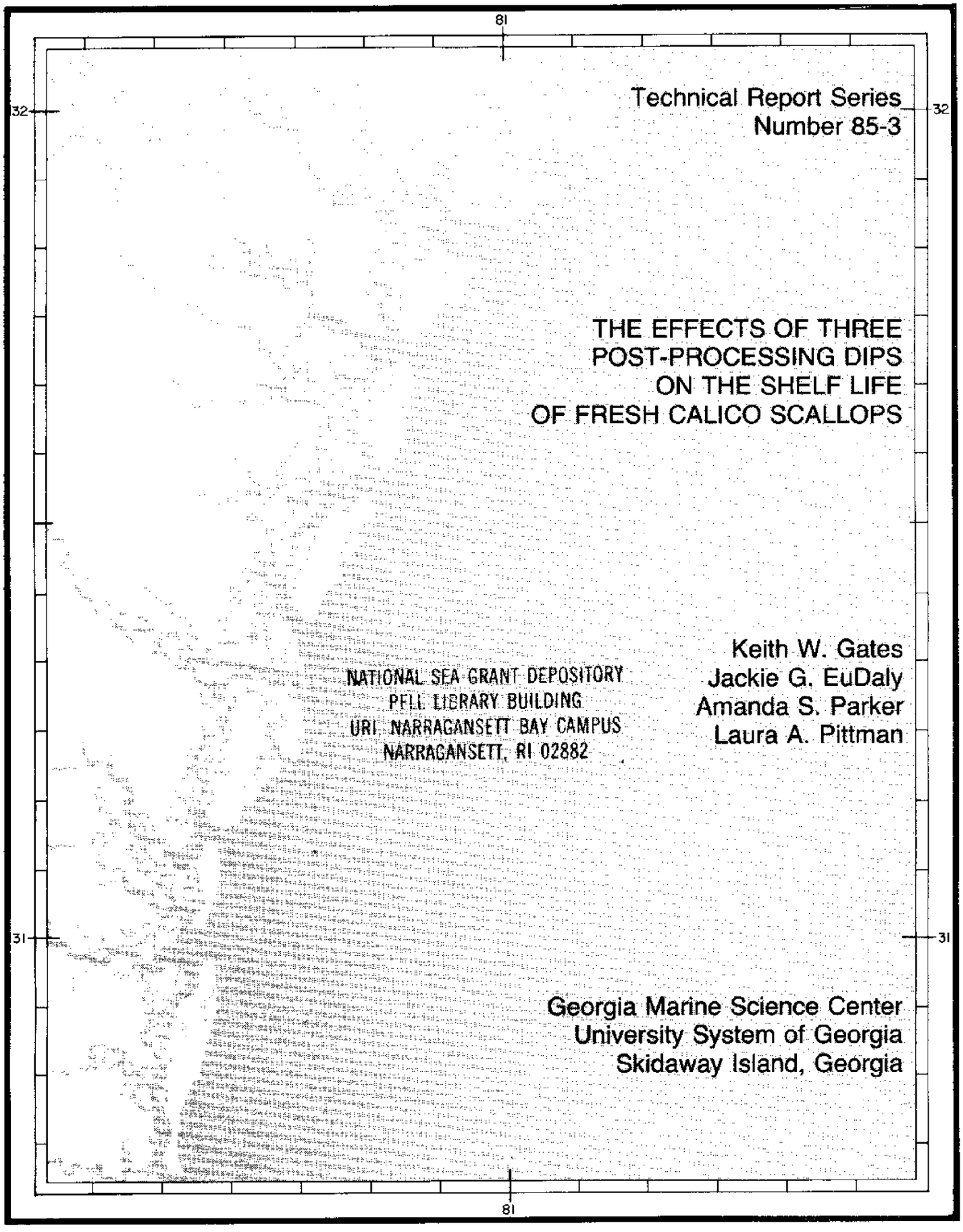

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by
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1985

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TABLE OF CONTENTS

	Page
Acknowledgments	i
Abstract	v
List of Figures	vii
List of Tables	ix
List of Appendices	xi
Introduction	1
Methods	1
Results	4
Discussion	53
Conclusions	56
References	59
Appendices	61

ABSTRACT

At the request of a local scallop processor, the Marine Extension Service evaluated the effects of three post-processing dips: one percent sodium bisulfite, 100 ppm calcium hypochlorite (HTH), and 20 ppm chlorine dioxide (Odocine) on the shelf life of fresh calico scallops packed in one gallon plastic containers and held on ice. The following parameters were monitored over a 35-day period: pH, ammonium, trimethylamine, total aerobic plate count, total fecal streptococci plate count, MPN total coliforms, MPN E. coli, and MPN coagulase positive staphylococci. Additionally, a trained sensory panel rated the samples for odor and appearance characteristics. Untreated, HTH, and Odocine samples exceeded a plate count of 500,000 organisms/g following 12 days of storage, while bisulfite samples remained below 500,000 organisms/g through 26 days of iced storage.

LIST OF FIGURES

Figure		Page
1.	pH levels for bisulfite, HTH, Odocine, and untreated scallops	5
2.	Mean ammonium levels for bisulfite, HTH, Odocine, and untreated scallops	6
3.	Mean trimethylamine levels for bisulfite, HTH, Odocine, and untreated scallops	9
4.	Mean aerobic plate counts for bisulfite, HTH, Odocine, and untreated scallops	12
5.	Mean fecal streptococci plate counts for bisulfite, HTH, Odocine and untreated scallops	14
6.	MPN total coliform organisms for bisulfite, HTH, Odocine, and untreated scallops	16
7.	MPN *E. coli* organisms for bisulfite, HTH, Odocine, and untreated scallops	17
8.	MPN coagulase positive staphylococci organisms for bisulfite, HTH, Odocine, and untreated scallops	18
9.	Mean briny scores for bisulfite, HTH, Odocine, untreated, and frozen control scallops	20
10.	Mean sweet scores for bisulfite, HTH, Odocine, untreated, and frozen control scallops	22
11.	Mean ammonia scores for bisulfite, HTH, Odocine, untreated, and frozen control scallops	24
12.	Mean post room scores for bisulfite, HTH, Odocine, untreated, and frozen control scallops	27
13.	Mean putrid scores for bisulfite, HTH, Odocine, untreated, and frozen control scallops	30
14.	Mean sour scores for bisulfite, HTH, Odocine, untreated, and frozen control scallops	32

Figure		Page
15.	Mean fishy scores for bisulfite, HTH, Odocine, untreated, and frozen control scallops	35
16.	Mean consumer odor scores for bisulfite, HTH, Odocine, untreated, and frozen control scallops	37
17.	Mean slimy scores for bisulfite, HTH, Odocine, untreated, and frozen control scallops	39
18.	Mean light-dark scores for bisulfite, HTH, Odocine, untreated, and frozen control scallops	42
19.	Mean firmness scores for bisulfite, HTH, Odocine, untreated, and frozen control scallops	44
20.	Mean adhesiveness scores for bisulfite, HTH, Odocine, untreated, and frozen control scallops	47
21.	Mean wetness scores for bisulfite, HTH, Odocine, untreated, and frozen control scallops	49
22.	Mean consumer appearance scores for bisulfite, HTH, Odocine, untreated, and frozen control scallops	51

LIST OF TABLES

Table		Page
1.	Mean ammonium levels of the experimental scallops, Tukey's studentized range test, and pooled standard errors	7
2.	Mean trimethylamine levels of the experimental scallops, Tukey's studentized range test, and pooled standard errors	10
3.	Mean aerobic plate counts of the experimental scallops, Tukey's studentized range test, and pooled standard errors	13
4.	Mean fecal streptococci plate counts of the experimental scallops, Tukey's studentized range test, and pooled standard errors	15
5.	Mean briny levels of the experimental and control scallops, Tukey's studentized range test, and pooled standard errors	21
6.	Mean sweet levels of the experimental and control scallops, Tukey's studentized range test, and pooled standard errors	23
7.	Mean ammonia levels of experimental and control scallops, Tukey's studentized range test, and pooled standard errors	25
8.	Mean post room odor levels of the experimental and control scallops, Tukey's studentized range test, and pooled standard errors	28
9.	Mean putrid levels of the experimental and control scallops, Tukey's studentized range test, and pooled standard errors	31
10.	Mean sour levels of the experimental and control scallops, Tukey's studentized range test, and pooled standard errors	33
11.	Mean fishy levels of the experimental and control scallops, Tukey's studentized range test, and pooled standard errors	36

Table		Page
12.	Mean consumer rating odor levels of the experimental and control scallops, Tukey's studentized range test, and pooled standard errors	38
13.	Mean slimy levels of the experimental and control scallops, Tukey's studentized range test, and pooled standard errors	40
14.	Mean light-dark levels of the experimental and control scallops, Tukey's studentized range test, and pooled standard errors	43
15.	Mean firmness levels of the experimental and control scallops, Tukey's studentized range test, and pooled standard errors	45
16.	Mean adhesiveness levels of the experimental and control scallops, Tukey's studentized range test, and pooled standard errors	48
17.	Mean wetness levels of the experimental and control scallops, Tukey's studentized range test, and pooled standard errors	50
18.	Mean consumer appearance levels of the experimental and control scallops, Tukey's studentized range test, and pooled standard errors	52

LIST OF APPENDICES

Appendix		Page
A.	Ammonium means, number of samples, and standard errors of the mean	62
B.	TMA means, number of samples, and standard errors of the mean	63
C.	Aerobic plate count means, number of samples, and standard errors of the mean	64
D.	Fecal streptococci means, number of samples, and standard errors of the mean	65
E.	Briny means, number of samples, and standard errors of the mean	66
F.	Sweat means, number of samples, and standard errors of the mean	67
G.	Ammonia means, number of samples, and standard errors of the mean	68
H.	Post room means, number of samples, and standard errors of the mean	69
I.	Putrid means, number of samples, and standard errors of the mean	70
J.	Sour means, number of samples, and standard errors of the mean	71
K.	Fishy means, number of samples, and standard errors of the mean	72
L.	Consumer rating odor means, number of samples, and standard errors of the mean	73
M.	Slimy means, number of samples, and standard errors of the mean	74
N.	Light-dark means, number of samples, and standard errors of the mean	75
O.	Firmness means, number of samples, and standard errors of the mean	76

Appendix		Page
P.	Adhesiveness means, number of samples, and standard errors of the mean	77
Q.	Wetness means, number of samples, and standard errors of the mean	78
R.	Consumer rating appearance means, number of samples, and standard errors of the mean	79

INTRODUCTION

The recent rapid expansion of the calico scallop (Argopecten gibbus) industry from less than five million pounds processed in 1979 to greater than 15 million pounds processed in 1981 generated an intense interest in scallops among coastal Georgia seafood companies. Four new scallop plants were established in Georgia by the summer of 1982. Georgia processors, new to the business, requested advisory assistance from the Marine Extension Service. In addition to handling, sanitation, and quality control assistance, one processor requested that three post-processing treatments be evaluated for their effects on the shelf life of fresh scallops. In the spring of 1983, a study was initiated to determine the effects of three post-processing dips on the shelf life of scallops held on ice: (1) one percent sodium bisulfite, (2) 100 ppm calcium hypochlorite (HTH, Olin Corporation), and (3) 20 ppm chlorine dioxide (Odocine, ODCO Laboratories, Inc.).

METHODS

The scallops (300-400 count) used in the study were caught off the coast of Cape Canaveral, Florida on 20 March 1983, transported aboard trucks to Darien, Georgia, and processed by a commercial mechanical shucking line on 21 March 1983. Following shucking and inspection, the scallops passed through an iced brine tank that reduced the meat temperature to 8.5°C. The scallops were drained and hand packed in one gallon (3.63 kg) plastic containers. The contents of three separate containers were each dipped into 14 liters of one of the following solutions for 30 seconds: (1) one percent sodium bisulfite (pH = 5.13), (2) 100 ppm calcium hypochlorite (HTH) (pH = 9.51), or (3) 20 ppm chlorine dioxide (Odocine) (pH = 7.92). The scallops were drained, packed in fresh plastic containers, and placed on ice. The iced containers were held in a refrigerator at 4°C for the duration of the study. The coolers containing the iced scallop containers drained continuously. Fresh ice was added as needed. An untreated control one gallon (3.63 kg) container was also placed on ice. Small subsamples of the same lot of scallops were placed in Whirl-pak bags, frozen (-23°C), and used as sensory control samples for later organoleptic evaluations.

Bisulfite, HTH, Odocine and untreated samples were evaluated chemically, microbiologically, and organoleptically at the end of 1, 2, 4, 7, 11, 14, and 16 days. Panel members deemed all but bisulfite and frozen control samples organoleptically spoiled and

unfit for additional evaluation at the end of 16 days. Bisulfite scallops continued to be sampled through 18, 21, 25, 28, 30, 32, and 35 days of storage organoleptically and through day 32 microbiologically. Frozen control samples were monitored through 30 days of storage before the supply of product was exhausted. Each sample was analyzed in duplicate for ammonium (Ward et al., 1978) and trimethylamine (Chang et al., 1976) concentrations. A single composite sample was used to determine pH levels. The following microbiological analyses were completed in duplicate: aerobic plate counts (FDA, 1978), and fecal streptococci (enterococci) plate counts (Speck, 1976). MPN total coliforms, MPN total E. coli, and MPN coagulase positive staphylococci populations were also determined.

Staff of the Marine Extension Service were presented with fresh scallop samples, some of which had been artificially aged through storage at room temperature. Over a one-week period, the participants evaluated the samples and developed modified aroma and appearance profiles to characterize the scallops. A continuous sensory scale of 0 to 5 described each aroma or appearance characteristic. A score of 0 indicated lack of detection by a panel member for a given trait, while a score of 5 indicated the strongest impression for that trait (Cardello, 1981), (Civille and Szczesniak, 1973), (Civille and Liska, 1975). Additionally, each sample was evaluated for aroma and appearance on a consumer-based scale from 0 to 5, with a score of 5 indicating the greatest level of acceptance. The following aroma characteristics were defined:

(1) Briny Smell: The aromatics associated with the smell of clean fresh seaweed and ocean air.

(2) Sweet: The sweet fragrance, minus the associated aromatics of many products, such as cooked fresh fish.

(3) Ammonia: The characteristic odor of ammonia. A sharp irritation to the nostrils.

(4) Post Room Odor: The aroma associated with the viscera of freshly killed animals.

(5) Putrid: The aromatics associated with decaying fish and meat products.

(6) Sour: The aromatics associated with vinegar or lemon.

(7) Fishy: The aromatics associated with seafood that is beginning to age, but is not yet old or spoiled.

(8) Consumer Rating: A general evaluation of the product from a consumer's viewpoint. An excellent scallop in the freshest state would rate 5.

The following appearance characteristics were defined:

(1) Slimy: The amount of moist sticky substance coating the individual scallops.

(2) Light-Dark: The color of the scallop ranging from white (0) to grey (5).

(3) Firmness: The textural appearance and tactile sensation of the scallop. Zero indicated poor shape definition and a mushy feeling to the touch. Five indicated a well-defined shape with a turgid appearance and a firm feeling to the touch.

(4) Adhesiveness: The tendency of individual scallops to clump together and stay that way. A score of 5 indicated a cohesive mass.

(5) Wetness: The amount of free moisture on the surface and drained from the scallops. Zero characterized a dry sample.

(6) Consumer Rating: A general evaluation of the product from a consumer's viewpoint. An excellent scallop rated 5.

A trained six-member sensory panel evaluated each sample for aroma and appearance. Single scallop samples were presented to each panel member utilizing a single blind experimental design.

All chemical, microbiological, and organoleptic data sets containing two or more values for each dependent variable were analyzed statistically with the Statistical Analysis System (SAS) (Ray, 1982). The methods included the General Linear Regression Model utilizing an analysis of variance procedure to compare the dependent variables for each day of storage with the three experimental groups and one control group. Dependent variable means were compared for significant differences at the 0.05 level using Tukey's studentized range test (HSD) (Ray, 1982). Every treatment completed in duplicate was analyzed by a regression analysis on each dependent variable against time, for the first 16 days of the storage study. Additionally, bisulfite scallop data were analyzed for each dependent taste panel variable over 35 days of storage and over 32 days of storage for the dependent chemical and microbiological variables. A significant correlation between

a dependent variable and time was considered for probability values p less than 0.05.

In the remainder of the paper, all significant differences will refer to p less than 0.05. Significant differences among means will refer to Tukey's studentized range test, and significant regressions will refer to a standard linear regression model (Ray, 1982). Means, number of samples, and standard errors of the mean are listed in Appendices A through R.

RESULTS

A. pH

The pH values of the treated and untreated scallops showed few consistent differences throughout the storage period (Figure 1). The HTH, Odocine, and untreated sample pH values decreased from 6.85 to 6.63, from 6.80 to 6.64, and from 6.80 to 6.61, respectively, over 16 days of iced storage. The scallops dipped in one percent sodium bisulfite had an initial pH of 6.90, which dropped to 6.64 on the fourth day of storage, increased to 6.90 by day 13 of storage, and returned to 6.83 on day 35 of storage. Tukey's studentized range test and the regression analysis were not used to analyze the pH data.

B. Ammonium

Mean ammonium concentrations determined for HTH, Odocine, and untreated scallops increased over the 16 days of monitored storage, but showed no significant differences among treatments (Figure 2, Table 1). Initial and final levels for the three treatments were 11.5–22.1 mg/100g, 10.5–18.8 mg/100g, and 11.4–18.0 mg/100g, respectively. The bisulfite sample had ammonium levels that exceeded the values determined for the other samples on all occasions. An initial mean ammonium concentration of 51.50 mg/100g increased to 180 mg/100g by day 16, 285 mg/100g by day 18, dropped to 187.5 mg/100g by day 30, and increased to 233 mg/100g by day 35 (Figure 2). Ammonium levels were significantly greater in the bisulfite samples than in the other samples on days 1, 4, 7, 11, and 14 (Table 1).

The sample treated with bisulfite exhibited a significant regression correlation ($r^2 = 0.632$) between ammonium concentration and time for the first 16 days of storage and for the total 32 days of iced storage ($r^2 = 0.607$). The HTH and Odocine samples exhibited significant ammonium correlations with time ($r^2 = 0.332$,

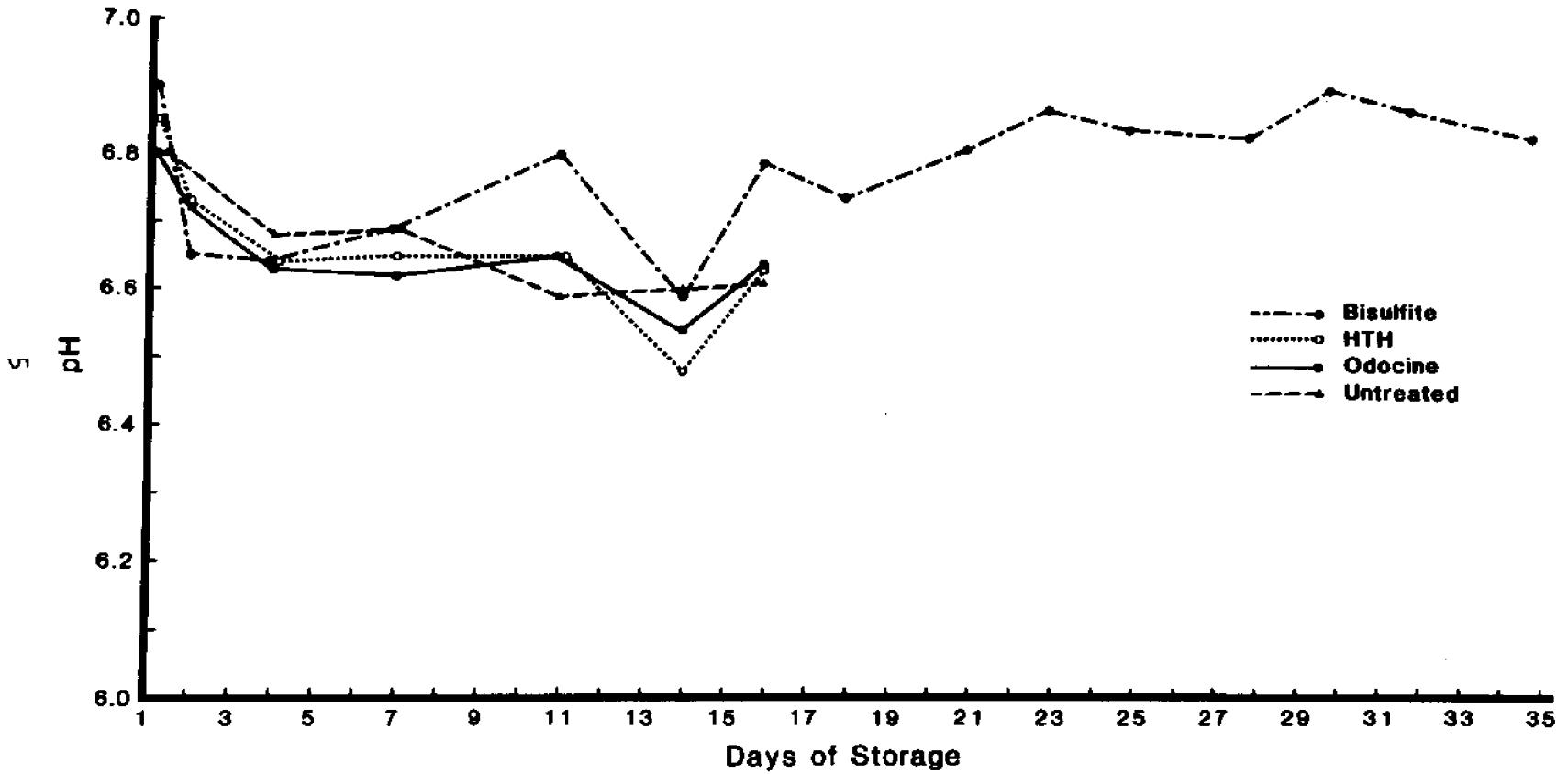

Figure 1. pH for bisulfite, HTH, Odocine, and untreated scallops

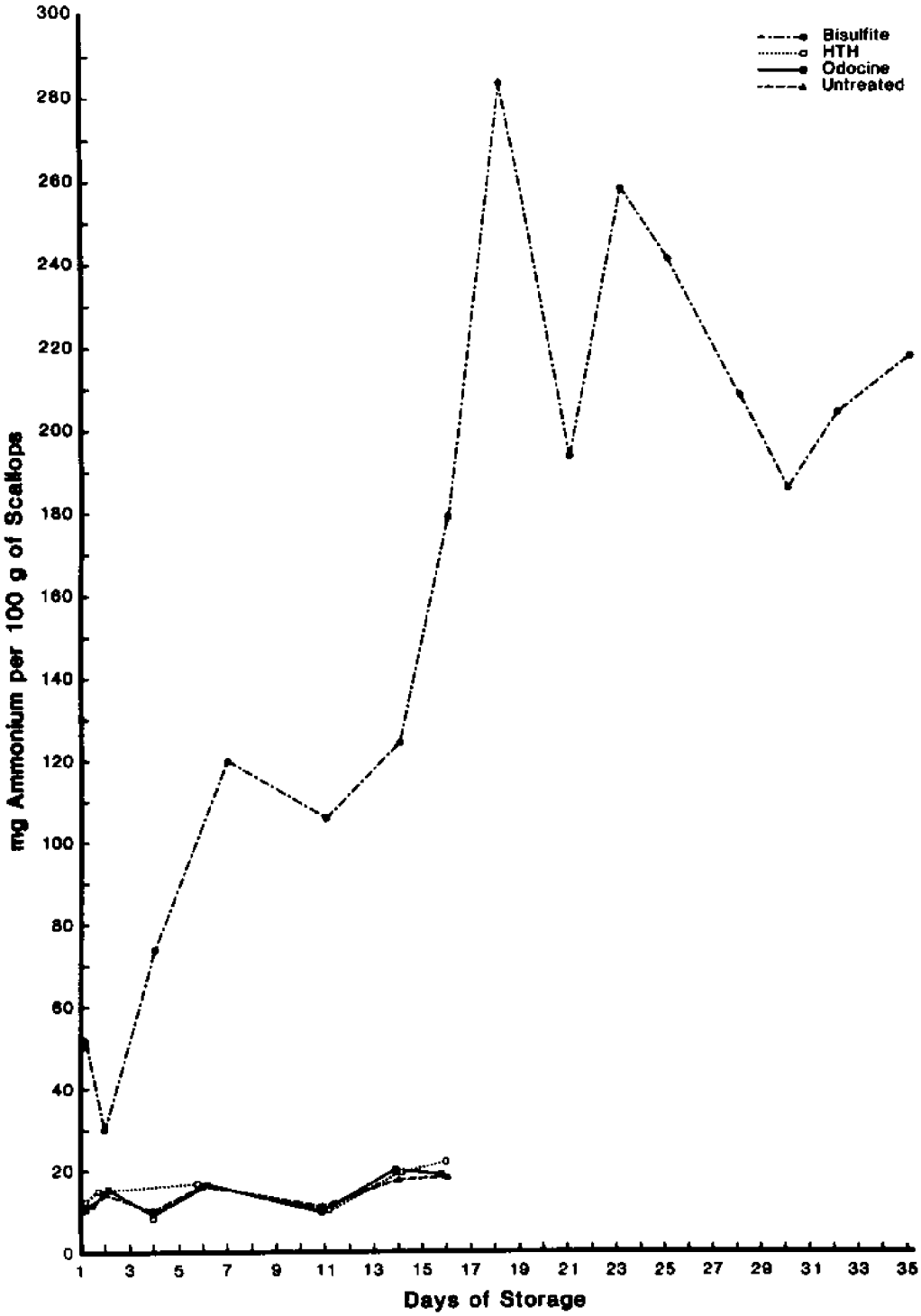

Figure 2. Mean ammonium levels for bisulfite, HTH, Odocine, and untreated scallops

Ammonium
mg/100g

Days of Storage	Mean	Treatment	Days of Storage	Mean	Treatment
1	A 51.50	Bisulfite	14	A 125.00	Bisulfite
	B 11.50	HTH		B 19.95	Odocine
	B 11.40	Untreated		B 19.50	HTH
	B 10.45	Odocine		B 17.50	Untreated
	PSE = 2.146			PSE = 1.263	
2	No significant difference		16	No significant difference	
	PSE = 3.744			PSE = 17.505	
4	A 74.00	Bisulfite	18	—	—
	B 10.35	Untreated			
	B 9.30	Odocine	21	—	—
	B 8.50	HTH			
	PSE = 0.284		23	—	—
7	A 120.00	Bisulfite	25	—	—
	B 16.50	HTH			
	B 16.15	Odocine	28	—	—
	B 16.00	Untreated			
	PSE = 6.31		30	—	—
11	A 106.50	Bisulfite	32	—	—
	B 11.50	Untreated			
	B 10.15	HTH	35	—	—
	B 9.65	Odocine			
	PSE = 0.416				

Table 1. Mean ammonium 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.

r^2 = 0.430) for the first 16 days of the study. No significant correlation was observed for the untreated samples.

