NOAA TECHNICAL MEMORANDUM
NMFS SEFC-54

THE REFRIGERATED SHELFLIFE OF SPANISH MACKEREL (*SCOMBEROMORUS MACULATUS*) AND KING MACKEREL (*SCOMBEROMORUS CAVALLA*) HARVESTED FROM THE SOUTHEASTERN UNITED STATES

Melvin E. Waters

June 1982

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Southeast Fisheries Center
Charleston Laboratory
P.O. Box 12607
Charleston, South Carolina 29412 - 0607

NOAA Technical Memorandum NMFS-SEFC-54

Technical Memorandums are used for documentation and timely communication of preliminary results, interim reports, or special-purpose information, and have not received complete formal review, editorial control, or detailed editing.

THE REFRIGERATED SHELFLIFE OF SPANISH MACKEREL (*Scomberomorus maculatus*) AND KING MACKEREL (*Scomberomorus cavalla*) HARVESTED FROM THE SOUTHEASTERN UNITED STATES

Melvin E. Waters

June 1982

U. S. DEPARTMENT OF COMMERCE
Malcolm Baldrige, Secretary
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
John V. Byrne, Administrator
NATIONAL MARINE FISHERIES SERVICE
William G. Gordon, Assistant Administer for Fisheries

THE REFRIGERATED SHELFLIFE OF SPANISH MACKEREL (*Scomberomorus maculatus*) AND KING MACKEREL (*Scomberomorus cavalla*) HARVESTED FROM THE SOUTHEASTERN UNITED STATES.

MELVIN E. WATERS
NATIONAL MARINE FISHERIES SERVICE, NOAA
Southeast Fisheries Center, Charleston Laboratory
Charleston, S C 29412

ABSTRACT--Freshly caught Spanish mackerel (*Scomberomorous maculatus*) and king mackerel (*Scomberomorous cavalla*) were processed into various market forms and stored, either iced or packaged, at 4°C. Representative samples of each product form were removed from storage at regular intervals and assessed for quality using organoleptic, microbial and chemical methods. The resultant shelflife of Spanish mackerel, after processing, was 9 days for gutted, as well as for headed and gutted (H&G) fish (iced) and 5-6 days for tray-pack skin-on and skinless fillets (4°C). The resultant shelflife of king mackerel was 15 days for whole fish (iced) and 9 days for portions (4°C). Total volatile nitrogen (TVN) and trimethylamine-nitrogen (TMA-N) values increased dramatically after 5 days of storage at 4°C for Spanish mackerel and 9 days at 4°C for king mackerel, and compared favorably with sensory scores. Thiobarbituric acid (TBA) values for king mackerel (whole fish and portions) increased fairly regularly with an increase in storage time. TBA values for all except one sample of the products examined during this study did not exceed 5 mg of malonaldehyde (MA)/kg of sample which has been suggested as the upper limit that can be present in fishery products without being detected by sensory panels. It was concluded that spoilage was due to microbial activity and not oxidative rancidity as indicated by low TBA values.

INTRODUCTION

The mackerels are inhabitants of coastal waters, the genus *Scomberomorous* being distributed worldwide throughout tropical and subtropical regions (Lyle, 1969). The Spanish mackerel (*Scomberomorous maculatus*) is an important commercial species in the U.S. with annual landings in 1980 of approximately 12 million pounds valued at $3.1 million ex-vessel (U.S. Department of Commerce, 1980). In the past, king mackerel (*Scomberomorous cavalla*) was considered to be a recreational fish. In recent years, however, it too has become of commercial importance. In 1980, approximately 7 million pounds of king mackerel were landed at a value of $5.4 million ex-vessel (U.S. Department of Commerce, 1980).Ninety percent of the U.S. landings were confined to the east coast of Florida and the Florida Keys.

The mackerels have been utilized as a food fish for many years and provide a food with a delicate flavor and one of high nutritional value. The flesh is high in protein, vitamins, calcium and phosphorous; low in sodium and cholesterol (Hale, 1978). The high oil content of the mackerels make them ideal for broiling, baking and smoking. The species offer versatility in the preparation of various seafood recipes. Spanish mackerel is served extensively in seafood restaurants.

Spanish and king mackerel are generally eviscerated at sea, packed in crushed ice and landed within a few days after catch. Evisceration and packing in crushed ice immediately after harvest is particularly important with mackerels to slow down spoilage to increase the shelflife. Although the bulk of the Spanish mackerel catch is filleted and sold fresh or frozen, whole (eviscerated) fish may also be marketed fresh and frozen. King mackerel are usually sold to retail outlets as whole fish (eviscerated) and subsequently processed into steaks for the retail trade at grocery stores and seafood markets. King mackerel are marketed fresh or frozen.

Marketing of Spanish mackerel at the retail level (fresh or frozen) has been limited partially because of its relatively short shelflife. Frozen fish begin to show signs of rancidity in 3 months and are usually rejected by taste panels between 6 and 9 months of storage (Farragut, 1972). The texture of fresh Spanish mackerel is soft and the flesh subject to rapid spoilage. Therefore, Spanish mackerel and processed products must be handled expeditiously and carefully in marketing channels to insure that it reaches the consumer in good quality. The market manager does not always take the handling and storage precautions required for Spanish mackerel, resulting in a poor quality product being offered to the consumer. This in part accounts for limited consumption of the species.

