

Frozen Storage Stability of Whole and Headless Freshwater Prawns, *Macrobrachium rosenbergii*

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Introduction

The culture of freshwater prawns, *Macrobrachium rosenbergii*, in temperate zones is potentially profitable (Roberts and Bauer, 1978; Liao and Smith, 1980). The prawns must be seasonally batch harvested, however, before water temperatures become lethal (Brody et al., 1980); thus, most of the prawns must be frozen for later marketing. Commercial operations in more tropical areas, such as Hawaii, selectively harvest larger prawns from year-round culture ponds for marketing as a fresh product, primarily to the restaurant trade. Recently, rapidly increasing production has stimulated interest in the marketing of frozen products (Reddy et al., 1981).

Little information is available on the

frozen storage stability of freshwater prawns. Miyajima and Cobb (1977) reported their preliminary observations on prawns frozen and stored both whole and headed and either glazed or vacuum packaged. They measured nitrogenous compounds (ammonia, trimethylamine, and total volatile nitrogen) and bacterial counts. A significant decrease in organoleptic quality of heads-on prawns was noted after more than 6 months of storage, but this was not indicated by their chemical or microbiological test results. Nip and Moy (1979) evaluated prawns that had been frozen by several different methods and stored for 1 month at -15°C . Textural changes were noted but there were no significant losses in sensory quality due to frozen storage.

This study was conducted in cooperation with personnel of the South Carolina Marine Resources Research Institute (MRRRI), who have been developing culturing methods for prawns for several years. Our objectives were to evaluate the frozen storage stability of headed

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ABSTRACT—The freshwater prawn, *Macrobrachium rosenbergii*, is being increasingly cultured in tropical regions and has aquacultural potential in temperate zones. Very little information on frozen storage stability has been published, however. In this study, frozen glazed prawns were stored whole (both raw and precooked) and deheaded (raw) for 9 months at -20°C . Chemical, physical, microbiological, and sensory evaluations were made at intervals during

storage. All samples had a firmer texture after 3 months of frozen storage but the samples stored and cooked whole had a consistently softer texture than those stored as tails. This was due more to the prawns being boiled whole than to changes during frozen storage. An increase in total volatile nitrogen between 6 and 9 months was not reflected in other measurements, but there was a general decline in acceptability over the course of the study.

prawns and whole prawns which could be marketed as a gourmet restaurant product, as in Hawaii.

Materials and Methods

The *Macrobrachium* prawns used in this study were provided by MRRRI personnel from the October 1979 harvest of experimental culture ponds. The freshly harvested prawns were immersed in ice water and transported to the Marine Resources Center where they were graded. Large prawns weighing about 50 g (9/pound) were selected for storage whole and medium prawns weighing about 25 g (18/pound) were selected for storage as tails.

Three experimental packs were prepared: 1) Raw tails, 2) raw whole prawns, and 3) prawns that were boiled, frozen, and stored whole (precooked). The prawns were layered on trays and rapidly frozen in a Hobart¹ blast freezer to an internal temperature of -34°C . The frozen prawns were glazed by being dipped twice into ice water before they were packaged in 5-pound waxed paperboard cartons and stored at -20°C . A reference standard sample was prepared, consisting of raw frozen tails (18 count). The tails were glazed, packed in waxed cartons, wrapped with PVC film, sealed in freezer bags, and stored at -40°C . Sufficient samples were prepared for evaluation at zero time and 1, 3, 6, and 9 months. The evaluations included organoleptic ratings of appearance, flavor, texture, and overall acceptability plus mechanical shear values, total volatile nitrogen (TVN), pH, and microbiological analyses.

Sensory Evaluation

Sensory evaluations were made by a trained taste panel consisting of 12 laboratory personnel. All tests were made with the cold, boiled product. Experimentally stored tails, and the reference standard, were thawed, peeled, and deveined, cooked in boiling 2 percent salt-water for 2 minutes and rinsed with cold water. The whole, raw stored samples

¹Mention of trade names or commercial firms does not imply endorsement by the National Marine Fisheries Service, NOAA.

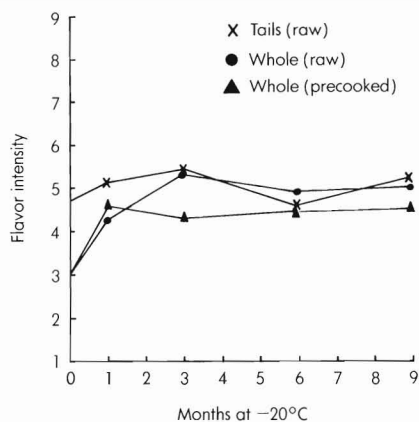


Figure 1.—Average flavor intensity of frozen prawns as perceived by taste panel (scale of 1 to 9, standard reference = 5.0).

