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ABSTRACT

The quality and nutrition of frozen breaded shrimp available to the consuming public have been a recent concern of breaded shrimp manufacturing companies, state and federal regulatory agencies, retail merchants, and consumers themselves. The current study monitored a single lot of 8-ounce breaded fantail shrimp held in a large warehouse freezer, an upright retail, and a horizontal retail freezer over a thirteen month period. Monthly samples were collected for percent moisture, percent protein, percent ash, percent breading, ammonium, trimethylamine, riboflavin, thiamine, aerobic plate count, MPN total coliforms, MPN *E. coli*, and MPN coagulase positive staphylococci determinations. Concurrently, a 7-member panel evaluated the products for textural and flavor characteristics.

The results of the study indicate that significant organoleptic deterioration can be detected as early as three to four months after production when shrimp are stored in a retail freezer. Net weight and percent moisture changes support the contention. As the age of the product increases, shorter storage times at the retail level will precipitate measureable organoleptic and chemical deterioration within the product. Storage at the wholesale level below -20°C proved to be an effective method to maintain the quality of frozen shrimp for at least thirteen months of storage.

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INTRODUCTION

The quality and nutrition of frozen breaded shrimp available to the consuming public have been a recent concern of breaded shrimp manufacturing companies, state and federal regulatory agencies, retail merchants, and consumers themselves. Breaded shrimp manufacturers were convinced that they were producing a safe, nutritious, and appetizing product for public consumption. Periodic consumer complaints and regulatory actions led the processors to believe that the consuming public was not necessarily purchasing the same quality product that left their manufacturing facilities. Two previous papers, Rao, et al. (1975) and Williams, et al. (1981), addressed the problems encountered with moisture migration within breaded shrimp that caused the shrimp to lose moisture to the surrounding breading. The decreased weight of shrimp coupled with an increased breading weight caused the product to fall below the United States Food and Drug Administration Standard of Identity for frozen breaded shrimp specifying a minimum shrimp content of 50% (FDA, 1976). Additional questions have been raised regarding the nutritional and hedonic quality of breaded shrimp in the market place. Again, breaded shrimp manufacturers believed that they were producing fine products, but that handling abuses at the retail level were depriving consumers of expected quality on some occasions. The following study was initiated to illuminate those problems.

METHODS

The project was designed to determine chemical, microbiological, and organoleptic changes in frozen breaded shrimp as it moved through the wholesale-retail distribution system. A large Georgia seafood processor provided a single lot of 8-ounce frozen breaded fantail shrimp produced and blast frozen in Brownsville, Texas on July 6, 1982. The lot was moved to a wholesale freezer in Glynn County, Georgia, on July 11, 1982. Initial and replacement product was supplied from the freezer to two retail merchants operating in Brunswick, Georgia. The first market stored and displayed the product for retail sale in a vertical or upright closed door freezer case, Warren/Sherer model HRL-5U. The second cooperating market displayed and stored the frozen shrimp in a horizontal or coffin freezer open to the air, Hill model EZ 6KF. The product was loaded into the upright freezer on July 29, 1982, and into the coffin freezer on August 10, 1982. Additional product was supplied to each retail store when requested by the managers (Figure 1). In all cases, the product was delivered following completion of each month's sampling program. Product age and storage time in the warehouse freezer were documented. Although product age was known, exact residence times for individual shrimp packages in the retail cases could not be determined.

Coffin Freezer	Upright Freezer
	29 July 1982
10 August 1982	25 August 1982
19 October 1982	
	12 November 1982
14 December 1982	
2 March 1983	23 March 1983
27 April 1983	27 April 1983
6 July 1983	6 July 1983

Table 1. Product delivery dates to the retail freezers.

Ryan battery-powered thermographs were used to continuously monitor temperatures at each storage location. A model K-45 recorder was installed in the warehouse freezer while a model K-10 thermograph was installed in each retail display case.

Five eight-ounce packages were collected monthly at random from each storage area for chemical, microbiological, and organoleptic analyses. Samples from each location were composited for all determinations. The product sample of green headless shrimp collected before the Brownsville, Texas, production run was completed in July 1982. Frozen breaded shrimp collected from the wholesale freezer were first analyzed in July 1982. Initial retail samples of breaded shrimp from each display case were taken in August 1982. Monthly samples of frozen breaded shrimp from each storage location were collected through July 1983. The retail establishment providing the coffin freezer discontinued sales of seafood at the beginning of August 1983. Final breaded shrimp samples were collected from the upright freezer and the wholesale freezer in August 1983.

The following chemical analyses, except for percent breading, were completed in duplicate for the initial green headless shrimp samples and monthly on breaded shrimp collected from each location:

(1) Percent moisture (Horowitz, 1980)
(2) Percent Kjeldahl Protein (Horowitz, 1980)
(3) Percent Ash (Horowitz, 1980)
(4) Percent Breading (Horowitz, 1980)
(5) Ammonium, specific ion electrode (Ward et al., 1978)
(6) Trimethylamine, specific ion electrode (Chang et al., 1976)

Bioassay vitamin analyses were completed for the same series of samples:

(1) Riboflavin (Difco, 1977) (Horowitz, 1980)
(2) Thiamine (Difco, 1977) (Horowitz, 1980)

Microbiological levels were determined for all green headless and frozen breaded shrimp samples:

(1) Aerobic Plate Count (FDA, 1978)
(2) MPN Total Coliforms and E. coli (FDA, 1978)
(3) MPN Coagulase Positive Staphylococci (FDA, 1978)

Marine Extension Service staff members were presented with samples of freshly frozen commercial breaded shrimp, commercial breaded shrimp held for approximately one year under poor storage conditions, and breaded shrimp purchased from retail stores representing five different manufacturers. Over a two-month period, the group developed modified flavor and textural profiles to characterize the breaded shrimp samples. Duplicate samples were presented to each panel member utilizing a single blind experimental design. A continous sensory scale of 0-5 was used to

describe each flavor or textural characteristic. A score of zero indicated lack of detection by a panel member for a given trait while a score of five indicated the strongest impression for that trait (Cardello, 1981) (Civille and Szczesniak, 1973) (Civille, and Liska, 1975). The following textural characteristics were defined:

(1) Hardness: The perceived force required to compress the sample using the molar teeth.
(2) Chewiness: The total perceived effort required to prepare the sample to a state ready for swallowing.
(3) Fibrousness: The perceived degree (number x size) of fibers evident during mastication.
(4) Oily Mouth Coating: The perceived degree of oil and/or water left on the teeth, tongue, and pallet after swallowing.
(5) Moistness: The perceived degree of oil and/or water in the sample during chewing.

The following flavor characteristics were defined:

(1) Overall Shrimp Intensity: The perceived degree of shrimp flavor exhibited by the sample.
(2) Sweet: The perceived degree of sweetness associated with the sample.
(3) Nutty buttery: The aromatics associated with the rich full flavor of chopped nuts such as pecans and warm melted butter.
(4) Old Seafood: The aromatics associated with cooked seafood that is getting "off" but is still acceptable.
(5) Freezer burn: The taste associated with a stale refrigerator or freezer that has been used to store food.
(6) Rancid Taste: The after-taste common to country ham.

A taste panel consisting of seven trained members was selected to evaluate frozen breaded shrimp samples, fried for 3 minutes at 177°C in peanut oil, for textural and flavor characteristics. Panel members were presented with a control sample of breaded shrimp at each meeting in addition to the three experimental samples. The control sample was the latest code date breaded fantail shrimp produced by a local seafood processor. Samples were presented in duplicate utilizing a single blind experimental design.

RESULTS

A. Temperature

The warehouse freezer exhibited a maximum daily temperature variation of 2 - 3°C, the smallest deviation of any freezer studied (Figure 1). Temperatures reached -20°C or less on 70% of the monitored days and were below -7°C on all occasions. The maximum recorded temperature of -10°C

occurred in August 1982 following a freezer malfunction. The minimum temperature of -24°C occurred during December 1982 and January 1983. No consistent defrost cycle was noted.

A maximum daily temperature variation of 34°C occurred for the coffin freezer in February 1983 (Figure 2). Daily temperature variation was approximately 12°C with a 6 - 8 hour defrost cycle. The freezer's daily minimum temperature reached -20°C on one percent of the monitored days and -7°C on 99% of the days. The freezer exceeded 0°C on 5% of the monitored days and reached a maximum temperature of 17°C following malfunctions in November 1982 and January 1983. The lowest temperature of -20°C was achieved in February and March 1983.

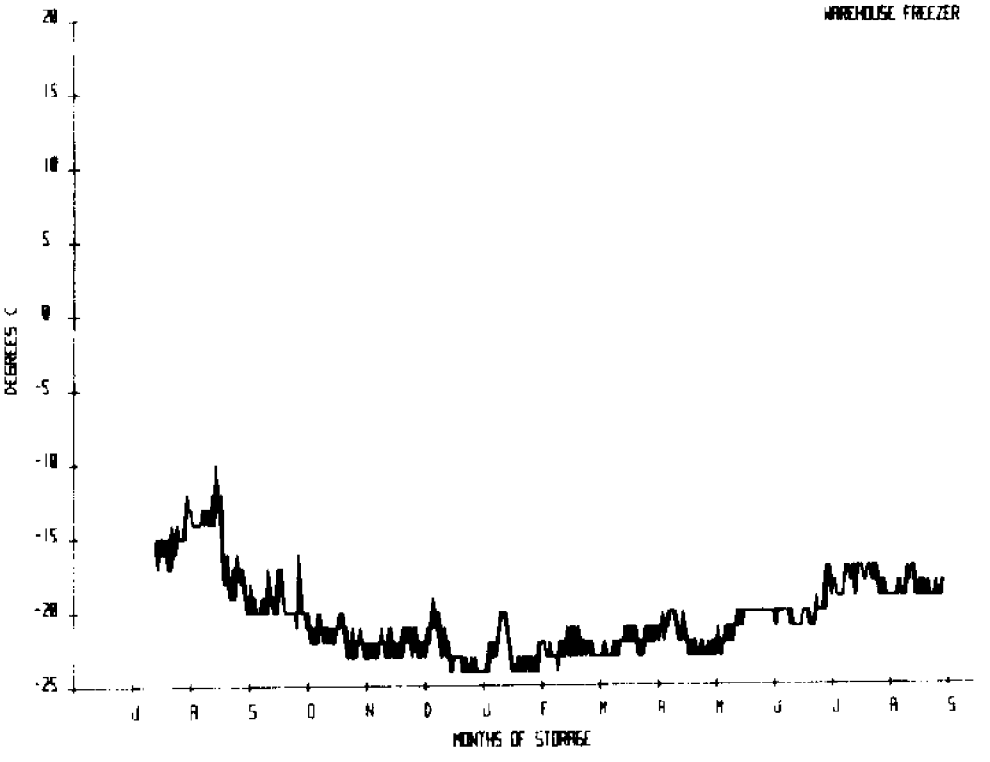

Figure 1. Daily maximum and minimum storage temperatures for the warehouse freezer.

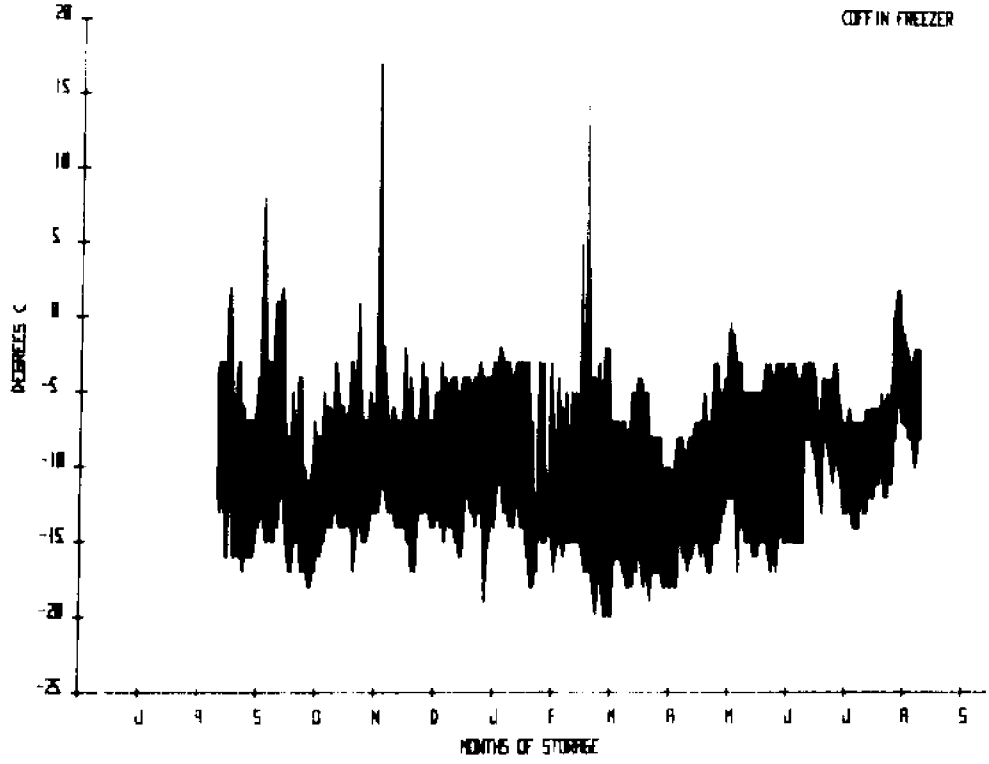

Figure 2. Daily maximum and minimum storage temperatures for the coffin freezer.

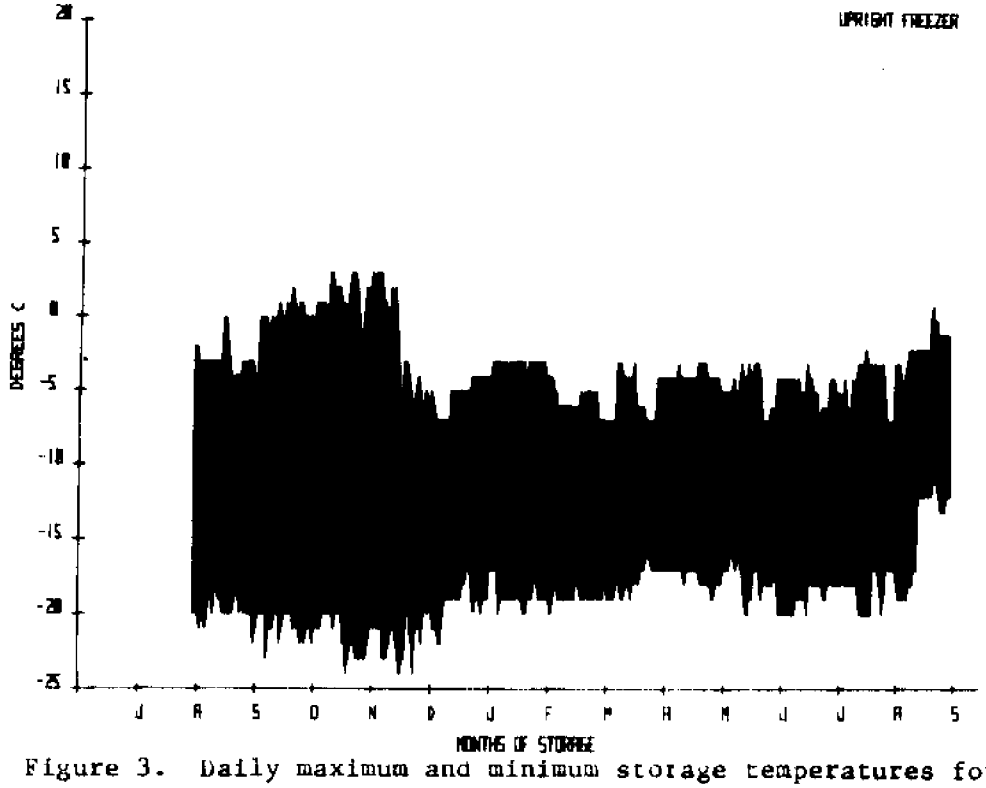

Figure 3. Daily maximum and minimum storage temperatures for the upright freezer.

The upright freezer had a maximum daily temperature variation of 25°C in October 1982 (Figure 3). A 6 - 12 hour defrost cycle with a 14 - 18°C temperature variation was observed for the freezer. Daily product temperatures reached -20°C on 36% of the monitored days, and -7°C on all occasions. The freezer exceeded 0°C on 18% of the monitored days, reached a maximum temperature of 3°C in October 1982 and a minimum temperature of -24°C in both October and November 1982.

The minimum daily freezer temperatures observed for the warehouse freezer were consistently less than those measured for the upright freezer. The mean minimum daily coffin freezer temperatures were consistently greater than those of the warehouse or upright freezer (Figure 4). The maximum daily temperatures of the coffin freezer were greater than those of the upright freezer, which in turn were greater than the warehouse freezer temperatures (Figure 5).

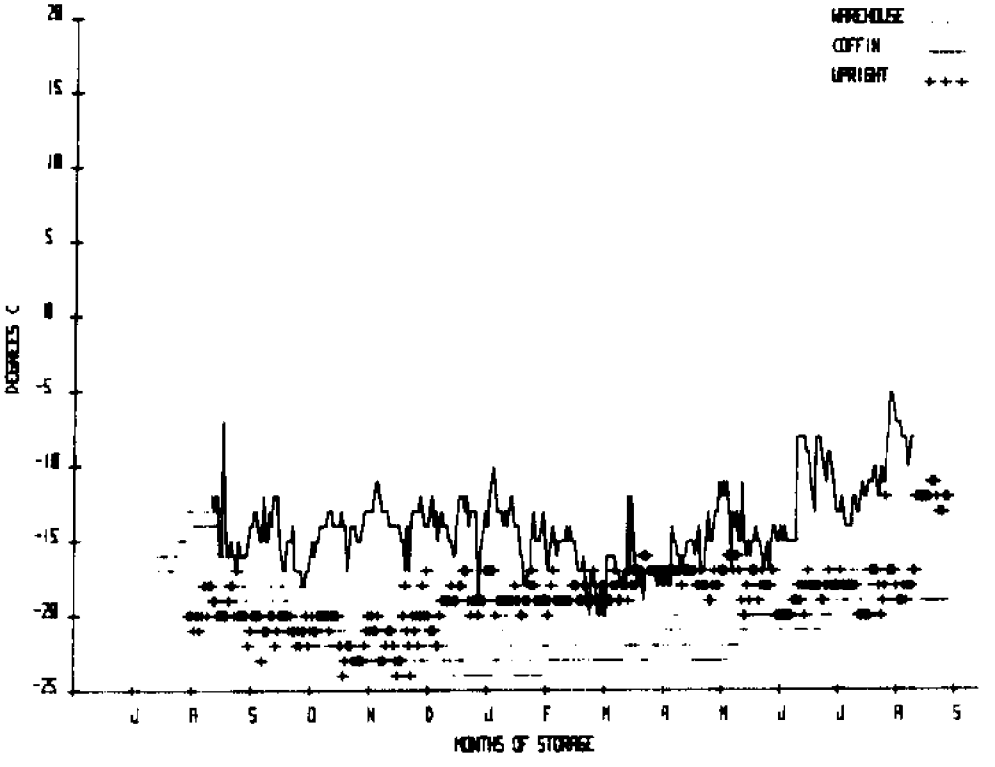

Figure 4. The minimum daily temperatures for the warehouse, coffin, and upright freezers.

Percent Moisture	74.78
Percent Protein	18.48
Percent Ash	4.39
Ammonium, mg/100g	18.00
TMA, mg/100g	7.98

Table 2. Mean chemical analyses of green headless shrimp used to produce the control lot of frozen breaded shrimp.

Thiamine, mg/100g	0.050
Riboflavin, mg/100g	0.003

Table 3. Mean vitamin content of green headless shrimp used to produce the control lot of frozen breaded shrimp.

Aerobic Plate Count Organisms/g	2.40×10^5
MPN Total Coliforms Organisms/g	240
MPN *E. coli* Organism/g	<2
MPN Coagulase Pos. Staph. Organisms/g	<3

Table 4. Mean microbiological levels of green headless shrimp used to produce the control lot for frozen breaded shrimp.

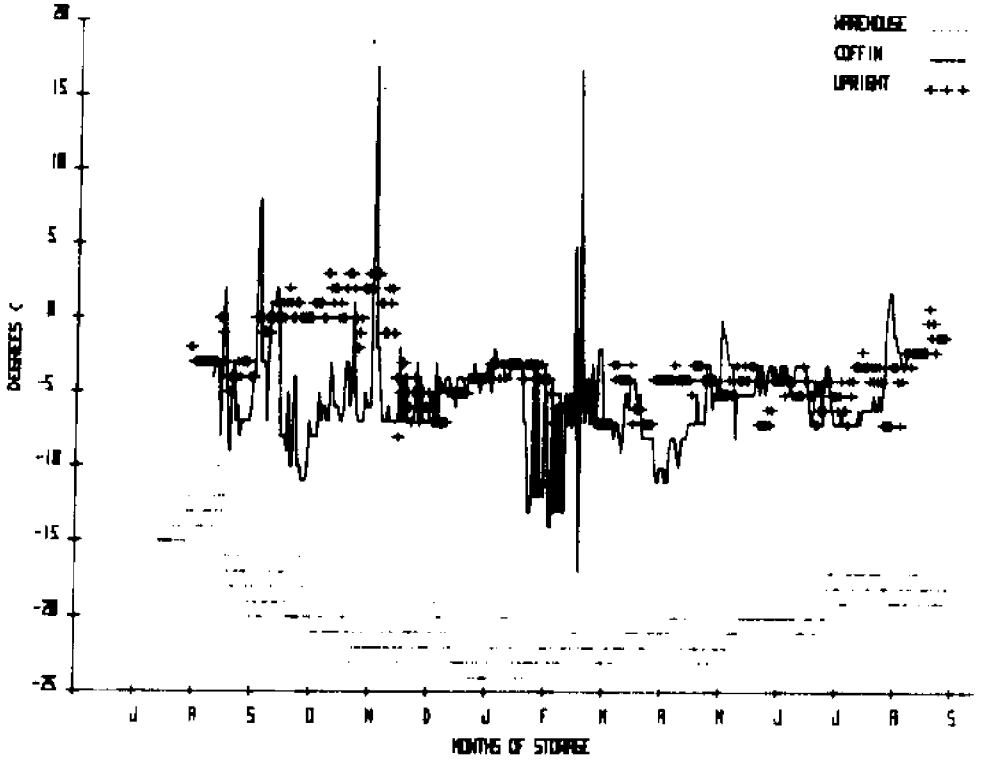

Figure 5. The maximum daily temperatures for the warehouse, coffin, and upright freezers.

B. Analyses

Table 1 presents the dates that frozen breaded shrimp were delivered from the warehouse freezer to the retail upright and coffin freezers.

Tables 2-4 present the chemical, vitamin, and microbiological analyses of the frozen green headless shrimp used to produce the control lot of breaded shrimp at the Brownsville facility. Figures 6-33 detail the results of monthly chemical, microbiological, and organoleptic analyses of the frozen breaded shrimp stored in each of the freezers.

All chemical, microbiological, and organoleptic data sets containing duplicate or greater than two values for each dependent variable were analyzed statistically with the Statistical Analyses System (SAS) (Ray, 1982). The methods included General Linear Regression Model (GLM), utilizing an analysis of variance procedure to compare monthly data for each dependent variable at each storage location. Dependent variable means were compared for significant differences at the 0.05 level using Tukey's studentized range test (HSD) (Ray, 1982). Pooled standard errors were calculated for Tukey's studentized range test.

$$PSE = \sqrt{\text{error mean square/number of observations}}$$

In the remainder of the paper, a significant difference between means refers to Tukey's studentized range test with $p < 0.05$. Means, numbers of samples, and standard errors of the mean are presented for all variables analyzed by SAS in the appendix (Tables 32 - 52).

C. Net Weights

The inital mean net weight of shrimp stored in the wholesale freezer (July 1982) was 238.76g. The net weights began to decline in May 1983 (234.89g), reached a minimum of 225.3g in July, and returned to 228.47g for the final August sample. The average net weight of shrimp stored in the coffin retail freezer was less than the net weight of shrimp stored in the upright or wholesale freezers on all sampling dates except for the initial August 1982 determination (Figure 6). Weights ranged from a maximum of 234.58g (August 1982) to a minimum of 206.68g (July 1983). Shrimp stored in the vertical freezer showed a marked increase from the initial average net weight of 235.65g to 259.59g and 275.3bg, respectively in October and November 1982, (Figure 6). Large ice crystals observed in packages of shrimp collected during the two-month period were responsible for the increased net weights. No additional patterns were noted in the data until June 1983. The mean net weight of 239.88g marked the beginning of a rapid weight decline which reached a minimum value of 219.2bg in August 1983.

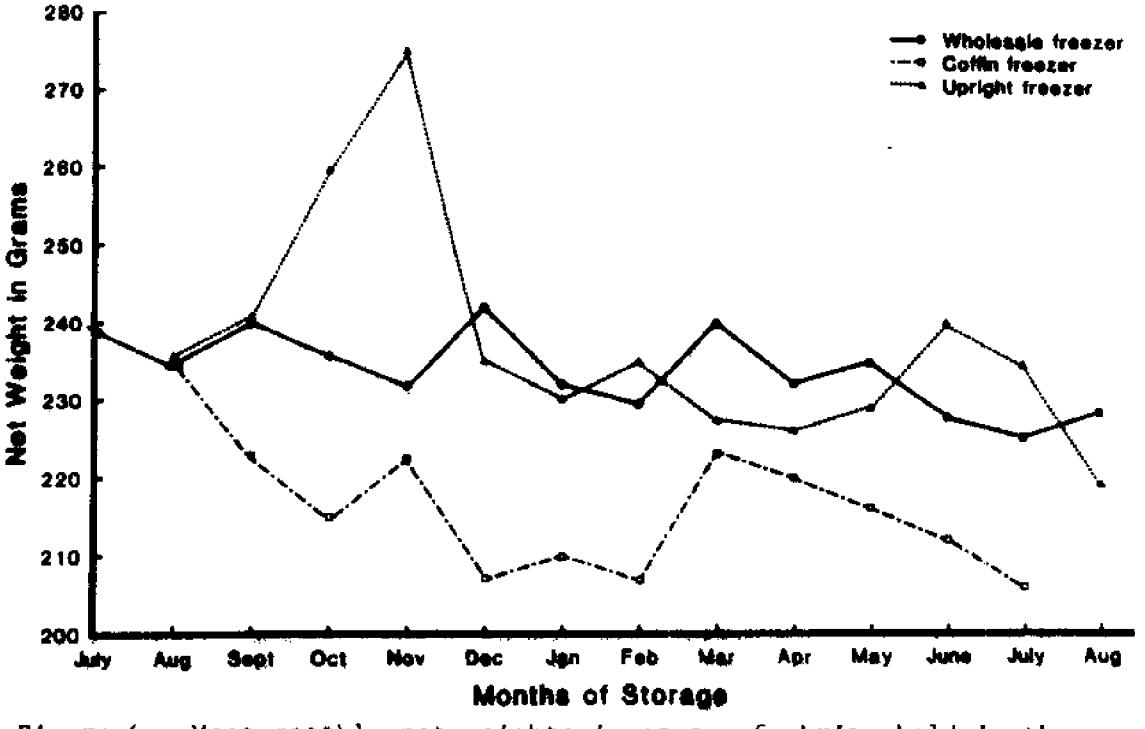

Figure 6. Mean monthly net weights in grams of shrimp held in the warehouse, coffin, and upright freezers.

