the container before measuring each sample. Samples were then frothed as previously described. The entire experiment was replicated three times using a different milk sell by date for each replication.

**2.4 Frothing Procedure**

The same frothing procedure was used in this study as described in Chapter Two, Materials and Methods for the Market Survey section (page 17-20).
2.5 Statistical Analysis

The Dunnett Method for comparison of all treatments with a control was used to compare the twelve cleaning solution combinations for each variable. Means for steam froth value (SFV) and foam volume (FV) were analyzed using the Tukey multiple comparison procedure to find differences between the rates of addition due to evidence indicating there was interaction between both the rates and solution type using a significance level of 0.05.

3. Results and Discussion

Visually, the 1% water addition treatment did not affect the frothing capacity of the milk using the steam injection method. The treatments that contained the alkaline cleaner produced larger foam bubble formation. The acid treatments visually produced smaller air bubbles, closely resembling the bubbles in the control. The defoamer treatment only occasionally affected overall visual gas bubbles formation. The three variables (SFV, Foam Volume, and % Dissipation) were each analyzed separately for the twelve treatments.

3.1 Steam Froth Value (SFV)

Steam froth value is the overrun of the milk when introduced to steam injection. As seen in Figure 3.1, the treatments that were significantly different (p<0.05) from the control were: water at 5% addition, alkaline at both 1% and 5% addition, defoamer at 1% and 5%, alkaline+defoamer at both 1% and 5%, and acid+defoamer at both addition rates of 1% and 5%.
SFV of the two milk treatments that contained the acid solution alone, (no defoamer added) was not significantly different from the SFV of the control milk (p>0.05). During sanitation, acid is applied to act on inorganic soil, therefore not affecting the proteins in the milk matrix (Tact Wins). The milk proteins, which have been proven to be the main source for milk foaming properties, were not affected by the addition of acid at the rate of 1% and 5% (Rouimi 2005). Adding the acid solution to the milk also lowered the pH of the system to 6.7 for 1% and 6.3 for the 5% addition rate as seen in Table 3.2.
<table>
<thead>
<tr>
<th>Table 3.2 Milk pH after addition of solutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
</tr>
<tr>
<td>Cleaning Solution</td>
</tr>
<tr>
<td>Water</td>
</tr>
<tr>
<td>Alkaline</td>
</tr>
<tr>
<td>Acid</td>
</tr>
<tr>
<td>Defoamer</td>
</tr>
<tr>
<td>Alkaline+Defoamer</td>
</tr>
<tr>
<td>Acid+Defoamer</td>
</tr>
</tbody>
</table>

The results for the acid resemble the results from previous work of Augustine and Clarke (2008). In their study it was discovered that lowering the pH of skim milk powders using citrate led to an increase in SFV (2008). However, these results contradict the findings from Borcherding and others (2009), “Overall, skimmed milk tends to show a higher overrun with increasing pH…” In the study of Borcherding and others (2009) the pH was increased to 7.0, matching the pH of the alkaline at 1% addition rate. Further in their study it was discovered that the bubble size increased with increasing pH (2009). This supports the visual results seen here with the alkaline solutions creating larger bubbles in the foam. While an increase in pH causes an increase in bubble size (Borcherding and others 2009) therefore producing more overrun, this does not necessarily lead to better overall foam quality.

Water at the 1% addition rate also did not affect the steam froth value when compared to the control for SFV. Borcherding and others (2009) also considered the
dilution of the proteins in milk and their effect on milk foam. Their results show that milk proteins could be diluted without causing an effect on the foaming qualities of milk.

There was sufficient evidence to indicate that the cleaner solution and the rates had an interaction, therefore the rates and the solutions were collectively considered. With this comparison, there were significant differences (p<0.05) between the addition rates of water as well as the rates of the alkaline+defoamer. Increasing the water to the 5% addition possibly caused more widespread distribution of the proteins, resulting in fewer formed bubbles, so an overall lower steam froth value. The alkaline+defoamer at 5% addition resulted in the lowest steam froth value of all of the treatments. These results match with what is to be expected with both the increase of alkaline and defoamer to 5% addition, both acting on the proteins in the system decreasing the ability to produce foam.

