
Storage Stability and Some Costs of Cryogenically Frozen, Whole Freshwater Prawns

Bulletin 1073 -- April 1998

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ABSTRACT

Live prawns (*Macrobrachium rosenbergii*) were harvested during early fall 1995 and transported live to a fish processing plant in Macon, Mississippi. They were first placed in ice water and held for about 5 minutes. They were then frozen on a CO₂ freezing tunnel for about 10 minutes, water glazed, placed in 2.7-mil polyethylene bags, and packed in 15-pound cardboard boxes. After storage at -18 °C (0 °F) for 1, 133, and 225 days, groups of prawns were boiled for 7 minutes while still frozen (control) and after thawing for 4, 8, 12, 24, 30, 36, and 48 hours at 2 °C (35 °F). Shear force (firmness) was highest for frozen prawns and those thawed for up to 8 hours. Taste panelists rated one-day-frozen prawns acceptable, regardless of thawing time. Prawns stored for 133 and 225 days had acceptable texture after 4 and 24 hours of thawing, respectively. Prawns tended to be firmer but more brittle as frozen storage time increased. Live prawns can be cryogenically frozen and kept in frozen storage for up to 7.5 months. Prawns should be cooked unthawed or after thawing for not more than 4-8 hours. Claws were observed to fall off the body after frozen storage, probably due to handling.

INTRODUCTION

The temperate zones of the United States have the potential to capitalize on the technology and consumer demand for freshwater prawns (22). Studies on prawn production (3, 10, 12) have shown some economic potential, especially if the pond and associated facilities are already available and certain management practices are followed. Studies have also shown that prawns are very acceptable to the restaurant trade (6) and the retail market. Freshwater prawns, stocked in the ponds during late spring, must be seasonally harvested before water temperatures drop below 64 °F (18 °C) (20). This seasonality warrants freezing preservation for year-round availability.

Initial studies on the frozen storage stability of freshwater prawns showed early deterioration in texture when prawns were stored whole (7). Deheaded, frozen prawns had a consistently firmer texture than whole prawns.

Miyajima and Cobb (11) reported a significant decrease in the sensory texture quality of whole frozen prawns after 6 months of storage. Nip and Moy (13) noted significant textural changes in whole frozen prawns after 1 month of frozen storage, but found no significant differences in other sensory parameters as did Reddy et al. (16).

Reports by Nip et al. (14, 15) and Baranowski et al. (2) showed that the addition of a collagenolytic enzyme fraction to prawn tissue increased the hydrolysis of prawn collagen.

Data collected at Mississippi State University during a 5-year period show that softening of freshwater prawns may occur quickly regardless of whether they were frozen whole or deheaded (17). Thus, not only product form but also handling and thawing may contribute to the softening of prawns. Whole prawns frozen individually overnight in a blast freezer (18) or individually quick frozen (21) held their "texture" well for 6-12 months of frozen storage. The type of thawing seemed to influence softening.

The objectives of this study were to freeze whole, live prawns cryogenically and study their meat firmness and sensory acceptability as affected by frozen storage and thawing times.

MATERIALS AND METHODS

The prawns used for this study were grown in earthen ponds located at the Mississippi Agricultural and Forestry Experiment Station Aquaculture Unit located at the Mississippi State University Animal Research Center near Starkville, Mississippi. Juvenile prawns (0.17 to 0.75 grams) were stocked at densities of 16,000 per acre in 0.15- to 0.17-surface-acre ponds during early May. They were fed a 25 percent crude protein, pelleted, sinking feed at a rate based upon mean individual weight (percent of body weight) (4, 5). Prawns were harvested in late September 1995 and ranged in weight from 30-50 grams.

Harvesting, Freezing, and Storage

After harvest from the ponds, prawns were placed in tanks with oxygenated water for transport to the processing facility. Upon arrival, prawns were placed in baskets between layers of ice. This procedure was performed to increase ease of handling before freezing. Whole prawns were individually placed on the conveyor belt in a cryogenic freezing tunnel (Liquid Carbonic, Jackson, Mississippi) and frozen with CO₂ for 10 minutes through adjustment of belt speed. Prawns were then passed through a water glaze (ice water, -35 °F), and placed in 1.5-mil polyethylene bags. The bags were then placed in 15-pound cardboard boxes which were stored at -18 °C (0 °F). Prawns were held in frozen storage for up to 225 days.

Thawing and Cooking

Prawns were analyzed for effect of duration of frozen storage (1, 133, or 225 days) and thawing. Prawns were evaluated after not thawing (control), and 4, 8, 12, 24, 30, 36, and 48 hours after thawing at 2 °C (35 °F) over ice. After each thawing period, prawns were placed in boiling water (at least 5 parts water for every part of prawns) for 7 minutes. Upon removal, prawns were immediately cooled by placing them in iced water for about 1-2 minutes with intermittent stirring. After iced water immersion, prawns were deheaded, peeled, and washed with tap water in preparation for evaluation.