Table 5 lists significant differences among net weight means by month at the 0.05 level using Tukey's studentized range test. Beginning in September 1982 (two months storage), the mean net weights of shrimp stored in the retail coffin freezer were significantly less than the warehouse and/or the upright freezer in all months but March and May 1983 (eight and ten months storage). The net weights of shrimp stored in the upright freezer during October and November 1982 (three and four months storage) were greater than those found in the other two freezers. The increased net weights coincided with the formation of large ice crystals on the product, wide temperature fluctuations in the coffin freezer, and maximum temperatures exceeding 0°C (Figure 3). The only significant differences in net weights between the warehouse and upright freezers occurred in October and November 1982.

D. Moisture

Moisture content (Figure 7) of the wholesale shrimp underwent no consistent pattern of change, with an initial mean of 58.96% (July 1982) and a final mean of 58.93% (August 1983). The initial moisture content of shrimp in the coffin freezer, 58.43% (August 1982), was reduced to 52.47% by August 1983 with a minimum value of 50.64% in May 1983. The moisture contents of all horizontal freezer samples paralleled the net weight data and were less than the values determined for the other samples except for March 1983. The March sample, stored in the vertical freezer (53.89%), contained less moisture than the sample stored in the coffin freezer (54.87%). The abrupt rise in assayed moisture noted for October (63.06%) and November (64.81%) 1982 samples was consistent with earlier net weight data and the observed accumulation of ice crystals on packaged shrimp. Final moisture levels were reduced from 59.63% to 56.44%.

Table 6 lists significant differences among percent moisture means by month at the 0.05 level using Tukey's studentized range test. The percent moisture content of shrimp stored in the coffin freezer was significantly less than the levels detected in the product from the other freezers except in July 1982 (initial month) and April 1983 (nine months storage), when no significant differences were observed. Paralleling the net weight data, the percent moisture content of the shrimp stored in the upright freezer during October and November 1982 (three and four months storage) was significantly greater than the moisture content found in the warehouse and coffin freezers. The moisture content of the warehouse freezer was significantly greater than the moisture content of the upright freezer for six of the last nine months of the study. No significant differences were determined for the April sample (nine months storage), which followed stocking of the upright freezer with packages from the warehouse freezer in March 1983. Only freshly stocked material was available for sampling.

Net Weight Grams

Month	Mean	Freezer
July 82	--	--
Aug 82	No significant difference PSE = 2.38	
Sept 82	A 240.63 A 240.17 B 222.08 PSE = 2.47	Upright Warehouse Coffin
Oct 82	A 259.59 B 235.58 C 215.16 PSE = 2.62	Upright Warehouse Coffin
Nov 82	A 275.36 B 231.74 B 222.55 PSE = 6.05	Upright Warehouse Coffin
Dec 82	A 241.96 A 235.10 B 207.06 PSE = 1.97	Warehouse Upright Coffin
Jan 83	A 232.09 BA 230.30 B 209.67 PSE = 3.22	Warehouse Upright Coffin
Feb 83	A 235.10 A 229.49 B 206.71 PSE = 2.77	Upright Warehouse Coffin
March 83	No significant difference PSE = 3.42	
April 83	A 232.35 BA 226.33 B 220.03 PSE = 1.56	Warehouse Upright Coffin
May 83	No significant difference PSE = 3.83	
June 83	A 239.88 BA 227.96 B 211.85 PSE = 3.83	Upright Warehouse Coffin
July 83	A 234.58 BA 225.37 B 206.68 PSE = 3.56	Upright Warehouse Coffin
Aug 83	No significant difference PSE = 2.50	

Table 5. Mean net weights significantly different at the 0.05 level and pooled standard error (PSE), Tukey's studentized range test. Means with the same letter are not significantly different.

Percent Moisture

Month	Mean	Freezer	Month	Mean	Freezer
July 82	--	--	Feb 83	A 59.76	Warehouse
				A 58.68	Upright
Aug 82	A 60.55	Warehouse		B 50.70	Coffin
	B 59.63	Upright		PSE = 0.073	
	C 58.43	Coffin			
	PSE = 0.028		March 83	A 57.94	Warehouse
				B 54.86	Coffin
Sept 82	A 59.22	Warehouse		B 53.89	Upright
	A 59.10	Upright		PSE = 0.088	
	B 55.64	Coffin			
	PSE = 0.024		April 83	No significant difference	
Oct 82	A 63.06	Upright		PSE = 0.398	
	B 58.40	Warehouse			
	C 53.35	Coffin	May 83	A 58.92	Warehouse
	PSE = 0.048			B 57.84	Upright
				C 50.64	Coffin
Nov 82	A 64.30	Upright		PSE = 0.055	
	B 57.50	Warehouse			
	B 56.21	Coffin	June 83	A 59.49	Warehouse
	PSE = 0.095			B 55.62	Upright
				C 52.65	Coffin
Dec 82	A 59.57	Warehouse		PSE = 0.087	
	B 58.70	Upright			
	C 54.95	Coffin	July 83	A 58.74	Upright
	PSE = 0.026			A 57.58	Warehouse
				B 52.47	Coffin
Jan 83	A 59.09	Warehouse		PSE = 0.085	
	B 57.22	Upright			
	C 54.54	Coffin	Aug 83	A 58.92	Warehouse
	PSE = 0.056			B 56.44	Upright
				PSE = 0.044	

Table 6. Mean percent moistures significantly different at the 0.05 level and pooled standard error (PSE), Tukey's studentized range test. Means with the same letter are not significantly different.

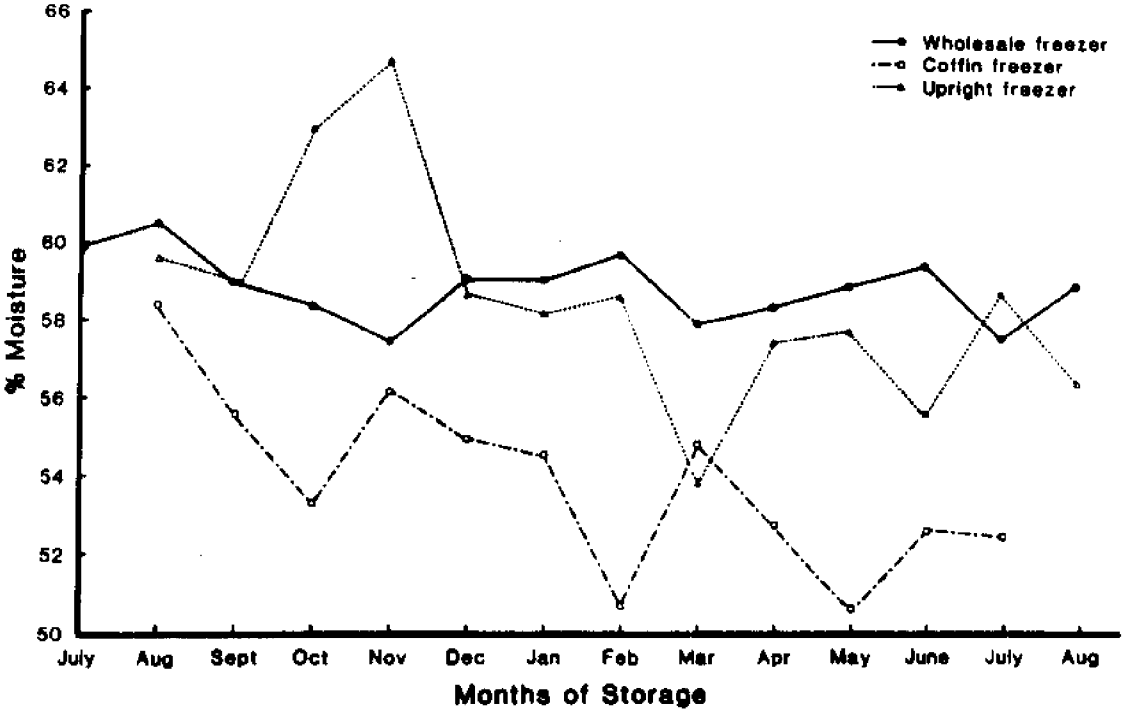

Figure 7. Mean monthly percent moisture content of breaded shrimp stored in the warehouse, coffin, and upright freezers.

E. Ammonium

The determined levels of ammonium (Figure 8) for all three storage conditions were greater at the end of the study than at the beginning. The wholesale freezer shrimp increased from 5.60 mg/100g to 8.75 mg/100g, the horizontal retail freezer shrimp increased from 13.5 mg/100g to 15.6 mg/100g, and the vertical retail freezer shrimp increased from 10.4 mg/100g to 13.2 mg/100g. The ammonium levels of the shrimp stored in the coffin freezer exceeded those of the warehouse samples from October 1982 through the end of the study. The determined ammonium levels also exceeded those found for the vertical freezer samples from October 1982 through the end of the study, except for the May 1983 sample. Coffin ammonium levels peaked in January 1982 (20.5 mg/100g) and in June 1983 (22.0 mg/100g). The ammonium levels were greater for shrimp in the upright freezer than for those in the wholesale freezer from December 1982 through August 1983 except for February 1983, with maximum levels of 18.50 mg/100g (May 1983) and 15.85 mg/100g (June 1983). Moisture-free/ash-free ammonium levels (Figure 9) followed the same pattern.

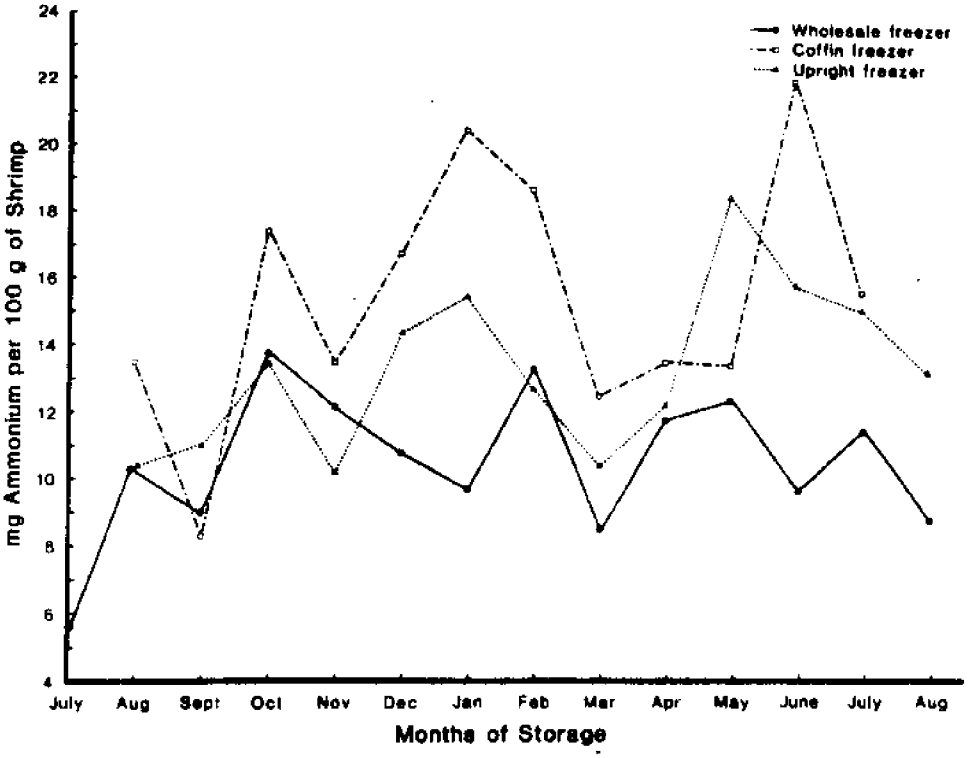

Figure 8. Mean monthly ammonium levels in breaded shrimp stored in the warehouse, coffin, and upright freezers.

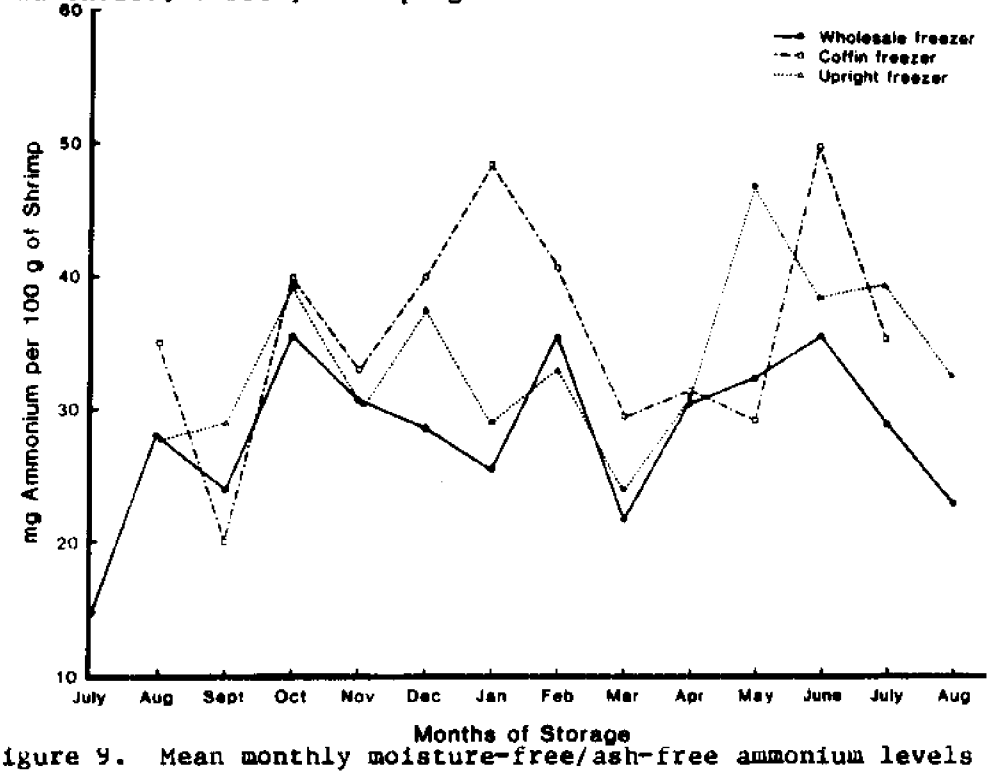

Figure 9. Mean monthly moisture-free/ash-free ammonium levels in breaded shrimp stored in the warehouse, coffin, and upright freezers.

Tables 7 and 8 list significant differences among means by months at the 0.05 level for ammonium (mg/100g shrimp) and moisture-free/ash-free ammonium (mg/100g shrimp) concentrations, respectively, determined by Tukey's studentized range test. Significant differences among the means on a wet basis determined for October 1983 (three months storage), November 1982 (four months storage), and February 1983 (seven months storage) were not indicated on a moisture-free/ash-free basis. The warehouse freezer samples had ammonium concentrations that were significantly less than those of the coffin or upright freezer beginning in December 1982 (five months storage) and continuing through the end of the study, except for April and June 1983 (nine and twelve months storage), which showed no significant differences.

F. Percent Shrimp

The initial percent shrimp determined for the wholesale freezer samples of 46.24% on July 12 was 5.26% less than the 51.50% shrimp determined on July 6 in Brownsville, Texas, during the product production run (Figure 10). Percent shrimp determined for the wholesale samples was consistently greater than the retail samples beginning in June 1983 and continuing to the end of the study. The lowest percent shrimp values of 42.29% and 41.27% in October and November 1982 were reported for shrimp stored in the upright freezer when the samples also exhibited maximum moisture contents. Percent shrimp levels were not statistically analyzed by the SAS procedures.

G. Protein

On a wet weight basis, protein levels of shrimp stored in the coffin freezer exceeded all other tested shrimp except for the January and March 1983 samples (Figure 11). However, on a moisture-free/ash-free basis, no apparent pattern was ascertained (Figure 12). The final moisture-free/ash-free levels were slightly higher at the end of the study than at the beginning. Wholesale mean levels increased from 28.25% - 30.02%, coffin freezer levels from 28.27% - 29.36%, and upright freezer levels from 29.36% - 30.88%.

Tables 9 and 10 list significant differences among means by month at the 0.05 level for percent protein and percent moisture-free/ash-free protein, respectively, determined by Tukey's studentized range test. On a wet basis, the coffin freezer samples had significantly higher protein contents than the warehouse or upright freezers in September 1982, November 1982, May 1983, June 1983, and July 1983. However, when protein levels are corrected for moisture content, no consistent pattern emerges, and all months except September 1982 and February 1983 showed no signficant differences in moisture-free/ash-free protein.

Ammonium
mg/100g

Month	Mean	Freezer
July 82	--	--
Aug 82	No significant difference PSE = 0.420	
Sept 82	A 11.00	Upright
	BA 9.00	Warehouse
	B 8.30	Coffin
	PSE = 0.153	
Oct 82	A 17.45	Coffin
	B 13.75	Warehouse
	B 13.50	Upright
	PSE = 0.203	
Nov 82	A 13.50	Coffin
	BA 12.15	Warehouse
	B 10.25	Upright
	PSE = 0.122	
Dec 82	A 16.75	Coffin
	A 14.40	Upright
	B 10.75	Warehouse
	PSE = 0.187	
Jan 83	A 20.50	Coffin
	A 15.50	Upright
	B 9.70	Warehouse
	PSE = 0.334	
Feb 83	A 18.75	Coffin
	B 13.25	Warehouse
	B 12.65	Upright
	PSE = 0.287	
March 83	A 12.50	Coffin
	BA 10.40	Upright
	B 8.50	Warehouse
	PSE = 0.196	
April 83	No significant difference PSE = 0.129	
May 83	A 18.50	Upright
	B 13.45	Coffin
	B 12.35	Warehouse
	PSE = 0.238	
June 83	A 22.00	Coffin
	B 15.85	Upright
	C 9.65	Warehouse
	PSE = 0.224	
July 83	No significant difference PSE = 0.318	
Aug 83	A 13.20	Upright
	B 8.75	Warehouse
	PSE = 0.079	

Table 7. Mean ammonium levels, mg/100g shrimp, significantly different at the 0.05 level and pooled standard error (PSE), Tukey's studentized range test. Means with the same letter are not significantly different.

Moisture-Free/Ash-Free Ammonium
mg/100g

Month	Mean	Freezer
July 82	--	--
Aug 82	No significant difference PSE = 0.937	
Sept 82	A 28.94	Upright
	BA 23.90	Warehouse
	B 20.12	Coffin
	PSE = 0.630	
Oct 82	No significant difference PSE = 0.872	
Nov 82	No significant difference PSE = 0.495	
Dec 82	A 39.90	Coffin
	B 37.56	Upright
	B 28.58	Warehouse
	PSE = 0.777	
Jan 83	A 48.60	Coffin
	BA 39.10	Upright
	B 25.54	Warehouse
	PSE = 1.32	
Feb 83	No significant difference PSE = 1.13	
March 83	A 29.48	Coffin
	BA 24.18	Upright
	B 21.72	Warehouse
	PSE = 0.738	
April 83	No significant difference PSE = 0.490	
May 83	A 47.13	Upright
	B 32.30	Warehouse
	B 29.24	Coffin
	PSE = 0.946	
June 83	A 50.00	Coffin
	B 38.49	Upright
	C 25.60	Warehouse
	PSE = 0.809	
July 83	No significant difference PSE = 1.26	
Aug 83	A 32.75	Upright
	B 23.00	Warehouse
	PSE = 0.330	

Table 8. Mean moisture-free/ash-free ammonium levels, mg/100g shrimp, significantly different at the 0.05 level and pooled standard error (PSE), Tukey's studentized range test. Means with same letter are not significantly different.

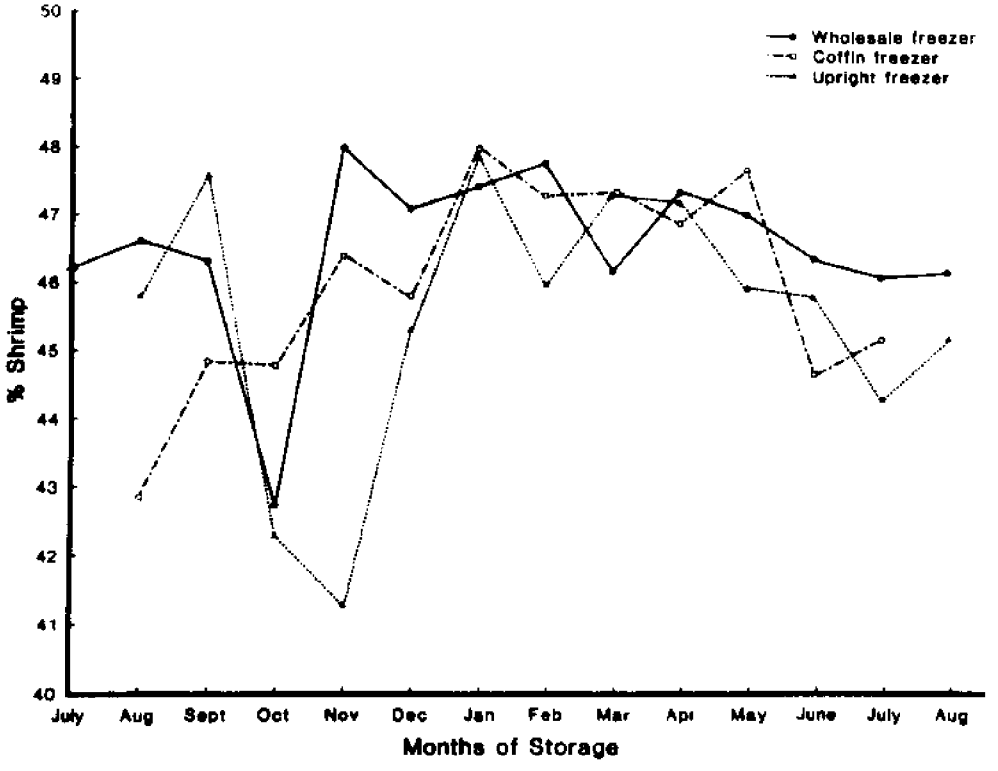

Figure 10. Monthly percent shrimp for the warehouse, coffin, and upright freezers.

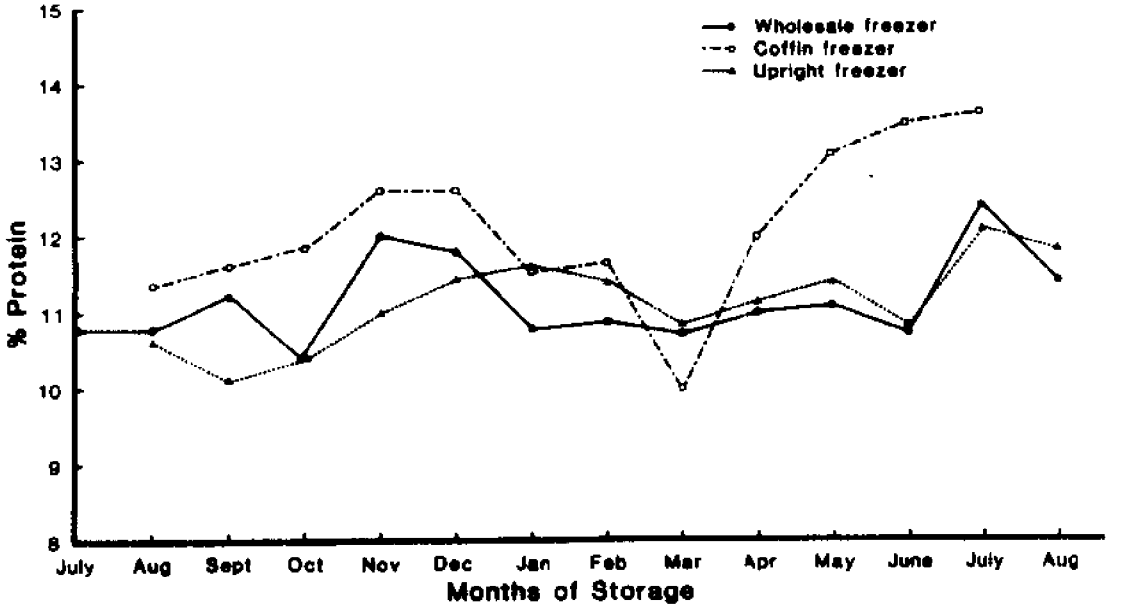

Figure 11. Mean monthly percent protein levels in the warehouse, coffin, and upright freezers.

Percent Protein

Month	Mean	Freezer
July 82	--	--
Aug 82	No significant difference PSE = 0.087	
Sept 82	A 11.62 BA 11.22 B 10.12 PSE = 0.071	Coffin Warehouse Upright
Oct 82	No significant difference PSE = 0.098	
Nov 82	A 12.60 BA 12.04 B 10.99 PSE = 0.085	Coffin Warehouse Upright
Dec 82	No significant difference PSE = 0.075	
Jan 83	No significant difference PSE = 0.075	
Feb 83	No significant difference PSE = 0.071	
March 83	No significant difference PSE = 0.182	
April 83	No significant difference PSE = 0.146	
May 83	A 13.10 B 11.40 B 11.09 PSE = 0.078	Coffin Upright Warehouse
June 83	A 13.52 B 10.84 B 10.72 PSE = 0.106	Coffin Upright Warehouse
July 83	A 13.64 B 12.42 B 12.09 PSE = 0.062	Coffin Warehouse Upright
Aug 83	No significant difference PSE = 0.225	

Table 9. Mean percent protein levels significantly different at the 0.05 level and pooled standard error (PSE), Tukey's studentized range test. Means with the same letter are not significantly different.

Percent Moisture-Free/Ash-Free Protein

Month	Mean	Freezer
July 82	--	--
Aug 82	No significant difference PSE = 0.366	
Sept 82	A 29.70 A 28.17 B 26.18 PSE = 0.164	Warehouse Coffin Upright
Oct 82	No significant difference PSE = 0.406	
Nov 82	No significant difference PSE = 0.391	
Dec 82	No significant difference PSE = 0.297	
Jan 83	No significant difference PSE = 0.299	
Feb 83	A 29.70 A 29.12 B 25.34 PSE = 0.285	Upright Warehouse Coffin
March 83	No significant difference PSE = 0.711	
April 83	No significant difference PSE = 0.557	
May 83	No significant difference PSE = 0.279	
June 83	No significant difference PSE = 0.392	
July 83	No significant difference PSE = 0.252	
Aug 83	No significant difference PSE = 0.909	

Table 10. Mean percent moisture-free/ash-free protein levels significantly different at the 0.05 level and pooled standard error (PSE), Tukey's studentized range test. Means with the same letter are not significantly different.

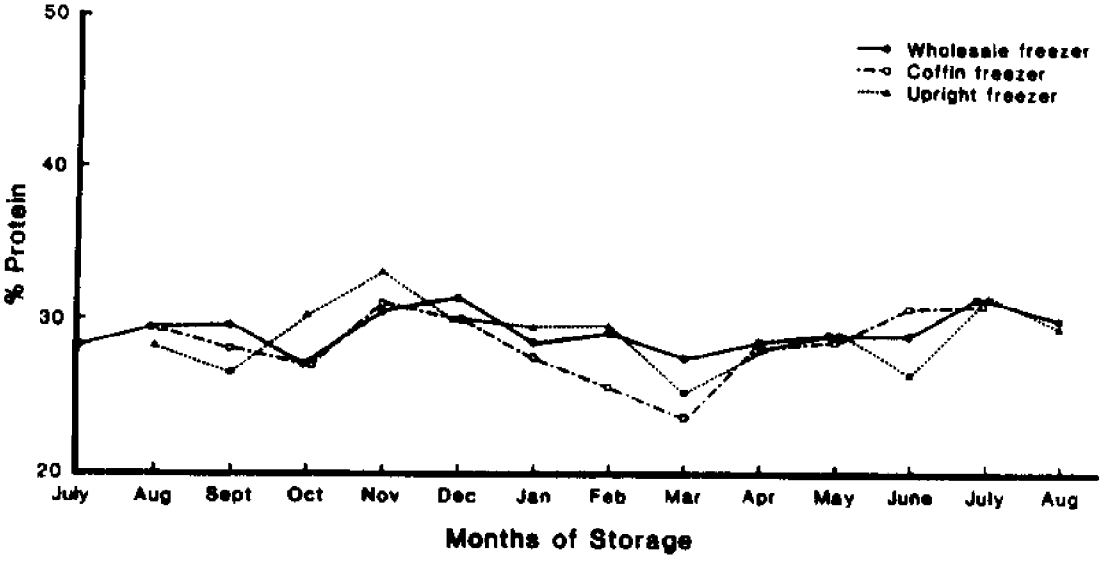

Figure 12. Mean monthly moisture-free/ash-free percent protein levels in the warehouse, coffin, and upright freezers.