C. Trimethylamine

Mean trimethylamine (TMA) levels increased for all monitored samples over the first 16 days of storage (Figure 3), with a rapid rise in TMA levels between days 11 and 16 of storage. Mean TMA levels on days 1, 11, and 16 were: 6.98, 6.86, and 36.65 mg/100g, untreated; 9.98, 14.36, and 36.65 mg/100g, HTH; 8.75, 7.63, and 34.58 mg/100g, Odocine; and 16.57, 24.24, and 49.65 mg/100g, bisulfite. Bisulfite sample TMA levels fell to 17.44 mg/100g by day 23, but increased to 43.74 mg/100g by day 35 of storage. TMA levels in the bisulfite scallops were significantly greater than those found in the other scallops following two, four, and seven days (Table 2). At day one, the bisulfite scallops had significantly more TMA than the Odocine or untreated samples, but were not significantly different from the HTH samples. On day 14, both the bisulfite and untreated samples contained significantly greater TMA than the other scallops. All scallop samples had a significant positive correlation between TMA levels and storage time over the first 16 days of storage. The r^2 values were: 0.564, bisulfite; 0.420, HTH; 0.403, Odocine; and 0.604, untreated. TMA levels determined for the bisulfite samples correlated positively (r^2 = 0.200) for 35 days of storage.

D. Aerobic Plate Count

The mean number of bacteria detected in the samples increased over the first 16 days of storage for the following samples: untreated, 2.06×10^5 (log 5.31) to 7.20×10^6 (log 6.86) organisms/g; HTH, 1.29×10^5 (log 5.11) to 1.11×10^7 (log 7.05) organisms/g; and Odocine, 1.85×10^5 (log 5.27) to 1.43×10^7 (log 7.16) organisms/g. During the first 16 days of storage, the bisulfite scallop aerobic plate counts decreased from 1.84×10^5 (log 5.26) to 5.20×10^4 (log 4.72) organisms/g (Figure 4). The aerobic plate count values continued to decrease through day 23, reaching a minimum of 1.11×10^4 (log 4.05) organisms/g. The plate counts then increased to a maximum value of 2.01×10^7 (log 7.30) organisms/g by day 35. The following treated scallops exceeded FDA aerobic plate count guidelines (5.00×10^5 organisms/g, Cockey, 1983): HTH and Odocine samples at 11 days of storage (5.15×10^5 and 5.30×10^5 organisms/g), untreated at 14 days (2.13×10^6 organisms/g), and bisulfite at 28 days (3.64×10^6 organisms/g) (Figure 4). Tukey's studentized range test detected significant differences among the treatment means on days 1, 4, 7, and 11 (Table 3). On day one, the HTH sample had a significantly lower plate count than the other scallops. The bisulfite sample population was significantly less than the

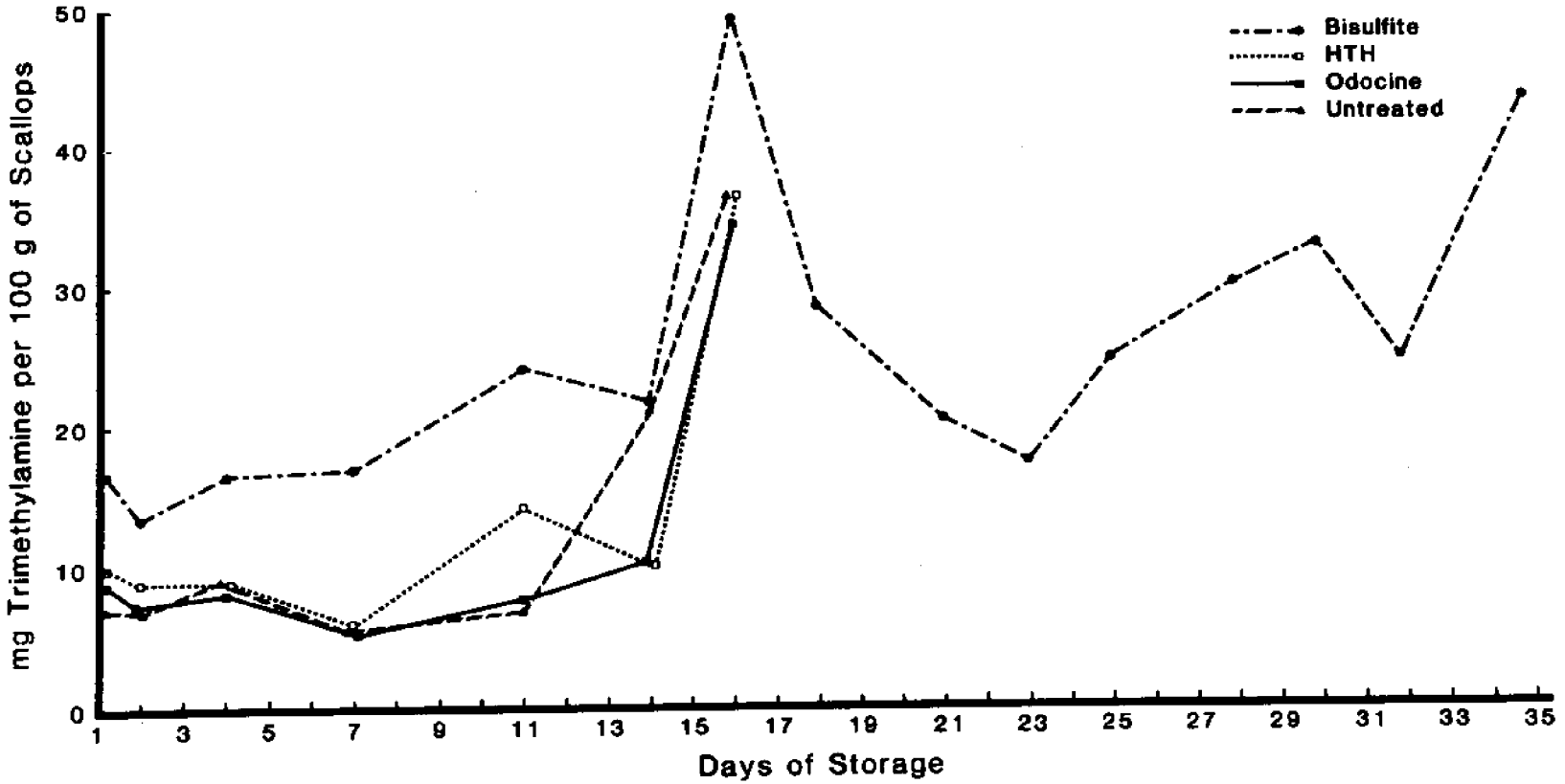

Figure 3. Mean trimethylamine levels, mg/100g, for bisulfite, HTH, Odocine, and untreated scallops

Trimethylamine
mg/100g

Days of Storage	Mean	Treatment	Days of Storage	Mean	Treatment
1	A 16.67	Bisulfite	14	A 21.87	Bisulfite
	BA 9.98	HTH		A 21.28	Untreated
	B 8.75	Odocine		B 10.40	Odocine
	B 6.98	Untreated		B 10.28	HTH
	PSE = 0.650			PSE = 0.613	
2	A 13.48	Bisulfite	16	No significant difference	
	B 8.98	HTH		PSE = 1.356	
	B 7.33	Odocine			
	B 6.86	Untreated			
	PSE = 0.279		18	—	—
4	A 16.55	Bisulfite	21	—	—
	B 9.16	Untreated			
	B 8.98	HTH	23	—	—
	B 8.22	Odocine			
	PSE = 0.641		25	—	—
7	A 17.14	Bisulfite	28	—	—
	B 6.08	HTH			
	B 5.62	Untreated	30	—	—
	B 5.32	Odocine			
	PSE = 0.246		32	—	—
11	No significant difference		35	—	—
	PSE = 1.872				

Table 2. Mean Trimethylamine 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.

Odocine or untreated samples by day four, less than the HTH samples on day seven, and less than all samples on day 11. For the first 16 days of storage, the bisulfite scallops showed a significant negative correlation ($r^2 = 0.587$). The increase in aerobic plate counts over time for the HTH and Odocine samples correlated significantly for 16 days of storage with $r^2 = 0.647$ and $r^2 = 0.540$. The untreated sample bacterial levels did not correlate significantly with time. Over 32 days of storage, the bisulfite samples exhibited no significant correlation between time and aerobic plate counts. Growth of microorganisms in all samples appeared to be a threshold response. A logarithmic growth phase was initiated at seven days for the HTH, Odocine, and untreated samples, and at 23 days for the bisulfite samples.

E. Fecal Streptococci Plate Counts

All sample fecal streptococci levels, except for the HTH scallops, decreased in numbers over the entire storage period. Initial and final fecal streptococci populations were: 3,800–1,470 organisms/g, bisulfite; 385–725 organisms/g, HTH; 3,800–1,542 organisms/g, Odocine; and 4,100–3,450 organisms/g, untreated (Figure 5). From day four of storage through day 14, the bisulfite samples had significantly fewer mean organisms/g than one or more of the other scallop samples (Table 4). No other consistent differences among means were noted. Bisulfite and Odocine scallop samples had significant negative correlations ($r^2 = 0.386$, $r^2 = 0.342$) over the first 16 days of storage.

F. MPN Total Coliform and E. coli Organisms

Total coliform levels increased with time for all scallop samples except the bisulfite product, which registered a net decrease (Figure 6). Initial and final MPN total coliform levels were: 79–240 organisms/g, HTH; 240–542 organisms/g, Odocine; and 34–348 organisms/g, untreated. Initial bisulfite populations of 348 organisms/g dropped to 23 organism/g by day 16 and to less than 2 organisms/g by day 32. All samples exceeded the FDA Shellfish Guideline of less than 23 organisms/g during the storage study. All E. coli determinations were negative except for the untreated sample collected on day one with an MPN of 2 (Figure 7). No E. coli organisms are permitted in shellfish according to FDA guidelines (Cockey, 1983).

G. MPN Coagulase Positive Staphylococci

Four or less coagulase positive organisms per gram were detected from all collected samples (Figure 8). No consistent pattern was determined for the data. No sample exceeded Georgia guidelines of 100 coagulase positive staphylococci per gram.

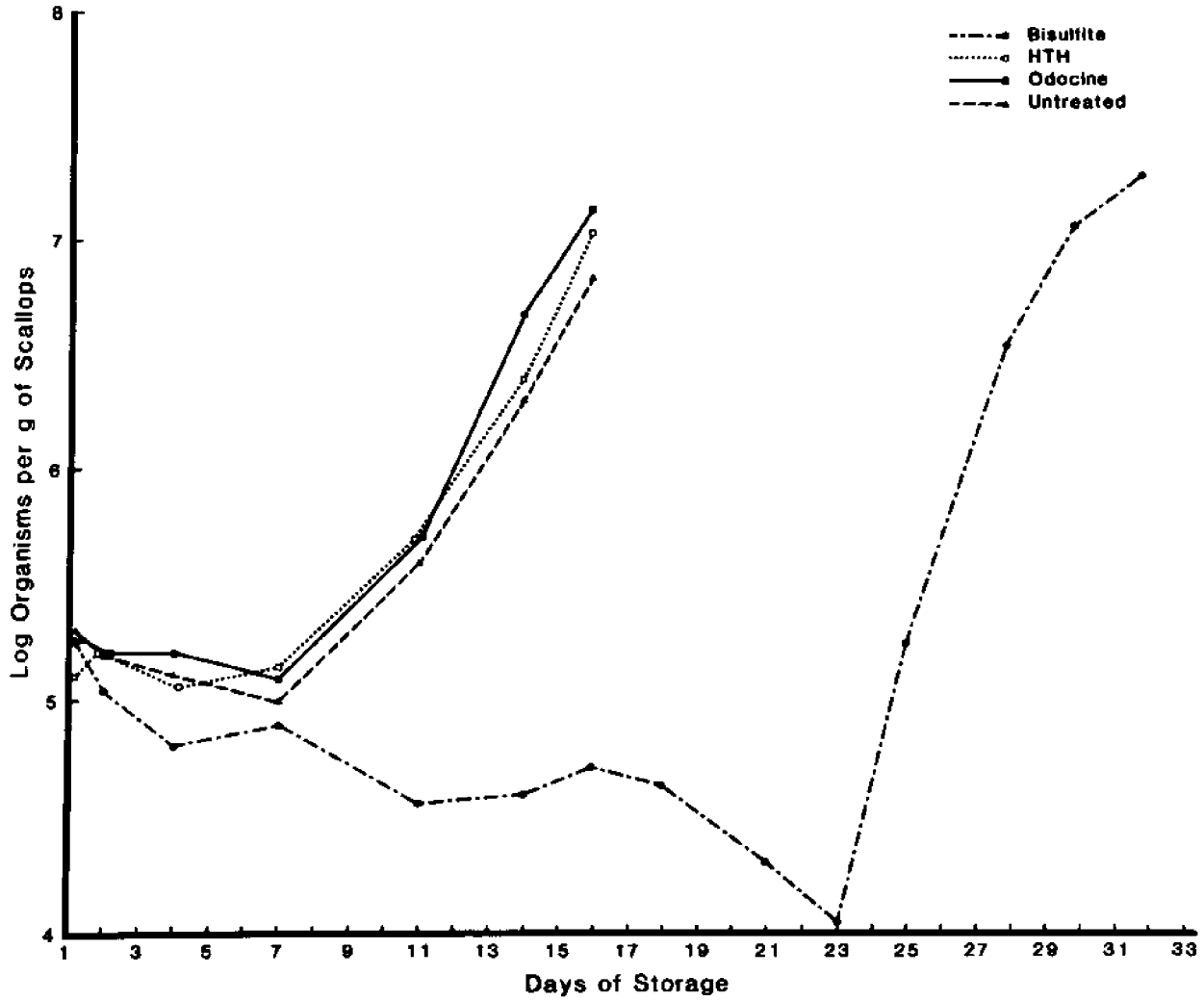

Figure 4. Mean aerobic plate counts, organisms/g for bisulfite, HTH, Odocine and untreated scallops

Aerobic Plate Count
Org/g

Days of Storage	Mean	Treatment
1	A 2.06×10^5	Untreated
	A 1.84×10^5	Odocine
	A 1.84×10^5	Bisulfite
	B 1.29×10^5	HTH
	PSE = 4.18×10^3	
2	No significant difference	
	PSE = 6.61×10^3	
4	A 1.62×10^5	Odocine
	A 1.32×10^5	Untreated
	BA 1.17×10^5	HTH
	B 6.45×10^4	Bisulfite
	PSE = 5.81×10^3	
7	A 1.36×10^5	HTH
	BA 1.24×10^5	Odocine
	BA 1.01×10^5	Untreated
	B 7.80×10^4	Bisulfite
	PSE = 5.12×10^3	
11	A 5.30×10^5	Odocine
	A 5.15×10^5	HTH
	A 3.95×10^5	Untreated
	B 3.65×10^4	Bisulfite
	PSE = 2.72×10^4	
14	No significant difference	
	PSE = 8.73×10^4	
16	No significant difference	
	PSE = 6.89×10^4	
18	—	—
21	—	—
23	—	—
25	—	—
28	—	—
30	—	—
32	—	—
35	—	—

Table 3. Mean aerobic plate counts 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.

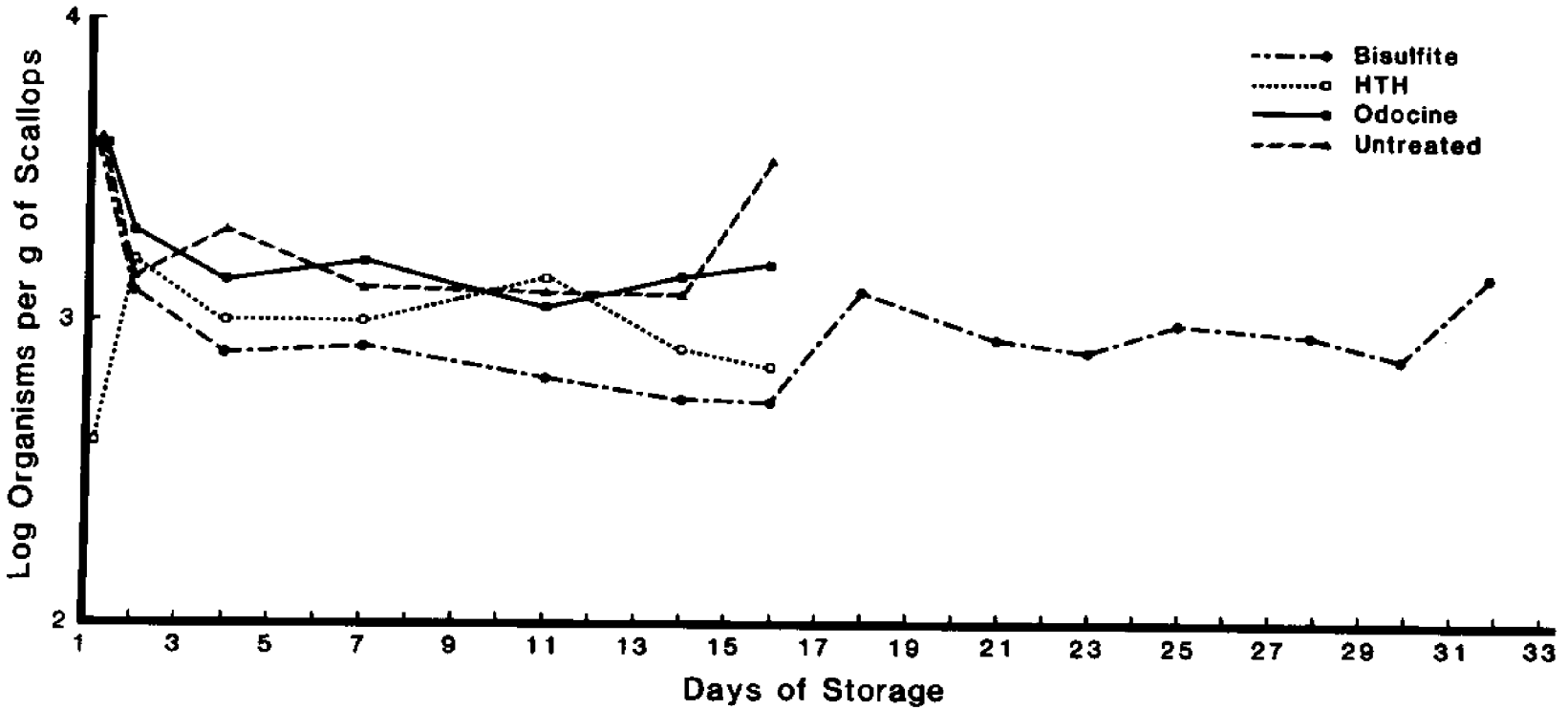

Figure 5. Mean fecal streptococci (enterococci) plate counts, organisms/g, for bisulfite, HTH, Odocine, and untreated scallops

Fecal Streptococci
Org/g

Days of Storage	Mean	Treatment	Days of Storage	Mean	Treatment
1	A 4.10×10^3	Untreated	14	A 1.43×10^3	Odocine
	A 3.80×10^3	Bisulfite		BA 1.22×10^3	Untreated
	A 3.80×10^3	Odocine		BA 805	HTH
	B 385	HTH		B 545	Bisulfite
	PSE = 258			PSE = 65	
4	No significant difference		16	No significant difference	
	PSE = 67			PSE = 290	
7	A 1.60×10^3	Odocine	18	—	—
	BA 1.33×10^3	Untreated			
	B 1.02×10^3	HTH	21	—	—
	B 825				
	PSE = 44		23	—	—
11	A 1.37×10^3	HTH	25	—	—
	A 1.26×10^3	Untreated			
	A 1.22×10^3	Odocine	28	—	—
	B 655	Bisulfite			
	PSE = 32		30	—	—
			32	—	—
			35	—	—

Table 4. Mean fecal streptococci plate counts 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.

