Characteristics of a cream of cheese with bacon frozen soup concentrate[1]

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The effect of heating, freezing, and reheating on wheat flour and starch in a frozen soup concentrate was tested objectively and evaluated by a sensory panel.

The frozen food industry is one food industry enjoying expansion and increasing sales. In 1979, total frozen food sales rose to almost $24 billion, a gain of 17.22 percent over 1978 (1). A portion of this gain was in the $6.119 billion sales of frozen prepared foods. Many starch-containing items are included in these prepared and precooked foods (2,3).

High-quality, frozen, starch-containing prepared foods can be developed and be accepted by consumers (4). However, the preparation of such high-quality foods requires further work and definition of the relationship between effects of thermal stress and characteristics of prepared foods. The purpose of this study was to examine the effect of processing and the associated thermal stresses on the complex combined starch system of a cream of cheese with bacon frozen soup concentrate. The effect of thermal stress was evaluated using both objective and subjective methods.

Experimental approach and methodology

STARCH-WATER SYSTEMS. To facilitate the interpretation of the scanning electron photomicrographs from the cheese soup, the two starches, Purity W,[3] modified waxy cornstarch (3.7 percent), and wheat flour[4] (1.85 percent) were each used to create a starch-water dispersion. These were the percentages of each starch used in the commercial cheese soup. Each dry starch was added to redistilled water at 83° C. and held at this temperature for 15 minutes in an oilbath. Samples were obtained from the dispersions with minimal lumping. Samples for scanning electron microscopy were obtained immediately after addition and incorporation of Purity W or wheat flour and upon completion of the holding time. Scanning electron micrographs were prepared as indicated in the first article (5) of this series.

CREAM OF CHEESE WITH BACON FROZEN SOUP CONCENTRATE. Cream of cheese with bacon frozen soup concentrate was prepared by and samples were obtained from the manufacturer.[2] Also obtained were samples of the raw starches and of soup at the intermediary stage of processing and upon completion of cooking (final stage). The intermediary stage product consisted of a mixture of water, non-fat dried milk, chicken base, margarine, and rendered bacon fat heated to 78 to 88° C. The Purity W starch (3.7 percent) and wheat flour (1.85 percent), dispersed in cold water, were added at this point and stirred in by the auger on the heat exchanger. A sample was then removed for testing. After onions, spices, bacon bits, celery, and cheese were added, the mixture was heated until the cheese was melted (71 to 77° C.). At this point, the final cooked stage, a second sample was removed. After cooking, the 1,800-lb. batch of soup was cooled and mechanically bagged into three 4-lb. bags per case. From a lot, one case was refrigerated, and two were frozen and stored in a food freezer[5] (−26° C.) for eight weeks.

VISCOSITY DETERMINATIONS. At the manufacturer's, viscosity of the soup was determined, using a viscometer[6] at appropriate speeds, at both the intermediary and the final stages of cooking. Data from the viscometer readings were converted to centipoises (CPS) using the conversion chart provided by Brookfield Engineering Laboratory (6). At the university, the viscosity of the soup was similarly determined (spindle 3, speed 20) with the same type of viscometer.

SCANNING ELECTRON MICROSCOPY. For scanning electron micrographs, the starch or starch-water dispersion at each stage of processing and during sensory evaluation was prepared as described in the first paper (5) of this series.

SENSORY TESTS. Sensory tests were conducted at Coed Cottage Cooperative, Oregon State University, using approximately 37 women college students who evaluated: (a) overall acceptability (1 = excellent, to 5 = poor); (b) texture acceptability (1 = excellent, to 5 = poor; (c) consistency (1 = stiff, too thick, to 5 = very thin and runny); and (d) syneresis (1 = much separation, to 5 = no separation and very smooth and creamy) of the reconstituted soups. The initial taste panels evaluated the soup after one day of refrigerated storage and the counterpart frozen soup after eight weeks of storage. Soup was served at lunch or dinner with cold cuts, bread, salad or vegetable, dessert, and beverage.

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[2]The authors thank Chef Francisco, Eugene, Oregon, for the contribution of frozen soup samples. They also thank Mary Nuwer and Fred Michael for assistance in obtaining the samples from Chef Francisco.
[3]National Biochemical Corporation, Chicago.
[4]Fisher Mills, Inc., Seattle.

[5]Frigidaire Food Freezer, Model 191, General Motors, Dayton, Ohio.
[6]Brookfield Synchro-Lectric Viscometer (Model RVF, spindle 6), Brookfield Engineering Laboratory, Inc., Stoughton, Massachusetts.

