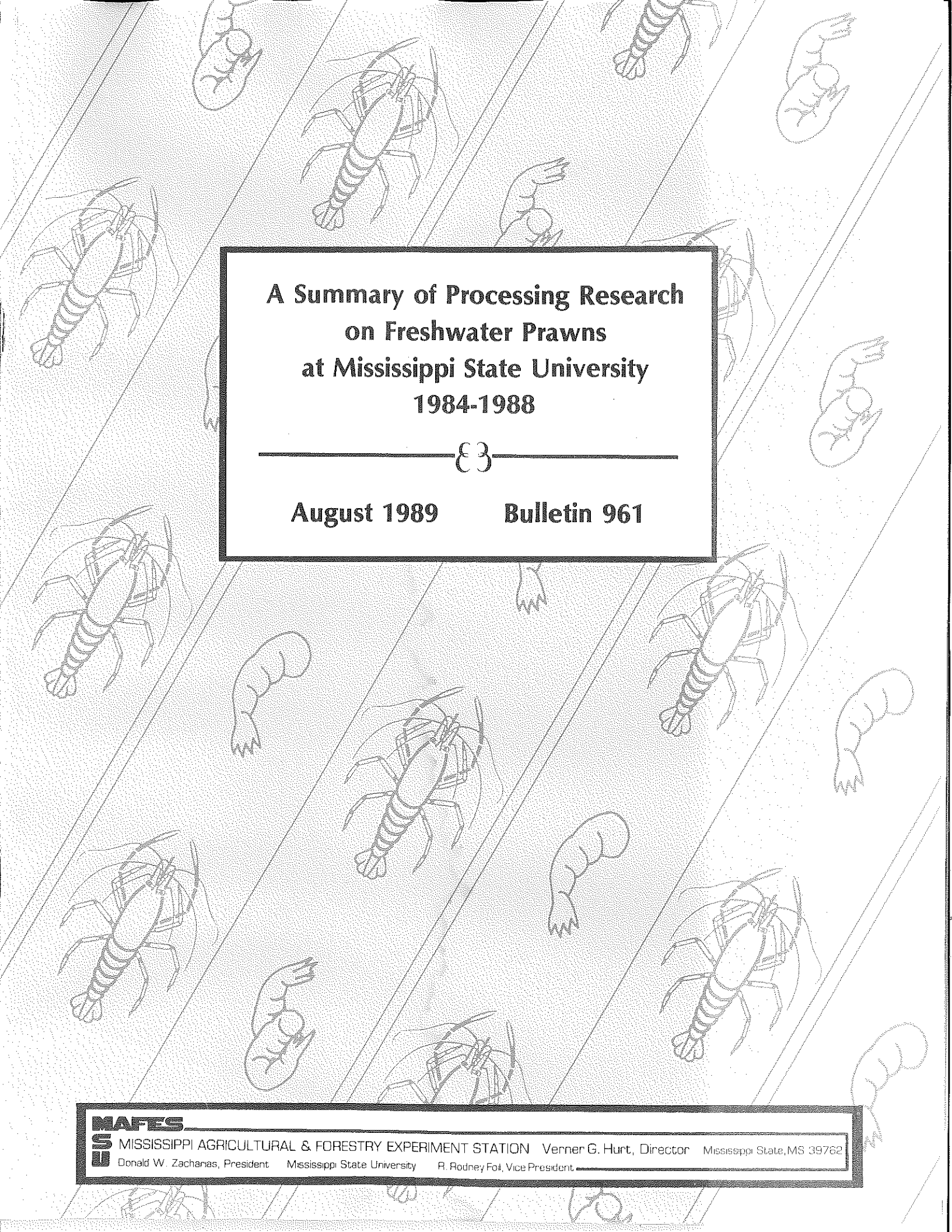

A Summary of Processing Research on Freshwater Prawns at Mississippi State University 1984-1988

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MAFES
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Donald W. Zacharias, President Mississippi State University R. Rodney Foil, Vice President

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Compiled and Edited By

Juan L. Silva, Assistant Professor
Department of Food Science and Technology

James O. Hearnsberger, Professor
Department of Food Science and Technology

Fay Hagan, Professor
Department of Experimental Statistics

Gale R. Ammerman, Professor Emeritus
Department of Food Science and Technology

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Contributors

George P. Abide, former Graduate Research Assistant in the Department of Food Science and Technology, MSU, is now with the Department of Food Science, Purdue University, West Lafayette, IN.

Gale R. Ammerman, Food Technologist and Professor Emeritus, Department of Food Science and Technology, Mississippi State University.

Susan Bradway, Former Research Assistant, Department of Food Science and Technology, MSU, is now with the Mississippi State Health Department, Jackson, MS.

Fay Hagan, Professor, Department of Experimental Statistics, Mississippi State University.

James O. Hearnsberger, Food Scientist and Professor, Department of Food Science and Technology, Mississippi State University.

William E. Poe, Associate Biochemist, Department of Biochemistry and Molecular Biology, Mississippi State University.

Juan L. Silva, Food Technologist and Assistant Professor, Department of Food Science and Technology, Mississippi State University.

Pedro L. Silva, Laboratory Assistant, Department of Food Science and Technology, Mississippi State University.

Rosemary Wander, Former Professor, Department of Food Science and Technology, MSU, is now with the Department of Food Science, Oregon State University, Corvallis, OR.

Robert P. Wilson, Professor, Department of Biochemistry and Molecular Biology, Mississippi State University.

Vernon Woodruff, Former Research Assistant, Department of Food Science and Technology, MSU, is now with McCarty Foods, Jackson, MS.

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Chapter I

Introduction

J. L. Silva, J. O. Hearnsberger, and G. R. Ammerman

The temperate zones of the United States have the potential to capitalize on the technology and consumer demand for freshwater prawns (*Macrobrachium rosenbergii*) (Wellborn, 1985). Studies on the production (Bauer et al., 1976; Liao and Smith, 1983) of the prawns have shown some economic potential, especially if the pond and associated facilities are already available. Studies have also shown that prawns are very acceptable to the restaurant trade (Dillard et al., 1986) and the retail market. Freshwater prawns, placed in the ponds after the cold season has ended, must be seasonally harvested before the temperature of the water drops below 64°F (18°C) (Smith et al., 1978). It is this seasonality that makes the freezing preservation necessary to keep a year-round supply.

Information on the frozen storage stability of freshwater prawns showed early deterioration in texture when the prawns were stored whole (Hale and Waters, 1981). A significant decrease in the organoleptic texture quality of whole frozen prawns after 6 months of storage was reported by Miyajima and Cobb (1977). Nip and Moy (1979) noted significant textural changes in whole frozen prawns after one month of frozen storage, but found no significant differences in other organoleptic parameters. Deheaded, frozen prawns had a consistently firmer texture than the whole prawns (Hale and Waters, 1981).

Deheaded prawns were reported by Angel et al. (1981) to be composed of 79.3% moisture, 17.5% crude protein, 1.9% fat, and 1.3% ash. Moreover, an apparent increase in moisture with a decrease in crude protein were found after 14 days of storage at 0°C. Sidwell et al. (1974) found that the edible portion of deheaded prawns contained 75.3% moisture, 16.8% protein, 1.2% fat, and 2.7% ash.

Chilled-killed prawns in ice ready to be processed.

Reddy et al. (1981) reported that prawns contained approximately 1.6% fat, which is composed of 23% saturated, 46% monounsaturated, and 31% polyunsaturated fatty acids.

Chanmugam et al. (1983), however, reported that freshwater prawns contained about 3.2% fat, consisting of 35.8% saturated, 35.2% monounsaturated, and 29.0% polyunsaturated fatty acids. There was no complete information on the feed type or morphology of the prawns in these studies, and this may account for the differences in the composition of the fatty acids.

Although the fat is mostly unsaturated, freshwater prawns are stable to oxidative rancidity because the 2-thiobarbituric acid (TBA) values reported by Reddy et al. (1981) for frozen prawns held for 12 months did not exceed 3.0, a minimum TBA value associated with rancidity in seafood. Angel et al. (1981) reported TBA values between 0.25 and 0.66 for frozen prawns held at 0°C (32°F) for up to 14 days.

Baranowski et al. (1984) suggested that the enzyme system in the prawns contains a collagenolytic portion believed to be responsible for the breakdown of tail muscle texture. A report by Nip et al. (1985) showed that the addition of a collagenolytic enzyme fraction to prawn tissue increased the hydrolysis of prawn collagen.

Because the literature is conflicting with respect to the composition and freezing stability of freshwater prawns, food technologists at Mississippi State University studied the processing yield, chemical composition, freezing stability, chemical and physical changes, and organoleptic acceptability of the prawns as affected by various processing variables.

This bulletin is a summary of data accumulated from 4 years of research in the processing and storage of freshwater prawns raised in Mississippi. The reader is encouraged to contact the authors for additional information.

The prawns used for the studies reported in this bulletin were reared at the Mississippi Agricultural and Forestry Experiment Station (MAFES) Aquaculture Unit located on the Mississippi State University Animal Research Center near Starkville. The prawns were stocked at densities of 16,000 to 48,000 per acre in 0.15-acre to 0.17-acre ponds. They were fed a 25% crude protein, pelleted, sinking feed at a rate of 20% of body weight in the early growth stages, reducing to a rate of 3% of body weight prior to harvesting (D'Abramo et al., 1986; 1988). The ponds were stocked in early May with nursed juveniles, ranging in weight from 0.17 gram to 0.75 gram. Prawns were harvested in late September or early October and ranged in weight from 30 grams to 50 grams.

Chapter II

Composition of Freshwater Prawns

J. L. Silva, J. O. Hearnsberger, G. R. Ammerman, W. E. Poe, R. P. Wilson, G. Leigeber, and R. Wander

The literature is conflicting when reporting the composition of freshwater prawns (USDA, 1963; Sidwell et al., 1974). The reported fat content of prawn tissue ranged from 1.2% to 1.9% or higher (Sidwell et al., 1974; Angel et al., 1981). Additionally, the fatty acid composition, which gives a measure of the degree of saturation of lipids, is known to be influenced by the feed, age, and morphology of the prawns and by environmental conditions. Though very low in fat, the cholesterol content of the prawns is of interest to both researchers and consumers. Free amino acids have been reported to give an indication of the enzyme activity in prawns. Iodine content of a sample of prawns is also of concern since allergic reactions to iodine in shellfish are known to occur in humans.

