MOISTURE MIGRATION IN JALAPENO JELLY LAYERED CHEVE CHEESE

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ABSTRACT

The objective of this study was to determine if moisture migration between cheve goat cheese and jalapeno jelly layers is the cause of observed product defects in the final. Cheese was made from the pasteurized milk, from one goat in mid- late lactation, and rennet/starter culture. The milk had problems in the first batch reaching 165°F in the original SafGard Pres-Vac electric pasteurizer, which had to be replaced with another of the same model. Each batch of cheese made was divided in half, one salted and the other non-salted, both categories were tested for moisture, solids, and water activity. The two batches of cheese were tested in duplicate. The second batch was tested at time 0 and 12 days. The jalapeno jelly was made and tested for moisture, solids, and water activity in duplicate. A two tailed t- test was used to determine if the differences seen were significant. Significance was found in the a_w between the salt and non-salt for test date 6/2/11 and the percent moisture and percent solids in the comparison of salt and non-salt of test dates 5/10/11 and 6/2/11. The statistical analysis of the t-test showed that there was a significant difference between test day batches, although it may not be important. The lack of test data on the a_w for the t=12 caused lack of firm conclusion to the experiment. The results indicated that a difference in water activity was present between the layers of cheese and jelly driving a_w equilibrium to create a water layer between each layer of cheese and jelly. Solution options would require more study into packaging and sensory, along with a more intensive look into the a_w of the product.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

Moisture migration is a topic that the food industries fight for longer shelf live and for more stable food products. The migration of moisture is a natural process that occurs in life. The water activity in most food products vary and with foods that are layered or in contact with each other this causes a problem. The difference between the two separate water activities in adjacent layers is an imbalance at the place of contact. This imbalance in water activities requires the unbound water molecules to reach equilibrium between the two domains. The goal of the industry is to minimize this transfer, so that their product retains the original desired product traits.

Although the migration of moisture decreases the shelf life, I choose to look at it for this study in the aspect of product consistency. The product that is the focus of this study is made by my family and is not yet in mass production. The cheese being used in this layer product is a fresh goat cheese that is hung in a butter muslin, and the jalapeño jelly is a family recipe that has been adjusted to have the correct amount of heat from the pepper's capsaicin. We have found that by storing the product in its final form the jelly layers tend to become thin and watery. This is an unattractive visual to the consumer. The objective of this study is to better understand the nature of the problem.

LITERATURE REVIEW

Water is the main interest in manufacturing for the many factors that it influences and roles water can be used. Water/ moisture content is a concern in food production because it affects a product's quality and food safety. The quality of the product may include shelf life, texture, flavor, and smell. Spoilage organisms, such as mold and bacterium, flourish in high moisture environments which effect the food safety aspect of food products (Unknown, 2011). Water is in all food products in one of its states, weather that be liquid, gas, or solid. How the manufacturer manipulates and formulates the state and amount of water is in a product determines how the product is identified, as certain textures identify that food category and not reaching that required standard would qualify as a defect (Labuza, 1977). This is certainly the case when there are products that have multiple component that are not the same in moisture content. Common examples of this is found in pre-packaged and prepared food product combinations such as ice cream and cones, snack packs, and filled bakery style items. Migration of water plague these products and cause the industry to conduct research into solutions.

In order to regulate the water in a product, the manufactures have to measure the amount that is in the product. When measuring water, the determination of bound and free water within the food product is essential. Bound water is the water that is chemically bound to the chemical structure of the food product. Free water is water not bound in the product. The distribution and amount of free water can be influenced by factors such as the matrix structure of the product, heat treatment, concentration, viscosity, and the chemical structure of the food. The testing that is used most to measure free water would be water activity (a_w). In measuring a_w, the equilibrium relative humidity(ERH) is solved for in the equation:

(1) $\%ERH = a_w * 100 = (p/p_0) * 100$ (Labuza and Hyman, 1998)

The actual vapor pressure of the water in the sample is represented by p, and p_0 represents the vapor pressure of pure water. Most literature the measurement is express in a_w and not in ERH.

