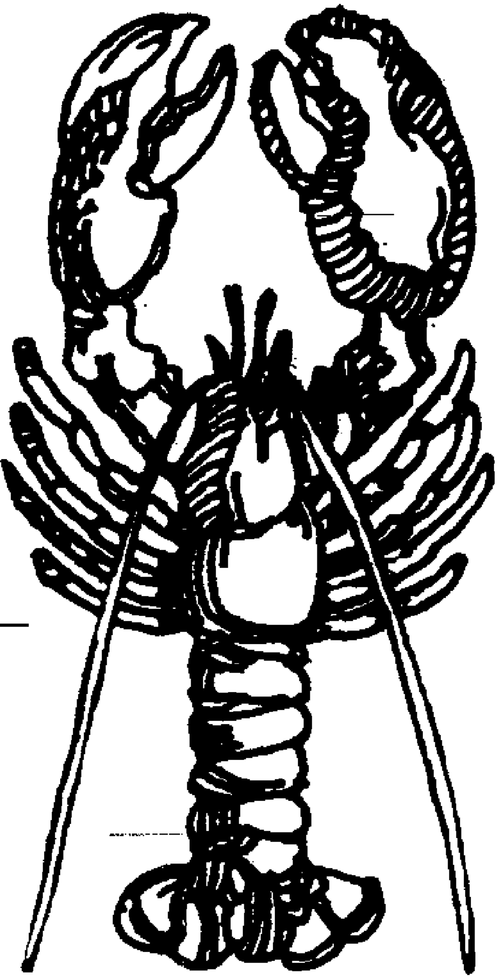

Frozen Soft-shell **Lobster** Quality

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ABSTRACT

Tails and claws of soft-shell (SSL) and hard-shell (HSL) lobsters (*Homarus americanus*) were blast-frozen, stored for 3 months, then compared after steaming with meat removed from fresh HSL. Sensory panelists described the interior of frozen SSL meat as pinker than fresh HSL meat. Samples were not significantly different in flavor. HSL tail was toughest by sensory evaluation, and tail meat had higher shear-force values than either type of claw. Hunter L, a, and b values were higher for frozen meat. SEM revealed greater muscular organization in fresh HSL claws. Freezing appears to influence lobster quality more than does shedding.

INTRODUCTION

Lobsters (*Homarus americanus*), like other crustaceans, shed their shells annually to accommodate growth. Prior to ecdysis (shedding), muscle mass is reduced to allow the claws to be withdrawn through narrow joints. While the new shell is still pliable, lobsters expand their bodies with water to stretch the shell sufficiently to allow for muscle growth during the next year. These newly-molted or soft-shell (SSL) lobsters are weak and vulnerable to cannibalism and predation until the new shell hardens.

Molting lobsters affect the economy of New England coastal regions. Lobster pounds may hold up to several million pounds of lobsters in the summer and thus could sustain large losses due to cannibalism of SSL. Lobsters that survive molting command a lower price as new-shell lobsters because consumers perceive them to be a poor value since the meat does not fill the shell.

These economic problems could be offset if a market could be developed for SSL. Soft-shell blue crabs and crawfish are gourmet items that are priced much higher than are their hard-shell counterparts (Wear, 1990). Since information on the food quality of SSL is scarce, this study was undertaken to determine the quality of newly-molted lobsters as compared to hard-shell lobsters (HSL).

MATERIALS & METHODS

Lobster Preparation

Since the shell becomes leathery within a few hours after molting, SSL must be used immediately or frozen for later use. We chose to study the quality of frozen SSL compared with fresh HSL since the distance between the University and the lobster pounds prevented immediate processing of the newly-molted lobsters. Frozen soft-shell crabs and crawfish are now available commercially, presumably for the same reason.

In August twenty lobsters that had begun to split their shells were obtained from a lobster pound. Tails and claws were removed and washed in cold water to remove any traces of hepatopancreas that could promote tissue deterioration (Godber et al., 1989). The meat from each lobster was placed in a large ziplock freezer bag and blast-frozen overnight at -21°C. The pieces were stored for 3 months at -3°C, then thawed for 1 day at 4°C. A few claws that exhibited yellow discoloration at their tips were discarded because such discoloration is reportedly due to lipid oxidation (Dyer and Horne, 1953).