Separating the 1% and 5% addition rates as seen in Table 3.3, and comparing the cleaners within the addition rates gave several unexpected results. At the 1% addition rate, when comparing all solutions, water at 1% was significantly different from all other 1% solutions except the acid treatment. The 1% addition rate of water did not affect the ability of the milk to produce froth, nor the acid cleaner at 1% addition rate. Both these treatment solutions and rates produced higher steam froth values than the other treatments.
Table 3.3 Comparison for Steam Froth Value (SFV)

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>Cleaning Solution 1%</th>
<th>Cleaning Solution 5%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>94.6 cm</td>
<td>95.9 a A</td>
<td>83.6 b AB</td>
</tr>
<tr>
<td>Water</td>
<td>94.6 cm</td>
<td>79.4 a B</td>
<td>74.0 a BC</td>
</tr>
<tr>
<td>Alkaline</td>
<td>86.5 a AB</td>
<td>80.7 a B</td>
<td>80.8 a B</td>
</tr>
<tr>
<td>Acid</td>
<td>86.5 a AB</td>
<td>79.4 a B</td>
<td>74.0 a BC</td>
</tr>
<tr>
<td>Defoamer</td>
<td>77.9 a B</td>
<td>80.7 a B</td>
<td>80.8 a B</td>
</tr>
<tr>
<td>Alkaline+Defoamer</td>
<td>78.0 a B</td>
<td>70.5 b C</td>
<td></td>
</tr>
<tr>
<td>Acid+Defoamer</td>
<td>78.0 a B</td>
<td>70.5 b C</td>
<td></td>
</tr>
</tbody>
</table>

Lower case letters are for the comparison of rates and upper case letters are for the comparison of solutions. Means with the same letter are not significantly different. Standard error for individual means is 2.31.

The addition rate at 5% of the acid treatment was significantly different from all other solutions except water (p<0.05). At the 5% rate, acid allowed the highest steam froth value, even higher than the water at this addition rate. Vasbinder and Kruif (2003) discovered that at a pH of 6.35, β-lactoglobulin showed more denaturation. This allowed the protein to become more available, exposing the hydrophobic and hydrophilic ends, producing more foam.

3.2 Percent Dissipation (%D)

When all treatments were compared to the control for percent foam dissipation, alkaline+defoamer at the 1% addition rate, acid+defoamer at 1% and 5%, as well as the
water treatment at 5% were all significantly different from the control (p<0.05). An increase in percent dissipation ultimately corresponds to the rate of instability of the foam. Among the solutions that were different from the control, most included the added defoamer. However, the defoamer alone at either addition rate used, did not effect the percent dissipation. It is expected that the defoamer would act quickly on the foam and have a higher percent dissipation; however, this did not occur for the treatments with the defoamer (Maldono-Valderrama 2007). The alkaline+defoamer at 5% addition did not differ from the control, which was unexpected. With alkaline acting on the proteins as well as the defoamer decreasing the air bubbles, this combination was expected to have higher percent foam dissipation than the control. The alkaline solution raised the pH of the milk to 7.0 at 1% and 8.1 at the 5% addition rate, Augustine and Clarke stated that when increasing the pH it actually increases the foam stability which is the percent dissipation in this study (2008). “At high pH it is possible that the viscosity effects have a major contributory effect on enhancing foam stability.” (Augustine and Clark 2008). Increase viscosity could be due to the fact that disruption has occurred on the casein micelles (Huppertz 2010). The 5% addition rates overall were actually closer to the control than the 1% addition rates as seen in Figure 3.2
**Figure 3.2** Comparison of treatments to control for Percent Dissipation (%D), * indicates statistical difference from control (p<0.05).