The U.S. commercial catch of king mackerel has remained relatively static since 1975 (unpublished data - FMP for Coastal Migratory Pelagic Resources) and is not expected to increase based on historical data and current fishing conditions. Consequently, better knowledge of its storage characteristics is needed to maximize the utility and quality of a limited resource. The flesh of king mackerel is firm, contains a large dark lateral line, gray in color and consumption is limited almost entirely to those familiar with the species.

Detailed information on the refrigerated shelflife of king and Spanish mackerel in various product forms is limited. Such information need to be developed and provided to producers and market managers to encourage them to offer a better quality product to their customers. Data on product shelflife is also needed by nutritionists, economists, and marketing specialists working to capitalize on the desirable qualities of the mackerels and to ensure profitable operations.

The objectives of this study were to determine the refrigerated shelf-life of (1) Spanish mackerel stored as gutted fish, H&G fish, skin-on and skinless fillets, and (2) king mackerel stored as whole fish and steaks, these being the major commercial product forms of the mackerels.

EXPERIMENTAL

FISH SAMPLES

Spanish mackerel were obtained from commercial harvests off the northwest coast of Florida in September, 1977. The mackerel were caught by gillnet, part of the viscera removed on the vessel by deck hands and the fish packed in crushed ice. The catch was landed at Port St. Joe, Florida and subsequently transported to the laboratory for further preparation. The fish had been caught 24 h prior to preparation for experimental work. One hundred pounds (100 fish) were divided into 4 groups of 25 fish each. One group was completely gutted, washed in cold tap water, packed in crushed ice (about 1^{o}C) and designated as gutted fish. The second group was headed, completely gutted, washed and packed in crushed ice (H&G fish). The third group was filleted (skin left intact), washed, drained and placed on polystyrene food trays. The fourth group was filleted, skinned, washed, drained and placed on polystyrene food trays. The trays of product in the third and fourth groups were overwrapped with polyvinyl chloride (PVC) film.

Six king mackerel (uneviscerated) weighing 20 to 30 pounds each were obtained from a sport fisherman and were caught off the coast of Mississippi in June of 1978. The fish were packed in crushed ice on board the vessel after being caught and landed within 8 h. They were transported to the laboratory, re-iced, held in a cooler (4^{o}C) and prepared for experimental work 48 h later. Three fish were washed and packed in crushed ice and designated as whole fish. Three fish were skinned, filleted and the dark lateral line removed from the fillets. The fillets from these three fish were further cut vertically into portions, the portions placed on food trays and overwrapped with PVC packaging material.

Packaged product forms of both species were held in a cooler at $4^{o}C$. The iced fish were also held in the cooler at $4^{o}C$ and provided with good drainage to allow melt water to drain away. Product quality assessments began on the day after preparation and continued at intervals of 2 to 4 days thereafter throughout the storage period.

PRODUCT EVALUATION

Representative samples of each product form of Spanish and king mackerel were removed from storage and evaluated for total aerobic plate counts (TAPC), organoleptic quality and chemical properties. Samples for analyses of gutted and H & G Spanish mackerel were obtained by removing fillets from the fish. Samples for analyses of whole king mackerel were obtained by cutting 2, 1/2 inch portions from the loin at different locations each day of sampling and the dark lateral line removed. Microbiological samples were removed aseptically from each product form prior to conducting the other analyses. Microbial and chemical analyses were conducted on three samples of each product form corresponding to each period of assessment and the results averaged.

Organoleptic evaluation --- Appearance, odor and texture were assessed on the raw products by a panel of 6 judges experienced in evaluating fresh fish quality. Evaluation of whole fish was based on steaks removed from king mackerel and fillets removed from gutted Spanish mackerel. Evaluation of H & G Spanish mackerel was also based on fillets. Assessments were made using a

9-point hedonic scale ranging from 9 (highest affirmative value) to 1 (lowest value) with 5 taken as the borderline quality for acceptability. Results are reported as an average of the 6 assessments.

Microbial analyses --- The microbial analyses consisted of total aerobic plate count (TAPC), following the procedure outlined in FDA's Bacteriological Analytical Manual for Foods (1976) except the plates were incubated 72 h at 22°C. Standard plate count agar was used as the plating media. Results are reported as count per g of sample.

Chemical analyses --- Total volatile nitrogen (TVN) and trimethylamine-nitrogen (TMA-N) analyses were conducted using the modified Conway Micro-diffusion technique described by Obrink (1955) as modified by Cobb, et al (1973). Results are reported as mg N/100 g of sample. Oxidative rancidity was determined by the thiobarbituric acid (TBA) method using the procedure of Vynke (1972) and results reported as mg malonaldehyde (MA)/kg of sample. Determination of pH was conducted using the method described by the A.O.A.C. (1975).

RESULTS AND DISCUSSION

Spanish Mackerel --- Results of the pH, TAPC, oxidative rancidity (TBA) and organoleptic evaluations for Spanish mackerel are shown in Table I. The pH of all product forms remained about the same for the first 3 days of storage. After the third day of storage, tray-pack skin-on and skinless fillets increased slightly but consistently over the initial pH. The pH of gutted and H&G fish, after 3 days of storage, was consistently lower than the two forms of fillets, indicating that the fillets had spoiled at a faster rate. An increase in pH results from a breakdown of proteins brought about by the activity of proteolytic enzymes releasing ammonia, amines and other products of bacterial metabolism.

