BACTERIOLOGICAL SURVEY OF FILLETING PROCESSES IN THE PACIFIC NORTHWEST

III. BACTERIAL AND PHYSICAL EFFECTS OF PUGHING FISH INCORRECTLY

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SUMMARY

Pughing of various species of bottom fish was quantitatively evaluated with regard to the incidence of pugh marks, the percentage weight loss in trimming away pugh-damaged area, the rate of spoilage of pugh-damaged areas, the predisposition toward discoloration of these areas, and the bacterial effects of pughing before and after iced storage.

Pughs are used to facilitate the handling of fish, as it has long been considered good practice to lift a fish by inserting the tine of the pugh into its head. By use of this technique, the fish handler avoids piercing the body of the fish, and since the head is not used for human food, the edible flesh is not damaged.

Lack of knowledge by a handler, however, as to the need to pugh only the head, often results in unnecessary damage to the flesh and quickens subsequent spoilage. In fact, some workers make little or no effort to avoid mutilating the body of the fish. To speed handling, these workers frequently use forks, which are multi-tined and which therefore can hardly be employed without piercing the body.

When pughs or forks are thus misued (see Figures 1 and 2), the tines not only pierce, tear or bruise the flesh but also convey foreign material into it, often including that from the viscera. Penetration of bacteria and enzymes introduced by the tines, leachings of body fluids, and exposure of the flesh at the opening of the wound result in rapid deterioration.

Ellison *(1)*, Pottinger and Puncochar *(7)*, Reay and Shewan *(8)*, Harvey *(2)* and Heen *(1)* have considered the detrimental effects of incorrect pughing as have also the National Fisheries Institute *(5, 6)*, Federal Specifications *(11)*, and the National Canners Association *(12, 13, 14)*.

A high incidence of pugh marks (holes) in the body of the fish has been noted in filleting operations at plants in the Pacific Northwest. From these observations, it appears that the holes resulting from pughing are not recognized as being significant sources of spoilage by fish handlers. The purpose of this paper therefore is to furnish quantitative information on the extent of damage caused by improper pughing.

Our first step in this survey was to determine precisely how extensive was the pughing of the fish and what exactly was the resulting loss, in short, was it really as serious as our offhand observations had indicated. Next, we were concerned as to the bacterial counts at the pugh marks and the effect of pughing on the deterioration of the quality of the fish during storage. We also were concerned about discoloration, as it is one of the most evident effects of pughing. Pughing, however, does not invariably result in discoloration, which raises the question as to why. Another question that occurs is the effect of the time of pughing, since the fish are repeatedly pughed from the time they are caught to the time they are filleted. Accordingly, we performed five experiments to determine the following: *(a)* incidence of pugh marks and resulting loss, *(b)* bacterial counts at pugh marks, *(c)* relation of pughing to deterioration during storage, *(d)* discoloration resulting from pughing, and *(e)* bacterial counts as affected by time of pughing.

INCIDENCE OF PUGH DAMAGE

The purpose of the first experiment was to ascertain the incidence of pugh damage in commercial fish and in the fillets cut therefrom by determining the following: *(a)* the average number of pugh marks in the body per fish, *(b)* the average number of pugh marks in the fillets, *(c)* the incidence of discoloration of the pugh marks in the fillets, and *(d)* the loss of material due to the trimming of flesh damaged by pughing.

Procedure

Every 10th fish on a conveyor leading to the filleting line from a commercial landing of flounder *(Atheresthes stomias)* was removed for examination, which resulted in a sample totaling 614 fish. Each of these fish was examined, and the number of pugh marks in the head and in the body were counted. In this count, the pugh marks on both sides of the body were included.

In order that the trimming loss caused by pughing could be determined, the plant's filleters were requested to leave the pugh holes undisturbed. Each of the whole, unwashed fillets was examined, and every hole and tear was counted. The discolored holes were itemized separately. Opposing holes ap-

TABLE 1. PUGH MARKS AND TRIMMING LOSS IN A SAMPLE OF COMMERCIAL FLOUNDER AND FILLETS

Fish examined	614
Pugh marks in heads of fish	495
Pugh marks in bodies of fish	2360
Total pugh marks in fish	2855
Fillets examined	1228
Pugh marks in fillets	1774
Discolored pugh marks	164
Trimmed fillets (A)	596 lb.
Trimmings (B)	22 lb.
Trimming loss $= \frac{(B)}{A + B} \times 100$	3 %

pearing on opposite sides of a fillet were counted as one. After the pugh-damaged fillets were examined and weighed, they were trimmed of pugh marks (discolored areas and loose torn flesh). The trimmed fillets and trimmings were weighed to ascertain the trimming loss.