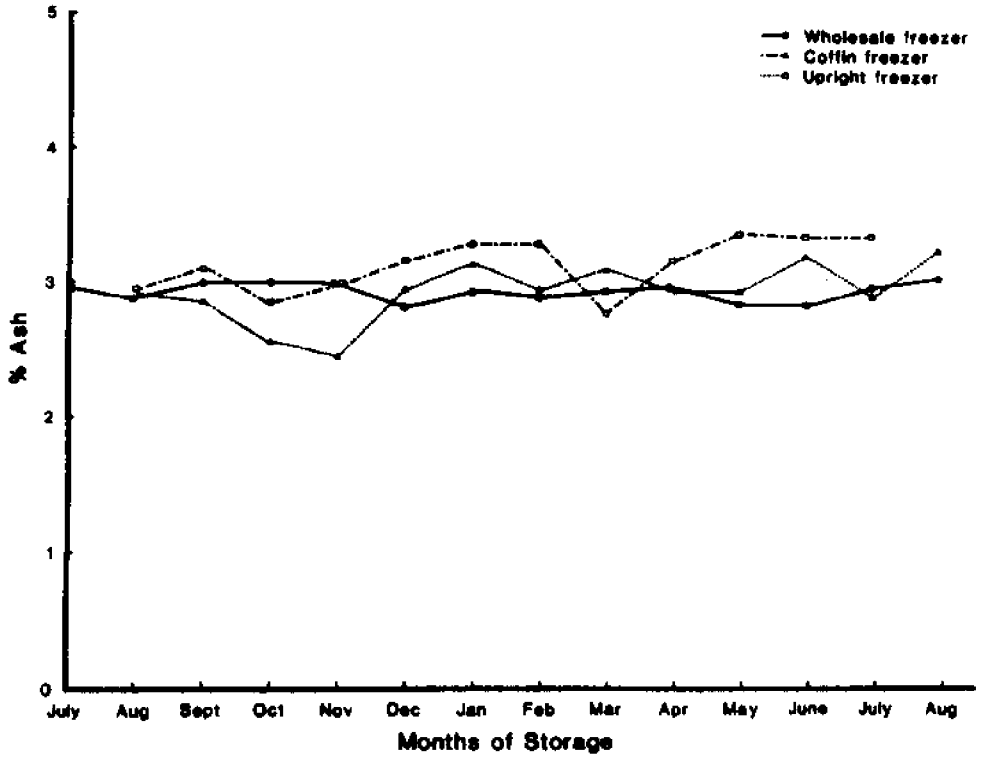

Figure 13. Mean monthly percent ash levels for the warehouse, coffin, and upright freezers.

H. Ash

Percent ash levels exhibited no persistent pattern with time in any storage area (Figure 13). Mean significant differences in percent ash concentrations by month, determined by Tukey's studentized range test, are presented in Table 11. The coffin freezer samples have significantly greater ash contents than the warehouse or upright freezer samples from November 1982 through July 1983, with the exception of March 1983, which shows no significant differences. The data reflect the lower moisture content of the coffin freezer samples. No consistent percent ash patterns were noted for the warehouse or upright freezers.

I. Thiamine

Thiamine concentrations of all collected samples exhibited an initial rapid decline between July and September 1982 (Figure 14). Wholesale thiamine levels were reduced from 0.150 mg/100g to 0.020 mg/100g, coffin freezer levels from 0.069 mg/100g to 0.020 mg/100g, and upright freezer levels from 0.194 mg/100g to 0.019 mg/100g. No additional trends were observed for wet weight or moisture-free/ash-free thiamine (Figure 15) levels during the rest of the study. Thiamine values were not evaluated by the SAS program.

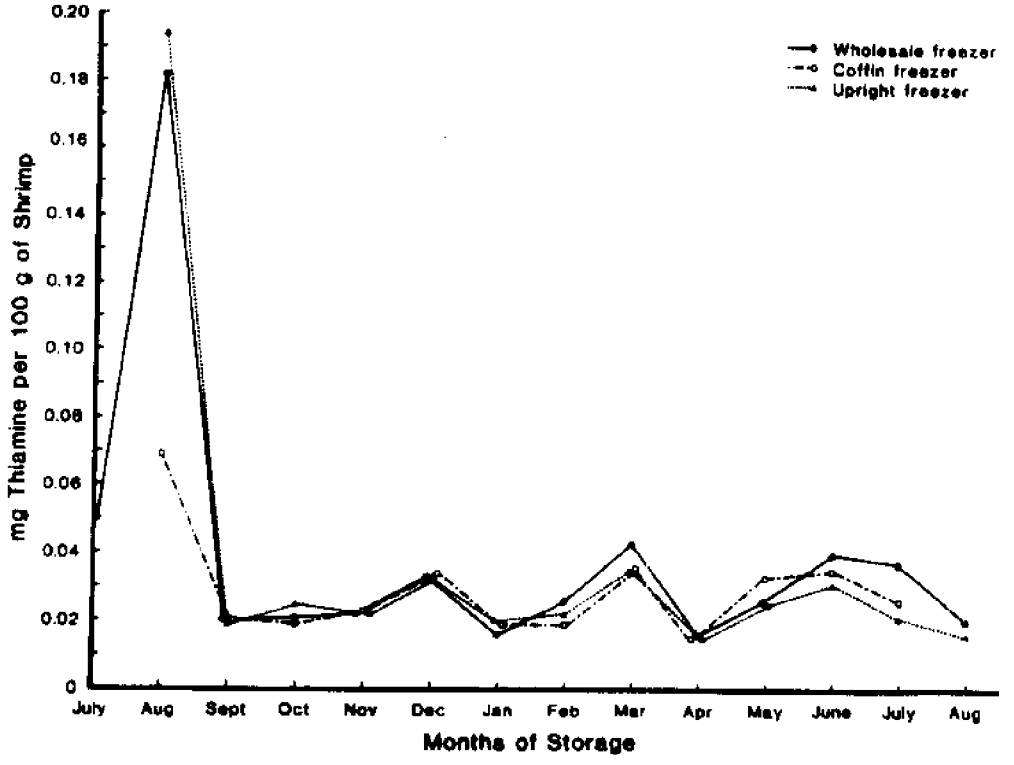

Figure 14. Monthly thiamine concentrations for the warehouse, coffin, and upright freezers.

Percent Ash

Month	Mean	Freezer
July 82	--	--
Aug 82	No significant difference PSE = 0.006	
Sept 82	A 3.11	Coffin
	B 3.00	Warehouse
	C 2.86	Upright
	PSE = 0.004	
Oct 82	A 3.00	Warehouse
	BA 2.86	Coffin
	B 2.56	Upright
	PSE = 0.019	
Nov 82	A 3.00	Coffin
	A 2.98	Warehouse
	B 2.45	Upright
	PSE = 0.018	
Dec 82	A 3.16	Coffin
	B 2.96	Upright
	C 2.82	Warehouse
	PSE = 0.004	
Jan 83	A 3.28	Coffin
	BA 3.13	Upright
	B 2.93	Warehouse
	PSE = 0.016	
Feb 83	A 3.30	Coffin
	B 2.94	Upright
	B 2.89	Warehouse
	PSE = 0.010	
March 83	No significant difference PSE = 0.084	
April 83	A 3.16	Coffin
	B 2.96	Warehouse
	B 2.94	Upright
	PSE = 0.011	
May 83	A 3.36	Coffin
	BA 2.92	Upright
	B 2.84	Warehouse
	PSE = 0.027	
June 83	A 3.35	Coffin
	A 3.20	Upright
	B 2.82	Warehouse
	PSE = 0.021	
July 83	A 3.34	Coffin
	B 2.96	Warehouse
	C 2.88	Upright
	PSE = 0.002	
Aug 83	A 3.25	Upright
	B 3.03	Warehouse
	PSE = 0.010	

Table 11. Mean percent ash significantly different at the 0.05 level and pooled standard error (PSE), Tukey's studentized range test. Means with the same letter are not significantly different.

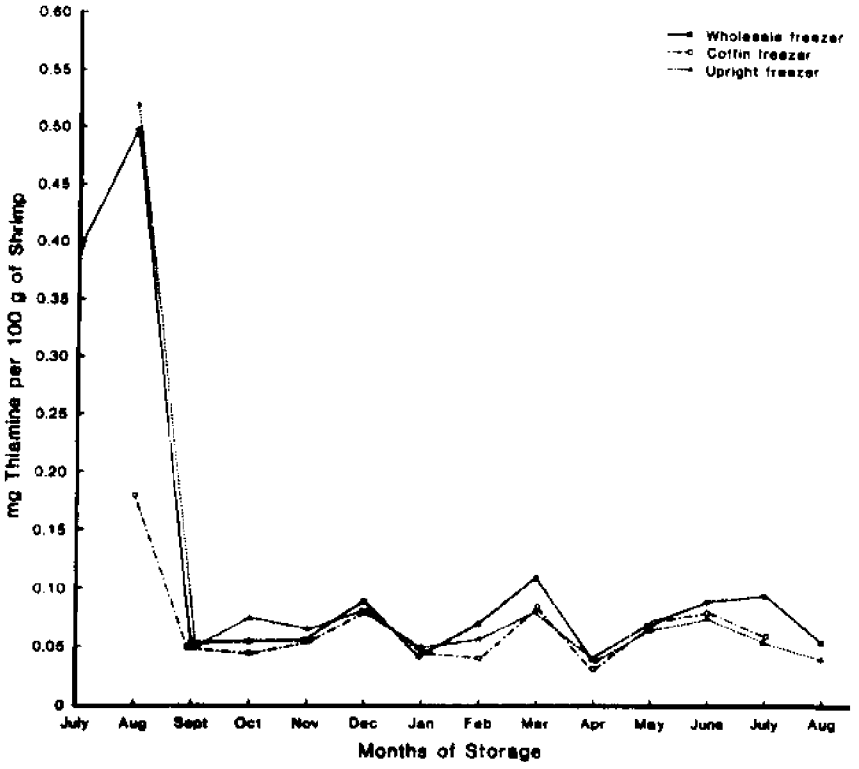

Figure 15. Monthly moisture-free/ash-free thiamine concentrations for the warehouse, coffin, and upright freezers.

J. Riboflavin

No consistent trend or patterns were observed for riboflavin concentrations on a wet (Figure 16) or moisture-free/ash-free basis (Figure 17). Initial and final riboflavin concentrations for the wholesale, coffin, and upright freezers were 0.071 mg/100g, 0.031 mg/100g; 0.068 mg/100g, 0.037 mg/100g; and 0.063 mg/100g, 0.045 mg/100g, respectively. Riboflavin levels were not interpreted by the SAS program.

K. Trimethylamine

Trimethylamine concentrations on a wet weight (Figure 18) or moisture-free/ash-free basis (Figure 19) revealed no consistent patterns or differences among the treatment conditions.

Monthly mean significant differences in trimethylamine (TMA) and moisture-free/ash-free TMA determined by Tukey's studentized range test are listed, respectively, in Tables 12 and 13. On a wet weight basis, the coffin freezer samples had significantly higher TMA levels than the upright or warehouse freezer samples in February, March, and July 1983. Although significant differences in mean moisture-free/ash-free TMA concentrations were noted for August 1982, October 1982, December 1982, February 1983, March 1983, July 1983, and August 1983, no consistent pattern by storage location was discerned.

Trimethylamine
mg/100g

Month	Mean	Freezer
July 82	--	--
Aug 82	No significant difference PSE = 0.682	
Sept 82	No significant difference PSE = 0.773	
Oct 82	No significant difference PSE = 0.089	
Nov 82	No significant difference PSE = 0.155	
Dec 82	No significant difference PSE = 0.258	
Jan 83	No significant difference PSE = 0.328	
Feb 83	A 15.60 A 14.62 B 5.79 PSE = 0.389	Coffin Upright Warehouse
March 83	A 8.16 B 3.42 B 2.90 PSE = 0.179	Coffin Upright Warehouse
April 83	No significant difference PSE = 0.433	
May 83	No significant difference PSE = 0.128	
June 83	No significant difference PSE = 0.082	
July 83	A 18.62 B 15.37 B 12.41 PSE = 0.187	Coffin Upright Warehouse
Aug 83	No significant difference PSE = 0.190	

Table 12. Mean trimethylamine levels mg/100g shrimp, significantly different at the 0.05 level and pooled standard error (PSE), Tukey's studentized range test. Means with the same letter are not significantly different.

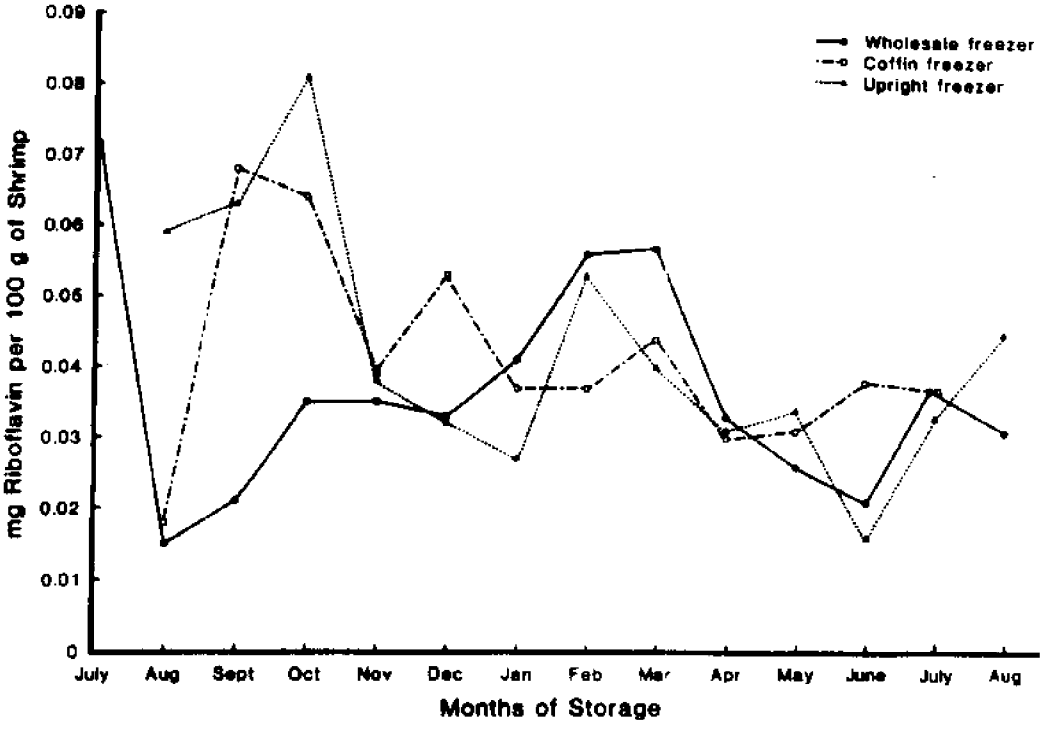

Figure 16. Monthly riboflavin levels for the warehouse, coffin, and upright freezers.

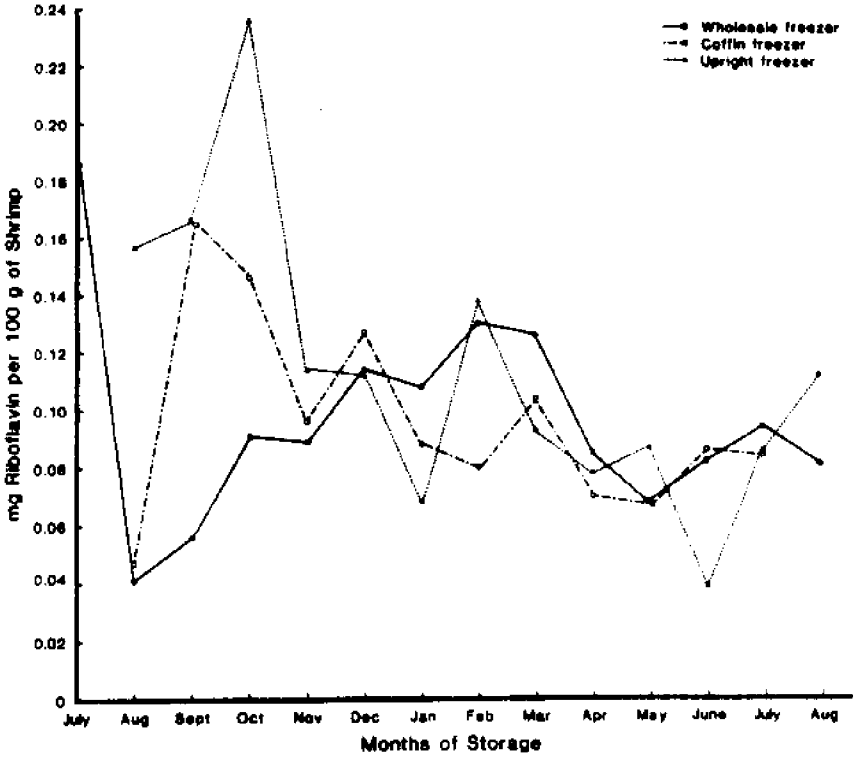

Figure 17. Monthly moisture-free/ash-free riboflavin levels for the warehouse, coffin, and upright freezers.

Moisture-Free/Ash-Free Trimethylamine
mg/100g

Month	Mean	Freezer
July 82	--	--
Aug 82	A 56.54	Warehouse
	A 47.42	Coffin
	B 14.78	Upright
	PSE = 2.75	
Sept 82	No significant difference	
	PSE = 3.209	
Oct 82	A 21.04	Upright
	B 15.52	Coffin
	B 15.46	Warehouse
	PSE = 0.271	
Nov 82	No significant difference	
	PSE = 0.312	
Dec 82	A 26.81	Coffin
	BA 23.89	Warehouse
	B 21.28	Upright
	PSE = 0.523	
Jan 83	No significant difference	
	PSE = 1.317	
Feb 83	A 40.22	Upright
	A 33.91	Coffin
	B 15.50	Warehouse
	PSE = 0.998	
March 83	A 19.38	Coffin
	B 7.96	Upright
	C 7.41	Warehouse
	PSE = 0.194	
April 83	No significant difference	
	PSE = 1.643	
May 83	No significant difference	
	PSE = 0.222	
June 83	No significant difference	
	PSE = 0.244	
July 83	A 43.13	Coffin
	A 40.05	Upright
	B 31.45	Warehouse
	PSE = 0.333	
Aug 83	A 19.72	Warehouse
	B 13.78	Upright
	PSE = 0.414	

Table 13. Mean moisture-free/ash-free trimethylamine levels, mg/100g shrimp, significantly different at the 0.05 level and pooled standard error (PSE), Tukey's studentized test. Means with the same letter are not significantly different.

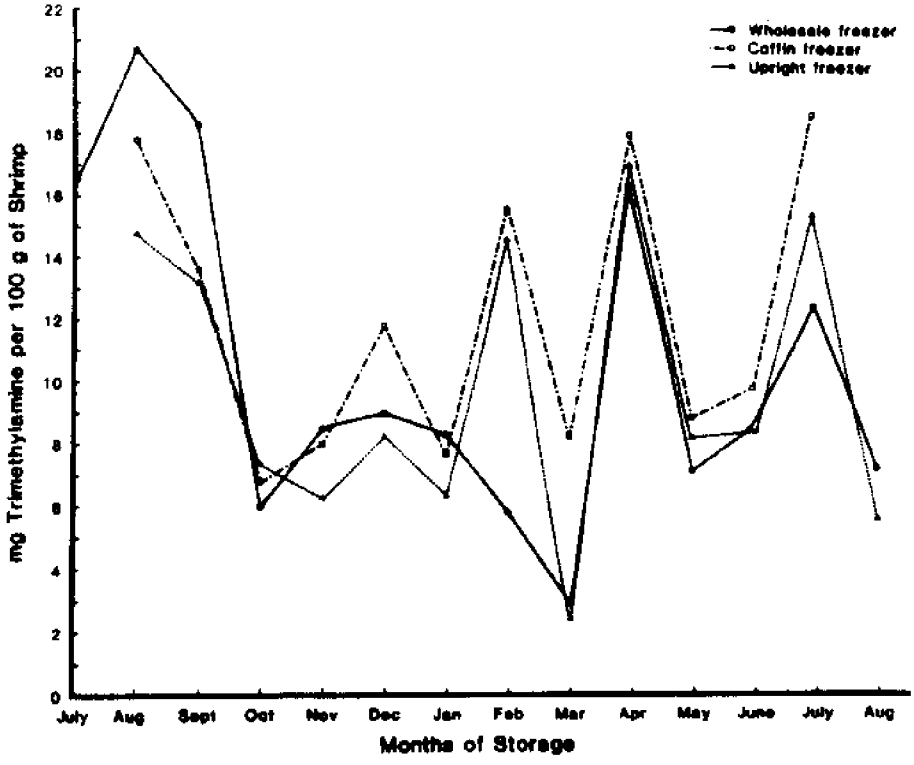

Figure 18. Mean monthly trimethylamine levels for the warehouse, coffin, and upright freezers.

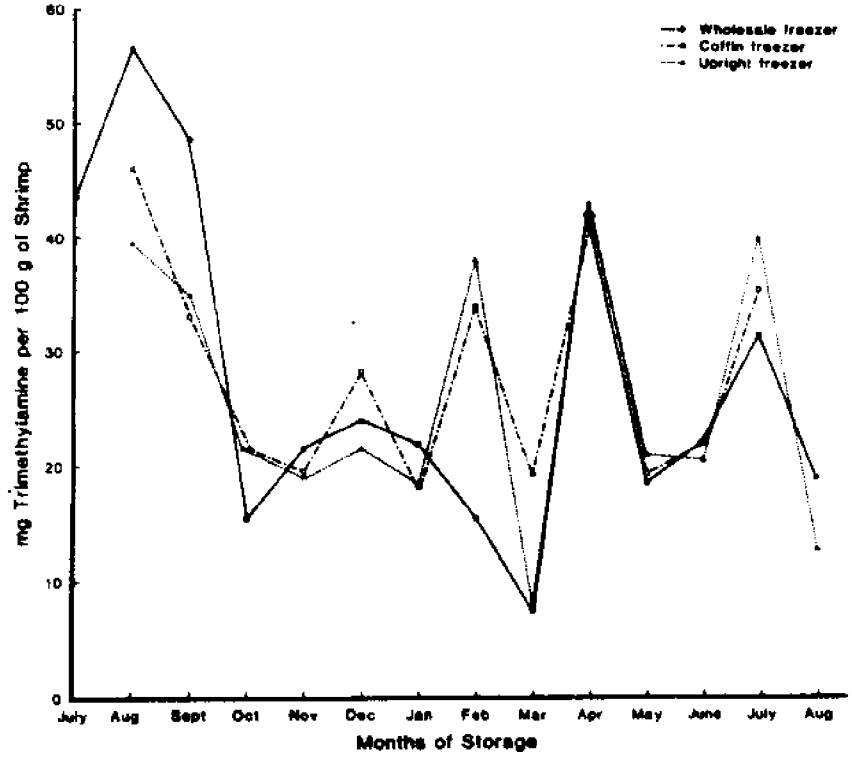

Figure 19. Mean monthly moisture-free/ash-free trimethylamine levels for the warehouse, coffin, and upright freezers.

L. Microbiological Analyses

All samples examined microbiologically were within Georgia Department of Agriculture Guidelines for raw breaded shrimp. Monthly mean aerobic plate counts, MPN total coliforms, and MPN coagulase positive staphylococci levels were depicted in Figures 20, 21, and 22, respectively. No E. coli organisms were detected, with all MPN total E. coli levels equal to <2 organisms/g.

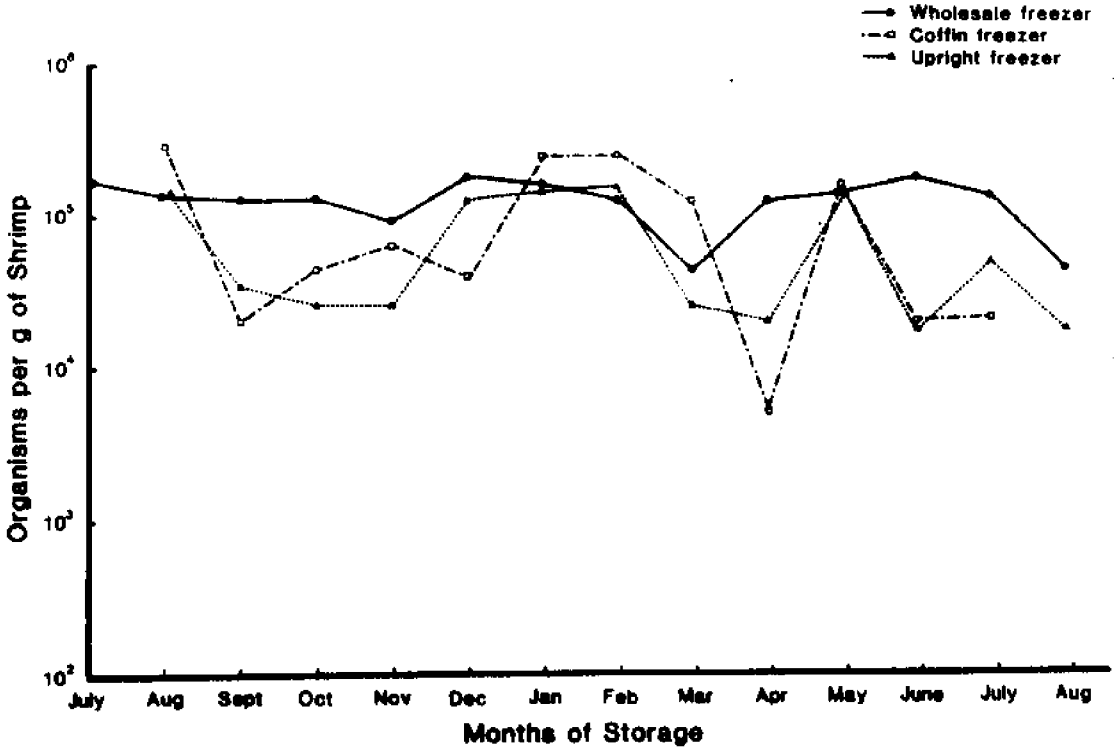

Figure 20. Monthly aerobic plate counts for the warehouse, coffin, and upright freezers.

The standard aerobic plate count data was analyzed by Tukey's studentized range test (0.05 level). Although significant differences among the means at each storage location were shown for nine of the sampled months, no consistent pattern with location was discernable (Table 14).

M. Taste Panel

Seven taste panel members were available monthly to evaluate the textural and flavor characteristics of frozen breaded shrimp (Figures 22 - 33).