In November twenty HSL from another lobster pound were blanched for 70 sec at 85°C (Getchell and Highlands, 1957) to facilitate meat removal. Tails were split longitudinally before cooking. HSL claws and tail halves were steamed for 4 min; SSL pieces were steamed for 5 min because they were not previously blanched. The new shell, which resembled a skin, was removed prior to evaluations.

Ten HSL were blast frozen whole for humane purposes under the same conditions as for SSL, but freezing occurred in November. Tails and claws were removed from the carcasses after blast-freezing, then stored for 3 months and steamed in the same manner as for SSL. These frozen HSL were not used in sensory evaluation since it was impossible to guarantee that non-shedding lobsters frozen in the summer were HSL, not recently-hardened SSL. Most consumers in the United States are familiar with fresh lobsters; therefore, we felt a comparison of frozen SSL with fresh HSL was reasonable. However, objective testing of frozen HSL allowed us to compare the effect of freezing on lobster meat.

Sensory Evaluation

Eleven University of Maine staff members who had previous lobster evaluation experience volunteered to participate in this study. Samples of steamed HSL and SSL meat and traditional boiled lobster were served during a training session and the panel was asked to choose terms that best described the color, flavor, and texture of the meat. The samples were portioned as shown in Fig. 1. Only the center portion of crusher claws was served to each panelist; ends of tails were discarded, then tails were split in half longitudinally.

The following descriptive scales were selected by the panel: color, 1=very yellow, 4=white, 7=very pink; flavor, 1=strong fishy, 4=bland, 7=strong lobster; tenderness, 1=very tender, 4=neither tender nor tough, 7=very tough; moisture, 1=very dry, 4=neither dry nor moist, 7=very moist; geometric textural characteristics, 1=very mushy, 4=neither mushy nor stringy, 7=very stringy/ fibrous. Each panelist was presented with a plate containing 4 samples: SSL crusher claw and tail meat and HSL crusher claw and tail meat. Each sample was assigned a random 3-digit code, and the order of presentation was balanced to provide each panelist with a different sequence of samples. Panelists were asked to choose an integer between 1 and 7 to describe each attribute for each sample.

Color Measurement

A Labscan II colorimeter (Hunter Associates Laboratory Inc., Reston, VA) with a D-65 illuminant was used to measure differences in exterior cooked color between pincher and crusher claws. Interior meat color was also measured for the claws and for tail meat. Five samples of each claw and tail from SSL and both fresh and frozen HSL were evaluated.

Texture Measurement

A Warner-Bratzler Shear (G.- R. Electric Mfg. Co., Manhattan, KS) was used to determine differences between the resistance to shear of samples, recorded as maximum force/mm thickness per sample. Claws were cut across the midpoint and the thickness of each sample was measured with a vernier caliper. Four crusher claws per group, 6 pincher claws, and 10 tails were analyzed. Tails were placed so that muscle segments, not connective tissue, were severed.

Scanning Electron Microscopy (SEM)

Samples from the center portion of cooked pincher claws of SSL and fresh and frozen HSL were fixed overnight in 1% glutaraldehyde/4% paraformaldehyde in 0.1M phosphate buffer with 10% sucrose. After three half-hour rinses in phosphate buffer, samples were fixed for 1.5 hr in 1% osmium tetroxide in 0.1M phosphate buffer. After three additional rinses, samples were dehydrated in increasingly concentrated ethanol solutions, then placed in a critical point dryer (Samdri PVT-3, Tousimis, Rockville, MD). A gold sputter-coat of 300Å was applied. An AMR Model 1000 scanning electron microscope (AMRAY, Inc., Bedford, MA) was used to photograph the samples with Polaroid 665 Positive/Negative instant film (Cambridge, MA).

Statistical Analysis

One-way analysis of variance was used to determine differences in color and shear values among samples. Duncan's (1955) multiple range test ($p=0.05$) was applied to means which were significantly different ($p \leq 0.05$). The Kruskal-Wallis (1952) test was applied to sensory evaluation data and significant differences were further evaluated using the Mann-Whitney (1947) two-sample test for pairwise comparisons.