There is a limiting factor to the accuracy of testing for a_w as the results tend to fluctuate with temperature (Berret, et al., 1998). Although contributions to a_w in food are the processing methods, ingredients, sizes and distribution of capillaries and interactions that the occur at the surface of the food (Labuza and Hyman, 1998). The instruments that measure a_w have sample cavities that can be enclosed so that the sample moisture content can equalize with the air humidity within the space. The instruments use the difference of the two and the temperature to find the a_w. The two types of instruments that commonly are used, chilled-mirror dew point technology and relative humidity with sensors that change electrical resistance, differ mainly in the method used to obtain the results. For example the chilled-mirror dew point measures the a_w by sensors that react when dew forms on the mirror in the enclosed space that hold the sample. The temperature is also taken and then the internal computers use both measurements to determine the a_w of the sample (Unknown, 2011).

Water activity equilibrium (thermodynamics) is one of the two main factors in moisture migration in food that have multiple contributing ingredients or regions. The other is the diffusion rate and factors within the product (mass transfer) (Labuza and Hyman, 1998). Foods with different moistures between the components will have water migrate throughout the product till an equilibrium is reached. The force of the gradient usually is high a_w will lose water to a low a_w region, this also includes the environment that the product is stored or packaged (Labuza and Hyman, 1998). If moisture migration in not accounted for when a product is formulated this could result in undesirable changes in the product. An example of this can be seen in cereal that contains raisins. The raisins have higher a_w than the cereal, which can result in a cereal product that does not have the correct product texture (Labuza and Hyman, 1998). Diffusion can be influenced by the capillaries and the viscosity of the product the smaller the pore size of the capillaries and the higher the viscosity, the slower rate of diffusion will occur in the product. Also additions such as membranes or lipids would slow the diffusion rate(Labuza and Hyman, 1998).

The current research to find a solution to moisture migration would be in edible films/membranes . The current solution would be to formulate the product with the moisture migration factored into the manufacturing of the product, with the a_w of the components as close together in range as possible (Labuza and Hyman, 1998). With manufacturers looking into water content in food and how to control it, more research in heat treatments and into controlling product and environment humidity will be used in further work.

MATERIALS AND METHODS

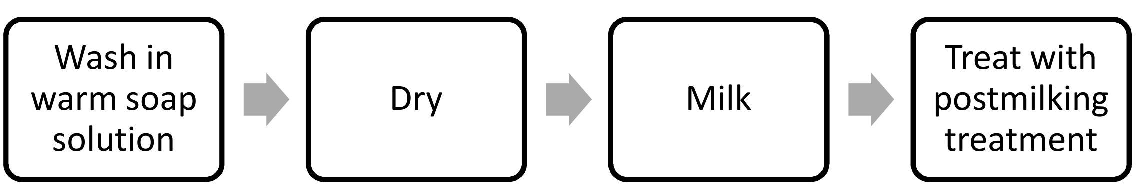
This experiment was conducted in two locations, my family's home and the products testing lab in the Cal Poly's dairy product technologies center. My family's home is a small parcel where we have about twenty goats for milk and meat. At the time of this experiment only two animals were in lactation. No other external variables were changed in the animals routines. The testing was completed with permission in the Cal Poly facility because of the equipment that was available. The tested samples were produced in the family home and transported to the facility. The samples remained at refrigerated temperature throughout storage and transportation.

GOAT MILK

PROCEDURE OF COLLECTION

The milk was obtained from one animal in the fourth to sixth month of lactation. The collection process was done by the same person, who milked at an interval of twelve hours apart for both the morning and afternoon milking, ensuring consistency in sanitary procedure. At the beginning of the experiment period the goat's udder was shaved to reduce contamination sources. The milking protocol that was followed was: wash udder in warm water that had a mild soap dissolved in it, dry, milk, treat teats with Fight Back® post milking treatment. The milk was then transported to be filtered, stored and cooled to 38°F.

Figure2. Milking protocol applied to the goat in production.



PASTEURISATION & CHEESEMAKING

The milk from four milkings was comingled before pasteurization in a two gallon SafGard Pres-Vac electric pasteurizer. The milk temperature was monitored at each stage of the pasteurization process to ensure proper pasteurization conditions. The milk entered the pasteurizer at 38°F. The machine indicator sounded at 35min with the milk temperature being 128°F. Since the correct temperature was not reached, the milk volume was transferred to a stovetop heating element and brought to the correct temperature of 164.5°F after an additional 35min. The milk was then cooled in a water bath for 35min to the temperature to reach 77°F. The milk was then transferred to another container on heating element to begin the cheese making process. The first batch of cheese made had temperatures that were recorded using the original machine and were not up to pasteurization standard. This was the reason for the second heating step. Another machine of similar manufacture was acquired for the uses in the other batch of the experiment. The second pasteurizer temperatures were recorded and meet the temperature requirement for safety.