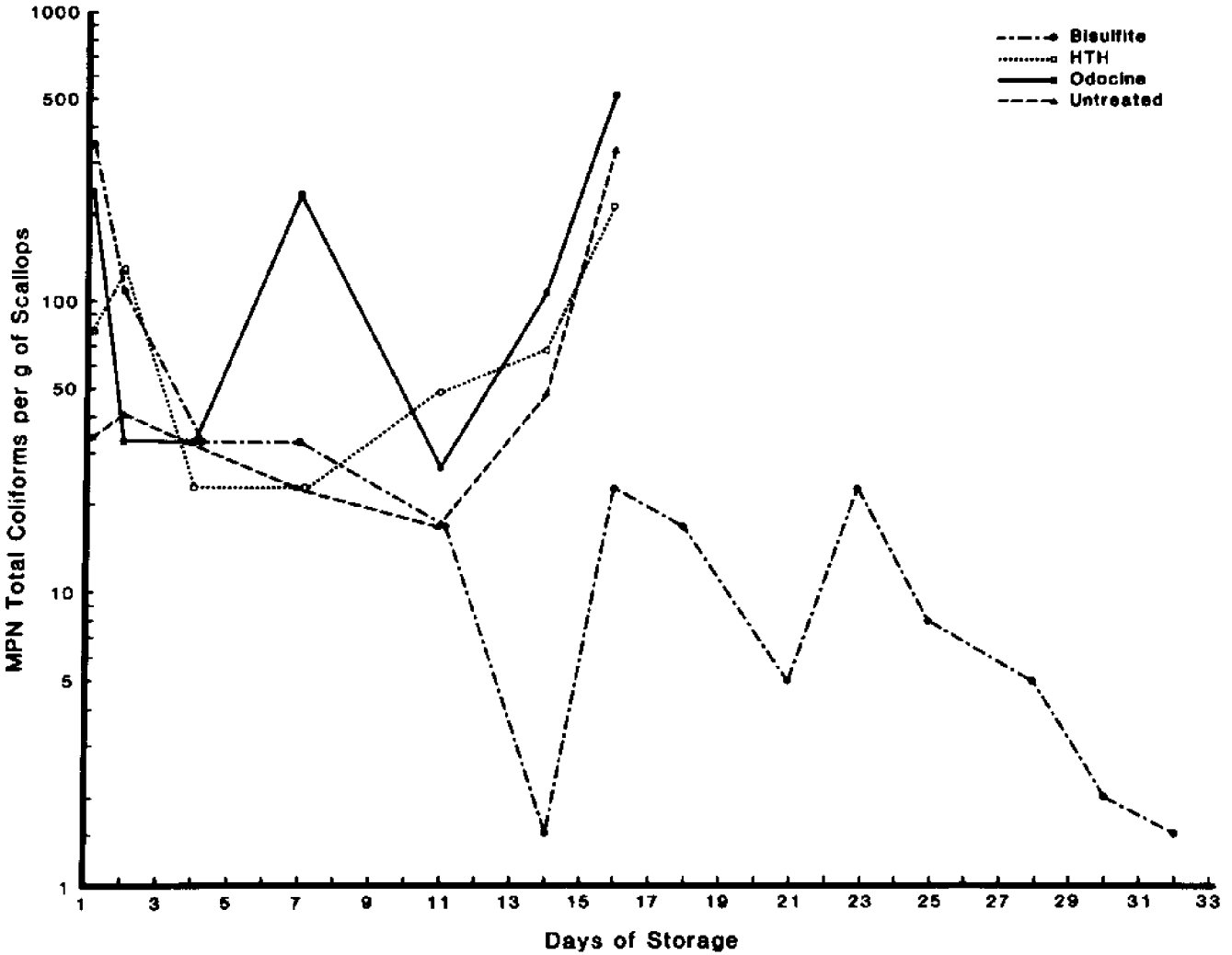

Figure 6. MPN total coliform organisms/g for bisulfite, HTH, Odocine, and untreated scallops

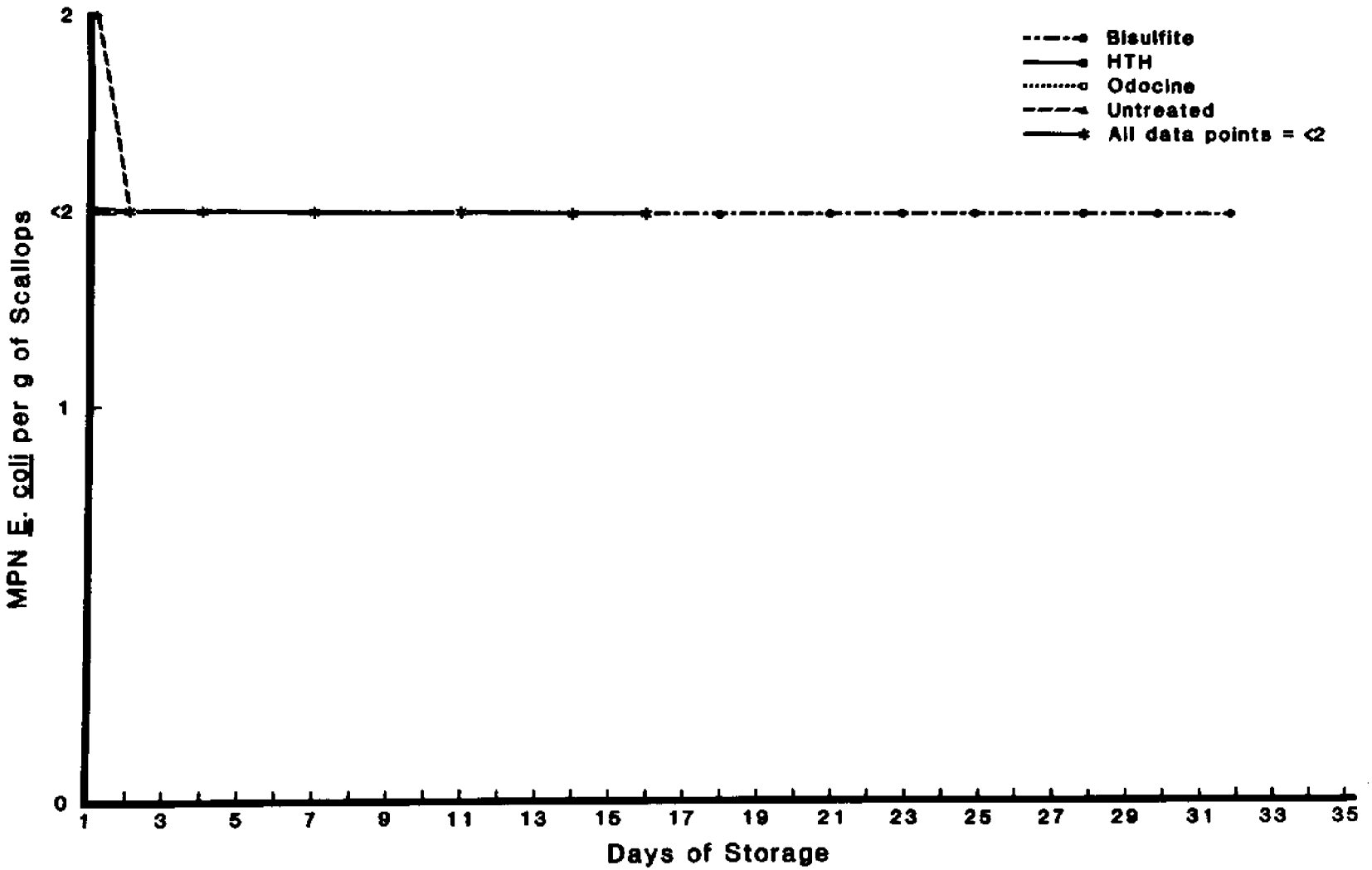

Figure 7. MPN E. coli organisms/g for bisulfite, HTH, Odocine, and untreated scallops

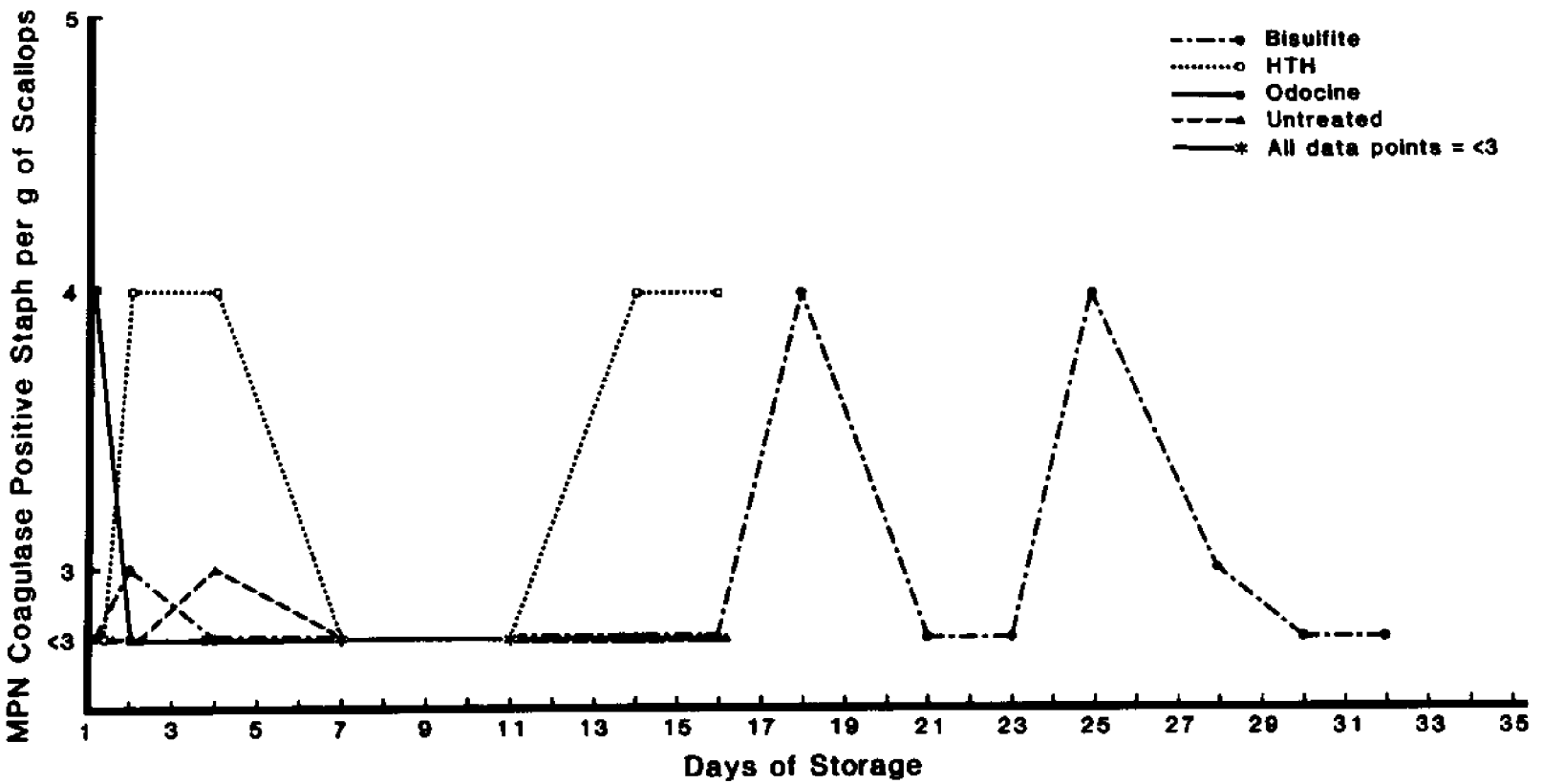

Figure 8. MPN coagulase positive staphylococci organisms/g for bisulfite, HTH, Odocine, and untreated scallops

H. Briny

The perceived briny odor of all scallop samples decreased with time. Initial and final mean values were 3.00–0.17, HTH; 3.00–0.17, Odocine; 3.00–0.17, untreated; and 3.33–1.92, frozen control. Initial bisulfite levels of 3.33 dropped to 1.67 by day 16 and 0.67 on day 35 (Figure 9). The briny aroma decreased rapidly following 11 days of storage. Briny levels on days 11, 14, and 16 were 1.83, 0.67, 0.17, HTH; 2.00, 0.67, 0.17, Odocine; and 2.50, 0.00, and 0.17, untreated. The bisulfite scallops briny score decreased rapidly from 1.67 on day 25 to 0.67 on day 35. HTH, Odocine, and untreated samples had significantly lower mean briny ratings than the frozen control or bisulfite scallops by days 14 and 16 (Table 5). The briny aroma of the bisulfite samples remained below that of the frozen control samples from day four through day 30, but was significantly less than the control samples on days 16, 18, 23, 28, and 30 (Table 5). Bisulfite, HTH, Odocine, and untreated scallops had a significant negative briny correlation with time for the first 16 days of storage, r^2 = 0.333, r^2 = 0.742, r^2 = 0.764 and r^2 = 0.680. Over 35 days of storage, a significant negative correlation (r^2 = 0.418) was determined for the briny aroma of the bisulfite sample.

I. Sweet

The mean levels of sweetness determined for the frozen control, HTH, and untreated samples decreased over the first 16 days of storage (Figure 10). The initial and final perceived values were 1.50–0.67, frozen control; 1.67–0.50, HTH; and 2.00–0.83, untreated. The Odocine samples returned to the initial value of 1.00 after 16 days, while the bisulfite scallops increased from 1.00 to 1.67. Over 35 days of storage the bisulfite samples decreased from 1.00 to 0.83 with a minimum value of 0.33 on day 18. Few significant differences among the means of the treatments on a daily basis were noted (Table 6). No consistent pattern was determined. Over a 16 day period, the HTH sample exhibited a significant negative correlation between sweetness and time (r^2 = 0.193). The bisulfite scallops decreased significantly in sweetness with respect to time over 35 days of iced storage (r^2 = 0.142). No additional correlations were apparent.

J. Ammonia

Final perceived ammonia levels were greater than initial levels in all cases (Figure 11). Following 16 days of storage, Odocine samples and untreated samples increased from mean initial ammonia values of 0 to 1.75 and 0 to 1.83. Frozen control, HTH, and bisulfite readings were the same on day 16 as on day one, at 0,

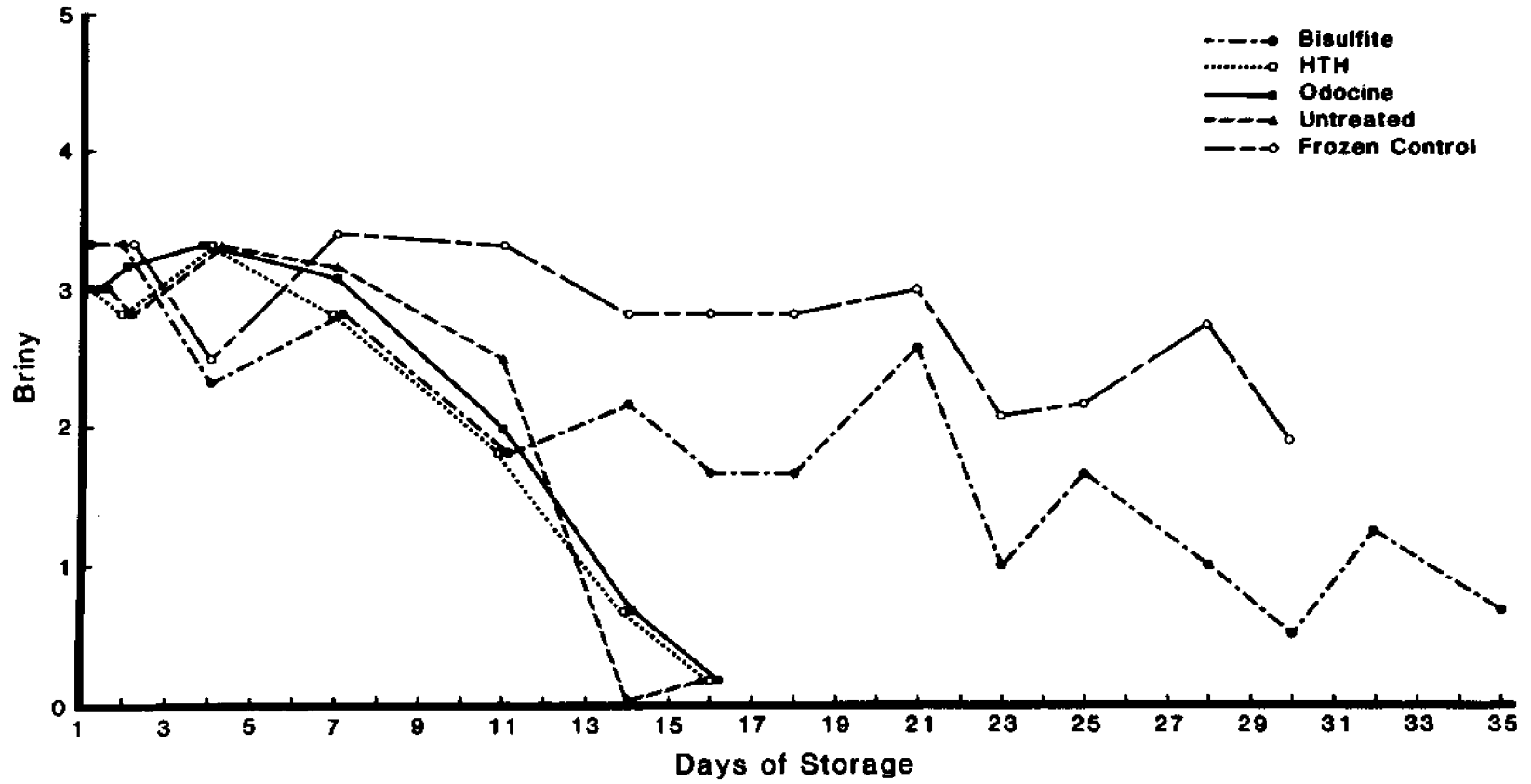

Figure 9. Mean briny sensory scores for bisulfite, HTH, Odocine, untreated, and frozen control scallops

Briny

Days of Storage	Mean	Treatment
1	No significant difference	
	PSE = 0.154	
2	No significant difference	
	PSE = 0.111	
4	A 3.33	HTH
	A 3.33	Odocine
	A 3.33	Untreated
	BA 2.50	Frozen Control
	B 2.33	Bisulfite
	PSE = 0.095	
7	No significant difference	
	PSE = 0.115	
11	A 3.33	Frozen Control
	BA 2.50	Untreated
	B 2.00	Odocine
	B 1.83	Bisulfite
	B 1.83	HTH
	PSE = 0.106	
14	A 2.83	Frozen Control
	A 2.17	Bisulfite
	B 0.67	HTH
	B 0.67	Odocine
	B 0.00	Untreated
	PSE = 0.117	
16	A 2.83	Frozen Control
	B 1.67	Bisulfite
	C 0.17	HTH
	C 0.17	Odocine
	C 0.17	Untreated
	PSE = 0.789	
18	A 2.83	Frozen Control
	B 1.67	Bisulfite
	PSE = 0.186	
21	No significant difference	
	PSE = 0.253	
23	A 2.08	Frozen Control
	B 1.00	Bisulfite
	PSE = 0.136	
25	No significant difference	
	PSE = 0.186	
28	A 2.75	Frozen Control
	B 1.00	Bisulfite
	PSE = 0.202	
30	A 1.92	Frozen Control
	B 0.50	Bisulfite
	PSE = 0.236	
32	--	--
35	--	--

Table 5. Mean briny 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.

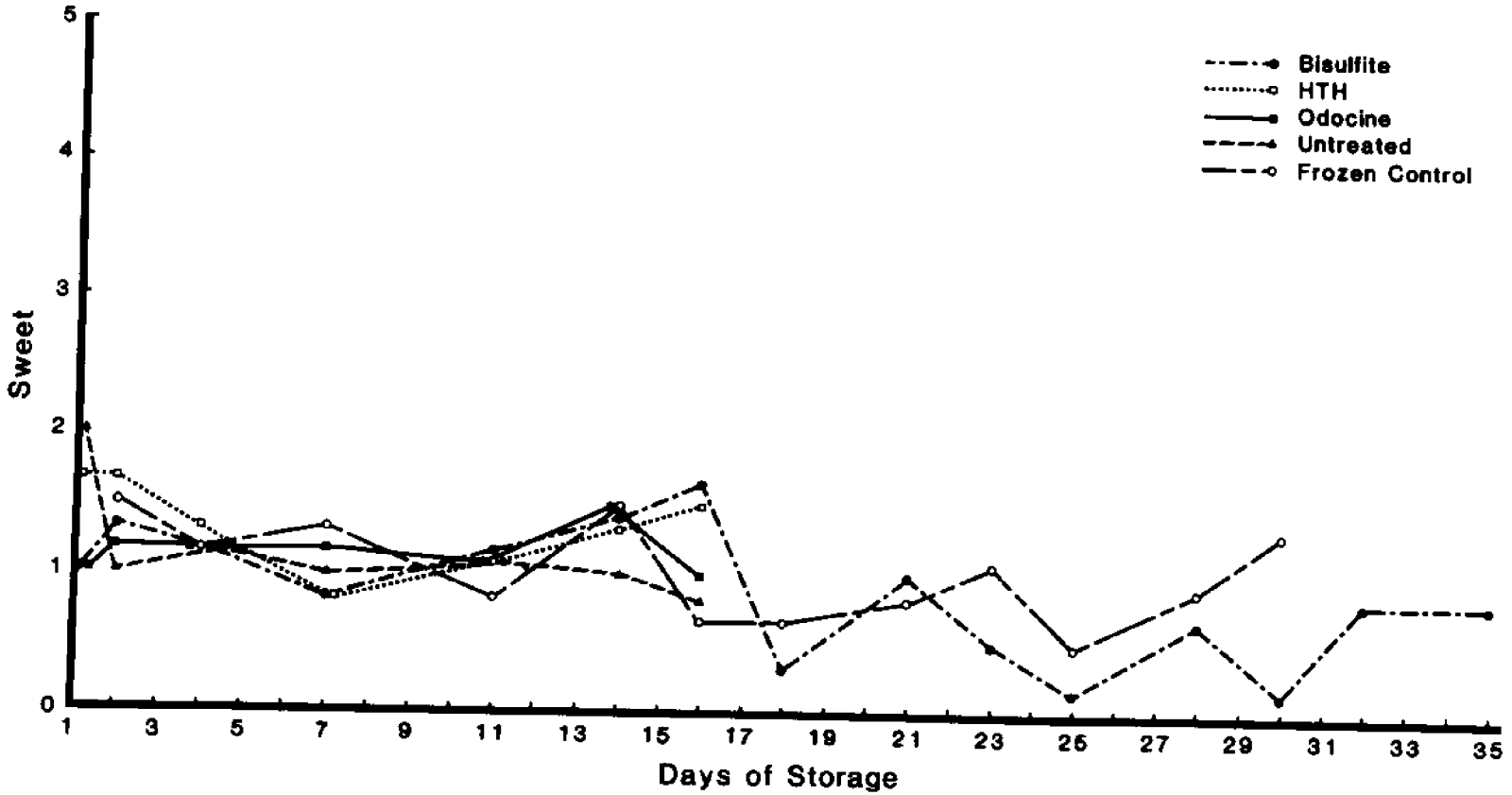

Figure 10. Mean sweet sensory scores for bisulfite, HTH, Odocine, untreated, and frozen control scallops

Sweet

Days of Storage	Mean	Treatment
1	A 2.00	Untreated
	BA 1.67	HTH
	B 1.00	Bisulfite
	B 1.00	Odocine
	PSE = 0.105	
2	No significant difference	
	PSE = 0.110	
4	No significant difference	
	PSE = 0.107	
7	No significant difference	
	PSE = 0.099	
11	No significant difference	
	PSE = 0.076	
14	No significant difference	
	PSE = 0.129	
16	A 1.67	Bisulfite
	BA 1.00	Odocine
	BA 0.83	Untreated
	BA 0.67	Frozen Control
	B 0.50	HTH
	PSE = 0.110	
18	No significant difference	
	PSE = 0.149	
21	No significant difference	
	PSE = 0.083	
23	No significant difference	
	PSE = 0.031	
25	No significant difference	
	PSE = 0.139	
28	No significant difference	
	PSE = 0.146	
30	A 1.33	Frozen Control
	B 0.17	Bisulfite
	PSE = 0.134	
32	--	--
35	--	--

Table 6. Mean sweet 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.

