Shelf Life Extension of Drawn Whole Atlantic Cod, *Gadus morhua*, and Cod Fillets by Treatment With Potassium Sorbate

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Introduction

Despite attempts to improve handling practices and sanitation, seafoods remain one of our most perishable foodstuffs. The primary limiting factors in the shelf-life of seafoods is the unavoidable contamination by spoilage bacteria during processing, and by their proliferation during storage. The method studied in this work seeks to preserve fish and extend its shelf life by the use of a safe chemical preservative, in this case potassium sorbate (KS) which has been shown to inhibit those bacteria responsible for spoilage odors.

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Sorbic acid and its water soluble salt, potassium sorbate, are classified by the U.S. Food and Drug Administration as GRAS (generally recognized as safe) when used at the lowest level to accomplish its function. Sofos and Busta (1981) have reviewed the use of sorbates as a food perservative in great detail. Debevere and Voets (1972) showed that treatment of Atlantic cod, *Gadus morhua*, fillets with 0.135 or 0.4 percent KS inhibited aerobic bacterial growth, with sorbate being particulary effective in repressing those organisms responsible for formation of trimethylamine (TMA), the compound that produces the typical spoiled fish odor. Chung and Lee (1981, 1982) demonstrated that 1.0 percent KS in English sole, *Parophrys vetulus*, homogenate delayed the onset of logarithmic bacterial growth (or lag phase) to 6 days at 0°C, but did not alter the spoilage flora when the fish was stored aerobically. And, Tomlinson et al. (1978) reported that the addition of 0.2 percent KS to half-strength refrigerated seawater used for holding whole Atlantic cod could extend the sensory shelf life of fillets from the fish by 30 percent.

Besides inhibiting spoilage bacteria, KS has been shown to inhibit foodborne pathogens in seafoods. Robach and Hickey (1978) reported inhibition of three strains of *Vibrio parahaemolyticus* in flounder, *Hippoglossus hippoglossoides*, and blue crab, *Callinectes sapidus*, homogenate by 0.05 percent sorbic acid. Lynch and Potter (1982) demonstrated substantial inhibition of *Staphylococcus aureus* in minced Atlantic cod stored at 7° and 15°C.

Our study was done to determine the effect of a KS dip on the shelf life of commercially filleted Atlantic cod cut from fish 1-5 days post-capture. A secondary goal was to determine the shelf life of fillets cut from drawn Atlantic cod held in chilled seawater containing KS. This procedure simulated processing plant holding of fish over a weekend or for later processing, and could also be applicable to certain fishing vessel holding systems.

ABSTRACT—Potassium sorbate has been used as an antifungal and antimicrobial agent in foods for many years, and has been generally recognized as safe (GRAS) by the U.S. Food and Drug Administration. Since its specific action on bacterial growth or inhibition has not yet been clearly estalished, especially in seafoods, an empirical experiment was conducted wherein fillets cut from Atlantic cod, Gadus morhua, *of known post-capture age (i.e. 1, 3, and 5 days) were dipped in 2.5 and 5.0 percent fresh potassium sorbate, individually packaged in either polyethylene or polyethylenephthalate pouches, iced, and given sensory examinations at 2- to 3-day intervals until the end of acceptable shelf life (when any sensory attribute average at either the raw or cooked evaluation fell below 5.0 (borderline) on a 9-point objective scale). We found that dipping fillets in 2.5 and 5.0 percent potassium sorbate and individually packaging them in plastic film, especially oxygen resistant polyethylenephthalate, was definitely beneficial in extending the iced shelf life of the fillets, in some cases more than doubling it. Dipping in potassium sorbate was effective in retarding trimethylamine formation. Shelf life was not appreciably extended for fillets cut 1, 3, and 5 days post-capture from whole, gutted cod that had been stored in chilled sea water containing 0.5 percent potassium sorbate for 2 days prior to filleting and sensory examination.*

Materials and Methods

Dipping Fish Fillets in Potassium Sorbate

Commercially filleted and skinned Atlantic cod fillets cut from 1-, 3-, and 5-day-old iced fish were used. Each fillet was dipped about 15 seconds in cold, fresh 2.5 or 5.0 percent (w/w) KS solutions (<24 hours old), placed either in 0.75 mil low-density polyethylene or

4.5 mil Scotchpak[1] (polyethylenephthalate) pouches which were securely tied off with wire twine. Control fillets were identically packaged but not dipped. All pouches were then placed in ice and held at 0.5°C. These films were used to determine the influence on shelf life of packaging the fish either in a highly oxygen permeable package (polyethylene) or one very low in oxygen permeability (polyethylenephthalate). One mil polyethylene has an oxygen transmission rate of 500-1,000 cc/100 inches[2] in 24 hours at atmospheric pressure, while 4.5 mil Scotchpak has an oxygen transmission rate of about 5/cc/100 inches[2] in 24 hours (Fitz[2]).

