COMMERCIAL FISHERIES REVIEW

January 1966 Washington, D. C. Vol. 28, No. 1

NEW APPROACHES TO QUALITY CHANGES IN FRESH CHILLED HALIBUT

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ABSTRACT

Results of some new and simplified objective methods for measuring quality differences in iced halibut were compared with subjective or sensory methods. In this interim report to industry, the potential applicability of some of these results to industry practice is discussed. The quality aspects considered are freshness, raw-meat elasticity, cooked texture, and the abnormal chalky condition.

INTRODUCTION

Few data exist on the relation between the degree of freshness of halibut to its retention of quality during frozen storage. This information is needed to develop meaningful criteria for grading fresh halibut as landed, especially since halibut before final consumption may be held in ice for over 3 weeks prior to dockside delivery and may be additionally held in frozen storage for 1 to 2 years. To define the initial quality of the landed fresh halibut in subjective and objective terms and to relate it to the time-temperature rate of change in quality of the frozen product were the main purposes of this study. This is an interim report mainly concerned with the general aspects of the first objective.

From a practical and a laboratory standpoint, we need simple, rapid tests for both measuring and confirming quality differences in halibut of varying lengths of time out of water--tests that do not involve judgment or bias. Such tests must be both practical and useful to government and industry inspectors who are asked to spot check random lots of halibut. The tests are intended for application to a representative sample of a given lot rather than to each halibut unloaded. Also, the tests should involve new concepts and new approaches--with an eye to future needs.

In this report, I plan to discuss very briefly some highlights of our current work and to indicate, where possible, the potential practical aspects of this work. The discussion will be limited to the evaluation of the following four aspects of halibut[1/] quality: (1) freshness, (2) raw-meat elasticity, (3) texture of the cooked meat, and (4) abnormal chalky condition.

To avoid any misunderstanding, I wish to emphasize that I am reporting preliminary tests that have not as yet been statistically evaluated. Hence, before any of these potential tests can be recommended for acceptance, they will require further study.

FRESHNESS

In evaluating freshness, I felt that it would be more practical to favor methods that are simple, rapid, and different in conceptual approach. Thus, some chemical and physical meth-

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1/Talk delivered at Bureau of Commercial Fisheries Pacific Northwest Regional Conference on Fresh Dressed Halibut Quality and Standards on February 18, 1965, Seattle, Wash.
2/The halibut in this study were caught off the Washington coast, about 20-40 miles southwest of Cape Flattery in 90 fathoms of water, with a locally chartered halibut vessel.

U. S. DEPARTMENT OF THE INTERIOR
Fish and Wildlife Service
Sep. No. 749

ods along with our usual sensory procedures were simultaneously used. Briefly and without detailed explanation, the following results are given--again with the understanding that further work is still needed.

CHEMICAL METHODS: The two chemical criteria employed--(1) hypoxanthine, a postmortem breakdown product that develops from adenosine triphosphate (ATP, a compound involved in muscle action in the live fish), and (2) magnesium (also involved in ATP muscle action)--both change during the postmortem period with the degradation of cellular muscle tissue and biochemical constituents.

Hypoxanthine: The increase in hypoxanthine (by the method of Spinelli, Eklund, and Miyauchi 1964) in the halibut nape with increase of days in ice is shown in figure 1. At about the 19th day, our taste panel rejected the halibut because of off-flavor; this corresponds to about 0.28 mg. hypoxanthine per gram of meat. Hypoxanthine values below 0.15 therefore indicate a high level of freshness. Provisionally, we may consider Grade 1 halibut as having values below 0.21 and Grade 2, values between 0.21 and 0.27.

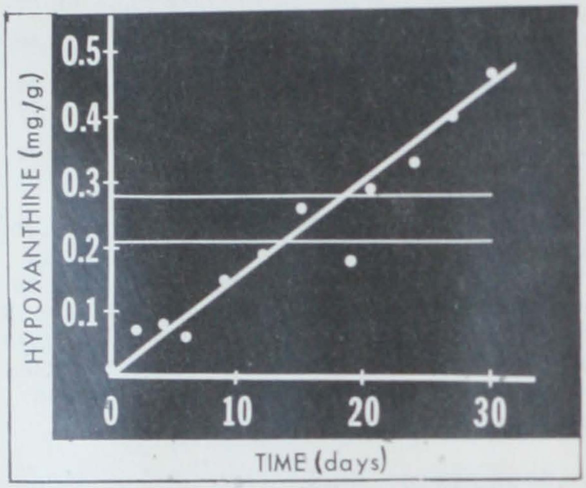

Fig. 1 - Variation in hypoxanthine content of halibut nape during iced storage.