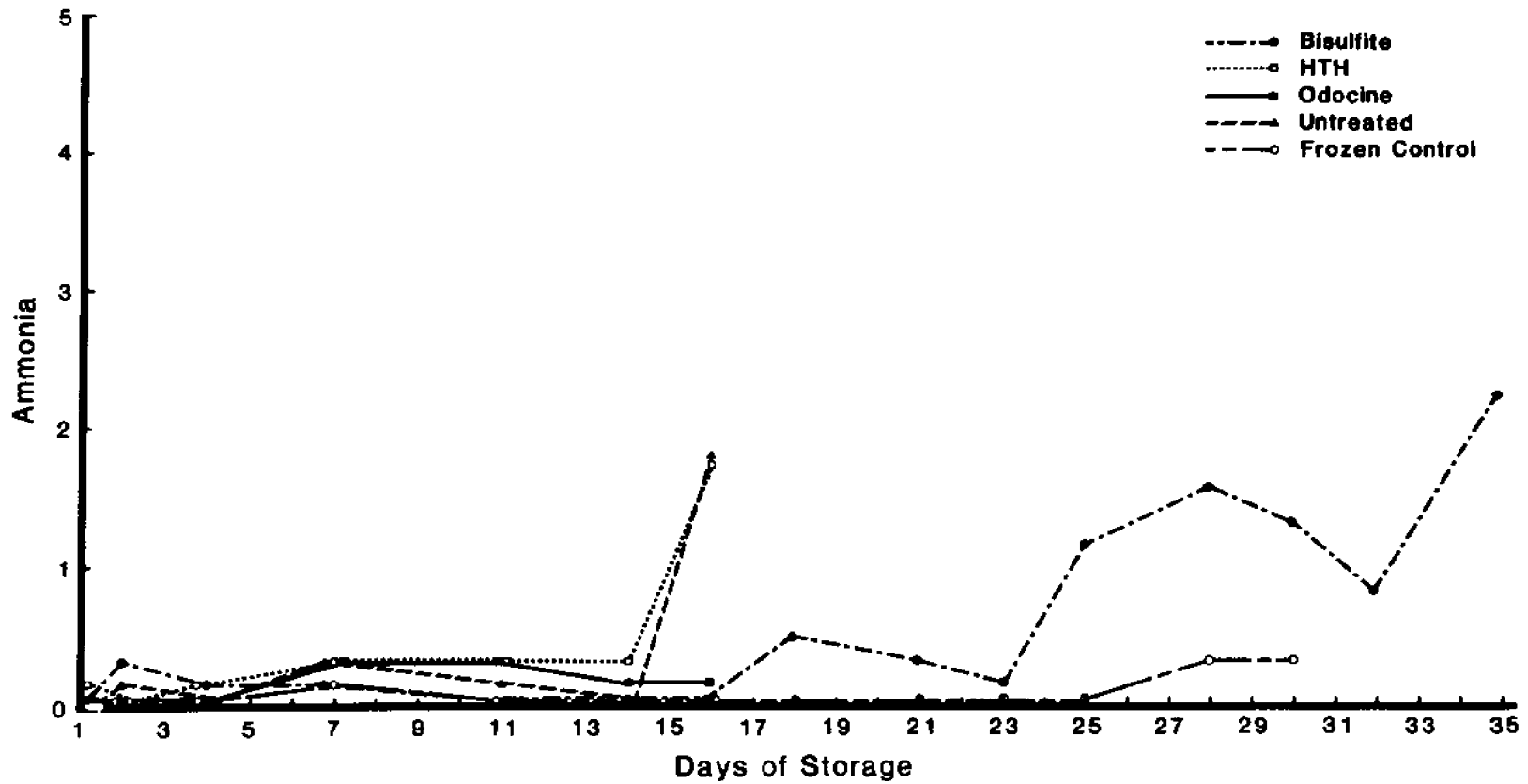

Figure 11. Mean ammonia sensory scores for bisulfite, HTH, Odocine, untreated, and frozen control scallops

Ammonia

Days of Storage	Mean	Treatment	Days of Storage	Mean	Treatment
1	No significant difference PSE = 0.042		18	A 0.50 B 0.00 PSE = 0.112	Bisulfite Frozen Control
2	No significant difference PSE = 0.054		21	No significant difference PSE = 0.105	
4	No significant difference PSE = 0.471		23	A 0.17 B 0.00 PSE = 0.833	Bisulfite Frozen Control
7	No significant difference PSE = 0.870		25	A 1.17 B 0.00 PSE = 0.239	Bisulfite Frozen Control
11	No significant difference PSE = 0.068		28	A 1.58 B 0.33 PSE = 0.215	Bisulfite Frozen Control
14	No significant difference PSE = 0.054		30	A 1.33 B 0.33 PSE = 0.200	Bisulfite Frozen Control
16	A 1.83 A 1.75 B 0.17 B 0.00 B 0.00 PSE = 0.113	Untreated Odocine HTH Bisulfite Frozen Control	32	—	—
			35	--	--

Table 7. Mean ammonia 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.

0.17, and 0, respectively. Bisulfite samples increased to 2.25 at the end of 35 days. Frozen control samples reached 0.33 at the end of 30 days. Following 16 days of storage, untreated and Odocine scallops had significantly greater ammonia scores than the remaining samples (Table 7). On days 18, 23, 25, 28, and 30, the bisulfite samples had significantly higher ammonia ratings than the frozen control samples.

Significant positive correlations were found for the following treatments with time over the first 16 days of storage: Odocine ($r^2 = 0.292$), untreated ($r^2 = 0.238$), and bisulfite ($r^2 = 0.133$). The 35-day storage period for the bisulfite sample produced a significant positive correlation ($r^2 = 0.351$) between perceived ammonia and time.

K. Post Room Odor

Final post room odor scores were greater than those values determined on the first day of storage for all treatments (Figure 12). Over the first 16 days of storage, all treatments except for the frozen control sample registered a net increase in mean scores. The frozen control scallops remained unchanged at 0.17. The HTH, Odocine, untreated, and bisulfite scallop scores increased over the 16-day period from: from 0.67 to 2.42, from 0.50 to 3.33, from 0.67 to 3.33, and from 0 to 0.83, respectively. Post room odor perceived from HTH, Odocine, and untreated scallops increased sharply from day 11 through day 16. On days 11, 14, and 16, the following post room odor scores were determined: 0.83, 2.33, 2.42, HTH; 0.50, 2.42, 3.33, Odocine; and 0.50, 3.58, 3.33, untreated. At the end of 30 and 35 days, respectively, the bisulfite and frozen control scores were 1.50 and 0.67 post room odor units. Table 8 shows significantly lower mean post room odor for the bisulfite and frozen control samples than the other scallops on days 14 and 16. Bisulfite scallops had significantly greater post room odor levels than the frozen control samples on days 18, 23, and 28 (Table 8).

No significant correlation between time and post room odor was determined for the frozen control samples. Bisulfite scallops showed a low ($r^2 = 0.085$) but significant positive correlation with time over 35 days of storage. HTH, Odocine, and untreated post room odor correlated significantly with time over 16 days of storage: $r^2 = 0.471$, $r^2 = 0.292$, and $r^2 = 0.569$, respectively.

L. Putrid

Mean putrid levels determined by the sensory panel increased rapidly for HTH, Odocine, and untreated samples from zero through day 11 to 0.83, 1.08, and 1.83 on day 14, with final values of

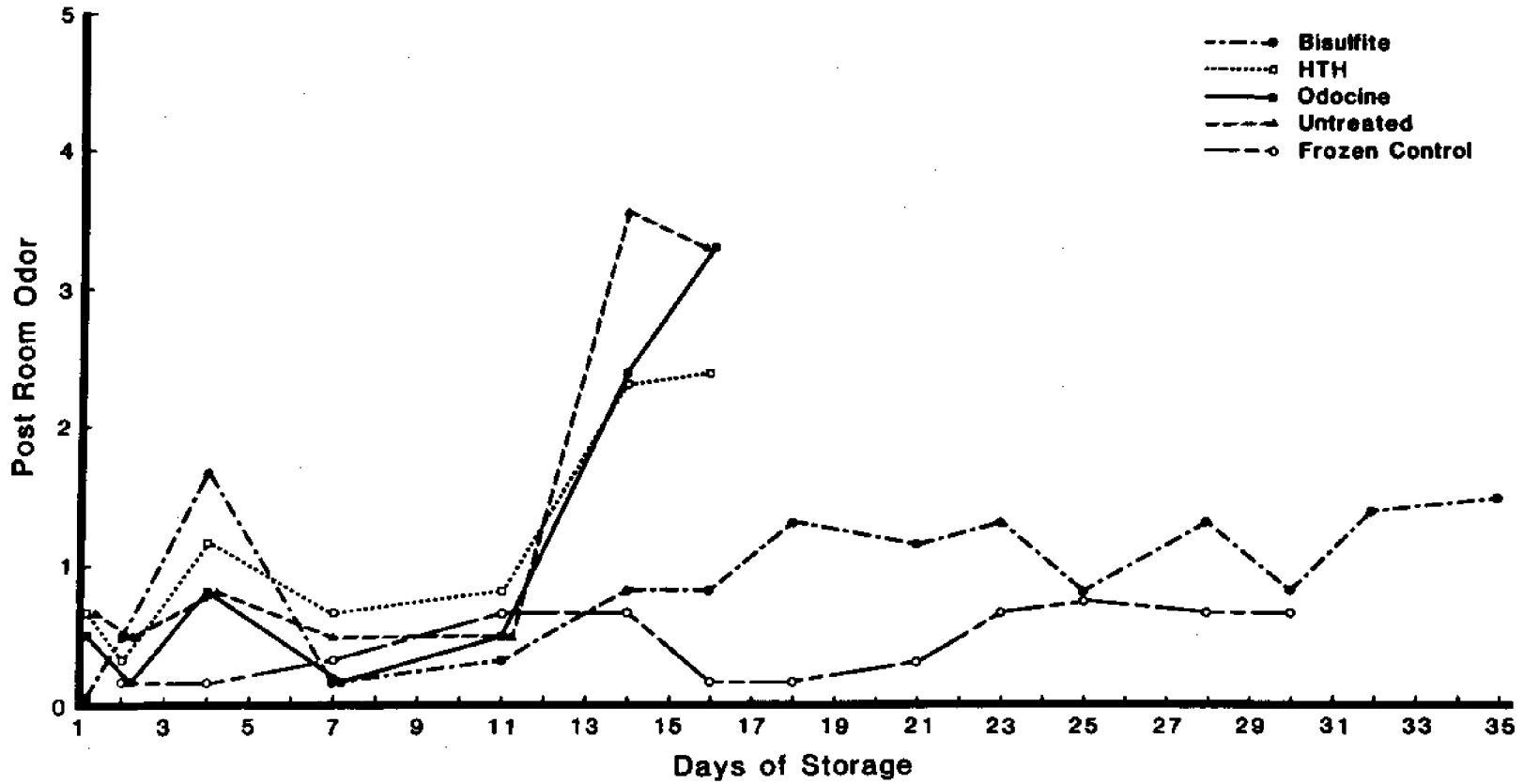

Figure 12. Mean post room odor sensory scores for bisulfite, HTH, Odocine, untreated and frozen control scallops

Post Room Odor

Days of Storage	Mean	Treatment
1	No significant difference	
	PSE = 0.113	
2	No significant difference	
	PSE = 0.089	
4	A 1.67	Bisulfite
	BA 1.17	HTH
	CB 0.83	Odocine
	CB 0.83	Untreated
	C 0.17	Frozen Control
	PSE = 0.079	
7	No significant difference	
	PSE = 0.088	
11	No significant difference	
	PSE = 0.093	
14	A 3.58	Untreated
	A 2.42	Odocine
	A 2.33	HTH
	B 0.83	Bisulfite
	B 0.67	Frozen Control
	PSE = 0.141	
16	A 3.33	Odocine
	A 3.33	Untreated
	A 2.42	HTH
	B 0.83	Bisulfite
	B 0.17	Frozen Control
	PSE = 0.113	
18	A 1.33	Bisulfite
	B 0.17	Frozen Control
	PSE = 0.134	
21	No significant difference	
	PSE = 0.227	
23	A 1.33	Bisulfite
	B 0.67	Frozen Control
	PSE = 0.149	
25	No significant difference	
	PSE = 0.227	
28	A 1.33	Bisulfite
	B 0.67	Frozen Control
	PSE = 0.149	
30	No significant difference	
	PSE = 0.186	
32	--	--
35	--	--

Table 8. Mean post room odor 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.

2.08, 1.83, and 2.83 on day 16 (Figure 13). Putrid scores remained at zero for the bisulfite samples through day 28, and increased to 0.67 by day 35. Frozen control scallops scored zero for all sample determinations. By day 14, the untreated scallops had a significantly greater putrid rating than HTH, bisulfite, or frozen control samples (Table 9). The Odocine sample level was significantly greater than the bisulfite or frozen control samples. By day 16, the untreated scallops had significantly greater mean putrid ratings than all other samples, with HTH and Odocine levels greater than those determined for bisulfite and frozen control scallops (Table 9).

Frozen control samples showed no significant correlation between putrid levels and storage time. Following 16 days of storage, HTH, Odocine, and untreated samples had significant positive putrid correlations with time: $r^2 = 0.546$, $r^2 = 0.589$, and $r^2 = 0.625$. Bisulfite samples had a low ($r^2 = 0.140$) but significant correlation between the parameter and storage time at the end of 35 days.

M. Sour

Mean sour levels for HTH, Odocine, and untreated samples remained at zero through 11 days of storage, then increased to 0.50 for all samples by day 16 (Figure 14). Bisulfite scallops reached a mean sour level of 0.17 by day 11, dropped back to zero by day 16, and reached 0.17 on days 32 and 35. Table 10 indicates no significant differences among mean sour values by treatment throughout the storage study. Significant correlations between the sour rating and time were determined over the first 16 days of storage for HTH, Odocine, and untreated scallops: $r^2 = 0.163$, $r^2 = 0.130$, and $r^2 = 0.154$.

N. Fishy

The mean fishy odor determined by the sensory panel was erratic for all sample treatments (Figure 15). The frozen control level began at a mean of 1.17, peaked at 1.50 on days seven and 18, and ended at 0.50 on day 30. The HTH scallops began at 0.67, peaked at 1.17 by day two and ended at 0.83 on day 16. The initial fishy level for the Odocine scallops was 0.50, which increased to a maximum of 1.42 by day seven and ended on day 16 with a value of 1.33. The initial untreated sample rating of 1.00 reached 1.50 by day 11 and ended at 1.42 on day 16. The bisulfite sample began at 1.50, reached 3.17 by day 30, and returned to 1.50 by day 35. Although Table 11 shows several significant differences among means on days 11, 16, and 30, no consistent pattern was observed. A significant but low correlation

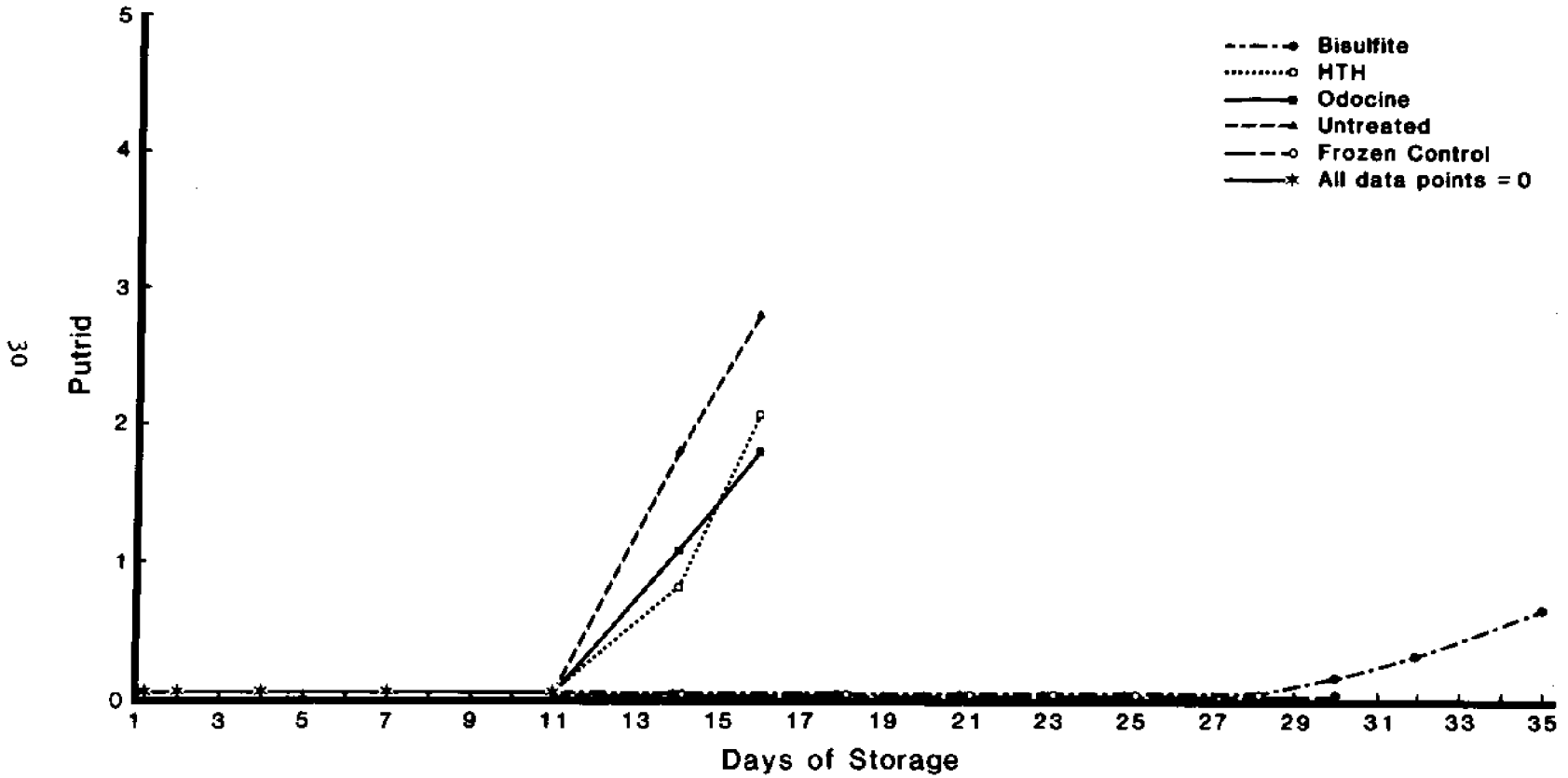

Figure 13. Mean putrid sensory scores for bisulfite, HTH, Odocine, untreated, and frozen control scallops

Putrid

Days of Storage	Mean	Treatment
1	No significant difference PSE = 0.000	
2	No significant difference PSE = 0.000	
4	No significant difference PSE = 0.000	
7	No significant difference PSE = 0.000	
11	No significant difference PSE = 0.000	
14	A 1.83 BA 1.08 CB 0.83 C 0.00 C 0.00 PSE = 0.102	Untreated Odocine HTH Bisulfite Frozen Control
16	A 2.83 B 2.08 B 1.83 C 0.00 C 0.00 PSE = 0.067	Untreated HTH Odocine Bisulfite Frozen Control
18	No significant difference PSE = 0.000	
21	No significant difference PSE = 0.000	
23	No significant difference PSE = 0.000	
25	No significant difference PSE = 0.000	
28	No significant difference PSE = 0.000	
30	No significant difference PSE = 0.083	
32	---	---
35	---	---

Table 9. Mean putrid 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.

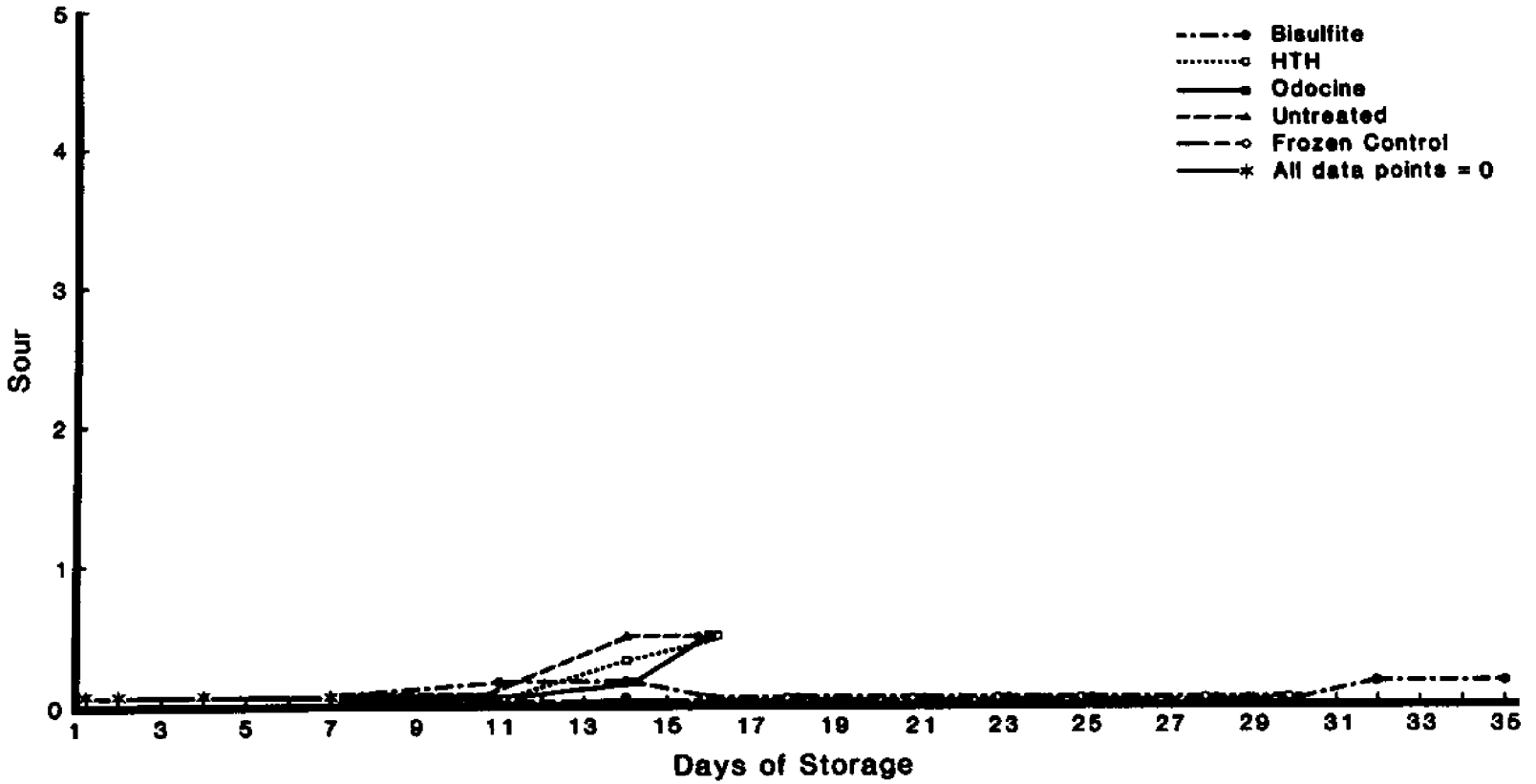

Figure 14. Mean sour sensory scores for bisulfite, HTH, Odocine, untreated, and frozen control scallops

Sour

Days of Storage	Mean	Treatment	Days of Storage	Mean	Treatment
1	No significant difference PSE = 0.000		18	No significant difference PSE = 0.000	
2	No significant difference PSE = 0.000		21	No significant difference PSE = 0.000	
4	No significant difference PSE = 0.000		23	No significant difference PSE = 0.000	
7	No significant difference PSE = 0.000		25	No significant difference PSE = 0.000	
11	No significant difference PSE = 0.105		28	No significant difference PSE = 0.000	
14	No significant difference PSE = 0.093		30	No significant difference PSE = 0.000	
16	No significant difference PSE = 0.118		32	--	--
			35	--	--

Table 10. Mean sour 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.

(r^2 = 0.165) was determined for the fishy ratings of the bisulfite sample during the first 16 days of storage.

O. Consumer Rating, Odor

The overall consumer rating for the frozen control sample changed very little through 32 days of storage, with initial and final values of 3.50 and 3.42 (Figure 16). The overall rating for HTH, Odocine, and untreated scallops began at 3.33, 3.83, and 3.67, reached values of 3.83, 3.75, and 3.92 by day 11, and then rapidly declined to 2.33, 2.50, and 2.08 by day 14 and 1.42, 1.83, and 1.17 by day 16. Bisulfite sample ratings declined gradually from 3.83 on day one to 3.42 by day 16 and 1.88 by day 35. Table 12 shows no significant differences among treatment means until day 11 of storage. The frozen control and untreated mean consumer odor ratings were significantly greater than those determined for the bisulfite scallops. On day 14, the frozen control sample had a significantly higher rating than the Odocine, HTH, and untreated samples. The perceived quality of the bisulfite scallops was significantly greater than the untreated sample. By day 16, the frozen control and bisulfite scallops were rated significantly higher than the other samples. Frozen control samples rated better consumer odor scores than the bisulfite samples on days 18, 23, 25, 28, and 30. Significant negative correlations between the overall consumer rating and storage time for the first 16 days were obtained for HTH (r^2 = 0.475), Odocine (r^2 = 0.661), and untreated (r^2 = 0.496) scallops. Bisulfite samples had a significant negative correlation over 35 days of storage, r^2 = 0.429.