Sensory Evaluation

Raw Fillets

At 2- to 3-day intervals, fillets from each treatment lot (control, 2.5 percent dip, and 5.0 percent dip) were removed from iced storage and presented for evaluation to a 12-member laboratory panel experienced in the evaluation of fishery products. Each sample was evaluated for appearance, odor, and texture on a 9-point objective scale where 9 = excellent, 8 = very good, 7 = good, 6 = fair, 5 = borderline, 4 = slightly poor, 3 = poor, 2 = very poor, and 1 = inedible.

Cooked Fillets

The fillets were then cut into twelve 1.5×1.5-inch squares, placed in foil-covered pans in a double boiler, steamed for 12 minutes, and then served to the panel on coded plates. The samples were evaluated for appearance, odor, flavor, and texture using the same 9-point scale.

The acceptable shelf life of each sample was considered at an end when the average of any sensory attribute such as odor or flavor, either in the raw or cooked tests, fell below 5.0 (borderline). If, for example, an average for a sensory attribute scored below 5.0 on day 16 of storage, and it was acceptable on day 13, its shelf life would be 14-15 days and would be reported as 14.5 for statistical purposes. Each experiment on fillets cut from 1-, 3-, and 5-day-old cod, was repeated three times and the results were averaged.

TMA Analysis

Fillet samples dipped in 2.5 and 5.0 percent KS as well as nondipped controls were sent to the Monsanto Company Food Analysis Laboratory, St. Louis, Mo., for TMA and microbiological analysis. These samples were stored at 2°C. At 3- to 4-day intervals, duplicate samples from each treatment were frozen. At the conclusion of the refrigerated storage period, all frozen samples were analyzed in triplicate for trimethylamine content by gas chromatography. The chromatograph was equipped with a nitrogen-phosphorus selective detector and temperature programmer. The column was 1×2 mm i.d. glass packed with 80/100 Chromosorb 103. (Conditions: Helium, 30 ml/minute; air, 60 ml/minute; hydrogen, 3.5 ml/minute; injection port, 200°C at 16°C/minute; detector, 300°C).

A 10 g sample of fish flesh was homogenized in 20 ml of 6 percent $HClO_4$. The mixture was filtered and 2 ml of filtrate was mixed with 2 ml n-amyl alcohol and 2 ml of 65 percent KOH. This mixture was heated at 60°C for 10 minutes, shaken 5 minutes, then centrifuged at 1,500 rpm for 5 minutes. One microliter of the supernatant was injected into the gas chromatograph, and the area of the peak at the rentention time of TMA was measured. Total aerobic bacterial plate counts were done on each sample taken for trimethylamine analysis.

Holding Drawn Fish in Chilled Seawater With KS

In this section, whole, drawn 4- to 6-pound cod 1, 3, and 5 days postcapture were held for an additional 2 days in 1) chilled sea water (CSW) only, 2) CSW containing 0.5 percent (w/w) of potassium sorbate, 3) fish from the same lot iced down in 100-pound boxes in the normal commercial manner (control). This procedure simulated plant holding conditions where a load of surplus fish caught or delivered on a Friday could be held over for the Monday market, without holding them iced in boxes or in holding pens aboard ship. After 2 days of CSW/KS storage, the fish were transferred to clean wooden boxes with perforated bottoms, reiced, and held at 33-34°F for sensory testing.

Raw Evaluation of Whole Fish

Every 2-3 days, two iced, CSW, and CSW/KS fish were withdrawn from iced storage. Ice and slime were washed off, and they were presented on coded trays for sensory evaluation.

For this assessment, panelists rated the drawn fish for the appearance of the skin, color and condition of the eyes, color of gills and gill mucus, flesh texture, and the odor and color of the gill and visceral cavities. Numerical evaluation was on the same 9-point system.