Materials and Methods

Materials

Chill-killed freshwater prawns were obtained from the Mississippi Agricultural and Forestry Experiment Station (MAFES) aquaculture research facilities. The prawns were fed diets containing 25% protein, similar to those for channel catfish (D'Abramo et al., 1986; 1988). The prawns weighed 30-50 g (1 to 2 oz.), whole weight, and were kept in ice for not longer than 12 hours before being processed and stored frozen. Approximately 2,500 prawns were used for these studies.

Methods

Data reported in this chapter are the result of several experiments. Proximate (chemical) composition of the prawn meat was determined from prawns following the design and methods described in Chapter 7. Fatty acid profile was conducted based on designs described in Chapters 7 and 8.

Sample preparation. At zero-day and at 60-day intervals, six tails per treatment were selected at random, partially thawed, shelled, and the meat was chopped manually with knife. The chopped samples were weighed. Twenty grams of chopped meat were taken for TBA value determination and the rest were dried, as described below, to be used for other determinations.

Moisture. The moisture of the chopped sample was determined by the method described in AOAC 24.003 (1980), which specifies drying for 18 hours at 100°C (212°F). Total moisture in the sample on a wet weight basis was calculated.

Protein. The percent protein (Kjeldahl N x 6.25) was determined on a 0.7004-gram portion of the chopped, dried sample and the result was converted to a wet weight basis. The AOAC method 2.057 (1980) for total Kjeldahl N was used.

Fat. Fat was extracted from 2 grams of the chopped, dried sample by refluxing for 5 hours in ethyl ether as described by AOCS Ba 3-38 (1981). The result was converted to a wet weight basis and reported as percent fat.

Ash. The AOAC method 7.009 (1980) was used to determine ash on a 2-gram portion of the chopped, dried sample. The result was converted to a wet weight basis and reported as percent ash.

TBA value. The 2-thiobarbituric acid was determined by the distillation method described by Tarladgis et al. (1960) using a 10-gram portion of the chopped sample. The optical density of the sample was read against a blank at a wavelength of 538 nm. The O.D. reading was multiplied by the factor 7.8 to convert to milligrams of malonaldehyde per kilogram (mg/kg) of sample.

Free fatty acids. The fat extracted from the chopped, dried samples for fat determination was used to determine the percent free fatty acids. The AOCS official method Ca 5a-40 (1981) was slightly modified to determine the free fatty acids. Fifty milliliters (ml) of hot neutralized alcohol and 0.01 N NaOH were used. The percent free fatty acids of the fat was calculated and expressed as oleic acid on a whole sample basis.

Fatty acid profiles. The fat was extracted from the chopped, dried sample by the procedure of AOCS Ba 3-38 (1981). The liberated fatty acids were esterified according to AOAC methods 28.053-28.056 (1980). A boron trichloride catalyst was used rather than the boron trifluoride reagent. Hexane was replaced with isooctane for the extraction. Methyl esters of the fatty acids were separated and analyzed by the

gas chromatographic methods of AOAC 28.057-28.065 (1980). Results were reported for each acid as a percent of the total fatty acids. Fatty acid profiles were performed on the headless prawns at 60, 120, and 300 days of frozen storage.

Free Amino Acids. Free amino acids were determined from each replicate of raw prawn tails stored for up to 6 months at −18°C. Prawn tails were frozen in liquid nitrogen and ground with a mortar and pestle. Approximately 1.0 gram of freshly ground tail was blended with 3.0 ml of 4% 5-sulfosalicylic acid (to precipitate any protein present) in a ground glass grinder. The solution was centrifuged and the supernatant injected onto a Beckman Model 120C (Blue Bell, PA) ion exchange amino acid analyzer. Results were reported as milligrams of free amino acid per gram (mg/g) dry tissue.

Cholesterol. Cholesterol was determined after extraction of the lipids in the prawn tissue with hexane and saponification using alcoholic potassium-hydroxide. Cholesterol was determined colorimetrically. The effects of cooking (frying and boiling), blanching, packaging, and tissue type were evaluated for compositional variations.

Iodine. The iodine content on a sample of five prawn tails (200 g) was determined by ion selective electrode analysis according to the method of Hoover et al. (1971).

Results and Discussion

The chemical composition of freshwater prawns (tissue) as influenced by different processing and storage conditions is shown in Table 2.1. Blanched prawns showed higher ($P < 0.05$) protein values and higher ($P < 0.05$) fat values than raw prawns. However, the differences were not of any practical significance since they were small. Packaging in vacuum bags or storage temperature did not have any effect on the composition of the prawns. Overall, the prawns contained 77.6% moisture, 19.9% protein, 0.4% fat, and 1.2% ash. Fat content for these freshwater prawns was half of that reported for marine shrimp (USDA, 1963).

Table 2.1. Effect of blanching, packaging and storage temperature on the composition of headless, frozen prawns.

	Composition (% of total weight)			
Treatment	**Moisture**	**Protein**	**Fat**	**Ash**
Blanching				
Blanched	77.4a*	20.2a	0.43a	1.21a
Not blanched	77.8a	19.6b	0.36b	1.23a
Packaging				
Vacuum	77.5a	19.9a	0.39a	1.24a
Atmosphere	77.7a	19.9a	0.40a	1.22a
Storage Temp (C)				
−23°	77.8a	19.7a	0.39a	1.22a
−18°	77.4a	20.1a	0.40a	1.22a
Overall Means	77.6a	19.9	0.40	1.22

*Means within a column in each treatment not followed by the same letter differ significantly ($P < 0.05$) as determined by the F-test in the ANOVA.

Table 2.2. Changes in the fatty acid composition of headless, frozen prawns during storage at −18°C (as percent of total fatty acids).

	Storage time (months)			
Fatty acid	**2**	**4**	**10**	**Overall means**
	% of total fatty acids			
C14:0	0.39	–	0.24	0.21
C16:0	29.64	16.13	23.54	23.10
C16:1	2.61	–	3.20	1.94
C17:0	0.24	–	0.07	0.11
C18:0	15.61	16.48	11.00	14.36
C18:1	34.64	32.68	27.96	31.76
C18:2 + 19:0	14.56	26.54	15.02	18.71
C18:3	0.80	–	1.76	0.85
C20:1	–	8.17	0.22	2.80
C20:2	–	–	0.18	0.06
C20:3	0.33	–	–	0.11
C20:4	0.51	–	6.32	2.28
C21:0	0.20	–	–	0.07
C22:1	–	–	7.33	2.44
SFA[1]	46.08	32.61	34.85	37.85
MUFA[2]	37.25	40.85	38.71	38.94
PUFA[3]	36.67	26.54	36.44	26.44

[1] Saturated fatty acids.
[2] Monounsaturated fatty acids.
[3] Polyunsaturated fatty acids.

Fatty acid composition of prawn tissue, as affected by storage time at −18°C, is shown in Table 2.2. Fatty acids varied during storage time, but no clear trend was noticed. Overall, oleic (C18:1), palmitic (C16:0), linoleic (C18:2), and stearic (C18:0) acids were the fatty acids present in largest quantities. These four fatty acids constituted approximately 88% of the total fatty acids in the prawns. Of the total fatty acids present, 37.9% were saturated, 38.9% monounsaturated, and 26.4% polyunsaturated. The fatty acid composition may be affected by the type of feed, sex, age, and/or size of the animals as well as by environmental conditions (Silva-Pacheco, 1986).

The free amino acid profile for freshwater prawn tissue, as affected by time of storage at −18°C, is shown in Table 2.3. There was an increase of 24.8 mg/g of dry weight in the total amount of free amino acids in prawn tissue after 2 months of frozen storage. However, there were no changes in the total amino acids after 6 months of frozen storage.

Glycine, proline, alanine, lysine, and serine content increased considerably throughout storage. Glycine has been reported as one of the major components in

collagen tissue and a factor in the formation and stability of the collagen triple helical structure (Matthews, 1975). Proline and alanine are also found in collagen of muscle tissue (Nip et al., 1981). The action of proteolytic enzymes found in the digestive tract (hepatopancreas) has been suggested to affect the texture and free amino acid content of prawn tissue (Baranowski et al., 1984). The action of a collagenolytic enzyme fraction on chilled stored prawns was suggested as a possible cause for mushiness in prawns (Nip et al., 1985).

Ammonia levels increased by the end of 2 months of frozen storage and remained at the same level thereafter. However, these ammonia levels are lower than those reported for spoiled white shrimp (*Penaeus setiterus*) under iced storage (Cobb et al., 1974).

The cholesterol content of freshwater prawns, as affected by type of tissue (tail tissue or whole body tissue), blanching (3 minutes at 100°C), and cooking method (raw, boiled for 8 minutes, and fried at 190°C until done) are shown in Table 2.4.(Leigeber, 1987). There was a higher ($P<0.05$) cholesterol content in the tissue from the tails than in the whole tissue of prawns. Blanching did not affect the cholesterol content of the prawns but cooking did ($P<0.05$). Boiled prawns contained more cholesterol than raw prawns (tail tissue); fried prawn tails contained the most. However, cholesterol on a dried basis was not affected by cooking method. These differences in cholesterol were probably caused by dehydration of the tissue during cooking.

Data reported by Hearnsberger (1987) showed the cholesterol content of prawn tail tissue to be 98.4 to 70.6 mg/100g of tissue. The cholesterol of marine shrimp was reported to be 125 mg/100 g (USDA, 1963) to 159 mg/100 g of tissue (Sidwell et al., 1974). The cholesterol content may depend on several factors such as diet, size of animal and environmental conditions, thus the conflicting data.

Iodine values were reported to be 0.14 ppm for prawn tissue (Hearnsberger, 1987). The iodine content of medium prawns (30 g whole weight) was found to be 0.14 ppm (Hearnsberger, 1987), which is below the average of 0.80 ppm for shellfish and 0.83 ppm for marine fish (Shils and Young, 1988).

Table 2.4. Cholesterol content of freshwater prawns as affected by type of tissue, blanching, and cooking method.

