The Washing of Fish: A Literature Assessment

By Freda A. Ramey, Joyce A. Taylor, Frank B. Thomas
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A LITERATURE ASSESSMENT

Authors: Freda A. Ramey, Joyce A. Taylor, Frank B. Thomas

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INTRODUCTION

In systematic reviews of the literature concerning the utilization of our seafood resources, we are aware of great blocks of knowledge. There are occasions, however, when we come upon areas that have been lightly addressed or almost overlooked. The washing of fish, its equipment, and related topics constitute one such area.

In 1979, the National Fisheries Institute awarded a scholarship grant to Sea Grant Advisory Services, Department of Food Science, North Carolina State University, to compile and assess the literature for this publication.

It has become evident that fishery technologists have placed much emphasis at times on radiation, chemical, microbial, and antibiotic treatments to control spoilage in fishery products. More often it appears that the basics of handling, washing, and general sanitation procedures have been overlooked.

In the simple procedure of washing of fish, ample evidence has been revealed that practically no evaluation of equipment efficiency has ever been demonstrated. Major fishing countries indicate most fish washing equipment is of local design and construction. Whether or not the equipment is effective or to what degree has never been determined. As technologists in fisheries utilization with training in sanitary engineering and related sciences, we have many areas of concern. A few such concerns relate to construction materials, contact time, water temperature, water reuse or recycling, water pressure, spray pattern and nozzle, if used, water quality, and composition. Those of us preparing this publication have been impressed with the great need for further studies in "the washing of fish."

It has been our intent to examine the available literature on washing of fish as it may relate to quality, shelf-life, equipment used, and generally related areas. The response to inquiries from fishing nations around the world failed to meet our expectations. The voids in our research area are as important to determine as those areas where much knowledge exists. Perhaps the pendulum of fisheries science and seafood utilization should return to the basics of washing and sanitation as compared to some of the more sophisticated technology in which we often find ourselves enmeshed.

Frank B. Thomas, Ph. D.
Extension Professor - Seafoods
THE WASHING OF FISH

1

Personal communication

H. H. Huss
Technological Laboratory, Ministry of Fisheries, Lyngby, Denmark, May 17, 1979

In answer to request for information on the washing of whole fish to reduce surface bacteria, Mr. Huss reports:

"Our results show a very limited effect of washing. Washing of very fresh fish has no effect, while in the case of older fish, washing may remove some of the spoilage flora and thus cause an extension of keeping time."

He indicates that washing therefore has an effect as a general hygienic precaution.

2

The effects of chlorine, washing and evisceration on the microbial population and storage-life of fresh fish

Charles Wade Neal
MS Thesis, Texas A & M University, 64 p., August 1977

None of the chlorine dips tested (free available chlorine concentrations of the test sodium hypochlorite solutions were 47, 157, or 200 ppm) significantly (10% level) reduced the bacterial levels or consistently increased the storage-life of treated fish as compared to control fish (untreated or dipped in water). However, in some cases definite numerical differences in bacterial counts were evident between chlorine treated and control fish, though these differences were not statistically significant.

Spraying trout (Cynoscion nebulosa) with tap water did not significantly reduce the bacterial counts of the fish as compared to untreated fish. However, definite numerical differences were evident. The treatment with chlorine was equally effective in all respects as the water spray. Bacterial counts were more easily reduced with the water spray and chlorine treatment on freshly caught fish than on fish after five days of ice storage. Compared to untreated fish, the water sprayed and chlorine treated samples kept about one day longer in ice storage.
The predominant bacterial genera found on freshly caught trout were: Moraxella-like, Moraxella, Coryneform and Micrococcus species. Moraxella species increased most rapidly during ice storage. Pseudomonas species were not isolated from freshly caught trout but were found in low numbers after 3 and 8 days of ice storage.

3

The effects of antibacterial agents and washing procedures on the bacteriological quality of Gulf fish

C. Neal, C. Vanderzant, and R. Nickelson
Proceedings of the Second Annual Tropical and Subtropical Technological Conference of the Americas, compiled by Ranzell Nickelson II, Texas A & M University, Sea Grant College, pp. 148-164, Oct. 1977

Tests were conducted to determine the effects of various chlorine dips and tap water washing on the storage-life oficed flounder and trout. Total aerobic plate counts and changes in odor and appearance were the criteria used for judging the effects of the treatments. Treatments tested with sodium hypochlorite as the chlorine source were: (I) 200 ppm free available chlorine (FACl), submersion for 5 minutes, water temperature 25°C; (II) 200 ppm FACl, 5 minutes, 25°C, pH brought to 5.5 with acetic acid; (III) 200 ppm FACl, 5 minutes, 55°C; (IV) 200 ppm FACl, 5 minutes, 55°C, pH 5.5; (V) 40 ppm FACl, 1 hour, 3°C; (VI) 157 ppm FACl, 1 hour, 3°C. When compared with nonchlorinated controls, none of these treatments reduced total aerobic plate counts or affected storage life. Washing treatments reduced total aerobic plate counts and extended shelf life several days. Four fresh-caught trout and 4 trout about 5-7 days old were sprayed with a forceful stream of tap water for 1 minute. This spraying treatment reduced the bacterial levels by 1-2 log10 and extended the storage life 2 days relative to untreated fish. The tests showed that more thorough eviscerating and washing of fresh fish extend the storage life and reduce bacterial levels as compared to untreated fish as much or more than a chlorine dip.

4

Effect of chlorinating the washing water on storage of cod and plaice

W. Vyncke
Sta. de Peche Maritime, Ostende, Belgium, Revue de L'Agriculture, 30(3):743-747, 1977
The addition of 50 ppm available Cl to the water used for washing cod and plaice for 1 minute in a rotary washing machine did not improve the shelf life of the fish, as shown by sensory, chemical and microbiological evaluation.

5
Effect of washing on the storage life of plaice

W. Vyncke
Sta. de Peche Maritime, Ostende, Belgium, Revue de L'Agriculture, 30(4):1031-1036, 1977

A rotary washing machine was used in trials on plaice. While bacterial load was reduced by greater than 99% and shelf life extended by 1 or 2 days, washing enhanced grey discoloration of the dark side of the fish. No difference was noted between 0.5, 1 or 2 minutes washing. Washing was recommended only before filleting or dressing (beheading, removal of fins and tail, portioning) the fish.

6
Bacteriological evaluation of snapper (Chrysophrys auratus) at the time of unloading off New Zealand fishing boats

N. S. Boyd and N. D. C. Wilson
New Zealand Journal of Science 19:205-208, 1976

The surface bacteria on snapper (Chrysophrys auratus Förster) caught over an 8 month period were counted at the time of unloading off the catching vessels. It was found that these counts had no correlation with the organoleptic quality of the fish.

Surface counts can be considerably reduced by efficient washing. With fish of grade 6 (the quality grading of most of the fish landed) or better, the surface count was reduced to less than $10^3$/cm$^2$ by efficient washing, and the fillets produced from this fish also contained less than $10^3$/g. However, with fish of grade 5 or less the total count on the surface after washing was greater than $10^3$/cm$^2$ and the fillets produced had counts greater than $10^4$/g.

Efficient washing removed all the staphylococcus and coliform organisms from the surface of the fish. However, staphylococcal bacteria were found to have become established in the flesh of the poorer quality fish and thus could not be removed by washing.
Influence of washing on the shelf-life of cod

W. Vyncke
Min. de l'Agriculture, Commission pour la Recherche Sci.,

The effects of further washing eviscerated washed cod by means of a rotary washing machine, a flushing system with basket and water tank, and a spraying system with nozzle were evaluated by determination of total volatile basic N, Trimethylamine, total volatile acids, Hypoxanthine, total bacterial count (surface and flesh), and by organoleptic tests. Results are shown graphically. The rotary washing machine reduced surface bacterial count by 97.3% (1 minute) and 98.4% (2 minutes) and increased shelf-life by 1-2 days, which is negligible in practice. It was concluded that washing was useful only before filleting or dressing the fish (removal of head, fins, and tail, portioning).

Turbidimetric determination of the efficiency of fish washing machines

W. Vyncke

The use of turbidimetry for evaluating the efficiency of fish-washing machines was studied. Three systems for washing of cod were tested: (i) a rotary washer; (ii) a flushing system with a perforated basket; and (iii) a spray installation. Turbidimetric measurements were reproducible, especially with (i) and (ii). Turbidimetric studies clearly showed (i) to be the most efficient, followed by (ii) and (iii) in order of decreasing efficiency. With all 3 systems, the greatest washing effect was achieved in the first minute; prolonged washing increased losses and caused skin lesions. Total bacterial counts of the fish skin were similar for (i), (ii) and (iii); counts were reduced by 90-97% after 0.5 minute, 94-98% after 1 minute and 97-99% after 2 minutes. It is concluded that turbidimetry is a suitable method for evaluation of the efficiency of fish-washing procedures.
Effects of washing freshwater fish on keeping quality

D. C. Gillespie and Kurosh Ostovar

Slimes from northern pike (Esox lucius), walleye (Stizostedion vitreum vitreum), lake whitefish (Coregonus clupeaformis), yellow perch (Perca flavescens), and channel catfish (Ictalurus punctatus) were found to be good bacteriological media and supported growth of $10^9$-$10^{10}$ organisms per gram. The effects of washing fish on keeping quality as judged by bacterial count and organoleptic scoring were examined. Undressed, unwashed fish stored at 3°C became inedible after several days (less than 8) even though the flesh contained few bacteria. Two fish washed for 5 minutes under cold-water jets showed 100-fofold lower counts than similar unwashed fish. This method of washing removed only loose slime and did not achieve thorough cleaning. The flesh from the washed fish after 11 days' storage produced no colonies after plating, yet it had a pronounced spoiled odor.

Diffusion of metabolic products from bacterial growth on the slime produced strong odors and flavors in the flesh.

It is recommended that the fish be washed in order to improve keeping quality. Thorough washing could probably reduce coliform organisms to an undetectable level.

The less attractive or less familiar appearance of washed fish in the first few days of iced storage may lead to rejection or downgrading of these fish for the fresh fish market; however, the increased storage life should compensate for this.