RESULTS & DISCUSSION

The sensory panel determined that the meat from frozen SSL was pink, while that from fresh HSL was off-white (Table 1). Frozen canned lobster meat reportedly had pink inner color which was significantly correlated with overall acceptability by researchers in Nova Scotia (LeBlanc and LeBlanc, 1990). The panel found no differences between claw and tail meat for either type of lobster. All samples had typical lobster flavor ($p \leq 0.05$). Fresh HSL tail meat was rated toughest, but the other three types of meat were not different in tenderness from each other. Increased tenderness found in frozen SSL was expected because muscle fibers are reduced in number during molting (Mykles and Skinner, 1982).

Both SSL and HSL claw meat were considered by the panel to be more moist ($p \leq 0.05$) than the tail meat samples. Stroud and Dalgarno (1982) determined that lobster claws had higher moisture than tails. Frozen SSL tails were not different in stringiness from fresh HSL tails but both types of crusher claw were significantly less stringy ($p \leq 0.05$).

The exteriors of cooked claws from all types of lobster were the characteristic orange-red color, but the SSL claws were darker (Table 2). Both types of frozen were more red and more yellow (higher *b* values) than fresh HSL. Hunter *L*, *a*, *b* values of claw and tail interiors were lower for fresh HSL and frozen SSL when compared with frozen HSL, which were significantly lighter (Table 3). Although frozen HSL had higher Hunter a values, frozen SSL meat was also slightly red. Freezing may rupture carotenoid-bearing chromatophores near the surface of lobsters, thereby releasing the pigments into the flesh. Overall differences are due in part to geographic and temporal differences between the lobster groups. Since frozen HSL were cooked separately from the other types, errors made in cooking and other aspects of sample preparation cannot be ruled out.

Pincher and crusher claw meat from SSL and both types of HSL were less resistant to shear than were tail pieces (Table 4). This finding is due, in part, to differences in structure between the two types of muscle. The ratio of thin-to-thick muscle filaments is 12:1 for claws and 3:1 for tails. Filaments in claw muscles are nearly twice as long as those in the tail, although filament diameters are similar (Hayes et al. 1971). The SSL tails were less resistant to shear than were the fresh HSL tails, but frozen HSL tail segments had the lowest shear force/mm, possibly due to differences in thickness among the groups of lobsters used in this study.

SEM indicated greater disorganization in frozen SSL (Fig. 2c) and frozen HSL pincher claw tissue (Fig. 2b) than in fresh HSL pincher claw tissue (Fig. 2a). Freezing disrupts muscle tissue via freeze-concentration-induced protein denaturation and by cell rupture by ice crystals. Small ball-like structures were unique to the SSL sample. The ability of muscle fibrils in cooked fish to slide without restriction by interstitial material was associated with tenderness in several fish species (Hatae et al, 1990). A similar mechanism may contribute to tenderness in SSL meat if molting reduces interstitial tissue in lobsters.

To date, no information on SSL as food has been published. The physiological changes that occur in molting lobsters appear to influence color and texture. Further refinement of lobster texture evaluation techniques may yield differences not found in this study. The pink color of frozen lobster meat could affect commercial development of a SSL market because most consumers are familiar with the whiter meat of freshly-cooked HSL. Although the mechanism for increased coloration during freezing is not known, this phenomenon warrants further study. Consumer acceptability of the pink color must be determined, preferably with persons who are not from lobster-producing areas, and thus would have less rigid ideas of what lobster meat should be.

Lobster meat is somewhat tough, and softer SSL meat may appeal to consumers who dislike the texture of HSL. A new market for SSL may assist lobstermen faced with oversupply of live lobsters when prices are relatively low.