Treatment	Cholesterol (mg/100 g of tissue)	
	Wet basis[1]	Dry basis[2]
Tissue type		
Whole	154a*	636a
Tail	172b	763b
Blanching		
Control	159a	684a
Blanched	167a	715a
Cooking		
Raw	169a	798a
Boiled	232b	837a
Fried	334c	694a

[1] mg of cholesterol per 100 g of tissue.
[2] mg of cholesterol per 100 g of dry tissue.
* Means within treatment, in a column not followed by the same letter differ significantly ($P<0.05$) as determined by the LSD.

Table 2.3. Mean free amino acids in freshwater prawns by storage time at –18°C.

Amino Acid	Storage time (months)		
	0	2	6
	Free amino acids (mg/g dry tissue)		
Taurine	2.25	3.28	2.53
Aspartic acid	0.28	N/A	0.20
Threonine	0.96	2.36	2.37
Serine	6.94	9.87	10.47
Glutamic	0.78	1.26	1.40
Proline	1.69	5.26	4.17
Glycine	5.04	8.86	6.70
Alanine	4.06	8.27	7.30
Valine	1.28	2.10	1.97
Methionine	0.42	0.95	1.03
Isoleucine	0.44	1.02	0.87
Leucine	0.83	1.64	1.37
Tyrosine	0.44	1.66	1.00
Phenylalanine	N/A	0.94	0.83
Lysine	3.05	6.10	5.07
Histidine	2.12	3.32	3.37
Arginine	35.72	33.47	34.10
Ammonia	0.30	0.80	0.67
Total	66.60	91.16	85.42
SEM	1.45	1.85	0.52

Chapter III

Time and Motion Studies on Processing Freshwater Prawns

J. L. Silva, J. O. Hearnsberger, G. R. Ammerman, and G. P. Abide

In September 1985, a preliminary time study on deheading prawns was conducted at the Food Processing Laboratories at Mississippi State University. Six experienced prawn workers were chosen for this study.

Materials and Methods

Prawn workers were chosen at random and were observed without their knowledge. The number of prawns deheaded per unit of time was tabulated. This time reflected how long it took the person to dehead the washed prawns under continuous operating conditions. In most cases, 100 prawns per person per each random time were deheaded. Motion studies were conducted for each prawn size or morphotype.

Results and Discussion

Results (Table 3.1) show that, except in the case of jumbo prawns, one person can dehead 100 prawns in 5.5-5.8 minutes. This is equivalent to approximately 1,000 prawns deheaded per hour of operation. In the case of jumbos, the long deheading time (9.0 minutes) may have been caused by the difficulty in handling larger prawns. An experienced shrimp worker can dehead 120 pounds of shrimp per hour, peel 40 pounds of shrimp per hour, and peel and devein 10.8 to 13.2 pounds per hour (26- to 40-count shrimp) (Hearnsberger, 1987).

Table 3.2 shows the approximate capacity of a commercial shrimp peeler by category (size) of prawn. The Model 35 Jonsson (Gregor Jonsson Assoc., Highland Park, IL) shrimp peeler was tested at the MSU Food Processing Laboratories during September 1986. Positive results were found with the peeler, with very little down-time and excellent flexibility, insofar as adjusting for prawn size. Down-time was mostly attributed to the inexperience of the operators and the lack of a complete tail in some of the prawns for the machine to grasp. Generally, the peeler worked at a speed beyond the capability of the operator to keep the peeler supplied.

Conclusions

The results of this study indicate that an average of four deheaders and one operator can keep one peeler working at minimum capacity, producing 80 to 1,000 pounds per hour of peeled prawns, depending on the size.

Table 3.1. Time to dehead by hand 100 prawns of different sizes (categories).

Prawn category	Avg count (prawns/lb)	Total whole wt (lb)	Deheading time (min)	Deheaded wt (lb)	Deheaded yield (%)
Jumbo	6.6	15.1	9.0	6.1	40.6
Large	8.5	11.7 (±0.8)[1]	5.6 (±2.1)	5.6 (±0.8)	48.1
Medium	17.6	5.7 (±0.7)	5.8 (±0.6)	3.0 (±0.2)	52.1
Small	45.5	2.2 (±0.3)	5.6 (±1.0)	1.2 (±0.2)	56.0
BE Female[2]	15.7	6.4 (±0.5)	5.5 (±1.3)	3.4 (±0.1)	53.1

[1]Standard deviations of 100 observations, in parenthesis.
[2]Berried or egg containing females.

Table 3.2. Approximate capacity of a Jonsson Model 35[1] shrimp peeling machine for peeling prawns of different sizes.

Prawn category	Live count range (prawns/lb)	Peeling capacity (lb/hr)	
		5,000 prawns/hr[1]	4,000 prawns/hr[1]
Jumbo	4-7	1,250-710	1,000-570
Large	9-14	620-350	800-280
Medium	15-20	330-250	270-200
Small	36-50	140-100	115-80
BE-Female[2]	15-20	330-250	270-200

[1] From Gregor Jonsson Associates, Inc. 1986. "Model 35 Jonsson Shrimp Peeling Machine for Universal Processing," Highland Park, IL.
[2] Berried or egg-containing females.

Chapter IV

Prediction of Tail and Meat Weight of Freshwater Prawns

J. L. Silva and G. R. Ammerman

Processing yields for freshwater prawns are known to be dependent on the size and sex of the animals (Smith et al., 1980). In tropical areas, freshwater prawns can be selectively harvested because they can be seeded and grown year around. However, in more temperate climates, such as Mississippi, juvenile prawns are stocked only at the beginning of the growing season in May and harvested with the onset of the cool weather in September or early October (D'Abramo et al., 1986, 1988).

This type of highly seasonal single harvest, coupled with a wide range of prawn size within the population requires grading by morphotype and size to achieve maximum marketability. Dillard et al. (1986) studied the acceptability of various sizes of freshwater prawns prepared in different forms and found that the size of prawns affected the type of cooking and the consumer acceptability.

This study provides information on prediction of tail and meat weight of freshwater prawns by size-grade category, from whole and tail weight, respectively.

Materials and Methods

Freshwater prawns harvested during September 1985, were size graded by trained personnel working under the supervision of food technologists in the MAFES Food Processing facilities. Approximately 150 pounds of harvested, chill-killed prawns were divided into five categories: small, medium, large, jumbo, and females with eggs. Whole prawns were weighed individually before and after deheading and shelling. Data are reported in terms of whole, tail, and meat (tail meat, peeled) weight in grams. All animals were manually handled and processed.

Data were analyzed using the REG procedure (SAS, 1985) at the MAFES Experimental Statistics Laboratory. For overall prediction equations, test of homogeneity of equations (Boyle, 1987) was done using analysis of covariance (Johnston, 1972).

Results and Discussion

The categories, by type, are described in terms of size, range, and count in Table 4.1. The prediction equations for tail weight (with shell) from whole prawn weight for each category were significant ($P<0.05$). The coefficient of determination (R^2) was larger than 0.80 in all cases except for the overall prediction equation ($R^2 = 0.598$) (Table 4.2). The regression coefficient (slope) decreased with increased ($P < 0.05$) prawn size, except for the females, which

Table 4.1. Categories of freshwater prawns by size type.

Category (type)	Whole mean weight (g)	Weight range (g)	Mean count (no./lb)	Count range (no./lb)
Small	9.4	5.5-14.6	48	83-31
Medium	29.8	15.0-43.2	15	30-11
Large	54.1	38.4-76.2	8	12-6
Jumbo	81.6	54.5-99.9	6	8-5
Female (w/eggs)	42.1	28.2-62.4	11	16-7

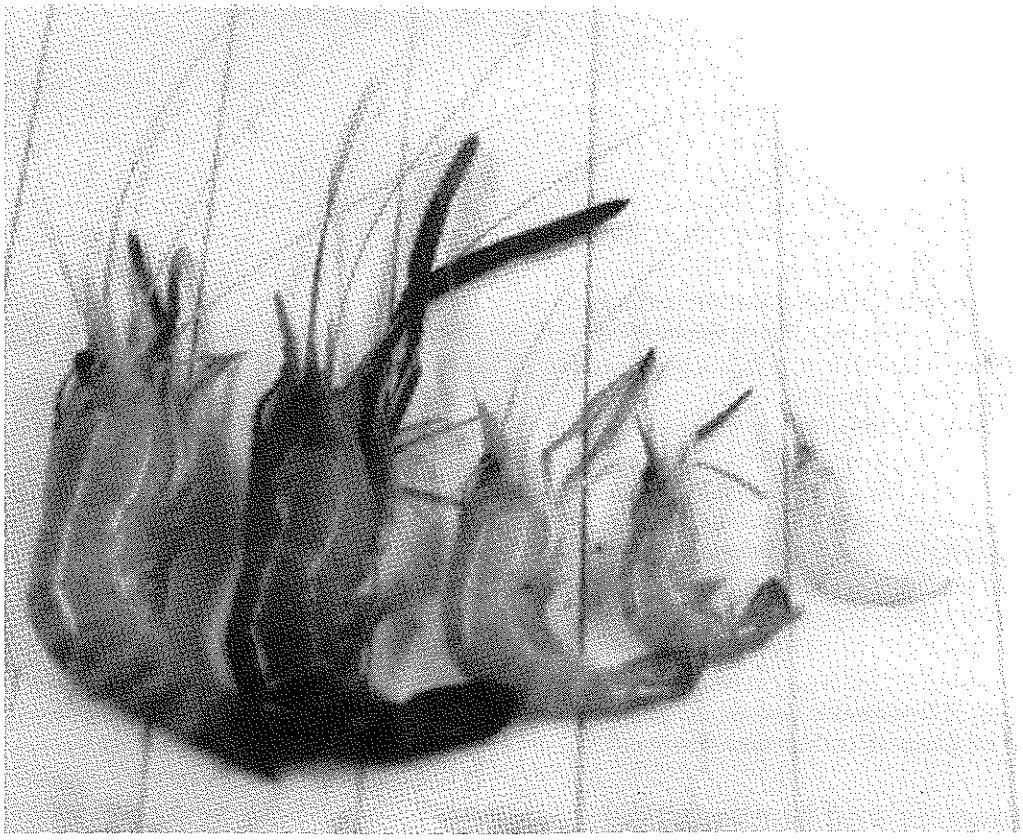
Table 4.2. Tail weight prediction of prawns from wholeweight by category.