Specific problems in the quality assessment of freshwater fish

E. G. Bligh
In Fish Inspection and Quality Control, Rudolf Kreuzer, ed., FAO, Fishing News (Books) Ltd., pp. 81-85, 1971

The effect of washing on bacterial and organoleptic quality of commercial whitefish (Coregonus clupeaformis) was studied in conjunction with the Department of Fisheries and Forestry
Inspection Laboratory. Washing is not standard procedure in the Canadian freshwater fish industry. The results showed a constantly lower count in washed than unwashed fish when both were stored for 8 days at 3°C (37°F). Organoleptic grading of both series of fish over the same period showed that for the first 2 days the unwashed scored somewhat higher than the washed fish. This was probably due to differences in appearance. From 3 to 8 days the washed fish scored higher than the unwashed fish with a constantly increasing spread between the two groups. Further studies in the laboratory on pike (Esox lucius), yellow perch (Perca flavescens), and walleye (Stizostedion vitreum) demonstrated that freshwater fish slime is an excellent medium for bacterial growth. Even at 3°C (37°F), slime samples showed a 10-fold increase in numbers of bacteria after 2 days and increased more slowly thereafter until counts approached 10^{10}/g after 6 days. At no time during these tests did flesh counts exceed 500 organisms/g. However, at longer storage times the fish flesh had a pronounced acrid-putrid odor showing that while bacteria do not readily penetrate unbroken fish skin, their products of metabolism are able to diffuse through to produce an unpalatable product. In the white fish washing experiment, all fish were positive for coliforms though the most probable number was higher in unwashed fish.

Cleaning of fish with surface active agents

T. Haraguchi and M. Iimori

The effect of cleaning jack mackerel (Trachurus trachurus) with different surface active agents, such as sodium alkylbenzene sulphonate (SAS), sucrose fatty acid ester (SE), and polyoxyethylene fatty alcohol (C_{16-18} ether (PEFA)) was examined. The surface active agents were dissolved in phosphate-citric acid buffer of different pH values. Treating the fish with FSTA and SAS at pH 5.0 resulted in a clean surface appearance and the removal of unpleasant fishy odors. Skin surface treated with SAS turned buff in color within 1-2 days after cleaning. Viable bacterial counts on the skin surface decreased to 1/100-1/1000 after cleaning with PEFA solution at pH 5.0. No other surface active agents tested showed similar effect.
Bacteria counts on cod and flounder fillets produced commercially from fish frozen at sea and thawed in water

M. J. Hayward and W. A. MacCallum
Journal of the Fisheries Research Board of Canada 26(12): 3217-3231, 1969

Fillets of flounder and cod produced from uncut fish which had been frozen in blocks at sea were found to contain fewer coliform bacteria than those produced from fish iced at sea. In processing blocks it is practical to thaw in an immersion thawer with only infrequent changes of the thawing water. The effect of this process on the bacterial counts on the fish was examined. The results show that efficient washing of the thawed fish before further treatment is necessary to maintain low counts. The bacterial counts in the thawing water were no indication of those on the washed fish. Experimental details are given and the results are tabulated.

Handling of fresh fish

F. Bramsnaes

Keeping quality of fish--handling fish at sea--fish hold outfitting--methods and rates of cooling--handling fish on shore--fish fillets.

Washing machines on board commercial vessels provide a more even flow of fish coming down into the hold, consequently allowing more time for carefully stowing and icing than previously, when the fish were apt to come below in large batches.

Factors influencing the effectiveness of fresh fish washing operations

W. A. MacCallum, M. W. Mullan and Isabel N. Plaunt

The effects of ratio of the amount of fish to that of wash water, kinetic energy of impinging water, method of water application and concentration of available chlorine in the
wash water on the washing of eviscerated fresh cod of
various caught-ages were studied. The studies were
designed to provide information of practical value to
engineers interested in designing machines to wash slime
and bacteria from fish received at filleting plants. A
quantitative relation between kinetic energy of impinging
wash water and fish to water ratio was established for
one practical type of spray washing equipment. Effective
spraying was found to be more efficient than fluming or
dipping. However, fish dipped several times in water
deposited less bacterial load on a clean surface than
fish washed effectively on the skin side only by a jet
of water. Thus, washing out the body cavity was found
to be important. Caught-age was found to influence the
results only for washing methods of relatively low effec-
tiveness, namely in fluming and in washing inefficiently
with a jet or spray of water. Ineffective spray washing
was shown to be associated with waste of equipment and
high costs while serving no useful production purpose.
Highly effective methods of spray washing fish of all
cought-ages were shown to be suitable for efficient appli-
cation in fish filleting and skinning lines. Free chloro-
line concentrations as high as 100 ppm in the wash water
did not increase washing effectiveness as measured by a
bacteriological method.

15
Changes in the skin flora of cod after washing and icing

D. L. Georgala

Bacterial counts done on the skin of North Sea cod show
that while washing with running sea water greatly reduced
the numbers on newly caught fish, contact with ice from
a trawler's ice bunker resulted in an immediate large
increase on the washed fish. Washing did not materially
alter the percentage representation of the various genera
present, but icing with trawler bunker ice could cause
major alterations and often added types of bacteria simi-
lar to those present on newly caught fish, indicating con-
tamination of the ice on board the trawler. The experiment-
tal lots of fish were gutted within a few minutes and
each fish washed, by hosing with sea water, for approxi-
mately 15 seconds.
Quantitative and qualitative aspects of the skin flora of North Sea cod and effect thereon of handling on ship and on shore

D. L. Georgala
Ph.D Thesis, Aberdeen University, Aberdeen, Scotland, 1957

After filleting, the average skin counts were $10^{3.6} \ (37^\circ C)$, $10^{5.0} \ (20^\circ C)$, and $10^{4.7} \ (0^\circ C)$ per cm$^2$ and were generally somewhat higher than the averages for the whole fish after washing, which were $10^{2.8} \ (37^\circ C)$, $10^{4.6} \ (20^\circ C)$, and $10^{4.2} \ (0^\circ C)$, respectively. Immediately after the first fillet-knife incision the count increased enormously. The subsequent increases are obviously the result of contact with the filleting benches, which, it is generally conceded, are the most important source of fillet contamination. The results of the examination of possible sources of contamination revealed that the filleting bench is the greatest single source of contamination.

Comparison of careful filleting done in the laboratory with commercial practice showed that the former always resulted in lower loads. Subsequent examination of normal commercial samples showed that in general the counts at $37^\circ C$, $20^\circ C$, and $0^\circ C$ ranged between $10^4$ to $10^5$ per cm$^2$ surface, with no differences between the loads on the surfaces next the skin or backbone.


Quantitative and qualitative aspects of the skin flora of North Sea cod and effect thereon of handling on ship and on shore

D. L. Georgala
Ph.D. Thesis, Aberdeen University, Aberdeen, Scotland, 1957

Sampling at numerous points along filleting lines at various times of the year showed that thorough washing of the fish on arrival can greatly reduce the bacterial population, though in factories where the washing was perfunctory this could actually increase the bacterial load. After filleting, the average counts on the skin were $10^{3.6}$
Flora of cod and the effect of handling

R. Spencer
Great Britain Dept. of Scientific and Industrial Research,
Report of the Food Investigation Board, pp. 20-21, 1956

1957, Unpublished data, Humber Laboratory, Hull, England

Spencer found that in 12 samples of water taken from commercial washing troughs where water was only occasionally running through the fish, the average counts were $5.0 \times 10^3$ and $2.2 \times 10^6$ per milliliter at $37^\circ C$ and $20^\circ C$ respectively, whereas with continuously running water the corresponding counts were $1.9 \times 10^3$ and $4.2 \times 10^5$. Such washing, on the average, reduced the load on the surfaces of marked fish by 75 to 80%, with intermittent running water, and by 90% in running water. Mechanical jet washing, on the other hand, reduced the load on the average by 95%, but it could be as low as 40%. With careful hand-washing, a 99% reduction could easily be attained.


Spoilage of fish in the vessels at sea: 2. Treatment on the deck and in the hold


A study has been made of some of the factors affecting the spoilage rate of fish in the trawlers at sea. It was found that two conditions were major causes of accelerated spoilage: (1) Treatments that resulted in heavy initial contamination such as storing the fish directly against the slimy wooden pen boards, and (2) Treatments
that resulted in a rise in the temperature of the fish. This latter may be a larger increase in temperature for a short period, such as exposure of the fish on the deck during warm summer weather, or a smaller increase over a longer period, such as results from inadequate or inefficient icing.

Because of the possibility that washing might actually be the means of grossly contaminating the gut cavity, experiments were carried out in which the fish were washed before gutting and compared to fish washed in the usual manner, and to others not washed at all. They showed no significant differences as the result of the treatment given.

The results of further experiments were not always the same. In some tests the unwashed fish were less uniform in quality than those which had been washed. This was particularly noticeable in regard to the development of surface slime. In other tests the fish washed before gutting kept longer than those washed after gutting. In others there was no apparent difference in the spoilage rate of washed and unwashed fish, or whether they were washed before or after gutting. In no instance did the effect of washing or not washing, or washing before or after gutting, become apparent before 6 days in stowage; more frequently it was not until after 7 or 8 days.

The effect of washing and of cleanliness of boxes


Equivocal results of washing, i.e., that it reduced the surface bacterial count but could increase it, were obtained. The washing process was carried out in tanks and not by hosing each fish.


Improving the effectiveness of nitrite dips

C. H. Castell
Progress Reports Fisheries Research Board of Canada, Atlantic Coast Stations, No. 56, July 1953
Generally speaking, there are three important factors that determine the effectiveness of preservatives:
(1) the strength or concentration of the solution used,
(2) the number of bacteria on the fish, (3) the degree of acidity or alkalinity in the fish.

In this experiment, the following results were obtained:

(1) Washing the fish before cutting increased the keeping time by two days stored at 36°-37°F.
(2) Nitrite, without washing, increased the keeping time by four days with a 0.2% solution, and five or six days with a 0.4% solution.
(3) Nitrite and washing together added eight days when a 0.2% solution was used, and ten to twelve days when a 0.4% solution was used.

Reduction of bacterial contamination on fillets by washing the round fish and by the use of mechanical skinners

C. H. Castell
Progress Reports Fisheries Research Board of Canada, Atlantic Coast Stations, No. 56, pp. 10-14, July 1953

Except in old fish, the muscle itself or the uncut fillet is almost free from bacteria before it is removed from the fish. In spite of this, fillets leave the cutting table heavily contaminated with spoilage bacteria, most of which come into the plant on the surface of the round fish. During cutting, the bacteria are transferred from the slimy outside of the fish to the cutting table to the fillets.