The TAPC of all product forms increased during storage, with tray-pack fillets reaching a peak at 7 days; gutted and H&G fish peaked at 9 days of storage. A possible explanation for TAPC peaking at 7 days with fillets is that the microorganisms reached the maximum stationary phase of growth at 7 days and entered the accelerated death phase on the 9th day. The counts on both forms of tray-pack fillets were always higher than the gutted and H&G fish. Lower counts on the latter may be attributed to the continuous washing action of the melting ice which is in contact with the skin and storage at a slightly lower temperature. Also, the cut surface may provide a better medium with more surface for growth. There was no appreciable difference between the TAPC of the two forms of tray-pack fillets nor were the counts different between the gutted and H&G fish. Generally, the increase in TAPC values of the various product forms were in agreement with an increase in pH.

Sensory scores for fillets prepared from gutted and H & G fish remained relatively high throughout storage and the fillets were judged edible at the end of storage. However, spoilage odors from the unfilleted fish were evident at 7 days, intensified at 9 days and storage terminated on the 9th day due to probable rejection by the consumer. On the 7th day, tray-pack skin-on and skinless fillets were judged to be of about borderline (score of 5) quality, due primarily to spoilage odors. The darker color of skin-on tray-pack fillets probably contributed to the lower appearance scores for this product form. Texture of the tray-pack fillets became "soft" toward the end of storage, accounting for the low texture scores. Organoleptic scores and comments by panelists indicated that the shelflife of gutted and H & G Spanish mackerel is 7 to 9 days and 5 to 6 days for tray-pack, skin-on and skinless fillets.

The TBA values were somewhat erratic but generally they increased for all product forms during early storage, then decreased at the end of storage. TBA values for gutted fish remained stable except on the 7th day when noticeably higher values were found. Values for the H&G fish increased gradually through 7 days then decreased on the 9th day. TBA values for tray-pack skin-on and skinless fillets reached a peak on the 5th day and 3rd day of storage, respectively. A decrease in TBA values toward the end of frozen storage for several species has been reported in the literature. Botta and Richards (1973), Castell et al (1966) and Buttkus (1967) experienced similar results with salmon, cod and trout, respectively. They suggested that thiobarbituric acid reactive substances react with protein and become partially unrecoverable for the TBA test. Buttkus (1969) also showed that malonaldehyde reacts with cysteine and methionine. The same reactions may be taking place in fresh fish.

TBA values did not exceed 5 mg MA/kg of sample except in one case with tray-pack skinless fillets examined on the 3rd day of storage. Five mg MA/kg is suggested in the literature (Thompson, 1962; Mendenhall, 1972) as the upper limit that can be present in smoked and raw fish fillets without being detected by sensory panels. Rancid odors were not reported by the sensory panel during evaluations of products which had been stored.

The TVN content of the different forms of Spanish mackerel is shown in Figure 1. TVN values for gutted and H&G fish remained stable throughout storage. Values for the two forms of tray-pack fillets were stable through 3 days, then increased appreciably at 5 days and continued to increase dramatically through the end of storage. The increased rate of spoilage of tray-pack fillets over gutted and H&G fish, as indicated by the TVN values, may be attributed to: (1) increased surface area of the fillets available to the gr wth of microorganisms, (2) the lack of continuous washing action of melting ice as employed for gutted and H&G fish and (3) slightly higher storage temperature of the tray-pack fillets. The TVN content of fillets was 22 to 28 mg N/100 g of sample when the sensory panel rated the products of borderline quality. Phillips and Cobb (1977) reported that 30 mg N/100 g of sample is the maximum level at which refrigerated, packaged, Gulf fish are judged to be acceptable. Results of the TVN content corresponded well with sensory scores, pH and microbial counts. The TVN method for determining the quality of refrigerated Spanish mackerel appears to be useful in predicting the onset of spoilage.

The TMA-N content of the different product forms of Spanish mackerel is shown in Figure 2. TMA-N content of gutted and H&G fish were 3 mg N/100 g of sample at 1, 3 and 9 days. While the values were higher at 5 days (5.5) and lower at 7 days (2.0), it is not clear whether these values are due to real changes or merely reflect sampling variability. TMA-N values for both forms of fillets were approximately 3 mg on the 1st day of storage then increased to approximately 3.5 mg on the 3rd day. The values increased on the 5th day to approximately 8 mg and continued to increase very rapidly throughout storage, indicating tray-pack fillets spoiled much more rapidly than gutted and H&G fish. It is important to note that the TMA-N content of fillets increased appreciably before the TVN increased, indicating that the TMA-N test may be a better indicator of the on-set of spoilage in mackerel. TMA-N values corresponded well with other tests used to evaluate the refrigerated shelflife of Spanish mackerel.

King Mackerel -- Results of the pH, TAPC, oxidative rancidity (TBA) and organoleptic evaluations for king mackerel are shown in Table 2. The pH of whole fish decreased on the 3rd day of storage and increased slightly upon further storage. However, the values remained below, or about equal to, the initial pH throughout the remainder of storage suggesting minimal protein degradation. The pH of portions also decreased on the 3rd day of storage, exceeded the initial pH on the 12th day and peaked on the 15th day. The increase in pH values indicated that some proteolysis occurred during the storage period. Results of the pH measurements indicated that portions, packaged and stored at 4°C, spoiled at a faster rate than whole fish stored in ice (1°C).