Category	Tail weight* prediction (g)	R^2	CV
Small	$0.509X(\pm 0.012)+0.486(\pm 0.114)$	0.979	3.51
Medium	$0.505X(\pm 0.013)+0.633(\pm 0.370)$	0.979	3.70
Large	$0.406X(\pm 0.023)+4.709(\pm 1.262)$	0.882	5.04
Jumbo	$0.394X(\pm 0.030)+4.503(\pm 2.450)$	0.809	5.88
Female (w/eggs)	$0.508X(\pm 0.021)+2.314(\pm 0.891)$	0.935	4.30
Overall	$0.433X(\pm 0.006)+2.800(\pm 0.275)$	0.598	6.12

* Standard error of the estimate in parenthesis.
CV – Coefficient of Variability.
X – Whole weight in grams.

showed a slope equal to the one for the small size prawns. This decrease in slope reflects a relative decrease in tail weight with increased prawn size. This is the result of the disproportionate growth of the head as compared to the body of the prawns. As the animal grows, the head containing the claws becomes heavier resulting in a lower tail to head ratio (Smith et al., 1978). Large dominant males, called 'blue claws,' have relatively heavy claws that contribute to the lower tail (with shell) yield. The high tail yield for the females is a result of the egg mass that they carry underneath the tail. This category of prawns would have to be peeled and the eggs removed before marketing because of the appearance.

Similar results were obtained for prediction of meat weight from tails (Table 4.3). Both small and medium prawns showed similar slopes within category. The slope for females was lower ($P<0.05$) because of the egg mass lost during peeling. This egg mass can be removed manually when hand peeling, or mechanically with no additional effort. The prediction equations for meat weight (grams) from tail weight (grams) for small and medium-size prawns combined ($R^2 = 0.996$) and for females with eggs ($R^2=0.897$) are shown in Table 4.3.



Size categories of freshwater prawns. From left: jumbo (orange and blue claw), large, medium, and small. Not pictured are females with eggs.

A summary of tail (with shell) and meat (tail without shell) yields for five categories of freshwater prawns are shown in Table 4.4. It was shown that the shell accounts for less than 20% of the tail weight and that the egg mass of female prawns accounts for about half of the losses in tail meat for the female prawns. Observations obtained in 1986 (data not reported) showed that meat yield for prawns peeled by a commercial shrimp peeling machine was similar to meat yield for prawns peeled by hand.

Conclusions

Although price of shrimp and of prawns increases with size of the animal, a lower yield of "marketable" meat is obtained. Economic analysis of two production schemes (Clardy et al., 1985) showed that larger revenues per unit weight harvested were obtained with medium-size prawns than with small-size prawns. The yield of prawns is controlled strictly by size and sex, thus, marketable yield will have to be controlled at the production stage (farm) and not at the processing stage.

Table 4.3. Tail meat weight prediction from whole weight of prawns by category.

Category	Meat weight* Prediction (g)	R^2	CV
Small	$0.869X(\pm 0.022) - 0.301(\pm 0.120)$	0.974	4.18
Medium	$0.826X(\pm 0.016) - 0.159(\pm 0.263)$	0.983	2.92
Small & Medium	$0.820X(\pm 0.006) - 0.056(\pm 0.066)$	0.996	3.42
Female	$0.580X(\pm 0.030) + 1.389(\pm 0.727)$	0.897	5.14

* Standard error of the estimate in parenthesis.
CV = Coefficient of Variability.
X = Whole weight in grams.

Table 4.4. Processing yields for freshwater prawns by category.

Category	Tail yield[1] (%)	Meat yield[2] (%)	Meat from tail yield[3] (%)
Small	55.9	45.4	81.1
Medium	52.5	42.9	81.6
Large	48.6	N/A	N/A
Jumbo	44.5	N/A	N/A
Female	56.2	35.8	63.7

[1]Tail (with shell) yield $= \frac{\text{Tail wt.}}{\text{Whole wt.}} \times 100$

[2]Meat (tail without shell) yield $= \frac{\text{Meat wt.}}{\text{Whole wt.}} \times 100$

[3]Meat from tail yield $= \frac{\text{Meat wt.}}{\text{Tail wt.}} \times 100$

N/A = Data not available.

Chapter V

Preservation of Freshwater Prawns Under Refrigerated and Iced Conditions

J. L. Silva, G. R. Ammerman, V. Woodruff, and S. Bradway

Previous studies have shown that whole prawns will keep on ice for up to 10 days (Angel et al., 1981) and that the prawns in the bottom layer of the ice will become mushy more quickly (Angel et al., 1985) but will remain acceptable for up to 9 days compared to 11 days for the prawns in the upper layer.

Other studies have shown a considerable decrease in eating quality in prawns held for more than 3 days under ice-chilled conditions (Nip et al., 1985b). Passey et al. (1983) reported a shelf-life of 8-9 days on whole, chilled prawns packed in a CO_2 atmosphere and kept at 4°C.

Refrigerated Prawns

Materials and Methods

The refrigerated shelf-life of whole freshwater prawns was studied in 1985. Prawns were received at the Food Processing Laboratory at Mississippi State University, washed, and given one of the following treatments: (1) a dip in a 0.3% (w/v) sorbic acid solution at 40°F (4°C) for 20 minutes to inhibit surface microbial buildup; (2) blanching for 3 minutes in

Table 5.1. Odor and color scores[1] for freshwater prawns stored at 35°F.

Attribute and treatment	Days of storage			
	1	4	6	8
Odor				
Control	4.8 a[2]	4.2 b	4.2 b	3.2 c
Blanched	5.0 a	4.2 b	4.4 b	3.8 b
Sorbic Acid	5.0 a	4.2 b	4.2 b	3.2 c
Color				
Control	5.0 a	5.0 a	4.4 b	4.0 b
Blanched	5.0 a	4.8 a	4.8 a	3.8 b
Sorbic Acid	5.0 a	5.0 a	4.4 b	3.8 b

[1] Rated on a scale of 1 to 5 with 5 being "fresh" and 1 being "spoiled."
[2] Means within rows differ ($P<0.05$) as determined by LSD.

Table 5.2. Texture and flavor scores[1] for freshwater prawns stored at 35°F.

Attribute and treatment	Days of Storage		
	2	5	9
Texture			
Control	7.3 a[2]	7.8 a	5.8 b
Blanched	8.1 a	7.9 a	6.3 b
Sorbic Acid	8.3 a	7.9a	7.1 b
Flavor			
Control	8.0 a	7.7 a	7.3 b
Blanched	7.8 a	7.8 a	7.1 b
Sorbic Acid	7.9 a	7.8 a	7.8 b

[1] Rated on a 9-point hedonic scale with 9 being "like extremely" and 1 being "dislike extremely."
[2] Means within rows followed by different letter differ significantly ($P<0.05$) as determined by LSD.

water at 212°F (100°C); and (3) a control treatment. Three replications of each treatment combination for a total of 762 pawns were involved in this study. The prawns were cooled and packed in 2.7-mil polyethylene bags and stored at 35°F (2°C) for the length of the study.

The raw prawns were evaluated visually for color and odor at days 1, 4, 6, and 8. They were subsequently boiled for 8 minutes and the meat evaluated for texture and flavor. The evaluation of the raw prawns was performed by trained panelists using a 5-point rating scale, with 5 being "fresh" and 1 being "spoiled." Boiled prawns were evaluated by trained taste panelists on a 9-point hedonic scale, with 9 being "like extremely" and 1 being "dislike extremely."

Results and Discussion

Results for odor and color scores are shown in Table 5.1. The prawns were very acceptable for color and odor for the first 6 days of storage. By the eighth day of storage, the color and odor scores were 4 or less for all treatments. Overall, the prawns received lower odor scores than color scores. Color of the prawns was acceptable for all treatments at the end of 8 days of storage although black spots, an indication of spoilage, were noticeable, especially in the non-blanched prawns.

Table 5.2 shows texture and flavor scores for the prawns stored at 35°F (2°C). All the samples were very acceptable after 5 days storage. At the ninth day, the control and blanched samples were "soft" and "mushy" in texture and were scored lower in flavor than the sorbic acid samples. The sorbic acid treatment may have inhibited or decreased the growth of spoilage bacteria and thus prevented some of the off-flavors from spoilage bacteria. Although the prawns were, for the most part, acceptable after 8 days in refrigerated storage, the microbial count was not followed in all samples and the overall appearance was not the same as the fresh prawns. Thus, not more than 8 days are recommended for storing prawns in 2.7-mil polyethylene bags at 35°F (2°C).

Iced Prawns

Materials and Methods

The second part of this study evaluated the shelf-life of freshwater prawns stored in ice. Whole prawns were received, washed, and divided into two lots. One lot was subjected to a blanch treatment by boiling at 212°F (100°C) for 3 minutes. Both treatments were replicated three times with a total of 762 prawns used in the study.

The prawns were stored in ice chests and kept in ice as needed for the duration of the study. The prawns were evaluated for odor, texture, and flavor by trained taste panelists using a 9-point hedonic scale. Tex-

Table 5.3. Mean sensory scores[1] on whole freshwater prawns stored in ice.

Attribute and treatment	Days of storage				
	0	5	9	12	16
Odor					
Raw	7.9 a[2]	7.6 ab	7.6 ab	7.7 ab	6.6 b
Blanched	8.1 a	7.8 a	7.6 ab	7.6 ab	6.8 b
Texture					
Raw	7.2 a	7.4 a	6.6 b	6.8 ab	6.8 ab
Blanched	7.5 a	7.5 a	7.1 ab	6.6 b	6.6 b
Flavor					
Raw	7.9 a	7.3 b	7.2 b	7.4 ab	6.5 c
Blanched	8.1 a	7.5 b	7.7 ab	6.8 c	6.2 d

[1] On a 9-point hedonic scale with 9 being "like extremely" and 1 being "dislike extremely."
[2] Means within rows followed by different letter differ significantly ($P<0.05$) as determined by the LSD.

ture was also evaluated by a shear press (FTC, Rockville, MD) using the peak of the shear force curve per 40 grams of sample as an indication of prawn meat firmness.

