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CHANGES IN THE TEXTURAL QUALITY OF SELECTED CHEESE TYPES AS A RESULT OF FROZEN STORAGE[1]

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Summary

The change in textural quality of cheese during frozen storage is of concern to the frozen food industry. Many food products such as frozen pizza and dinner entrees are stored at 0.5°F or below for extended periods of time. Food manufacturers have noted detrimental changes including reduced elasticity of cheese on pizza or the absence of melt in filled products. Dynamic rheological testing was used to determine the changes in Cheddar, Colby, and Mozzarella cheeses during frozen storage. Slices of cheese were tested at day 0 and after 30 days of storage at 0.5°F. Elastic attributes were measured at 40, 70, and 194°F. Results indicated that frozen storage reduced the elastic properties of all three cheeses. When cheeses were subjected to higher temperatures, the elastic properties decreased. These changes could be attributed to proteolysis, chemical composition, and component interactivity. Dynamic testing is rapid and may be a method of choice for cheese manufacturers to determine shelf life and quality.

(Key Words: Cheese, Melting Properties, Frozen Storage.)

Introduction

Frozen, prepared meals are becoming popular food choices for many people, and the demand for good-tasting, easy to prepare foods has increased each year. Frozen, prepared foods often contain cheese (e.g., pizza, Mexican-style food, pocket sandwiches), reflecting the increased demand for cheese in the U.S. and the increased practice of using cheese as an ingredient in tasty, nutritious foods.

Cheeses are consumed for flavor and texture. Cheese on pizza is expected to string and be chewy, whereas cheese used for frozen Mexican food should melt and become part of the filling. This can be a challenge to cheese and food manufacturers, because cheese is a dynamic system that continues to change in flavor and texture over time.

During the manufacture of cheese, an important processing step is the aging period. That is when enzymes react to create the unique textures and flavors associated with specific cheese varieties. For centuries, most cheeses were aged at cool to ambient temperatures, but in this century, frozen storage has become an accepted practice. The change in storage temperature greatly alters enzyme activities and rates. Therefore, flavor and texture development may not be consistent with those of a traditionally aged cheese.

Cheese texture is determined primarily by the pH and the ratio of intact casein to moisture. The texture generally changes markedly in the first 1 to 2 wks of ripening as a small fraction of á$_{s1}$-casein is hydrolyzed by residual rennin to the peptide á$_{s1-1}$casein, resulting in a general weakening of the casein network. The relatively slow change in texture thereafter is determined mainly by the rate of proteolysis, which, in turn, is controlled largely by the proportions of residual rennin and plasmin in the cheese, salt to moisture

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ratio, and storage temperature. Final cheese texture can range from springy to plastic to noncohesive, depending on pH and calcium content.

To evaluate the texture of cheese, different approaches can be taken. However, the most common one is to apply a defined force (strain) to the cheese sample and then measure the "cheese's response" (stress). Normally, the stress can be perceived as a deformation. But depending upon the temperature and the type of force, the cheese may respond by flowing. Thus, cheese is considered to be a viscoelastic food, having properties that are both elastic (shape change referred as storage modulus in units of G) and viscous (flow movement referred as loss modulus in units of G). The proportion of these characteristics in a food often reflects the protein, fat, and water binding properties. Understanding the rheological properties of cheeses may help to control functional properties and, thus, increase the demand for cheese. Thus, this study was undertaken to determine how a frozen storage period (30 days at 0.5°F) affects the elastic properties of Cheddar, Colby, and Mozzarella cheeses.

Procedures

Sharp Cheddar, Colby, and Mozzarella cheeses (of the same national brand) were purchased from a local grocery store (Manhattan). Rectangular cheese slices 2×2×.15 inches were cut using a meat slicer. Slices (with waxed paper in between) were vacuum packaged to prevent dehydration. The cheese samples were stored at 0.5°F until the day of measurement. Samples were allowed to equilibrate at 39°F for ease of separation of the cheese slices prior to testing.