Surface slime can be removed by scrubbing and washing; most bacteria will go with the slime. Those that remain are more easily destroyed because they are no longer embedded in the protective slime.

Washing fish before filleting reduces bacterial count on the fillets from 80-99% or more and will add 1-6 days to the keeping time, stored at 32-33°F.

Almost the same result can be obtained by using a machine skinner that cuts down the gross contamination occurring when fish are skinned by hand.
Relative importance of the factors causing spoilage of fish in boats at sea

C. H. Castell and W. A. MacCallum
Progress Reports Fisheries Research Board of Canada, Atlantic Coast Stations, No. 55, pp. 17-23, March 1953

Among the tests conducted was the study of the effect of washing fish at sea. In one experiment, different lots were 1) washed before being gutted, 2) gutted and unwashed, 3) washed in the usual manner (after gutting), and 4) washed and then dipped for 20 seconds in disinfectant containing approximately 1,000 ppm available chlorine. Fillets from these lots were tested for bacterial count, pH and trimethylamine values and found to have no difference in color, texture or odor. Results showed that, if anything, fish that were washed and dipped in the disinfectant appeared to be the poorest.

In another experiment, similar lots of haddock were washed and not washed before being iced down in large boxes. Fillets from these fish yielded the following figures:

<table>
<thead>
<tr>
<th></th>
<th>Bacterial Count</th>
<th>T.M.A.</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not Washed</td>
<td>600,000</td>
<td>0.9</td>
<td>6.6</td>
</tr>
<tr>
<td>Washed</td>
<td>180,000</td>
<td>0.5</td>
<td>6.5</td>
</tr>
</tbody>
</table>

Results indicating the benefit of washing the fish at sea were never consistent. However, fish that were not washed, but were well iced and otherwise handled carefully, did not show any marked deterioration compared with the washed fish.

The effect of mechanical washing of fish on the keeping quality of fillets prepared from them

H. L. A. Tarr and A. W. Lantz
Progress Reports Fisheries Research Board of Canada, Pacific Coast Stations, No. 81, pp. 80-83, December 1949

Work at this station demonstrated the desirability of using a mechanical device for washing fish prior to filleting them and showed that such a procedure markedly reduced the initial bacterial count and consequently improved the keeping quality of the fish.
In the present work, a machine originally developed as a flesh and bone separator was modified for washing fish prior to filleting. In place of the circular drum, a three- to six-sided drum of easily cleaned, non-corrosive 1/2- or 1-inch mesh screen from heavy-gauge metal was used. While the three-sided screen proved satisfactory as a washer for small fish it was not suitable for the larger species since the fish became wedged in the angles of the drum. The six-sided screen appears to be generally practicable. The secret of the screen’s effectiveness as a washer is immersion of the lower part of the drum during rotation in a tank of continually changing water.

Tests also indicated that fish slime becomes more viscous in such solutions as diluted alkaline phosphate, thereby preventing much facilitation of washing. Mildly acidic solutions coagulated the slime.

Experiments examining the effect of washing fish mechanically on the keeping quality of fillets indicated the superior keeping quality of fillets prepared from washed fish. The keeping quality was not improved to an important extent when an acid phosphate-sodium nitrite solution was used instead of water. In general, organoleptic spoilage became evident very much earlier in the unwashed than in the washed fillets.

The control of fillet contamination in fish plants: Part I-A survey of present conditions

C. H. Castell
Progress Reports Fisheries Research Board of Canada, Atlantic Coast Stations, No. 39, pp. 3-7, July 1947

In plants where the fish were not washed prior to filleting there was a direct relationship between the bacterial count and the number of days the fish had been out of water. But this was not the case in plants where the fish were transported through the plant by means of running water or where the fish were washed off immediately prior to filleting. Under these conditions, fillets cut from fish that were stored for more than 4 days had a marked decrease in bacteria.
26
Mikrobiologische Untersuchungen an See und Susserwasser-
fischen. II Mitteilung

W. Schwartz and Th. Zeiser
Arch. Mikrobiol. 10, p. 321, 1939

The investigators found that hosing with water reduced
the surface bacterial count of fish by 90-99%. However,
the fish they used were often spoiling when they reached
the laboratory; Georgala suggests that this might have
influenced the effect of subsequent washing.

[Reviewed by D. L. Georgala in Changes in the skin flora
of cod after washing and icing, Journal of Applied Bacteri-

27
Mikrobiologische Untersuchungen an Seefischchen

Fr. Lücke and W. Schwartz
Arch. Mikrobiol. 8, p. 207, 1937

The investigators reported that washing, as carried out
under normal commercial conditions, often reduced the
surface bacterial count but could increase it. The wash-
ing process was carried out in tanks and not by hosing
each fish.

[Reviewed by D. L. Georgala in Changes in the skin flora
of cod after washing and icing, Journal of Applied Bacteri-
EQUIPMENT FOR WASHING OF FISH

28
ABC0 Fish Processing Equipment, Atlantic Bridge Company Ltd., Lunenburg, Nova Scotia, Canada BOJ 2CO.

Dip and wash tanks, washing and de-icing drums, equipment for roundfish washing.

29
Arenco AB, Box 2041, S-421 02V. Frolunda 2, Sweden.

Arenco-KM. Washing and Scaling Machine STF.

Arenco-KM. Washing and Scaling Machine C1C. Primarily suited to all types of shoalfish and white fish of the more easily scaled type.

30
Baader-

Baader 670-Raw fish washing machine. Suitable for washing almost all types of fish, gutted and ungutted.

Baader 679-Fish washing machine. Same basic design as 676. For washing of round herring and similar fish the drum diameter has been increased.

Baader 677-Washing machine for flat fish.

Baader 676-Washing, de-bleeding and brining drum.

Baader 666-Fish washing machine. Suitable for washing herring and other fish measuring up to 70 cms in length.

Baader 653-Herring washing machine. Suitable for eel, also.

31
Key Equipment Co., P.O. Box 6, Milton-Freewater, Oregon 97862

Barrel Washer

32
Kusano Machine Company. 4-3, Nakanoshima, Shiogama City, Miyagi Prefecture.

Fish Scale Removing and Washing Machine of Eviscerated Fish.
33
Intel Engineers. Balmoral Works, Balmoral Road, Aberdeen
AB9 2LZ, Scotland.

Automatic fish washing machines. Two standard units, capacity
3.04 tons and 10.1 tons per hour.

34
Mechanized processing of fish aboard ships and ashore

J. Drews
Nordischer Maschinenbau Rud. Baader, Lubeck, Federal Republic
of Germany, Allgemeine Fischwirtschaftszeitung 28(1):46-48,
50-51, 1976

A description is given of available equipment for sorting,
washing, nobbing, eviscerating, beheading, skinning, filleting,
etc. of herrings and similar fish, flat fish, white
fish, and redfishes. Mechanical meat/bone separators are
also considered.

35
Mechanized line on boats for fishing and processing of cuttle-
fish

L. M. Popov
Dal'Tekhrybprom, USSR, Rybnoe Khozyaistvo, No. 9, pp. 62-63,
1975

The design and principles of operation of a cuttle-fish
fishing and processing line used on boats are described.
The line includes automatic fishing equipment, cuttle-
fish cutting device, washing machine, draining barrel,
troughs and conveyors. The processed cuttle-fish is
frozen. Characteristics of all parts of the line are
presented. The daily output of the line is 10 T, sea
water consumption is 30 M³/H and electric power consump-
tion 7 KW.

36
Equipment of fish processing plants

V. W. Chupakhin
Moscow, USSR: Pishchevaya Promyshlennost, 320 p., 1974

The 2nd edition of this book differs considerably from the
1st edition published in 1968. Description of old and
obsolete equipment has been left out and replaced by the
description of up-to-date machines and equipment manufac-
Mechanised fish processing aboard ship and ashore

J. Drews

Mechanization of fish processing is discussed, with reference to equipment for grading, washing, heading, filleting, skinning and splitting of herrings and similar species (sardines, pilchards, sprats, small mackerel), white fish, redfishes and flatfish. Aspects to be considered in selection of combinations of equipment for processing lines are discussed, including type of fish, size range of fish, capital cost and labor costs, space available, desired hourly capacity, and type of end product to be produced. Equipment for separation of flesh from fish frames, small fish or bony species of fish is also discussed.

Catalogue of machinery, equipment and apparatus produced by factories of the Ministry of Fisheries of the USSR


This illustrated catalogue lists technical information and 1967 prices of the following categories of fish-handling machinery, equipment and apparatus produced by factories of the USSR Ministry of Fisheries: washing machines; machines for preliminary treatment of fish and crabs and defrosting of fish; canning equipment; fish-salting machinery; heat exchangers and sterilizers; smokehouse equipment; sorting and packaging equipment; fish-pumping equipment; ancillary equipment; ice-making machines; transportation equipment; implements and stamping machines; ship's equipment (compressors, pumps, blocks,
various mechanical implements); industrial equipment (net-handling and emptying machinery, winches, and other equipment); net-making machinery; electric fish-stunning and fishing equipment.

New fish washing machine developed (Baader 670)

Commercial Fisheries Review, May 1969, p. 42 or Fishing News, March 14

"West Germany" by Baader of Lubeck. The machine is suitable for both gutted and whole fish; it is compact and practicable for aboard ship installation. It is described as a hexagonal drum-shell-type machine with an incorporated worm 6 inches high and turning rails; centrally mounted water pipe washes the fish during its run through the machine. Dirty water discharged through gill-shaped openings in drum shell runs to a water-collecting tray under drum and drains off through outlet pipe.

The drum fitted between two synthetic spur rings, is supported by plastic rollers. Drive for the drum is provided by a combined spur and gear rim.

Size of the machine: 144 inches long, 47 inches wide, 57 inches high. The 38-inch diameter drum is about 118 inches long.

The machine's output is approximately 5,000-6,000 kg per hour.