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At each taste session, two bags of soup were prepared according to label directions in a double boiler to an endpoint temperature of 78° C.

DATA ANALYSIS. Scanning electron microscope pictures were qualitatively analyzed and compared at the different stages of processing and storage. Means, standard deviations, analyses of variance, correlation, and regression analyses were computed on data as appropriate. The Statistical Interactive Programming System (7) on the CYBER 70/73 computer was used.

Results and discussion

To facilitate interpretation of the scanning electron micrographs from the cream of cheese with bacon soup, micrographs represented in Figure 1 were prepared. Purity W granules generally appeared to be round with a variety of sizes; wheat flour granules were either disk-shaped or small and round. Note the small globules of protein on the large wheat starch granule. These results are similar to those found by Hall and Sayre (8); however, those authors found that the disk-shaped granules were considerably larger and thinner than the small round granules. Both the Purity W and the wheat starches appeared to have a small amount of deformation. This is possibly due to the extraction and milling of the starch and flour (9) or packing in the endosperm of the wheat (10) or corn kernel. Additionally, the deformation with the modified waxy cornstarch, Purity W, may have been due to the cross-linking process.

There were observable differences in scanning electron micrographs of the modified cross-linked starch, Purity W (Figure 1-B), and wheat flour (Figure 1-E) immediately after they were added to the 83° C. redistilled water. Even in the 15-second period required to stir the starch into the heated water, considerable gelatinization took place. With both starches, the granule was appreciably swollen as compared to the raw (25° C.) starch (Figure 1-A, 1-D). The filamentous exudate in the dispersed corn (Figure 1-B) and wheat (Figure 1-E) starch is surprising, as little time occurred between dispersion and sampling. The fibrous appearance on the wheat granule (Figure 1-E, 1-F) could possibly be denatured protein; however, it may be a wheat granule exudate. In both starch dispersions the exudate could be amylose (5). There were few differences observed in the scanning electron micrographs when Purity W (Figure 1-C) was held 15 minutes. Wheat starch micrographs (Figure 1-F) showed considerable deformation and loss of granule integrity after holding for 15 minutes.

PROCESSING EFFECT. The micrographs in Figure 2 illustrate the effect of processing on the soup. The photomicrographs of the intermediary step (Figure 2-A) of processing indicated a definite granule structure with very few damaged granules. Both large and small granules were present. The large-disk shaped granules were probably wheat starch granules from the wheat flour, and the small granules were either the round or the oval wheat starch granules from the flour or the cross-linked waxy maize starch granules from the Purity W starch. The two starch systems were difficult to distinguish from each other after incorporation with other ingredients of the cream of cheese soup. Others have found similar problems with studying starch systems and flours (11).

The most obvious changes in the granules from the intermediary stage to the final stage of soup processing (Figure 2-A, 2-B) were the increase in deformation and the formation of a more homogeneous mass. No large increase in size, such as might be expected to accompany gelatinization during cooking of the soup, was seen, although a slight increase was observed. That