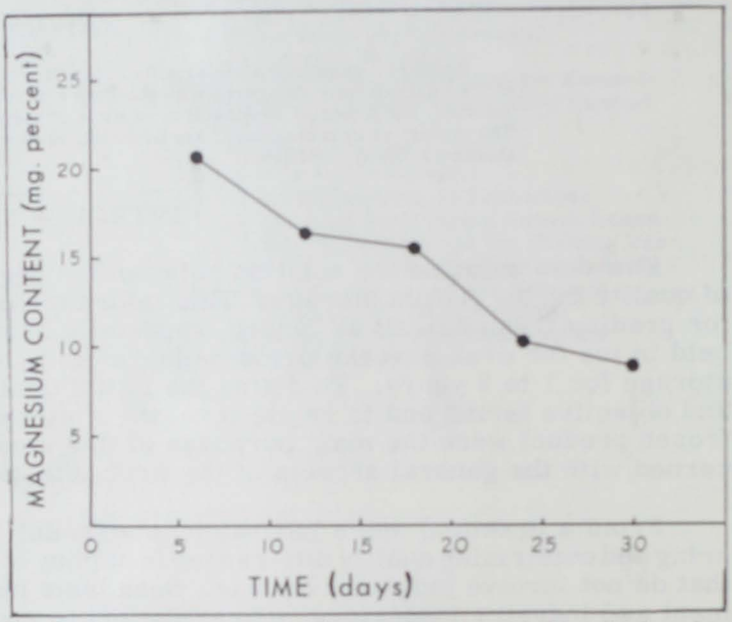

Fig. 2 - Magnesium content of the free drip of iced halibut (24-hour drip at 33° F., nape meat.)

Magnesium: The decrease of magnesium (by a modified method of Orange and Rhein 1951) in the free drip (24-hour drip at 33° F.) is shown in figure 2. At about the 19th day, our taste panel rejected the halibut because of off-flavor; this corresponds to 14-15 mg. percent magnesium. (We reject at a flavor score of 5 on a 0 to 10 sensory scale.) Magnesium values above 18 to 20 mg. percent indicate a high level of freshness.

These two chemical indices show initial promise but will have to be tested further on other series of halibut.

PHYSICAL METHODS: Physical methods, because of their inherent simplicity, offer the possibility for rapid examination of large numbers of samples. Two such methods were employed in this study: (1) pH difference between the skin surface and interior meat and (2) the electronic fish tester (Model V, developed in Germany).

pH difference: The pH measurements are made by setting the electrode in contact with the fish-skin surface and then with the interior meat. Values are read on the expanded scale of the pH meter after equilibration of the pH, usually within a couple of minutes. The pH difference between the skin surface and interior meat is a measure of the relative change in acidity due to bacteriological activity on the surface. Figure 3 shows little pH difference (about 0.2) until about the 10th or 12th day of iced storage, after which the rate of change increases sharply. At about the 19th day, the halibut becomes unacceptable to a taste panel at which time we note a fivefold increase in the pH difference. Although evidence of panel rejection appeared on the 19th day, we still found some acceptable fish in the 24-day fish. The estimated possible quality range values could be: Grade 1 halibut below 0.6 and Grade 2 between 0.6 and 0.9.

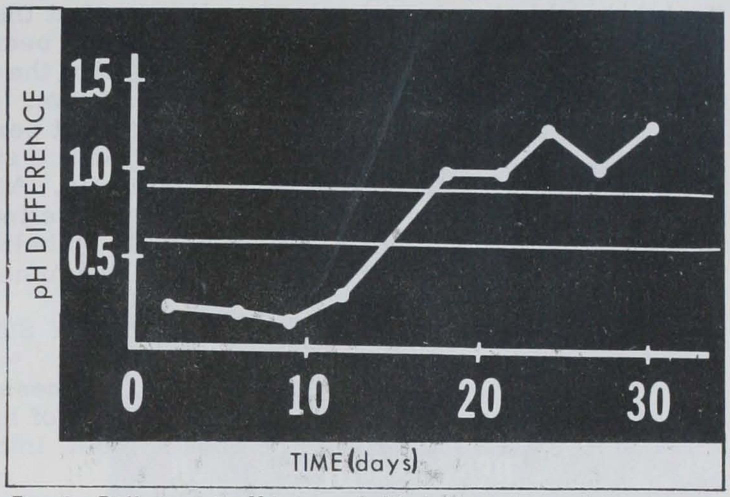

Fig. 3 - Difference in pH between halibut skin surface and interior meat at nape during iced storage in a 38° F. chill room.