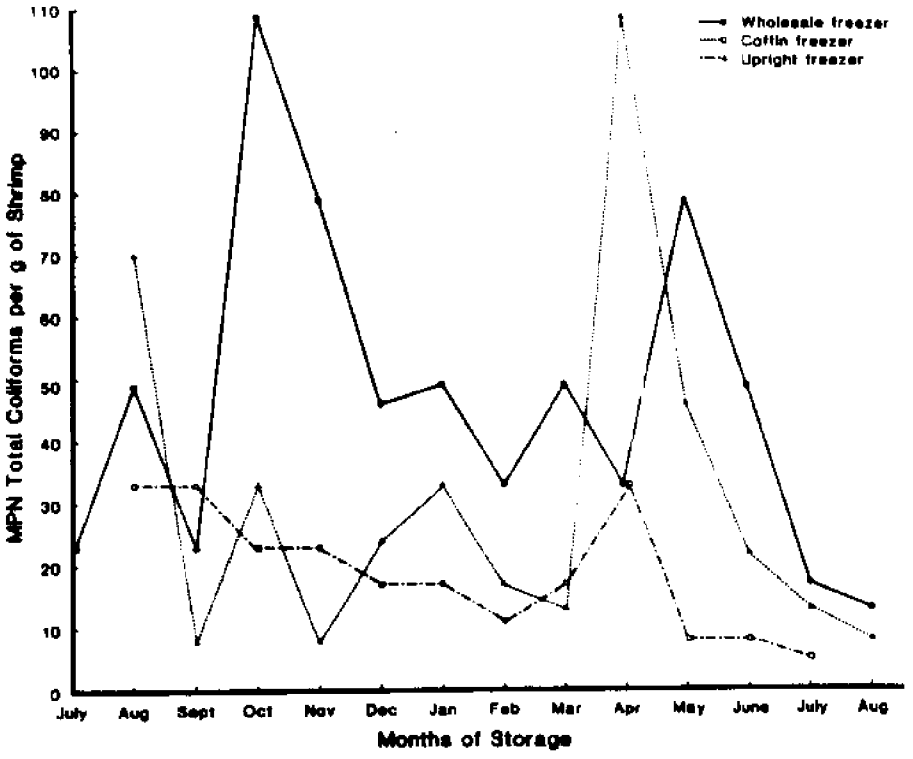

Figure 21. Monthly MPN total coliform organisms for the warehouse, coffin, and upright freezers.

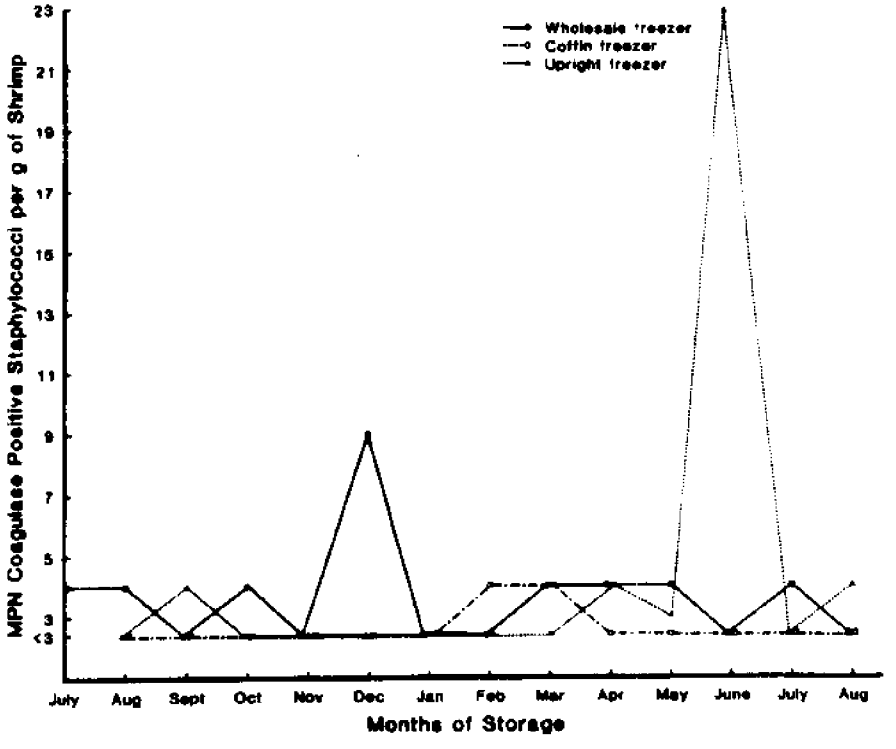

Figure 22. Monthly MPN coagulase positive staphylococci for the warehouse, coffin, and upright freezers.

Standard Plate Count
Org/g

Month	Mean	Freezer
July 82	--	--
Aug 82	A 4.50×10^5	Coffin
	B 1.41×10^5	Upright
	B 1.24×10^5	Warehouse
	PSE = 8.85×10^3	
Sept 82	A 1.03×10^5	Warehouse
	BA 5.25×10^4	Upright
	B 2.95×10^4	Coffin
	PSE = 5.16×10^3	
Oct 82	No significant difference	
	PSE = 1.13×10^4	
Nov 82	A 9.65×10^4	Warehouse
	A 7.85×10^4	Coffin
	B 4.20×10^4	Upright
	PSE = 2.22×10^3	
Dec 82	A 2.78×10^5	Warehouse
	B 1.08×10^5	Upright
	B 5.95×10^4	Coffin
	PSE = 7.75×10^3	
Jan 83	A 3.85×10^5	Coffin
	B 2.22×10^5	Warehouse
	B 1.70×10^5	Upright
	PSE = 1.54×10^4	
Feb 83	A 4.00×10^5	Coffin
	BA 1.85×10^5	Upright
	B 1.02×10^5	Warehouse
	PSE = 2.42×10^4	
March 83	A 1.24×10^5	Coffin
	B 6.30×10^4	Warehouse
	B 4.15×10^4	Upright
	PSE = 4.47×10^3	
April 83	No significant difference	
	PSE = 8.25×10^3	
May 83	No significant difference	
	PSE = 8.85×10^3	
June 83	No significant difference	
	PSE = 2.42×10^3	
July 83	A 1.28×10^5	Warehouse
	B 7.15×10^4	Upright
	B 3.18×10^4	Coffin
	PSE = 5.48×10^3	
Aug 83	A 6.60×10^4	Warehouse
	B 2.40×10^4	Upright
	PSE = 1.12×10^3	

Table 14. Mean standard plate count, org/g, significantly different at the 0.05 level and pooled standard error (PSE), Tukey's studentized range test. Means with the same letter are not significantly different.

N. Hardness

The mean hardness rating of shrimp (Figure 23) stored in the coffin freezer exceeded all other samples in October 1982 (3.50) and continued to do so until the end of the study (4.11). The initial hardness value for the horizontal freezer was 2.29. The perceived hardness of shrimp from the upright freezer exceeded the hardness of the wholesale samples in May 1983 (2.50) and remained greater than those samples until the end of the study (2.75). As with the other retail sample, the final hardness level exceeded the initial hardness value (2.14). The hardness of the wholesale shrimp decreased from 3.00 in August 1982 to 2.00 in August 1983. The hardness of the control sample ranged between 2.00 and 2.79.

Mean taste panel hardness values significantly different at the 0.05 level, determined by Tukey's studentized range test, are listed in Table 15 for each storage location and for the latest production date sample of shrimp. Freshly produced frozen breaded shrimp served as the monthly taste panel control. The November 1982 (four months storage) hardness rating for shrimp held in the coffin freezer was signficantly greater than shrimp hardness determined for the other storage locations. The coffin freezer samples remained greater than the others for each succeeding month, except for March 1983 (eight months storage), when there was no signficiant difference between the coffin freezer hardness and the upright freezer. No consistent differences were noted for the other storage locations.

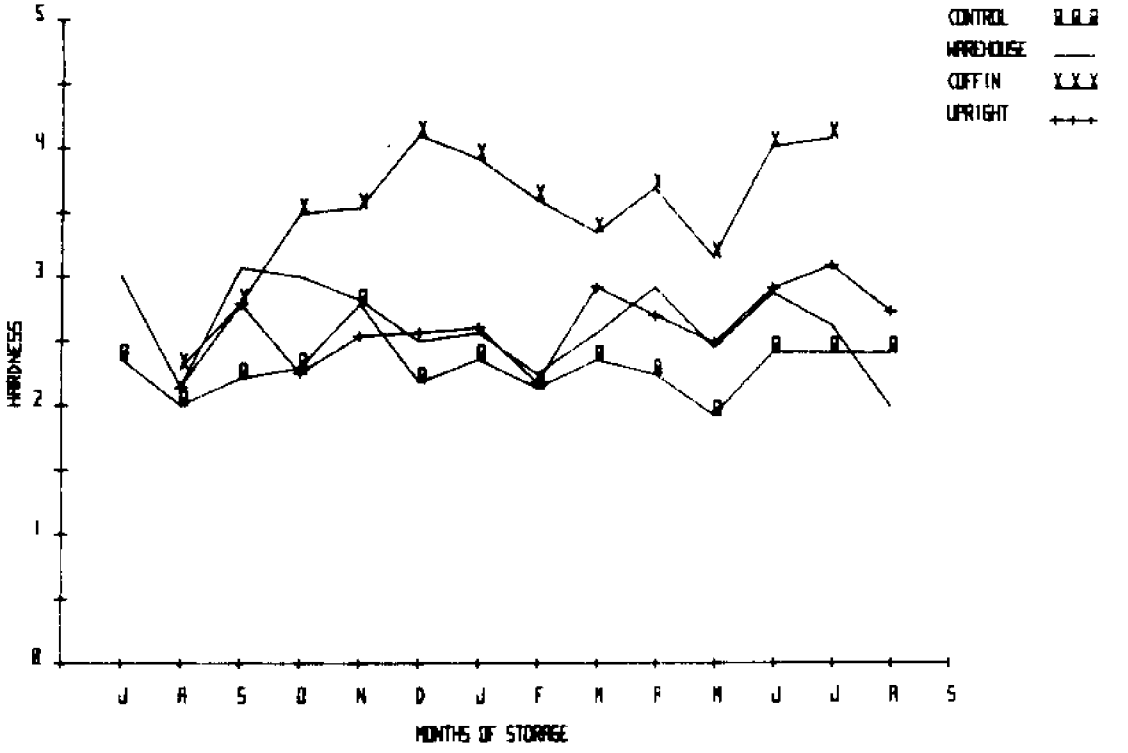

Figure 23. Mean monthly hardness levels for control, warehouse, coffin, and upright samples.

Hardness

Month	Mean	Freezer
July 82	A 3.08	Warehouse
	B 2.36	Control
	PSE = 0.106	
Aug 82	No significant difference	
	PSE = 0.087	
Sept 82	A 3.08	Warehouse
	A 2.79	Coffin
	A 2.79	Upright
	B 2.21	Control
	PSE = 0.59	
Oct 82	A 3.50	Coffin
	A 3.00	Warehouse
	B 2.29	Control
	B 2.25	Upright
	PSE = 0.076	
Nov 82	A 3.54	Coffin
	B 2.82	Warehouse
	B 2.79	Control
	B 2.54	Upright
	PSE =0.092	
Dec 82	A 4.11	Coffin
	B 2.57	Upright
	B 2.50	Warehouse
	B 2.18	Control
	PSE = 0.058	
Jan 83	A 3.93	Coffin
	B 2.61	Upright
	B 2.57	Warehouse
	B 2.36	Control
	PSE = 0.088	
Feb 83	A 3.61	Coffin
	B 2.25	Warehouse
	B 2.18	Upright
	B 2.14	Control
	PSE = 0.054	
March 83	A 3.36	Coffin
	BA 2.93	Upright
	B 2.57	Warehouse
	B 2.36	Control
	PSE = 0.085	
April 83	A 3.71	Coffin
	B 2.93	Warehouse
	B 2.71	Control
	B 2.25	Upright
	PSE = 0.093	
May 83	A 3.17	Coffin
	B 2.50	Upright
	B 2.46	Warehouse
	B 1.93	Control
	PSE = 0.086	
June 83	A 4.04	Coffin
	B 2.93	Upright
	B 2.89	Warehouse
	B 2.43	Control
	PSE = 0.082	
July 83	A 4.07	Coffin
	B 3.11	Upright
	B 2.64	Warehouse
	C 2.43	Control
	PSE = 0.067	
Aug 83	A 2.75	Upright
	BA 2.43	Control
	B 2.00	Warehouse
	PSE = 0.093	

Table 15. Mean hardness significantly different at the 0.05 level and pooled standard error (PSE), Tukey's studentized range test. Means with the same letter are not significantly different.

O. Chewiness

The chewiness results (Figure 24) were similar to the hardness data. The horizontal freezer samples exceeded all other samples in November 1982 (3.50) and remained greater than the other determinations through July 1983 (4.21). Vertical freezer determinations exceeded or were equal to the wholesale values beginning in February 1983, and exceeded them from June 1983 through the end of the study. Chewiness ratings for the coffin freezer increased fron an initial value of 2.36 to 4.21, and for the upright freezer from 2.29 to 2.75. Chewiness of the wholesale shrimp decreased from an initial value of 3.14 to a final characterization of 2.07. The control samples ranged from 2.34 to 2.57.

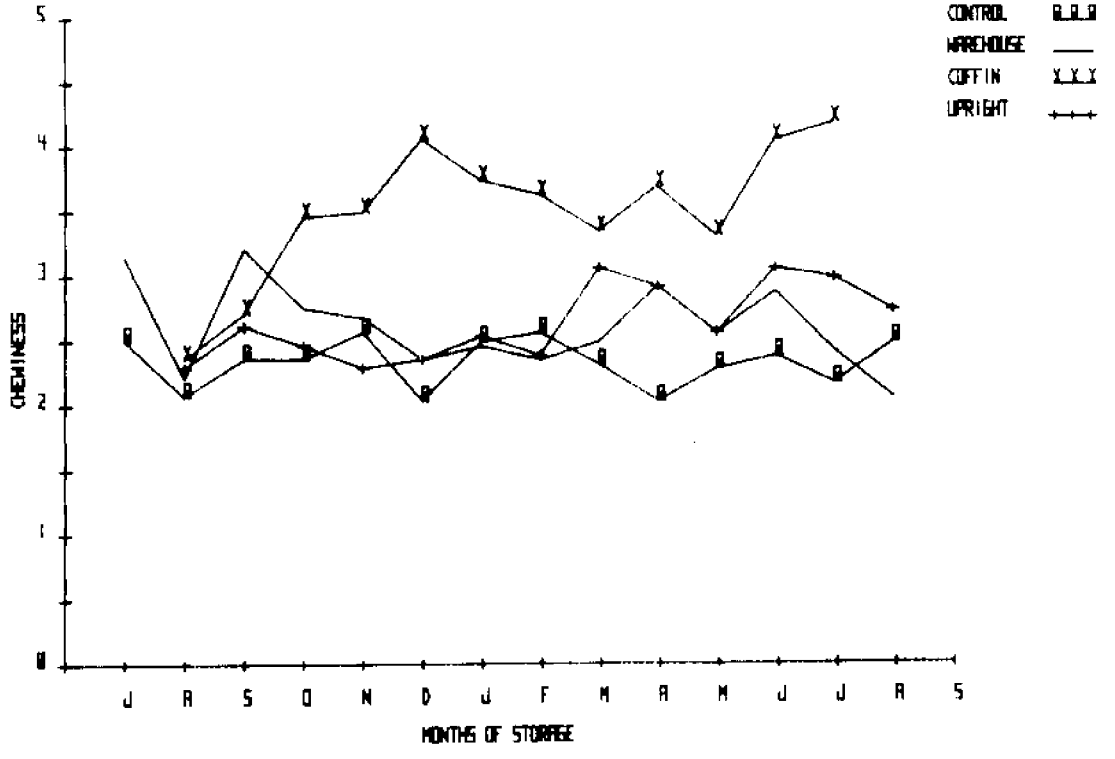

Figure 24. Mean monthly chewiness levels for control, warehouse, coffin, and upright samples.

The perceived chewiness of the shrimp stored in the coffin freezer (Table 16) followed a pattern similar to the hardness ratings, with the coffin freezer samples rated significantly chewier than the warehouse freezer samples from October 1982 (three months storage) through July 1983 (twelve months storage). Horizontal samples were significantly greater than upright samples for the same period, with the exception of March 1983 when no significant differences between the two freezers was detected. The chewiness ratings of the upright samples were significantly

Chewiness

Month	Mean	Freezer
July 82	A 3.14	Warehouse
	B 2.50	Control
	PSE = 0.113	
Aug 82	No significant difference	
	PSE = 0.087	
Sept 82	A 3.21	Warehouse
	BA 2.71	Coffin
	BA 2.61	Upright
	B 2.36	Control
	PSE = 0.088	
Oct 82	A 3.46	Coffin
	B 2.75	Warehouse
	B 2.46	Upright
	B 2.36	Control
	PSE = 0.079	
Nov 82	A 3.50	Coffin
	B 2.68	Warehouse
	B 2.58	Upright
	B 2.29	Control
	PSE = 0.079	
Dec 82	A 4.07	Coffin
	B 2.36	Upright
	B 2.36	Warehouse
	B 2.04	Control
	PSE = 0.062	
Jan 83	A 3.75	Coffin
	B 2.54	Upright
	B 2.50	Control
	B 2.46	Warehouse
	PSE = 0.075	
Feb 83	A 3.75	Coffin
	B 2.57	Control
	B 2.39	Upright
	B 2.36	Warehouse
	PSE = 0.068	
March 83	A 3.36	Coffin
	BA 3.07	Upright
	CB 2.50	Warehouse
	C 2.32	Control
	PSE = 0.088	
April 83	A 3.71	Coffin
	B 2.93	Upright
	B 2.93	Warehouse
	C 2.04	Control
	PSE = 0.090	
May 83	A 3.32	Coffin
	B 2.57	Upright
	B 2.57	Warehouse
	B 2.29	Control
	PSE = 0.086	
June 83	A 4.07	Coffin
	B 3.07	Upright
	CB 2.89	Warehouse
	C 2.39	Control
	PSE = 0.068	
July 83	A 4.21	Coffin
	B 3.00	Upright
	C 2.43	Warehouse
	C 2.18	Control
	PSE = 0.068	
Aug 83	A 2.75	Upright
	BA 2.50	Control
	B 2.07	Warehouse
	PSE = 0.097	

Table 16. Mean chewiness significantly different at the 0.05 level and pooled standard error (PSE), Tukey's studentized range test. Means with the same letter are not significantly different.

greater than the warehouse samples in July and August 1983 following twelve and thirteen months of storage.

P. Fibrousness

The fibrousness rating (Figure 25) for the horizontal freezer samples rose from the initial value of 2.57 to 3.82 in July 1983, exceeding all other sample levels from October 1982 through the end of the testing period. No other differences were apparent. The initial and final values of the wholesale, upright, coffin, and control samples were as follows: 2.43, 2.21; 2.36, 2.68; and 2.57, 3.82. The control samples ranged from 1.86 to 2.67.

The mean fibrousness level of the breaded shrimp stored in the horizontal freezer was significantly greater (Table 17) than the ratings for the upright and/or warehouse freezers from December 1982 (five months storage) through July 1983 (twelve months storage). No significant differences in perceived fibrousness were determined between the upright and warehouse freezers.

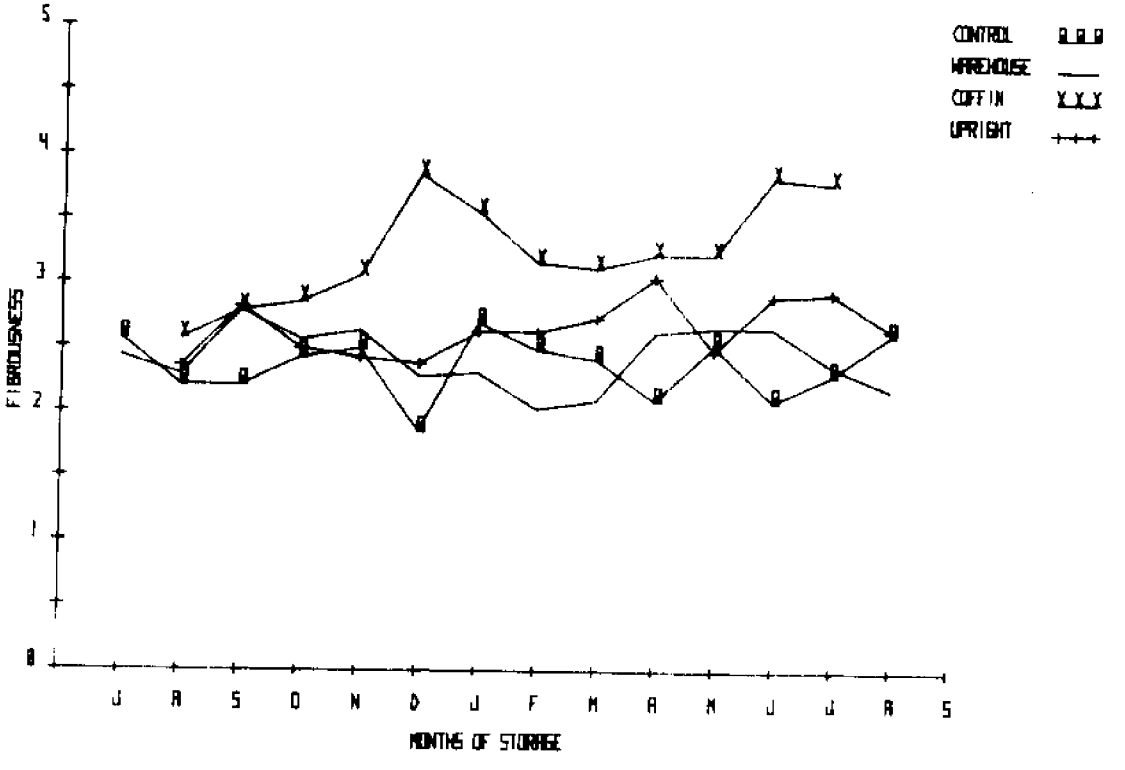

Figure 25. Mean monthly fibrousness levels for control, warehouse, coffin, and upright samples.

Fibrousness

Month	Mean	Freezer
July 82	No significant difference	
	PSE = 0.088	
Aug 82	No significant difference	
	PSE = 0.083	
Sept 82	A 2.82	Upright
	A 2.79	Coffin
	A 2.79	Warehouse
	B 2.21	Control
	PSE = 0.069	
Oct 82	No significant difference	
	PSE = 0.091	
Nov 82	No significant difference	
	PSE = 0.093	
Dec 82	A 3.86	Coffin
	B 2.39	Upright
	B 2.29	Warehouse
	C 1.86	Control
	PSE = 0.057	
Jan 83	A 3.57	Coffin
	B 2.71	Control
	B 2.64	Upright
	B 2.32	Warehouse
	PSE = 0.088	
Feb 83	A 3.18	Coffin
	B 2.57	Upright
	B 2.50	Control
	B 2.04	Warehouse
	PSE = 0.081	
March 83	A 3.14	Coffin
	BA 2.75	Upright
	B 2.43	Control
	B 2.11	Warehouse
	PSE = 0.093	
April 83	A 3.25	Coffin
	A 3.07	Upright
	BA 2.64	Warehouse
	B 2.11	Control
	PSE = 0.084	
May 83	A 3.25	Coffin
	BA 2.68	Warehouse
	B 2.54	Control
	B 2.50	Upright
	PSE = 0.090	
June 83	A 3.86	Coffin
	B 2.93	Upright
	CB 2.68	Warehouse
	C 2.11	Control
	PSE = 0.084	
July 83	A 3.82	Coffin
	B 2.96	Upright
	B 2.39	Warehouse
	B 2.32	Control
	PSE = 0.110	
Aug 83	No significant difference	
	PSE = 0.092	

Table 17. Mean fibrousness levels significantly different at the 0.05 level and pooled standard error (PSE), Tukey's studentized range test. Means with the same letter are not significantly different.

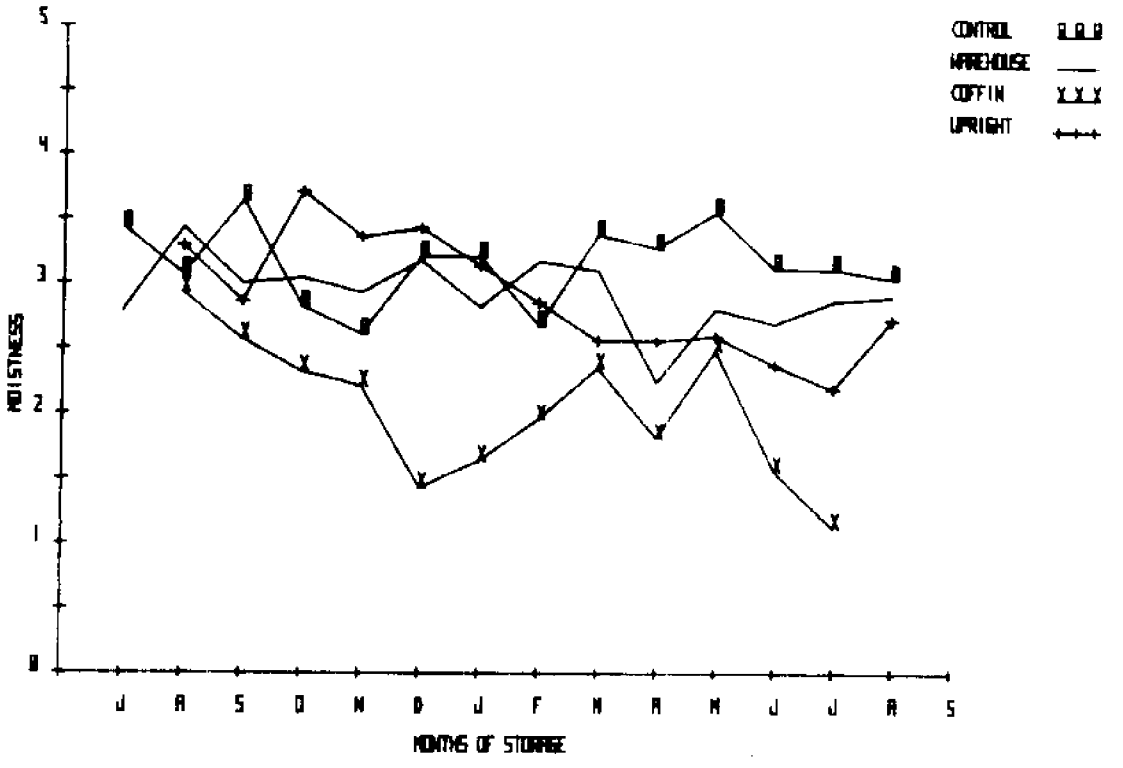

Figure 26. Mean monthly moistness levels for control, warehouse, coffin, and upright freezers.

Q. Moistness

The moistness rating for shrimp (Figure 26) stored in the coffin freezer was less than the other samples on all occasions, with an initial value of 2.93 (August 1982) and a final value of 1.14 (July 1983). The upright freezer samples had an initial value of 3.29 (August 1982) and a final value of 2.75 (August 1983). Moistness levels fell below the wholesale and control samples in May 1983 and stayed below them until the end of the study. Perceived moistness for the wholesale samples began at 2.79 and ended at 2.93. Control moistness ranged from 2.61 to 3.64.