The cheese making process was started directly after the milk was cooled in the water bath to 77°F. The volume was then heated to 86°F, where the starter culture/rennet from New England Cheese Making Supply Company, was added after 20min. The packet contained Chevre (C20G), Lactose, S. Lactis, S. Cremoris, Biovar Diacetylactis, microbial coagulant enzyme. A lid was then put on top of the pot containing the milk/starter solution and was left undisturbed for 12 hours. The curd at 77.2°F, was then poured in to a section of butter muslin to hang for 10 hours. The temperature at the time of taking the curd out of the muslin was 62.5°F, where the cheese was then salted with a teaspoon salt and put into refrigeration at 38°F . Two batches where made between the months of June to August for testing.

JALEPENO JELLY

PREPARATION

The ingredients used in the preparation of the jalapeño jelly were two cups of cider vinegar, one cup of finely chopped jalapeno peppers, where the ribs had been removed with half the seeds, six cups of granulated sugar, and 6 ounces of Sure-Jell Certo liquid fruit pectin ®. The recipe used instructed to fill a water bath canner about half full, then add the empty six half-pint size canning jars and brought to a boil. After a boil was attained to lower heat and leave jars in the hot water. A saucepan was also to be filled with water and brought to a boil. Lower the heat after boiling and add the lids, keeping the water hot. In a large stainless steel stockpot, vinegar, chopped/processed jalapeno peppers, and sugar were combined, and brought to a full rolling boil over medium-high heat, stirring constantly. Six ounces of liquid pectin was stirred in and then returned to a full rolling boil for one minute. The stockpot was removed from heat and any foam was skimmed off. The resulting mixture was then ladled into the hot jars, leaving 1/4-inch headspace and the jar rims were wiped with a wet paper towel. The jars were fitted with lids and the bands screwed on firmly. The jars were then placed in the canner on a rack and more boiling water was added to at least 1 inch above the jars. This was brought to a boil, covered, and kept boiling for 10 minutes. The pint jars should be processed for 15 minutes to ensure food safety.

WATER ACTIVITY DETERMINATION

The AquaLab®, model series 3TE from Decagon Devices, Inc., Pullman, Washington was used for all water activity measures. The equipment was already calibrated before testing, and sample cups were used in the testing process.

The jelly was mixed to homogenous before testing to insure that there was little to no variation within samples. This was done by hand and would have been more consistent had there been a mixer or food processor to use.

MOISTURE DETERMINATION

The LabWave 9000, from DSC in Encino, California, was the CEM- moisture balance/ solids analyzer used in the testing for moisture content of the both cheese and jelly. The program used for testing the cheve cheese was the cheddar cheese and the jelly was tested on the pre-programmed cream cheese program. The predefined settings for the cheddar program was: sample size 4-5g, power 60-80%, and 4 min. The predefined settings for the cream cheese program was 2.5-3.5g, power 40-60%, and 5min. The instrument had a digital read out for appropriate sample weights. Testing began with tarring the sample papers, then placing the sample between the two pieces. The sample and paper were placed in the CEM and the selected program run. The cheese in both batches were stored in plastic zip top bag to keep the variable of storage consistent. The cheese from test date 6/2/2011 was stored for twelve days to determine if there was a change in moisture content and if there was a change in the water activity. There was condensation observed on the interior surface of the storage bag. Each cheese was mixed to be sure that the samples were consistent. The two jars of jalapeno jelly were from one batch, and each individual jar was also mixed for consistent samples before testing. Within the jelly jars the seeds had risen in the jelly matrix and needed to be redistributed. The samples tested of jelly were observed to be burnt on exiting the CEM. A possible change in program suited to jelly would yield more accurate results. None were found in program catalogue.