When the solutions were compared against each other and not the control there were no significant differences (p>0.05) viewed in **Table 3.4**.
Table 3.4 Comparison for Percent Dissipation (%D)

<table>
<thead>
<tr>
<th></th>
<th>11.5 %</th>
<th>( % )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cleaning Solution</td>
<td>1%</td>
<td>5%</td>
</tr>
<tr>
<td>Water</td>
<td>15.6 a A</td>
<td>16.5 a A</td>
</tr>
<tr>
<td>Alkaline</td>
<td>15.3 a A</td>
<td>14.7 a A</td>
</tr>
<tr>
<td>Acid</td>
<td>15.7 a A</td>
<td>15.0 a A</td>
</tr>
<tr>
<td>Defoamer</td>
<td>15.8 a A</td>
<td>15.0 a A</td>
</tr>
<tr>
<td>Alkaline+Defoamer</td>
<td>16.4 a A</td>
<td>15.0 a A</td>
</tr>
<tr>
<td>Acid+Defoamer</td>
<td>17.1 a A</td>
<td>18.6 a A</td>
</tr>
</tbody>
</table>

Lower case letters are for the comparison of rates and upper case letters are for the comparison of solutions. Means with the same letter are not significantly different. Standard error for individual means is 1.38.

3.3 Foam Volume (FV)

All treatment solutions differed from the control for foam volume (p<0.05) except for three treatments viewed in Figure 3.3.
Figure 3.3 Comparison of treatments to control for Foam Volume (FV) in cm, * indicates statistical difference from control (p<0.05).

The three treatments that were not significantly different were the water at 1% addition rate as well as the acid at both 1% and 5% addition rates. The results are to be expected; the foam volume is the volume after five minutes dissipation, the treatments with the lower foam volume included both the alkaline treatments, all six treatments that included the defoamer, as well as the water at 5% addition treatment. Results from steam froth value and foam volume, are very similar when looking at trends compared to the control, Figure 3.1 and 3.3.

Results indicate that there is an interaction between the addition rate and the cleaner solution therefore, they must be jointly considered. The following solutions were
different (p<0.05), water, alkaline+defoamer, and acid+defoamer. While the defoamer alone made no difference at 1% or 5% addition rate, when added to the acid and alkaline treatments, the defoamer caused differences between the 1% and 5% addition rates for these two solutions.

When the 1% addition rates (Table 3.5), were examined, the water and acid treatments were significantly different from all other solutions at this rate except acid (p<0.05). At the 5% addition rate, the acid was different from all other solutions at this rate except water and the defoamer. The acid at 5% addition rate allowed a higher foam volume than the 1% addition rate, as seen with the steam froth value.

<table>
<thead>
<tr>
<th>Table 3.5 Comparison for Foam Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Cleaning Solution</td>
</tr>
<tr>
<td>Water</td>
</tr>
<tr>
<td>AC-103</td>
</tr>
<tr>
<td>Red 55-5</td>
</tr>
<tr>
<td>FNOX</td>
</tr>
<tr>
<td>FNOX+AC-103</td>
</tr>
<tr>
<td>FNOX+Red 55-5</td>
</tr>
</tbody>
</table>

Lower case letters are for the comparison of rates and upper case letters are for the comparison of solutions. Means with the same letter are not significantly different. Standard error for individual means is 0.096.
While most previous studies use skim milk, or powder, when evaluating milk foam, it sets limitations not looking at the system in its entirety. While milk foam is an increasing research subject, so many different variables make it difficult to compare studies, different foaming apparatuses, milk fat content, homogenization, milk processing methods, temperature at time of foaming, as well as measuring technique used. Goh and others (2009) along with Silvia and others (2008), took into consideration different methods for air incorporation into milk to form foam. Their studies conclude that while there are underlying compositional considerations as well as processing methods that must be noted, overall “…foams prepared by different methods can be considered comparable.” (Huppertz 2010).

Age of milk has been considered in relation to milk foam as well. Levy (2003) and Gamboa and Barraquio (2012) both took into consideration milk age, Levy going to ten days and Gamboa and Barraquio (2012) stopping at 9 days of age. Both studies found that the age of milk did not effect the frothing capacity of milk overall, Gamboa and Barraquio (2012) found a difference within foam volume.