Significant differences in mean moistness determined by the taste panel (Table 18) place the moistness level of the coffin freezer samples below the other experimental treatments on eight of ten sampling trials, from October 1982 (three months storage) through July 1983 (twelve months storage). The exceptions are March and May 1983 when no significant differences among the treatments were determined. The moistness ratings closely parallel the actual percent moisture levels listed in Table 6. The upright freezer exhibited significantly greater moistness and moisture values in October (three months storage) and November 1982 (four months storage). Both levels occurred concurrently with the highest temperatures recorded for the upright freezers, a maximum of 3°C (Figure 3). The moistness levels of the upright freezer samples were rated significantly less than the warehouse freezer samples in June and

Moistness

Month	Mean	Freezer
July 82	A 3.43	Control
	B 2.79	Warehouse
	PSE = 0.089	
Aug 82	No significant difference	
	PSE = 0.849	
Sept 82	A 3.64	Control
	BA 3.00	Warehouse
	B 2.86	Upright
	B 2.57	Coffin
	PSE = 0.095	
Oct 82	A 3.71	Upright
	B 3.04	Warehouse
	CB 2.82	Control
	C 2.32	Coffin
	PSE = 0.103	
Nov 82	A 3.71	Upright
	B 3.04	Warehouse
	CB 2.82	Control
	C 2.32	Coffin
	PSE = 0.091	
Dec 82	A 3.43	Upright
	A 3.21	Control
	A 3.18	Warehouse
	B 1.43	Coffin
	PSE = 0.067	
Jan 83	A 3.21	Control
	A 3.14	Upright
	A 2.82	Warehouse
	B 1.64	Coffin
	PSE = 0.081	
Feb 83	A 3.18	Warehouse
	A 2.86	Upright
	A 2.68	Control
	B 1.96	Coffin
	PSE = 0.083	
March 83	A 3.39	Control
	BA 3.11	Warehouse
	B 2.57	Upright
	B 2.36	Coffin
	PSE = 0.105	
April 83	A 3.29	Control
	B 2.57	Upright
	CB 2.25	Warehouse
	C 1.82	Coffin
	PSE = 0.069	
May 83	A 3.57	Control
	B 2.82	Warehouse
	B 2.61	Upright
	B 2.50	Coffin
	PSE = 0.088	
June 83	A 3.14	Control
	BA 2.71	Warehouse
	B 2.39	Upright
	C 1.57	Coffin
	PSE = 0.799	
July 83	A 3.14	Control
	A 2.89	Warehouse
	B 2.21	Upright
	C 1.14	Coffin
	PSE = 0.085	
Aug 83	No significant difference	
	PSE = 0.010	

Table 18. Mean moistness levels significantly different at the 0.05 level and pooled standard error (PSE), Tukey's studentized range test. Means with the same letter are not significantly different.

July 1983 following eleven and twelve months storage, but no significant difference was determined between the samples in August 1983. However, fresh product from the warehouse freezer was delivered to the upright freezer on 6 July 1983 (Table 1).

R. Oily Mouth Coating

The control sample oily mouth coating rating (Figure 27) was consistently less than the experimental samples. Table 19 shows that the perceived oily mouth coating of the control sample was significantly less than one or more of the experimental samples in 9 of 14 months. No other trend was noted.

S. Overall Shrimp Intensity

The overall shrimp intensity of horizontal freezer shrimp (Figure 28) with an initial value of 1.65 was less than that perceived for wholesale shrimp on all occasions. Shrimp intensity remained below reported vertical freezer values from December 1982 with a minimum value of 0.39 in June 1983 and a final value of 0.71 in July 1983. Upright freezer intensities were less than wholesale freezer samples on ten occasions and remained below them from June 1983 through August 1983. Initial and final values were 1.78 and 1.71, respectively. Initial and final wholesale levels were 2.07 and 2.39. Control samples ranged between 2.15 and 3.32.

Beginning in December 1982 (following five months storage) the horizontal freezer samples rated significantly less than the other samples for overall shrimp flavor (Table 20). The upright freezer levels were significantly less than perceived for the warehouse freezer during the last three months of the study (eleven - thirteen months storage). No other consistent pattern of monthly significant differences were determined.

T. Sweet

Perceived sweet levels (Figure 29) from the shrimp stored in the horizontal freezer were less than all other evaluated shrimp except for the November 1982 sample, (1.93) which was greater than the upright freezer value of 1.58. Initial and final horizontal freezer levels were 1.86 and 0.61. Upright freezer evaluations of sweetness were less than tabulated wholesale freezer levels on all but two occasions, September 1982 (2.00 upright, 1.93 wholesale) and May 1983 (2.00 upright, 1.86 wholesale). Initial and final vertical freezer samples were evaluated at 2.22 and 1.68, respectively. In contrast to the retail samples, the perceived sweetness of the wholesale sample increased from an initial value of 1.93 to a final level of 2.39. The control sample ranged from 2.14 to 3.29.

Oily Mouth Coating

Month	Mean	Freezer
July 82	No significant difference	
	PSE = 0.130	
Aug 82	A 3.29	Upright
	BA 2.93	Coffin
	BA 2.93	Warehouse
	B 2.57	Control
	PSE = 0.070	
Sept 82	No significant difference	
	PSE = 0.085	
Oct 82	A 2.75	Upright
	BA 2.50	Coffin
	BA 2.43	Warehouse
	B 1.86	Control
	PSE = 0.100	
Nov 82	A 2.46	Upright
	A 2.36	Warehouse
	BA 2.07	Coffin
	B 1.64	Control
	PSE = 0.090	
Dec 82	No significant difference	
	PSE = 0.088	
Jan 83	No significant difference	
	PSE = 0.087	
Feb 82	A 2.89	Warehouse
	BA 2.54	Upright
	B 2.29	Coffin
	C 1.64	Control
	PSE = 0.081	
March 83	A 2.86	Upright
	A 2.61	Coffin
	A 2.57	Warehouse
	B 1.79	Control
	PSE = 0.099	
April 83	A 2.86	Coffin
	BA 2.68	Upright
	BA 2.57	Warehouse
	B 2.11	Control
	PSE = 0.096	
May 83	A 3.11	Warehouse
	A 3.07	Coffin
	BA 2.61	Upright
	B 2.39	Control
	PSE = 0.073	
June 83	A 2.86	Upright
	A 2.82	Coffin
	A 2.75	Warehouse
	B 1.93	Control
	PSE = 0.077	
July 83	No significant difference	
	PSE = 0.106	
Aug 83	A 2.68	Upright
	A 2.61	Warehouse
	B 1.79	Control
	PSE = 0.092	

Table 19. Mean oily mouth coating levels significantly different at the 0.05 level and pooled standard error (PSE), Tukey's studentized range test. Means with the same letter are not significantly different.

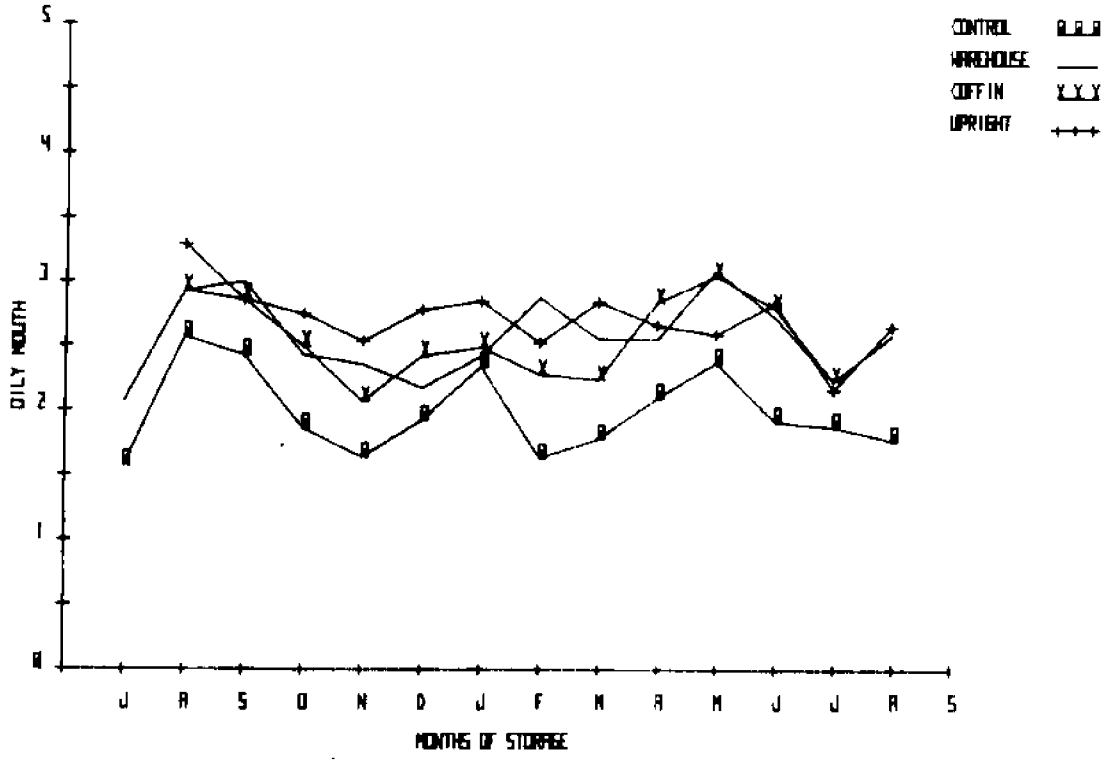

Figure 27. Mean monthly oily mouth coating levels for control, warehouse, coffin, and upright samples.

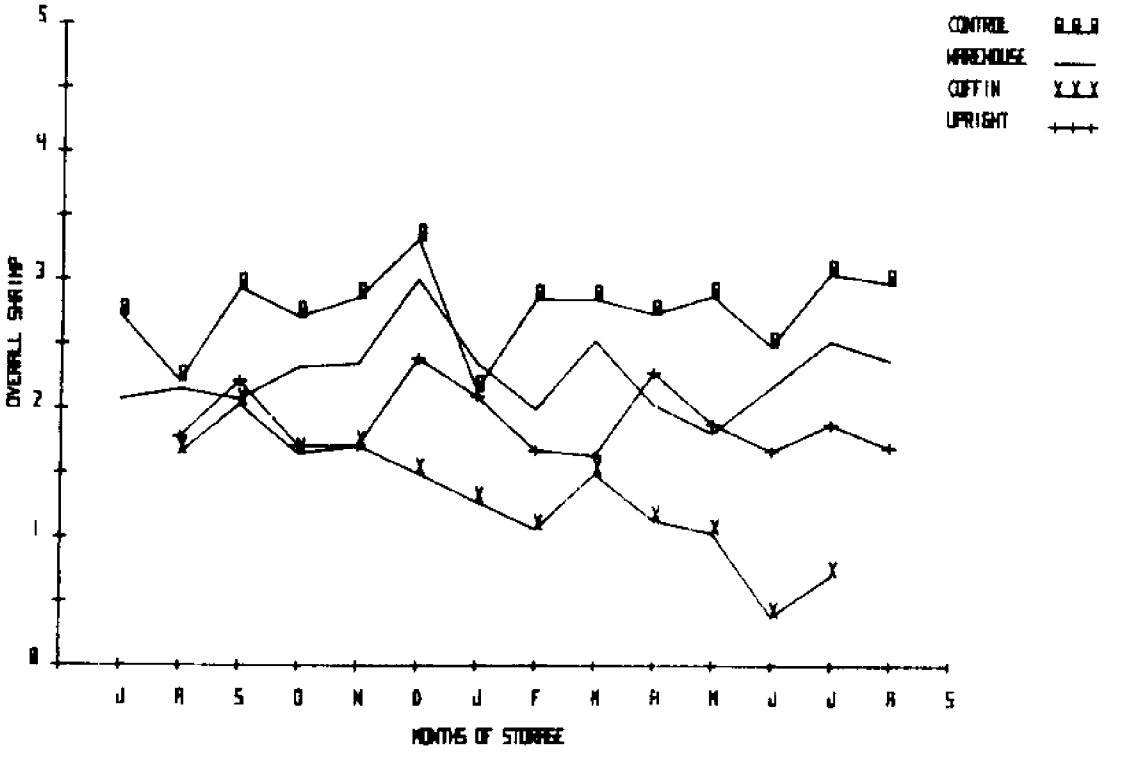

Figure 28. Mean monthly overall shrimp intensity for control, warehouse, coffin, and upright samples.

Overall Shrimp

Month	Mean	Freezer
July 82	A 2.71	Control
	B 2.07	Warehouse
	PSE = 0.094	
Aug 82	A 2.21	Control
	A 2.14	Warehouse
	BA 1.79	Upright
	B 1.64	Coffin
	PSE = 0.104	
Sept 82	A 2.93	Control
	B 2.21	Upright
	B 2.07	Warehouse
	B 2.04	Coffin
	PSE = 0.095	
Oct 82	A 2.79	Control
	BA 2.32	Warehouse
	CB 1.71	Upright
	C 1.64	Coffin
	PSE = 0.104	
Nov 82	A 2.86	Control
	A 2.36	Warehouse
	B 1.71	Coffin
	B 1.71	Upright
	PSE = 0.078	
Dec 82	A 3.32	Control
	A 3.00	Warehouse
	B 2.39	Upright
	C 1.50	Coffin
	PSE = 0.058	
Jan 83	A 2.36	Warehouse
	A 2.14	Control
	A 2.11	Upright
	B 1.29	Coffin
	PSE = 0.110	
Feb 83	A 2.86	Control
	B 2.00	Warehouse
	B 1.68	Upright
	C 1.07	Coffin
	PSE = 0.068	
March 83	A 2.86	Control
	A 2.54	Warehouse
	B 1.64	Upright
	B 1.50	Coffin
	PSE = 0.102	
April 83	A 2.75	Control
	BA 2.29	Upright
	B 2.04	Warehouse
	C 1.14	Coffin
	PSE = 0.099	
May 83	A 2.89	Control
	B 1.89	Upright
	B 1.82	Warehouse
	C 1.04	Coffin
	PSE = 0.113	
June 83	A 2.50	Control
	A 2.25	Warehouse
	B 1.75	Upright
	C 0.39	Coffin
	PSE = 0.097	
July 83	A 3.07	Control
	A 2.53	Warehouse
	B 1.89	Upright
	C 0.71	Coffin
	PSE = 0.126	
Aug 83	A 3.00	Control
	B 2.39	Warehouse
	C 1.71	Upright
	PSE = 0.091	

Table 20. Mean overall shrimp levels significantly different at the 0.05 level and pooled standard error (PSE), Tukey's studentized range test. Means with the same letter are not significantly different.

Consistent monthly significant differences in sweetness (Table 21) were not apparent until June 1983 (following eleven months storage). The coffin freezer levels were significantly less than the other experimental treatments for June and July 1983. Sweetness ratings for the upright freezer samples were significantly less than the warehouse freezer on five occasions, November 1982, February 1983, March 1983, June 1983, and August 1983, but no patterns of variations were distinguished.

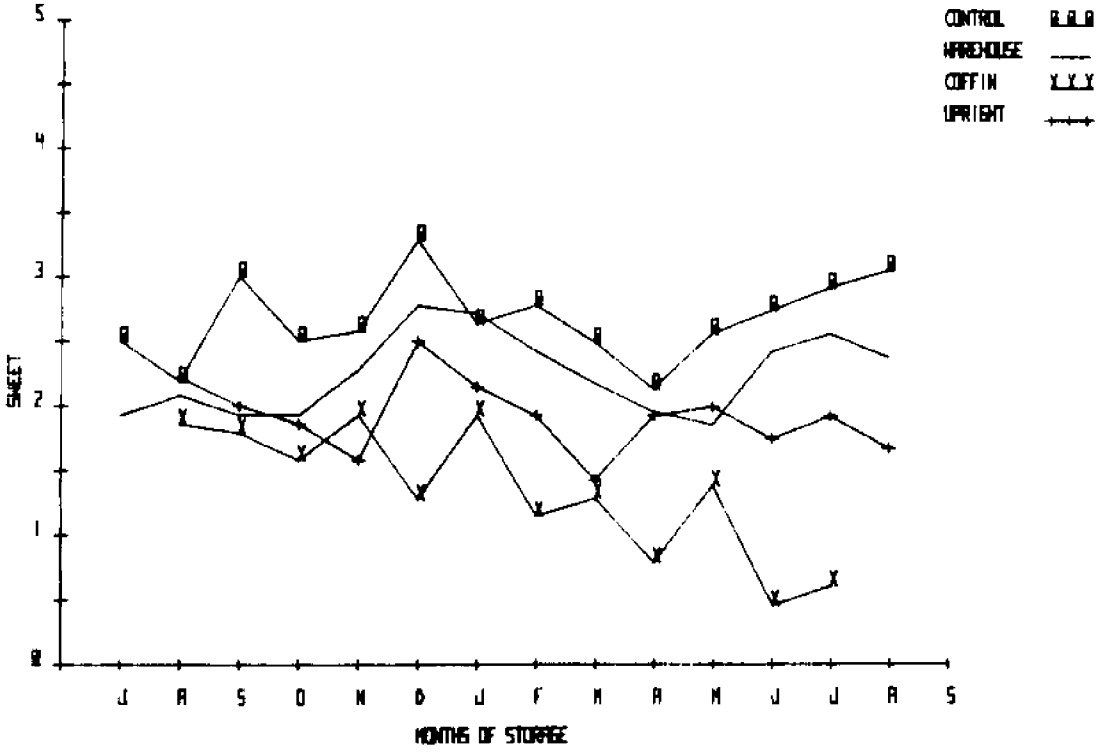

Figure 29. Mean monthly sweet intensity for control, warehouse, coffin, and upright samples.

U. Nutty Buttery

The initial nutty buttery rating of shrimp (Figure 30) stored in the horizontal freezer fell from 2.71 to 0.96 at the end of the study with a minimum of 0.57 in June 1983. The flavor rating remained below the wholesale level beginning in November 1982 and below the upright freezer ratings following December 1982. The perceived nutty buttery flavor from shrimp stored in the upright freezer was less than that observed in the wholesale shrimp for nine months of the study, with initial and final values of 2.65 and 1.89, respectively. The final three samples rated less than the wholesale shrimp. Wholesale ratings began at 2.58 and ended at 2.43, with a minimum value of 2.11 observed in May 1983. Control levels ranged from 2.11 to 3.28.

The perceived values of nutty buttery flavor for shrimp stored in the coffin freezer were significantly less than the warehouse and/or

Sweet

Month	Mean	Freezer
July 82	A 2.50	Control
	B 1.93	Warehouse
	PSE = 0.088	
Aug 82	No significant difference	
	PSE = 0.091	
Sept 82	A 3.00	Control
	B 2.00	Upright
	B 1.93	Warehouse
	B 1.79	Coffin
	PSE = 0.085	
Oct 82	A 2.50	Control
	BA 1.93	Warehouse
	BA 1.86	Upright
	B 1.57	Coffin
	PSE = 0.094	
Nov 82	A 2.57	Control
	BA 2.29	Warehouse
	CB 1.93	Coffin
	C 1.57	Upright
	PSE = 0.080	
Dec 82	A 3.29	Control
	BA 2.79	Warehouse
	B 2.50	Upright
	C 1.29	Coffin
	PSE = 0.078	
Jan 83	A 2.71	Warehouse
	BA 2.64	Control
	BA 2.14	Upright
	B 1.93	Coffin
	PSE = 0.099	
Feb 83	A 2.79	Control
	A 2.43	Warehouse
	B 1.93	Upright
	C 1.14	Coffin
	PSE = 0.054	
March 83	A 2.50	Control
	A 2.18	Warehouse
	B 1.43	Upright
	B 1.29	Coffin
	PSE = 0.094	
April 82	A 2.14	Control
	A 1.96	Warehouse
	A 1.93	Upright
	B 0.79	Coffin
	PSE = 0.108	
May 83	A 2.57	Control
	BA 2.00	Upright
	BA 1.93	Warehouse
	B 1.39	Coffin
	PSE = 0.089	
June 83	A 2.75	Control
	A 2.43	Warehouse
	B 1.75	Upright
	C 0.46	Coffin
	PSE = 0.080	
July 83	A 2.93	Control
	BA 2.57	Warehouse
	B 1.93	Upright
	C 0.61	Coffin
	PSE = 0.108	
Aug 83	A 3.07	Control
	A 2.39	Warehouse
	B 1.68	Upright
	PSE = 0.115	

Table 21. Mean sweetness levels significantly different at the 0.05 level and pooled standard error (PSE), Tukey's studentized range test. Means with the same letter are not significantly different.

upright freezer for seven of the last eight samples (five - twelve months storage) (Table 22). May 1983 (ten months storage) showed no significant differences between the experimental groups. Fresh shrimp samples had been delivered to both retail locations the preceeding month, 27 April 1983. The nutty buttery rankings of the upright freezer were significantly less than those of the warehouse freezer for the final three months of storage (June - August 1983). No other patterns were noted.

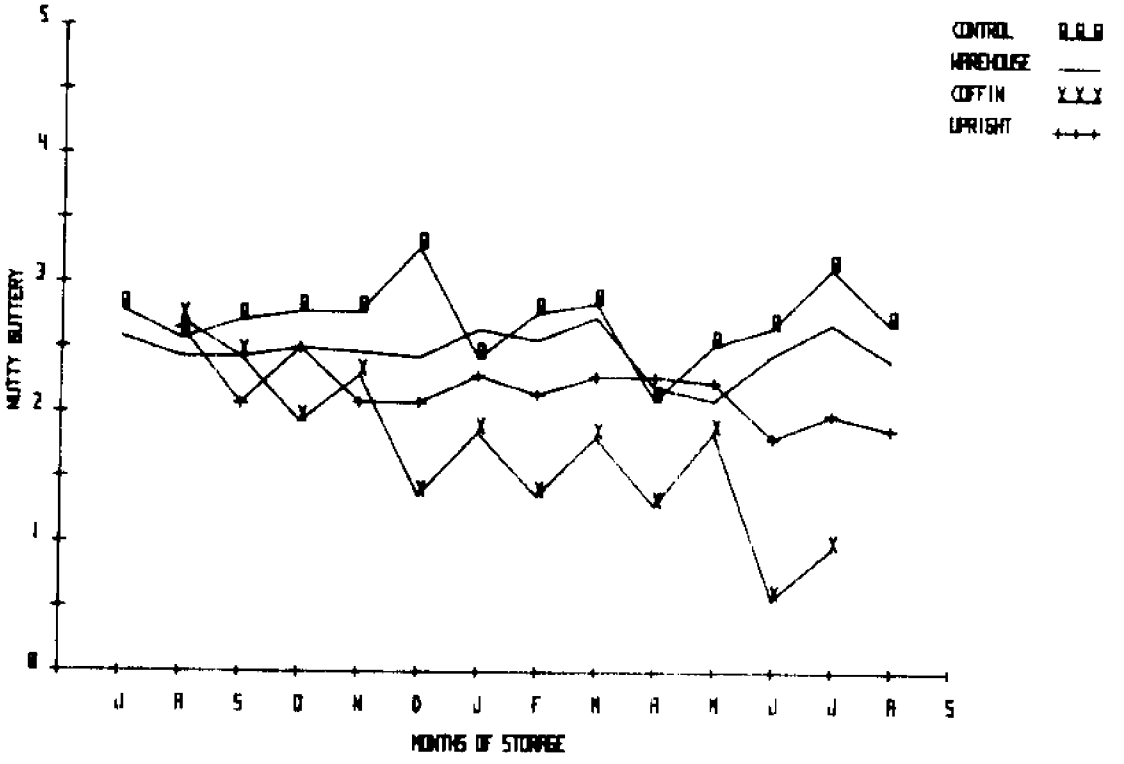

Figure 30. Mean monthly nutty buttery flavor for control, warehouse, coffin, and upright samples.

V. Old Seafood Flavors

Taste panel members perceived old seafood flavors in shrimp for the coffin freezer (Figure 31) to be greater than the wholesale samples on all occasions and greater than the upright freezer from December 1982 through the end of the study. Initial and final values were 1.64 and 3.39 with a maximum level of 3.75 (July 1983). The product from the vertical freezer exceeded the levels found in the wholesale freezer on all sampling dates except May 1983 (1.25 vertical, 1.46 wholesale). Initial and final vertical freezer levels were 2.07 and 1.68. Initial and final levels found in the wholesale freezer were 1.29 and 0.29 with peaks of 1.71 (September 1982) and 1.46 (May 1983). Control values ranged from 0.0 to 1.00.

Nutty Buttery

Month	Mean	Freezer
July 82	No significant difference	
	PSE = 0.089	
Aug 82	No significant difference	
	PSE = 0.081	
Sept 82	A 2.71	Control
	BA 2.43	Coffin
	BA 2.43	Warehouse
	B 2.07	Upright
	PSE = 0.080	
Oct 82	A 2.79	Control
	BA 2.50	Upright
	BA 2.50	Warehouse
	B 1.93	Coffin
	PSE = 0.083	
Nov 82	No significant difference	
	PSE = 0.099	
Dec 82	A 3.29	Control
	B 2.43	Warehouse
	B 2.29	Upright
	C 1.36	Coffin
	PSE = 0.065	
Jan 83	A 2.64	Warehouse
	BA 2.43	Control
	BA 2.29	Upright
	B 1.86	Coffin
	PSE = 0.081	
Feb 83	A 2.79	Control
	BA 2.57	Warehouse
	B 2.14	Upright
	C 1.36	Coffin
	PSE = 0.065	
March 83	A 2.86	Control
	A 2.75	Warehouse
	BA 2.29	Upright
	B 1.82	Coffin
	PSE = 0.101	
April 83	A 2.29	Upright
	A 2.14	Warehouse
	A 2.11	Control
	B 1.29	Coffin
	PSE = 0.081	
May 83	A 2.93	Control
	B 2.25	Upright
	B 2.11	Warehouse
	B 1.86	Coffin
	PSE = 0.083	
June 83	A 2.68	Control
	A 2.46	Warehouse
	B 1.82	Upright
	C 0.57	Coffin
	PSE = 0.065	
July 83	A 3.14	Control
	A 2.71	Warehouse
	B 2.04	Upright
	C 0.96	Coffin
	PSE = 0.073	
Aug 83	A 2.71	Control
	A 2.43	Warehouse
	B 1.89	Coffin
	PSE = 0.080	

Table 22. Mean nutty buttery levels significantly different at the 0.05 level and and pooled standard error (PSE), Tukey's studentized range test. Means with the same letter are not significantly different.

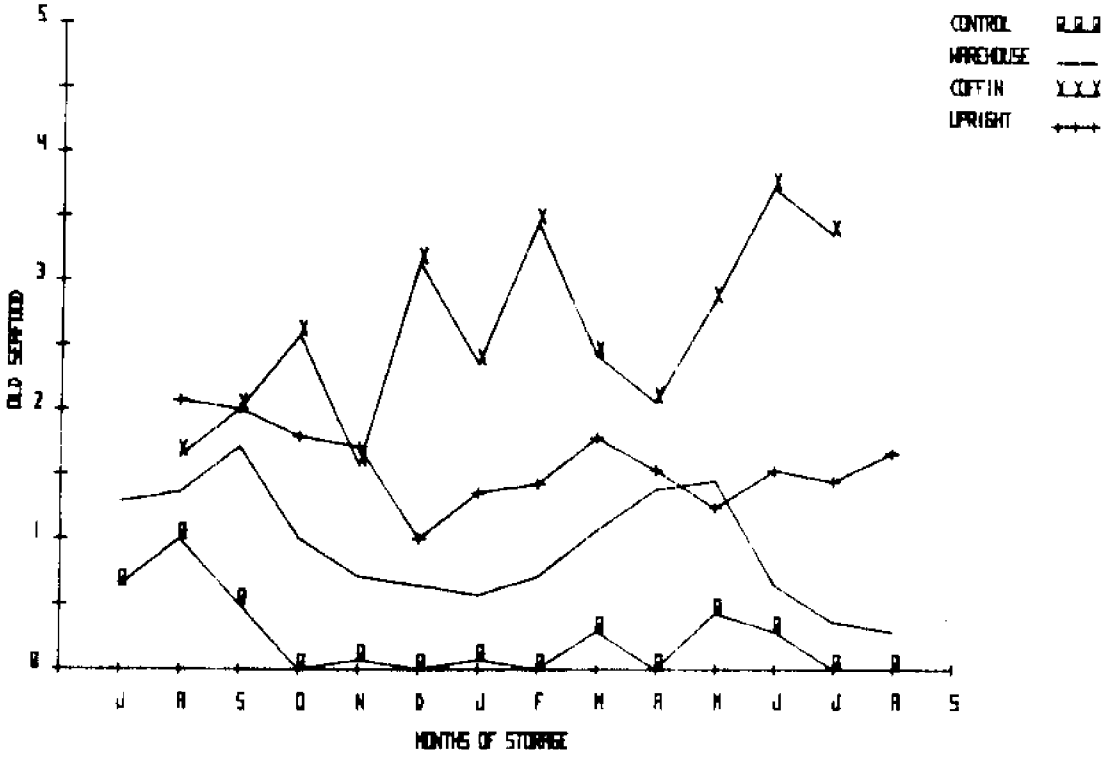

Figure 31. Mean monthly old seafood flavor for control, warehouse, coffin, and upright samples.