Results

The results are reported in Table 1. In the 614 fish examined, there were two to eight pugh marks per whole fish. Some of these fish had more than one pugh mark on the head; it was difficult, however, to determine the number when more than one was present. Although no pugh marks were found in the bodies of some fish, as many as six were found in the bodies of others. Altogether there were 2360 pugh marks in the bodies of the fish (average 3.8 per fish) and 1774 in the fillets cut therefrom (average 1.4 per fillet). Of the pugh marks in the fillets, 164 (9%) were discolored.

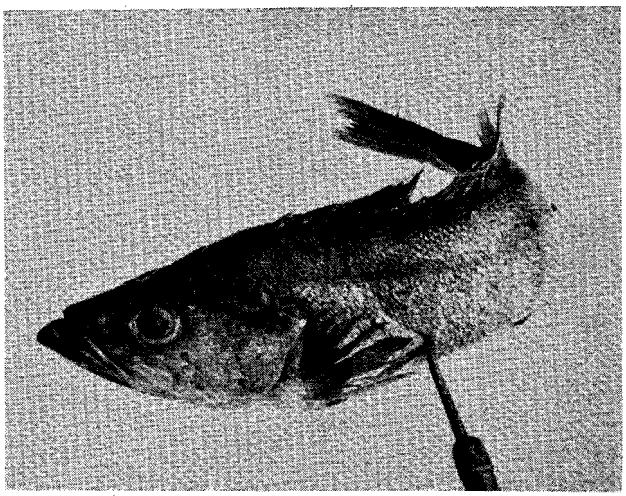

Figure 1. Improper pughing — pugh-piercing the body of a rockfish.

The results of the examination indicated that this load of fish had been subjected to a number of handlings from the time it was brought aboard the trawler to the time of filleting. As is evident from the data, the handlers had failed to pugh the fish in the head only. The trimmings appeared to consist primarily of discolored and torn flesh, and represented 3% of the weight of the fillets.

BACTERIAL COUNTS AT PUGH MARKS

The purpose of the second experiment was to determine the bacterial counts at the pugh mark and at a control area 5 cm distant on both the whole fish and on a fillet cut therefrom.

Procedure

Rockfish *(Sebastodes alutus)* that had been pughed in the body during commercial handling and had been spray-washed on a washing conveyor were sampled by swabbing 2 cm^2 areas at the pugh mark (location I, Figure 3) and at a location approximately 5 cm away (location II). Fillets were obtained

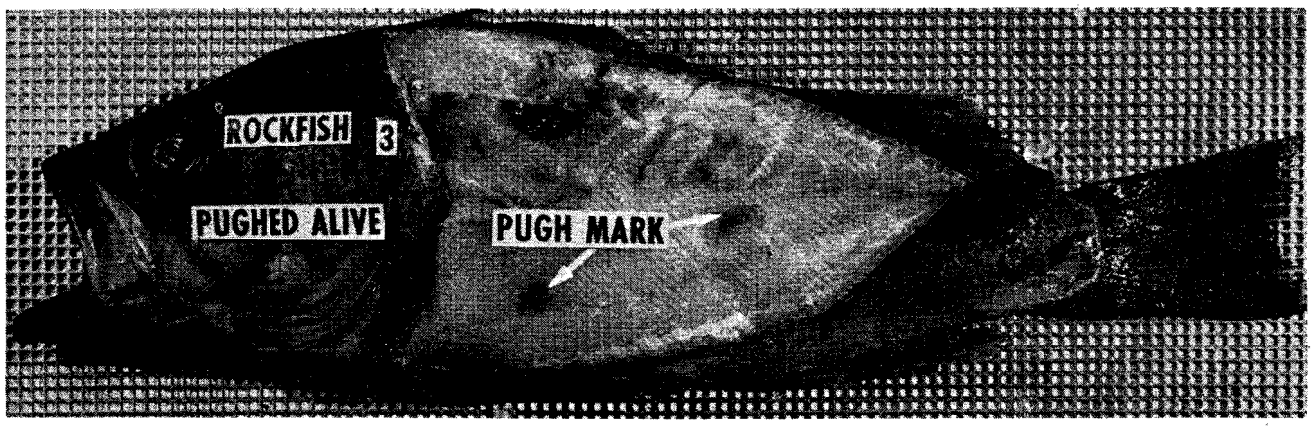

Figure 2. Rockfish, showing two discolored pugh marks in the flesh cutaway from backbone.