Competition lies within the milk matrix for foam development. Free fatty acids that are a result of lipase, as well as milk proteins are both surface active components. However, the proteins in milk are the enablers for foam development in milk. When free fatty acid concentration is increased in the matrix, the overall ability for the milk to produce a stable foam decreased as seen with Kamath and others (2008) as well as Levy (2003). Proteins have been studied for their use in food systems as foaming agents, with the overall goal to make the protein more soluble by “…exposing more of the buried
hydrophobic amino acids to the aqueous solvent.” (Murray 2007). Hydrophobins are small proteins that are derived from filamentous fungus (Cox and others 2009). These proteins are divided into two classes, within this division the Class II hydrophobins are more “…readily dissolved in aqueous solution.” (Cox and others 2009). Furthermore, (Cox and others 2009) have gone on to stabilize foams for up to four days at room temperature, far surpassing the capability of β-lactoglobulin. Their study also analyzes a chocolate milkshake that was stored for 5 weeks at 5°C using 0.1% wt of the Class II hydrophobin, had only minor changes during storage. Coffee drinks with milk foam that could extend to this length of shelf life, would open many opportunities currently outside of the scope in respect to foam stability.

4. Limitations

Making the cleaner solutions in much smaller volumes than the ability of processing facilities could have placed a limitation; especially with the small amount of the defoamer usage rate. To avoid the temperature affecting the frothing ability of the milks, the solutions were placed in the refrigerator before adding to the milk. Most cleaners are run in the CIP process at much higher temperatures. Trying to mimic the foaming style used by baristas for this experiment, the foaming was based on the response of the milk treatment in respect to moving the cylinder down as foam formed. Other studies have used consistent height and constant position of the steam tip versus the method used here. The use of an electronic caliper could have aided measuring accuracy.
5. Conclusion

Researchers are beginning to focus more on bubble formation and the stability involved with foams in recent years, this area is expected to grow with more available research on the way (Dickinson 2010). Limitations include the quick dissipation of liquid foams and the ability to fully understand their rheology, which would lead to an equation model (Jang 2006).

Several cleaning solutions affected the ability for the whole milk to produce quality foam. The foam volume and steam froth value had very similar results with the same solutions, the water at 1% and the acid at both 1% and 5% addition rate, not being different from the control. Leaving all other treatment solutions not producing quality foam either by the overrun amount or amount of foam left after five minutes dissipation. Visually and overall statistically, the 1% addition rate of water did not effect foam production. Results from this study demonstrate that cleaning solutions that may end up in milk at abusive levels could be a source of poor frothing characteristics in whole milk.

6. Further Studies

Consideration was taken into making the solutions up to ten times the amount of the highest recommended usage rate. Addition of acid cleaning solutions at this rate caused the milk to coagulate making it unacceptable for additional study. Being able to run imaging studies to view the formation and collapse of the air cell may enable a greater understanding of the dynamics in making quality milk foam.
Literature Cited:


CHAPTER FOUR

STUDY CONCLUSION

Identifying the source of poor quality foam from milk needs further analysis. While research is expanding on this topic, there are still many questions left unanswered due to the short life of the foam produced, and even shorter the individual air bubbles, as this is a constantly changing system. The results indicate there are differences in conventional and organic milks for steam froth value as well as percent dissipation. The cleaner solutions showed to have differences on the ability of milk to produce stable foam and amount of foam. The acid cleaner as well as the water at 1% addition rate overall affected foam production the least.

Being able to receive samples from coffee houses of the milk that is not producing quality foam and having the ability to run imaging on these samples could also lead to other answers of the poor foaming ability. Finding the answer to milk froth stability and factors effecting, will aid the dairy industry in working synergistically with the coffee industry in meeting the increase demand for gourmet coffee drinks, a trend that continues to grow.
APPENDICES
Appendix A

SPECIFICATION SHEETS FOR RED 55-5, AC-103, AND FOAM NOX
AC-103

PRODUCT DESCRIPTION

AC-103 is a heavy-duty liquid alkaline detergent for CIP, bottlewashing and boil out applications.