The TAPC of whole fish remained relatively stable during the first 5 days of storage then increased rapidly on the 9th day. The values decreased slightly on the 12th day, then increased reaching a peak on the 15th day. The count on portions was slightly lower on the 3rd day than the initial value, increased to approximately the initial value on the 5th day, then increased sharply to a peak on the 15th day of storage. The values for portions were consistently higher than those for whole fish in particular on the 9th day and through the remainder of storage. The high counts for portions may be attributed to: (1) increased surface area exposed to bacterial contamination, and (2) slightly higher storage temperature. The increase in TAPC values generally followed an increase in the pH of both product forms, particularly toward the end of storage.

Organoleptic scores for samples from the whole fish remained in the acceptable range throughout storage, except for the odor and texture on the 15th day, which were borderline. Portions were acceptable through 9 days of storage. Portions were rejected by the sensory panel on the 12th day due to spoilage odors and discoloration of the surface. Texture of the portions was soft to mushy on the 15th day.

TBA values for whole fish increased consistently after 3 days of storage. However, the high value obtained on initial storage cannot be xplained. Values for portions generally increased with storage and ranged from 0.1 mg MA/kg at initial storage to 1.11 mg on the 15th day. Values for whole fish were generally lower than portions, indicating that less oxidative rancidity took place in the whole fish. TBA values of both product forms were always below that level considered to be detectable by sensory panels (Thompson, 1962; Mendenhall, 1972).

The TVN content of the two product forms of king mackerel is shown in Figure 3. Values for whole fish were fairly consistent throughout the storage period, ranging from a low of about 12 mg N/100 g on the 9th day to a high of about 14 mg on the 12th day. TVN content of portions remained relatively stable through 9 days of storage (about 14 mg), then increased rapidly thereafter to 29 mg on the 15th day. TVN values for portions were 20.5 mg when rejected by the sensory panel. An increase in the TVN content parallelled closely with an increase in pH, TAPC, TBA values and a decrease in sensory scores.

The TMA-N content of the two forms of king mackerel is shown in Figure 4. TMA-N values for the whole fish were somewhat inconsistent, ranging from a low of 5 mg N/100 g on the first day of storage to a high of 7.2 mg on the 5th day, and remained essential stable throughout storage. Values for portions were also slightly erratic through the first 9 days of storage. Values increased drastically after 9 days to reach a high of 11.0 mg on the 15th day. TMA-N values corresponded well with other tests used to assess the shelflife of king mackerel.

Organoleptic scores, supported by chemical and microbial results, indicate that the refrigerated shelflife of whole king mackerel is about 15 days and 9 days for steaks.

CONCLUSIONS

Quality assessment methods indicated that the refrigerated shelflife of Spanish mackerel is about 7 to 9 days for iced, gutted and H&G fish and 5 to 6 days for tray-pack, skin-on and skinless fillets held at 4°C.

Likewise, the refrigerated shelflife of king mackerel was determined to be about 15 days for iced whole fish and 9 days for packaged portions held at 4°C.

In general, TBA values for Spanish mackerel increased with storage up to a point, then decreased toward the end of storage. Values for king mackerel increased slowly but consistently with storage. Slow or minimal changes in TBA values indicate that spoilage by oxidative mechanisms is much slower than microbial spoilage which produces TMA-N and TVN. Consequently, oxidative spoilage is less important than microbial spoilage of iced fish.

TVN and TMA-N of spanish and king mackerel increased with storage and corresponded very closely with organoleptic scores. Values for TVN and TMA-N increased dramatically when samples were rated of borderline quality. TMA-N appears to be a suitable test to indicate the on-set of spoilage in Spanish mackerel.

The increase in TAPC of all product forms corresponded well with an increase in TMA-N and TVN and a decrease in organoleptic scores.

Iced fish (storage temperature approximately 1°C) is a realistic marketing form for mackerel products and allows greater flexibility in marketing with maximum control of storage temperature. Packaged fillets and steaks (storage temperature approximately 4°C) are also common, convenient marketing forms, but this approach requires special care in the marketplace; i.e., timely rotation of product, careful monitoring and removal of products exhibiting spoilage characteristics and maintenance of a constant and lowest practicable temperature.

REFERENCES

Association of Official Analytical Chemists. 1975. Official Methods of Analysis. 12th edition. Washington, D.C.; 417 pp.

Association of Official Analytical Chemists. 1976. Bacteriological Analytical Manual for Foods. Association of Official Analytical Chemists, Washington, D.C.

Botta, J.R. and J.F. Richards. 1973. Thiobarbituric acid value, total long-chain free fatty acids, and flavor of Pacific halibut (Hippoglossus stenolepis) and chinook salmon (Onocorhynchus tshanytscha) frozen at sea. J. Fish. Res. Bd. Can., 30(1), 63-69.

Buttkus, H. 1967. The reaction of myosin with malonaldehyde. J. Food Sci. 32:432-434.

Buttkus, H. 1969. The reaction of cysteine and methionine with malonaldehyde. J. Amer. Oil Chem. Soc. 46:88-93.

Castell, C.H., B.A. Moore, P.M. Janaard, and W.E. Neal. 1966. Oxidative rancidity in frozen stored cod fillets. J. Fish. Res. Bd. Can. 23, 1385-1401.

Cobb, B.F., I. Alaniz, and C.A. Thompson, Jr. 1973. Biochemical and microbial studies on shrimp: volatile nitrogen and amino nitrogen analysis. J. Food Sci. 38:431.