Production line for dressing fish


USSR Patent, 1969, 246 795

To ensure automatic dressing of the fish, e.g. bass, the production line (consisting of loading bin, inspecting device, washing machine, and inclined scraper/conveyor) is equipped with a dressing machine slited at the bottom of a side wall of the loading bin. The bin is fitted with longitudinal blades between the arms of the conveyor along the whole of the washing zone. A transporter for bringing the fish to the inspection zone is situated directly under the loading bin.
Equipment for fish processing plants

V. M. Chupakhin
Moscow, Pishchevaya Promyshlennost, 346 p., 1968

This book, intended for technical personnel working in the fish processing industry, covers basic equipment used in fish processing plants. Lists equipment for materials handling, conveyors, elevators, cranes, washing machines, containers, sorting machines, fish de-sliming and de-scaling machines, machines for cutting off fins and heads and for evisceration, portioning machines, multipurpose machines for treatment of fish meat as pressing, dosing and filling. Lists equipment for heat processing of fish: grilling, frying, boiling, sterilizing, autoclaving, and continuous sterilization of fish tins. Equipment for batch or continuous smoking of fish, for processing fish oil and fish meal. Lists mechanized and automated production lines for the fish industry and for packaging finished products.

Equipment in fish processing factories

V. M. Chupakhin
Moscow: Pishchevaya Promyshlennost, 3rd edition revised, 648 p., 1968

This book is intended primarily for students of food colleges and for the technical and research staff of relevant factories and research institutes. The subject is in 11 chapters, as follows; Equipment for Unloading and Transporting Fish and Fish Products; Fish Washing Machines; Fish Handling Machines; Portioning and Container Filling Machines; Can Sealing Machines; Chopping, Mixing and Pressing Machines; Heat Treatment Installations; Drying and Smoking Installations; Fish Oil and Fish Meal Installations; Continuous Mechanized Lines; and Machines for Labelling, Packing, and Other Purposes. Numerous diagrams and illustrations are included, but there is no subject index.

Process and apparatus for treatment of fish

This machine washes, drains and rinses the fish automatically. The fish do not come into contact with moving parts and are, therefore, undamaged.

Handling and preparation of fishery products—washing and scaling


The industrial development unit of the White Fish Authority has developed a fish-washer for use on board trawlers. The initial development was done on boats operating out of Granton on fishing boats which box the catch at sea and all gutting and sorting is done in the deck prior to washing. This equipment has been in operation on one vessel for a year and several other ships may be similarly fitted.

The washer consists of a rectangular tank containing two nylon-covered wire baskets. Down the long sides of the tank are two perforated spray tubes, so arranged that the jets of water play on to the baskets. Due to the motion of the ship, a sluicing action is given to the mass of water.

Spill ports are cut out on the opposite side of the tank to that of the spray pipes. They serve to get rid of dirty water and control the level.

The method of operation is to tip small baskets of sorted and gutted fish into one of the baskets in the washer and allow the surging and spray action to wash the fish. After washing, the fish are tipped into a second small basket for handling into the fishrooms. By alternating the baskets a steady work flow can be maintained. A longer washer could accommodate more than two baskets.

Mechanically deicing and weighing groundfish at the dock in New England

John A. Peters, Joseph W. Slavin, and Arvey H. Linda

Better methods of handling groundfish, both on the vessel and at the dock, are needed to increase the efficiency of
operations and to improve the quality of product. This paper reports on the design of five mobile fish de-icing and weighing units to improve the handling of groundfish at the dock as the fish are unloaded from the trawler. Information is included on the fabrication of two of these units and their subsequent testing under conditions of commercial operation.

46
Experimental mobile de-icing, washing, and weighing unit for unloading fish from vessels

Joseph W. Slavin

[also in Fishing Gazette 74(10):52,55.]

The design of an experimental mobile fish de-icing, washing, and weighing unit for unloading groundfish from a fishing vessel in New England is described. The experimental unit consists of a wooden unloading platform, a receiving hopper, a combination de-icer and washer, a conveyor, a weighing hopper, and a scale—all mounted on a steel frame supported on wheels.

The combination de-icer and washer consists of a rotating screen 8 ft. in length and 3 ft. in diameter. The screen is made of 3/16-inch diameter wire mesh, suitably reinforced, with openings 1 3/4 inches square. Water, flowing through a 1 1/2-inch diameter pipe perforated along the bottom and located within the upper half of the rotating cylindrical screen, provides for the washing of the fish. Power for the rotation of the screen is provided by a 2 h.p. electric motor.

47
Apparatus for fish rinsing

Fishermen's Bulletin, Sea Fisheries Research Station, No. 9, p. 38, September 1956

A fish rinsing machine has been developed and put into production by the Haifa Harbor Workshops of the Fishermen's Union, Israel. The new machine consists of a cylindrical container pivoting on an axle. The container is made of galvanized wire netting and is 71 cm (28 in.) long and 35 cm (13 3/4 in.) in diameter. The axle is
made of a 19 mm (3/4 in.) galvanized steel pipe, which is perforated by many small holes and is easily connected to the deck water pipe. The water entering the pipe is then forced out through the holes and thus sprays and rinses the fish in the container. Only one operator is needed to feed the container with fish, rotate it by means of a handle and empty it into the boxes. The fish are cleaner, work is faster and takes less effort than the old, primitive methods which required 2 to 3 men. The first fish rinsing machine was installed aboard the f.v. Dror, and having proven successful, was then introduced to most of the Israeli trawlers.

48
A new automatic salt fish washer

W. A. MacCallum
Progress Reports Fisheries Research Board of Canada, Atlantic Coast Stations, No. 62, pp. 38-41, July 1955

Counter-rotating brushes and a pre-washing soaking conveyor belt allow effective scrubbing of fish on both sides under a spray of water. Capabilities of the washer: 30,000 lb. soaked and washed in 8 hours.

49
A salt fish washer


A salt fish washer designed in 1953 and developed fully in 1954 is being tested under commercial conditions. Until Nov. 1954, it had washed about 2,500,000 lb. (1,134 tons) of wet salt fish, 95% of which was out of kench. The production of various sizes of fish was as follows: small, 55%; medium, 25%; large, 15%; extra large, 5%. In washing efficiency and in its treatment of the fish, the machine appears to be successful. It also seems to be a practical mechanical device, appearing to have (1) a good life expectancy, (2) few maintenance requirements, and (3) capability of being fitted into salt fish handling operations conveniently. The machine eliminates hand-soaking and hand-washing, while increasing plant production, thus freeing labor for other tasks. The following production figures and other pertinent data are presented: power requirements: less than 4 h.p. of electrical energy; water requirements: 25-30 gal./min.
(113.7 to 136.4 l) at about 5 lb./sq. in. (0.35 kg/cm²) gauge pressure; production rate for medium-sized heavily salted fish: 4,000 lb./man hr. (1,814 kg) with one man feeding the machine.

Andrews washer


A revised model of the Andrews' washer constructed for trial operation in Canada, performed well and has cut the cost of the hand-washing of the previous season by about two-thirds. The fish is placed nape first, skin side up, on an inclined conveyor belt 18 in. (45.7 cm) wide which travels under 2 sprays, and 2 cylindrical revolving brushes. It falls from this belt onto a second one--face up--and under sprays and brushes as on the first belt. It has washed heavily salted fish at the following rates during production: small fish (12 to 18 in. or 30.5 to 45.7 cm)--2,694 lb./hr. (1,222 kg/hr.); medium sized fish (18 to 23 in. or 45.7 to 58.4 cm)--4,494 lb./hr. (2,039 kg/hr.); large (above 23 in.)--7,120 lb./hr. (3,230 kg/hr.). The rate for lightly salted fish is much the same. However, the surface of lightly salted fish is merely sprayed as brushing tends to roughen it. It may be seen from the above figures that small fish are far more costly to work; this is true throughout the production picture--from splitting to packing. It is felt that this washer can be further modified to make it a more compact and efficient machine. The machine can be decreased in length, improved mechanically and made more readily mobile so that it can be moved to the fish to be washed.
51
Quality assessment of fresh fish and the role of the naturally occurring microflora

Roy E. Martin, Rodney J. H. Gray, and Merle D. Pierson
Food Technology 32(5):188-192, 1978

Review article covering fish spoilage and methods for assessing degree of spoilage, including trimethylamine and dimethylamine assays; nucleotide assays-dephosphorylation of inosine 5-monophosphate (IMP), formation of hypoxanthine; and microbial assays. Extensive list of references.

52
Stowage of fish in chilled sea water

J. H. Kelman
Torry Advisory Note No. 73, Ministry of Agriculture, Fisheries and Food, Torry Research Station, 10 p., 1977

The design and operation of suitable chilled sea water systems on board the catching vessel are briefly described. Advantages of stowage in CSW over stowage in ice include cooling the catch more rapidly, requiring less effort to stow and unload it, providing less likelihood of fish being crushed or losing weight, being able to safely lower the temperature of the sea water to about -1°C without freezing the fish contained in it. Other advantages are effective washing and bleeding, and a tendency to firm the flesh of the fish. Since some species keep as well or a little better than in ice for 3-4 days, but thereafter spoil more quickly, and since some species take up unacceptable amounts of water and salt when kept in sea water, the method of stowage in CSW is usually confined to short term storage of particular species caught in large quantities within a short time.

53
Deteriorative changes during frozen storage in fillets and minced flesh of silver hake (Merluccius bilinearis) processed from round fish held in ice and refrigerated sea water

D. F. Hiltz, B. S. Lall, D. W. Lemon, and W. J. Dyer
During frozen storage at -10°C, deterioration in the muscle of silver hake (Merluccius bilinearis) was marked by rapid and extensive production of dimethylamine, concomitant decrease in extractable protein and by lipid hydrolysis. Evidence of lipid oxidation in this gadoid species of relatively high fat content (2-4%) was also obtained. Holding round fish for up to 6 days in refrigerated sea water (RSW) at 0-1°C before processing extended the frozen storage life of fillets at -10°C by 2-3 weeks and of minced flesh by 1 week over that for comparable material prepared from round fish held in ice. In all silver hake materials, negligible deterioration occurred during frozen storage at -26°C for up to 6 months. During pre-processing storage of round silver hake in RSW, a firm texture and acceptable appearance were retained for several days longer than in round fish held in ice, where objectionable softening of the flesh occurred, particularly in summer-caught fish. Saturation of the sea water with CO₂ retarded the onset of bacterial spoilage in RSW-held fish, which otherwise developed more rapidly than in iced fish.

54

Control of fish quality

J. J. Connell

Contents include: Intrinsic quality; quality deterioration and extrinsic quality defects in raw material; quality deterioration and defects in products; methods of assessing and selecting for quality; organization of quality control and official inspection; standards; and codes of practice.

States that the numbers of microorganisms can be reduced to a small percentage of those originally present in many cases by washing with cold water the surface of the fish free of slime, debris, gut fragments and faeces. Also, in discussing the use of refrigerated sea water, states that among its advantages are effective washing, descaling and (in the case of gutted fish) bleeding.