Electronic Fish Tester: The electronic fish tester was tried with fair success at our laboratory on several species of bottomfish. The main advantages of this instrument are its simplicity of use, its portability, and its speed of operation. About 2 to 3 halibut per minute can readily be evaluated, making practical the field examination of a large number of samples.

PRINCIPLE OF TEST: After a fish dies, electrophysiological changes occur. This instrument is supposed to measure the difference in resistance of the cell membranes of a fish to two alternating currents (sent through electrodes applied to the fish surface)--one at a low frequency and one at a high frequency. The freshness is measured as follows: $Q = \frac{(R_L - R_H)\,100}{R_H}$, where Q = freshness reading on instrument, and R_L and R_H are the resistances at low and high frequencies, respectively. In a fresh fish (with the cell membranes intact), there is a large difference in resistance between the low and high frequencies, so instrument Q values are high. However, as the fish ages, the cell membranes of the fish begin to break down; they increase their permeability to charge-carrying ions, which reduce their resistance and capacitance, such that now the difference in resistance at the low and high frequencies decrease, and eventually disappear. Instrument Q values are low (Hennings 1963).

RESULTS WITH HALIBUT: In figure 4, we see that the instrument readings decrease very rapidly during the first 4 days of storage but decrease more gradually during subsequent storage, down to zero and below on some halibut.

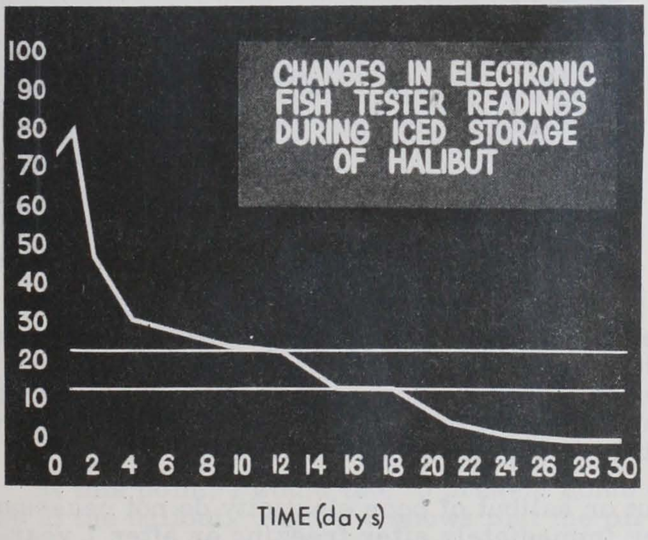

Fig. 4 - Variation in fish-tester readings during iced storage of halibut in a 38° F. chill room.

Looking at figure 4, we might consider 0 to 4 days as being a rapid cellular breakdown phase, 4 to 12 days as being an equilibration phase for diffusion of cellular constituents and gradual bacterial buildup, and 12 to 24 days as being the period of accelerated microbial action (this agrees with the pH data in fig. 3) and further cellular breakdown. The halibut becomes unacceptable to the taste panel on about the 19th day, at a fish-tester reading of about 12. Fish-tester readings above 25 indicate a high level of freshness. Therefore, it would appear that values above a reading of about 20 could be considered for Grade 1, and between about 15 to 20 for Grade 2. Of course, more work will have to be done to confirm these limits on a statistical basis before they can be recommended to industry.

APPLICABILITY TO HALIBUT: Although the fish tester gives a fairly good estimate of the freshness or quality of a lot of fish, it will give abnormally low values for individual fish if: (a) the skin has been bruised or damaged at the point measured, (b) the fish has been partially or completely frozen, or (c) the fish has been subjected to excessive pressures or stresses. Since halibut is a rather large fish, the possibility of bruising and surface abrasion during normal handling presents a problem. However, if the sampling size is sufficiently large, which is practical since 2 to 3 halibut per minute can readily be evaluated, it appears that the bruising factor does not introduce serious variability in the instrument determinations of the halibut freshness on a lot basis. Also, in spite of the wide variability in halibut thickness, instrument readings appear to be independent of this factor within a given halibut. In summary, we can say that our data on halibut freshness looks promising enough to warrant further evaluation of this type of instrumental measurement on halibut.