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Table 1. Sensory Evaluation of Lobster Meat

	Sensory Characteristics[a]				
Sample Type	Color	Flavor	Tenderness	Moisture	Geometry
Fresh HSL					
Crusher Claw	4.3 ± 0.6 a	4.7 ± 1.7 a	2.5 ± 1.1 a	5.7 ± 1.3 b	3.6 ± 1.7 a
Tail	3.7 ± 1.4 a	5.4 ± 0.7 a	4.8 ± 1.2 b	3.8 ± 1.4 a	5.5 ± 0.7 b
Frozen SSL					
Crusher Claw	5.7 ± 1.1 b	5.5 ± 1.2 a	3.0 ± 1.7 a	5.4 ± 1.3 b	3.7 ± 1.5 a
Tail	6.1 ± 1.1 b	5.1 ± 1.1 a	3.2 ± 1.2 a	3.2 ± 1.1 a	4.8 ± 0.8 b

[a] Means within columns followed by different letters are significantly different ($p \leq 0.05$).

Table 2. Exterior Color Differences Among Lobster Samples

Sample	L[a,b]	a	b
Fresh HSL			
Crusher Claw	31.51 ± 1.42 bc	8.58 ± 1.33 a	6.45 ± 0.57 a
Pincher Claw	32.72 ± 0.85 c	7.68 ± 0.26 a	6.20 ± 0.11 a
Frozen HSL			
Crusher Claw	33.29 ± 2.65 c	19.30 ± 3.28 c	11.71 ± 2.78 c
Pincher Claw	30.92 ± 2.38 bc	22.78 ± 3.82 d	12.22 ± 1.95 c
Frozen SSL			
Crusher Claw	28.83 ± 1.04 a	14.25 ± 0.89 b	7.67 ± 0.87 ab
Pincher Claw	29.95 ± 1.43 ab	15.02 ± 0.65 b	8.61 ± 0.93 b

[a] Hunter L: 0 = black, 100 = white; Hunter a, +a = red, -a = green; Hunter b, +b = yellow, - b = blue.

[b] Means within columns followed by different letters are significantly different ($p \leq 0.05$).

Table 3. Interior Color Differences Among Lobster Samples

Sample	L[a,b]	a	b
Fresh HSL			
Crusher Claw	30.32 ± 0.59 a	-0.30 ± 0.35 a	0.27 ± 0.26 a
Pincher Claw	29.90 ± 0.68 a	-0.06 ± 0.34 a	0.93 ± 0.18 a
Tail	30.66 ± 0.98 a	-0.20 ± 0.12 a	0.87 ± 0.19 a
Frozen HSL			
Crusher Claw	57.73 ± 2.99 b	4.12 ± 0.58 c	6.12 ± 1.16 d
Pincher Claw	57.19 ± 3.23 b	3.87 ± 1.92 c	4.98 ± 1.97 c
Tail	71.03 ± 3.64 c	5.67 ± 1.42 d	8.26 ± 0.56 e
Frozen SSL			
Crusher Claw	31.49 ± 0.48 a	2.36 ± 0.77 b	2.67 ± 0.48 b
Pincher Claw	31.08 ± 1.03 a	1.89 ± 0.54 b	2.30 ± 0.42 b
Tail	31.48 ± 0.98 a	1.68 ± 0.56 b	2.16 ± 0.29 b

[a] Hunter L: 0 = black, 100 = white; Hunter a, +a = red, -a = green; Hunter b, +b = yellow, - b = blue.

[b] Means within columns followed by different letters are significantly different ($p \leq 0.05$).

Table 4 - Lobster Meat Resistance to Shear[a]

	Lobster Meat Type		
	Frozen SSL	Fresh HSL	Frozen HSL
Crusher Claw	0.10 ± 0.02 ab	0.08 ± 0.02 ab	0.07 ± 0.02 a
Pincher Claw	0.10 ± 0.02 ab	0.10 ± 0.02 ab	0.09 ± 0.02 ab
Tail	0.14 ± 0.02 c	0.17 ± 0.04 c	0.12 ± 0.02 b

[a] Force/mm thickness. Means followed by different numbers are significantly different ($p \leq 0.05$).