P. Slimy

The mean slimy appearance rating for all samples increased between the initial and final values. The untreated sample fell from an initial value of 3.17 to 1.00 by day four, reached 1.92 on day 11, 2.83 on day 14, and 3.33 by day 16. The HTH and Odocine scallops increased respectively from a mean rating of 0.67 to 3.42 and from 0.83 to 3.42 by day 16 of storage (Figure 17). The most rapid increase for both samples occurred through days 11, 14, and 16. HTH and Odocine values were recorded as 1.67, 2.50, 3.42; and 1.92, 2.75, 3.42, respectively. Bisulfite samples increased from 0.83 to 2.33 by day 16 and to 3.17 by day 35. Frozen control samples increased from 1.33 to a peak sliminess of 2.17 on day 16 and a final level of 1.67 by day 30. The mean slimy rating for the bisulfite sample was significantly higher than the frozen control sample from days 21 through 30 (Table 13). Significant regression correlations were determined for all sample treatments through day 16. The following significant r^2 values were recorded for 16 days of storage: 0.581, bisulfite; 0.566, HTH; 0.576, Odocine;

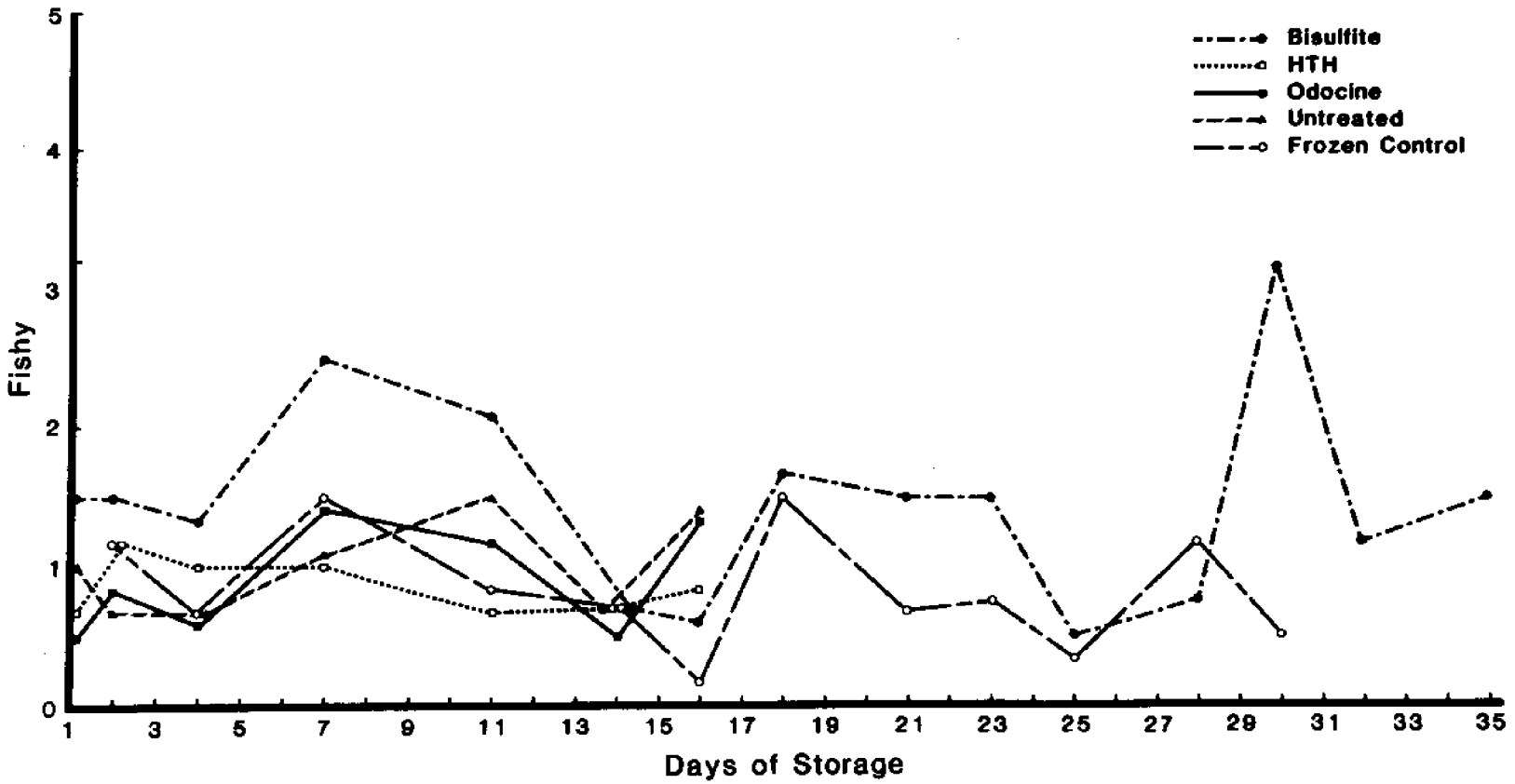

Figure 15. Mean fishy sensory scores for bisulfite, HTH, Odocine, untreated, and frozen control scallops

Fishy

Days of Storage	Mean	Treatment
1	No significant difference	
	PSE = 0.147	
2	No significant difference	
	PSE = 0.099	
4	No significant difference	
	PSE = 0.122	
7	A 2.50	Bisulfite
	BA 1.50	Frozen Control
	BA 1.42	Odocine
	BA 1.08	Untreated
	B 1.00	HTH
	PSE = 0.157	
11	A 2.08	Bisulfite
	BA 1.50	Untreated
	BA 1.17	Odocine
	BA 0.83	Frozen Control
	B 0.67	HTH
	PSE = 0.138	
14	No significant difference	
	PSE = 0.097	
16	A 1.42	Untreated
	BA 1.33	Odocine
	BA 0.83	HTH
	BA 0.50	Bisulfite
	B 0.17	Frozen Control
	PSE = 0.130	
18	No significant difference	
	PSE = 0.201	
21	No significant difference	
	PSE = 0.201	
23	No significant difference	
	PSE = 0.212	
25	No significant difference	
	PSE = 0.154	
28	No significant difference	
	PSE = 0.150	
30	A 3.17	Bisulfite
	B 0.50	Frozen Control
	PSE = 0.230	
32	--	--
35	--	--

Table 11. Mean fishy 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.

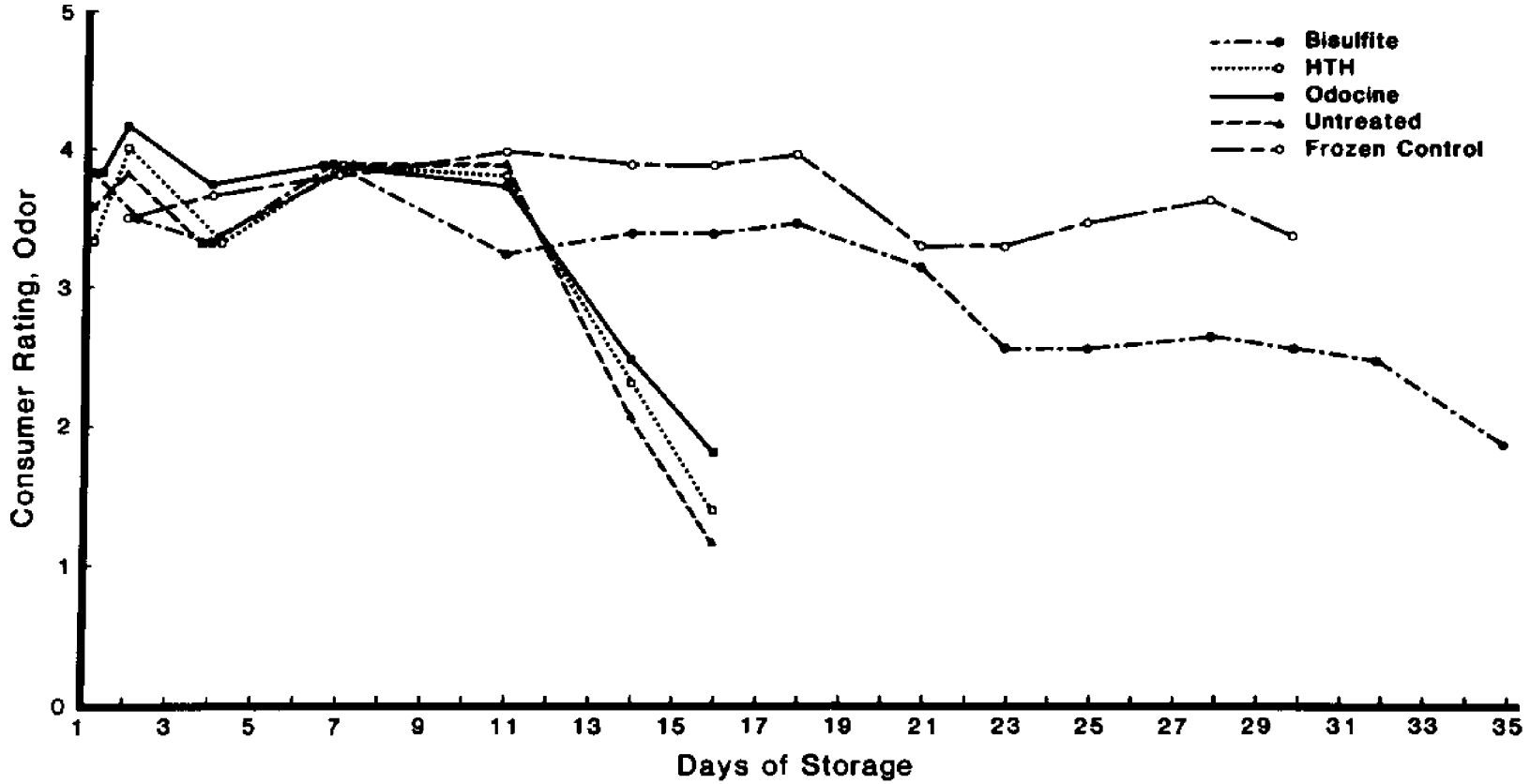

Figure 16. Mean consumer odor sensory scores for bisulfite, HTH, Odocine, untreated and frozen control scallops

Consumer Rating, Odor

Days of Storage	Mean	Treatment
1	No significant difference	
	PSE = 0.095	
2	No significant difference	
	PSE = 0.107	
4	No significant difference	
	PSE = 0.091	
7	No significant difference	
	PSE = 0.054	
11	A 4.00	Frozen Control
	A 3.92	Untreated
	BA 3.83	HTH
	BA 3.75	Odocine
	B 3.25	Bisulfite
	PSE = 0.071	
14	A 3.92	Frozen Control
	BA 3.42	Bisulfite
	CB 2.50	Odocine
	CB 2.33	HTH
	C 2.08	Untreated
	PSE = 0.118	
16	A 3.92	Frozen Control
	A 3.42	Bisulfite
	B 1.83	Odocine
	B 1.42	HTH
	B 1.67	Untreated
	PSE = 0.111	
18	A 4.00	Frozen Control
	B 3.50	Bisulfite
	PSE = 0.065	
21	A 3.33	Frozen Control
	B 3.17	Bisulfite
	PSE = 0.149	
23	A 3.33	Frozen Control
	B 2.58	Bisulfite
	PSE = 0.133	
25	A 3.50	Frozen Control
	B 2.58	Bisulfite
	PSE = 0.164	
28	A 3.67	Frozen Control
	B 2.67	Bisulfite
	PSE = 0.175	
30	A 3.42	Frozen Control
	B 2.58	Bisulfite
	PSE = 0.142	
32	--	--
35	--	--

Table 12. Mean consumer rating odor 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.

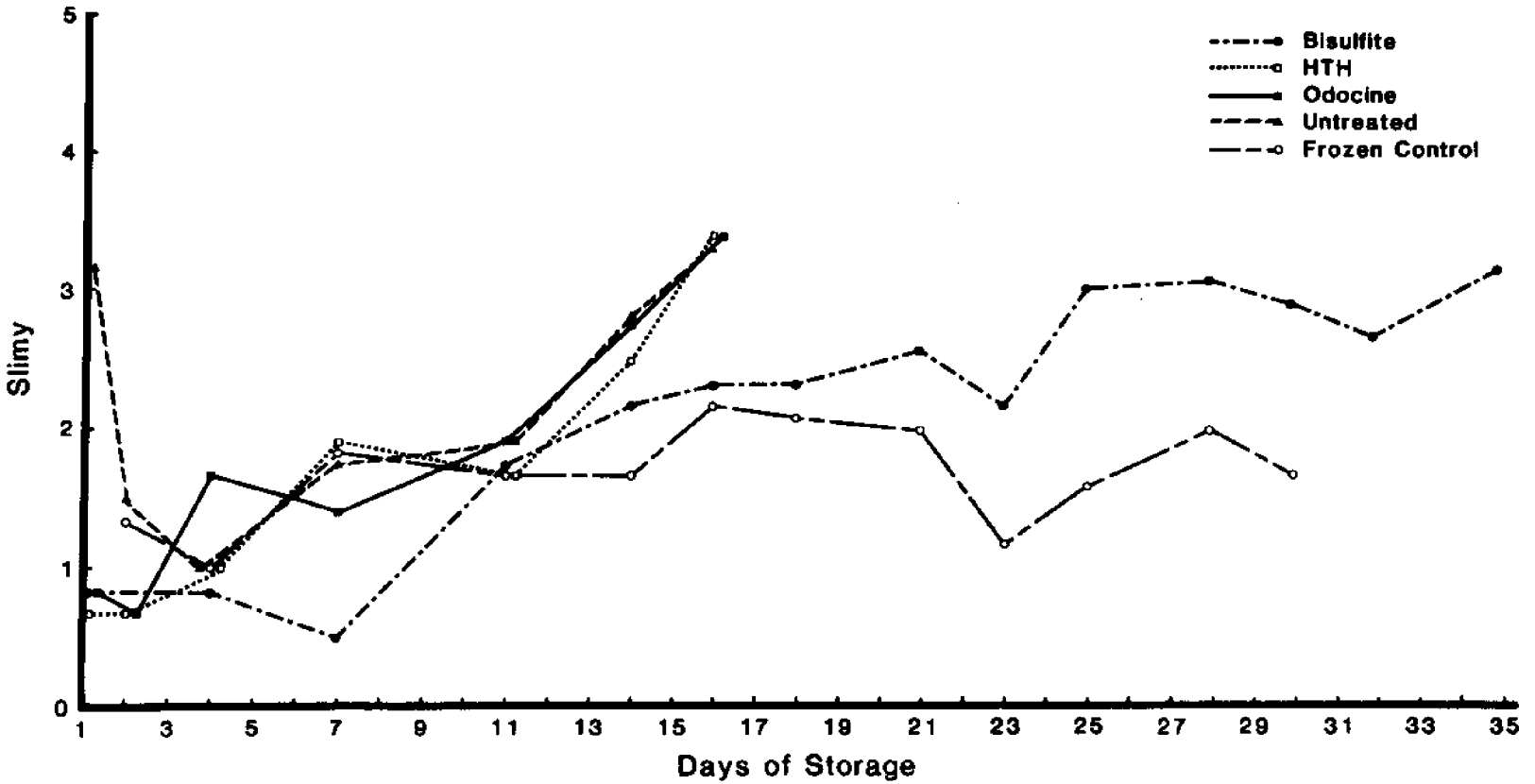

Figure 17. Mean slimy sensory scores for bisulfite, HTH, Odocine, untreated, and frozen control scallops

Slimy

Days of Storage	Mean	Treatment
1	A 3.17	Untreated
	B 0.83	Bisulfite
	B 0.83	Odocine
	B 0.67	HTH
	PSE = 0.110	
2	No significant difference	
	PSE = 0.092	
4	No significant difference	
	PSE = 0.131	
7	A 1.92	HTH
	BA 1.83	Frozen Control
	BA 1.75	Untreated
	BA 1.42	Odocine
	B 0.67	Bisulfite
	PSE = 0.134	
11	No significant difference	
	PSE = 0.109	
14	No significant difference	
	PSE = 0.152	
16	No significant difference	
	PSE = 0.146	
18	No significant difference	
	PSE = 0.172	
21	A 2.58	Bisulfite
	B 2.00	Frozen Control
	PSE = 0.634	
23	A 2.17	Bisulfite
	B 1.17	Frozen Control
	PSE = 0.207	
25	A 3.03	Bisulfite
	B 1.58	Frozen Control
	PSE = 0.146	
28	A 3.08	Bisulfite
	B 2.00	Frozen Control
	PSE = 0.059	
30	A 2.92	Bisulfite
	B 1.67	Frozen Control
	PSE = 0.146	
32	--	--
35	--	--

Table 13. Mean slimy levels significantly different at the 0.05 level and pooled standard error (PSE), Tukey's studentized range test. Means with the same letter not significantly different.

0.475, untreated; and 0.146, frozen control. The bisulfite samples correlated significantly with time over 35 days of storage, $r^2 = 0.622$.

Q. Light-Dark

The final mean light-dark levels for all scallops were greater than the sensory panel evaluations on day one (Figure 18). The following mean light-dark ratings were recorded for days one and 16: 2.00-2.33, bisulfite; 1.83-3.08, HTH; 1.50-2.92, Odocine; 2.00-2.92, untreated; and 2.50-3.00, frozen control. After 30 and 35 days of storage the frozen control and bisulfite ratings were 3.25 and 3.00, respectively. Table 14 indicates that the bisulfite sample was significantly lighter than the frozen control sample on days 7, 18, 21, and 25. On day 16, the HTH sample was significantly darker than the bisulfite sample. Significant positive correlations were determined for the HTH ($r^2 = 0.229$), Odocine ($r^2 = 0.298$), and untreated ($r^2 = 0.299$) samples for the first 16 days of storage. The bisulfite scallops correlated positively for 35 days of storage ($r^2 = 0.186$).

R. Firmness

Panel members perceived a decrease in mean firmness from days 1 through 16 for HTH (3.50-3.08), Odocine (3.67-2.92), and untreated (3.50-2.17) scallops (Figure 19). Bisulfite samples decreased rapidly in firmness ratings from day one (3.83) to day four (1.50), increased to 3.83 by day 16, and ended the study at 2.42 on day 35. Frozen control firmness levels decreased slightly from 2.67 to 2.50 during 30 days of storage. The mean firmness score for bisulfite scallops on day four was significantly less than for all other samples (Table 15). By day 16, the bisulfite samples were significantly firmer than the Odocine or untreated samples. Small but significant negative correlations were determined between firmness and time for all samples: $r^2 = 0.052$, bisulfite (35 days); $r^2 = 0.110$, HTH; $r^2 = 0.282$, Odocine; $r^2 = 0.335$, untreated; and $r^2 = 0.182$, frozen control.

S. Adhesiveness

Frozen control and untreated scallops exhibited a gradual increase in adhesiveness over 30 and 16 days of storage, 1.33-2.17 (frozen control) and 1.33-2.50 (untreated), (Figure 20). Initial HTH, Odocine, and bisulfite mean scores fell rapidly from day one to reach minimum values: HTH, 2.83-2.08 (day 7); Odocine, 2.83-1.83 (day 7); and bisulfite 3.83-2.00 (day 4); and then increased to 2.75 (HTH, day 16), 2.83 (Odocine, day 16), 2.83 (bisulfite, day 16) and 3.08 (bisulfite, day 35). Frozen control samples were significantly less adhesive than the other treatments throughout

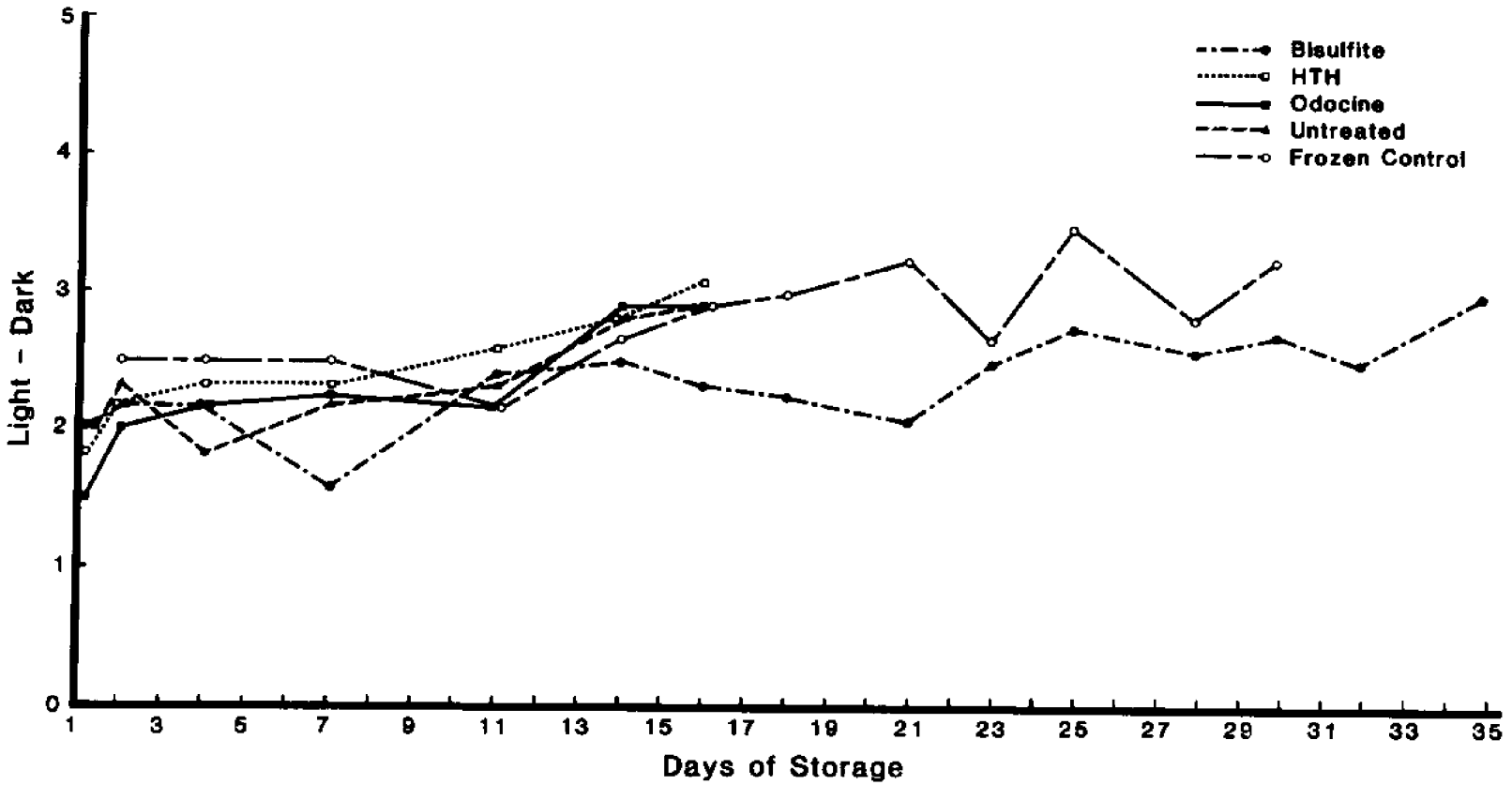

Figure 18. Mean light-dark scores for bisulfite, HTH, Odocine, untreated, and frozen control scallops

Light-Dark

Days of Storage	Mean	Treatment
1	No significant difference PSE = 0.115	
2	No significant difference PSE = 0.106	
4	No significant difference PSE = 0.133	
7	A 2.50	Frozen Control
	BA 2.33	HTH
	BA 2.25	Odocine
	BA 2.17	Untreated
	B 1.58	Bisulfite
	PSE = 0.095	
11	No significant difference PSE = 0.081	
14	No significant difference PSE = 0.095	
16	A 3.08	HTH
	BA 2.92	Frozen Control
	BA 2.92	Odocine
	BA 2.92	Untreated
	B 2.33	Bisulfite
	PSE = 0.070	
18	A 3.00	Frozen Control
	B 2.25	Bisulfite
	PSE = 0.085	
21	A 3.25	Frozen Control
	B 2.08	Bisulfite
	PSE = 0.095	
23	No significant difference PSE = 0.139	
25	A 3.50	Frozen Control
	B 2.75	Bisulfite
	PSE = 0.125	
28	No significant difference PSE = 0.113	
30	No significant difference PSE = 0.175	
32	—	—
35	—	—

Table 14. Mean light-dark 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.