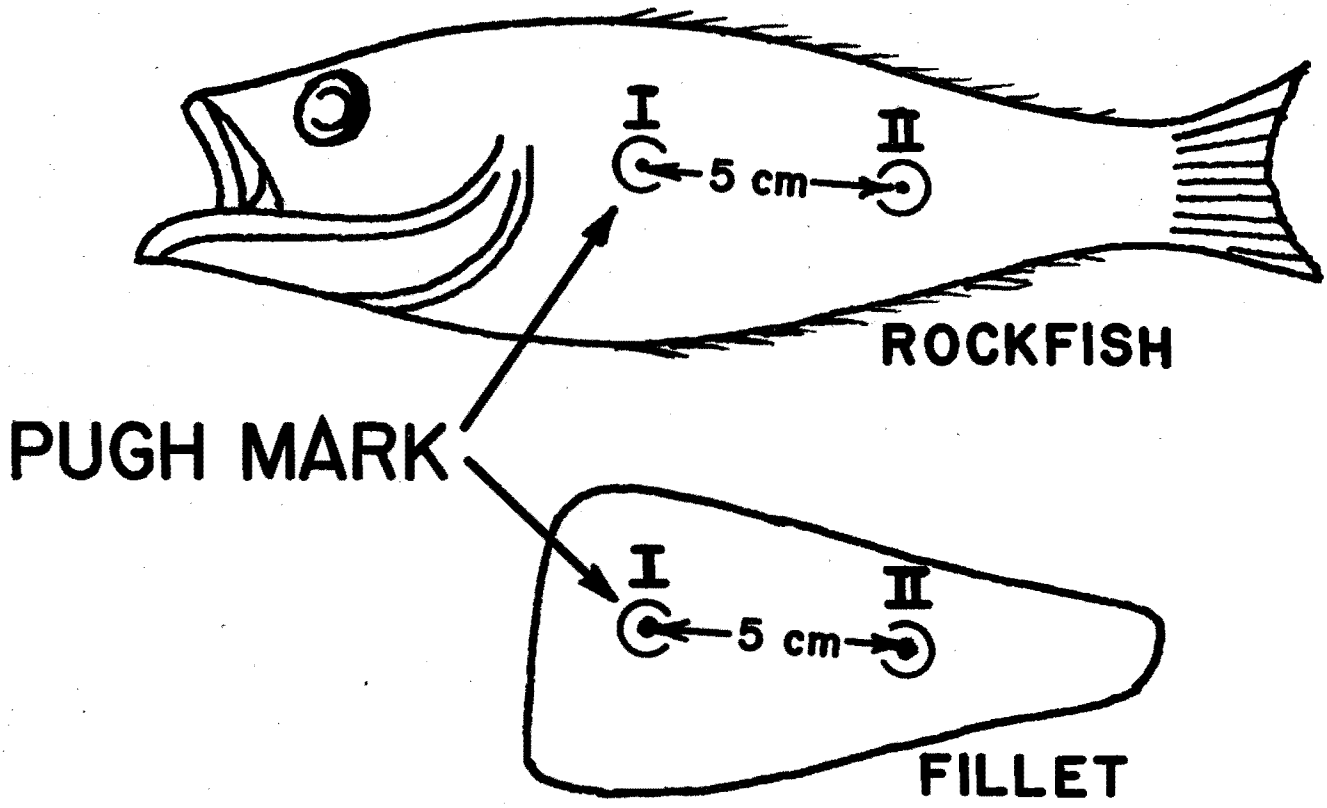

Figure 3. Rockfish and fillet cut thereof illustrating pugh mark (location I) and sampling area (location II) approximately 5 cm distant.

from the same side of the fish that had been sampled whole, and the skin side of the skinned fillets were similarily swabbed at the pugh mark and at 5 cm distant (See Figure 3). Aerobic plate counts of the samples were determined by the procedure of Tretsven *(9, 10)*.

Results

Bacterial counts from the whole fish at the pugh marks were distinctly higher than were those obtained at the control area 5 cm distant. This observation was also true for the bacterial counts for the fillets; however, the counts for the fillets were much lower than were those for the whole fish (Table 2).

PUGHING AND DETERIORATION OF QUALITY DURING STORAGE

The purpose of the third experiment was to obtain an estimate of the rate of spoilage of pugh-damaged flesh relative to the rate of spoilage of undamaged flesh in the same fillet.