Farragut, R.N. 1972. Effect of some antioxidants and EDTA on the development of rancidity in Spanish mackerel (Scomberomorous maculatus) during frozen storage. U.S. Department of Commerce, NOAA Technical Report NMFS SSRF-650, 1 - 12.

Hale, M.B. 1978. Preservation technology for Spanish Mackerel and related species-A literature review. Proceed. of the Mackerel Colloquium, March 16, 73-77.

Lyles, C.H. 1969. The Spanish mackerel and king mackerel fisheries. U.S. Fish Wildl. Serv., C.F.S. No. 4936, ii + 21 p.

Mendenhall, V.T. 1972. Oxidative rancidity in raw fish fillets harvested from the Gulf of Mexico. J. Food Sci. 37, 547.

Obrink, K.J. 1955. A modified conway unit for microdiffusion analysis. Biochem. J. 59:134-136.

Phillips, J.M. and B.F. Cobb, III. 1977. Effect of various processing forms, packaging material, storage temperature, and ice storage time on the shelflife of fresh Gulf fish. Proc. Second Tropical and Subtropical Fish. Technol. Conference of the Americas, TAMU-SG-78-101, 222.

Thompson, M.H. 1962. Effect of butylated hydroxy toluene and potassium sorbate on development of rancidity in smoked mullet. Comm. Fish. Rev., 24(4):5.

U.S. Department of Commerce. 1981. Fisheries of the United States, 1980. Current Fisheries Statistics, No. 8100.

Vynke, W. 1972. Direct determination of the thiobarbituric acid value in trichloracetic acid extracts of fish as a measure of oxidative rancidity. Fette. Seifen Anstrichm. 72:1084-1088.

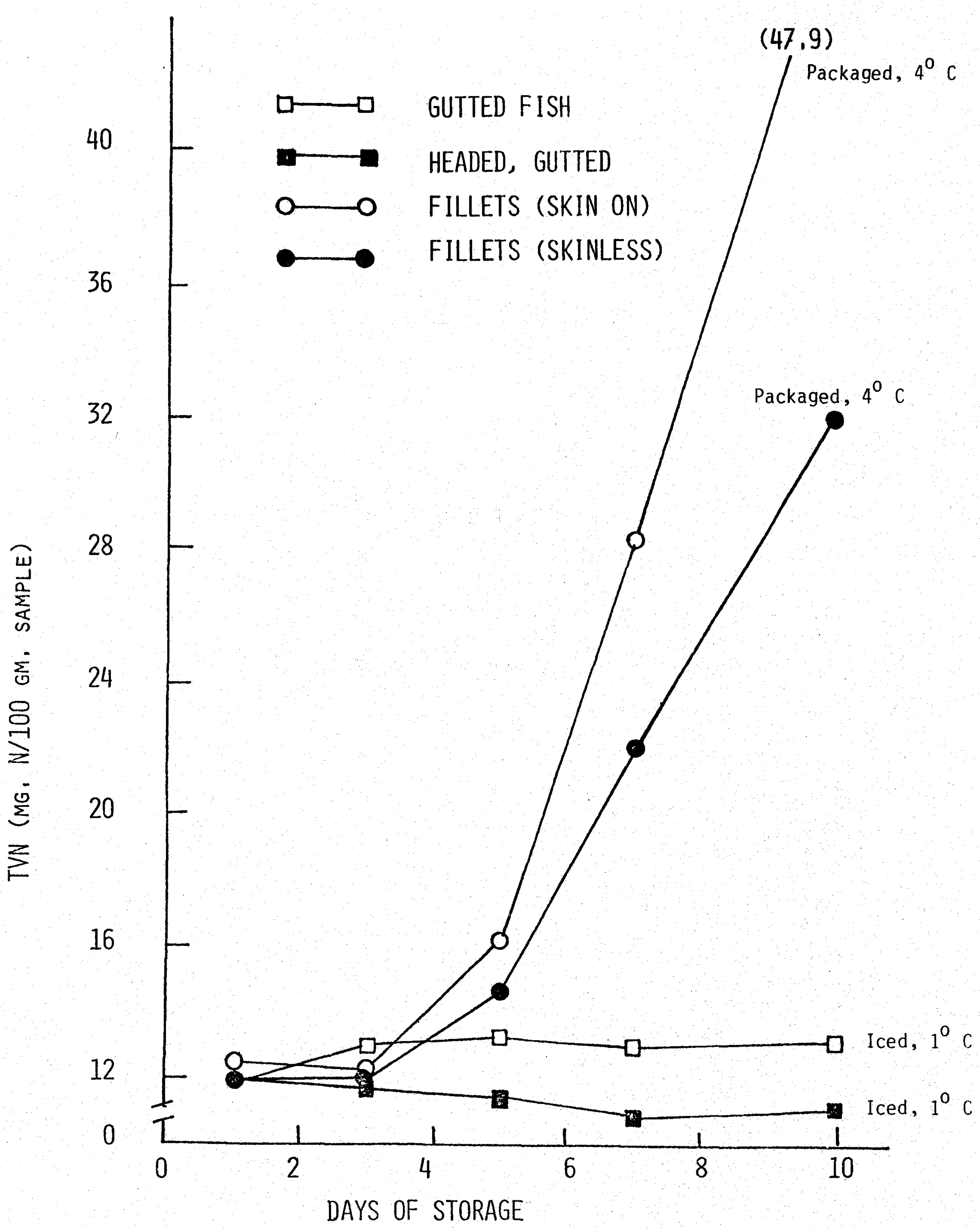

Figure 1 -- The total volatile nitrogen (TVN) content of the various product forms of spanish mackerel stored at 1° C and 4° C.