Results and Discussion

Table 5.3 shows taste panel scores on the whole iced prawns for the 16 days storage. Both treatments yielded prawns that were highly acceptable after 12 days storage in ice as indicated by the odor scores. The prawns developed a "strong" off-odor by the 16th day of storage. Texture scores fluctuated for both treatments. The blanched prawns were highly acceptable in firmness after 9 days of storage but the scores declined thereafter, although they were still acceptable. Flavor of the raw prawns was acceptable after 12 days of storage. By the 16th day of storage, the prawns had scored less acceptable on flavor.

Table 5.4. Shear press values[1] for whole freshwater prawns stored in ice.

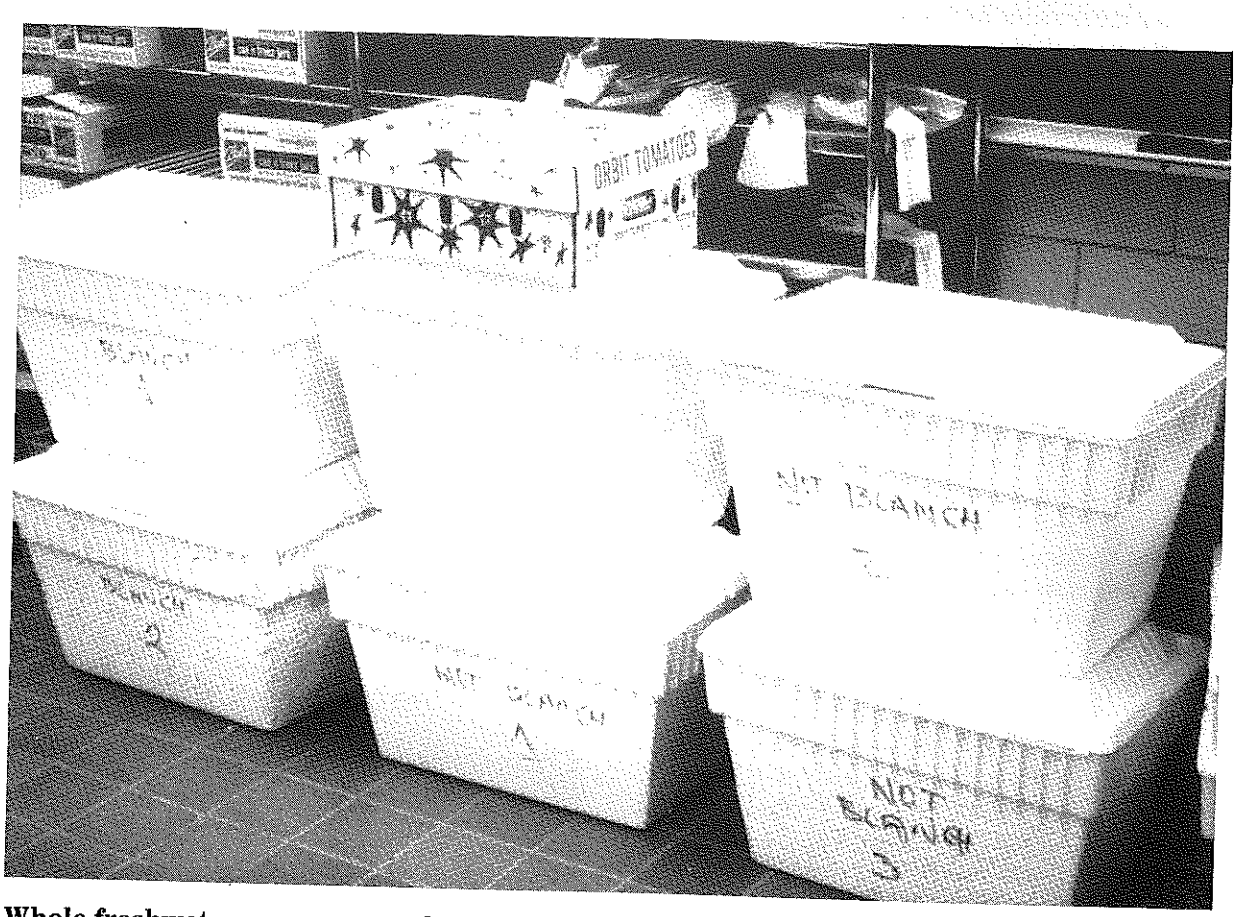
Treatment	Storage Time (days)		
	0	7	14
	Shear force (lb/40g)		
Raw	232 aA[2,3]	228 aA	253 bA
Blanched	292 abB	278 aB	331 bB

[1] Peak values of shear force curves standardized to 40 grams of sample.

[2] Means within rows followed by different lower case letter (ab) differ significantly ($P<0.05$) as determined by LSD.

[3] Means within columns followed by different capital letter (AB) differ significantly ($P<0.05$) as determined by LSD.

The shear press values for the prawns increased ($P<0.05$) with time of storage as shown in Table 5.4. This indicates increased toughness of the prawns with storage time, probably because they lost moisture. This was confirmed by the taste panelists, who indicated that the prawns were "brittle" and "dry" at the 14th day of storage. The blanched prawns had higher ($P<0.05$) shear press values because moisture was lost during blanching, resulting in shrinkage of the meat and some protein coagulation, forming a stronger muscle bond. This data showed that whole freshwater prawns stored in ice remained acceptable to the consumer for a minimum of 12 days.



Whole freshwater prawns were held in ice chests to simulate ice-holding and storing in the market.

Chapter VI

The Effect of Precooking, Packaging, and Storage Temperature on Shelf-Life of Deheaded Freshwater Prawns

J. L. Silva and G. R. Ammerman

The objectives of this study were to determine the organoleptical acceptability; to determine the development of oxidative rancidity and the liberation of free fatty acids as related to precooking, packaging, and storage temperature; and to determine the shelf-life of deheaded freshwater prawns.

Materials and Methods

Materials

Chill-killed freshwater prawns were obtained from the MAFES aquaculture research facilities in 1984. The prawns were kept in ice for up to 6 housr before being packed and frozen.

Experimental design

A 2x2x2x7 factorial design with a single replication was used and the mean squares of high order interactions were used to estimate the residual error (Cochran and Cox, 1957). A total of 1,680 prawns were analyzed. The treatments were: (1) precooking for 3 minutes in boiling water vs. raw or uncooked; (2) storage of glazed prawns in waxed cartons vs. storage in polymylar pouches with vacuum imposed; (3) storage of prawns at –19°C vs. storage at –23°C; and (4) different frozen storage times (0, 2, 4, 6 , 8, 10, 12 months). All the results were analyzed statistically by analysis of variance. The means were separated by Least Significant Differences (LSD) (Steel and Torrie, 1980).

Precooking and control

Whole prawns were washed and divided into two lots. One lot was subjected to a boiling water treatment for 3 minutes and cooled in iced water. The other lot served as an untreated control. Both lots were subsequently deheaded and rewashed.

Packaging

The two lots were each divided into two sub-lots. The packaging treatments consisted of wax-coated, 5-pound shrimp boxes and 1.5-mil polymylar bags under vacuum. Fourteen prawns were placed in each box, a layer of water added, then frozen in a blast freezer to –18°C and top-glazed by spraying chilled water over them.

Another treatment consisted of packaging 14 headless prawns in 1.5-mil polymylar pouches and subjecting them to 700 mm Hg vacuum and sealing by using a Kenfield Vacuum Sealer, Model C14-E (Kenfield Corp., Skokie, IL).

Storage

Half of the sub-lots from each packaging experimental factor were stored at –18°C. The other half were stored at –23°C. The prawns were evaluated every 2 months for one year, with the day after the prawns were frozen considered to be zero time.

Deheaded prawns after being water blanched in a steam-jacketed kettle.

Chemical Analysis

TBA value, free fatty acids and fatty acids profiles were measured. The sampling and analytical procedures were the same as those described in Chapter 2.

Sensory evaluation

Sensory evaluation of the headless prawns was conducted by thawing the prawns overnight at 2°C, cooking them in boiling water for 8 minutes, and cooling to room temperature. Six trained panelists evaluated each sample for odor, appearance, texture, and flavor. A 9-point hedonic scale was used to rank the samples, with 9 being "like extremely" and 1 being "dislike extremely." The overall acceptability was obtained by averaging the four sensory factors from each panelist.

Results and Discussion

Fatty acid profile

There appeared to be no effect on the fatty acid composition of headless frozen prawns due to blanching, packaging or frozen storage temperature (data not shown).

TBA values

Table 6.1 shows the TBA values for headless, frozen prawns stored from 0 to 12 months under various conditions of blanching, packaging, and storage temperatures. The TBA values did not change for the first 10 months of frozen storage but increased significantly after 12 months. This agrees with previous studies (Reddy et al., 1981; Nakayama and Yamamoto, 1977) with frozen prawns and frozen minced fish flesh.

Table 6.1. Effect of storage time, blanching, packaging and storage temperature on TBA values of headless, frozen prawns.

Treatment	TBA value[1]
Storage time (months)	
0	0.42 a[2]
2	0.41 a
4	0.47 a
6	0.43 a
8	0.47 a
10	0.42 a
12	0.53 b
Blanching	
Blanched	0.45 a
Not blanched	0.45 a
Packaging	
Vacuum	0.45 a
Atmospheric	0.45 a
Storage temperature (°C)	
−23°	0.44 a
−18°	0.46 b

[1] mg of malonaldehyde per kg of prawn meat.
[2] Means not followed by same letter differ significantly ($P<0.05$) as determined by LSD.

Table 6.2. Effect of length of storage and temperature of storage on the free fatty acids of headless,frozen prawns.

Treatment	Free Fatty Acids[1]
Storage time (months)	
2	0.10 a[2]
4	0.13 b
8	0.13 b
10	0.14 b
Storage temperature (°C)	
−23°	0.11 a
−18°	0.14 b

[1] Percent oleic acid on a whole sample basis.
[2] Means within treatment not followed by the same letter differ significantly ($P<0.05$) as determined by LSD.