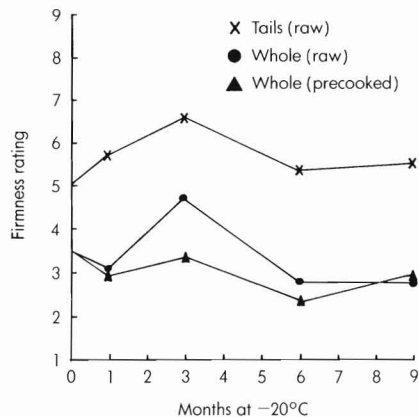


Figure 2.—Texture (firmness) of frozen stored prawns relative to standard reference sample at 5.0.

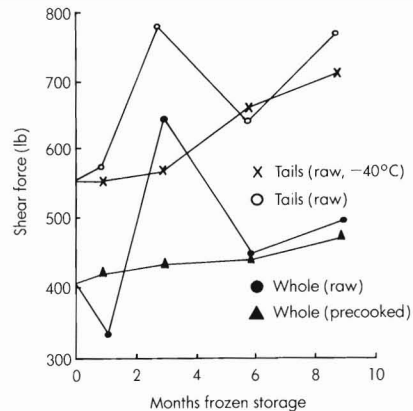


Figure 3.—Average mechanical shear values for experimental and standard reference samples.

were cooked in boiling 3 percent salt-water for 3 minutes, rinsed, deheaded, peeled, and deveined. The third set of samples, precooked whole as above prior to frozen storage, were thawed, headed, peeled, and deveined. All samples were refrigerated for at least 2 hours between cooking and sensory evaluation.

The taste panelists rated the samples for appearance, flavor, and texture relative to the reference standard sample. A 9-point rating scale was used in which the fifth, or center point, was labeled as equal to the standard. The overall acceptability was rated on a 9-point hedonic scale without reference to the standard. Ratings ranged from "like extremely" at 9 through "neutral" at 5 to "dislike extremely" at 1.

Physical Analyses

The texture of the prawns was evaluated mechanically by use of a Kramer shear press. Peak heights of force curves were measured for triplicate 100 g samples of cooked, chilled tail meat.

Chemical Analyses

Total volatile nitrogen (TVN) analyses were conducted using the modified Conway microdiffusion technique described by Obrink (1955) and further modified by Cobb et al. (1973). The pH was measured by direct contact of a

combination pH electrode with the thawed, macerated flesh.

Microbial Analyses

The total aerobic plate count (TAPC), most probable number (MPN) of coliform bacteria and *Escherichia coli*, and the presence or absence of salmonella were determined according to FDA's Bacteriological Analytical Manual for Foods (AOAC, 1976). Standard plate count agar was used as the plating medium for the TAPC. Plates were incubated at two different temperatures: 35°C for 48 hours and 22°C for 5 days. Suspect salmonella cultures were subjected to serological testing for identification. The TAPC is reported as per gram of sample, coliforms and *E. coli* as MPN per 100 g of sample, and salmonella as presence or absence of the organism. Reported results are the average of three replicates.

Results and Discussion

Flavor and Appearance

Sensory evaluations of flavor and appearance showed no definite trends over the 9-month period of frozen storage. The taste panel evaluations of flavor intensity are shown in Figure 1. The test scale ranged from 1 (much milder) to 9 (much stronger) with 5 being equal in flavor to the reference standard sample

stored at -40°C. Moderate increases in flavor intensity over the first 3 months of storage leveled out over the remainder of the study.

Texture

The taste panel evaluations of texture are shown in Figure 2. The raw samples increased in firmness (relative to the standard) during the first 3 months of frozen storage. After 9 months the whole prawns were slightly softer and the tails slightly firmer than initial values (relative to the standard). The softer texture of the whole raw and precooked samples was due primarily to the fact that they were cooked whole, in contact with the enzymes of the hepatopancreas, while the raw tails and standard reference samples were boiled as peeled tails. This is indicated by the texture difference (Fig. 2) between the tails and whole prawns at the beginning of the storage study. The shear values for replicate 100 g samples, as measured with the mechanical shear press, are shown in Figure 3. The pattern is similar to that perceived by the taste panel but shows a more pronounced increase in firmness for the raw experimental samples at 3 months. The standard reference sample showed a moderate but steady increase in shear value. The precooked sample had a very slight increase in firmness over the 9-month frozen storage period.

This stability may be attributed to a partial destruction of enzymes by cooking.

The increased firmness of the *Macrobrachium* with storage was not expected. Webb et al. (1975), however, reported that brown shrimp, *Penaeus aztecus*, showed increased mechanical shear values after storage for 60 days at -20°C . Hose and Lightner (1980) reported that the tail muscle of cultured *P. stylirostris* produced small amounts (up to 4.8 ppm) of formaldehyde during postmortem decomposition. Trimethylamine oxide (TMAO) is the precursor of formaldehyde (which causes toughening of the flesh) and dimethylamine (DMA) in gadoid fish species. No TMA was detected in our analyses of fresh or stored *Macrobrachium*, however.

Chemical and Microbiological Tests

The results of analyses for TVN, TAPC, and pH are listed in Table 1. The TVN values remained relatively low for all samples through the first 6 months of storage. The higher values for the final 9-month samples have not been explained and were not reflected in the sensory evaluations. The bacterial plate counts decreased steadily over the frozen storage period. Although not shown, coliform counts dropped from 60/100 g to 9/100 g MPN and neither *E. coli* nor salmonella was detected. The pH values remained relatively stable throughout the storage period.