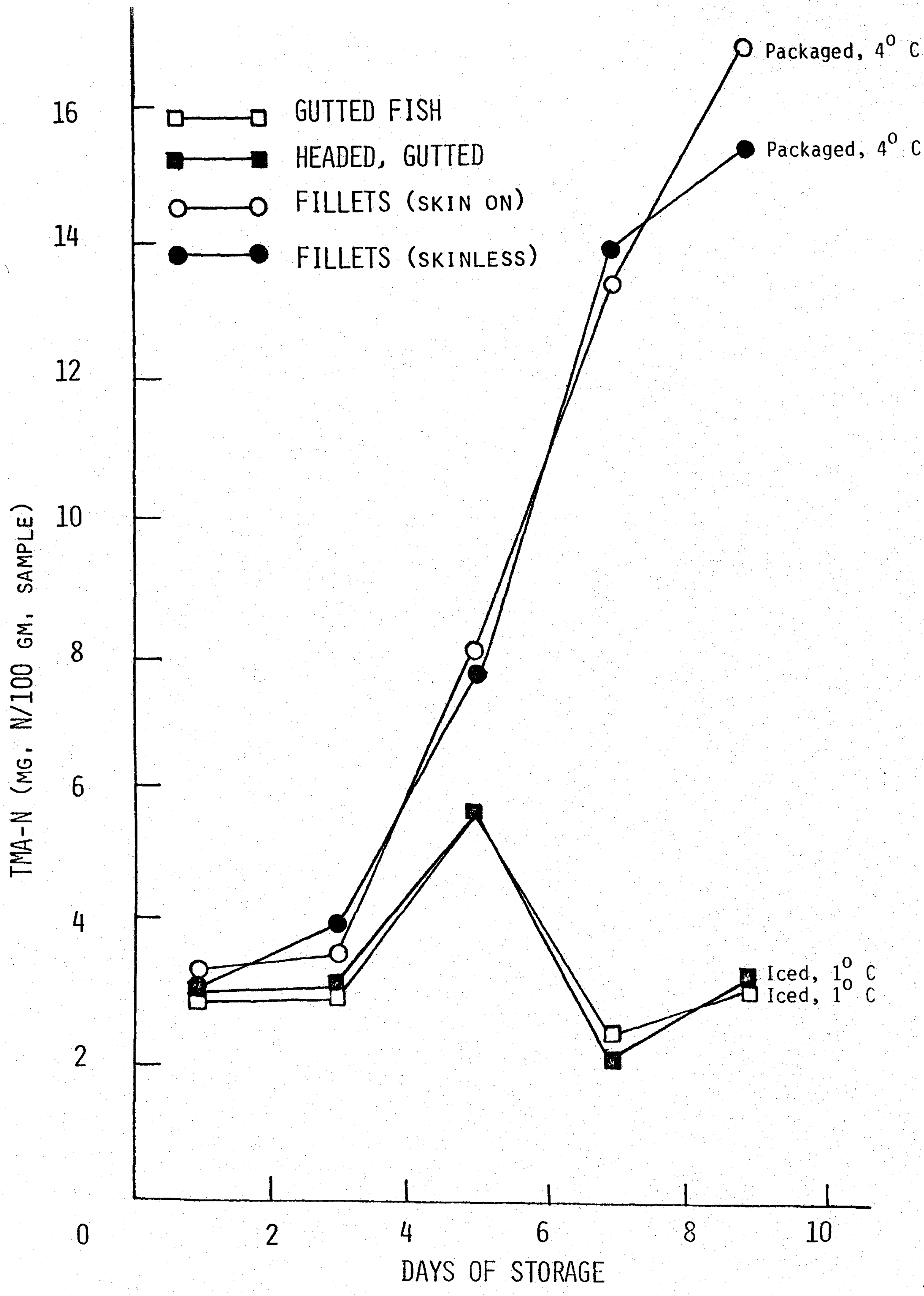

Figure 2 -- The trimethylamine-nitrogen (TMA-N) content of the various product forms of spanish mackerel stored at 1° C and 4° C.