STATISTICS

For each sample, tests were completed in duplicate, and averaged. The data was analyzed using Windows excel functions. The data was inputted into a two tailed formulation of t-test using two sample unequal variance. The significance level for the analysis was $p < 0.05$. The statistical analysis completed were: 1) test date 5/10/2011 comparing salted verse non salted in moisture, solids, and a_w, 2) test date 6/2/2011 comparing salted verse non salted in moisture, solids, and a_w, 3) the 6/2/2011 replicates $t=0$ and $t=12$ were tested using the t-test.

RESULTS AND DISCUSSION

Table 1 contains the averaged CEM and a_w data, although there is no data for a_w in the 6/14/11 test date. This was an oversight and if this study is repeated will need to be completed. Table 2 contains the averaged CEM and a_w, while tables 3-5 contain the t-test data. In table 3 there was a significant difference in the a_w between the salt and non-salt for test date 6/2/11. Significance can also be found in table 4 for salt and non-salt in the %moisture and %solids of the comparison of test date 5/10/11 and 6/2/11. No significance was found in table 5, which was the comparison of the t=0 and t=12 samples.

When comparing the a_w of the cheve cheese to the jalapeño jelly, it can be seen that the cheese has a much higher a_w vales than the jelly, which may contribute to the some of the problems seen in shelf life of the product. The significant values in table 7 are not important to the experiment for the difference in the two batches can be attributed to un-standardized product. The 6/2/2011 test date batch of cheese tested before (t=0) and after the twelve days (t=12), showed a observed condensation on the inside of the bag it was stored in. That water was not measured. It would have been beneficial to have tested the t=12 sample for a_w, it cannot be concluded whether or not is was statistically significant without the data. Factors that would have influenced data would be the late stage of lactation of the goat chosen to supply milk for the cheese making, and the components of this milk.

Table1. Average percent moisture, percent solids, and a_w of Cheve cheese.

Test Date		Moisture %	Solids %	a_w
5/10/2011				
	Salted	65.15% (+/-)0.0069	34.85% (+/-)0.0069	0.942 (+/-)0.0007
	Non-salted	63.72% (+/-)0.0066	36.28% (+/-)0.0066	0.948 (+/-)0.0035
6/2/2011				
	Salted	56.89% (+/-)0.0098	43.12% (+/-)0.0098	0.944 (+/-)0.0007
	Non-salted	57.83% (+/-)0.0040	42.18%(+/-)0.0040	0.951 (+/-)0.0
6/14/2011				
	Salted	56.56% (+/-)0.0	43.44% (+/-)0.0	-
	Non-salted	56.83% (+/-)0.0061	43.17% (+/-)0.0061	-

Table2. Average percent moisture, percent solids, and a_w of two jars of Jalapeño jelly.

Test Date	Moisture %	Solids %	a_w
6/14/2011			
Jar 1	40.18% (+/-)0.0177	59.83% (+/-)0.0177	0.767 (+/-)0.0071
Jar 2	42.29% (+/-)0.0197	57.71% (+/-)0.0197	0.77 (+/-)0.0014

Table 3. T-test for salt vs. no salt by test date. Significance p<0.05

Test Date	% Moisture	% Solids	a_w
5/10/2011	0.1700	0.1724	0.2408
6/2/2011	0.3875	0.3875	**0.0424**

Table 4. T-test comparing test date 5/10/2011 vs. 6/2/2011. Significance p<0.05

Test Date	% Moisture	% Solids	a_w
Salt	**0.0146**	**0.0146**	0.1056
No salt	**0.0161**	**0.0196**	0.3949

Test 5. T-test comparing 6/2/2011 (t=0 vs. t=12). Significance p< 0.05

Test Date	% Moisture	% Solids	a_w
Salt	0.7212	0.7215	-
No salt	0.2125	0.2125	-

CONCLUSIONS

Tables 1 and 2 show the difference between a_w in the cheve cheese and jalapeño jelly is showing that there the two products are different and not in a_w equilibrium. Thermodynamics will cause the non bound water in the cheese and jelly to balance, thus creating a migration of water from the cheese (higher a_w) to the jelly (lower a_w) (Labuza, 1998). This migration is the cause for the excess liquid seen in packaging of the final layered product. If further experimentation on this product were to be done, topics such as packaging types and the layering order should be looked at from the point of view on how they impact the product. This can be seen in Figure 3.