BENEFITS

Promotes Quality Assurance
- Enhances finished product quality and shelf life when used in a total Ecolab product and professional services program
- Maintains effectiveness even during high temperature recirculation and boil out cleaning
- Ideal for bottlewashing applications and CIP of all types of stainless steel process equipment

Saves Time and Labor
- No mixing or dissolving necessary
- Fast soil penetration and emulsification to speed cleaning applications

Helps Reduce Cleaning Costs
- Highly concentrated to provide optimal use-cost performance
- Noncorrosive to stainless steel at recommended use dilutions to help protect equipment investment

Environmentally Responsible
- Contains no phosphorus
## AC-103

### PROPERTIES

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Form</td>
<td>clear to slightly hazy liquid</td>
</tr>
<tr>
<td>Color</td>
<td>pale tan</td>
</tr>
<tr>
<td>Odor</td>
<td>none</td>
</tr>
<tr>
<td>pH of 0.1% solution</td>
<td>12.5</td>
</tr>
<tr>
<td>Alkalinity</td>
<td>11.7</td>
</tr>
<tr>
<td>Active as Na₂O</td>
<td>37.4%</td>
</tr>
<tr>
<td>Total as Na₂O</td>
<td>37.8%</td>
</tr>
<tr>
<td>Specific gravity</td>
<td>1.522</td>
</tr>
<tr>
<td>Pounds per gallon</td>
<td>12.08 (6.75 kg)</td>
</tr>
</tbody>
</table>

Formula ingredients contain no phosphorus.

Store AC-103 above 50°F to prevent crystallization.

### TO USE

To prepare a 1.0% active caustic solution, use 1.4 gallons of AC-103 for each 100 gallons (14 mL/L) of water.

For CIP of product lines, use 52–60 oz. of AC-103 per 100 gallons (2.0–2.9 mL/L) of 150°–160°F (66°–74°C) water to provide 0.25–0.28% total product (0.15–0.20% active caustic) for a minimum of 10 minutes at temperature per spurt.

For CIP of cold product storage tanks, use 32–36 oz. of AC-103 per 100 gallons (2.5–2.8 mL/L) of 135°–140°F (57°–60°C) water to provide 0.25–0.28% total product (0.18–0.20% active caustic).

- **Large tankers:** 6–10 minutes at temperature
- **Small tankers:** 8 minutes at temperature
- **Horizontal tanks:** 10 minutes at temperature
- **Silo:** 15–20 minutes at temperature

To CIP processing vats, use 89–142 oz. of AC-103 per 100 gallons (7.0–11.1 mL/L) of 160°–165°F (71°–74°C) water to provide 0.70–1.1% total product (0.5–0.8% active caustic) for 40–45 minutes.

To CIP HTST units, use 160–194 oz. of AC-103 per 100 gallons (12.5–15.2 mL/L) of 178°–180°F (76°–82°C) water to provide 1.25–1.5% total product (0.9–1.1% active caustic) for 45–60 minutes.

Consult your Ecolab representative for specific use instructions and recommended dispensing equipment.

For precautionary and first aid information, consult the Material Safety Data Sheet (MSDS) or product label.

### AUTHORIZATION

AC-103 is authorized by the U.S. Department of Agriculture for use in federally inspected meat and poultry plants as a cleaner for use only in soak tanks or with steam or mechanical cleaning devices in all departments. Before using AC-103, all food products and packaging materials must be removed from the room or carefully protected. After using this product, all surfaces must be thoroughly rinsed with potable water.
AC 55-5 Red

PRODUCT DESCRIPTION
AC 55-5 Red is a highly concentrated blended acid specially formulated for CIP and COP cleaning of food and beverage processing equipment. AC 55-5 Red is formulated for acid cleaning where low foam characteristics are required.

BENEFITS

- **Saves Time and Money**
  - High concentration enables the product to be used at a lower concentration with faster reaction time.