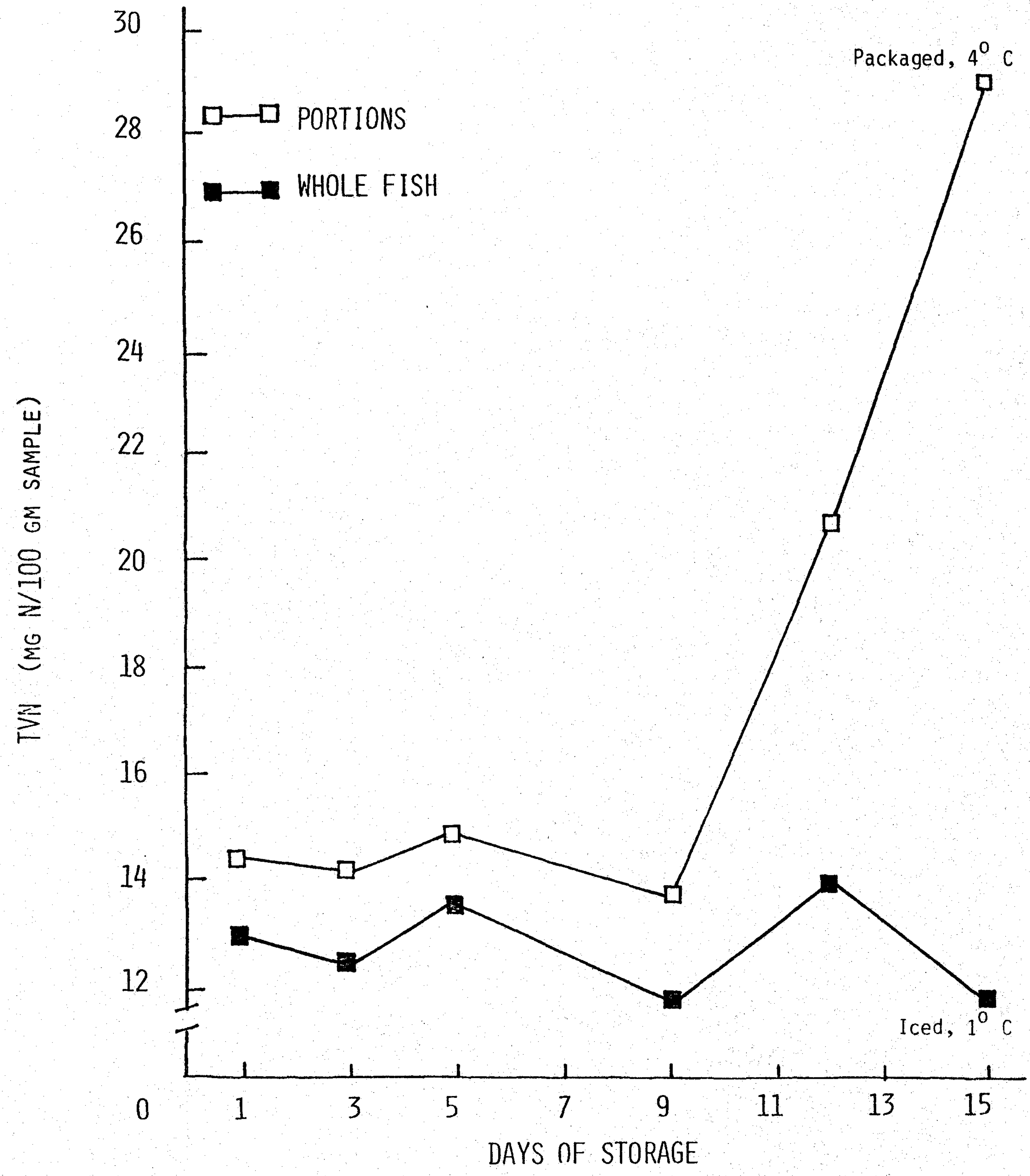

Figure 3 -- The total volatile nitrogen (TVN) content of whole fish and portions of king mackerel stored at 1° and 4° C.