Neither blanching nor packaging under vacuum had any effect on TBA values. The TBA values for headless prawns stored at −23°C were significantly lower than the TBA values for prawns stored at −18°C. However, none of the individual TBA values for frozen prawns analyzed exceeded 0.62.

Sinnhuber and Yu (1958) reported that a TBA value of 3 represented a highly acceptable product for frozen seafoods. Fisher and Ammerman (1983) reported that frozen channel catfish with TBA values as high as 0.79 were very acceptable by taste panelists. Silva and Ammerman (1984) showed that a TBA value of 2 represents a highly acceptable frozen channel catfish.

The range of TBA values in this study agrees well with that reported by Angel et al. (1981). Prawns appear to be stable to oxidative rancidity during frozen storage regardless of blanching, packaging, or frozen storage temperature.

Free fatty acids

The effect of length of storage and temperature at which prawns were stored on the free fatty acid content of headless, frozen prawns is reported in Table 6.2. There were no significant interactions. The free fatty acids increased significantly after 4 months of frozen storage then remained constant through the tenth month. Headless, frozen prawns stored at −23°C for 10 months had a lower free fatty acid content than those stored at −18°C for 10 months. The content of free fatty acids (FFA) after 10 months of frozen storage for headless, frozen prawns was 0.14%. This value is well below the 3.35% FFA reported by Yang and Ammerman (1983) for completely acceptable frozen channel catfish after 12 months of frozen storage. Sanneh and Ammerman (1984) reported that catfish with

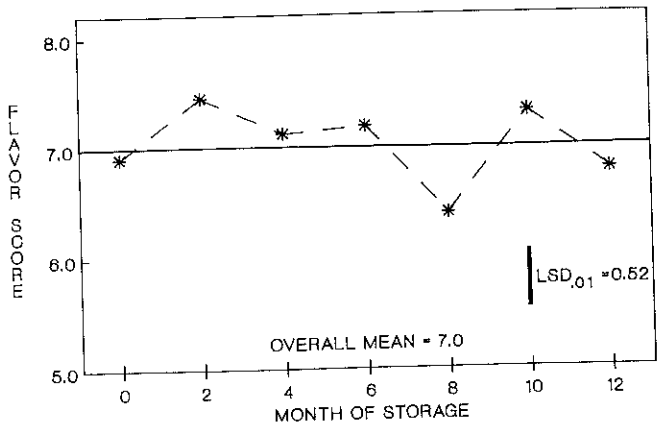


Figure 6.1. Flavor scores for headless, frozen prawns as judged by a taste panel using a 9-point hedonic

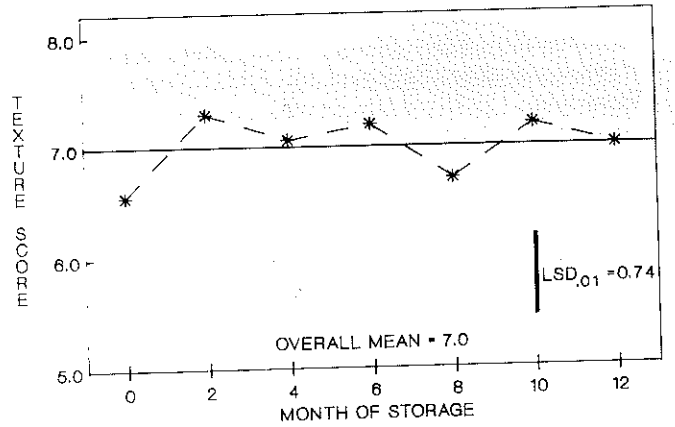


Figure 6.2. Texture scores for headless, frozen prawns as judged by a taste panel using a 9-point hedonic scale.

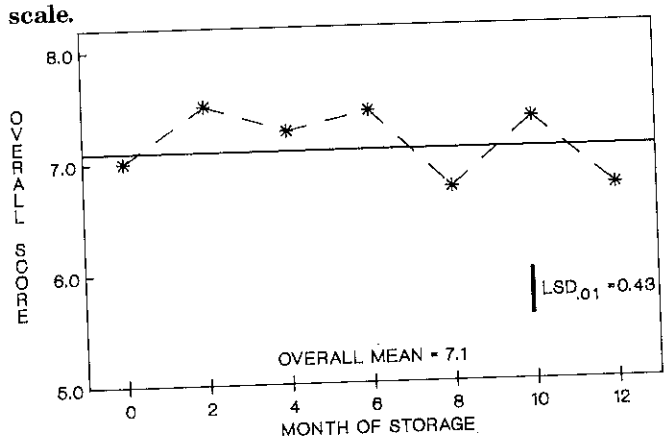


Figure 6.3. Overall acceptability of frozen, headless prawns as judged by a taste panel using a 9-point hedonic scale.

values of 7.13% FFA stored at –18°C after 196 days was acceptable to taste panelists.

Neither blanching nor packaging had any effect on the free fatty acids content of headless, frozen prawns after 10 months of storage.

Sensory evaluation

Figure 6.1 shows the taste panel evaluation for flavor of headless, frozen prawns during 12 months of storage. There was a significant decrease in the flavor score after 8 months of storage, but the prawns were still acceptable. The flavor scores increased after 10 months of frozen storage and then decreased to a score not different from the score of the fresh samples (month 0). This agrees well with Hale and Waters (1981) who showed no significant differences in flavor scores of frozen prawn tails, but only after 9 months storage at –20°C. Texture scores for headless, frozen prawns during 12 months of frozen storage are shown in Figure 6.2. The panelists did not find any differences in the overall texture of prawns after 12 months of frozen storage. An overall mean score of 7.0 on a 9-point hedonic scale indicated a very acceptable product throughout the study. There seemed to be no effect on the texture of the prawns due to blanching, packaging, or frozen storage temperature.

Overall taste panel scores for headless, frozen prawns are shown in Figure 6.3. The overall score remained constant for up to 6 months of frozen storage and then decreased to 6.7 at the eighth month. After 12 months of frozen storage, the overall acceptability score of frozen prawns did not differ from that of fresh prawns.

Conclusions

Headless, prawns, stored between –18 and –23°C remained highly acceptable after 12 months of storage. Although the TBA values and FFA values increased significantly after 12 months of storage, they did not reach a level associated with poor quality.

Precooking for 3 minutes in boiling water as compared to raw prawns did not have any effect in the shelf-life of the headless frozen prawns. Packaging in vacuum bags or glazing in cardboard boxes had no effect on the shelf-life of the prawns.

Chapter VII

Effect of Form of Prawn and Precooking on the Shelf-Life of Freshwater Prawns

J. L. Silva and G. R. Ammerman

Softening of the meat in freshwater prawns is attributed to a proteolytic enzyme system found in the hepatopancreas (Baranowski et al., 1984; Nip et al., 1985a). Nip et al. (1985b) reported the development of mushiness in prawn tail meat upon cooking, especially at the anterior end. The mushiness was the result of the gradual disintegration of the perimysium and endomysium, leading to the separation of the muscle fibers (Nip and Moy, 1988).

There have been contradicting reports on textural changes of whole freshwater prawns, some of which have shown significant changes in texture of prawns after as little as 1 month of frozen storage (Nip and Moy, 1979) and as long as 6 months (Miyazima and Cobb, 1977). Hale and waters (1981) reported early deterioration in texture of whole prawns compared to headless prawns (tails), stored frozen.

This research was to study the changes in frozen stored freshwater prawns as affected by form (whole vs. deheaded) and by precooking (raw vs. precooked).

Materials and Methods

Freshwater prawns raised at the MAFES aquaculture facility were chill-killed (placed in ice water for 10 minutes) and transported in ice to the Food Processing Laboratory. Half of the prawns were deheaded and washed while the other half were washed and kept whole. Half of each one of the two lots (whole and deheaded) were precooked for 3 minutes in water at 100°C (212°F). The prawns were cooled to about 20°C. Prawns from each of the four lots (replicated three times) were placed in 2.2-kg (5-lb) shrimp boxes (20 prawns per box) and frozen in a sharp freezer at –23°C. The prawns were glazed by spraying with cold water (2°C), and were stored frozen at –18°C until needed. Samples were analyzed after 0, 3, 6, 9, and 12 months of frozen storage. A total of 1,908 prawns were used in this study.

At each sampling time, prawns were analyzed for shear force and total energy necessary to shear the muscle. Five prawns were used for each measurement and the results given in units (force and energy) per gram of prawn. The procedure is described in Chapter 8. Moisture, fat, free fatty acids (FFA), and the 2-thiobarbituric acid values (TBA) were measured in duplicate samples and the values averaged. Procedures were the same as described in Chapter 2.

Sensory evaluation of the samples was conducted by eight experienced panelists. The average score of the eight panelists was taken for each of the attributes in each sample. The panelists rated the prawns on odor, appearance, texture, and flavor using a 9-point hedonic scale, with 9 being "like extremely" and 1 being "dislike extremely." The prawns were prepared by boiling for 8 minutes in water without prior thawing and presenting them to the panelists in the form of tails with the shell on. The prawns were served at room temperature (25°C).

Results and Discussion

There were no significant changes in appearance scores or absorbed energy in the prawns as related to form (whole vs. tail), precooking (raw vs. precooked) and frozen storage time (0, 3, 6, 9, 12 months).

Odor, flavor, and texture scores for the prawns were affected by precooking (Table 7.1). The raw stored prawns scored higher ($P < 0.05$) than the precooked stored prawns in all attributes. This might be the result of protein denaturation and tissue hardening upon cooking and freezing.

Table 7.1. Odor, flavor, and texture score means for freshwater prawns as affected by precooking.

	Sensory scores[1]		
Treatment	**Odor**	**Flavor**	**Texture**
Raw	7.3 a	7.0 a	6.8 a
Precooked	7.1 b	6.1 b	6.1 b
LSD (0.05)	0.2	0.4	0.5
CV (%)	5.8	11.1	12.0

[1] Scores are based on a 9-point hedonic scale with 9 being "like extremely" and 5 being "neither like nor dislike."
CV = Coefficient of Variability.

Table 7.3. Effect of form of prawn and time in frozen storage on mean moisture content[1] of freshwater prawns.