55

Effect of some antibiotics on microbiological and chemical determination in fish during storage at 0°C

S. M. Taha, A. H. Taha, and F. M. Thabet
Faculty of Agriculture, Ain Shams University, Cairo, Egypt, p. 77, 1975
The effect of dipping fresh, gutted bolti, bayad, morgan and sardine fish in dilute solutions (10 ppm) of aureomycin, terramycin or chloramphenicol for 5 min. on the keeping quality of fish during storage at 0°C was investigated. Aureomycin was found to be the most effective; it caused complete disappearance of \( \text{H}_2\text{S} \)-producing bacteria, retarded accumulation of volatile N compounds (especially trimethylamine), and increased storage time to 12-15 days at 0°C.

56
Pretreatment of solid foods for microbiological examination (deep and surface infections)

Nordic Committee on Food Analysis, Nordic Standard, No. 91, 3 p., 1975

Detailed techniques are prescribed for uniform sampling of all solid or semi-solid foods for either separate or combined determination of the surface and deep microbiological flora (excluding obligate halophilic bacteria and non-sporeforming rods). The basic method consists of removing a portion representing a known surface area or of known weight and mixing it with a diluent containing 8.5 g NaCl and 1 g peptone/l distilled water. Procedures are: for (I) surface flora only (e.g. meat, fish, poultry) an area of 10 cm\(^2\) is marked with a template and a thin layer (1-2mm) is removed with a sterile scalpel; for (II) deep flora (meat, fish, cheese), the surface is singed and then removed, and a weighed sample is taken from the interior; for the total flora in (III) solid foods, packaged foods, vegetables, or (IV) soft pastes a weighed sample is taken of the whole. (I) and (IV) are mixed with the diluent by shaking with glass beads, and (II) and (III) by use of a blender at 14,000-15,000 rev/min.

57
Studies on preservation of fish in refrigerated sea water

P. A. Perigreen, S. Ayyappan Pillai, P. K. Suresh, and T. K. Govindan
Fishery Technology 12(2):105-111, 1975

Comparative studies were conducted on storage of (I) oil sardine (Sardinella longiceps), (II) mackerel (Rastrelliger kanagura) and (III) seer (Scomberomorus guttatus) in crushed ice (CI) or in refrigerated sea water (RSW) at -1.1°C, for less than or equal 6 days for (I), less than
or equal 8 days for (II) and less than or equal 16 days for (III). Tables and graphs are given showing the weight changes, % NaCl in muscle of RSW-stored fish, and changes in the peroxide value, free fatty acid content, total bacterial count and organoleptic properties of the stored fish. In general, RSW-stored fish were of better appearance and firmer texture than CI-stored samples; weight and NaCl content of fish tended to increase during storage in RSW. Peroxide value of (I) tended to increase more rapidly in RSW-stored than in CI-stored fish; changes in free fatty acid concentration followed the same pattern, but to a lesser extent. Differences in total counts of (I) were small. Organoleptic properties of RSW-stored (I) were inferior to those of CI-stored (I) after 2 days; storage life for (I) was approximately 2 days in RSW, approximately 4 days in CI. (II) stored in RSW were superior to those stored in CI during the first 2 days of storage; after this, deterioration was similar in RSW and in CI; storage life was approximately 6 days. RSW-stored (III) were superior to CI-stored samples; (III) could be stored in CI for 9 days, vs. 14 days in RSW.

58

The effect of cooling of herring and horse-mackerel in refrigerated sea water and ice on the quality of frozen products

J. Pielichowski and J. Nodzynski
Prace Morskiego Instytutu Rybackiego 17:161-185, 1974

Fresh herring and horse mackerel were held prior to on-ship freezing in (I) ice or (II) refrigerated sea water plus ice (agitated or nonagitated). Quality (organoleptic properties, composition and microbiological quality) was evaluated after holding for less than or equal 72 hours. Samples for further examination ashore were frozen and tested at monthly intervals after storage for 7-8 months at -25°C to -27°C. Cooling was fastest in agitated (II), which also gave the highest quality. Fish stored in (I) underwent partial freezing with a consequent decline in quality. For maximum quality and shelf-life of the frozen product, fish should be held in refrigerated sea water for less than or equal 1 day. The bacterial count of the refrigerated sea water increased with increasing storage time; the fish had a high skin count after removal from the tank. This did not appear to affect the quality of the fish. Careful rinsing of the fish before freezing is recommended.
Fishing hygiene

V. Meyer
Archiv für Lebensmittelhygiene 25(1):1-4, 1974

This lecture, presented at a meeting on food hygiene in Hamburg in May 1973, deals with the subject from the viewpoints of washing of fish and subsequent ice storage; insulation of the fish hold; and disinfection of all appliances in contact with the fish.

The influence of hygiene in catch handling on the storage life of iced cod and plaice

Journal of Food Technology 9:213-221, 1974

Investigations of commercial fisheries in the North Sea and the Kattegat show that the bacterial load of the fish as caught is generally low. Substantial bacterial infection may occur, however, during sorting, gutting and other fish handling on deck, depending on the hygienic standard on board.

The influence of the hygiene in catch handling on the storage life of iced cod and plaice was studied at all seasons of the year.

During the first week of iced storage, no difference was found in the eating quality and in the contents of TVA in plaice and TVB in cod, whether the initial bacterial infection was low, medium or high. The three levels of infection were the result of very clean, reasonably clean and very dirty handling conditions, respectively. During the second week of storage, little difference was found between fish handled under very clean or reasonably clean conditions. Very dirty conditions, however, resulted in a slightly faster decrease of quality and in 1-3 days reduction in the total storage life in ice.

Latest results in technology of preserving and handling small pelagic fish for food and feed

A. Mjelde and N. Urdahl
In Fishery Products, Rudolf Kreuzer, ed., FAO, Fishing News (Books) Ltd., pp. 74-77, 1974
Winter capelin were caught during spawning period when they were not feeding and had a low content of digestive enzymes; spoilage then was due mainly to microbiological activity. The capelin were stored in bins and tanks in large quantities, creating anaerobic conditions. Large numbers of facultative anaerobic bacteria have been isolated during storage and identified.

In other seasons autolysis is caused by enzymes, both from the fish meat and the digestive tract.

The prevention of contamination at all stages before processing includes: (1) having clean fish-holds, carriers, and tanks, (2) reduction of temperature, and (3) the use of chemical preservatives.

62
Microbiological considerations in the handling of raw fin fish

C. H. Castell

General article with recommended sanitation guidelines. To help prevent the transfer of bacteria from surface slime of the round fish (gutted) onto the freshly cut surfaces of the fillets, it is recommended that the processors wash the round fish thoroughly before they reach the cutting tables.

63
The microbiology of fish and fishery products--a progress report

J. M. Shewan

Review article discusses: (1) identification of strains isolated, including differentiation between Pseudomonas, Aeromonas and Vibrio, differentiation within the Flavobacterium group, differentiation within the Achromobacter group, Coryneform bacteria, the luminous bacteria, the photobacteria, and the lucibacteria, (2) effect of species and environment on the flora of newly caught fish, (3) effects of handling, and (4) spoilage, including skin penetration, bacterial groups involved and spoilage of salt fish.
Prepackaged fresh fish

H. H. Huss
In Fish Inspection and Quality Control, Rudolf Kreuzer, ed., FAO, Fishing News (Books) Ltd., pp. 60-65, 1971

A short review of experiments in washing; report on chemical treatments, surface pasteurization, packaging, storage temperature, quality control.

Specification for mackerel, fresh

India, Standards Institution, Indian Standard, IS:6032, 8 p., 1971

The standard prescribes requirements, methods of sampling and testing and packaging of fresh mackerel. Two grades based on weight are specified. Material must be washed in water containing 5 ppm Cl, iced and stored in containers so that the temperature of the fish does not exceed 5°C at any time. Requirements for fresh fish cover color, appearance of eyes, gills, skin, color of flesh, firmness of meat and stomach portion, and odor. Recommended microbiological limits/g meat are total count 100,000, Escherichia coli 20, Salmonella 0. For cooked mackerel, requirements are specified for color and appearance of the skin, and for color, texture, odor and flavor of the meat. Methods for sampling and cooking tests are prescribed in an appendix.

Bacteriological standards for fish and fishery products

J. M. Shewan
Chemistry and Industry, pp. 193-199, 1970

Discusses infrequency of occurrence of pathogens Salmonella lae and Clostridium botulinum and frequency of occurrence of Vibrio parahaemolyticus in fish and fishery products. Suggests bacteriological standards of fish and fishery products. Presents bacteriological data on some fishery products.

Disinfection in the seafood industry

John Liston
Discussion of the microbiological problem, fishing operations, processing, shellfish, fish meal and fish concentrates. Suggests that bacterial populations on skin surface, gills, and in intestine of fish coming on board the vessel may be eliminated by washing and by evisceration. However, many of the potential spoilage agents remain unaffected after the treatment. Discusses cleaning procedures for contaminated surfaces of the vessel.

68
Recommendations for the sanitary operation of plants that process fresh and frozen fish

J. Perry Lane
Fishery Industrial Research 6(2):63-82, 1970

This article covers recommended guidelines that can assist the processors of fresh and frozen fish in evaluating their existing sanitation practices or in establishing new ones.

69
Recommended practices for vessel sanitation and fish handling

Edgar W. Bowman and Alfred Larsen

It is recommended that effective fish handling include washing the catch. Immediately after being taken from the water, the catch should be placed in a large, self-draining culling-washing box, not more that 6-8 inches deep. By immediately washing the fish, their total bacterial population will be reduced significantly and rapid spoilage will be prevented. All fish should be washed with water containing 100 ppm of available chlorine. The water should be drawn by pump while the vessel is running in open water far enough away from shore areas, harbors, and dumping grounds. All fish should be washed by spraying the water downwards; water pressure should be 15 to 20 pounds per square inch.

70
Care of fish holds

Wayne I. Tretven
The stowage of iced fish in the hold of a fishing vessel causes the hold to become wet and dirty, which in turn may cause deterioration of the vessel as well as spoilage of the fish handled thereafter.

This problem was studied, and procedures for solving it were developed and used effectively on commercial vessels. The procedures involve: (1) use of better methods of cleaning and sanitizing the hold, (2) use of a solubilized, copper-8-quinolinolate to preserve the wood in wooden holds, and (3) application of plastic sheeting, 6-mils (.006-inch) thick, to line the hold in order to prevent it from becoming wet and dirty and to prevent the fish from contacting it.