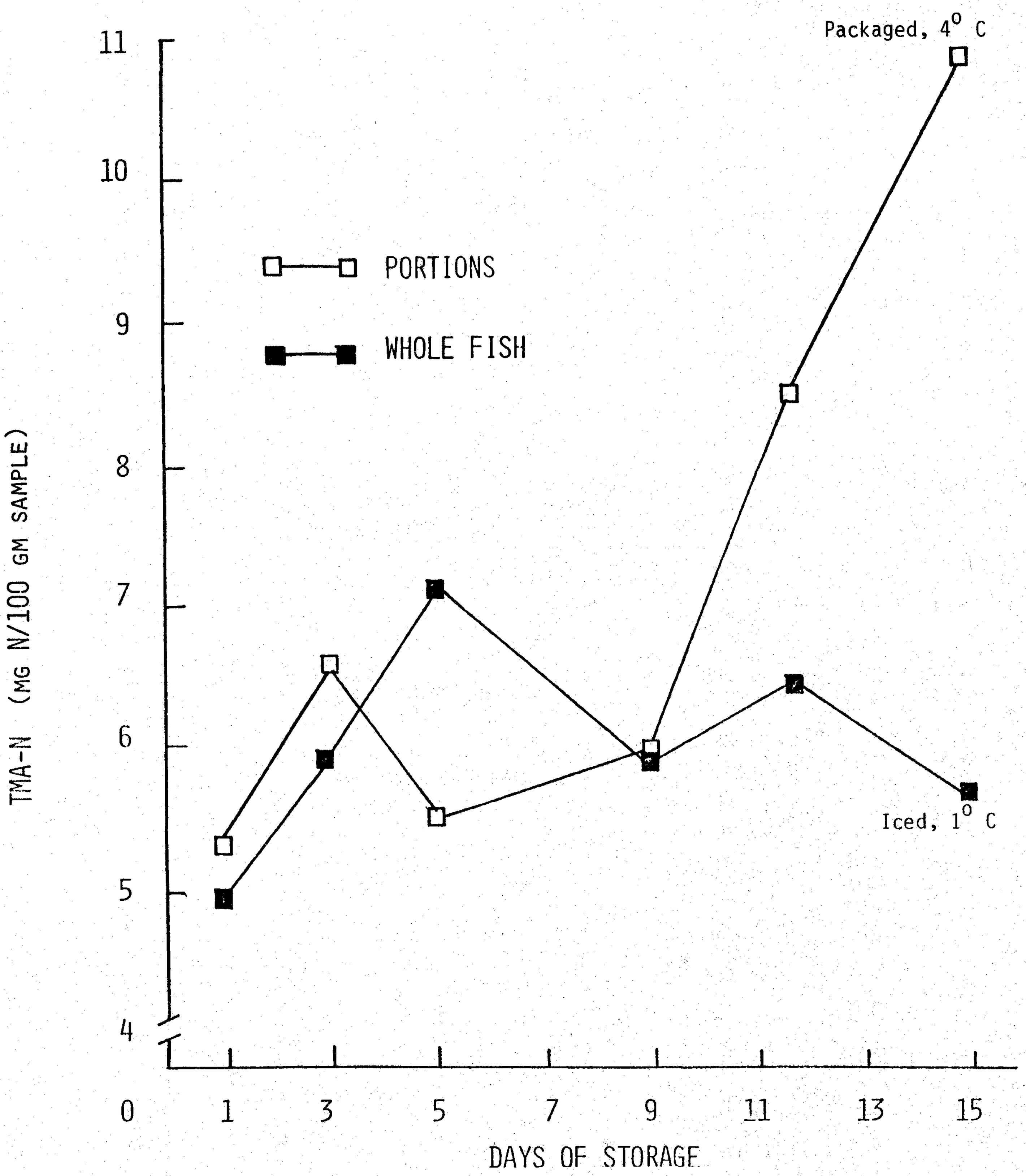

Figure 4 -- The trimethylamine-nitrogen (TMA-N) content of whole fish and portions of king mackerel stored at 1° and 4° C.

Table 1 -- Results of the assessment of various product forms of Spanish mackerel stored at 1°C and 4° C.

Product Form	Storage Time (days)	Quality Factors					
		pH 3/	Total Aerobic Plate Count (count/g) 3/	Organoleptic Scores 4/			TBA Values (mg MA 2/ /kg) 3/
				App. 1/	Odor	Texture	
Gutted	1	6.49	5.4 X 10^4	7.2	6.2	7.0	2.37
Fish	3	6.45	1.2 X 10^5	7.5	7.3	6.7	2.35
Iced	5	6.30	8.6 X 10^5	7.5	8.0	7.0	2.82
(1° C)	7	6.28	9.1 X 10^5	7.2	7.2	6.3	4.61
	9	6.61	6.2 X 10^6	7.0	7.5	6.5	2.40
	1	6.30	1.1 X 10^5	7.8	7.7	7.2	0.32
H & G Fish	3	6.48	8.2 X 10^4	7.7	7.7	7.3	1.69
	5	6.29	5.7 X 10^5	8.0	7.5	7.5	3.33
Iced	7	6.28	1.5 X 10^6	6.3	6.2	6.2	2.70
(1° C)	9	6.63	1.9 X 10^7	7.0	6.0	6.5	2.42
Skin-on	1	6.39	3.4 X 10^5	6.7	6.8	7.2	2.90
Fillets	3	6.44	1.2 X 10^6	7.8	7.0	6.8	3.64
Packaged	5	6.77	6.6 X 10^7	6.5	6.5	7.0	4.78
(4° C)	7	6.66	3.6 X 10^8	5.7	4.3	6.4	3.52
	9	6.63	1.3 X 10^8	2.0	2.0	3.0	3.40
Skinless	1	6.52	4.7 X 10^5	7.8	7.2	7.5	1.85
Fillets	3	6.45	3.5 X 10^6	7.0	6.7	7.2	5.90
Packaged	5	6.83	6.1 X 10^6	7.5	7.0	6.5	2.89
(4° C)	7	6.89	3.9 X 10^6	5.2	3.7	5.3	2.65
	9	6.93	7.4 X 10^7	3.5	2.5	4.0	3.56

1/ Appearance

2/ Calculated as mg malonaldehyde/kg of flesh

3/ Indicate average of three separate sample analyses

4/ 9 = Highest affirmative value
5 = Borderline
1 = Lowest negative value

Table 2 -- Results of the assessment of whole fish and portions of king mackerel stored at 1° and 4° C.

Product Form	Storage Time (days)	Quality Factors					
		pH[3/]	Total Aerobic Plate Count (count/g)[3/]	Organoleptic Scores[4/]			TBA Values (mg MA[2/]/kg)[3/]
				App.[1/]	Odor	Texture	
Whole Fish Iced (1° C)	1	6.37	1.1×10^3	8.0	8.0	7.7	0.16
	3	6.23	1.7×10^3	8.0	8.3	8.2	0.01
	5	6.27	2.0×10^3	8.2	8.2	8.0	0.01
	9	6.27	5.3×10^5	8.2	8.0	7.7	0.04
	12	6.34	1.1×10^5	7.2	6.3	6.5	0.06
	15	6.34	6.8×10^5	6.6	5.4	5.8	0.23
Fish Portions Packaged (4° C)	1	6.01	1.1×10^4	8.0	8.5	8.2	0.10
	3	5.90	2.5×10^3	8.0	7.8	7.8	0.31
	5	5.88	1.6×10^4	8.0	8.2	7.6	0.21
	9	5.91	3.0×10^7	7.7	7.7	7.3	0.26
	12	6.13	7.2×10^6	5.5	3.7	5.8	1.09
	15	6.29	5.7×10^8	4.8	1.6	2.6	1.11

1/ Appearance

2/ Calculated as mg malonaldehyde/kg of flesh

3/ Indicate average of three separate sample analyses

4/ 9 = Highest affirmative value
5 = Borderline
1 = Lowest negative value