ELASTICITY STUDIES

The relative subjective elasticity and softness of the raw meat of the landed fresh halibut is presently employed in dockside grading of halibut. We were therefore interested in its relation to textural quality of the cooked meat, initially and after frozen storage.

INSTRUMENTAL MEASUREMENT: The instrument we used to measure halibut softness or elasticity objectively is illustrated in figure 5. To estimate the elasticity subjectively, we press our finger into the halibut meat (fig. 5a) and then evaluate the rate and amount of recovery from the depression (fig. 5b) as a measure of the elasticity. To duplicate this action with the instrument, we apply a 1-pound weight to the fish surface through a round plastic knob for 10 seconds and read the total depth of depression on a dial; we then remove the weight, allow the depression to recover for 10 seconds, and read the depth of the remaining depression of the dial. The remaining depression after recovery, expressed as a percentage of the depression caused by the 1-pound weight, is the percentage residual deformation or percentage loss of elasticity.

Fig. 5 - Measuring the elasticity of halibut.

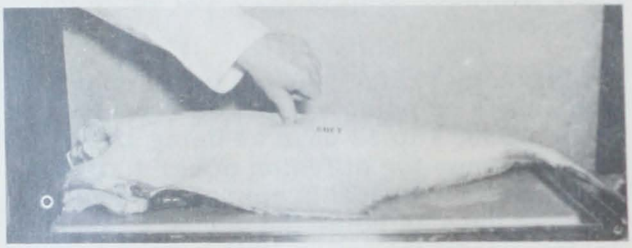

Fig. 5a - Pressing finger into halibut meat to estimate softness and elasticity.

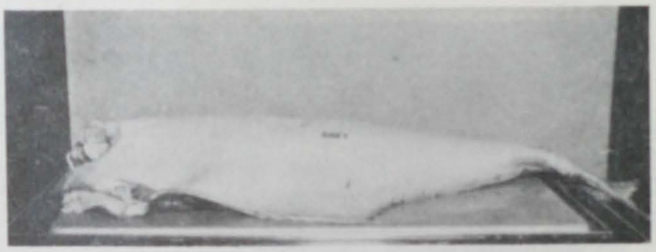

Fig. 5b - Showing residual deformation in soft halibut with poor elasticity.

RESULTS: In figure 6, the curve indicates the increasing percentage loss in elasticity (percentage residual deformation, fig. 5b) with days in ice. Now, if we cook samples from these halibut before we freeze the halibut or after 1 year of storage of the frozen halibut at -20° F. and evaluate the cooked texture with a taste panel or our hydraulic shear instrument (Dassow, McKee, and Nelson 1962), we find little, if any, noticeable difference.

Provisionally, we may say that soft halibut or halibut of poor elasticity do not necessarily result in poor cooked textural quality, either immediately after freezing or after 1 year of storage at -20° F. (The effect of 0° F. storage on the rate of degradation in cooked texture is under study.) We should, however, point out that if our iced storage conditions are improved, we get a less steeply rising curve than that shown in figure 6--that is, we get a lower rate of loss of elasticity. Under these latter circumstances, although the texture characteristics do not show any real difference again, the product quality is increased from a freshness standpoint (sensory flavor evaluation).

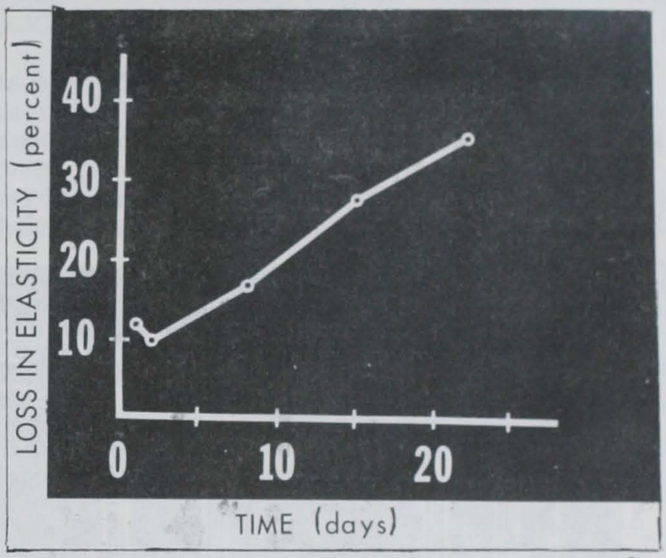

Fig. 6 - Loss of elasticity of halibut during iced storage in 40° to 60° F. chill room.