Form of prawn	Storage time (months)				
	0	3	6	9	12
	(%)				
Whole	77.2a[2]	76.1a	77.1a	76.0a	76.1a
Tail	77.9a	76.1a	76.4a	75.4b	71.3c
LSD (0.05)		1.8			
CV (%)		1.9			

[1] As percent moisture on a wet basis.
[2] Means within row not followed by the same letter differ significantly ($P<0.05$) as determined by LSD.

Free fatty acids (FFA) and 2-thiobarbituric acid (TBA) values varied with storage (Table 7.2). The FFA values increased and TBA values decreased. However, by the ninth month, the values for FFA decreased but increased for TBA. These values were too small to be considered important as far as fat oxidation is concerned. Odor scores fluctuated with storage time, with the lowest score of 6.8 was considered moderately acceptable on the 9-point hedonic scale.

The moisture content of the headless prawns decreased ($P<0.05$) after 12 months of frozen storage, whereas the moisture of the prawns stored whole did not decrease significantly (Table 7.3). The moisture loss in the tails is attributed to the larger surface area of tissue exposed to the air while in storage. Breakage of the ice layer (glaze) and subsequent dehydration of the tissue also caused moisture loss.

The force necessary to shear and break the prawns as affected by form, precooking, and storage time is shown in Table 7.4. The force required to shear the meat from tails was higher ($P<0.05$) than for meat from whole prawns stored for 6 months or longer. This might have been the result of dehydration and of protein denaturation during freezing since the tails have a muscle area exposed as compared to the whole prawns, which are entirely covered by their shell.

Conclusions

Freshwater prawns stored for up to 12 months at −18°C were highly acceptable to taste panelists, especially if they were not precooked. There was no significant evidence of fat oxidation, but there was some moisture loss from the tails after 12 months of frozen storage. The precooked tails appeared to get tougher after 6 months of frozen storage, possibly due to dehydration.

The data showed that prawns which are handled and frozen properly then stored raw at −18°C may be acceptable for at least one year.

Table 7.2. Mean FFA, TBA values, and odor scores of freshwater prawns during frozen storage.

Storage time (months)	FFA[1]	TBA[2]	Odor scores[3]
0	0.15 a	0.54 a	7.6 a
3	0.09 a	0.41 b	7.2 b
6	0.58 a	0.05 c	6.9 bc
9	0.09 a	0.26 c	7.4 ab
12	0.09 a	0.13 d	6.8 c
LSD (0.05)	0.16	0.05	0.31
CV (%)	96.0	22.9	5.8

[1] As percent oleic acid on a wet sample basis.
[2] As mg malonaldehyde per kg of sample.
[3] Scores are based on a 9-point hedonic scale with 9 being "like extremely" and 1 being "dislike extremely."
CV = Coefficient of Variability.

Table 7.4. Mean shear force values[1] of freshwater prawns as affected by form of prawn, precooking, and frozen storage time.

Storage time (months)	Raw		Precooked	
	Whole	Tail	Whole	Tail
	lb/g			
0	1.66 a	1.84 a	1.50 a	1.97 a
3	1.60 a	1.73 a	1.12 b	1.84 a
6	1.54 c	2.44 b	1.36 c	3.82 a
9	1.82 b	2.00 a	1.42 b	2.27 a
12	1.75 b	1.91 a	1.69 b	2.30 a
LSD (0.05)	0.42			
CV (%)	11.0			

[1] In pounds of force per gram of flesh sample.
[2] Means within storage time not followed by the same letter differ significantly ($P<0.05$) as determined by LSD.

Chapter VIII

Effect of Form, Ice-Holding and Thawing Times on the Texture and Shelf-Life of Freshwater Prawns

J. O. Hearnsberger, P. L. Silva, and J. L. Silva

The texture (softness) of freshwater prawns is the most important quality or acceptability attribute (Angel et al., 1981). Softening is brought about by collagenolytic enzymes found in the hepatopancreas of the animal (Baranowski et al., 1984). Tissue softening is attributed to the action of these enzymes on collagen in the tissue (Nip et al., 1985b).

The objectives of this study were to determine whether the softening of the prawns was caused by the prawn form, by holding prawns in ice prior to freezing, or by thawing time after freezing. Shelf-life and organoleptic acceptability of the prawns were also studied.

Materials and Methods

Chill-killed freshwater prawns from the MAFES aquaculture facilities, ranging from 30 grams to 50 grams in size, were transported in ice to the MSU Food Processing Laboratory. The prawns were held in ice for 0, 24, and 48 hours prior to processing. Half of the prawns from each ice-holding time were deheaded. The prawns were then rewashed, frozen in a sharp freezer at –23°C, packaged in 7-kg boxes lined with 1.5-mil polyethylene bags, and stored at –18°C. Samples were analyzed at 0, 6, and 12 months of frozen storage. Frozen prawns were thawed at 2°C for 0, 24, and 48 hours prior to cooking in boiling water for 8 minutes. The cooked samples were cooled in tap water and analyzed. A total of 2,430 prawns were analyzed.

The cooked samples were analyzed for shear force and total energy using an FTC Texture Test System (Food Technology Corp., Rockville, MD) 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 psi. The force to shear the prawns was recorded as the height of the peak on the texturegram and energy as the integral area of the texturegram as (force x distance traveled) read in the Texture Integrator. Force and energy were recorded as units per gram of sample in the cell. Tissue from three prawns (100 g) was used for each measurement.

Color values were recorded using a Hunter Color/Color Difference Meter (Hunter Associates Laboratory, Reston, VA) standardized by use of a white cell with: L = 92.70 (brightness); a = –0.60 (redness); and b = –0.20 (yellowness). Color was measured on three prawns from each sample placed so that they would have a continuous flat surface exposed to the color sensor. Organoleptic scores on color, firmness, chewiness, flavor and overall acceptability were conducted by a semi-trained panel using a 5-point rating scale with 5 being "excellent" and 1 being "unacceptable" (Larmond, 1977).

This study was split-plot in a completely randomized design with storage times as the whole plot treatment, and with ice holding and thawing times as the subplot treatments. The whole plot treatments were replicated three times. Data were analyzed using the analysis of variance and means were separated using Fisher's protected LSD (Steel and Torrie, 1980).

Results and Discussion

Results shown in Table 8.1 indicate that taste panelists could not detect any differences in color, flavor, and overall acceptability of the boiled freshwater prawns at zero time (fresh) or after 6 months of frozen storage. Taste panel scores indicate that deheaded prawns were firmer than whole prawns when fresh but no differences in firmness were found after 6 or 12 months of frozen storage. However, the taste panelists did find the whole prawns to be brittle as shown by the lower chewiness score after 6 and 12 months of frozen storage.

The force necessary to shear the prawns decreased after 24 hours of holding in ice and remained the same after 48 hours of ice holding for prawns stored for up to 6 months (Table 8.2). This suggests that any enzymatic action on the prawns occurs within the first 24 hours of holding and that thawing time and prawn type have little effect on texture of prawns if they are held less than 6 months in frozen storage.

Table 8.1 Mean organoleptic scores[1] for freshwater prawns as affected by storage time and type of prawn.

Storage time (months)	Type of prawns	Organoleptic scores				
		Color	Firmness	Chewiness	Flavor[NS]	Overall[NS]
0	Whole	4.0 a[2]	3.2 a	4.6 a	4.1	4.1
	Deheaded	4.1 a	4.3 b	4.3 a	4.6	4.2
6	Whole	4.0 a	3.7 a	3.7 a	4.5	3.7
	Deheaded	4.1 a	4.1 a	4.4 b	4.6	4.1
12	Whole	3.6 a	3.3 a	3.4 a	4.5	3.4
	Deheaded	4.3 b	3.9 a	4.3 b	4.3	4.0

[1] Scores were based on a 5-point rating scale with 5 being "excellent" and 1 being "unacceptable."
NS No significant differences.
[2] Means within column, within times differ significantly ($P < 0.05$) as determined by LSD.

Table 8.2. Mean shear force (peak height) for freshwater prawns as affected by frozen storage time and ice-holding time.

Storage time (months)	Ice time (hours)	Shear force (N/g)
0	0	57 a*
	24	46 b
	48	44 b
6	0	43 a
	24	32 b
	48	35 b

* Means within storage time not followed by the same letter differ significantly ($P<0.05$) as determined by LSD.

Table 8.3. Mean shear force (peak height) for freshwater prawns as affected by frozen storage time and thawing time.

Storage time (months)	Thawing time (hours)	Shear force (N/g)
0	0	50 a*
	24	49 a
	48	49 a
6	0	42 a
	24	36 b
	48	31 c

* Means within each storage time not followed by the same letter differ significantly ($P<0.05$) as determined by LSD.

Results on shear force values for prawns stored frozen for 6 months as affected by thawing time are shown in Table 8.3. Shear Force required to break prawn meat remained constant with no storage. However, the force necessary to shear the prawn meat decreased after 24 hours of thawing and again after 48 hours of thawing time after 6 months of frozen storage. This may be the result of higher enzyme activity due to tissue disruption in freezing of the prawns which will cause more breakdown of the collagen or prawn tissue.

After 12 months of frozen storage, the shear force values for tissue from stored whole prawns was less than the force from prawn tails, if kept in ice for 24 hours or less (Table 8.4). Holding in ice for 48 hours did not affect the shear force of the whole prawns but lowered the shear force of the tails.

Table 8.4. Mean shear force on freshwater prawns stored at –18°C for 12 months as affected by type of prawn for different ice-holding times.

Prawn type	Ice-holding time		
	0 hr	24 hr	48 hr
	Shear force (N/g)		
Whole	39 a*	26 a	36 a
Deheaded	41 b	54 b	33 a

* Means within row not followed by the same letter differ significantly ($P<0.05$) as determined by LSD.

Conclusions

The texture measurements showed no difference in shear between whole and deheaded prawns stored frozen for up to 6 months. Texture of the prawns deteriorated within the first 24 hours of ice holding and was influenced by thawing time when the prawns were stored for 6 months. After 12 months of frozen storage, whole prawns appeared to be softer than deheaded (tail) prawns regardless of thawing time and for any prawn held in ice for 24 hours or less.

References

Angel, S., D. Basker, J. Kanner, and B. J. Juven. 1981. Assessment of shelf-life of freshwater prawns stored at 0°C. J. Food Tech. 16:357.