- **Helps Promote Quality Assurance**
  - When used with a total Ecolab cleaning program, AC 55-5 Red helps provide a clean production environment.
  - Oxidizing formulation helps reduce corrosion which can inhibit complete soil removal.
AC 55-5 Red

PROPERTIES

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Form</td>
<td>liquid</td>
</tr>
<tr>
<td>Color</td>
<td>red</td>
</tr>
<tr>
<td>pH 1% Solution</td>
<td>1.3</td>
</tr>
<tr>
<td>Acidity as Phosphoric acid</td>
<td>32.3%</td>
</tr>
<tr>
<td>Acidity as Nitric acid</td>
<td>41.6%</td>
</tr>
<tr>
<td>Specific Gravity @ 68°F (20°C)</td>
<td>1.249</td>
</tr>
</tbody>
</table>

Formula ingredients contain not more than 0.5% phosphorus, 0.6 grams per gal. of average recommended use concentration.

DIRECTIONS FOR USE

For CIP or COP applications only:

Use 1 - 3 ounces of AC 55-5 Red per gallon (7.8 - 23.4 mL/L) of water. Circulate at 150 - 165°F (65° - 74°C). Rinse with potable water.

Consult your Ecolab Representative for specific use instructions and recommended dispensing equipment.

For cautionary and first aid information, consult the Material Safety Data Sheet (MSDS) or product label.

STATEMENT OF ASSURANCE

This product is effective under the intended conditions of use as outlined on the product label or specified in a Sanitation Standard Operating Procedure (SSOP).

This product will not adulterate food product provided that before using it, food products and packaging materials are removed from the room or carefully protected and after using these compounds, surfaces are thoroughly rinsed with potable water.

A Letter of Guaranty as indicated in USDA’s Sanitation Performance Guideline is available from your Ecolab representative.

ECOLAB SUSTAINABILITY POLICY

We have a commitment to our customers to provide effective programs that help protect the health and safety of their customers and employees. We will sell products or services that maximize performance, limit total environmental impact, and are safe as our customers commonly use them. We will inform our customers of the environmental impacts of our products or services, and of their correct use.

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Foam-Nox™

PRODUCT DESCRIPTION
Foam-Nox is a blend of liquid surfactants with defoaming and wetting properties.

BENEFITS
Saves Money
- Controlled foam levels help maintain peak cleaning efficiency
- Economical use-cost at recommended use dilutions

Saves Time
- Lower surface tension enhances penetration for cleaning effectiveness, decreases cleaning cycle time
- Use concentration is easily controlled through automatic dispensers

Promotes Quality Assurance
- Enhances finished product quality and shelf life when used in a total Ecolab product and professional services program
- Enhances soil penetration and removal through reduction of surface tension

Convenient to Use
- Can be used in spray cleaning applications such as case washers, pan washers, and can washers
- Concentration can be varied to control foam, from no foam to desired foam level
- Defoams over a temperature range of 130°F-200°F (54°C-93°C)
- Free rinsing - ideal for almost any CIP application
Foam-Nox™

**PROPERTIES**

- Form: liquid
- Pounds per gallon: 8.65 (3.92 kg)
- Color: yellow
- 100% solution pH: XXX
- Odor: faint
- pH 1% solution: 8.0
- Foam: low
- pH 0.1% solution: 7.6
- Wetting ability: excellent
- Spec. Grav. @ 68°F (20°C): 1.038

Formula ingredients contain no phosphorus.

**DIRECTIONS FOR USE**

Add to cleaning solution in quantity required to reduce foam to desired level. Normally, an ideal starting concentration would be 1 oz of Foam Nox to 20 gallons (0.4 mL/L) of water.

Consult your Ecolab Representative for specific use instructions and recommended dispensing equipment.

For cautionary and first aid information, consult the Material Safety Data Sheet (MSDS) or product label.

**STATEMENT OF ASSURANCE**

This product is effective under the intended conditions of use as outlined on the product label or specified in a Sanitation Standard Operating Procedure (SSOP). This product will not adulterate food product provided that before using it, food products and packaging materials are removed from the room or carefully protected and after using these compounds, surfaces are thoroughly rinsed with potable water.

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