The mean levels of old seafood flavors detected in the coffin freezer samples were significantly greater than all other samples from October 1982 (three months storage) through July 1983 (twelve months storage) (Table 23). The levels remained significantly greater than the other areas except for the November 1982 and April 1983 coffin freezer samples which were preceeded by a 19 October 1982 and 2 March 1983 restocking of the freezers with breaded shrimp from the warehouse freezer. The perceived mean significant differences in old seafood flavor for the upright freezer exhibited an interesting pattern. October and November 1982 samples (three and four months storage) were significantly greater than warehouse samples and reflected the elevated storage temperatures associated with the upright freezer for those months. The old seafood level that was significantly greater than the warehouse value in February 1983 (seven months storage) occurred three months after the November 1982 stocking of the upright freezer. The control sample had significantly less perceived old seafood flavors than the warehouse freezer for nine of fourteen sample months; however, the last three months of the study exhibited no significant differences between the two samples.

W. Freezer Burn

Perceived freezer burn (Figure 32) from the coffin freezer samples exceeded the levels detected in all wholesale freezer samples except September 1982 (1.07 coffin, 1.07 wholesale). Freezer burn ratings were greater than the upright freezer samples from December 1982 through the end of the study. Initial and final horizontal freezer values were 1.14

Old Seafood

Month	Mean	Freezer
July 82	A 1.36	Warehouse
	B 0.64	Control
	PSE = 0.103	
Aug 82	A 2.07	Upright
	BA 1.64	Coffin
	BA 1.36	Warehouse
	B 1.00	Control
	PSE = 0.063	
Sept 82	A 2.00	Coffin
	A 2.00	Upright
	A 1.71	Warehouse
	B 0.50	Control
	PSE = 0.075	
Oct 82	A 2.57	Coffin
	B 1.79	Upright
	C 1.00	Warehouse
	D 0.00	Control
	PSE = 0.081	
Nov 82	A 1.79	Upright
	A 1.57	Coffin
	B 0.71	Warehouse
	C 0.07	Control
	PSE = 0.080	
Dec 82	A 3.14	Coffin
	B 1.00	Upright
	B 0.64	Warehouse
	C 0.07	Control
	PSE = 0.077	
Jan 83	A 2.36	Coffin
	B 1.36	Upright
	CB 0.64	Warehouse
	C 0.14	Control
	PSE = 0.078	
Feb 83	A 3.46	Coffin
	B 1.43	Upright
	C 0.71	Warehouse
	D 0.00	Control
	PSE = 0.070	
March 83	A 2.43	Coffin
	BA 1.79	Upright
	B 1.07	Warehouse
	C 0.29	Control
	PSE = 0.082	
April 83	A 2.07	Coffin
	A 1.54	Upright
	A 1.39	Warehouse
	B 0.00	Control
	PSE = 0.084	
May 83	A 2.86	Coffin
	B 1.46	Warehouse
	CB 1.25	Upright
	C 0.43	Control
	PSE = 0.090	
June 83	A 3.75	Coffin
	B 1.54	Upright
	C 0.64	Warehouse
	C 0.29	Control
	PSE = 0.062	
July 83	A 3.39	Coffin
	B 1.46	Upright
	C 0.36	Warehouse
	C 0.00	Control
	PSE = 0.078	
Aug 83	A 1.68	Upright
	B 0.29	Warehouse
	B 0.00	Control
	PSE = 0.076	

Table 23. Mean old seafood levels significantly different at the 0.05 level and pooled standard error (PSE), Tukey's studentized range test. Means with the same letter are not significantly different.

and 4.14. Upright freezer samples received higher freezer burn ratings than the wholesale freezer except for the September 1982 determination (1.04 upright, 1.07 wholesale). Initial and final freezer burn ratings were 1.86 and 2.54. Wholesale freezer burn levels began at 0.93, ended at 0.75, and peaked at 1.75 in May 1983. Control samples ranged between 0.0 and 0.43.

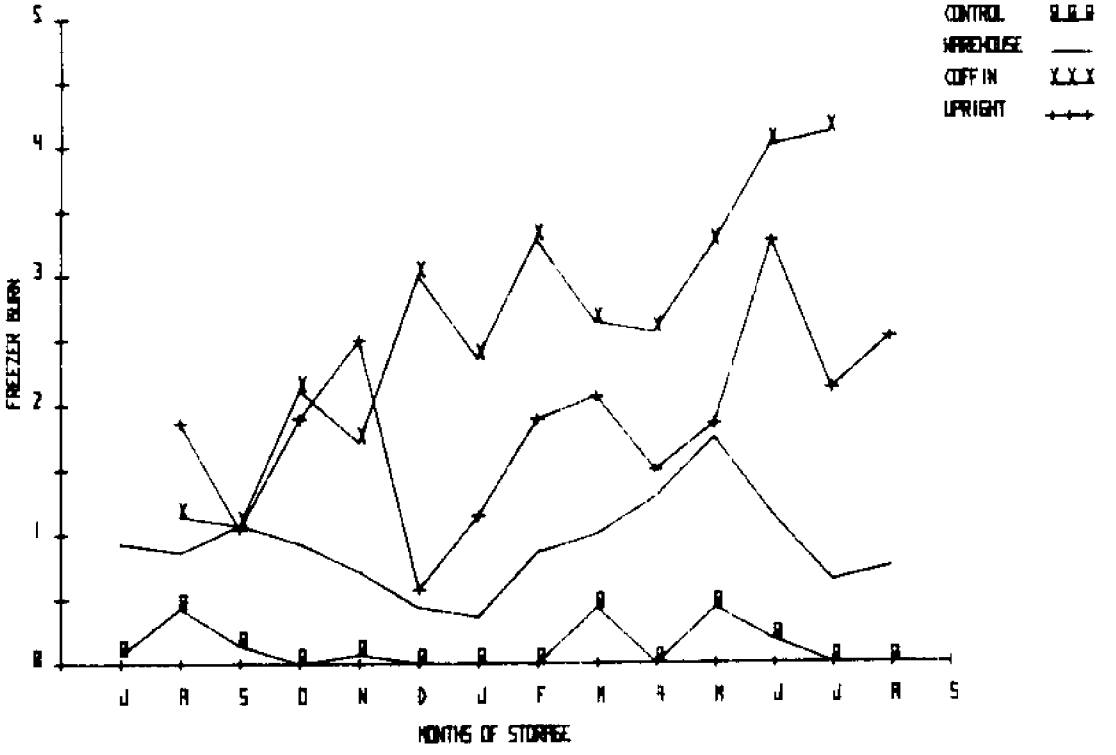

Figure 32. Mean monthly freezer burn flavor for control, warehouse, coffin, and upright samples.

Samples collected from the horizontal freezer had mean freezer burn levels significantly greater than the warehouse freezer and control shrimp from October 1982 (three months storage) through July 1983 (twelve months storage) (Table 24). The freezer burn ratings made by panelists for the upright freezer were significantly greater than the warehouse and control ratings in October and November 1982 (three and four months storage). Again the high freezer temperatures of October and November (Figure 3) were reflected by sensory results. The upright freezer burn sample levels were significantly greater than the warehouse and control shrimp in February and March (seven and eight months storage) three and four months after stocking the freezer on 12 November 1982 (Table 1). Mean monthly freezer burn levels were significantly greater than the warehouse and control samples for the final three months of the study, following eleven through thirteen months of storage. Control sample freezer burn rankings were significantly less than warehouse values for seven of fourteen samples, but no consistent pattern was determined.

Freezer Burn

Month	Mean	Freezer
July 82	A 0.93	Warehouse
	B 0.07	Control
	PSE = 0.104	
Aug 82	A 1.86	Upright
	BA 1.14	Coffin
	B 0.86	Warehouse
	B 0.43	Control
	PSE = 0.096	
Sept 82	A 1.07	Coffin
	A 1.07	Warehouse
	A 1.04	Upright
	B 0.14	Control
	PSE = 0.112	
Oct 82	A 2.11	Coffin
	A 1.89	Upright
	B 0.93	Warehouse
	C 0.00	Control
	PSE = 0.093	
Nov 82	A 2.29	Upright
	A 1.71	Coffin
	B 0.71	Warehouse
	B 0.07	Control
	PSE = 0.110	
Dec 82	A 3.00	Coffin
	B 0.57	Upright
	CB 0.43	Warehouse
	C 0.00	Control
	PSE = 0.071	
Jan 83	A 2.36	Coffin
	B 1.14	Upright
	CB 0.36	Warehouse
	C 0.00	Control
	PSE = 0.111	
Feb 83	A 3.29	Coffin
	B 1.89	Upright
	C 0.86	Warehouse
	D 0.00	Control
	PSE = 0.079	
March 83	A 2.64	Coffin
	A 2.07	Upright
	B 1.00	Warehouse
	B 0.43	Control
	PSE = 0.108	
April 83	A 2.57	Coffin
	B 1.50	Upright
	B 1.29	Warehouse
	C 0.00	Control
	PSE = 0.116	
May 83	A 3.25	Coffin
	B 1.86	Upright
	B 1.75	Warehouse
	C 0.05	Control
	PSE = 0.089	
June 83	A 4.04	Coffin
	B 2.29	Upright
	C 1.14	Warehouse
	D 0.18	Control
	PSE = 0.091	
July 83	A 4.14	Coffin
	B 2.14	Upright
	C 0.64	Warehouse
	C 0.00	Control
	PSE = 0.090	
Aug 83	A 2.54	Upright
	B 0.75	Warehouse
	C 0.00	Control
	PSE = 0.079	

Table 24. Mean freezer burn levels significantly different at the 0.05 level and pooled standard error (PSE), Tukey's studentized range test. Means with the same letter are not significantly different.

X. Rancidity

Panel members rated rancidity levels (Figure 33) from all coffin freezer samples greater than the wholesale freezer samples except for September 1982 (0.93 coffin freezer, 1.00 wholesale freezer). Coffin randicity levels increased from 1.07 (August 1982) to 2.04 (July 1983) with a peak of 2.57 in June 1983. The horizontal freezer levels remained above the upright freezer determinations from December 1982 through the end of the study. The vertical freezer level began at 1.43, ended at 0.36 and reached a maximum value of 1.79 (March 1983). Upright freezer rancidity levels exceeded wholesale levels except for two months, September 1982 (1.00 upright freezer, 1.00 wholesale freezer) and May 1983 (0.75 vertical freezer, 0.82 wholesale freezer). Initial and final wholesale freezer randicity levels were 0.79 and 0.0 with maximum of 1.00 in September 1982. Control samples ranged between 0.0 and 0.29.

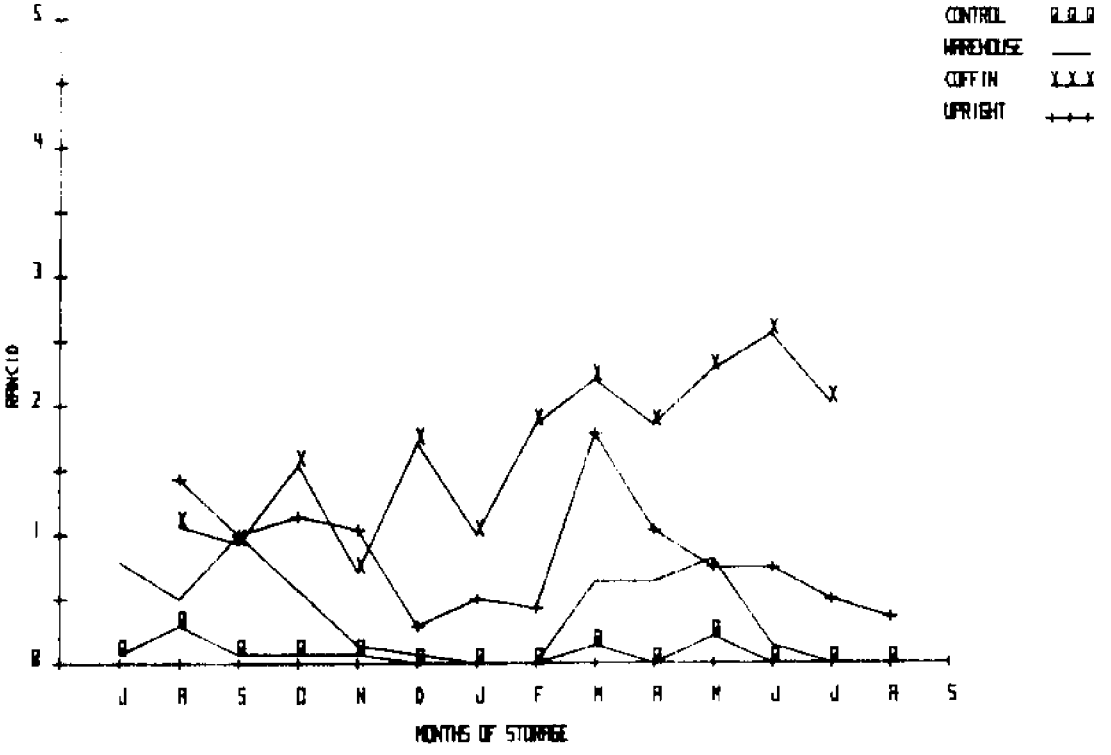

Figure 33. Mean monthly rancid flavor for control, warehouse, coffin, and upright samples.

Mean significant differences in rancidity patterns for the coffin freezer paralleled the freezer burn data with rancidity significantly greater than levels detected in the warehouse freezer from October 1982 (three months storage) through July 1983 (twelve months storage) (Table 25). Upright freezer samples had rancidity levels significantly greater than warehouse shrimp on three occasions, November 1982 (three

Rancid

Month	Mean	Freezer
July 82	A 0.79	Warehouse
	B 0.71	Control
	PSE = 0.100	
Aug 82	A 1.43	Upright
	BA 1.07	Coffin
	CB 0.50	Warehouse
	C 0.36	Control
	PSE = 0.085	
Sept 82	A 1.00	Upright
	A 1.00	Warehouse
	A 0.93	Coffin
	B 0.07	Control
	PSE = 0.098	
Oct 82	A 1.54	Coffin
	BA 1.14	Upright
	CB 0.57	Warehouse
	C 0.07	Control
	PSE = 0.088	
Nov 82	A 1.18	Upright
	A 0.71	Coffin
	B 0.14	Warehouse
	B 0.07	Control
	PSE = 0.075	
Dec 82	A 1.71	Coffin
	B 0.29	Upright
	B 0.07	Warehouse
	B 0.00	Control
	PSE = 0.054	
Jan 83	A 1.00	Coffin
	BA 0.50	Upright
	B 0.00	Control
	B 0.00	Warehouse
	PSE = 0.073	
Feb 83	A 1.86	Coffin
	B 0.43	Upright
	B 0.00	Control
	B 0.00	Warehouse
	PSE = 0.067	
March 83	A 2.21	Coffin
	A 1.79	Upright
	B 0.64	Warehouse
	B 0.14	Control
	PSE = 0.123	
April 83	A 1.86	Coffin
	B 1.04	Upright
	CB 0.64	Warehouse
	C 0.00	Control
	PSE = 0.096	
May 83	A 2.29	Coffin
	B 0.82	Warehouse
	B 0.75	Upright
	B 0.21	Control
	PSE = 0.121	
June 83	A 2.57	Coffin
	B 0.75	Upright
	B 0.14	Warehouse
	B 0.00	Control
	PSE = 0.103	
July 83	A 2.04	Coffin
	B 0.50	Upright
	B 0.00	Control
	B 0.00	Warehouse
	PSE = 0.091	
Aug 83	A 0.36	Upright
	B 0.00	Control
	B 0.00	Warehouse
	PSE = 0.056	

Table 25. Mean rancidity levels significantly different at the 0.05 level and pooled standard error (PSE), Tukey's studentized range test. Means with the same letter are not significantly different.

months storage), March 1983 (eight months storage), and August 1983 (thirteen months storage). Control rancidity levels were significantly less than warehouse levels in July 1982 and September 1982. No other patterns were apparent.

DISCUSSION

Net weight, percent moisture, and ammonium levels were the most useful chemical analyses in differentiating the three treatment conditions. The wholesale product lost 4.31% net weight by the end of the storage study (Table 26). The mean net weight of product stored in the upright freezer increased 8.72% and 15.33%, respectively, in October and November (1982), but registered a net decrease of 5.45% by the end of the study. Weight loss in the coffin freezer was greatest, with a net decrease of 13.44% when the study terminated. Moisture values reflected the net weight data (Table 27). The wholesale freezer lost 0.03% moisture, the upright freezer 2.52% and the coffin freezer 6.49%. Percent moisture increases of 4.10% and 5.85% in October and November 1982 paralleled net weight gain in the upright freezer during the same months. Maximum ammonium levels at the beginning and at the end of the study exhibited the same pattern: wholesale 5.00 mg/100g - 8.75 mg/100g, upright freezer, 10.4 mg/100g - 13.2 mg/100g, and coffin 13.5 mg/100g - 15.6 mg/100g. Trimethylamine data failed to differentiate the three treatment conditions.

Tukey's studentized range test (Ray, 1982) applied to the chemical data indicate that net weights and percent moisture, followed by ammonium levels were the most effective analyses to differentiate product collected from the three storage areas. The mean net weights of the coffin freezer sample were significantly less than those of the upright and/or warehouse freezer samples from the third through the twelfth month of storage, with the exception of the eighth and tenth months. The mean net weights of the upright freezer samples were significantly greater than the other samples in October and November 1983, concurrent with observed ice crystal formation and increased maximum daily temperatures of the upright freezer. Moisture levels determined for the coffin freezer shrimp were significantly less than the other storage area samples from one month of storage until the end of the project, except for the ninth month. The upright freezer registered significantly greater percent moisture content in October and November, paralleling the net weight gains for the same months. Product dessication was indicated by significantly lower moisture levels determined for upright samples during six of the last nine months of storage, including the final August 1983 sample. Ammonium levels from coffin stored shrimp were significantly greater than the other sample values from five months of storage through the eleventh month except for the ninth month. The freezer had been restocked one month earlier, so that total residence time in the coffin freezer was only one month.

Time From Manufacture	Wholesale Freezer	Retail Coffin Freezer	Retail Vertical Freezer
2 Weeks	238.76(0.00%)	----------	----------
1 Month	234.49(-1.79%)	234.58(-1.75%)	235.65(-1.30%)
6 Months	232.09(-2.79%)	209.67(-12.18%)	233.17(-2.34%)
9 Months	232.35(-2.68%)	220.03(-7.84%)	226.33(-5.21%)
12 Months	225.37(-5.61%)	206.68(-13.44%)	234.58(-1.75%)
13 Months	228.47(-4.31%)	----------	225.75(-3.45%)

Table 26. Mean net weight values of frozen breaded shrimp and percent change from the initial wholesale freezer mean value.

Time From Manufacture	Wholesale Freezer	Retail Coffin Freezer	Retail Vertical Freezer
2 Weeks	58.96%(0.00%)	----------	----------
1 Month	60.55%(+1.59%)	58.43%(-0.53%)	59.63%(+0.67%)
6 Months	59.06%(+0.10%)	54.29%(-4.67%)	57.23%(-1.73%)
9 Months	58.45%(-0.51%)	53.71%(-5.25%)	57.49%(-1.47%)
12 Months	57.58%(-1.38%)	52.47%(-6.49%)	58.74%(-0.22%)
13 Months	58.93%(-0.03%)	----------	56.44%(-2.52%)

Table 27. Mean percent moisture values and percent change of frozen breaded shrimp calculated from the initial wholesale freezer mean value.

The percent shrimp determined for all wholesale and retail samples failed to meet the Standard of Identity for breaded shrimp that specifies a minimum content of 50% shrimp for frozen raw breaded shrimp (FDA, 1976). The initial wholesale freezer sample, six days after the production run, contained 5.26% less shrimp (46.24%) than was determined at the Brownsville, Texas facility (51.50%) on the production line (Table 28). The rapid decrease in percent shrimp, net weight decreases, and percent moisture changes attributed to moisture migration from the shrimp into the breading and out of the package is consistent with studies by Rao, et al. (1975) and Williams, et al. (1981).

Williams monitored changes in net weight, percent moisture, and percent shrimp during a nine month study of blast frozen breaded shrimp stored in warehouse and retail freezers. Williams' results were similar to those determined by this study. The net weight of shrimp stored in the retail freezer decreased more rapidly than shrimp stored in the warehouse freezer (Table 29). The mean net weight of shrimp frozen for Williams' study decreased 0.6% following freezing by the blast freezer. After freezing, percent decreases for the wholesale freezer at one, six and nine months were 1.3%, 0.2%, and 1.8% compared with 1.79%, 2.79%, and 2.68% decreases for the present study (Table 27). Williams' retail freezer samples lost 1.4%, 6.2%, and 9.3% net weight following one, six and nine months of storage. The vertical freezer samples lost less weight than Williams' retail freezer with 1.30%, 2.34%, and 5.21% decreases, while the coffin freezer results were mixed with 1.75%, 12.18%, and 7.84% decreases for one, six, and nine months, respectively. Percent moisture changes detected from shrimp stored in Williams' wholesale and retail freezers were similar to the present results. Initial freezing reduced mean moisture content by 0.9%. Moisture loss was accelerated in the retail freezers, compared with warehouse freezers. Moisture loss from samples in Williams' warehouse freezer was greater than that determined for the present study. The dessication of samples from Williams' retail freezer was greater than that determined for our upright freezer, but less than the observed values for the coffin freezer (Tables 27 and 29).

Data from Williams, et al. (1980) and Rao, et al. (1975) indicate a rapid loss in the relative percent shrimp present in a breaded shrimp sample after freezing. Williams' samples lost 6.80% shrimp following blast freezing which reduced mean percent shrimp levels from 51.1% to 44.3%. The relative percent loss of shrimp was reduced to 4.3% by the second week (Table 30). The current study determined a 5.26% shrimp loss at the end of two weeks storage in the warehouse freezer (Table 28). Rao reported 14.24% and 13.62% losses following one and two weeks of storage (Table 31). The overall decrease in percent shrimp was greater for the retail freezers than the warehouse freezers in Williams' and the present study (Tables 28 and 30). In the current study, percent shrimp loss decreased for both wholesale and retail freezers after initial freezing, reached a minimum at six months, and increased through the next six months of storage (Table 28 and Figure 10).

Time From Manufacture	Wholesale Freezer	Retail Coffin Freezer	Retail Vertical Freezer
0	51.50%(0.00%)*	----------	----------
2 Weeks	46.24%(-5.26%)	----------	----------
1 Month	45.81%(-5.62%)	42.86%(-8.64%)	45.81%(-5.69%)
6 Months	47.43%(-4.07%)	48.04%(-3.46%)	47.88%(-3.62%)
9 Months	47.36%(-4.14%)	46.87%(-4.63%)	47.20%(-4.30%)
12 Months	46.12%(-5.38%)	45.18%(-6.32%)	44.32%(-7.18%)
13 Months	46.17%(-5.33%)	----------	45.20%(-6.30%)

* Before Freezing

Table 28. Mean percent shrimp values and percent change of frozen breaded shrimp calculated from the initial percent shrimp content of the production line before freezing.

Storage Time	Net Weights		Moisture	
	Wholesale	Retail	Wholesale	Retail
2 Weeks	-1.1%	-1.2%	+0.8%	0.0%
1 Month	-1.3%	-1.4%	+0.7%	+0.5%
6 Months	-0.2%	-6.2%	-1.4%	-3.6%
9 Months	-1.8%	-9.3%	-1.2%	-6.3%

Table 29. Mean percent net weight and moisture changes in blast frozen breaded shrimp calculated from data presented by S. K. Williams, et al. (1981).

Storage Time	Percent Shrimp	
	Wholesale	Retail
2 Weeks	-4.3%	-3.2%
1 Month	-5.6%	-2.7%
6 Months	-6.0%	-5.3%
9 Months	-5.7%	-7.9%

Table 30. Mean percent shrimp changes in blast frozen breaded shrimp calculated from data presented by S. K. Williams, et al. (1981).

Storage Time Weeks	Percent Shrimp
1	-14.24
2	-13.62
3	-13.35
4	-11.84
5	-10.11

Table 31. Mean percent shrimp changes in slow frozen (-21°C) breaded shrimp from Rao, et al. (1975).

The transfer of moisture to and from packaged breaded shrimp and the movement of moisture within the product itself represents a continuing quality and regulatory problem facing the manufacturers of frozen breaded shrimp. The data indicate that the storage of breaded shrimp at the retail level compounds the problem and hastens quality deterioration. The constant defrosting and higher storage temperatures of the coffin and upright freezers reduced moisture contents, net weights, and percent shrimp of products stored at the retail level more rapidly than was observed under the controlled conditions encountered in the wholesale freezer. The higher mean temperatures observed in the coffin freezer produced significant reductions in moisture content by the first month of storage and significant reductions in mean net weights by the second month of storage. The upright samples experienced a significant net weight gain in October and November of 1982. Large ice crystals collected in the packages following two months of freezer defrost temperatures that exceeded 0°C. Significant dessication was also observed in the upright freezer by the end of the study.

The development of frozen seafood packaging that provides a moisture barrier and a program to educate retail merchants on proper frozen seafood handling and temperature control would reduce the dessication of frozen breaded products. The control of moisture migration within the product was beyond the scope of this project; however, the work of Williams, et al. (1981) and Rao, et al. (1975) provides some answers to moisture migration problems associated with frozen breaded shrimp. The use of rapid IQF (individually quick frozen) and finer breading material helped reduce percent shrimp loss from frozen product. Moisture loss was less rapid and net weights remained more constant following rapid freezing. Fine breading helped maintain a more constant equilibrium between percent breading and percent shrimp values. The fine breading wicked away moisture at a rate more closely approximating the migration of moisture from the shrimp into the breading.

The nutritional and microbiological analyses revealed no apparent differences for breaded shrimp stored in the three freezers. Product wet weight protein and ash increased from April through July in the coffin freezer, but the trend disappeared on moisture-free/ash-free and moisture-free bases, respectively. Thiamine levels decreased rapidly for all three experimental samples from July to September, 1982. Thiamine concentrations stabilized and randomly ranged from 0.014 - 0.043 mg/100g shrimp with a mean of 0.025 mg/100g for the reaminder of the study. Riboflavin concentrations decreased from their initial levels but stabilized in November 1982 and randomly ranged from 0.016 - 0.057 mg/100g shrimp with a mean of 0.037 mg/100g through August 1983. The range of thiamine concentrations from September 1982 (0.014 - 0.043 mg/100g) bracketed the 0.03 mg/100g value given by the Department of Agriculture Handbook No. 8 (Watt and Merrill, 1975) for breaded shrimp. The mean value 0.025 mg/100g was less than the accepted value. Riboflavin levels from November 1982 (0.016 - 0.057 mg/100g) bracketed the Department of Agriculture value of 0.03 mg/100g and the mean of 0.037 mg/100g exceeded the published value. All microbiological levels were within Georgia Department of Agriculture standards. No sample differences were noted.

The nutritional quality of shrimp stored in the wholesale and retail freezers was maintained throughout the study as evidenced by protein, thiamine, and riboflavin levels. The nutritional quality of the shrimp could not be differentiated by the three storage conditions. Thiamine and riboflavin concentrations decreased following the first three to four months of storage, but the mean vitamin levels were within -0.005 mg/100g and +0.007 mg/100g of published vitamin levels for thiamine and riboflavin, respectively (Watt and Merrill, 1975).