Acceptability

The average taste panel judgments on the overall acceptabilities of the experimental products are shown in Figure 4. There was a general downward trend in acceptability and deviations could be related to texture. The whole raw sample tended to be too soft after cooking whole but the increased firmness at 3 months resulted in an increase in acceptability, which was followed by a decline. Conversely, the tails were disagreeably tough at 3 months and the decreased firmness at 6 months corresponded with a slightly higher acceptability.

Statistical Analysis

The taste panel results required analysis by nonparametric statistics because

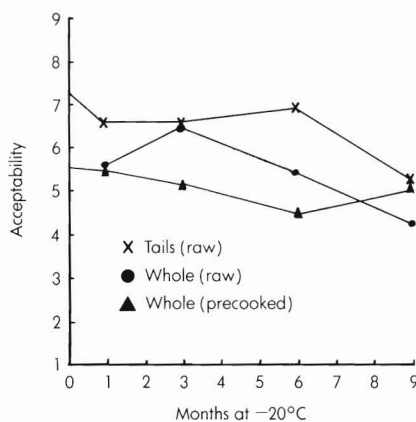


Figure 4.—Acceptability of frozen stored prawns as judged by taste panel (9 point hedonic scale).

scoring was limited to nine discrete values. The Friedman two-way analysis of variance (ANOVA) tests indicated that at $\alpha = 0.05$ there were significant differences between sample medians for texture but not for flavor or acceptability. The nonparametric Wilcoxon signed-rank test was applied to pairs of products at each storage time with the results as shown in Table 2. The whole and precooked whole samples were significantly softer than the tails.

The results of the Welch ANOVA tests for equality of product means for TVN and mechanical shear press values are listed in Table 3. The differences in shear press values are highly significant.

Conclusions

The *Macrobrachium* prawns that were frozen and stored whole, either raw or precooked, had a significantly softer texture than the samples stored as raw tails. The softness was due primarily to the samples being cooked whole, in contact with digestive enzymes, rather than to changes occurring during storage. This was indicated by the difference between firmness of tails and whole prawns at zero time, which persisted during frozen storage.

Raw samples stored at -20°C devel-

Table 1.—Total volatile nitrogen (TVN, mg N/100g), total aerobic plate count (TAPC), and pH of frozen *Macrobrachium* prawns.

Storage period	Sample ¹ code	TAPC/g		pH	
		TVN	@22°C		@35°C
0	T-R	28.16	78X10 ⁴	64X10 ⁴	6.30
1 month	T-R-20	12.87	55X10 ⁴	55X10 ⁴	6.60
	T-R-40	14.40	—	—	6.70
	W-R-20	14.29	—	—	6.58
	W-C-20	10.17	—	—	6.60
3 months	T-R-20	13.04	—	—	6.60
	T-R-40	12.79	—	—	6.60
	W-R-20	12.60	—	—	6.50
	W-C-20	11.78	—	—	6.90
6 months	T-R-20	10.03	17X10 ⁴	18X10 ⁴	6.43
	T-R-40	10.80	—	—	6.45
	W-R-20	12.82	—	—	6.45
	W-C-20	11.85	—	—	6.65
9 months	T-R-20	26.22	47X10 ³	35X10 ³	6.28
	T-R-40	25.72	—	—	6.30
	W-R-20	20.09	—	—	—
	W-C-20	17.72	—	—	6.55

¹T-R-20 = Tails, stored at 20°C ; T-R-40 = Tails, 40°C ; W-R-20 = Whole, raw, 20°C ; W-C-20 = Whole, precooked, -20°C .

²the TVN and TAPC values are averages of three replicate analyses each.

Table 2.—Results of nonparametric Wilcoxon signed-rank tests on each pair of products at each storage time. * indicates rejection of equality of median at the significance level $\alpha = 0.05$.

Item	Month	Month				
		0	1	3	6	9
Whole vs. precooked	Flavor					
	Texture			*		
	Acceptability					
Whole vs. tail	Flavor					
	Texture		*	*	*	*
	Acceptability					
Precooked vs. tail	Flavor	*				
	Texture		*	*	*	*
	Acceptability					*

Table 3.—P values of the Welch ANOVA tests to test equality of means among product forms for TVN and shear value at each storage time. Equality of means is rejected when $P < 0.05$.

Month	P value	
	TVN	Shear value
0	—	0.0022
1	0.0394	0.0001
3	0.8948	0.0004
6	0.1432	0.004
9	0.0914	0.0075

oped peak firmness after 3 months. There was little change in the texture of the precooked prawns but they were very soft from the beginning and were of borderline acceptability. The acceptability of the raw samples declined during storage and if a taste panel rating of 5 is taken as the borderline of acceptability, the storage life is estimated to be about 7 months for whole prawns and about 10 months for tails. The frozen storage life for whole prawns could be greater if other methods for cooking are used.

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