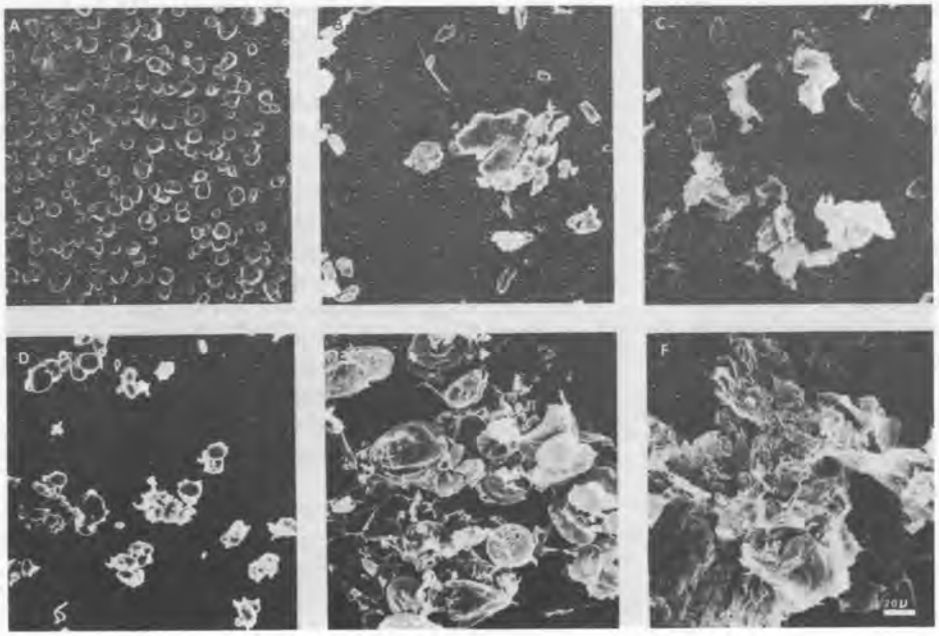

FIG. 1. *Scanning electron micrographs (400X) of Purity W and wheat flour* (left to right): *A, Purity W, raw; B, Purity W, 83°C.; C. Purity W, 83°C. held 15 minutes; D, wheat flour, raw; E, wheat flour, 83°C.; F, wheat flour, 83°C., held 15 minutes.*

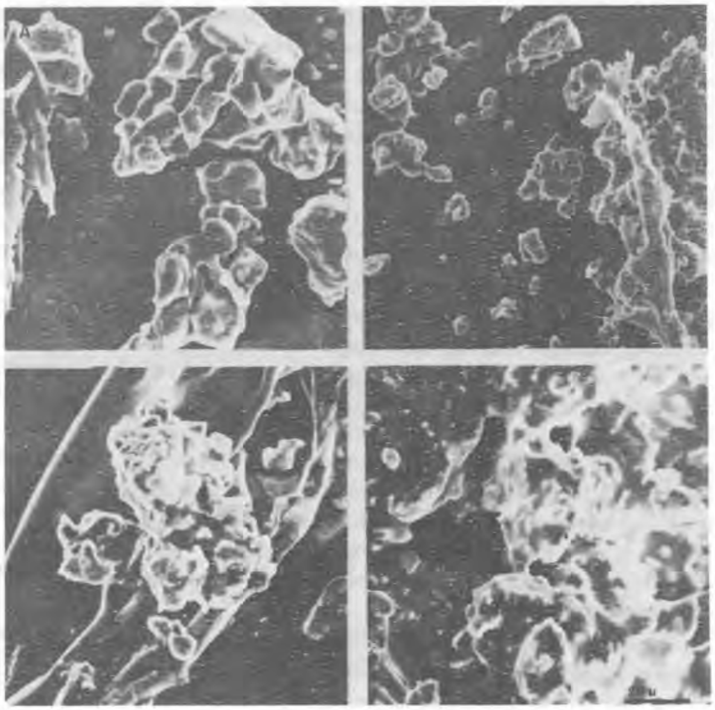

FIG. 2. *Scanning electron micrographs (700X) of cheese soup concentrate at various stages of processing and service* (left to right): *A, intermediate stage; B, final stage; C, refrigerated and reheated; D, frozen and reheated.*

there was no large definitive change in size could be attributable to the characteristics of both Purity W and the wheat flour. Perhaps the Purity W starch had swollen to its limit when the first sample was taken. The cross-linking of the Purity W starch would restrict the swelling ability of this starch because of the additional intermolecular bonding. The difficulty of defining the changes in starch with the added stirring and heating from the intermediate to cooked stage is compounded by the other flour and soup components. Granules in Figure 2 appeared to be attached or embedded in a matrix. Other workers (10,12) have mentioned an association between starch and protein. Comparisons within Figure 1 of D, E, and F would indicate that the formation of a more homogeneous mass could be due to the prolonged cooking of the wheat flour system (13). In the present study, the increase in homogeneity could indicate starch granule breakdown. Such breakdown usually results in decreased viscosity. Although not significant, a decrease in viscosity between the intermediary and final cooked stages was shown by viscosity measurements (Table 1) in this study.

The effect of refrigerating the soup for approximately 24 hours and then reheating it is shown in the photomicrograph Figure 2-C. With the reheating of the fresh soup to 78° C, one was able to distinguish less

Table 1. Test scores during processing and reheating of cream of cheese with bacon frozen soup concentrate*

test	*intermediate stage*†	*final stage*†	*refrigerated sample*‡	*frozen sample*‡
viscosity (CPS)	28,620±42,410	5,190±23,010	490±180	500±90
temperature (C.)	64.8±2.4	69.4±7.4	72.4±6.9	75.2±2.0
sensory evaluation				
overall acceptability#	—	—	1.8±0	2.2±0.1¶
texture acceptability#	—	—	2.0±0.1	2.2±0.1
consistency#	—	—	2.8±0	3.0±0.1
syneresis#	—	—	4.3±0.1	3.9±0.3

*Means and standard deviation for the four replications.

†Intermediate and final stages during processing of cream of cheese with bacon frozen soup concentrate.