The textural and flavor characteristics of shrimp stored in the wholesale and retail freezers, as perceived by the taste panel, proved to be the most discriminating tool to differentiate product quality throughout the study. Hardness and chewiness increased for both coffin and upright freezer samples with time. The initial and final horizontal and vertial ratings were 2.29 - 4.11, 2.14 - 2.75 hardness and 2.36 - 4.21, 2.29 - 2.75 chewiness. Hardness and chewiness ratings of coffin freezer samples exceeded both upright and wholesale levels by November 1982 and the upright freezer exceeded wholesale levels in June 1983. Wholesale freezer hardness and chewiness levels decreased from 3.00 - 2.00 and 3.14 - 2.07, respectively. The coffin freezer samples were rated significantly harder than the other samples by the fourth month of storage. The pattern continued until the end of the study, except for March 1983 which showed no significant difference between upright and horizontal samples. The upright freezer had not been restocked for four months before the March sample was collected. The chewiness pattern was similar to the hardness observations for the coffin freezer. The upright freezer samples were significiantly chewier than the warehouse samples for the twelfth and thirteenth months of storage. Coffin freezer fibrousness increased from 2.57 - 3.82 and was significantly greater than other sample ratings from October 1982 through July 1983 (five - twelve months storage).

Early product dessication was indicated by moistness ratings from the coffin freezer samples. Horizontal freezer moistness profiles were less than those perceived for the other sample conditions during the entire study. Coffin freezer values dropped from 2.93 - 1.14. Vertical freezer samples decreased from 3.29 - 2.75 and fell below the wholesale samples in May 1983. Wholesale moistness ratings increased from 2.79 - 2.93 by August 1983. The perceived moistness of coffin freezer samples was significantly less than the warehouse and upright freezer samples for the third through the twelfth month of storage, except for March and May 1983 when no significant difference was detected. Significantly greater moistness ratings than the other storage areas were given to vertical samples in October and November 1982. The ratings correlated with significantly greater percent moisture values determined for the same samples. Significant dessication in upright freezer samples was detected in the eleventh and twelfth months of storage when compared to the warehouse samples. The thirteenth month, one month after product was delivered to the vertical freezer from the wholesale freezer, showed no significant difference. Oily mouth coating values failed to differentiate the three storage conditions.

Textural properties of fried breaded shrimp perceived by a trained taste panel proved to be an effective method to detect quality changes in shrimp stored under wholesale and retail conditions. Panel members detected lower perceived moistness in samples from the coffin freezer as early as the first month of storage and significantly different by the third month. Decreased moistness was detected in the upright freezer samples by the tenth month of storage and significantly different by the eleventh month. Coffin freezer samples registered significantly greater hardness and chewiness ratings by the fourth month of storage, while vertical freezer sample chewiness was differentiated by the eleventh month of storage. Textural changes in the wholesale shrimp were less than those observed in the retail samples. The greatest textural changes occurred in the coffin freezer samples and these changes were detected much earlier in the storage study than quality changes associated with the vertical freezer. Vertical freezer sample rating differences with storage time were greater than those perceived for the wholesale freezer.

Panel members readily detected flavor profile differences in breaded shrimp stored under the three experimental conditions. The detected level of overall shrimp flavor decreased from 1.65 - 0.71 for the coffin freezer and 1.78 - 1.71 for the vertical freezer. Overall shrimp flavor detected from coffin freezer shrimp was significantly less than the other samples by the fifth month of the study while the vertical freezer shrimp levels remained significantly less than the wholesale shrimp following the eleventh month of storage. Nutty buttery ratings exhibited the same pattern as the overall seafood values except for May 1983 which showed no significant differences between the experimental samples. New product had been transferred from the warehouse freezer to both retail freezers in April. Sweet levels showed significantly lower levels for the coffin freezer samples for the eleventh and twelfth months of storage. Detected old seafood flavors increased most rapidly in the coffin stored shrimp (1.64 - 3.39) and significantly exceeded the levels of the other samples by the third month of storage. The levels remained greater than the other areas except for the November 1982 and April 1983 samples, which were collected one month after restocking the coffin freezer. Perceived old seafood flavors decreased for the wholesale (1.29 - 0.29) and vertical retail (2.07 - 1.68) freezers with time, but the wholesale level fell more rapidly and remained significantly below the vertical freezer ratings by the eleventh month of the study. Additionally, the old seafood flavor ratings for October and November 1983 showed the vertical freezer samples to be significantly greater than the warehouse shrimp. The data reflect temperature abuse detected in the upright freezer at that time (Figure 3), when maximum defrost temperatures exceeded 0°C. The February 1983 upright freezer sample had a significantly higher old seafood rating than the warehouse freezer. The February sample was collected three months after the last product was transferred to the upright freezer. Detectable freezer burn increased with time for both the coffin freezer samples (1.14 - 4.14) and the vertical freezer samples (1.86 - 2.54). Wholesale freezer burn ratings decreased from 0.93 - 0.75. Freezer burn results closely parallelled the patterns developed by overall shrimp flavor, nutty buttery flavor, and old seafood flavor.

The coffin freezer had significantly greater ratings, indicating poorer quality than the upright and warehouse freezers from the third through the twelfth month of storage. The temperature abuse detected in the upright freezer registered as significantly greater freezer burn than the warehouse samples in October and November 1982. February and March 1983 rated signficantly higher freezer burn levels than the warehouse freezer, three and four months, respectively, after the freezer was restocked. The final three months of the storage study provided significantly greater freezer burn levels for the vertical freezer samples than warehouse samples. Rancidity ratings increased with storage time for the coffin freezer samples (1.07 - 2.04) while the other samples decreased with time. The coffin freezer rancidity levels were significantly greater than warehouse values from the third through twelfth months. Again the wholesale freezer levels (0.70 - 0.00) fell more rapidly than the vertical freezer samples (1.43 - 0.36).

Modified flavor profiles of fried frozen breaded shrimp effectively differentiated samples collected from the three storage conditions. Sample deterioration was detected within three to five months of storge for the coffin freezer samples, and within eleven months of storage for the vertical freezer samples. Samples stored in the wholesale freezer exhibited the least changes during storage.

CONCLUSIONS AND RECOMMENDATIONS

The nutritional quality of frozen breaded shrimp showed little deterioration following thirteen months of storage at the wholesale and retail levels. Protein, thiamine, and riboflavin levels revealed no differences among a warehouse freezer, an upright freezer, and a horizontal coffin freezer. Vitamin levels decreased rapidly following two months of storage; however, levels remained fairly constant for the next eleven months and within 0.007 mg/100g of published U. S. Department of Agriculture nutritional data (Watt and Merrill, 1975).

Monthly monitoring of percent moisture, net weights, ammonium levels, and organoleptic qualities proved effective methods to evaluate product quality and differentiate frozen breaded shrimp stored in a wholesale warehouse, a retail upright freezer, and a retail horizontal freezer. Product stored in the wholesale freezer exhibited the least deterioration with time. The quality of the retail product decreased much more rapidly in the coffin freezer, showing more rapid and earlier deterioration than the upright freezer. Approximately four months into the study, the quality of shrimp stored in the retail coffin freezer was less than that associated with the vertical retail freezer or the warehouse freezer. Product stored in the horizontal freezer was exposed to higher minimum temperatures than were encountered in the vertical or warehouse freezer. Daily minimum temperatures were consistently 5 - 10°C greater than the minimum upright freezer temperatures, while little difference in daily maximum temperatures was noted. Freezer temperatures exceeded -7°C on 5% of the monitored days. Minimum freezer temperatures were

≤-20°C on only 14 of the monitored days. Variations between maximum and minimum temperatures for the retail freezers were approximately 12°C for the coffin freezer and 14 - 18°C for the upright freezer. The defrost cycles were 6 - 8 hours and 6 - 12 hours, respectively. The vertical freezer exceeded 0°C on 5% of the days, but reached a minimum temperature of ≤-20°C on 36% of the days. Elevated temperatures in October and November 1982 were readily detected by chemical and organoleptic monitoring of product stored in the upright freezer. The warehouse freezer exhibited the lowest mean temperatures with only a 2 - 3°C daily temperature variation. Organoleptic evaluation against the control product indicated no consistent significant differences following thirteen months of storage. Eleven months into the study, noticeable and consistent quality deterioration was detected in the vertical freezer samples. Product samples from the vertical freezer in February and March 1983 (three and four months after breaded shrimp had been restocked) showed significantly different organoleptic qualities than those observed for the wholesale freezer. Product quality in the coffin freezer was judged to be below minimum consumer standards by the end of the study.

The results of the study indicate that significant organoleptic deterioration can be detected as early as three to four months after production when shrimp are stored in a retail freezer. Net weight and percent moisture changes support the contention. As the age of the product increases, shorter storage times at the retail levels will precipitate measureable organoleptic and chemical deterioration within the product. Storage at the wholesale level below -20°C proved to be an effective method to maintain the quality of frozen breaded shrimp for at least thirteen months of storage.

All tested product failed to meet the U. S. Standard of Identity for frozen breaded shrimp of a minimum of 50% shrimp content, despite the fact that the breaded product contained 51.5% shrimp before freezing (FDA, 1976). Product held in the warehouse freezer had the greatest shrimp levels after thirteen months of storage. Williams, et al. (1981) and Rao, et al. (1975) suggest rapid freezing and the use of finer grained breading to reduce the relative loss of percent shrimp through moisture migration. The introduction of moisture barrier packaging would also help alleviate quality and regulatory problems associated with moisture migration.

An educational program should be developed to apprise retail merchants of the importance of temperature control and good product handling techniques for maintenance of proper quality for all frozen foods, but especially seafood. The current study indicates that the greatest quality deterioration occurs on the retail level; however, consumer dissatisfaction and regulatory action is generally directed to the original manufacturer. Additional handling abuses are probable while the product is transported from the wholesale to retail locations. The effects of product transportation on quality were not addressed by this study. Development of improved product packing, breading formulations, and the training of retail personnel would greatly increase the quality of frozen breaded shrimp offered to the consuming public.

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APPENDIX

Month	Freezer	N	Mean	Std. Error of Mean	Month	Freezer	N	Mean	Std. Error of Mean
July 82	Upright	-	--	--	Feb 83	Upright	5	235.10	3.88
	Warehouse	5	238.76	4.64		Warehouse	5	229.49	2.21
	Coffin	-	--	--		Coffin	5	206.71	7.01
Aug 82	Upright	5	235.65	4.99	March 83	Upright	5	227.53	4.29
	Warehouse	5	234.49	4.61		Warehouse	5	240.09	2.82
	Coffin	5	234.58	2.24		Coffin	5	223.26	8.89
Sept 82	Upright	5	240.63	3.23	April 83	Upright	5	226.33	2.42
	Warehouse	5	240.17	4.41		Warehouse	5	232.35	3.31
	Coffin	5	222.08	5.00		Coffin	5	220.03	2.23
Oct 82	Upright	5	259.59	5.25	May 83	Upright	5	229.12	3.79
	Warehouse	5	235.58	5.24		Warehouse	5	234.89	3.47
	Coffin	5	215.16	2.64		Coffin	5	216.30	10.29
Nov 82	Upright	5	275.36	17.65	June 83	Upright	5	239.88	9.40
	Warehouse	5	231.74	1.61		Warehouse	5	227.96	2.64
	Coffin	5	222.55	3.88		Coffin	5	211.85	6.08
Dec 82	Upright	5	235.10	1.78	July 83	Upright	5	234.58	2.66
	Warehouse	5	241.96	5.01		Warehouse	5	225.37	1.90
	Coffin	5	207.06	2.58		Coffin	5	206.68	10.18
Jan 83	Upright	5	230.30	2.33	Aug 83	Upright	5	219.26	4.50
	Warehouse	5	232.09	4.29		Warehouse	5	228.47	2.14
	Coffin	5	209.67	8.34		Coffin	-	--	--

Table 32. Net Weight (grams) means, number of samples, and standard errors of the mean.

Month	Freezer	N	Mean	Std. Error of Mean	Month	Freezer	N	Mean	Std. Error of Mean
July 82	Upright	-	--	--	Feb 83	Upright	2	58.68	0.25
	Warehouse	2	58.96	0.04		Warehouse	2	59.75	0.21
	Coffin	-	--	--		Coffin	2	50.70	0.11
Aug 82	Upright	2	59.63	0.06	March 83	Upright	2	53.89	0.40
	Warehouse	2	60.55	0.09		Warehouse	2	57.94	0.08
	Coffin	2	58.43	0.08		Coffin	2	54.87	0.09
Sept 82	Upright	2	59.09	0.03	April 83	Upright	2	55.59	1.89
	Warehouse	2	59.21	0.03		Warehouse	2	58.40	0.05
	Coffin	2	55.63	0.11		Coffin	2	53.75	0.05
Oct 82	Upright	2	63.05	0.21	May 83	Upright	2	57.85	0.07
	Warehouse	2	58.40	0.07		Warehouse	2	58.93	0.01
	Coffin	2	53.35	0.01		Coffin	2	50.64	0.25
Nov 82	Upright	2	64.31	0.03	June 83	Upright	2	55.63	0.33
	Warehouse	2	57.50	0.12		Warehouse	2	59.49	0.11
	Coffin	2	56.21	0.43		Coffin	2	52.65	0.23
Dec 82	Upright	2	58.70	0.09	July 83	Upright	2	58.74	0.16
	Warehouse	2	59.57	0.09		Warehouse	2	57.58	0.14
	Coffin	2	54.95	0.15		Coffin	2	52.47	0.34
Jan 83	Upright	2	57.23	0.09	Aug 83	Upright	2	56.44	0.13
	Warehouse	2	59.09	0.03		Warehouse	2	58.93	0.05
	Coffin	2	54.54	0.25		Coffin	-	--	--

Table 33. Percent Moisture means, number of samples, and standard errors of the mean.

Month	Freezer	N	Mean	Std. Error of Mean	Month	Freezer	N	Mean	Std. Error of Mean
July 82	Upright	-	--	--	Feb 83	Upright	2	12.65	0.85
	Warehouse	2	5.60	0.20		Warehouse	2	13.25	0.75
	Coffin	-	--	--		Coffin	2	18.75	0.75
Aug 82	Upright	2	10.40	0.60	March 83	Upright	2	10.40	0.60
	Warehouse	2	10.30	0.70		Warehouse	2	8.50	0.50
	Coffin	2	13.50	0.50		Coffin	2	12.50	0.50
Sept 82	Upright	2	11.00	0.60	April 83	Upright	2	12.25	0.25
	Warehouse	2	9.00	0.40		Warehouse	2	11.75	0.25
	Coffin	2	8.30	0.10		Coffin	2	13.50	0.50
Oct 82	Upright	2	13.50	0.60	May 83	Upright	2	18.50	0.50
	Warehouse	2	13.75	0.75		Warehouse	2	12.35	0.85
	Coffin	2	17.45	0.05		Coffin	2	13.45	0.55
Nov 82	Upright	2	10.25	0.25	June 83	Upright	2	15.85	0.35
	Warehouse	2	12.15	0.15		Warehouse	2	9.65	0.05
	Coffin	2	13.50	0.50		Coffin	2	22.00	1.00
Dec 82	Upright	2	14.40	0.40	July 83	Upright	2	15.10	0.10
	Warehouse	2	10.75	0.75		Warehouse	2	11.45	1.45
	Coffin	2	16.75	0.25		Coffin	2	15.60	0.40
Jan 83	Upright	2	15.50	1.50	Aug 83	Upright	2	13.20	0.00
	Warehouse	2	9.70	0.10		Warehouse	2	8.75	0.25
	Coffin	2	20.50	0.50		Coffin	-	--	--

Table 34. Ammonium (mg/100g) means, number of samples, and standard errors of the mean.

Month	Freezer	N	Mean	Std. Error of Mean	Month	Freezer	N	Mean	Std. Error of Mean
July 82	Upright	-	--	--	Feb 83	Upright	2	32.97	2.21
	Warehouse	2	14.99	0.24		Warehouse	2	35.47	2.01
	Coffin	-	--	--		Coffin	2	40.76	1.63
Aug 82	Upright	2	27.75	1.60	March 83	Upright	2	24.17	1.39
	Warehouse	2	28.15	1.91		Warehouse	2	21.73	1.27
	Coffin	2	34.95	1.29		Coffin	2	29.47	1.15
Sept 82	Upright	2	28.95	1.55	April 83	Upright	2	30.95	0.63
	Warehouse	2	23.90	1.06		Warehouse	2	30.41	0.65
	Coffin	2	20.12	0.24		Coffin	2	31.34	1.16
Oct 82	Upright	2	39.25	1.75	May 83	Upright	2	47.13	1.30
	Warehouse	2	35.61	1.95		Warehouse	2	32.30	2.22
	Coffin	2	39.85	0.11		Coffin	2	29.25	1.19
Nov 82	Upright	2	30.83	0.75	June 83	Upright	2	38.49	0.85
	Warehouse	2	30.74	0.38		Warehouse	2	25.61	0.13
	Coffin	2	30.09	1.23		Coffin	2	50.00	2.27
Dec 82	Upright	2	37.55	1.05	July 83	Upright	2	39.35	0.26
	Warehouse	2	28.59	1.99		Warehouse	2	29.02	3.67
	Coffin	2	39.99	0.60		Coffin	2	35.31	0.91
Jan 83	Upright	2	39.09	3.79	Aug 83	Upright	2	32.75	0.00
	Warehouse	2	25.54	0.26		Warehouse	2	23.00	0.66
	Coffin	2	48.59	1.19		Coffin	-	--	--

Table 35. Moisture Free/Ash Free Ammonium (mg/100g) means, number of samples, and standard errors of the mean.

Month	Freezer	N	Mean	Std. Error of Mean	Month	Freezer	N	Mean	Std. Error of Mean
July 82	Upright	-	--	--	Feb 83	Upright	2	11.39	0.31
	Warehouse	2	10.76	0.03		Warehouse	2	10.87	0.03
	Coffin	-	--	--		Coffin	2	11.66	0.14
Aug 82	Upright	2	10.59	0.19	March 83	Upright	2	10.85	0.33
	Warehouse	2	10.76	0.23		Warehouse	2	10.71	0.67
	Coffin	2	11.34	0.29		Coffin	2	9.99	0.43
Sept 82	Upright	2	10.12	0.32	April 83	Upright	2	11.15	0.37
	Warehouse	2	11.23	0.09		Warehouse	2	10.99	0.23
	Coffin	2	11.61	0.05		Coffin	2	12.01	0.54
Oct 82	Upright	2	10.39	0.17	May 83	Upright	2	11.40	0.09
	Warehouse	2	10.42	0.43		Warehouse	2	11.09	0.20
	Coffin	2	11.85	0.05		Coffin	2	13.10	0.30
Nov 82	Upright	2	10.99	0.36	June 83	Upright	2	10.84	0.10
	Warehouse	2	12.05	0.13		Warehouse	2	10.71	0.31
	Coffin	2	12.61	0.11		Coffin	2	13.53	0.39
Dec 82	Upright	2	11.45	0.15	July 83	Upright	2	12.09	0.14
	Warehouse	2	11.79	0.19		Warehouse	2	12.42	0.26
	Coffin	2	12.51	0.27		Coffin	2	13.65	0.01
Jan 83	Upright	2	11.61	0.23	Aug 83	Upright	2	11.83	0.49
	Warehouse	2	10.77	0.19		Warehouse	2	11.42	0.51
	Coffin	2	11.53	0.19		Coffin	-	--	--

Table 36. Percent Protein means, number of samples, and standard errors of the mean.

Month	Freezer	N	Mean	Std. Error of Mean	Month	Freezer	N	Mean	Std. Error of Mean
July 82	Upright	-	--	--	Feb 83	Upright	2	29.69	0.79
	Warehouse	2	28.25	0.07		Warehouse	2	29.11	0.07
	Coffin	-	--	--		Coffin	2	25.35	0.31
Aug 82	Upright	2	28.27	0.49	March 83	Upright	2	25.21	0.75
	Warehouse	2	29.41	0.63		Warehouse	2	27.39	1.73
	Coffin	2	29.36	0.75		Coffin	2	23.57	1.01
Sept 82	Upright	2	26.18	0.42	April 83	Upright	2	28.16	0.92
	Warehouse	2	29.71	0.23		Warehouse	2	28.43	0.61
	Coffin	2	28.17	0.12		Coffin	2	27.87	1.25
Oct 82	Upright	2	30.20	0.48	May 83	Upright	2	29.06	0.23
	Warehouse	2	26.99	1.11		Warehouse	2	29.01	0.53
	Coffin	2	27.05	0.10		Coffin	2	26.54	0.61
Nov 82	Upright	2	33.05	1.09	June 83	Upright	2	26.33	0.25
	Warehouse	2	30.48	0.34		Warehouse	2	28.43	0.81
	Coffin	2	30.89	0.29		Coffin	2	28.57	0.81
Dec 82	Upright	2	29.86	0.39	July 83	Upright	2	31.51	0.37
	Warehouse	2	31.33	0.49		Warehouse	2	31.48	0.66
	Coffin	2	29.88	0.63		Coffin	2	30.89	0.03
Jan 83	Upright	2	29.29	0.59	Aug 83	Upright	2	29.36	1.23
	Warehouse	2	28.35	0.49		Warehouse	2	30.02	1.34
	Coffin	2	27.35	0.47		Coffin	-	--	--

Table 37. Percent Moisture Free/Ash Free Protein means, number of samples, and standard errors of the mean.

Month	Freezer	N	Mean	Std. Error of Mean	Month	Freezer	N	Mean	Std. Error of Mean
July 82	Upright	-	--	--	Feb 83	Upright	2	2.95	0.01
	Warehouse	2	2.95	0.01		Warehouse	2	2.89	0.01
	Coffin	-	--	--		Coffin	2	2.29	0.05
Aug 82	Upright	2	2.89	0.02	March 83	Upright	2	3.09	0.11
	Warehouse	2	2.87	0.01		Warehouse	2	2.93	0.03
	Coffin	2	2.95	0.01		Coffin	2	2.77	0.39
Sept 82	Upright	2	2.87	0.01	April 83	Upright	2	2.94	0.03
	Warehouse	2	2.99	0.01		Warehouse	2	2.97	0.03
	Coffin	2	3.11	0.01		Coffin	2	3.17	0.03
Oct 82	Upright	2	2.55	0.01	May 83	Upright	2	2.93	0.05
	Warehouse	2	2.99	0.07		Warehouse	2	2.84	0.04
	Coffin	2	2.86	0.06		Coffin	2	3.67	0.11
Nov 82	Upright	2	2.45	0.01	June 83	Upright	2	3.20	0.10
	Warehouse	2	2.98	0.04		Warehouse	2	2.83	0.01
	Coffin	2	2.99	0.07		Coffin	2	3.35	0.00
Dec 83	Upright	2	2.95	0.01	July 83	Upright	2	2.89	0.01
	Warehouse	2	2.82	0.01		Warehouse	2	2.97	0.01
	Coffin	2	3.17	0.01		Coffin	2	3.35	0.01
Jan 83	Upright	2	3.13	0.03	Aug 83	Upright	2	3.25	0.03
	Warehouse	2	2.93	0.03		Warehouse	2	3.03	0.01
	Coffin	2	3.27	0.07		Coffin	-	--	--

Table 38. Percent Ash means, number of samples, and standard errors of the mean.

Month	Freezer	N	Mean	Std. Error of Mean
July 82	Upright	-	--	--
	Warehouse	2	16.55	0.00
	Coffin	-	--	--
Aug 82	Upright	2	14.77	0.59
	Warehouse	2	20.69	2.95
	Coffin	2	17.73	1.18
Sept 82	Upright	2	13.24	2.13
	Warehouse	2	18.33	2.95
	Coffin	2	13.65	0.41
Oct 82	Upright	2	7.39	0.29
	Warehouse	2	5.97	0.06
	Coffin	2	6.79	0.29
Nov 82	Upright	2	6.33	0.17
	Warehouse	2	8.51	0.71
	Coffin	2	7.98	0.06
Dec 82	Upright	2	8.27	0.23
	Warehouse	2	8.99	0.23
	Coffin	2	11.82	1.18
Jan 83	Upright	2	7.33	0.95
	Warehouse	2	8.27	1.19
	Coffin	2	7.69	0.35
Feb 83	Upright	2	14.63	1.63
	Warehouse	2	5.79	0.59
	Coffin	2	15.60	0.65
March 83	Upright	2	3.43	0.23
	Warehouse	2	2.90	0.06
	Coffin	2	8.15	0.11
April 83	Upright	2	17.08	1.83
	Warehouse	2	16.25	0.29
	Coffin	2	18.03	0.89
May 83	Upright	2	8.15	0.11
	Warehouse	2	7.09	0.00
	Coffin	2	8.87	0.59
June 83	Upright	2	8.45	0.18
	Warehouse	2	8.45	0.18
	Coffin	2	9.75	0.29
July 83	Upright	2	15.37	10^{-7}
	Warehouse	2	12.41	10^{-7}
	Coffin	2	18.61	0.89
Aug 83	Upright	2	5.55	0.11
	Warehouse	2	7.21	0.59
	Coffin	-	--	--

Table 39. Trimethylamine (mg/100g) means, number of samples, and standard errors of the mean.

Month	Freezer	N	Mean	Std. Error of Mean	Month	Freezer	N	Mean	Std. Error of Mean
July 82	Upright	-	--	--	Feb 83	Upright	2	40.23	2.11
	Warehouse	2	43.44	0.00		Warehouse	2	15.50	1.58
	Coffin	-	--	--		Coffin	2	33.91	1.41
Aug 82	Upright	2	14.77	0.59	March 83	Upright	2	7.97	0.55
	Warehouse	2	56.54	8.08		Warehouse	2	7.41	0.15
	Coffin	2	47.41	1.53		Coffin	2	19.39	0.13
Sept 82	Upright	2	34.81	5.59	April 83	Upright	2	41.19	4.41
	Warehouse	2	48.49	7.82		Warehouse	2	42.07	0.77
	Coffin	2	33.60	0.50		Coffin	2	41.85	2.06
Oct 82	Upright	2	21.05	0.43	May 83	Upright	2	20.64	0.15
	Warehouse	2	15.47	0.15		Warehouse	2	18.54	0.00
	Coffin	2	15.51	0.67		Coffin	2	19.92	0.65
Nov 82	Upright	2	19.29	0.27	June 83	Upright	2	20.52	0.44
	Warehouse	2	20.63	0.89		Warehouse	2	22.42	0.48
	Coffin	2	19.63	0.07		Coffin	2	22.51	0.33
Dec 82	Upright	2	21.27	0.31	July 83	Upright	2	40.05	0.00
	Warehouse	2	23.89	0.62		Warehouse	2	31.45	0.00
	Coffin	2	26.81	1.41		Coffin	2	43.13	1.00
Jan 83	Upright	2	18.47	2.39	Aug 83	Upright	2	13.78	0.29
	Warehouse	2	21.79	3.12		Warehouse	2	19.73	0.77
	Coffin	2	18.46	0.42		Coffin	-	--	--

Table 40. Moisture Free/Ash Free Trimethylamine (mg/100g) means, number of samples, and standard errors of the mean.