Procedure

Approximately 10-g portions of the flesh at locations I and II (Figure 3) were excised from rockfish fillets using an aseptic technique. Each of the portions was placed into a separate, clean, sterile, covered petri dish. The samples were coded, placed in a dark room at 1 C, and evaluated for odor initially, and after 7 and 15 days. The cover of the petri dish was merely tilted to allow the investigator to smell the sample. Inasmuch as some of the samples from location II were not spoiled on the 15th day, they were kept in storage and examined on the 22nd day. Subjective evaluations of odor were expressed by two critics, according to the following numerical scale:

5	-	fresh
4	-	slightly stale
3	-	stale
2	-	spoiled
1	-	putrid

Results

In the comparison of the odors of portions of flesh from locations I and II, the odors (average numerical scores) at the various examinations were as follows:

Location	Initial	7th day	15th day
I (pugh mark)	4.6	1.1	1.0
II (control)	4.9	3.4	2.0

The samples examined on the 22nd day scored "4" and had an average bacterial count of 44,000 per g

TABLE 2. BACTERIAL COUNTS OBTAINED BY SWABBING 2 CM² AT THE PUGH MARK (LOCATION I) AND 5 CM DISTANT (LOCATION II) ON ROCKFISH AND FILLETS

Sample	Log of bacterial count			
	Whole fish at		Fillet at	
	I	II	I	II
(No.)	(log. per 2 cm²)			
1	5.86	5.74	5.56	5.00
2	5.90	5.81	5.38	5.34
3	6.20	5.64	5.81	5.26
4	7.72	5.68	5.56	5.34
5	5.76	5.56	5.45	5.42
6	6.15	5.79	5.65	5.73
7	5.87	5.76	5.61	5.34
8	5.74	5.72	5.48	5.00
9	5.95	5.80	5.62	5.42
10	5.86	5.82	5.58	5.59
Average	5.90	5.73	5.57	5.34
Bacterial count	800,000	540,000	370,000	220,000

at that time.

It is significant to note that the flesh in the control area 5 cm from the pugh mark kept considerably longer than did that at the pugh mark.

DISCOLORATION EFFECTS OF PUGHING

The purpose of the fourth experiment was to determine if there was any correlation between *(a)* discoloration at pugh marks, and *(b)* whether the fish were alive or dead when pughed.

Procedure

Fillets were cut from fish that had been pughed in the body while the fish were still alive; the following kinds of fish were represented: cod *(Gadus macrocephalus)*, lingcod *(Ophiodon elongatus)*, rockfishes *(Sebastodes* sp*)*, sole *(Microstomus pacificus)*, and flounder *(Atheresthes stomias)*. These fillets were compared with fillets obtained from similar fish that were pughed after death.

Results

Of the fillets cut from the fish that had been pughed in the body after death, less than 3% were discolored at the pugh mark. Of the similar species of fish that were pughed in the body while the fish were alive, approximately 10% of the fillets were discolored at the pugh mark. Both the intensity and the incidence of discoloration were most apparent when the pugh pierced the body in the proximity of the backbone and when the fish were handled roughly.

BACTERIAL COUNTS AS AFFECTED BY TIME OF PUGHING

The purpose of the fifth experiment was to determine if there is any significant difference in the bacterial counts of fish pughed and then held in ice for several days compared with fish held in ice for the same period and then pughed.

Procedure

Bacterial counts of the flesh at the pugh marks and at a distance 5 cm away in a control area were determined on rockfishes pughed and grouped as follows:

A. Six rockfish were obtained that had been pughed in the body while they were alive.

B. Six other were obtained that had been pughed approximately 20 minutes after being landed.

C. Three others were obtained that had been pughed after they had been stored in ice for 5 days.

For use as a control, three rockfish of group A and three of group B were frozen rapidly with solid CO_2 within 5 hr after being pughed on the boat. The three others of group A and three of group B were stored in ice.

The fish were sampled 5 days after they had been caught. Using aseptic technique, we excised 5 g of the flesh at the pugh mark of each fish. The excised flesh from the three fish in each group was blended with 9 parts (by weight) of cold, sterile phosphate diluent at 22,000 rpm for 30 seconds, and total bacterial counts were determined.

Results

Table 3 reports the results. The counts were similar in the flesh of fish that had been pughed in the body while alive (group A) and after death (group B). The pugh-damaged flesh (groups A and B) that had been held in ice 5 days had counts that were quite similar but considerably higher than

TABLE 3. BACTERIAL COUNTS OF PUGH-DAMAGED FLESH OF ROCKFISH PUGHED WHILE ALIVE (GROUP A), PUGHED IMMEDIATELY AFTER DEATH (GROUP B), AND PUGHED AFTER 5 DAYS OF STORAGE IN ICE (GROUP C)

Group	Bacterial count[a]	
	Frozen after pughing	In ice 5 days
	No./g	No./g
A	48,000	900,000,000
B	55,000	800,000,000
C		16,000,000

[a]Composite sample consists of 5 g of pugh-damaged flesh from each of three fish.

those of the same groups that had been frozen as a control (see Table 3). The bacterial counts of the pugh-damaged flesh of fish that had been in ice 5 days before being pughed (group C) were higher than for those in groups A and B that had been pughed at landing and frozen, yet were very markedly lower than were those for groups A and B that had been in ice 5 days after being pughed.