Recommendations for improving the quality of vessel-caught groundfish

J. Perry Lane

Because fish start to lose their quality as soon as they are taken from the sea and because the basic causes of the loss in quality are not readily observable to the eye, fishermen need guidelines for slowing the rate at which the quality of the fish is lost.

Recommended here are suggestions that will enable fishermen to slow the rate of quality loss. These recommendations provide guidelines that are designed (1) to reduce the initial numbers of bacteria on newly caught fish, (2) to prevent the fish from being crushed and otherwise physically damaged, (3) to protect the fish from being contaminated by bacteria from such sources as pugs, hand contact, and viscera, (4) to retard the activity of bacteria and enzymes by rapid and sustained chilling of the fish, and (5) to protect the fish from contamination from such sources as fuel oil and sour bilges.

It is recommended that the round fish be washed thoroughly with a deck hose after they have been dumped in the checkers.

Factors affecting the quality of fresh fish and its retention by chilling

R. Balakrishnan Nair and N. L. Lahiry
Review article discusses three topics: (1) the complex process of fish spoilage, including types of fish and fishery, bacterial flora of freshly caught fish and sources of contamination, and freshness tests; (2) the influence of temperature on quality of fish, including temperature of storage and rigor mortis, temperature and bacterial growth, temperature and rate of spoilage; and (3) chilling of fish, including cold air, ice, and chilled water or brine.

73
Psychrophilic spoilage bacteria of fish

B. G. Shaw and J. M. Shewan

Sterile press juice from raw muscle of cod and ethylene oxide-sterilized cod muscle blocks were used to determine the spoilage potential of representative bacterial species present on cod, and to ascertain the incidence of spoilers on whole gutted fish during storage in ice. Growth and spoilage rates of selected cultures were studied between -60° and +60°. A high proportion of Pseudomonas spp. spoil fish at 0-60°, particularly members of groups II, III, and IV. The proportion of active spoilers of the total viable population of fish does not alter markedly during spoilage and remains below 25%. Growth of and spoilage by single Pseudomonas spp. is evident at -30° even after a period of about 3 weeks.

74
The bacteriology of fish spoilage and preservation

J. M. Shewan and G. Hobbs
Progress in Industrial Microbiology 6:169-208, 1967

Discusses the bacterial flora of newly caught fish, quantitative and qualitative aspects, and pathogenic flora.

Discussion of the preservation and spoilage of fish in ice, whole gutted fish and fillets.

75
The handling of fish at sea

In Fish Handling and Processing, G. H. O. Burgess, C. L. Cutting (in part), J. A. Lovern, and J. J. Waterman, eds., pp. 4-37, 1967
The use of a washing machine, during gutting on board the trawler, has several advantages. It can be arranged so that rehandling of the fish from one side of the deck to the other is avoided, and it can help to ensure that fish is put below as soon as possible and at a steady rate. The washing machine is usually connected with portable metal chutes which guide the fish leaving the machine through the hatch and to the point of stowage. The first part of the chute usually consists of a roller conveyor which assists drainage of the fish.

Where there is no washing machine, the gutted fish should be washed by hand and put below. Washing should be done in a galvanized steel or light alloy tank. A continuous flow of clean water should be maintained from the pump and the fish washed in open-mesh baskets swirled around in the tanks. If the fish must be put below in baskets, they should be drained thoroughly to avoid introducing dirty water into the fishroom and contaminating the ice, boards, or boxes. Washing need be sufficient only to remove all visible blood, debris and filth from the skin and gills and the belly cavity. More intensive washing than this will do little, if any, good.

During processing of wet fish on land, it is important that fish be thoroughly washed before filleting, to remove the surface slime that contains large numbers of bacteria. Almost 99% of these surface bacteria can be removed in laboratory experiments by careful and thorough washing in running water. Suitable mechanical washing gives results approaching this figure. Where filleting troughs have to be used, some system of spraying the fish with fresh water seems to be the only satisfactory answer. The fish should not be kept in washing water longer than is necessary because of the risk of undue softening.

76

Fresh Fish

G. H. O. Burgess


States that after two to four days' storage in ice, the flesh of gutted cod and similar species is invaded by bacteria. These are present on the skin, gills, and in the gut of the living fish and although careful gutting
will remove many, and washing will also reduce numbers on the surface, it is practically impossible to remove all without recourse to chemical agents or relatively high temperatures. The numbers of bacteria on the surface of the fish may be increased by methods of catching or handling.

77
Handling wet fish at sea and on shore

J. J. Waterman

Summarizes means by which European industry has approached the problem of quality in seafood and discusses possible improvements in handling and preserving wet fish. Handling on deck is improved by reducing the time fish remain on deck, by providing protection for the catch during that time, by reducing the amount of handling through greater use of mechanical aids, and by reducing the effort required of the crew.

Stowage of chilled fish at sea continues to depend largely upon correct use of sufficient ice. Methods of handling below deck can be improved by better equipment and better design engineering.

78
Improved methods of handling fresh fish in the United States: Part IV Use of antibiotics for preservation of fresh fish

M. E. Stansby
Proceedings of Indo-Pacific Fish Council 2(3):274-278, 1965

Antibiotics, particularly chlorotetracycline, are effective as preservatives for fish when applied by dipping the fish in appropriate solutions. They are somewhat less effective when incorporated in the ice in which the fish are stored. When used in ices, through essentially a washing action, the solution affected only a limited amount of the surface; in the case of whole fish, this is the skin.

79
Sanitation in seafood production and distribution

J. Liston
Journal of Milk and Food Technology 28:152-158, 1965
Review article.

The natural flora of fish, exclusive of the intestine, consists principally of psychrophilic bacteria of the genera *Pseudomonas*, *Achromabacter*, and *Vibrio* plus a few eurythermic types such as *Micrococcus*. The numbers of such organisms found on freshly caught fish range from about $10^2$ to $10^5$ per cm$^2$ of skin surface. Most of the bacteria are gram negative psychrophilic types.

**Storing groundfish in refrigerated sea water: use of ultraviolet radiation to control bacterial growth**

John A. Peters, Joseph W. Slavin, Clarence J. Carlson, and Daniel W. Baker II


The use of RSW as a storage medium for fish shows some promise, particularly in those fisheries where holding periods are less than one week and where little or no ice is used. The rapid cooling rate and lower storage temperature made possible by well-engineered RSW systems can do much to improve the quality of fish in the market-place.

For long-term storage there are still problems to be solved before this method can be unreservedly recommended. Chief among these problems are the development of off-odors in the RSW or on the skin surface of the fish that are transmitted to the fish flesh, and the development of rancidity in the fatty tissue occurring during the winter months in whiting and pollock and possibly other species yet to be investigated.

**Technological problems of handling and distribution of fresh fish in southern Brazil**

Ko Watanabe


Along with examining chlorotetraacycline as ice additive, the investigators examined harbor water and found total bacterial counts of 3,000 to 17,000 per ml, and coliform bacteria amounting to 100 to 1,000 per ml were present.
in each sample. It was pointed out that the use of harbor water for washing fish is highly objectionable. It is suggested that water which is not bacteriologically safe should be chlorinated using 10 ppm free chlorine.

82
Ultraviolet irradiation of circulating refrigerated fish storage brines

J. W. Boyd and B. A. Southcott

Irradiation of refrigerated brines with ultraviolet radiation was effective in controlling bacterial development in the brine during the post-mortem storage of lingcod (Ophiodon elongatus) and sockeye salmon (Oncorhynchus nerka). The bacteriological and organoleptic quality of the fish was not improved by continuous or intermittent exposure of brines to ultraviolet radiation. Irradiation of highly contaminated turbid brines resulted in the killing of a large percentage of the initial bacterial population. Intermittent or continuous irradiation of brines produced off-odors in the brine and in the stored fish. Discoloration developed in the irradiated brine and on exposed surfaces of the stored fish.

83
Handling fresh fish

John A. Dassow

Accepted fundamentals in handling fresh fish discussed: effective fishing methods; dressing; chilling procedures including use of ice, preservative ices, refrigerated sea water; sanitation aboard vessel; unloading; and filleting in the shore plant.

84
Standards and requirements for fish handling, processing, distribution and quality control

D. D. Tapiador and J. E. Carroz
FAO Fisheries Reports No. 9 Flf/R9, Food and Agriculture Organization of the United Nations, Rome, 249 p., 1963

38
Study and digest of governmental codes, laws and regulations.

It is recommended for handling fish during and after the landing that all fish should be adequately washed immediately prior to processing to reduce the spoilage bacteria on the skin. The authors point out that it has been demonstrated that washing prior to processing may drastically reduce the number of bacteria on the skin. For washing to be considered adequate, a high proportion of the bacteria should be removed in the process, if possible by more than 90%.

85
The bacteriology of fresh and spoiling fish and some related chemical changes

J. M. Shewan

Flora of newly caught fish--effect of handling on board ship--effect of handling on shore--some of the chemical changes occurring during microbial spoilage.

86
The preservation of fish at sea

G. C. Eddie

Preservation by chilling--quality assessment of iced fish--chilled sea water--freezing at sea--factory trawlers--freezing trawlers.

Regarding inhibition of bacterial growth, work at Torry and in South Africa has shown that the rate of cooling of fish in crushed ice, and the final quality, are better the higher the ambient air temperature. The reason for this is that the cooling of the fish is done mostly by melt water and direct contact is of secondary importance. The flow of melt water moreover washes away stale blood, slime and bacterial products and maintains the fresh "bloom" so valued in the trade.

Regarding initial bacterial load present on the skin and gills, it was suggested that gross visible contamination
by mud or intestinal filth accelerated condemnation by 1 or 2 days; washing of fish which already appear clean to the eye has little effect.

87
The microbiology of sea-water fish

J. M. Shewan

Review of (1) bacterial flora of marine fish, including newly caught fish, effect of handling on board ship, effect of handling on shore, and effect of subsequent handling and processing; and (2) microbiological spoilage of marine fish, including sites of attack, muscle substrates, and spoilage of fish.