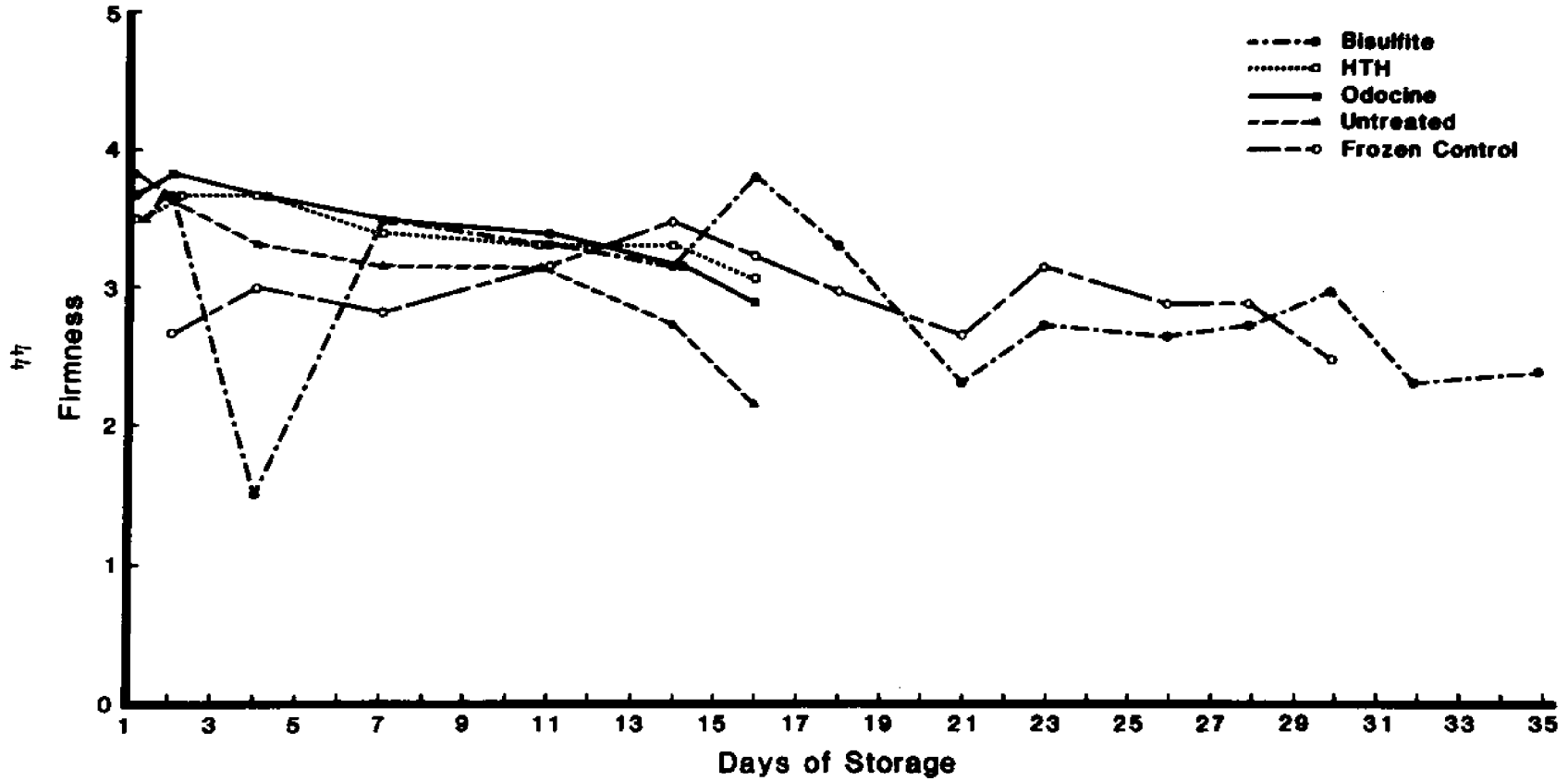

Figure 19. Mean firmness sensory scores for bisulfite, HTH, Odocine, untreated, and frozen control scallops

Firmness

Days of Storage	Mean	Treatment
1	No significant difference	
	PSE = 0.104	
2	A 3.83	Odocine
	A 3.67	Bisulfite
	A 3.67	HTH
	A 3.67	Untreated
	B 2.67	Frozen Control
	PSE = 0.091	
4	A 3.67	HTH
	A 3.67	Odocine
	A 3.33	Untreated
	A 3.00	Frozen Control
	B 1.50	Bisulfite
	PSE = 0.134	
7	No significant difference	
	PSE = 0.102	
11	No significant difference	
	PSE = 0.113	
14	No significant difference	
16	A 3.83	Bisulfite
	BA 3.25	Frozen Control
	BA 3.08	HTH
	CB 2.92	Odocine
	C 2.17	Untreated
	PSE = 0.093	
18	No significant difference	
	PSE = 0.154	
21	No significant difference	
	PSE = 0.134	
23	No significant difference	
	PSE = 0.136	
25	No significant difference	
	PSE =0.146	
28	No significant difference	
	PSE = 0.115	
30	No significant difference	
	PSE = 0.144	
32	--	--
35	--	--

Table 15. Mean firmness 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.

the study except for days 16, 18, and 30 (Table 16). No other significant differences were determined among treatment means. Significant positive regression correlations were determined for frozen control (r^2 = 0.200), HTH (r^2 = 0.224), Odocine (r^2 = 0.194), and untreated (r^2 = 0.216) samples for the first 16 days of storage. A very small but significant regression correlation was determined for the bisulfite samples over 35 days of storage (r^2 = 0.082).

T. Wetness

Mean wetness levels determined by panel members increased from days two through 16 for the Odocine (2.33-3.67) and untreated (2.67-4.17) samples (Figure 21). HTH samples increased from 2.67 (day 2) to a maximum wetness of 3.67 on day 11 and decreased to 3.17 by day 16. Initial and final wetness levels for the bisulfite scallops were both 2.75 with a minimum of 2.25 (day 7) and a maximum of 3.83 (day 4). The frozen control sample exhibited no consistent pattern, with an initial reading of 4.17 and a final reading of 3.50 (day 30). On day two, the frozen control sample had a significantly greater wetness rating than the other samples (Table 17). On day four, the frozen control sample wetness was significantly greater than the Odocine and untreated scallops and on day seven, greater than the Odocine and bisulfite scallops. By day 16, both the untreated and frozen control samples scored significantly higher wetness values than the bisulfite sample. Wetness levels for the frozen control samples were significantly greater than the bisulfite scallops on days 18 and 25. Significant positive wetness regression correlations were determined for the Odocine (r^2 = 0.164) and untreated (r^2 = 0.635) samples during the first 16 days of storage.

U. Consumer Rating, Appearance

The consumer rating, by appearance, decreased from initial to final scores for all samples except the frozen control scallops: HTH, 4.17-2.50 (1-16 days); Odocine, 4.33-2.25 (1-16 days); untreated, 3.75-1.67 (1-16 days); bisulfite, 4.33-2.42 (1-35 days); and frozen control, 2.83-3.33 (1-30 days). Consumer appearance ratings decreased most rapidly on days 11, 14, and 16 for the following samples: HTH, 3.33, 3.00, 2.50; Odocine, 3.83, 2.75, 2.25; and untreated, 3.75, 2.58, 1.67 (Figure 22). By day 14, (Table 18) the Odocine and untreated consumer appearance ratings were significantly less than those determined for the frozen control sample. Following 16 days of storage, the bisulfite scallops rated significantly higher than the HTH, Odocine, or untreated samples. Significant negative correlations between storage time and appearance ratings were determined for

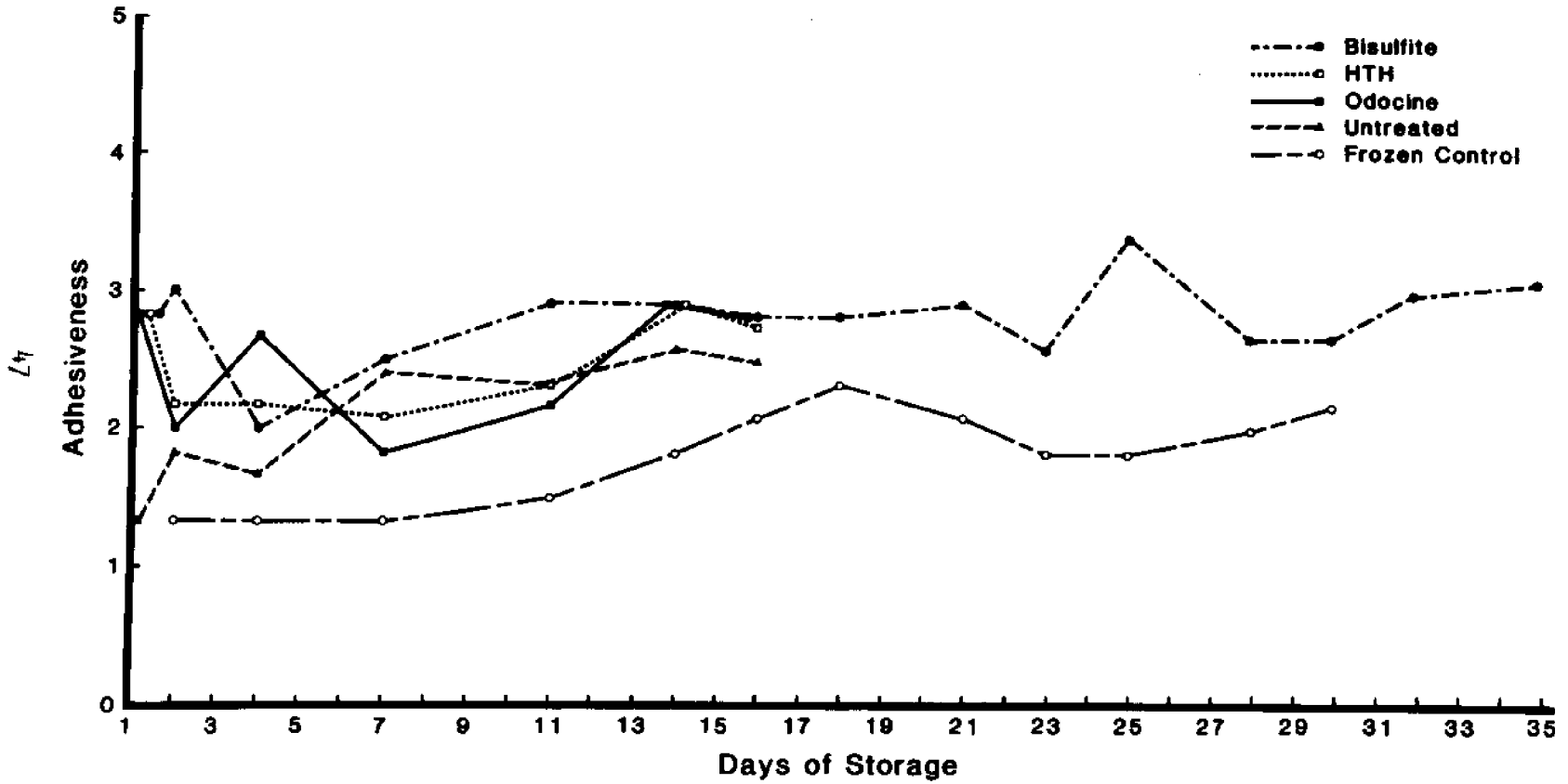

Figure 20. Mean adhesiveness sensory scores for bisulfite, HTH, Odocine, untreated, and frozen control scallops

Adhesiveness

Days of Storage	Mean	Treatment
1	A 3.83	Bisulfite
	A 2.83	HTH
	A 2.83	Odocine
	B 1.33	Untreated
	PSE = 0.128	
2	A 2.67	Bisulfite
	BA 2.17	HTH
	BA 2.00	Odocine
	BA 1.83	Untreated
	B 1.33	Frozen Control
	PSE = 0.092	
4	A 2.67	Odocine
	BA 2.17	HTH
	BA 2.00	Bisulfite
	BA 1.67	Untreated
	B 1.33	Frozen Control
	PSE = 0.120	
7	A 2.50	Bisulfite
	A 2.42	Untreated
	BA 2.08	HTH
	BA 1.83	Odocine
	B 1.33	Frozen Control
	PSE = 0.097	
11	A 2.92	Bisulfite
	BA 2.33	HTH
	BA 2.33	Untreated
	BA 2.17	Odocine
	B 1.50	Frozen Control
	PSE = 0.098	
14	A 2.92	Bisulfite
	A 2.92	HTH
	A 2.92	Odocine
	BA 2.58	Untreated
	B 1.83	Frozen Control
	PSE = 0.104	
16	No significant difference	
	PSE 0.091	
18	No significant difference	
	PSE = 0.118	
21	A 2.92	Bisulfite
	B 2.08	Frozen Control
	PSE = 0.142	
23	A 2.58	Bisulfite
	A 1.83	Frozen Control
	PSE = 0.184	
25	A 3.42	Bisulfite
	B 1.83	Frozen Control
	PSE = 0.113	
28	A 2.67	Bisulfite
	B 2.00	Frozen Control
	PSE = 0.105	
30	No significant difference	
	PSE = 0.134	
32	—	—
35	—	—

Table 16. Mean adhesiveness 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.

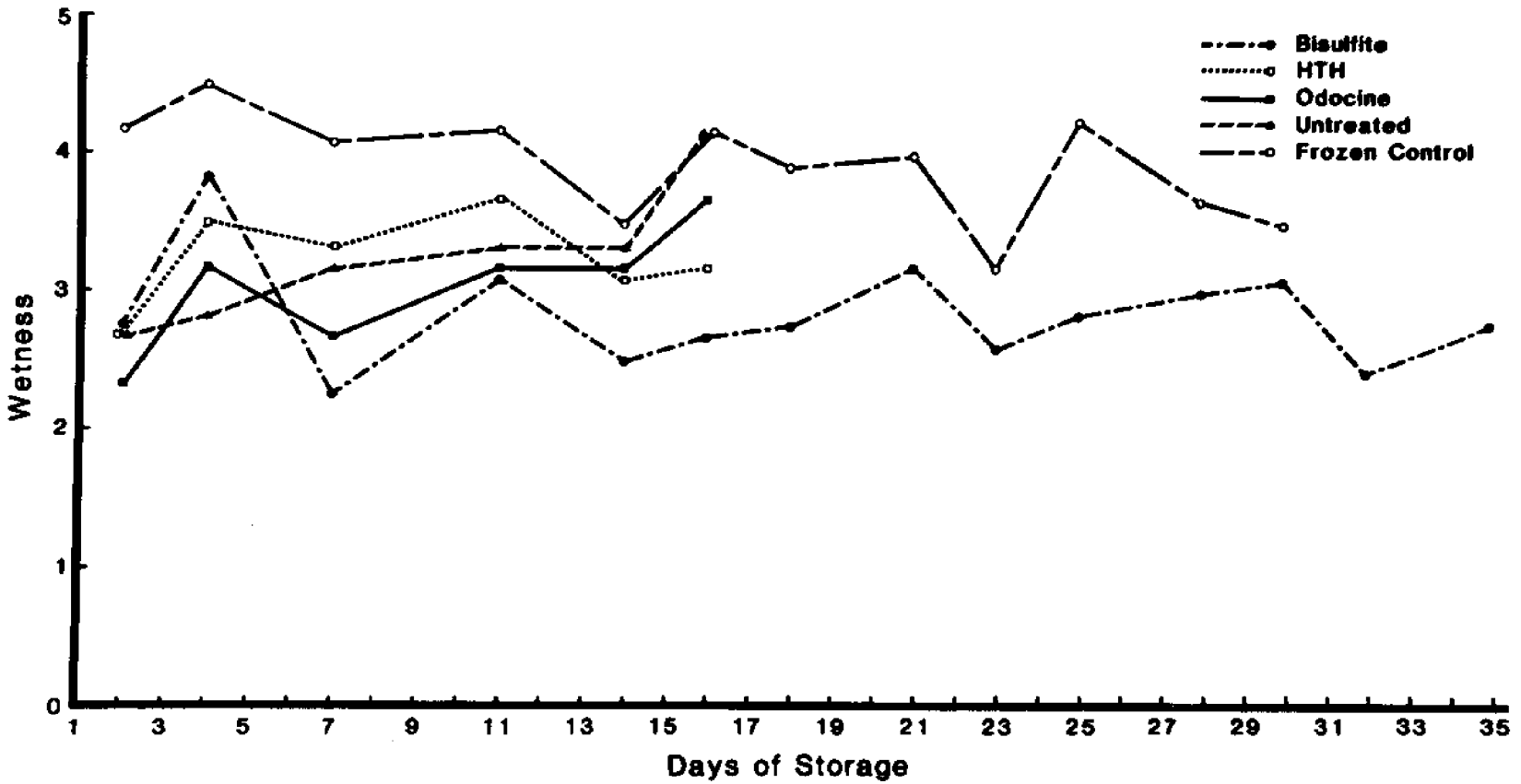

Figure 21. Mean wetness sensory scores for bisulfite, HTH, Odocine, untreated, and frozen control scallops

Wetness

Days of Storage	Mean	Treatment
1	—	—
2	A 4.17	Frozen Control
	B 2.75	Bisulfite
	B 2.67	HTH
	B 2.67	Untreated
	B 2.33	Odocine
	PSE = 0.101	
4	A 4.50	Frozen Control
	BA 3.83	Bisulfite
	BA 3.50	HTH
	B 3.17	Odocine
	B 2.83	Untreated
	PSE = 0.124	
7	A 4.08	Frozen Control
	BA 3.33	HTH
	BA 3.17	Untreated
	B 2.67	Odocine
	B 2.25	Bisulfite
	PSE = 0.124	
11	No significant difference	
	PSE = 0.121	
14	No significant difference	
	PSE = 0.177	
16	A 4.17	Frozen Control
	A 4.17	Untreated
	BA 3.67	Odocine
	BA 3.17	HTH
	B 2.67	Bisulfite
	PSE = 0.111	
18	A 3.75	Frozen Control
	B 2.75	Bisulfite
	PSE = 0.177	
21	No significant difference	
	PSE = 0.201	
23	No significant difference	
	PSE = 0.224	
25	A 4.25	Frozen Control
	B 2.83	Bisulfite
	PSE = 0.176	
28	No significant difference	
	PSE = 0.167	
30	No significant difference	
	PSE = 0.187	
32	—	—
35	—	—

Table 17. Mean wetness levels significantly different at the 0.05 level, Tukey's studentized range test. Means with the same letter are not significantly different.

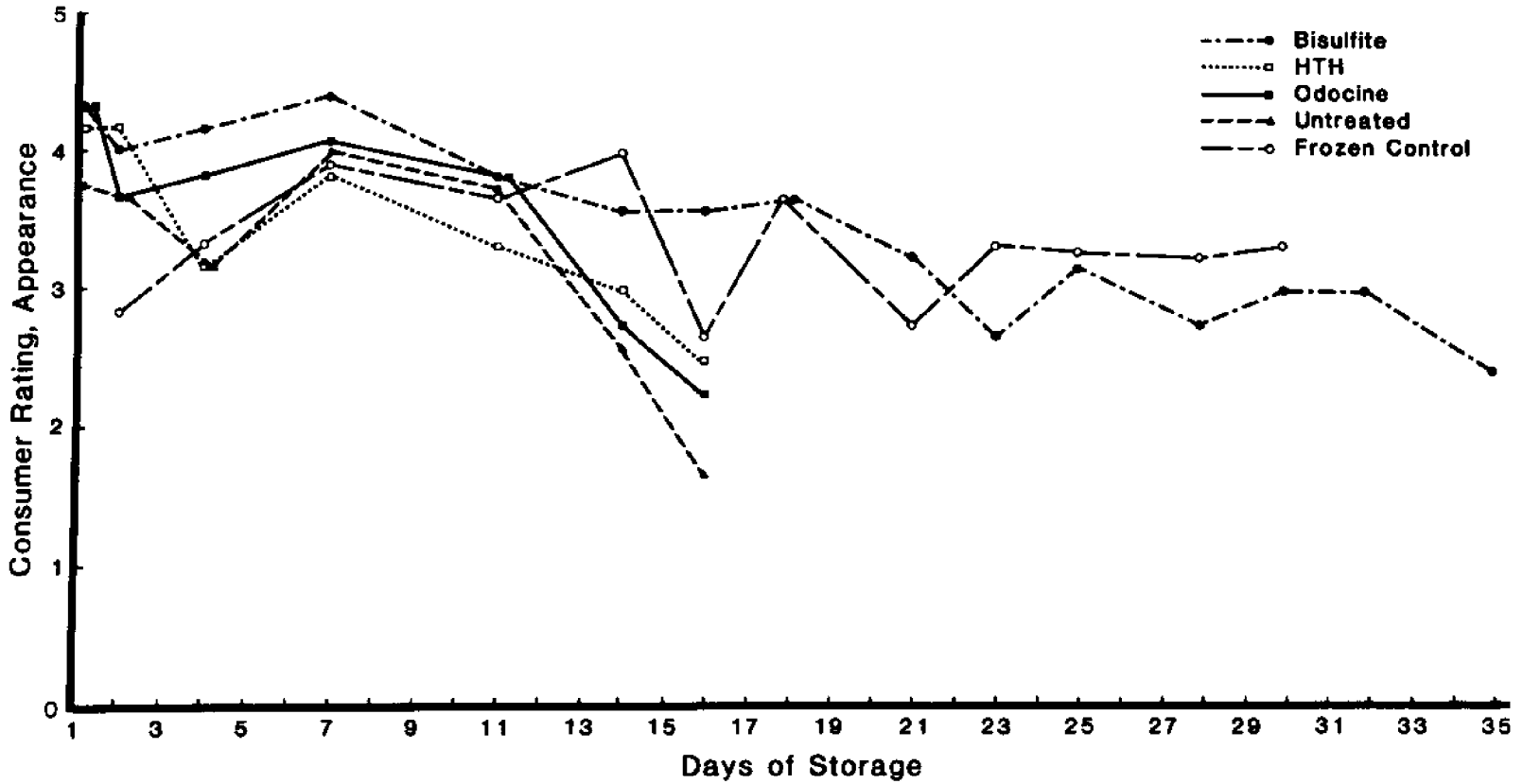

Figure 22. Mean consumer appearance sensory scores for bisulfite, HTH, Odocine, untreated, and frozen control scallops

Consumer Rating, Appearance

Days of Storage	Mean	Treatment
1	No significant difference	
	PSE = 0.161	
2	A 4.33	Odocine
	A 4.17	HTH
	A 4.00	Bisulfite
	BA 3.67	Untreated
	B 2.83	Frozen Control
	PSE = 0.105	
4	No significant difference	
	PSE = 0.140	
7	No significant difference	
	PSE = 0.068	
11	No significant difference	
	PSE = 0.079	
14	A 4.00	Frozen Control
	BA 3.58	Bisulfite
	BA 3.00	HTH
	B 2.75	Odocine
	B 2.58	Untreated
	PSE = 0.111	
16	A 3.58	Bisulfite
	BA 2.83	Frozen Control
	CB 2.50	HTH
	CB 2.25	Odocine
	C 1.67	Untreated
	PSE = 0.091	
18	No significant difference	
	PSE = 0.118	
21	No significant difference	
	PSE = 0.137	
23	A 3.33	Frozen Control
	B 2.67	Bisulfite
	PSE = 0.118	
25	No significant difference	
	PSE = 0.117	
28	No significant difference	
	PSE = 0.121	
30	No significant difference	
	PSE = 0.154	
32	—	—
35	—	—

Table 18. Mean consumer ratings for appearance 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.

all but the frozen control sample: HTH, $r^2 = 0.298$; Odocine, $r^2 = 0.583$; untreated, $r^2 = 0.412$; and bisulfite, $r^2 = 0.139$ (16 days) and $r^2 = 0.514$ (35 days).

DISCUSSION

Several of the analyses and sensory panel descriptors failed to differentiate scallop quality over time or the effects of the various treatments. The following parameters fit into the above category.

The pH levels (Figure 1) of the experimental and control scallops were slightly greater than the values reported by Waters (1964) over 16 days of storage. Waters' samples increased in pH with time from 6.55 to 6.65. The HTH, Odocine, and untreated samples decreased approximately 0.2 pH units over 16 days: from 6.80 to 6.61, from 6.85 to 6.63, and from 6.80 to 6.64. The bisulfite scallops had an initial pH value of 6.90 and a final pH value of 6.83. The pH values did not serve as an effective indicator of spoilage.

Ammonium (Figure 2) levels determined for the bisulfite samples were greater than all other sample levels (significantly so on days 1, 4, 7, 11, and 14), but no correlation with quality was demonstrated (Table 1).

Fecal streptococci plate counts, MPN *E. coli* or MPN coagulase positive staphylococci results failed to define product quality or show treatment differences (Figures 5, 7, and 8). MPN total coliform levels decreased from 348 to less than 2 organisms/g over 35 days of bisulfite scallop storage. The coliform levels of other samples increased with time, and all exceeded the FDA (Cockey, 1983) guidelines of an MPN equal to or less than 23 organisms/g during the study (Figure 6).

Sensory evaluations of sweet (Figure 10), ammonia (Figure 11), sour (Figure 14), and fishy (Figure 15) odors failed to differentiate product quality or treatments (Tables 6, 7, 10, and 11). The appearance characteristics of slimy (Figure 18), light-dark (Figure 19), adhesiveness (Figure 21), and wetness (Figure 22) did not prove useful (Tables 13, 14, 16, and 17). Although firmness (Figure 26) did not distinguish treatment or product quality following the iced storage of scallops, the significantly lower rating on day four for the bisulfite sample indicated a possible marketing problem (Table 15). The initial firmness rating fell from 3.67 to 1.50 by day four, but returned to 3.50 by day seven.

Of the 22 monitored chemical, microbiological, and organoleptic parameters, only seven proved useful in differentiating the quality of scallops during the storage study: aerobic plate count, TMA, briny odor, post room odor, putrid odor, consumer odor rating, and the appearance rating.