Although freezing destroys some bacteria, we may assume that the counts of the frozen samples of groups A and B indicate the approximate number of bacteria contaminating the flesh at the time of pughing. The higher counts after 5 days of storage in ice represent contamination with higher-count material from the visceral cavity and surface and growth of the contaminants in the pughed flesh.

CONCLUSIONS

Specific

In 614 fish examined, the bodies average 3.4 pugh marks per fish, and the fillets cut therefrom averaged 1.4 pugh marks per fillet. Of the pugh marks in the fillets, 9% were discolored. Loss due to the trimming away of pugh-damaged flesh represented 3% of the weight of the fillets.

Bacterial counts from the whole fish at the pugh marks were distinctly higher than were those obtained at a control area 5 cm distant. Though the counts were lower on the fillets, the same pattern of counts was observed.

Pugh-damaged flesh spoiled markedly faster than did the flesh in the control area of the same fillets. On the 7th day, the pugh-damaged flesh was putrid, whereas the control, though stale, was still edible.

Less than 3% of the fillets of commercial fish were discolored at the pugh marks when the fish were pughed after death, whereas 10% were discolored when the fish had been pughed when alive.

Bacterial counts at the pugh marks were markedly less in fish that had been held 5 days in ice and then pughed as compared with the counts at the pugh marks in fish that had been pughed and then held 5 days in ice.

RECOMMENDATIONS

Workers handling fish should be made aware of the contamination, spoilage, and loss of flesh due to pughing fish in the body.

The number of pugh marks per fish (two to eight) indicates that much hand labor is involved in moving fish and that use of mechanical methods might well result not only in fish of higher quality but also in economies as well.

REFERENCES

1. Ellison, W. A. Prevention of spoilage at sea. II. The hold. Fishing Gazette, pp. 17-19, April, 1934.

2. Harvey, E. W. Good handling helps to keep competi tive. Pacific Fisherman, 51: p. 40, September, 1953.

3. Heen, E. Importance of quality control of fresh fish. Improved quality and packing of fresh fish as a means of stimulating consumption. FAO report on workshop held in Norway, 11-16.

4. Jones, N. R. Fish muscle enzymes and their technological significance. Recent Advances in Food Science, 151-166. 1962.

5. National Fisheries Institute. Fish and Seafood Judging Forms. Set 9A, Sheet 1, 9/61; Set 10A, Sheet 1, 9/61; Set 11B, Sheet 1, 9/61; Set 12C, Sheet 1, 9/61; Set 21, Sheet 1, 9/61; Set 7B, Sheet 1, 9/61; Set 8B, Sheet 1, 9/61. 1961.

6. National Fisheries Institute, Guide-liner.

7. Pottinger, S. R. and J. F. Puncochar. Boston Fish Pier. 1949.

8. Reay, G. A. and J. M. Shewan. The care of the trawler's fish. Department of Science & Industrial Research, Food Investigation, Leaflet No. 3, Torry Research Station. 1949.

9. Tretsven, W. I. Bacteriological Survey of Filleting Processes in the Pacific Northwest. I. Comparison of methods of sampling fish for bacteria counts. J. Milk and Food Technol., 26:302-306. 1963.

10. Tretsven, W. I. Bacteriological Survey of Filleting Processes in the Pacific Northwest. II. Swab technique for bacteriological sampling. In Press. J. Milk and Food Technol.

11. U. S. Federal Specification. Salmon, Canned. 3.2 Description of the canned product. PP-S-31c, p. 2, February 3, 1954.

12. Yonker, W. V. Summary of the cleaning in the 1960 canned salmon peak. Memo to all Salmon Canners, National Canners Association, Northwest Research Laboratory. 1961.

13. Yonker, W. V. Summary of the cleaning in the 1961 canned salmon pack. Memo to all Salmon Canners, National Canners Association, Northwest Research Laboratory. 1962.

14. Yonker, W. V. Summary of the cleaning in the 1962 canned salmon pack. Memo to all Salmon Canners, National Canners Association, Northwest Research Laboratory. 1963.