Month	Freezer	N	Mean	Std. Error of Mean
July 82	Upright	-	--	--
	Warehouse	2	2.03×10^5	9.50×10^3
	Coffin	-	--	--
Aug 82	Upright	2	1.41×10^5	1.60×10^4
	Warehouse	2	1.25×10^5	7.50×10^3
	Coffin	2	4.50×10^5	2.00×10^4
Sept 82	Upright	2	5.25×10^4	1.15×10^4
	Warehouse	2	1.03×10^5	4.00×10^3
	Coffin	2	2.95×10^4	9.50×10^3
Oct 82	Upright	2	4.20×10^4	2.20×10^4
	Warehouse	2	1.05×10^5	2.35×10^4
	Coffin	2	6.30×10^4	1.00×10^4
Nov 82	Upright	2	4.20×10^4	6.00×10^3
	Warehouse	2	9.65×10^4	1.50×10^3
	Coffin	2	7.85×10^4	2.50×10^3
Dec 82	Upright	2	1.08×105	1.90×10^4
	Warehouse	2	2.77×10^5	1.35×10^4
	Coffin	2	5.95×10^4	1.50×10^3
Jan 83	Upright	2	1.69×10^5	9.50×10^3
	Warehouse	2	2.21×10^5	1.50×10^3
	Coffin	2	3.85×10^5	4.50×10^4
Feb 83	Upright	2	1.85×10^5	1.90×10^4
	Warehouse	2	1.01×10^5	4.50×10^3
	Coffin	2	4.00×10^5	7.00×10^4
March 83	Upright	2	4.15×10^4	6.50×10^3
	Warehouse	2	6.30×10^4	5.00×10^3
	Coffin	2	1.23×10^5	1.05×10^4
April 83	Upright	2	3.15×10^4	1.25×10^4
	Warehouse	2	1.10×10^5	9.00×10^3
	Coffin	2	7.00×10^4	2.20×10^4
May 83	Upright	2	1.73×10^5	1.10×10^4
	Warehouse	2	1.54×10^5	2.40×10^4
	Coffin	2	2.18×10^5	1.00×10^3
June 83	Upright	2	2.40×10^4	1.00×10^4
	Warehouse	2	2.69×10^5	7.15×10^4
	Coffin	2	3.11×10^4	3.15×10^3
July 83	Upright	2	7.15×10^4	1.55×10^4
	Warehouse	2	1.29×10^5	5.50×10^3
	Coffin	2	3.17×10^4	750
Aug 83	Upright	2	2.40×10^4	1.00×10^3
	Warehouse	2	6.60×10^4	2.00×10^3
	Coffin	-	--	--

Table 41. Standard plate count (org/g) means, number of samples, and standard errors of the mean.

Month	Freezer	N	Mean	Std. Error of Mean	Month	Freezer	N	Mean	Std. Error of Mean
July 82	Upright	--	--	--	Feb 83	Upright	14	2.18	0.10
	Warehouse	14	3.07	0.16		Warehouse	14	2.25	0.11
	Coffin	--	--	--		Coffin	14	3.61	0.12
	Control	14	2.35	0.13		Control	14	2.14	0.10
Aug 82	Upright	14	2.14	0.18	March 83	Upright	14	2.93	0.14
	Warehouse	14	2.14	0.18		Warehouse	14	2.57	0.17
	Coffin	14	2.29	0.16		Coffin	14	3.36	0.23
	Control	14	2.00	0.18		Control	14	2.36	0.14
Sept 82	Upright	14	2.79	0.11	April 83	Upright	14	2.71	0.20
	Warehouse	14	3.07	0.07		Warehouse	14	2.93	0.17
	Coffin	14	2.79	0.15		Coffin	14	3.71	0.23
	Control	14	2.21	0.11		Control	14	2.25	0.13
Oct 82	Upright	14	2.25	0.11	May 83	Upright	14	2.50	0.14
	Warehouse	14	3.00	0.18		Warehouse	14	2.46	0.13
	Coffin	14	3.50	0.17		Coffin	14	3.17	0.25
	Control	14	2.29	0.13		Control	14	1.93	0.15
Nov 82	Upright	14	2.54	0.13	June 83	Upright	14	2.93	0.15
	Warehouse	14	2.82	0.23		Warehouse	14	2.84	0.18
	Coffin	14	3.54	0.17		Coffin	14	4.04	0.18
	Control	14	2.79	0.19		Control	14	2.43	0.16
Dec 82	Upright	14	2.57	0.14	July 83	Upright	14	3.11	0.06
	Warehouse	14	2.50	0.14		Warehouse	14	2.64	0.13
	Coffin	14	4.11	0.08		Coffin	14	4.07	0.18
	Control	14	2.18	0.10		Control	14	2.43	0.14
Jan 83	Upright	14	2.61	0.13	Aug 83	Upright	14	2.75	0.21
	Warehouse	14	2.57	0.14		Warehouse	14	2.00	0.10
	Coffin	14	3.93	0.22		Coffin	--	--	--
	Control	14	2.36	0.20		Control	14	2.43	0.15

Table 42. Hardness means, number of samples, and standard errors on the means.

Month	Freezer	N	Mean	Std. Error of Mean	Month	Freezer	N	Mean	Std. Error of Mean
July 82	Upright	--	--	--	Feb 83	Upright	14	2.39	0.13
	Warehouse	14	3.14	0.18		Warehouse	14	2.36	0.12
	Coffin	--	--	--		Coffin	14	3.75	0.16
	Control	14	2.50	0.14		Control	14	2.57	0.14
Aug 82	Upright	14	2.29	0.16	March 83	Upright	14	3.07	0.16
	Warehouse	14	2.21	0.19		Warehouse	14	2.50	0.14
	Coffin	14	2.36	0.17		Coffin	14	3.36	0.24
	Control	14	2.14	0.18		Control	14	2.32	0.14
Sept 82	Upright	14	2.61	0.18	April 83	Upright	14	2.93	0.14
	Warehouse	14	3.21	0.19		Warehouse	14	2.93	0.14
	Coffin	14	2.71	0.19		Coffin	14	3.71	0.23
	Control	14	2.36	0.13		Control	14	2.04	0.19
Oct 82	Upright	14	2.46	0.13	May 83	Upright	14	2.57	0.16
	Warehouse	14	2.75	0.11		Warehouse	14	2.57	0.12
	Coffin	14	3.46	0.20		Coffin	14	3.32	0.23
	Control	14	2.36	0.17		Control	14	2.29	0.16
Nov 82	Upright	14	2.29	0.19	June 83	Upright	14	3.07	0.10
	Warehouse	14	2.68	0.16		Warehouse	14	2.89	0.11
	Coffin	14	3.50	0.13		Coffin	14	4.07	0.20
	Control	14	2.57	0.14		Control	14	2.39	0.12
Dec 82	Upright	14	2.36	0.13	July 83	Upright	14	3.00	0.15
	Warehouse	14	2.36	0.13		Warehouse	14	2.43	0.13
	Coffin	14	4.07	0.05		Coffin	14	4.21	0.15
	Control	14	2.04	0.15		Control	14	2.18	0.11
Jan 83	Upright	14	2.54	0.13	Aug 83	Upright	14	2.75	0.18
	Warehouse	14	2.46	0.13		Warehouse	14	2.07	0.16
	Coffin	14	3.75	0.16		Coffin	--	--	--
	Control	14	2.50	0.17		Control	14	2.50	0.16

Table 43. Chewiness means, number of samples, and standard errors of the mean.

Month	Freezer	N	Mean	Std. Error of Mean	Month	Freezer	N	Mean	Std. Error of Mean
July 82	Upright	--	--	--	Feb 83	Upright	14	2.57	0.16
	Warehouse	14	2.43	0.17		Warehouse	14	2.04	0.15
	Coffin	--	--	--		Coffin	14	3.18	0.19
	Control	14	2.57	0.14		Control	14	2.50	0.14
Aug 82	Upright	14	2.36	0.20	March 83	Upright	14	2.75	0.19
	Warehouse	14	2.29	0.16		Warehouse	14	2.11	0.13
	Coffin	14	2.57	0.17		Coffin	14	3.14	0.23
	Control	14	2.21	0.11		Control	14	2.43	0.18
Sept 82	Upright	14	2.82	0.16	April 83	Upright	14	3.07	0.18
	Warehouse	14	2.79	0.15		Warehouse	14	2.64	0.16
	Coffin	14	2.79	0.11		Coffin	14	3.25	0.19
	Control	14	2.21	0.11		Control	14	2.11	0.14
Oct 82	Upright	14	2.50	0.14	May 83	Upright	14	2.50	0.16
	Warehouse	14	2.57	0.17		Warehouse	14	2.68	0.13
	Coffin	14	2.86	0.18		Coffin	14	3.25	0.24
	Control	14	2.43	0.23		Control	14	2.54	0.17
Nov 82	Upright	14	2.50	0.25	June 83	Upright	14	2.93	0.15
	Warehouse	14	2.64	0.13		Warehouse	14	2.68	0.14
	Coffin	14	3.07	0.20		Coffin	14	3.86	0.22
	Control	14	2.50	0.13		Control	14	2.11	0.15
Dec 82	Upright	14	2.39	0.13	July 83	Upright	14	2.96	0.19
	Warehouse	14	2.29	0.13		Warehouse	14	2.39	0.14
	Coffin	14	3.86	0.10		Coffin	14	3.82	0.23
	Control	14	1.86	0.10		Control	14	2.32	0.12
Jan 83	Upright	14	2.64	0.17	Aug 83	Upright	14	2.68	0.18
	Warehouse	14	2.32	0.12		Warehouse	14	2.21	0.14
	Coffin	14	3.57	0.25		Coffin	--	--	--
	Control	14	2.71	0.13		Control	14	2.64	0.16

Table 44. Fibrousness means, number of samples, and standard errors of mean.

Month	Freezer	N	Mean	Std. Error of Mean	Month	Freezer	N	Mean	Std. Error of Mean
July 82	Upright	--	--	--	Feb 83	Upright	14	2.86	0.13
	Warehouse	14	2.79	0.11		Warehouse	14	3.18	0.10
	Coffin	--	--	--		Coffin	14	1.96	0.26
	Control	14	3.43	0.14		Control	14	2.68	0.12
Aug 82	Upright	14	2.86	0.21	March 83	Upright	14	2.57	0.25
	Warehouse	14	3.43	0.14		Warehouse	14	3.11	0.22
	Coffin	14	2.93	0.16		Coffin	14	2.36	0.23
	Control	14	3.07	0.16		Control	14	3.39	0.12
Sept 82	Upright	14	2.86	0.21	April 83	Upright	14	2.57	0.16
	Warehouse	14	3.00	0.21		Warehouse	14	2.25	0.11
	Coffin	14	2.57	0.20		Coffin	14	1.82	0.12
	Control	14	3.64	0.13		Control	14	3.29	0.15
Oct 82	Upright	14	3.71	0.15	May 83	Upright	14	2.61	0.12
	Warehouse	14	3.04	0.19		Warehouse	14	2.82	0.21
	Coffin	14	2.32	0.18		Coffin	14	2.50	0.21
	Control	14	2.82	0.10		Control	14	3.57	0.14
Nov 82	Upright	14	3.36	0.21	June 83	Upright	14	2.39	0.16
	Warehouse	14	2.93	0.22		Warehouse	14	2.71	0.16
	Coffin	14	2.21	0.15		Coffin	14	1.57	0.13
	Control	14	2.68	0.14		Control	14	3.14	0.18
Dec 82	Upright	14	3.43	0.17	July 83	Upright	14	2.21	0.15
	Warehouse	14	3.18	0.10		Warehouse	14	2.89	0.18
	Coffin	14	1.43	0.14		Coffin	14	1.14	0.16
	Control	14	3.21	0.11		Control	14	3.14	0.18
Jan 83	Upright	14	3.14	0.14	Aug 83	Upright	14	2.75	0.20
	Warehouse	14	2.82	0.14		Warehouse	14	2.93	0.16
	Coffin	14	1.64	0.20		Coffin	--	--	--
	Control	14	3.21	0.15		Control	14	3.07	0.16

Table 45. Moistness means, number of samples, and standard errors of mean.

Month	Freezer	N	Mean	Std. Error of Mean	Month	Freezer	N	Mean	Std. Error of Mean
July 82	Upright	--	--	--	Feb 83	Upright	14	2.54	0.13
	Warehouse	14	2.07	0.22		Warehouse	14	2.89	0.15
	Coffin	--	--	--		Coffin	14	2.29	0.19
	Control	14	1.57	0.14		Control	14	1.64	0.17
Aug 82	Upright	14	3.29	0.13	March 83	Upright	14	2.86	0.14
	Warehouse	14	2.93	0.16		Warehouse	14	2.57	0.23
	Coffin	14	2.93	0.13		Coffin	14	2.61	0.25
	Control	14	2.57	0.14		Control	14	1.79	0.15
Sept 82	Upright	14	2.86	0.10	April 83	Upright	14	2.68	0.19
	Warehouse	14	3.00	0.18		Warehouse	14	2.57	0.21
	Coffin	14	2.86	0.18		Coffin	14	2.86	0.18
	Control	14	2.43	0.20		Control	14	2.11	0.20
Oct 82	Upright	14	2.75	0.24	May 83	Upright	14	2.61	0.12
	Warehouse	14	2.43	0.17		Warehouse	14	3.11	0.13
	Coffin	14	2.50	0.17		Coffin	14	3.07	0.16
	Control	14	1.86	0.21		Control	14	2.39	0.17
Nov 82	Upright	14	2.46	0.15	June 83	Upright	14	2.86	0.10
	Warehouse	14	2.36	0.23		Warehouse	14	2.75	0.17
	Coffin	14	2.07	0.16		Coffin	14	2.82	0.18
	Control	14	1.64	0.17		Control	14	1.93	0.16
Dec 82	Upright	14	2.43	0.17	July 83	Upright	14	2.18	0.18
	Warehouse	14	2.18	0.16		Warehouse	14	2.25	0.19
	Coffin	14	2.43	0.17		Coffin	14	2.25	0.30
	Control	14	1.93	0.20		Control	14	1.89	0.15
Jan 83	Upright	14	2.86	0.14	Aug 83	Upright	14	2.68	0.12
	Warehouse	14	2.43	0.17		Warehouse	14	2.61	0.19
	Coffin	14	2.50	0.14		Coffin	--	--	--
	Control	14	2.36	0.23		Control	14	1.79	0.15

Table 46. Oily Mouth Coating means, number of samples, and standard errors of the mean.

Month	Freezer	N	Mean	Std. Error of Mean	Month	Freezer	N	Mean	Std. Error of Mean
July 82	Upright	--	--	--	Feb 83	Upright	14	1.43	0.14
	Warehouse	14	1.36	0.13		Warehouse	14	0.71	0.16
	Coffin	--	--	--		Coffin	14	3.46	0.17
	Control	14	0.64	0.13		Control	14	0.00	0.00
Aug 82	Upright	14	2.07	0.22	March 83	Upright	14	1.79	0.26
	Warehouse	14	1.36	0.17		Warehouse	14	1.07	0.20
	Coffin	14	1.64	0.25		Coffin	14	2.43	0.21
	Control	14	1.00	0.18		Control	14	0.29	0.13
Sept 82	Upright	14	2.00	0.15	April 83	Upright	14	1.54	0.20
	Warehouse	14	1.71	0.16		Warehouse	14	1.39	0.28
	Coffin	14	2.00	0.21		Coffin	14	2.07	0.20
	Control	14	0.50	0.23		Control	14	0.00	0.00
Oct 82	Upright	14	1.79	0.21	May 83	Upright	14	1.25	0.11
	Warehouse	14	1.00	0.28		Warehouse	14	1.46	0.27
	Coffin	14	2.57	0.23		Coffin	14	2.86	0.29
	Control	14	0.00	0.00		Control	14	0.43	0.17
Nov 82	Upright	14	1.79	0.19	June 83	Upright	14	1.54	0.25
	Warehouse	14	0.71	0.16		Warehouse	14	0.64	0.17
	Coffin	14	1.57	0.17		Coffin	14	3.75	0.15
	Control	14	0.07	0.07		Control	14	0.29	0.20
Dec 82	Upright	14	1.00	0.10	July 83	Upright	14	1.46	0.30
	Warehouse	14	0.64	0.13		Warehouse	14	0.36	0.13
	Coffin	14	3.14	0.14		Coffin	14	3.39	0.38
	Control	14	0.07	0.07		Control	14	0.00	0.00
Jan 83	Upright	14	1.36	0.31	Aug 83	Upright	14	1.68	0.22
	Warehouse	14	0.64	0.13		Warehouse	14	0.29	0.16
	Coffin	14	2.36	0.27		Coffin	--	--	--
	Control	14	0.14	0.10		Control	14	0.00	0.00

Table 47. Overall Shrimp Flavor means, number of samples, and standard errors of the mean.

Month	Freezer	N	Mean	Std. Error of Mean	Month	Freezer	N	Mean	Std. Error of Mean
July 82	Upright	--	--	--	Feb 83	Upright	14	1.93	0.07
	Warehouse	14	1.93	0.16		Warehouse	14	2.43	0.14
	Coffin	--	--	--		Coffin	14	1.14	0.10
	Control	14	2.50	0.14		Control	14	2.79	0.11
Aug 82	Upright	14	1.93	0.20	March 83	Upright	14	1.43	0.20
	Warehouse	14	2.07	0.20		Warehouse	14	2.17	0.18
	Coffin	14	1.86	0.18		Coffin	14	1.29	0.16
	Control	14	2.21	0.15		Control	14	2.50	0.20
Sept 82	Upright	14	2.00	0.10	April 83	Upright	14	1.93	0.25
	Warehouse	14	1.93	0.20		Warehouse	14	1.96	0.20
	Coffin	14	1.79	0.19		Coffin	14	0.79	0.21
	Control	14	3.00	0.18		Control	14	2.14	0.20
Oct 82	Upright	14	1.86	0.23	May 83	Upright	14	2.00	0.15
	Warehouse	14	1.93	0.22		Warehouse	14	1.93	0.20
	Coffin	14	1.57	0.14		Coffin	14	1.39	0.18
	Control	14	2.50	0.20		Control	14	2.57	0.17
Nov 82	Upright	14	1.57	0.14	June 83	Upright	14	1.75	0.11
	Warehouse	14	2.29	0.19		Warehouse	14	2.43	0.18
	Coffin	14	1.93	0.13		Coffin	14	0.46	0.15
	Control	14	2.57	0.17		Control	14	2.75	0.18
Dec 82	Upright	14	2.50	0.17	July 83	Upright	14	1.93	0.19
	Warehouse	14	2.79	0.15		Warehouse	14	2.57	0.16
	Coffin	14	1.29	0.13		Coffin	14	0.61	0.13
	Control	14	3.29	0.16		Control	14	2.93	0.22
Jan 83	Upright	14	2.14	0.21	Aug 83	Upright	14	1.68	0.15
	Warehouse	14	2.71	0.16		Warehouse	14	2.39	0.25
	Coffin	14	1.93	0.22		Coffin	--	--	--
	Control	14	2.64	0.20		Control	14	3.07	0.19

Table 48. Sweetness means, number of samples, and standard errors of the mean.

Month	Freezer	N	Mean	Std. Error of Mean	Month	Freezer	N	Mean	Std. Error of Mean
July 82	Upright	--	--	--	Feb 83	Upright	14	2.14	0.08
	Warehouse	14	2.57	0.14		Warehouse	14	2.57	0.14
	Coffin	--	--	--		Coffin	14	1.36	0.17
	Control	14	2.79	0.11		Control	14	2.79	0.11
Aug 82	Upright	14	2.64	0.17	March 83	Upright	14	2.29	0.16
	Warehouse	14	2.43	0.17		Warehouse	14	2.75	0.21
	Coffin	14	2.71	0.16		Coffin	14	1.82	0.24
	Control	14	2.57	0.14		Control	14	2.86	0.18
Sept 82	Upright	14	2.07	0.13	April 83	Upright	14	2.29	0.14
	Warehouse	14	2.43	0.17		Warehouse	14	2.14	0.17
	Coffin	14	2.43	0.17		Coffin	14	1.29	0.20
	Control	14	2.71	0.16		Control	14	2.11	0.13
Oct 82	Upright	14	2.50	0.20	May 83	Upright	14	2.25	0.11
	Warehouse	14	2.50	0.17		Warehouse	14	2.11	0.17
	Coffin	14	1.93	0.16		Coffin	14	1.86	0.18
	Control	14	2.79	0.11		Control	14	2.93	0.20
Nov 82	Upright	14	2.21	0.26	June 83	Upright	14	1.82	0.08
	Warehouse	14	2.46	0.13		Warehouse	14	2.46	0.13
	Coffin	14	2.29	0.16		Coffin	14	0.57	0.16
	Control	14	2.79	0.21		Control	14	2.68	0.12
Dec 82	Upright	14	2.29	0.13	July 83	Upright	14	2.04	0.16
	Warehouse	14	2.43	0.14		Warehouse	14	2.71	0.10
	Coffin	14	1.36	0.13		Coffin	14	0.96	0.20
	Control	14	3.29	0.13		Control	14	3.14	0.10
Jan 83	Upright	14	2.29	0.13	Aug 83	Upright	14	1.89	0.13
	Warehouse	14	2.64	0.17		Warehouse	14	2.43	0.16
	Coffin	14	1.86	0.18		Coffin	--	--	--
	Control	14	2.43	0.17		Control	14	2.71	0.13

Table 49. Nutty buttery means, number of samples, and standard errors of the mean.

Month	Freezer	N	Mean	Std. Error of Mean	Month	Freezer	N	Mean	Std. Error of Mean
July 82	Upright	--	--	--	Feb 83	Upright	14	1.68	0.14
	Warehouse	14	2.07	0.16		Warehouse	14	2.00	0.00
	Coffin	--	--	--		Coffin	14	1.07	0.16
	Control	14	2.71	0.13		Control	14	2.86	0.18
Aug 82	Upright	14	1.79	0.11	March 83	Upright	14	1.64	0.17
	Warehouse	14	2.14	0.10		Warehouse	14	2.54	0.17
	Coffin	14	1.64	0.17		Coffin	14	1.50	0.14
	Control	14	2.21	0.11		Control	14	2.86	0.18
Sept 82	Upright	14	2.21	0.11	April 83	Upright	14	2.29	0.14
	Warehouse	14	2.07	0.13		Warehouse	14	2.04	0.12
	Coffin	14	2.04	0.15		Coffin	14	1.14	0.21
	Control	14	2.93	0.20		Control	14	2.75	0.19
Oct 82	Upright	14	1.71	0.19	May 83	Upright	14	1.89	0.15
	Warehouse	14	2.32	0.16		Warehouse	14	1.82	0.16
	Coffin	14	1.64	0.13		Coffin	14	1.04	0.20
	Control	14	2.79	0.15		Control	14	2.89	0.20
Nov 82	Upright	14	1.71	0.16	June 83	Upright	14	1.75	0.14
	Warehouse	14	2.36	0.17		Warehouse	14	2.25	0.10
	Coffin	14	1.71	0.16		Coffin	14	0.39	0.13
	Control	14	2.86	0.14		Control	14	2.50	0.13
Dec 82	Upright	14	2.39	0.13	July 83	Upright	14	1.89	0.16
	Warehouse	14	3.00	0.18		Warehouse	14	2.54	0.17
	Coffin	14	1.50	0.14		Coffin	14	0.71	0.14
	Control	14	3.32	0.16		Control	14	3.07	0.16
Jan 83	Upright	14	2.11	0.15	Aug 83	Upright	14	1.71	0.11
	Warehouse	14	2.36	0.13		Warehouse	14	2.39	0.17
	Coffin	14	1.29	0.13		Coffin	--	--	--
	Control	14	2.14	0.21		Control	14	3.00	0.10

Table 50. Old Seafood Flavor means, number of samples, and standard errors of the mean.

Month	Freezer	N	Mean	Std. Error of Mean	Month	Freezer	N	Mean	Std. Error of Mean
July 82	Upright	—	--	--	Feb 83	Upright	14	1.89	0.18
	Warehouse	14	0.93	0.20		Warehouse	14	0.86	0.21
	Coffin	--	--	--		Coffin	14	3.29	0.15
	Control	14	0.07	0.07		Control	14	0.00	0.00
Aug 82	Upright	14	1.86	0.25	March 83	Upright	14	2.07	0.27
	Warehouse	14	0.86	0.18		Warehouse	14	1.00	0.23
	Coffin	14	1.14	0.18		Coffin	14	2.64	0.17
	Control	14	0.43	0.14		Control	14	0.43	0.17
Sept 82	Upright	14	1.04	0.27	April 83	Upright	14	1.50	0.26
	Warehouse	14	1.07	0.22		Warehouse	14	1.29	0.26
	Coffin	14	1.07	0.25		Coffin	14	2.57	0.29
	Control	14	0.14	0.14		Control	14	0.00	0.00
Oct 82	Upright	14	1.89	0.27	May 83	Upright	14	1.86	0.18
	Warehouse	14	0.93	0.16		Warehouse	14	1.75	0.19
	Coffin	14	2.11	0.20		Coffin	14	3.25	0.16
	Control	14	0.00	0.00		Control	14	0.50	0.17
Nov 82	Upright	14	2.29	0.35	June 83	Upright	14	2.29	0.19
	Warehouse	14	0.71	0.16		Warehouse	14	1.14	0.24
	Coffin	14	1.71	0.19		Coffin	14	4.04	0.16
	Control	14	0.07	0.07		Control	14	0.18	0.12
Dec 82	Upright	14	0.57	0.14	July 83	Upright	14	2.14	0.21
	Warehouse	14	0.43	0.14		Warehouse	14	0.64	0.20
	Coffin	14	3.00	0.21		Coffin	14	4.14	0.22
	Control	14	0.00	0.00		Control	14	0.00	0.00
Jan 83	Upright	14	1.14	0.27	Aug 83	Upright	14	2.54	0.12
	Warehouse	14	0.36	0.13		Warehouse	14	0.75	0.20
	Coffin	14	2.36	0.32		Coffin	--	--	--
	Control	14	0.00	0.00		Control	14	0.00	0.00

Table 51. Freezer Burn means, number of samples, and standard errors of the mean.

Month	Freezer	N	Mean	Std. Error of Mean	Month	Freezer	N	Mean	Std. Error of Mean
July 82	Upright	--	--	--	Feb 83	Upright	14	0.43	0.14
	Warehouse	14	0.79	0.19		Warehouse	14	0.00	0.00
	Coffin	--	--	--		Coffin	14	1.86	0.23
	Control	14	0.07	0.07		Control	14	0.00	0.00
Aug 82	Upright	14	1.43	0.20	March 83	Upright	14	1.79	0.33
	Warehouse	14	0.50	0.14		Warehouse	14	0.64	0.20
	Coffin	14	1.07	0.20		Coffin	14	2.21	0.29
	Control	14	0.36	0.13		Control	14	0.14	0.10
Sept 82	Upright	14	1.00	0.23	April 83	Upright	14	1.50	0.26
	Warehouse	14	1.00	0.21		Warehouse	14	0.64	0.20
	Coffin	14	0.93	0.22		Coffin	14	1.86	0.25
	Control	14	0.07	0.07		Control	14	0.00	0.00
Oct 82	Upright	14	1.14	0.21	May 83	Upright	14	0.75	0.20
	Warehouse	14	0.57	0.17		Warehouse	14	0.82	0.24
	Coffin	14	1.54	0.21		Coffin	14	2.29	0.33
	Control	14	0.07	0.07		Control	14	0.21	0.15
Nov 82	Upright	14	0.18	0.22	June 83	Upright	14	0.75	0.23
	Warehouse	14	0.14	0.10		Warehouse	14	0.14	0.10
	Coffin	14	0.71	0.16		Coffin	14	2.57	0.33
	Control	14	0.07	0.07		Control	14	0.00	0.00
Dec 82	Upright	14	0.29	0.13	July 83	Upright	14	0.50	0.17
	Warehouse	14	0.07	0.07		Warehouse	14	0.00	0.00
	Coffin	14	1.71	0.16		Coffin	14	2.04	0.32
	Control	14	0.00	0.00		Control	14	0.00	0.00
Jan 83	Upright	14	0.50	0.17	Aug 83	Upright	14	0.36	0.17
	Warehouse	14	0.00	0.00		Warehouse	14	0.00	0.00
	Coffin	14	1.00	0.23		Coffin	--	--	--
	Control	14	0.00	0.00		Control	14	0.00	0.00

Table 52. Rancid Flavor means, number of samples, and standard errors of the mean.