Oscillatory measurements were carried out with a Bohlin VOR rheometer to determine the storage moduli (G) of the cheese samples. The viscoelasticity of the cheese was measured as a function of frequency between 0.1 and 10 Hz at isothermal temperatures of 40 ± 0.5°F, 73 ± 1°F, and 194 ± 2.0°F that were maintained with a circulatory water bath. The rheometer was equipped with a serrated 2.36 inch-diam. bottom plate and serrated 1.18 inch-diam. top plate to reduce slippage. The gap between the parallel plates was 0.15 inches The sample was held 4 min for temperature equilibration and 3 min for cheese relaxation. Initial strain sweep experiments were conducted to determine the linear viscoelastic region for the cheeses. A plot of complex modulus vs. strain at 1 Hz showed linear behavior up to about 0.005 strain. These results are in agreement with previous published data. Thus, a 0.002 strain was selected for all measurements to avoid deforming the cheese to the extent that the gel structure was compromised. A 93.54 g-cm torque bar was used.

Two replications were done on all cheeses. Data reported are averages of these replications.

Results and Discussion

Table 1 shows the typical compositions of Cheddar, Colby, and Mozzarella cheeses. Although protein content appears to be fairly consistent in the three varieties, great differences can be seen in the fat, moisture, and salt contents. Therefore, differences in the textures of these cheeses are expected. Mozzarella cheese is a young cheese, which means that it is eaten soon after production (2 wks). Usually by 10 wks of refrigerated storage, the cheese loses its melting and shredding abilities because of rapid protein breakdown. Colby cheese is also a young cheese, but usually is aged for several weeks before consumption. However, by 4 mo after production, it usually possesses strong flavors that are uncharacteristic for Colby cheese. Cheddar cheeses are aged, and as aging time increases, flavors become more strong and textures become more crumbly.

Storage (G) moduli (1 Hz) of the cheeses at 40, 73, and 194°F are shown in Figures 1, 2 and 3 respectively. At any given frequency, the G value was greater than G (not shown), indicating a dominant elastic character of all three cheeses. Although, both G and G exhibited frequency dependency throughout the range tested, no G -G crossover was present for any of the cheeses.

These results suggest that the cheeses are “physical gels” in contrast to gels that show very little frequency dependence and are designated as covalent gels (very firm). Practically, the lack of crossover means that the gels remained in the same state throughout the frequency range tested and didn’t change from a hard to a soft gel or from an elastic to a viscous gel.

Table 1. Typical Chemical Compositions (%) of Cheddar, Colby, and Mozzarella Cheeses

Cheese	Fat	Protein	Moisture	Salt
Cheddar	32	25	37	2
Colby	30	25	39	1.7
Mozzarella	18	22	53	0.7

Figures 1, 2, and 3 show that as test temperatures increased, storage moduli at 0 days decreased for all cheese varieties. This is probably a reflection of a greater proportion of the milk fat in the liquid state (melting), which would contribute to the viscous component of the cheeses. This overall trend agrees with previously reported results.

At each test temperature, the storage moduli varied among cheese varieties. This can be explained by the results in Table 1. The protein and solids contents varied in each cheese variety. In addition, the integrity of the casein network should be very different for the three cheeses. For instance, Mozzarella cheese has a high proteolytic activity, whereas sharp Cheddar (aged for > 6 mo) should exhibit signs of proteolytic behavior. However, Colby, a young cheese, should have the most intact casein network. The results at 40 and 194°F agree with these differences. At both temperatures, regardless of the amount of fat, the state of fat (proportion liquid to solid) should be fairly consistent -- relatively solid at 40, but liquid at 194°F. However, this relationship was not seen at 73°F. Thus, the data indicate that the total solids content may be the predominant contributor to the G value of these cheese varieties. For all three varieties, the milk fat should be in both liquid and solid states. Also, it should be incorporated into the casein network. But the production of these three varieties of cheese allows for different types of protein-fat interactions. Thus, the nature of these interactions may contribute to the elastic component of these cheeses. Another consideration should be the casein network itself, where the fibrous structure that is present in the Mozzarella cheese may not allow for as much fat or water binding. Therefore, the water and melted fat may contribute to the viscous phase vs being associated with the elastic component as in the Cheddar or Colby cheeses.