88
Storage and transport of fish in refrigerated sea water

S. W. Roach, J. S. M. Harrison, and H. L. A. Tarr
Fisheries Research Board of Canada, Bulletin No. 126, 61 p., 1961

Review publication setting forth the known uses of RSW, stressing dangers of improper applications, and showing the method has proved very valuable, especially for the holding and transportation of Pacific salmon. Experimental and industrial experience on the west coast with salmon and groundfish has shown that it is practical to maintain a temperature of 30°F with full-strength sea water and without significant freezing of the fish. It was emphasized that factors such as salt penetration and control of bacterial contamination must be carefully studied over given time intervals.

89
Antibiotics in fish preservation

H. L. A. Tarr
Fisheries Research Board of Canada, Bulletin No. 124, 24 p., 1960

Includes discussion of the use of antibiotics in refrigerated sea water storage of fish. Discusses advantages of RSW as a storage medium, but also points out the possibility of creating a heavy bacterial inoculum in a
favorable growth environment, especially where large loads of improperly washed fish are loaded into the tanks. When proper evisceration and washing are not possible, the use of antibiotics in RSW offers promise in extending normal holding periods. In a review of the experiments adding antibiotic to RSW, it was noted that the effect of improving organoleptic qualities of the fish was much more noticeable than its action in suppressing bacterial growth.

Furthermore, the numbers of viable bacteria were almost invariably much fewer than the total bacterial numbers, indicating that there was probably rapid "dying off" of the bacteria under these conditions.

Dipping whole fish in antibiotic solutions followed by icing them is discussed.

90
The bacterial flora of fish caught in the Pacific

J. J. Liston

[For comparison to the flora of fish caught in European waters, reported in the previous article by Shewan, et al., (pp. 463-468) as gram-negative rods Pseudomonas and Achromobacter predominating.]

Total colony counts and analyses of the bacterial flora of the skin slime of cod, carried out at 5-day intervals during the stowage of fish in ice, showed that organisms of the genera Pseudomonas and Achromobacter become predominant in the later stages of spoilage.

91
The care of the catch

G. A. Reay and J. M. Shewan

The main features of fish spoilage, largely caused by marine bacteria, and main factors in controlling it on trawlers, especially distant-water ones, are described and discussed. Temperature is the most important single factor affecting spoilage. Gutting and washing on deck inevitably delay stowage of the catch; but presently used
washing tanks considerably reduce delay and warming up and permit a more even flow of fish into the hold and a steadier rate of stowage in ice.

The bacterial load of the unused ice increases during the voyage from $10^2$ to $10^3$ per ml to $10^6$ to $10^7$ per ml as it lies in the ice pounds, the increase comprising mainly fish-spoiling types. Washed fish can thus rapidly regain their original bacterial loads. The effectiveness of antibiotic ices may partly be due to suppression of bacterial multiplication in the ice itself.

The Pseudomonas and Achromobacter groups of bacteria in the spoilage of marine white fish

J. M. Shewan, G. Hobbs, and W. Hodgkiss

Gram-negative rods of Pseudomonas and Achromobacter were predominant in all cases of spoilage of marine white fish.

Sanitation aboard fishing trawlers improved by using chlorinated sea water

Arvey H. Linda and Joseph W. Slavin
Commercial Fisheries Review, pp. 19-23, Jan. 1960

Chlorine, having proved effective as a sanitizing agent in fish-processing plants, was used for improving sanitation aboard the fishing vessel. The chlorinated sea water was effective in washing away the slime and blood from eviscerated fish at sea and in washing the hold of the vessel in port.

Observations indicated that there were fewer bilgy and spoiled fish landed by the vessel when chlorinated sea water was used than previously when plain sea water was used.

Effect of chlortetracycline (CTC) antibiotic on the keeping quality of lingcod stored in refrigerated sea water

E. G. Baker, B. A. Southcott, and H. L. A. Tarr
Progress Reports Fisheries Research Board of Canada, Pacific Coast Stations, No. 112, pp. 15-17, 1958
Definite retardation of rates of spoilage of lingcod occurred when CTC was added to refrigerated sea water. The amount of antibiotic added was usually between about 2 and 10 ppm.


95
Hygiene in handling fresh unfrozen fish
W. A. Empey
Food Preservation Quarterly 18(2):35-38, 1958

Washing whole or gutted fish with water free from bacteria may be expected to reduce the number of bacteria. Washing should be most effective at sea, using clean sea water on freshly caught, gutted fish. Washing should be carried out with flowing water, free from contamination, and water should drain away freely. A 90% reduction in bacterial populations is required to bring about a 2-day extension in storage life of fish packed in ice.

96
Handling and chilling of fresh fish on vessels at sea
F. Bramsnaes

Experiments with cod and haddock at sea, including fish in ice in the holds from 1-8 days, indicated that if the fish are properly and carefully gutted, there is very little added advantage in washing the fish at sea. Experiments showed both a better and poorer keeping quality in washed fish.

97
The processing of dried salted fish
S. A. Beatty and H. Fougère
Fisheries Research Board of Canada, Bulletin No. 112, 54 p., 1957

One chapter devoted to machine washing of salted fish. Describes three automatic washers: 1) Musgrave, a hand-assisted mechanical washer using counter-rotating brushes; 2) MacCallum, automatic machine for washing fish out of
pickle, using brushing action; 3) Andrews, employing conveyor belt and rotary brushes.

Handling of fish aboard the vessel

John A. Dassow
Refrigeration of Fish-Part Two: Handling Fresh Fish, Fishery Leaflet 428, Fish and Wildlife Service, Bureau of Commercial Fisheries, 84 p., 1956

Discusses handling procedure; effect of fishing methods on quality; relation of fish species to handling methods; good "housekeeping" aboard the vessel; sorting, dressing, and washing fish on deck; fresh-water ice; salt-water ice; bactericidal ice; mechanical refrigeration as an ice auxiliary; and other methods of holding fresh fish aboard the vessel.

Spoilage of fish in the vessels at sea: 5. bilgy fish

N. L. McLean and C. H. Castell
Fisheries Research Board of Canada 13(6):861-868, 1956

Offensive "bilgy" odors develop when fish are stored in contact with slime-soaked wooden surfaces. Anaerobic bacteria develop in the slime layer between the surfaces of the fish and the wood.

The muscle of bilgy fish has a higher hydrogen sulphide and a lower mercapten content than that of similar fish spoiling in ice but not in contact with wood. The tri-methylamine and volatile acid values are usually, but not consistently, high in bilgy fish.

In the observations described in this paper, the fillets of fish stored in contact with dirty pen boards acquired a distinct bilgy odor when the anaerobic bacteria on the skin exceeded 10⁶ per cm², at which point the hydrogen sulphide content of the muscle was 0.05 mg or more per 100 g of fish.

Spoilage of fish prior to freezing

Charles Butler
Refrigeration of Fish-Part Two: Handling Fresh Fish, Fishery Leaflet 428, Fish and Wildlife Service, Bureau of Commercial Fisheries, 84 p., 1956
The effects of bacterial action may vary considerably, depending on the species of fish, the form in which they are landed, and the methods used to protect quality. For such round fish as mackerel or herring, stored in the ungutted condition and without icing, careful washing in clean water is recommended as well as storage in clean boxes or shallow pans.

101
A study of the effects of Aureomycin-containing sea water and ices upon the storage life of round herring

T. Tomiyama, S. Kuroki, D. Maeda, S. Hamada, and A. Honda
Food Technology 10:215-218, 1956

Fairly extensive trials were conducted to determine the best conditions for application of CTC (chlorotetracycline) to prolong the storage life of unviscerated herring. When the fish were stored for a short time after capture on board the fishing vessel in ice water containing between 5 and 10 ppm of CTC, followed by storage on shore in CTC-containing ice, the keeping quality was extended at least 5 days over that of untreated herring.


102
Effectiveness of Aureomycin on the keeping quality of sardines

T. Tomiyama, M. Nomura, and S. Kuroki

A 1-hour dip of sardines or round eviscerated mackerel in a 5% salt solution containing 10 or 20 ppm of CTC (chlorotetracycline) caused the fish to keep roughly twice as long as untreated controls.

Fish handling and hold construction in Canadian North Atlantic trawlers

W. A. MacCallum
Fisheries Research Board of Canada, Bulletin No. 103, 61 p., 1955

Recommended practice in fish hold construction, refrigeration, and ice requirements as it relates to the control of spoilage aboard ship. Washing in particular is mentioned as washing gutted round fish or flounders in wash boxes in conjunction with normal dressing operations. Washing after gutting may remove some of the gross contamination, but unless the fish are washed separately from those lightly contaminated, the contamination from the dirtier fish will be deposited by the wash water onto other relatively clean fish.

Ices containing chlortetracycline in experimental fish preservation

D. C. Gillespie, J. W. Boyd, H. M. Bissett, and H. L. A. Tarr
Food Technology 9:296-300, 1955

Using coho salmon, eviscerated and non-eviscerated spring salmon, grey cod and lemon sole, tests show that so long as fish are not feeding actively, it is possible to store them in RSW plus CTC without evisceration for 8 to 9 days without appreciable spoilage.


Notes on handling fish on the trawler

W. A. MacCallum
Progress Reports Fisheries Research Board of Canada, Atlantic Coast Stations, No. 62, pp. 32-36, July 1955

Hosing fish, both before and after gutting, is recommended and careful icing of all fish is essential.
Refrigeration of tuna and sardines by sodium chloride brines

L. Farber
Food Technology 9:141-147, 1955

Indicated the desirability of chilling tuna and sardines in refrigerated sea water at 29° to 30°F for a day before freezing them in stronger brines at lower temperatures, thus ensuring a preliminary washing of the fish.


Transport and storage of fish in refrigerated sea water: II. Bacterial spoilage of blue-back salmon in refrigerated sea water and in ice, with and without added chlortetracycline

G. Steiner and H. L. A. Tarr
Progress Reports Fisheries Research Board of Canada, Pacific Coast Stations, No. 104, pp. 7-9, 1955

Order of preference of various treatments studied from the bacteriological standpoint: (I) RSW plus the antibiotic chlortetracycline (CTC), (II) ice containing 1 ppm of CTC, (III) ordinary ice, (IV) RSW alone. The poor bacteriological result with the sea water alone was explained by the fact that the sea water was naturally heavily contaminated with bacteria from the unwashed fish placed therein.

The fish stored in sea water containing CTC only had a moderate bacterial count after 16 days and were still in comparatively good condition after 23 days. The bacteriological counts obtained with the fish stored in plain sea water were definitely lower than those obtained with fish stored in plain ice. Of course, the initial bacterial contamination of the sea water will vary a great deal, though it could be physically controlled by washing the fish or by changing the sea water. However, these methods are not always practicable.