Texture and Sensory Evaluation

Cooked, peeled samples were analyzed for shear force (firmness) and total energy (overall texture) using an FTC Texture Test System (Food Technology Corp., Rockville, Maryland) with a 10-blade CS-2 standard cell (FTC) at a ram speed of 30 seconds in compression and a total pressure of 2,000 pounds per square inch. Tissue from three prawns (100 grams) was used for each measurement. The force necessary to shear the prawns was recorded as the height of the peak on the texturegram. Energy was recorded as the integral area

of the texturegram as (force x distance traveled) read in the Texture Integrator. Force and energy were expressed as units per gram of sample in the cell.

Eight trained panelists evaluated the cooked, peeled samples for firmness and overall acceptability (flavor, texture). A 7-point rating scale was used to rate the prawns with "7" being "firm and fresh sweet," "4" being "marginally firm and sweet," and "1" being "soft or tough/rubbery and stale or unacceptable" (9).

RESULTS AND DISCUSSION

Shear Force and Total Energy

Shear force of unthawed prawns appeared to increase slightly as storage time increased. Moreover, thawing resulted in lower shear force for prawns stored for 1 day. After 133 and 225 days of frozen storage, shear force of unthawed prawns was similar to that of prawns thawed for 4 hours. Thawing more than 4 hours resulted in lower shear force. Shear force of freshly frozen prawns was lower than that of those stored for 133 days or longer. Vongsawasdi and Noomhorin (21) reported a slight decrease in shear rate of individually quick frozen (IQF) whole prawns stored at -18 °C for 6 months, but panelists did not detect any differences. They concluded that IQF whole prawns could be held in frozen storage for 6 months without any significant effect on texture or acceptability.

Silva and Ammerman (17) reported that shear force of whole prawns or tails decreased after 6 months at -18 °C. Hearnberger et al. (8) reported a decrease in shear force on whole prawns or tails after 24 and 48 hours of thawing for up to 6 months storage at -18 °C. Silva and Ammerman (17) reported no significant loss in texture scores of whole prawns and prawn tails held for up to 12 months at -20 °C. However, all these studies were done with prawns that were chill-killed before freezing and frozen in a still air freezer overnight.

Data for total energy show trends that are similar to those for shear force. The data indicate that freshly frozen prawns possess a slightly more tender meat than those held in frozen storage for over 4 months. This condition is probably due to water loss and protein denaturation.

Sensory Evaluations

Panelists rated the freshly frozen whole prawns acceptable for texture whether unthawed or thawed for up to 24 hours, despite detectable decreases in shear rate after thawing. Overall acceptance ratings were also similar for all freshly frozen samples thawed up to 24 hours. In evaluations of prawns frozen for 133 days, panelists rated unthawed samples as firmer than those thawed for up to 48 hours. However, no clear trends in overall acceptability relative to thawing time were observed. Prawns held in frozen storage for 225 days were rated as high in firmness when cooked unthawed or after thawing for 4 hours. Lower scores were obtained when thawing exceeded 4 hours. Overall acceptability ratings were similar for unthawed prawns and those thawed for up to 24 hours. After 24 hours, sensory scores were marginal or unacceptable. Thus, although some tissue softening occurs after 4 hours of thawing, this characteristic is not singularly important (1) in determining acceptability. Sweetness or freshness of cooked prawns is maintained in prawns held for up to 24 hours of thawing. Hearnberger et al. (8) reported that whole prawns stored frozen for up to 12 months were marginally acceptable relative to firmness, but overall acceptability scores were usually higher. Taste panelists found individually frozen whole prawns to be acceptable through 12 months of storage at -18 °C (18).

SUMMARY

This study shows that cryogenically frozen live, whole prawns prepared without thawing are acceptable for up to 7.5 months of frozen storage. Some toughening of prawn meat occurs due to frozen storage; no appreciable softening is detected during frozen storage. However, if prawns are thawed for more than 4 hours, significant softening is detected.

Cryogenic Freezing Costs

It is estimated that it takes 1.5-2 pounds of CO₂ per pound of whole prawns. This estimate is based on preliminary figures, but efficiency of freezing tunnel and personnel will dictate the usage. The cost of CO₂ is about \$50 per ton; however, this depends on transportation and distance to source. Thus, it is estimated that the cost of freezing prawns cryogenically would be about 5 cents per pound (whole). Mechanical freezing (blast) of deheaded prawns was quoted as approximately 10 cents per pound. Costs of manual deheading are about 6 cents per pound based on 120 pounds per hour deheading time (19). These costs are for low-volume operations.

Costs associated with storage vary. These costs are estimated to be 5 cents per pound per month for holding and loading and unloading from the storage place.

All costs quoted here are estimates from preliminary commercial trials and past research. They only serve as a reference, and the reader is encouraged to research further before costing the process.

ACKNOWLEDGMENTS

The authors would like to acknowledge the assistance of Lou D'Abramo, Andrew Sullivan, Angus Irvine, and Mac Fondren of the Wildlife and Fisheries Department of Mississippi State University for providing the prawns, transportation, and expertise in the study. Also, we acknowledge the help of Lou D'Abramo, Ken Hood, and Keith Cadwallader in the review of the manuscript.

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