Using FDA's 500,000 (log 5.70) organisms/g guideline (Cockey, 1983) as a quality cut-off standard for shellfish necessitates a maximum shelf life of 11 days for the HTH and Odocine samples, 12 days for the untreated sample, and 25 days for the bisulfite sample (Figure 4). Bacterial growth moved into a logarithmic phase by day 11 for the HTH, Odocine, and untreated samples, and by day 25 for the bisulfite samples.

The TMA data for the HTH, Odocine, and untreated scallops paralleled the aerobic plate count results, with a rapid increase in levels from day 11 to day 16: HTH, from 6.86 to 36.65 mg/100g; Odocine, from 14.36 to 36.65 mg/100g; and untreated, from 7.63 to 34.58 mg/100g (Figure 3). The bisulfite samples exhibited two TMA peaks, one at 16 days (49.65 mg/100g) that decreased to 17.44 mg/100g TMA on day 23, and increased to 43.74 mg/100g by day 35. The second peak reflected bacterial growth; the first did not. The results indicated enzymatic release of TMA followed by bacterial production (Martin, et al., 1982). The TMA level determined for the bisulfite samples exceeded the levels determined for all other samples on all sample days and was significantly greater (Table 2) than the other samples on days two, four, and seven. Significant positive correlations existed for TMA and storage time for HTH (r^2 = 0.420), Odocine (r^2 = 0.403), and untreated (r^2 = 0.604) samples over 16 days of storage. Positive significant correlation coefficients were determined for bisulfite samples through days 16 (r^2 = 0.564) and 35 (r^2 = 0.200).

The sensory results from the briny odor determination were similar to the TMA and plate count data. HTH, Odocine, and untreated scallop briny scores decreased rapidly through days 11, 14, and 16. Mean values were respectively: 1.83, 0.67, 0.17, HTH; 2.00, 0.67, 0.17, Odocine; and 2.50, 0.00, 0.17, untreated. HTH, Odocine, and untreated briny levels were significantly less than the bisulfite and frozen control sample ratings on days 14 and 16 (Table 5). The bisulfite sample briny ratings decreased rapidly from day 25 (1.67) to day 35 (0.67) and were significantly less than those for the frozen control samples on days 18, 23, 28, and 30 (Table 3). Significant negative correlations were determined for HTH (r^2 = 0.742), Odocine (r^2 = 0.764), untreated (r^2 = 0.680), and bisulfite (r^2 = 0.418) samples over the storage period.

The rapid decline in HTH, Odocine, and untreated scallop quality between days 11 and 16 was mirrored by the increase in post room odor scores. On days 11, 15, and 16, the odor scores were as follows: 0.83, 2.33, 2.42, HTH; 0.50, 2.42, 3.33, Odocine; and 0.50, 3.58, 3.33, untreated (Figure 12). Bisulfite and frozen control samples had significantly lower post room odor ratings than the preceding samples (Table 8). Significant positive regression correlations were obtained for HTH (r^2 = 0.471), Odocine (r^2 = 0.292), and untreated (r^2 = 0.569) samples for the first 16 days of storage. The bisulfite samples scores increased over 35 days of storage, from 0.00 to 1.50. No quality break was discovered; however, the odor levels of the bisulfite scallops were significantly greater than those of the frozen control samples on days 4, 18, 23, and 28 (Table 8).

The putrid levels determined for all samples displayed a threshold response on day 14 for HTH, Odocine, and untreated samples and on day 30 for the bisulfite treated samples (Figure 13). For days 11, 14, and 16, the following responses were recorded: 0.00, 0.83, 2.08, HTH; 0.00, 1.08, 1.83, Odocine; and 0.00, 1.83, 2.83, untreated. On day 14, the Odocine and untreated sample odor levels were significantly greater than the bisulfite or untreated scallops (Table 9). On day 16, the bisulfite and frozen control samples had significantly lower scores than the other samples (Table 9). Putrid regression correlations were significant over 16 days for HTH (r^2 = 0.546), Odocine (r^2 = 0.589) and untreated (r^2 = 0.625) scallops. Bisulfite sample putrid odor ratings increased from 0.00 on day 28 to 0.67 by day 35.

The consumer aroma rating declined rapidly from day 11 through day 16 for the HTH, Odocine, and untreated samples (Figure 16). The aroma ratings on days 11, 14, and 16 were as follows: 3.83, 2.33, 1.42, HTH; 3.75, 2.50, 1.83, Odocine; and 3.92, 2.08, 1.17, untreated. On day 14, the preceding samples had significantly lower consumer odor ratings than the frozen control samples and by day 16, significantly lower ratings than the frozen control and bisulfite samples (Table 12). Significant regression correlations were determined over 16 days of storage for HTH (r^2 = 0.475), Odocine (r^2 = 0.661), and untreated (r^2 = 0.496) scallops. The bisulfite sample scores declined over 35 days of storage with no sharp quality break: day 1 = 3.83, day 16 = 3.42, and day 35 = 1.88. The samples had significantly lower ratings than the frozen control scallops on days 23 through 30. A significant negative regression correlation was determined for 35 days of storage (r^2 = 0.429).

The consumer appearance rating exhibited the steepest decline for HTH, Odocine, and untreated samples between 11 and 16 days of

storage (Figure 23). On days 11, 14, and 16, the following scores were recorded: 3.33, 3.00, 2.50, HTH; 3.83, 2.75, 2.25, Odocine; and 3.75, 2.58, 1.67, untreated. By day 16, the preceding sample ratings were significantly less than the bisulfite scallops (Table 18). Significant negative regression correlations were determined over 16 days of storage for the HTH ($r^2 = 0.298$), Odocine ($r^2 = 0.583$), and untreated samples ($r^2 = 0.412$). Bisulfite samples decreased gradually with storage time from 4.33 (day 1) to 2.42 (day 35) and had a significant negative regression correlation over the 35-day period ($r^2 = 0.514$).

CONCLUSIONS

The treatment of fresh calico scallops (Argopecten gibbus) with three post-processing dips - one percent sodium bisulfite, 100 ppm calcium hypochlorite (HTH), and 20 ppm chlorine dioxide (Odocine) - resulted in usable iced shelf lives of 25 days, 11 days, and 11 days, respectively. The experimental results compared with a 12-day shelf life for untreated scallops. Shelf life was arbitrarily defined as the time required for a sample to exceed an aerobic plate count of 500,000 organisms/g, FDA's shellfish guideline (Cockey, 1983).

Of the monitored chemical parameters, trimethylamine (TMA) levels proved to be a good quality indicator for HTH, Odocine, and untreated scallops but not for bisulfite scallops. TMA levels rose rapidly following 11 days of storage for all samples. The bisulfite scallops exhibited two TMA peaks - one at 16 days and one at 35 days. The first peak probably represented enzymatic release of TMA, and the second, bacterial release (Martin et al., 1982). Although TMA levels were greater in the bisulfite scallops than in the other samples, no sensory data correlated with the high TMA levels. Maximum TMA levels for all samples compared with the concentrations (greater than 50 mg/100g) determined by Waters (1964) for untreated scallops.

Four of the odor characteristics monitored by the sensory panel proved to be good indicators of scallop quality when compared to aerobic plate counts. Briny, post room, putrid, and consumer odor ratings each expressed the rapid quality deterioration experienced by HTH, Odocine, and untreated scallop samples between 11 and 16 days of storage. Significant differences between the above samples and frozen control and/or bisulfite scallops were determined for each odor characteristic. Briny was the only odor characteristic inversely related to rapid bacterial growth exhibited by the bisulfite scallops following 25

days of storage. Briny levels were significantly less than those determined for frozen control samples monitored at the same time.

Consumer appearance rating was the only visual characteristic that detected quality deterioration in the HTH, Odocine, and untreated scallops by 16 days of storage. The ratings were significantly less than those determined for the bisulfite sample. The characteristic did not successfully determine quality deterioration in the bisulfite sample.

The treatment of calico scallops with a one percent sodium bisulfite dip for 30 seconds extended the product shelf life from 12 to 25 days. The scallops remained microbiologically and organoleptically acceptable for that period.

The bisulfite treatment provides an effective method to extend the shelf life of scallops that are not expected to reach the market within 10 to 14 days. However, the treatment did cause a significant decrease in firmness by the fourth day of storage. Firmness ratings returned to normal by the seventh day. The treatment should not be used on scallops that will be marketed within one week. Although bisulfite is listed as GRAS by FDA (CRF, 1983), residual bisulfite levels should be determined before the treatment is adopted by the scallop industry. The current maximum FDA residual level is 100 ppm (Federal Register, 1985A). A labeling requirement for bisulfite levels exceeding 10 ppm is proposed (Federal Register, 1985B).

REFERENCES

Cardello, A. 1981. Psychophysical basis for the classification of fish by flavor, texture, and appearance. Gordon Research Conference on the Chemical Sciences. Andover, NH.

Chang, G. W., W. L. Chang, and K. B. K. Lew. 1976. Trimethylamine specific ion electrode for fish quality control. J. Food Sci.41: 723-724.

Civille, G. V. and A. S. Szczesniak. 1973. Guidelines to training a texture profile panel. J. of Textural Studies. 4: 204-223.

Civille, G. V. and T. H. Liska. 1975. Modifications and applications to food of the General Foods sensory texture profile technique. J. of Textural Studies. 6: 19-31.

Cockey, R. R. 1983. Bacteriological standards for fresh shellfish and crabmeat for selected states and Canada. Cooperative Shellfish Aquaculture and Technology Laboratory. Crisfield, MD.

Code of Federal Regulations. 1983. Food and Drugs (21) Parts 170 to 199. Part 182 Substances generally recognized as safe. pp. 359-384. U. S. Government Printing Office. Washington, DC.

Federal Register. 1985A Notice to Shippers, Distributors, Packers, and Importers of Shrimp Containing Sulfites. Vol. 50. No. 15. pp. 2957-2958.

Federal Register. 1985B. Food Labeling: Proposed Rule Concerning Sulfiting Agents. Vol. 50. No. 64. pp. 13,306-13,307.

Food and Drug Administration. 1978. Bacteriological Analytical Manual. pp. IV-1 to IV-10, V-1 to V-6, XI-1 to XI-7. Association of Official Analytical Chemists. Washington, DC.

Martin, R. E., G. J. Flick, C. E. Hebard, and D. R. Ward. [Ed.], 1982. Chemistry and Biochemistry of Marine Food Products. AVI Publishing Co., Inc. Westport, CT.

Ray, A. A. [Ed.], 1982. SAS User's Guide: Statistics. SAS Institute, Inc. Cary, NC.

Speck, M. L. [Ed.], 1976. Compendium of Methods for the Microbiological Examination of Foods. American Public Health Association. Washington, DC.

Ward, D. R., R. Nickelson II, and G. Finne. 1978. Preliminary report on the use of the specific ion electrode (ammonia) in determining the quality of shrimp. Proceedings of the Third Annual Tropical and Subtropical Fisheries Technological Conference of the Americas. pp. 83-88.

Waters, M. E. 1984. Comparison of chemical and sensory tests for assessing storage life of iced scallops (Pectin gibbus). Fishery Industrial Research, Vol 2(3): 5-10.

APPENDICES

Ammonium, mg/100g

Days of Storage	Treatment	N	Mean	Std. Error of Mean	Days of Storage	Treatment	N	Mean	Std. Error of Mean
1	Untreated	2	11.40	0.60	14	Untreated	2	17.50	0.50
	Bisulfite	2	51.50	8.50		Bisulfite	2	125.00	5.00
	Odocine	2	10.45	0.25		Odocine	2	19.95	0.05
	HTH	2	11.50	1.00		HTH	2	19.50	0.50
2	Untreated	2	29.55	14.95	16	Untreated	2	18.05	0.05
	Bisulfite	2	30.10	0.10		Bisulfite	2	180.00	70.00
	Odocine	2	15.60	0.90		Odocine	2	18.75	1.75
	HTH	2	15.10	0.10		HTH	2	22.15	0.05
4	Untreated	2	10.35	0.05	18	Bisulfite	2	280.00	40.00
	Bisulfite	2	74.00	1.00					
	Odocine	2	9.30	0.20	21	Bisulfite	2	195.00	0.00
	HTH	2	8.50	0.50					
					23	Bisulfite	2	260.00	20.00
7	Untreated	2	16.00	0.00					
	Bisulfite	2	120.00	10.00	25	Bisulfite	2	242.50	17.50
	Odocine	2	16.15	0.85					
	HTH	2	16.50	0.50	28	Bisulfite	2	210.00	20.00
11	Untreated	2	11.50	0.50	30	Bisulfite	2	187.50	17.50
	Bisulfite	2	106.50	1.50					
	Odocine	2	9.65	0.25	32	Bisulfite	2	206.00	16.00
	HTH	2	10.15	0.45					
					35	Bisulfite	2	232.50	12.50

Appendix A. Ammonium means, number of samples, and standard errors of the mean.

Trimethylamine, mg/100g

Days of Storage	Treatment	N	Mean	Std. Error of Mean
1	Untreated	2	6.97	0.35
	Bisulfite	2	16.67	2.48
	Odocine	2	8.75	0.47
	HTH	2	9.98	0.52
2	Untreated	2	6.85	0.11
	Bisulfite	2	13.48	0.71
	Odocine	2	7.33	0.71
	HTH	2	8.99	0.47
4	Untreated	2	9.17	0.89
	Bisulfite	2	16.55	2.36
	Odocine	2	8.22	0.06
	HTH	2	8.99	0.47
7	Untreated	2	5.61	0.29
	Bisulfite	2	17.14	0.59
	Odocine	2	5.32	0.71
	HTH	2	6.09	0.17
11	Untreated	2	6.85	0.59
	Bisulfite	2	24.23	5.91
	Odocine	2	7.63	0.05
	HTH	2	14.36	4.55
14	Untreated	2	21.27	2.37
	Bisulfite	2	21.87	0.59
	Odocine	2	10.40	0.23
	HTH	2	10.29	0.11
16	Untreated	2	36.65	1.17
	Bisulfite	2	49.65	4.73
	Odocine	2	34.57	0.29
	HTH	2	36.65	2.37
18	Bisulfite	2	28.67	0.29
21	Bisulfite	2	20.56	0.48
23	Bisulfite	2	17.44	2.66
25	Bisulfite	2	24.83	1.19
28	Bisulfite	2	31.33	0.59
30	Bisulfite	2	33.10	1.18
32	Bisulfite	2	24.83	0.59
35	Bisulfite	2	43.64	0.49

Appendix B. TMA means, number of samples, and standard errors of the mean.

Aerobic Plate Counts, organisms/g

Days of Storage	Treatment	N	Mean	Std. Error of Mean
1	Untreated	2	2.06×10^5	8.00×10^3
	Bisulfite	2	1.84×10^5	1.10×10^4
	Odocine	2	1.85×10^5	9.50×10^3
	HTH	2	1.29×10^5	2.00×10^3
2	Untreated	2	1.54×10^5	2.50×10^4
	Bisulfite	2	1.09×10^5	8.00×10^3
	Odocine	2	1.63×10^5	3.50×10^3
	HTH	2	1.61×10^5	500
4	Untreated	2	1.33×10^5	7.50×10^3
	Bisulfite	2	6.45×10^4	1.45×10^4
	Odocine	2	1.62×10^5	1.10×10^4
	HTH	2	1.17×10^5	1.20×10^4
7	Untreated	2	1.01×10^5	1.30×10^4
	Bisulfite	2	7.80×10^4	2.00×10^3
	Odocine	2	1.24×10^5	1.40×10^4
	HTH	2	1.37×10^5	6.50×10^3
11	Untreated	2	3.95×10^5	5.50×10^4
	Bisulfite	2	3.65×10^4	1.50×10^3
	Odocine	2	5.30×10^5	4.00×10^4
	HTH	2	5.15×10^5	8.50×10^4
14	Untreated	2	6.35×10^5	3.25×10^5
	Bisulfite	2	3.95×10^4	1.50×10^3
	Odocine	2	7.05×10^5	3.50×10^4
	HTH	2	5.30×10^5	1.20×10^5
16	Untreated	2	2.00×10^5	1.00×10^5
	Bisulfite	2	5.20×10^4	3.00×10^3
	Odocine	2	3.50×10^5	5.00×10^4
	HTH	2	5.50×10^5	2.50×10^5
18	Bisulfite	2	4.25×10^4	2.50×10^3
21	Bisulfite	2	2.04×10^4	400
23	Bisulfite	2	1.11×10^4	50
25	Bisulfite	2	6.19×10^4	3.61×10^4
28	Bisulfite	2	1.40×10^5	1.20×10^5
30	Bisulfite	2	2.50×10^5	2.50×10^5
32	Bisulfite	2	6.00×10^5	1.00×10^5
35	Bisulfite	2	—	—

Appendix C. Aerobic plate count means, number of samples, and standard errors of the mean.

Fecal Streptococci, organisms/g

Days of Storage	Treatment	N	Mean	Std. Error of Mean
1	Untreated	2	4100	500
	Bisulfite	2	3800	900
	Odocine	2	3800	0
	HTH	2	385	35
2	Untreated	2	1370	140
	Bisulfite	2	1240	140
	Odocine	2	1940	80
	HTH	2	1590	165
4	Untreated	2	2010	170
	Bisulfite	2	770	140
	Odocine	2	1350	95
	HTH	2	1010	45
7	Untreated	2	1330	10
	Bisulfite	2	825	85
	Odocine	2	1590	115
	HTH	2	1010	105
11	Untreated	2	1260	20
	Bisulfite	2	655	25
	Odocine	2	1210	125
	HTH	2	1370	10
14	Untreated	6	1230	165
	Bisulfite	6	545	25
	Odocine	6	1430	180
	HTH	6	805	85
16	Untreated	6	3450	1150
	Bisulfite	6	535	65
	Odocine	6	1550	115
	HTH	6	725	45
18	Bisulfite	2	1290	15
21	Bisulfite	2	885	55
23	Bisulfite	2	805	115
25	Bisulfite	2	990	30
28	Bisulfite	2	995	5
30	Bisulfite	2	756	115
32	Bisulfite	2	1470	260
35	Bisulfite	2	--	--

Appendix D. Fecal streptococci means, number of samples, and standard errors of the mean.

Briny

Days of Storage	Treatment	N	Mean	Std. Error of Mean
1	Untreated	6	3.00	0.37
	Bisulfite	6	3.33	0.21
	Odocine	6	3.00	0.37
	HTH	6	3.00	0.26
	Frozen Control	-	—	—
2	Untreated	6	2.83	0.17
	Bisulfite	6	3.33	0.33
	Odocine	6	3.17	0.17
	HTH	6	2.83	0.31
	Frozen Control	6	3.33	0.21
4	Untreated	6	3.33	0.21
	Bisulfite	6	2.33	0.21
	Odocine	6	3.33	0.21
	HTH	6	3.33	0.21
	Frozen Control	6	2.50	0.22
7	Untreated	6	3.17	0.31
	Bisulfite	6	2.83	0.31
	Odocine	6	3.08	0.27
	HTH	6	2.83	0.17
	Frozen Control	6	3.42	0.20
11	Untreated	6	2.50	0.22
	Bisulfite	6	1.83	0.31
	Odocine	6	2.00	0.26
	HTH	6	1.83	0.17
	Frozen Control	6	3.33	0.21
14	Untreated	6	0.00	0.00
	Bisulfite	6	2.17	0.17
	Odocine	6	0.67	0.33
	HTH	6	0.67	0.33
	Frozen Control	6	2.83	0.31
16	Untreated	6	0.17	0.17
	Bisulfite	6	1.67	0.21
	Odocine	6	0.17	0.17
	HTH	6	0.17	0.17
	Frozen Control	6	2.83	0.17
18	Bisulfite	6	1.67	0.33
	Frozen Control	6	2.83	0.17
21	Bisulfite	6	2.58	0.45
	Frozen Control	6	3.00	0.22
23	Bisulfite	6	1.00	0.26
	Frozen Control	6	2.08	0.08
25	Bisulfite	6	1.67	0.21
	Frozen Control	6	2.17	0.31
28	Bisulfite	6	1.00	0.37
	Frozen Control	6	2.75	0.17
30	Bisulfite	6	0.50	0.34
	Frozen Control	6	1.92	0.33
32	Bisulfite	6	1.25	0.36
35	Bisulfite	6	0.67	0.33

Appendix E. Briny means, number of samples and standard errors of the mean.

Sweet

Days of Storage	Treatment	N	Mean	Std. Error of Mean
1	Untreated	6	2.00	0.00
	Bisulfite	6	1.00	0.26
	Odocine	6	1.00	0.26
	HTH	6	1.67	0.21
	Frozen Control	-	—	—
2	Untreated	6	1.00	0.26
	Bisulfite	6	1.33	0.21
	Odocine	6	1.67	0.17
	HTH	6	1.67	0.21
	Frozen Control	6	1.50	0.34
4	Untreated	6	1.17	0.17
	Bisulfite	6	1.17	0.40
	Odocine	6	1.17	0.17
	HTH	6	1.33	0.21
	Frozen control	6	1.17	0.17
7	Untreated	6	1.00	0.26
	Bisulfite	6	0.83	0.17
	Odocine	6	1.17	0.17
	HTH	6	0.83	0.17
	Frozen Control	6	1.17	0.31
11	Untreated	6	1.08	0.27
	Bisulfite	6	1.17	0.17
	Odocine	6	1.08	0.08
	HTH	6	1.08	0.08
	Frozen Control	6	0.83	0.17
14	Untreated	6	1.00	0.37
	Bisulfite	6	1.42	0.27
	Odocine	6	1.50	0.22
	HTH	6	1.33	0.21
	Frozen Control	6	1.50	0.34
16	Untreated	6	0.83	0.31
	Bisulfite	6	1.67	0.21
	Odocine	6	1.00	0.26
	HTH	6	0.50	0.22
	Frozen Control	6	0.67	0.21
18	Bisulfite	6	0.33	0.21
	Frozen Control	6	0.67	0.21
21	Bisulfite	6	1.00	0.00
	Frozen Control	6	0.83	0.17
23	Bisulfite	6	0.50	0.22
	Frozen Control	6	1.08	0.27
25	Bisulfite	6	0.17	0.17
	Frozen Control	6	0.50	0.22
28	Bisulfite	6	0.67	0.21
	Frozen Control	6	0.92	0.20
30	Bisulfite	6	0.17	0.17
	Frozen Control	6	1.33	0.21
32	Bisulfite	6	0.83	0.17
35	Bisulfite	6	0.83	0.17

Appendix F. Sweet means, number of samples and standard errors of the mean.

Ammonia

Days of Storage	Treatment	N	Mean	Std. Error of Mean	Days of Storage	Treatment	N	Mean	Std. Error of Mean
1	Untreated	6	0.00	0.00	14	Untreated	6	0.00	0.00
	Bisulfite	6	0.00	0.00		Bisulfite	6	0.00	0.00
	Odocine	6	0.00	0.00		Odocine	6	0.17	0.17
	HTH	6	0.17	0.17		HTH	6	0.33	0.21
	Frozen Control	-	--	—		Frozen Control	6	0.00	0.00
2	Untreated	6	1.67	0.17	16	Untreated	6	1.83	0.31
	Bisulfite	6	0.33	0.21		Bisulfite	6	0.00	0.00
	Odocine	6	0.00	0.00		Odocine	6	1.75	0.44
	HTH	6	0.00	0.00		HTH	6	0.17	0.17
	Frozen Control	6	0.00	0.00		Frozen Control	6	0.00	0.00
4	Untreated	6	0.00	0.00	18	Bisulfite	6	0.50	0.22
	Bisulfite	6	0.17	0.17		Frozen Control	6	0.00	0.00
	Odocine	6	0.00	0.00	21	Bisulfite	6	0.33	0.21
	HTH	6	0.17	0.17		Frozen Control	6	0.00	0.00
	Frozen control	6	0.00	0.00	23	Bisulfite	6	0.17	0.17
7	Untreated	6	0.33	0.21		Frozen Control	6	0.00	0.00
	Bisulfite	6	0.17	0.17	25	Bisulfite	6	1.17	0.48
	Odocine	6	0.33	0.21		Frozen Control	6	0.00	0.00
	HTH	6	0.33	0.21	28	Bisulfite	6	1.58	0.37
	Frozen Control	6	0.17	0.17		Frozen Control	6	0.33	0.21
11	Untreated	6	0.17	0.17	30	Bisulfite	6	1.33	0.33
	Bisulfite	6	0.00	0.00		Frozen Control	6	0.33	0.21
	Odocine	6	0.33	0.21	32	Bisulfite	6	0.83	0.31
	HTH	6	0.33	0.21	35	Bisulfite	6	2.25	0.25
	Frozen Control	6	0.00	0.00					

Appendix G. Ammonia means, number of samples, and standard errors of the mean.