Raw and Cooked Evaluation of Fillets

Each fish was then filleted and skinned and the raw fillets were presented to the panelists for evaluation of appearance, odor, and texture. The fillets were then steamed as described and presented to the panel for evaluation. Shelf-life end points were determined as in the previous experiment. Each of these studies on whole drawn cod were done twice and the shelf-life end points were averaged.

Results and Discussion

KS Dipped Fillets

Sensory Analysis

Tables 1, 2, and 3 show the shelf life of cod fillets cut from 1-, 3-, and 5-day-old fish, dipped in 2.5 and 5.0 percent KS, and packaged in either 0.75 mil low-density polyethylene or 4.5 mil Scotchpak pouches. Shelf-life end points and their averages are given for each treatment.

The results indicate that dipping these fillets in KS solutions extended their refrigerated shelf life appreciably, in some cases more than doubling it. The fact that shelf life in some cases was much longer than that of fillets of the

[1]Mention of trade names or commercial firms does not imply endorsement by the National Marine Fisheries Service, NOAA.

[2]J. R. Fitz, Kapak Corp., 5305 Parkdale Dr., Minneapolis, MN 55416. Personal commun., 1985.

same age in another experiment cannot be explained, but it may have been due to inadvertent receipt of fillets cut from fish of lower quality—possibly from fish from the bottom of the fish hold or from poorly iced fish. In several cases, low scores from one or two panelists terminated shelf life prematurely.

Shelf life extension of the dipped fillets, especially those individually packaged in Scotchpak, tended to be longer with increasing age of the fish from which they were cut. This may be due to the microbiological protection of the flesh from contamination by the unbroken skin during the 3-5 days of iced storage.

The most effective KS treatment for extending fillet shelf life was a dip in 5 percent KS with individual packaging in 4.5 mil Scotchpak and storage at 33-34°F. At no time did any panelist detect any odor or taste that could be attributable to potassium sorbate.

TMA Analysis

Table 4 shows the results of the TMA analyses for the control and KS-dipped fillets. Potassium sorbate was very effective in retarding TMA formation. This observation is consistent with the results of Debevere and Voets (1972) and their conclusion that sorbate is particularly inhibitory toward seafood "spoilers." Bacterial reduction was not evident in KS-dipped fillets. Counts for the controls and dipped fillets were about the same, although work by Kruk and Lee (1982) with *Escherichia coli*, showed that sorbate was inhibitory toward TMAO reductase activity. The reduction in TMA production is quite apparent in the sensory scores our panelists assigned to fillets treated with sorbate, since TMA is a principle early sensory indicator due to its characteristic spoiled fish odor. Nondipped control fillets were rejected due to strong TMA production. Dipped fillets were finally rejected due to other odors (musty).

Table 1.—Shelf life of cod fillets cut from 1-day-old fish and dipped in potassium sorbate.

Treatment	Packaging	Shelf life (days)[1] Exp. I	Exp. II	Exp. III	Average
Control (no dip)	Polyethylene	9.5	6.0	10.5	8.7
	Scotchpak	9.5	8.5	10.5	9.5
2.5% KS dip	Polyethylene	10.5	9.5	15.0	11.7
	Scotchpak	10.5	15.0	17.5	14.3
5% KS dip	Polyethylene	10.5	15.0	17.5	14.3
	Scotchpak	13.5	19.5	19.0	17.3

[1]To determine shelf life from the day of dipping in KS, deduct 1 day from these figures.

Table 2.—Shelf life of cod fillets cut from 3-day-old fish and dipped in potassium sorbate.

Treatment	Packaging	Shelf life (days)[1] Exp. I	Exp. II	Exp. III	Average
Control (no dip)	Polyethylene	7.5	11.5	12.5	10.5
	Scotchpak	7.5	11.5	14.5	11.2
2.5% KS dip	Polyethylene	15.0	18.5	16.5	16.7
	Scotchpak	15.0	18.5	19.5	17.7
5% KS dip	Polyethylene	15.0	18.5	19.5	17.7
	Scotchpak	15.0	18.5	22.0	18.5

[1]To determine shelf life from the day of dipping in KS, deduct 3 days from these figures.

Table 3.—Shelf life of cod fillets cut from 5-day-old fish and dipped in potassium sorbate.