Aureomycin in experimental fish preservation. II.

D. C. Gillespie, J. W. Boyd, H. M. Blissett, and H. L. A. Tarr
Progress Reports Fisheries Research Board of Canada, Pacific Coast Stations, No. 100, pp. 12-15, 1954
Definite retardation of rates of spoilage of spring and coho salmon occurred when CTC was added to refrigerated sea water. The amount of antibiotic added was usually between about 2 and 10 ppm.


109
Microbiological deterioration of fish post mortem, its detection and control

H. L. A. Tarr

Review article discusses: (1) biochemical activities of microorganisms in spoiling fish, (2) effect of physical conditions on growth of microorganisms in fish flesh, (3) effect of chemical agents on growth of microorganisms causing fish spoilage, and (4) tests for detecting bacterial spoilage of fish.

110
Spoilage problems in fresh fish production

C. H. Castell
Fisheries Research Board of Canada, Bulletin No. 100, 35 p., 1954

Chapter 3: Bacteriological Problems in the Handling of Round Fish at Sea. Use of term "round fish" to mean "gutted" fish. The mechanism of round fish spoilage is topically discussed. Care in handling fish on deck does not necessarily include washing the gutted fish before icing them in the hold; if the fish are properly and carefully gutted, there is very little added advantage in washing the fish at sea.

111
The problem of slime in the sanitation of fish plants

C. H. Castell
Progress Reports Fisheries Research Board of Canada, Atlantic Coast Stations, No. 56, pp. 5-9, July 1953

Bacteria adheres to the slime of fish; there may be from a few dozen to many thousands per sq. inch in the surface
slime as the fish is taken from the water. After the fish is landed, the slime picks up contamination from surfaces it contacts. Slime is particularly well adapted for bacteria growth.

Fish slime for the first four or five days (on well iced fish) is tenacious and not easily washed off. When it becomes laden with bacteria, it acts as the principal means by which fish-spoiling bacteria are carried into the fish plant, including cutting tables.

The best method of preventing slime from reaching cutting tables is to thoroughly wash fish before they go to the tables. With fish that have been on ice five days or more, slime is more easily washed off; a strong spray removes most of it. With fresh fish, a spray is not enough. The slime requires either brushing or a machine that tumbles the fish and removes the slime by rubbing or abrasive action, plus a spray of water.

Where fish do not come in contact with water, the number of bacteria transferred from the slime to fillets increased with the age of the fish. When they were sliced around in water, there was a sharp decrease after the fourth day, or about the time the slime was more easily washed off.

112
The importance of Flavobacterium in fish spoilage

C. H. Castell and E. G. Mapplebeck

Two hundred forty-five cultures of Flavobacterium were isolated from fish; 16% reduced trimethylamine oxide; 25% reduced sodium nitrate; 50% were proteolytic; 70% grew at 2°C. None fermented dextrose or hydrolysed fat.

Many of the cultures produced a yellow discoloration, but no offensive spoilage odors on fish muscle. Other strongly proteolytic cultures produced putrid odors at 5 to 8 days on fish stored at 3°C.

Under commercial conditions they are not as important in the development of spoilage as the more active achromogenic rods which rapidly outgrow the Flavobacterium on stored fish.
Bacterial fish spoilage and its control

Ernest Hess
Food Technology 4:477-480, 1950

It is generally accepted that the changes occurring in fish flesh, which lower its palatability and consequently its consumer acceptance, are caused primarily by bacterial action. It is also accepted that the flesh of healthy, live fish is sterile, but that soon after death, bacteria begin to invade the muscle tissues from the surface slime and intestinal contents where they occur in large numbers. Recent studies on the effects of temperatures near the freezing point upon fish spoilage bacteria and their activity have emphasized their psychrophilic nature.

The main avenues of controlling the bacteria responsible for fish spoilage, namely the reduction of the initial contamination and the inhibition of bacterial growth and activity, are under investigation in various countries. The first is achieved by means of improved sanitary methods of handling fish aboard vessels and in fresh fish plants. In the achievement of the second, the most important single factor, low storage temperature, is emphasized through improved construction of vessels' holds and more effective methods of stowage and shipping.

The control of fillet contamination in fish plants: Part II-
The relationship between the initial contamination and the subsequent rate of spoilage

C. H. Castell
Progress Reports Fisheries Research Board of Canada, Atlantic Coast Stations, No. 41, pp. 10-13, January 1948

Questions investigated: What difference would it make in the keeping quality if the numbers of bacteria that are now transferred to the fillets from surface of the round fish and from the cutting and skinning tables could be eliminated or greatly reduced? Experiments set: 1) cutting fillets from market cod so that they were entirely free from bacteria and then determining their keeping time; 2) adding graded amounts of fish-spoiling bacteria to sterile or almost sterile fillets to find out the relation between the numbers of bacteria and the rate of spoilage; 3) attempting to determine to what extent the contamination from the fish slime, cutting tables, skinning tables, ice, lessened the keeping time of fillets.
The effect of chlorine solutions on the color and flavor and preservation of fish muscle

C. H. Castell
Progress Reports Fisheries Research Board of Canada, Atlantic Coast Stations, No. 40, pp. 7-9, November 1947

Tests in which cod fillets were immersed for 5 minutes in solutions containing up to 200 ppm available chlorine showed that the dips had very little effect on the subsequent development of bacteria, and that trimethylamine accumulated just as quickly as in the undipped controls. Similar tests with round fish, using the same amounts of chlorine, produced no improvement in keeping quality. The experimental evidence supports the view that it is safer and cheaper to increase the keeping quality of fillets by keeping the bacteria from getting on them, by having sanitary surroundings, rather than by trying to destroy the bacteria on the fish by chlorinating them.

Microorganisms from Atlantic cod

Frances E. Dyer
Journal Fisheries Research Board of Canada 7(3):128-136, 1947

Five hundred ninety-five organisms isolated from six cod were members of the genera Micrococcus, Microbacterium, Achromobacter, Pseudomonas, Flavobacterium, Proteus, Alkaligenes, moulds, and yeast-like organisms. A new species, Microbacterium piscarium, is described. 98% of the cultures produced acid from carbohydrates, 60% lysed fish muscle, 29% reduced trimethylamine oxide to trimethylamine, and 45% were chromogenic.

A rapid test for detection of spoilage in sea fish

W. H. Dyer, G. J. Sigurdsson, and A. J. Wood
Food Research (now Journal of Food Science) 9:183-187, 1944

A satisfactory routine practical method for the determination of the index of spoilage for cod, haddock, and flounder has been developed. Spoilage occurs almost entirely through bacterial action at the surface; therefore, the measurement of the end products of such bacterial action in the surface layer of the tissue provides the
most satisfactory index of spoilage. The simple measurement of surface pH by direct contact affords an extremely rapid and convenient method for the routine or laboratory determination of the spoilage index. The pH test can be used with equal ease on round fish or fillets by placing a glass electrode of a Beckman pH meter in contact with the moist surface of the tissue. It has been found that fresh fish have a pH range of 6.2 to 6.8; pH levels above 6.8 are indicative of spoilage; and the higher the pH above 6.8 the more extensive have been the spoilage changes.

118
The surface concept in measurement of fish spoilage

A. J. Wood, G. J. Sigurdsson, and W. J. Dyer

The contact plate method as used for cod muscle has revealed that the major changes rendering fish unfit for human consumption can be attributed almost entirely to surface pollution of the fish with spoilage bacteria. This is confirmed by three chemical tests, trimethylamine, tyrosine, and surface pH. The relative rates of increase in all three are much greater at the surface than in the interior of cod and haddock fillets. The more rapid surface changes are taken as evidence that tests for spoilage in fish products should be based on samples from the surface of the products and not from composite samples.

119
Studies of fish spoilage: IV. The bacterial reduction of trimethylamine oxide

Dennis W. Watson

In fish muscle press juice simulating the surface and the interior of muscle, there is an aerobic environment in the surface layer and an anaerobic environment in the body of the liquid. The Eh potential of the former is about 0.3 volts and of the latter from -0.5 to -0.10 volt.

It is found that the bacterial population proliferating at 2°C is chiefly Achromobacter, which can be divided into two groups, obligate aerobes and facultative anaerobes. Only the latter group, which is capable of
growth in the interior of surface, is responsible for the reduction of trimethylamine oxide with the evolution of trimethylamine. Since the initial total count is made up of a large number of obligate aerobes or non-oxide reducers, it is obvious that the total bacterial population cannot be related to trimethylamine production. The appearance of this base therefore may be taken to indicate a bacterial population which is in excess of that responsible for its production.

Molecular oxygen at surface exercises a trimethylamine oxide sparing effect. In practice, however, this effect is not significant from the point of view of the freshness test in the sense of Beatty and Gibbons.

120

The measurement of spoilage in fish

S. A. Beatty and N. E. Gibbons
Journal of Biological Board of Canada 3(1):77-91, 1937

The increase of volatile nitrogenous bases in codfish muscle between the pre-rigor period and the first appearance of odor is approximately 6 mg per 100 grams of tissue, and is due almost entirely to the action of bacteria. It can be used to follow the course of spoilage only if the original value of the fish in question is known, as the range in variation of the original values is as great as the increase to the appearance of odor.

A method for the rapid determination of trimethylamine in cod muscle has been devised. Its increase parallels the increase in bacterial population. Odors always appear at approximately the same level of trimethylamine. The increase resulting from autolysis is negligible. The increase during the development of spoilage is fifteen to twenty times the original value. Spoilage can be followed in fish preserved with borates as well as in untreated fish.

121

Bacterial decomposition of salmon

Albert C. Hunter
Journal of Bacteriology 5(4):353-361, 1933

In handling one lot of humpback salmon the fish were washed thoroughly with running water, cleaning the bodies
entirely of blood and slime. These salmon did not decompose as rapidly as had previous lots, and in the subsequent experiments particular attention was given to the effect of washing fish as soon as they were brought ashore.

Muscular tissue of freshly caught salmon is sterile. Since some of the bacteria in the flesh undoubtedly get there through the skin, the fact that the skin of the belly is thinner and more easily broken may help to explain this higher count. In most cases the fish which were washed upon arrival at the fish house had lower total counts than those held unwashed. The washed fish did not decompose as rapidly as did the unwashed fish.
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