When the results after 30 days of frozen storage (also shown in Figures 1, 2, and 3) are considered, the interpretations become more complicated. Even though some research shows that aging results in lowering the G , freezing of dairy protein overrides that effect to result in an increase in G . Because the proteolytic system of Mozzarella cheese is very fast, and the texture generally deteriorates to an unsaleable condition within 10 weeks, we would expect the G values to decrease after frozen storage. In tests at 40°F after frozen storage, G values did decrease for Mozzarella cheese but increased for Cheddar and Colby cheeses. Thus, these results confirm that the proteolytic enzymes in Mozzarella cheese continued to degrade the á$_{s-1}$ casein during storage. However, the increased elasticity of the other two cheeses may support the theory of reorganization of the casein network resulting from the casein being dehydrated (water removed) during frozen storage. Thus, if the elasticity is a result of interactions among components, a reorganization of these interactions would be expected to lead to a different structure that would have a different elasticity character.

However, these trends were not consistent at the other two testing temperatures, 73 and 194°F. This suggests that the storage moduli are affected not only by the order of the casein network and the extent of protein degradation but also by the physical state of the fat and the binding of components with one another.

Conclusions

Frozen storage, even for a short period of time (30 days), seems to induce reorganization of the casein structure and affect not only casein-casein interactions, but probably also interactions with fat and water in Cheddar, Colby, and Mozzarella cheeses. Thus, the storage moduli of the cheeses are affected by many factors. Probably, the net result of proteolysis, chemical composition, and component interactivity defines the elastic and viscous components of the product. This research showed that the conclusions drawn about the changes in viscoelastic properties of cheeses as a result of frozen storage are highly dependent upon the testing conditions. Obviously, the physical states of the fat and water can affect these properties. This study has given evidence that cheese can be used in frozen foods; however, the viscoelastic properties of the cheese will change over time. And even though the elastic component is minimal when cheese is heated, it is still affected by the storage conditions.

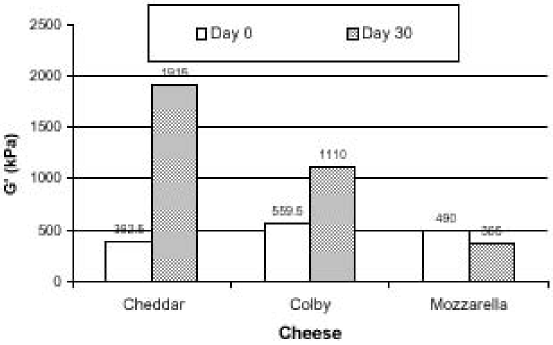

Figure 1. Storage Modulus (G′) of Various Cheeses Determined at 1 Hz and Measured at 40°F before and after Storage at −0.5°F for 30 Days.

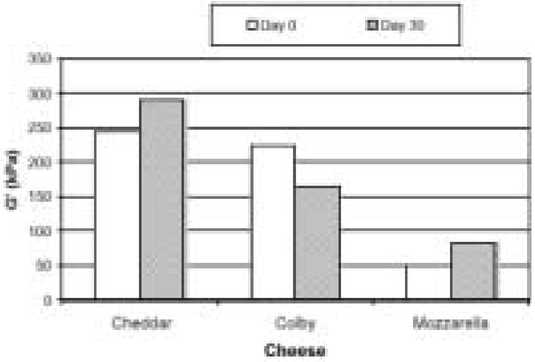

Figure 2. Storage Modulus (G′) of Various Cheeses Determined at 1 Hz and Measured at 73° F before and after Storage at −0.5° F for 30 Days.

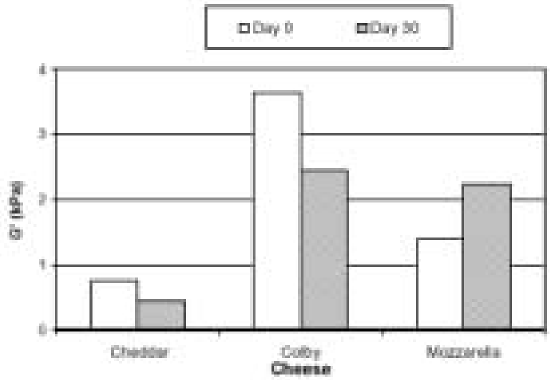

Figure 3. Storage Modulus (G′) of Various Cheeses Determined at 1 Hz and Measured at 194° F before and after Storage at −0.5° F for 30 Days.