Post Room Odor

Days of Storage	Treatment	N	Mean	Std. Error of Mean	Days of Storage	Treatment	N	Mean	Std. Error of Mean
1	Untreated	6	0.67	0.21	14	Untreated	6	3.58	0.20
	Bisulfite	6	0.00	0.00		Bisulfite	6	3.83	0.31
	Odocine	6	0.50	0.22		Odocine	6	2.42	0.27
	HTH	6	0.67	0.33		HTH	6	2.33	0.42
	Frozen Control	-	—	—		Frozen Control	6	0.67	0.33
2	Untreated	6	0.50	0.22	16	Untreated	6	3.33	0.31
	Bisulfite	6	0.50	0.22		Bisulfite	6	0.83	0.17
	Odocine	6	0.17	0.17		Odocine	6	3.33	0.31
	HTH	6	0.33	0.21		HTH	6	2.42	0.27
	Frozen Control	6	0.17	0.17		Frozen Control	6	0.17	0.17
4	Untreated	6	0.83	0.17	18	Bisulfite	6	1.33	0.21
	Bisulfite	6	1.67	0.21		Frozen Control	6	0.17	0.17
	Odocine	6	0.83	0.17	21	Bisulfite	6	1.17	0.40
	HTH	6	1.17	0.17		Frozen Control	6	0.33	0.21
	Frozen control	6	0.17	0.17	23	Bisulfite	6	1.33	0.21
7	Untreated	6	0.50	0.22		Frozen Control	6	0.67	0.21
	Bisulfite	6	0.17	0.17	25	Bisulfite	6	0.83	0.40
	Odocine	6	0.17	0.17		Frozen Control	6	0.75	0.36
	HTH	6	0.67	0.21	28	Bisulfite	6	1.33	0.21
	Frozen Control	6	0.33	0.21		Frozen Control	6	0.67	0.21
11	Untreated	6	0.50	0.22	30	Bisulfite	6	0.83	1.17
	Bisulfite	6	0.33	0.21		Frozen Control	6	0.67	0.33
	Odocine	6	0.50	0.22	32	Bisulfite	6	1.42	0.33
	HTH	6	0.83	0.17	35	Bisulfite	6	1.50	0.22
	Frozen Control	6	0.67	0.21					

Appendix H. Post room means, number of samples, and standard errors of the mean.

Putrid

Days of Storage	Treatment	N	Mean	Std. Error of Mean
1	Untreated	6	0.00	0.00
	Bisulfite	6	0.00	0.00
	Odocine	6	0.00	0.00
	HTH	6	0.00	0.00
	Frozen Control	-	—	—
2	Untreated	6	0.00	0.00
	Bisulfite	6	0.00	0.00
	Odocine	6	0.00	0.00
	HTH	6	0.00	0.00
	Frozen Control	6	0.00	0.00
4	Untreated	6	0.00	0.00
	Bisulfite	6	0.00	0.00
	Odocine	6	0.00	0.00
	HTH	6	0.00	0.00
	Frozen control	6	0.00	0.00
7	Untreated	6	0.00	0.00
	Bisulfite	6	0.00	0.00
	Odocine	6	0.00	0.00
	HTH	6	0.00	0.00
	Frozen Control	6	0.00	0.00
11	Untreated	6	0.00	0.00
	Bisulfite	6	0.00	0.00
	Odocine	6	0.00	0.00
	HTH	6	0.00	0.00
	Frozen Control	6	0.00	0.00
14	Untreated	6	1.83	0.31
	Bisulfite	6	0.00	0.00
	Odocine	6	1.08	0.27
	HTH	6	0.83	0.31
	Frozen Control	6	0.00	0.00
16	Untreated	6	2.83	0.28
	Bisulfite	6	0.00	0.00
	Odocine	6	1.83	0.17
	HTH	6	2.08	0.08
	Frozen Control	6	0.00	0.00
18	Bisulfite	6	0.00	0.00
	Frozen Control	6	0.00	0.00
21	Bisulfite	6	0.00	0.00
	Frozen Control	6	0.00	0.00
23	Bisulfite	6	0.00	0.00
	Frozen Control	6	0.00	0.00
25	Bisulfite	6	0.00	0.00
	Frozen Control	6	0.00	0.00
28	Bisulfite	6	0.00	0.00
	Frozen Control	6	0.00	0.00
30	Bisulfite	6	0.17	0.17
	Frozen Control	6	0.00	0.00
32	Bisulfite	6	0.33	0.33
35	Bisulfite	6	0.67	0.21

Appendix I. Putrid means, number of samples, and standard errors of the mean.

Sour

Days of Storage	Treatment	N	Mean	Std. Error of Mean	Days of Storage	Treatment	N	Mean	Std. Error of Mean
1	Untreated	6	0.00	0.00	14	Untreated	6	0.50	0.34
	Bisulfite	6	0.00	0.00		Bisulfite	6	0.17	0.17
	Odocine	6	0.00	0.00		Odocine	6	0.17	0.17
	HTH	6	0.00	0.00		HTH	6	0.33	0.21
	Frozen Control	–	—	—		Frozen Control	6	0.00	0.00
2	Untreated	6	0.00	0.00	16	Untreated	6	0.50	0.34
	Bisulfite	6	0.00	0.00		Bisulfite	6	0.00	0.00
	Odocine	6	0.00	0.00		Odocine	6	0.50	0.34
	HTH	6	0.00	0.00		HTH	6	0.50	0.34
	Frozen Control	6	0.00	0.00		Frozen Control	6	0.00	0.00
4	Untreated	6	0.00	0.00	18	Bisulfite	6	0.00	0.00
	Bisulfite	6	0.00	0.00		Frozen Control	6	0.00	0.00
	Odocine	6	0.00	0.00	21	Bisulfite	6	0.00	0.00
	HTH	6	0.00	0.00		Frozen Control	6	0.00	0.00
	Frozen control	6	0.00	0.00	23	Bisulfite	6	0.00	0.00
7	Untreated	6	0.00	0.00		Frozen Control	6	0.00	0.00
	Bisulfite	6	0.00	0.00	25	Bisulfite	6	0.00	0.00
	Odocine	6	0.00	0.00		Frozen Control	6	0.00	0.00
	HTH	6	0.00	0.00	28	Bisulfite	6	0.00	0.00
	Frozen Control	6	0.00	0.00		Frozen Control	6	0.00	0.00
11	Untreated	6	0.00	0.00	30	Bisulfite	6	0.00	0.00
	Bisulfite	6	0.17	0.17		Frozen Control	6	0.00	0.00
	Odocine	6	0.00	0.00	32	Bisulfite	6	0.17	0.17
	HTH	6	0.00	0.00	35	Bisulfite	6	0.17	0.17
	Frozen Control	6	0.00	0.00					

Appendix J. Sour means, number of samples, and standard errors of the mean.

Fishy

Days of Storage	Treatment	N	Mean	Std. Error of Mean
1	Untreated	6	1.00	0.37
	Bisulfite	6	1.50	0.34
	Odocine	6	0.50	0.22
	HTH	6	0.67	0.21
	Frozen Control	-	—	—
2	Untreated	6	0.67	0.33
	Bisulfite	6	1.50	0.22
	Odocine	6	0.83	0.17
	HTH	6	1.17	0.17
	Frozen Control	6	1.17	0.17
4	Untreated	6	0.67	0.21
	Bisulfite	6	1.33	0.21
	Odocine	6	0.58	0.20
	HTH	6	1.00	0.37
	Frozen control	6	0.67	0.33
7	Untreated	6	1.08	0.27
	Bisulfite	6	2.50	0.34
	Odocine	6	1.42	0.20
	HTH	6	1.00	0.37
	Frozen Control	6	1.50	0.50
11	Untreated	6	1.50	0.22
	Bisulfite	6	2.08	0.24
	Odocine	6	1.17	0.31
	HTH	6	0.67	0.33
	Frozen Control	6	0.83	0.40
14	Untreated	6	0.50	0.22
	Bisulfite	6	0.67	0.21
	Odocine	6	0.50	0.22
	HTH	6	0.67	0.21
	Frozen Control	6	0.67	0.21
16	Untreated	6	1.42	0.37
	Bisulfite	6	0.50	0.22
	Odocine	6	1.33	.33
	HTH	6	0.83	0.31
	Frozen Control	6	0.17	0.17
18	Bisulfite	6	1.67	0.33
	Frozen Control	6	1.50	0.22
21	Bisulfite	6	1.50	0.34
	Frozen Control	6	0.67	0.21
23	Bisulfite	6	1.50	0.34
	Frozen Control	6	0.75	0.25
25	Bisulfite	6	0.50	0.22
	Frozen Control	6	0.33	0.21
28	Bisulfite	6	0.75	0.25
	Frozen Control	6	1.17	0.17
30	Bisulfite	6	3.17	0.31
	Frozen Control	6	0.50	0.34
32	Bisulfite	6	1.17	0.31
35	Bisulfite	6	1.50	0.34

Appendix K. Fishy means, number of samples, and standard errors of the mean.

Consumer Rating, Odor

Days of Storage	Treatment	N	Mean	Std. Error of Mean
1	Untreated	6	3.67	0.21
	Bisulfite	6	3.83	0.17
	Odocine	6	3.83	0.17
	HTH	6	3.33	0.21
	Frozen Control	-	—	—
2	Untreated	6	3.83	0.31
	Bisulfite	6	3.50	0.22
	Odocine	6	4.17	0.17
	HTH	6	4.00	0.26
	Frozen Control	6	3.50	0.22
4	Untreated	6	3.33	0.21
	Bisulfite	6	3.33	0.21
	Odocine	6	3.75	0.17
	HTH	6	3.33	0.21
	Frozen control	6	3.67	0.21
7	Untreated	6	3.92	0.08
	Bisulfite	6	3.92	0.20
	Odocine	6	3.92	0.08
	HTH	6	3.92	0.08
	Frozen Control	6	3.38	0.11
11	Untreated	6	3.92	0.08
	Bisulfite	6	3.25	0.11
	Odocine	6	3.75	0.17
	HTH	6	3.83	0.11
	Frozen Control	6	4.00	0.26
14	Untreated	6	2.08	0.27
	Bisulfite	6	3.42	0.15
	Odocine	6	2.50	0.13
	HTH	6	2.33	0.44
	Frozen Control	6	3.92	0.20
16	Untreated	6	1.17	0.21
	Bisulfite	6	3.42	0.27
	Odocine	6	1.83	0.21
	HTH	6	1.42	0.20
	Frozen Control	6	3.92	0.33
18	Bisulfite	6	3.50	0.13
	Frozen Control	6	4.00	0.00
21	Bisulfite	6	3.17	0.21
	Frozen Control	6	3.33	0.21
23	Bisulfite	6	2.58	0.15
	Frozen Control	6	3.33	0.17
25	Bisulfite	6	2.58	0.27
	Frozen Control	6	3.50	0.18
28	Bisulfite	6	2.67	0.31
	Frozen Control	6	3.67	0.17
30	Bisulfite	6	2.58	0.20
	Frozen Control	6	3.42	0.20
32	Bisulfite	6	2.50	0.18
35	Bisulfite	6	1.88	0.21

Appendix L. Consumer rating, odor means, number of samples, and standard errors of the mean.

Slimy

Days of Storage	Treatment	N	Mean	Std. Error of Mean	Days of Storage	Treatment	N	Mean	Std. Error of Mean
1	Untreated	6	3.17	0.17	14	Untreated	6	2.83	0.31
	Bisulfite	6	0.83	0.31		Bisulfite	6	2.17	0.31
	Odocine	6	0.83	0.17		Odocine	6	2.75	0.31
	HTH	6	0.67	0.21		HTH	6	2.50	0.43
	Frozen Control	–	—	—		Frozen Control	6	1.67	0.33
2	Untreated	6	1.50	0.22	16	Untreated	6	3.33	0.56
	Bisulfite	6	0.83	0.17		Bisulfite	6	2.33	0.21
	Odocine	6	0.67	0.21		Odocine	6	3.42	0.20
	HTH	6	0.67	0.21		HTH	6	3.42	0.20
	Frozen Control	6	1.33	0.21		Frozen Control	6	2.16	0.31
4	Untreated	6	1.00	0.26	18	Bisulfite	6	2.33	0.21
	Bisulfite	6	0.50	0.22		Frozen Control	6	2.08	0.27
	Odocine	6	1.67	0.33	21	Bisulfite	6	2.58	0.20
	HTH	6	1.00	0.26		Frozen Control	6	2.00	0.00
	Frozen control	6	1.00	0.37	23	Bisulfite	6	2.17	0.11
7	Untreated	6	1.75	0.17		Frozen Control	6	1.67	0.40
	Bisulfite	6	0.67	0.21	25	Bisulfite	6	3.03	0.21
	Odocine	6	1.42	0.33		Frozen Control	6	1.58	0.20
	HTH	6	1.92	0.33	28	Bisulfite	6	3.08	0.08
	Frozen Control	6	1.83	0.31		Frozen Control	6	2.00	0.13
11	Untreated	6	1.92	0.20	30	Bisulfite	6	2.92	0.20
	Bisulfite	6	1.75	0.25		Frozen Control	6	1.67	0.21
	Odocine	6	1.92	0.33	32	Bisulfite	6	2.67	0.40
	HTH	6	1.67	0.21	35	Bisulfite	6	3.17	0.28
	Frozen Control	6	1.67	0.21					

Appendix M. Slimy means, number of samples, and standard errors of the mean.

Light-Dark

Days of Storage	Treatment	N	Mean	Std. Error of Mean
1	Untreated	6	2.00	0.00
	Bisulfite	6	2.00	0.26
	Odocine	6	1.50	0.22
	HTH	6	1.83	0.31
	Frozen Control	-	—	—
2	Untreated	6	2.33	0.21
	Bisulfite	6	2.17	0.17
	Odocine	6	2.00	0.26
	HTH	6	2.17	0.31
	Frozen Control	6	2.50	0.22
4	Untreated	6	1.83	0.17
	Bisulfite	6	2.17	0.31
	Odocine	6	2.17	0.31
	HTH	6	2.33	0.33
	Frozen control	6	2.50	0.34
7	Untreated	6	2.17	0.17
	Bisulfite	6	1.58	0.20
	Odocine	6	2.25	0.25
	HTH	6	2.33	0.21
	Frozen Control	6	2.50	0.22
11	Untreated	6	2.33	0.21
	Bisulfite	6	2.42	0.20
	Odocine	6	2.17	0.17
	HTH	6	2.58	0.15
	Frozen Control	6	2.17	0.17
14	Untreated	6	2.83	0.17
	Bisulfite	6	2.50	0.22
	Odocine	6	2.92	0.08
	HTH	6	2.83	0.31
	Frozen Control	6	2.67	0.21
16	Untreated	6	2.92	0.20
	Bisulfite	6	2.33	0.21
	Odocine	6	2.92	0.08
	HTH	6	3.08	0.08
	Frozen Control	6	2.92	0.15
18	Bisulfite	6	2.25	0.17
	Frozen Control	6	3.00	0.00
21	Bisulfite	6	2.08	0.08
	Frozen Control	6	3.25	0.17
23	Bisulfite	6	2.50	0.18
	Frozen Control	6	2.67	0.21
25	Bisulfite	6	2.75	0.21
	Frozen Control	6	3.50	0.13
28	Bisulfite	6	2.58	0.15
	Frozen Control	6	2.83	0.17
30	Bisulfite	6	2.72	0.31
	Frozen Control	6	3.25	0.17
32	Bisulfite	6	2.50	0.22
35	Bisulfite	6	3.00	0.13

Appendix N. Light-Dark means, number of samples, and standard errors of the mean.

Firmness

Days of Storage	Treatment	N	Mean	Std. Error of Mean	Days of Storage	Treatment	N	Mean	Std. Error of Mean
1	Untreated	6	3.50	0.22	14	Untreated	6	2.75	0.17
	Bisulfite	6	3.83	0.17		Bisulfite	6	3.17	0.11
	Odocine	6	3.67	0.21		Odocine	6	3.17	0.31
	HTH	6	3.50	0.22		HTH	6	3.33	0.31
	Frozen Control	–	—	—		Frozen Control	6	3.50	0.18
2	Untreated	6	3.67	0.21	16	Untreated	6	2.17	0.21
	Bisulfite	6	3.67	0.21		Bisulfite	6	3.83	0.21
	Odocine	6	3.83	0.17		Odocine	6	2.92	0.08
	HTH	6	3.67	0.21		HTH	6	3.08	0.15
	Frozen Control	6	2.67	0.21		Frozen Control	6	3.25	0.31
4	Untreated	6	3.33	0.42	18	Bisulfite	6	3.33	0.17
	Bisulfite	6	1.50	0.34		Frozen Control	6	3.00	0.26
	Odocine	6	3.67	0.21	21	Bisulfite	6	2.33	0.17
	HTH	6	3.67	0.21		Frozen Control	6	2.67	0.21
	Frozen control	6	3.00	0.26	23	Bisulfite	6	2.75	0.25
7	Untreated	6	3.17	0.31		Frozen Control	6	3.17	0.11
	Bisulfite	6	3.50	0.22	25	Bisulfite	6	2.67	0.21
	Odocine	6	3.50	0.22		Frozen Control	6	2.92	2.00
	HTH	6	3.42	0.20	28	Bisulfite	6	2.75	0.21
	Frozen Control	6	2.83	0.17		Frozen Control	6	2.92	0.08
11	Untreated	6	3.17	0.17	30	Bisulfite	6	3.00	0.22
	Bisulfite	6	3.33	0.36		Frozen Control	6	2.50	0.18
	Odocine	6	3.42	0.20	32	Bisulfite	6	2.33	0.17
	HTH	6	3.33	0.33	35	Bisulfite	6	2.42	2.00
	Frozen Control	6	3.17	0.11					

Appendix O. Firmness means, number of samples, and standard errors of the mean.

Adhesiveness

Days of Storage	Treatment	N	Mean	Std. Error of Mean
1	Untreated	6	1.33	0.21
	Bisulfite	6	3.83	0.17
	Odocine	6	2.83	0.31
	HTH	6	2.83	0.31
	Frozen Control	-	—	—
2	Untreated	6	1.83	0.17
	Bisulfite	6	2.67	0.33
	Odocine	6	2.00	0.00
	HTH	6	2.17	0.17
	Frozen Control	6	1.33	0.21
4	Untreated	6	1.67	0.21
	Bisulfite	6	2.00	0.37
	Odocine	6	2.67	0.21
	HTH	6	2.17	0.17
	Frozen control	6	1.33	0.33
7	Untreated	6	2.42	0.20
	Bisulfite	6	2.50	0.22
	Odocine	6	1.83	0.17
	HTH	6	2.08	0.27
	Frozen Control	6	1.33	0.21
11	Untreated	6	2.33	0.21
	Bisulfite	6	2.92	0.27
	Odocine	6	2.17	0.17
	HTH	6	2.33	0.21
	Frozen Control	6	1.50	0.22
14	Untreated	6	2.58	0.37
	Bisulfite	6	2.92	0.15
	Odocine	6	2.92	0.27
	HTH	6	2.92	0.08
	Frozen Control	6	1.83	0.17
16	Untreated	6	2.50	0.22
	Bisulfite	6	2.83	0.11
	Odocine	6	2.83	0.11
	HTH	6	2.75	0.31
	Frozen Control	6	2.08	0.20
18	Bisulfite	6	2.83	0.11
	Frozen Control	6	2.33	0.21
21	Bisulfite	6	2.92	0.20
	Frozen Control	6	2.08	0.20
23	Bisulfite	6	2.58	0.33
	Frozen Control	6	1.83	0.17
25	Bisulfite	6	3.42	0.15
	Frozen Control	6	1.83	0.17
28	Bisulfite	6	2.67	0.17
	Frozen Control	6	2.00	0.13
30	Bisulfite	6	2.67	0.25
	Frozen Control	6	2.17	0.11
32	Bisulfite	6	3.00	0.00
35	Bisulfite	6	3.08	0.08

Appendix P. Adhesiveness means, number of samples, and standard errors of the mean.

Wetness

Days of Storage	Treatment	N	Mean	Std. Error of Mean	Days of Storage	Treatment	N	Mean	Std. Error of Mean
1	Untreated	-	—	—	14	Untreated	6	3.33	0.21
	Bisulfite	-	—	—		Bisulfite	6	2.50	0.34
	Odocine	-	—	—		Odocine	6	3.17	0.40
	HTH	-	—	—		HTH	6	3.08	0.37
	Frozen Control	-	—	—		Frozen Control	6	3.50	0.56
2	Untreated	6	2.67	0.21	16	Untreated	6	4.17	0.17
	Bisulfite	6	2.75	0.17		Bisulfite	6	2.67	0.33
	Odocine	6	2.33	0.33		Odocine	6	3.67	0.21
	HTH	6	2.67	0.21		HTH	6	3.17	0.17
	Frozen Control	6	4.17	0.17		Frozen Control	6	4.17	0.31
4	Untreated	6	2.83	0.31	18	Bisulfite	6	2.75	0.17
	Bisulfite	6	3.83	0.17		Frozen Control	6	3.75	0.31
	Odocine	6	3.17	0.31	21	Bisulfite	6	3.17	0.17
	HTH	6	3.50	0.34		Frozen Control	6	4.00	0.37
	Frozen control	6	4.50	0.22	23	Bisulfite	6	2.58	0.20
7	Untreated	6	3.17	0.17		Frozen Control	6	3.17	0.40
	Bisulfite	6	2.25	0.31	25	Bisulfite	6	2.83	0.17
	Odocine	6	2.67	0.33		Frozen Control	6	4.25	0.31
	HTH	6	3.33	0.21	28	Bisulfite	6	3.00	0.13
	Frozen Control	6	4.08	0.33		Frozen Control	6	3.67	0.31
11	Untreated	6	3.33	0.33	30	Bisulfite	6	3.08	0.27
	Bisulfite	6	3.08	0.27		Frozen Control	6	3.50	0.26
	Odocine	6	3.17	0.31	32	Bisulfite	6	2.42	0.33
	HTH	6	3.67	0.25	35	Bisulfite	6	2.75	0.25
	Frozen Control	6	4.17	0.17					

Appendix Q. Wetness means, number of samples, and standard errors of the mean.

Consumer Rating, Appearance

Days of Storage	Treatment	N	Mean	Std. Error of Mean	Days of Storage	Treatment	N	Mean	Std. Error of Mean
1	Untreated	6	3.75	0.31	14	Untreated	6	2.58	0.20
	Bisulfite	6	4.33	0.21		Bisulfite	6	3.58	0.20
	Odocine	6	4.33	0.42		Odocine	6	2.75	0.21
	HTH	6	4.17	0.31		HTH	6	3.00	0.34
	Frozen Control	-	—	—		Frozen Control	6	4.00	0.26
2	Untreated	6	3.67	0.21	16	Untreated	6	1.67	0.17
	Bisulfite	6	4.00	0.26		Bisulfite	6	3.58	0.15
	Odocine	6	4.33	0.21		Odocine	6	2.25	0.11
	HTH	6	4.17	0.31		HTH	6	2.50	0.18
	Frozen Control	6	2.83	0.17		Frozen Control	6	2.83	0.33
4	Untreated	6	3.17	0.16	18	Bisulfite	6	3.67	0.17
	Bisulfite	6	4.16	0.40		Frozen Control	6	3.67	0.17
	Odocine	6	3.83	0.31	21	Bisulfite	6	3.25	0.17
	HTH	6	3.17	0.31		Frozen Control	6	2.75	0.21
	Frozen control	6	3.33	0.33	23	Bisulfite	6	2.67	0.17
7	Untreated	6	4.00	0.00		Frozen Control	6	3.33	0.17
	Bisulfite	6	4.42	0.20	25	Bisulfite	6	3.17	0.21
	Odocine	6	4.08	0.15		Frozen Control	6	3.28	0.10
	HTH	6	3.83	0.21	28	Bisulfite	6	2.75	0.17
	Frozen Control	6	3.92	0.08		Frozen Control	6	3.25	0.17
11	Untreated	6	3.75	0.17	30	Bisulfite	6	3.00	0.18
	Bisulfite	6	3.83	0.11		Frozen Control	6	3.33	0.25
	Odocine	6	3.83	0.17	32	Bisulfite	6	3.00	0.13
	HTH	6	3.33	0.21	35	Bisulfite	6	2.42	0.20
	Frozen Control	6	3.67	0.21					

Appendix R. Consumer rating, appearance means, number of samples, and standard errors of the mean.