‡Refrigerated and frozen samples were reconstituted with 2 percent skim milk and the processed soup reheated for service.

#Scale ranges: *overall acceptability* (1 = excellent, to 5 = poor); *texture acceptability* (1 = excellent, to 5 = poor); *consistency* (1 = stiff, too thick, to 5 = very thin and runny); *syneresis* (1 = much separation, to 5 = no separation and very smooth and creamy).

¶Overall acceptability scores for frozen and reheated cheese soup were significantly lower ($p<0.05$) than scores for refrigerated and reheated cheese soup.

clumping, and there was more apparent homogeneity. Perhaps this was due to the constant stirring and additional heat input during the reheating phase. In addition to possible starch granule breakdown during heating, stirring, and holding, part of the homogeneity may be caused by the leaching of amylose from the granule into the surrounding medium, creating a network between the ingredients (14). Miller et al. (14) suggested that this network contributed to viscosity.

Eight weeks of frozen storage did appear to affect the starch structure of the soup when it was reheated. The scanning electron micrograph comparisons (Figure 2-C and 2-D) of fresh and frozen soups that were reheated show the surface of the soup that had been frozen as a homogeneous mass with less defined individual granules. These findings are similar to research reported by Hood et al. (15) with work on the freezing and thawing of modified tapioca starch-milk gels. After several freeze-thaw cycles, those authors found ruptured starch granules and starch granule material spread throughout the continuous phase.

Viscosity varied considerably from one replication to another during the plant operation. The variation may be accounted for by the plus or minus 2 percent recipe deviation permitted by the company. No significant difference was observed between the intermediary and final steps of processing (Table 1), although individual data indicated a trend toward a decrease in viscosity. The wide variation in viscosities at these steps could account for the lack ot significance.

The viscosity of the reheated soup when ready for service after frozen storage was not statistically different (p of less than 0.05) from the viscosity of the ready-to-serve fresh soup. The short length of time may be the reason for the lack of a significant effect of frozen storage on the viscometer values. However, in a year-long storage study reported by Baldwin et al. (16), the viscosity of a modified waxy maize starch-containing gravy was more dissimilar from initial viscosity at eight weeks than at any of the shorter or longer sampling times.

SENSORY EVALUATION. Mean scores and standard deviations for the four quality characteristics are presented in Table 1. The scores indicated a general liking for the soup. The mean scores for consistency of the soup varied from thick to thin, with one score of "very thin and runny." Mean values for syneresis of the soup ranged from "separation or curdling" to "no separation and very smooth and creamy." The scores tended to center on "no separation, very smooth and creamy."

Whether soup was served for lunch or dinner had no significant effect on the sensory scores. Correlation analysis of test session and scores did indicate a time trend during the first four weeks of testing for decreased overall acceptability, texture acceptability, and syneresis. However, the difference in texture acceptability was the only one of the four that was statistically significant. For the soups evaluated after frozen storage there was no significant test session or score time trend. The novelty of the score and evaluation process during the first part of the study perhaps elevated the scores. Toward the end of the study, the soup was just part of the routine. Contrary to the results of work using a variety of starch-containing gravies (16), sensory scores did not correlate (p of less than 0.05) with viscosity measurements in the current study. Viscosity measurements taken 25 minutes after service were not significantly (p of less than 0.05) different from those taken at the time of service.

A difference in sensory scores between fresh and frozen with respect to overall acceptability was found at a p of less than 0.05 level (Table 1). This difference can be related to changes seen in the scanning electron microscope pictures. The panel may have perceived the possible granule breakdown. However, the changes seen did not seem to affect the component scores for texture acceptability, consistency, or syneresis, as there were no significant differences. These results suggest that the panel could detect overall changes in the soup, but more specific differences in texture, consistency, and syneresis were not significant enough to be noted. Baldwin et al. (16) reported no great difference (p of less than 0.05) when they evaluated texture, consistency, and mouth feel of gravy prepared with cross-bonded waxy maize starch after one year of frozen storage. Increased sampling at a range of storage times, more replications, and a larger consumer panel might have defined relationships to a greater degree.

Summary

The starch granules of both Purity W, a modified waxy cornstarch, and wheat flour were affected by processing, refrigeration, freezing, and reheating. The major change in starch granules shown by scanning electron micrographs was the trend towards greater deformation of the starch granule and, apparently, subsequent greater homogeneity of the mixture. Sensory evaluation revealed a statistically significant difference (p of less than 0.05) only in overall acceptability of the fresh vs. the frozen soup. The other quality characteristics of texture acceptability, consistency, and syneresis were not statistically (p of less than 0.05) different.

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