Treatment	Packaging	Shelf life (days)[1] Exp. I	Exp. II	Exp. III	Average
Control (no dip)	Polyethylene	11.5	13.0	10.5	11.7
	Scotchpak	9.5	13.0	13.0	11.8
2.5% KS dip	Polyethylene	16.5	17.5	17.5	17.2
	Scotchpak	18.5	21.5	17.5	19.2
5% KS dip	Polyethylene	21.5	17.5	17.5	17.2
	Scotchpak	21.5	21.5	17.5	20.2

[1]To determine shelf life from the day of dipping in KS, deduct 5 days from these figures.

Table 4.—Trimethylamine content (ppm) of Atlantic cod fillets dipped in KS and nondipped, (control), and stored in either polyethylene (P) or Scotchpak (S).

Days Storage at 2°C	Nondipped P	Nondipped S	2.5% KS dip P	2.5% KS dip S	5.0% KS dip P	5.0% KS dip S
0	115	144	90	94	110	97
3	73	102	58	58	49	74
7	385	345	65	120	54	117
12	1,450	1,310	78	92	53	71

Table 5.—Shelf life of drawn cod held in CSW with 0.5 percent KS for 2 days and then in ice.

Days boxed and in iced storage	Days held in CSW (control)	Days held in CSW and 0.5% KS	Shelf life of fillets cut from fish held in CSW and 0.5% KS	Total acceptable shelf life for fillets cut from control and treated fish
12	0			11.5
1	2			11.5
1		2.0	10.3	13.3
14	0			13.8
3	2.0			14.3
3		2.0	11.0	16.0
11	0			10.0
5	2.0			8.8
5		2.0	3.0	10.0

Drawn Fish Held in CSW With KS

Table 5 shows the shelf life of whole drawn cod, 1, 3, and 5 days post-capture, held in 0.5 percent KS in CSW for an additional 2 days, then reiced in boxes and stored at 1°C. These fish, both raw and cooked, were compared with conventionally iced fish and with fish held in CSW (controls).

Storage of 1- and 3-day-old fish in 0.5 percent KS in CSW did extend their shelf life over the iced and CSW treated controls, but only slightly. This difference in shelf life does not appear to warrant storage of fish in CSW containing 0.5 percent KS. Possibly storage in

CSW containing more than the percentage of KS used for this work would prove beneficial.

Conclusions

The use of a potassium sorbate dip for Atlantic cod fillets cut from iced fish up to 5 days old was definitely beneficial in extending the shelf life of the packaged fillets, especially those packaged in a relatively oxygen impermeable film like Scotchpak. In some cases, the shelf life of the dipped, iced fillets was more than double that of nondipped controls. Dipping fish fillets in both 2.5 and 5.0 percent potassium sorbate inhibited TMA formation, one of the principle and early indicators of fish spoilage. At no time did the panelists smell or taste the presence of potassium sorbate. This method, therefore, is recommended for commercial use. Holding 1- to 5-day-old fish in CSW containing 0.5 percent KS for 2 days was slightly useful in extending shelf life, but is not considered economically feasible.

Literature Cited

Chung, Y. M., and J. S. Lee. 1981. Inhibition of microbial growth in English sole (*Parophrys vetulus*). J. Food Prot. 44(1):66-68.

_____ and _____ . 1982. Potassium sorbate inhibition of microorganisms isolated from seafood. J. Food Prot. 45(14):1310-1313.

Debevere, J. M., and J. P. Voets. 1972. Influence of some preservatives on the quality of prepacked cod fillets in relation to the oxygen permeability of the film. J. Appl. Bact. 35: 351-356.

Kruk, M., and J. S. Lee. 1982. Inhibition of *Escherichia coli* trimethylamine-N-oxide reductose by food preservatives. J. Food Prot. 45(3): 241-243.

Lynch, D. J., and N. M. Potter. 1982. Effects of potassium sorbate on normal flora and on *Staphyloccus aureus* added to minced cod. J. Food Prot. 45(9):824-828.

Robach, M. C., and C. S. Hickey, 1978. Inhibition of *Vibrio parahaemolyticus* by sorbic acid in crabmeat and flounder homogenates. J. Food Prot. 41(9):699-702.

Sofos, J. N., and F. F. Busta. 1981. Antimicrobial activity of sorbate. J. Food Prot. 44(8):614-622.

Tomlinson, N., S. E. Geiger, G. A. Gibbard, D. T. Smith, B. A. Southcott, and J. W. Boyd. 1978. Improving landed quality of groundfish by modification of refrigerated seawater. Can. Fish. Mar. Serv. Tech. Rep. 783. Vancouver.