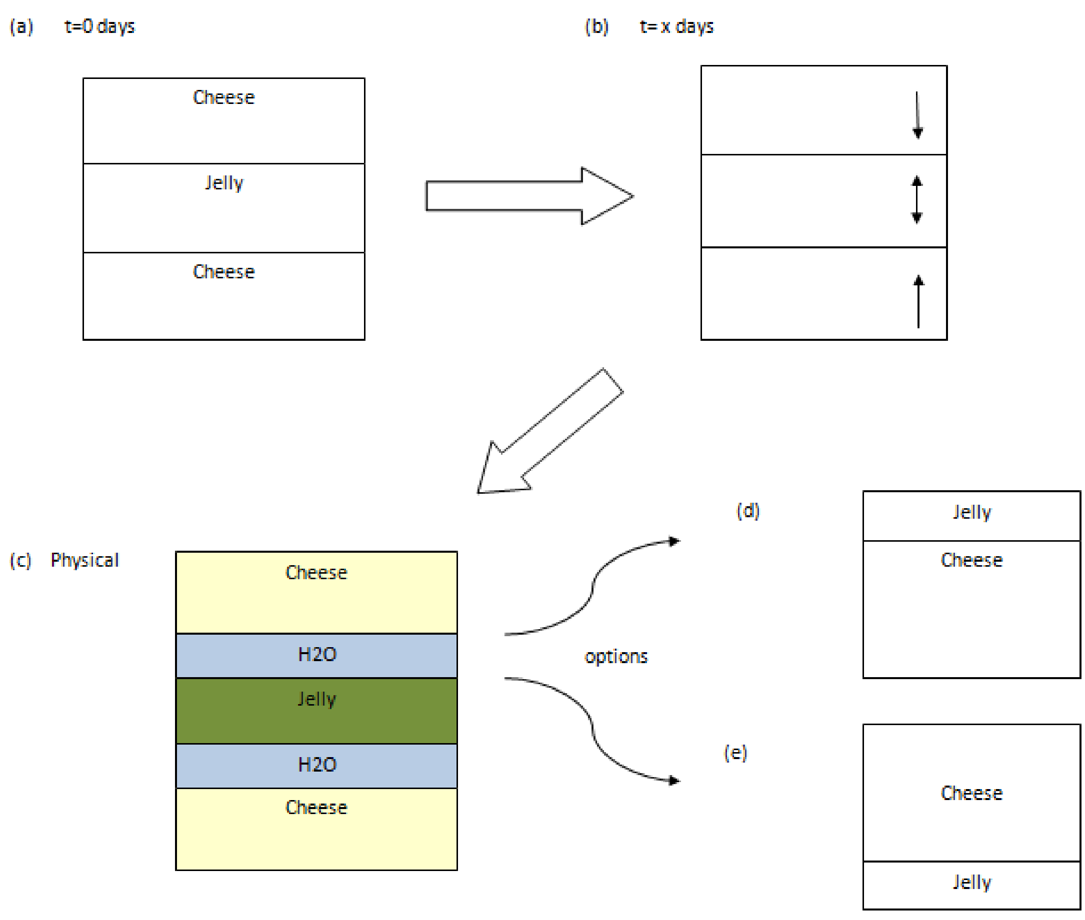


Figure 3. Visual representation of problem and possible solutions

In Figure 3a is shown the simplified structure of the final layered product, where in the 3b the a_w equilibrium directional forces can be seen. The un-bound water moves to create equilibrium, but cannot be absorbed into the jelly matrix. The personal observation of what is shown in (c) leads to the thought that the appearance is undesirable and the structure not as stable as possible, although neither were tested in this study for the supporting data. Possible solutions 3d and 3e take into account that the water layer may not be able to be fixed without causing and undesirable cheese product. With the position of the jelly as the top layer or as the bottom, the packaging type or style would be able to mask the defect and use it to the advantage of the product. Solution (e) initially seem to be the better of the two options if you use a packaging type that required the product to be released from the package by inversion . This would allow the water to aid the gravity dispersion of the jelly.

This study opens the idea that further experimentation will be needed before this product could be produce on a larger scale, for the problems with the migration of the moisture in the product may hinder product appeal and shelf life.

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