Angel, S., F. G. Weinbert, B. J. Juna, and P. Lindner. 1985. Quality changes in the freshwater prawn, *Macrobrachium rosenbergii)* during storage on ice. J.Food Tech. 20:553.

AOCS. 1981. Official and Tentative Methods of the American Oil Chemists' Society. AOCS, Champaign, IL.

AOAC. 1980. Official Methods of Analysis of the Association of Official Analytical Chemists. Association of Analytical Chemists, Washington, DC.

Baranowski, E. S., W. K. Nip, and J. H. Moy. 1984. Partial characterization of a crude enzyme extract from the freshwater prawn, *Macrobrachium rosenbergii.* J. Food Sci. 49:1494.

Bauer, L. L., P. A. Sandifer, T. I. Smith, and W. E. Jenkins. 1983. Economic feasibility of prawn *Macrobrachium rosenbergii* production in South Carolina, USA. Aquacultural Engineering 2:181.

Boyle, C. R. 1987. Testing the homogeneity of equations. Dept. of Experimental Statistics, Mississippi State University.

Chanmugam, P., J. Donovan, C. J. Wheeler, and D. H. Hwang. 1983. Differences in the lipid composition of freshwater prawn (*Macrobrachium rosenbergii)* and marine shrimp. J. Food Sci. 48:1440.

Clardy, G. N., J. J. Fuller, and J. E. Waldrop. 1985. Preliminary economic evaluation of freshwater shrimp production in Mississippi. Agric. Econ. Research Report 159. MAFES, Mississippi StateUniversity.

Cobb, B. F. III, C. Vanderzant, and K. Hyder. 1974. Effect of ice storage upon the free amino acid contents of tails of white shrimp (*Penaeus setiferus*). J. Agric. Food Chem.22:1052.

Cochran, W. G and G. M. Cox. 1957. "Experimental Designs." 2nd ed. John Wiley, New York, NY.

D'Abramo, L. R., A. J. Fuller, J. S. Collins, J. M. Heinen, M. J. Murphy, H. R. Robinette, J. E. Waldrop, and D. W. Whitten. 1986. Pond Culture of Freshwater Shrimp 1985. MAFES Info. Bull. 94. Mississippi State University.

D'Abramo, L. R., A. J. Fuller, J. S. Collins, J. M. Heinen, M. J. Murphy, H. R. Robinette, J. E. Waldrop, and D. W. Whitten. 1988. Pond Culture of Freshwater Shrimp 1986. MAFES Info. Bull. 119. Mississippi State University.

Dillard, J. G., M. J. Fuller, and D. W. Whitten. 1986. Consumer acceptance of freshwater shrimp in Mississippi restaurants. Agric. Econ. Research Report 170. Mississippi State University.

Fisher, A. J., and G. R. Ammerman. 1983. Stocking rates and catfish shelf-life. 12th Annual Processors Workshop, p. 48. Mississippi Cooperative Extension Service, Mississippi State University.

Hale, M. B., and M. E. Waters. 1981. Frozen storage stability of whole and headless freshwater prawns, *Macrobrachium rosenbergii.* Marine Fisheries Review 43(12):18.

Hearnsberger, J. O. 1987. Private communication. Mississippi State University.

Hoover, W. L., J. R. Melton, and P. Howard. 1971. Determination of iodine in foods and plants by ion selective electron analysis. J. of AOAC. 54:760.

Johnston, J. 1972. "Econometric Methods." 2nd ed. McGraw-Hill, New York, NY.

Larmond, E. 1977. Laboratory Methods for Sensory Evaluation of Food. Pub. 1637, Canada Dept. of Agric., Ottawa, Canada.

Leigeber, E. G. 1987. Effects of cooking and frozen storage on cholesterol levels of freshwater prawn (*Macrobrachium rosenbergii).* M.S. Thesis, Mississippi State University.

Liao, D. S., and T. I. Smith. 1983. Economic analysis of small-scale prawn farming in South Carolina. Journal of the World Mariculture Society, 13.

Liao, D. S., T. I. Smith, and P. A. Sandifer. 1982. Economic, market, and technical considerations for prawn farming in South Carolina. *In*: Proceedings Tropical and Subtropical Fish. Technol. Conf., New Orleans, LA, Jan. 11-14, 1982.

Matthews, M. B. 1975. Connective Tissue, Macromolecular Structure and Evolution. p. 15. Spring-Verlag, New York.

Miyajima, L. S., and B. S. Cobb. 1977. Preliminary observations on the frozen storage stability of the

freshwater prawn, *Macrobrachium rosenbergii*. Proc. 2nd Annual Trop. Subtrop. Fish. Technol. Conf. p.253-261. Texas A & M Univ. Publ. TAMU-SG-78-101.

Nakayama, T., and M. Yamamoto. 1977. Physical, chemical, sensory evaluation of frozen stored deboned (minced) fish flesh. J. Food Sci. 42:900.

Nip, W. K., and J. H. Moy. 1979. Effect of freezing methods on the quality of the prawn, *Macrobrachium rosenbergii*. Proc. World Maricult. Soc. 10:761.

Nip, W. K., and J. H. Moy. 1988. Microstructural changes of ice-chilled and cooked freshwater prawn, *Macrobrachium rosenbergii*. J. Food Sci. 53:319.

Nip, W. K., H. M. K. Zeidan, and J. H. Moy. 1981. Amino acid profile of insoluble collagen isolated from freshwater prawn, *Macrobrachium rosenbergii*. J. Food Sci. 46:1633.

Nip, W. K., C. Y. Lan, and J. H. Moy. 1985a. Partial characterization of a collagenolytic enzyme fraction from the helato-pancreas of the freshwater prawn, *Macrobrachium rosenbergii*. J. Food Sci. 50:1187.

Nip, W. K., J. H. Moy, and Y. Y. Tzang. 1985b. Effect of purging on quality changes of ice-chilled freshwater prawn, *Macrobrachium rosenbergii*. J. Food Technol. 20:9.

Passy, N., C. H. Mannheim, and D. Cohen. 1983. Effect of modified atmosphere and pretreatments on quality of chilled freshwater prawns (*Macrobrachium rosenbergii*). Lebensmittel-Wissenschaft and Technologia 16:4. *In* FSTA Abst. 16(5):5R316. 1984.

Reddy, S. K., W. K. Nip, and C. S. Tang. 1981. Changes in fatty acids and sensory quality of freshwater prawn (*Macrobrachium rosenbergii*) stored under frozen conditions. J. Food Sci. 46:353.

Sanneh, A., and G. R. Ammerman. 1984. Prediction of odor and flavor values by measurement of 2-thiobarbituric acid and free fatty acids in channel catfish. 13th Annual Catfish Processors Workshop. p. 27. Mississippi Cooperative Extension Service, Mississippi State University.

SAS. 1985. SAS "User's Guide: Statistics." SAS Institute. Cary, NC.

Shils, M. E., and V. R. Young. 1988. "Modern Nutrition in Health and Disease." 7th ed. Lea and Febiger, Philadelphia, PA.

Sidwell, V. D., P. R. Foncannon, N. S. Moore, and J. C. Bonnet. 1974. Composition of the edible portion of raw (fresh or frozen) crustaceans, finfish and mollusks. I. Protein, fat, moisture, ash, carbohydrate, energy value, and cholesterol. Marine Fish. Review 36:21.

Silva, J. L., and G. R. Ammerman. 1984. Effect of size of channel catfish (*Ictalurus punctatus*) on its storage stability and on its quality attributes. 13th Annual Catfish Processors Workshop. p. 18. Mississippi Cooperative Extension Service, Mississippi State University.

Silva-Pacheco, J. L. 1986. Yield, composition, lipid stability and organoleptic acceptance of farm-raised channel catfish (*Ictalurus punctatus*) as affected by fish size and time in frozen storage. Ph.D. dissertation. Mississippi State University.

Sinnhuber, R. O., and T. C. Yu. 1958. 2-thiobarbituric acid method for the measurement of rancidity in fishery products. 2. Quantitative determination of malonaldehyde. Food Technol. 12:9.

Smith, T. I. J., P. A. Sandifer, and M. H. Smith. 1978. Population structure of Malasyan prawns, *Macrobrachium rosenbergii* (de Man), reared in earthen ponds in South Carolina 1974-1976. Proc. World Maric. Soc. 9:21.

Smith, T. I., W. Waltz, and P. A. Sandifer. 1980. Processing yields for Malasyan prawns and the implications. Proc. World Maric. Soc. 11:557.

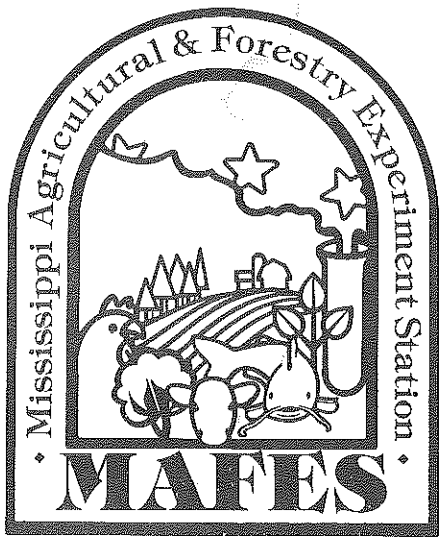
Steel, R. G. D., and J. H. Torrie. 1980. "Principles and Procedures of Statistics – A Biometrical Approach." 2nd ed. McGraw-Hill, New York.

Tarladgis, B. G., B. M. Watts, M. T. Younathan, and L. Dugan, Jr. 1960. A distillation method for the quantitative determination of malonaldehyde in rancid foods. J. Am. Oil Chem. Soc. 37:44.

USDA. 1963. USDA, Handbook No. 8: Composition of Foods. USDA, Washington, DC.

Wellborn, T. L. 1985. Production of freshwater shrimp. Mimeo, Mississippi Cooperative Extension Service, Mississippi State University.

Yang, K. T., and G. R. Ammerman. 1983. The effects of rations, packaging, and storage time on the yield, composition, and stability of farm-raised channel catfish. 12th Annual Catfish Processors Workshop. p. 39. Mississippi Cooperative Extension Service, Mississippi State University.



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