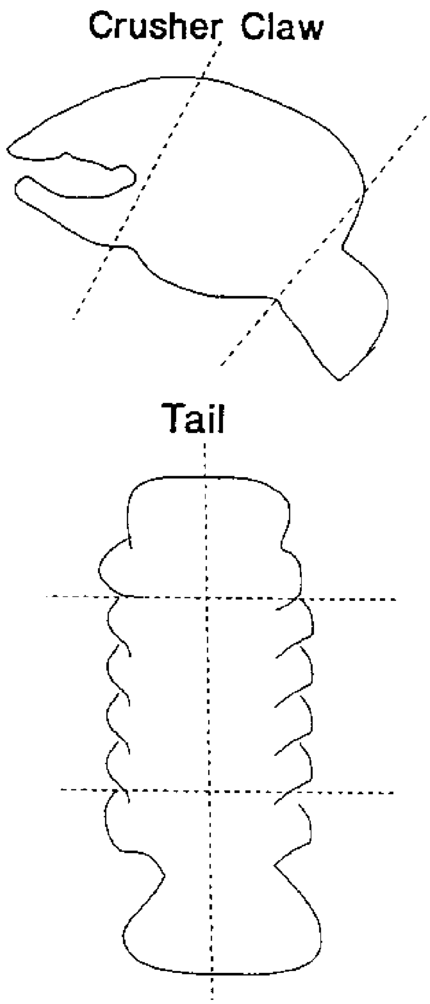

Fig. 1. Schematic drawing of sample preparation prior to sensory evaluation. Dashes indicate portions removed. Claws and tail are not drawn to scale.

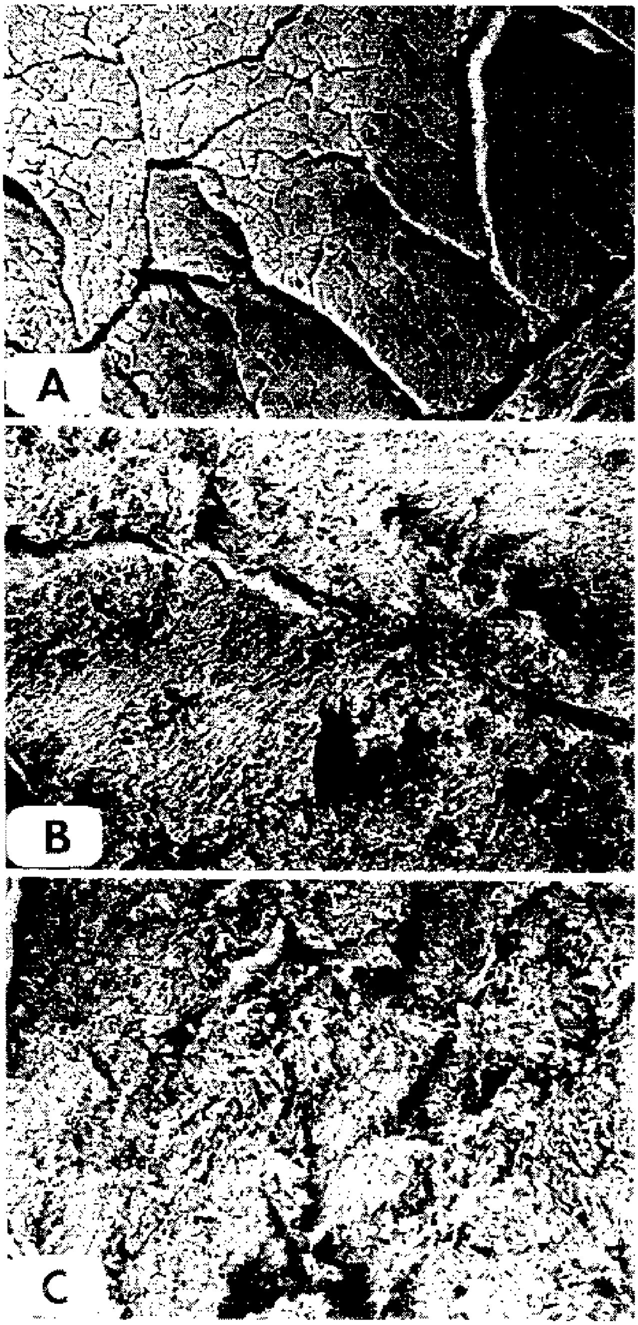

Fig. 2. SEM of pincher claw cross-section. A. fresh HSL (X 640); B. frozen HSL (X 430); C. frozen SSL (X 430). Bar = 50 μm.