TEXTURE STUDIES

We often find wide variability in cooked halibut texture within a given halibut and between halibut of similar origin. The wide variability of texture often observed cannot be directly related to days of iced storage. However, if we examine some of our data in terms of pH, we find an interesting correlation.

Figure 7 shows a comparison of the hydraulic shear or toughness of the frozen cooked halibut against the pH of the cooked drip for some 2- and 15-day iced halibut. (The hydraulic shear is obtained by cooking a frozen cylinder of halibut, placing the cooked plug between the set of jaws of the hydraulic shear instrument (Dassow, McKee, and Nelson 1962), and shearing to failure. The maximum hydraulic shear force represents the textural resistance or toughness of the halibut.)

Figure 7 also indicates that halibut of low pH are almost twice as tough as halibut of high pH, regardless of whether they are 2 days or 15 days old. We may conclude that the pH of the landed fish is of greater significance in determining the textural characteristics of the cooked product than the age of the landed halibut. The pH we know is related to the methods of catching and the degree of struggle of the halibut prior to death. This pH relation points to the importance of immediate stunning of halibut (not part of current vessel practice) in order to limit the degree of struggle.

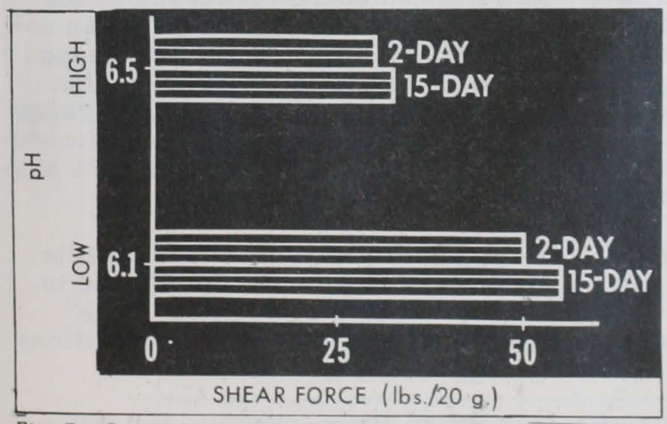

Fig. 7 - Comparison of hydraulic shear (toughness) of frozen cooked halibut against pH of the cooked drip for 2- and 15-day iced halibut after 1-year storage at -20° F.

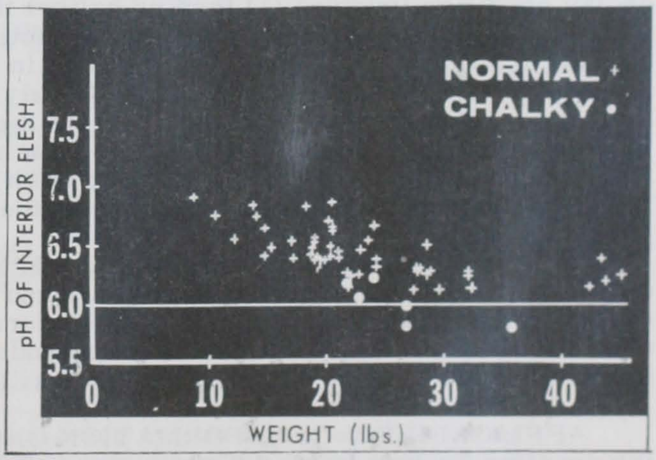

Fig. 8 - Variation of interior meat pH with weight of the halibut, head on and eviscerated.

At this point, I would like to present some data relating the pH of the interior meat to the size of the halibut. Figure 8 shows that the pH decreases with increasing weight of the halibut up to about 30 pounds and remains fairly constant above that weight. Of the six chalky halibut (discussion in next section) found in this experimental lot of halibut, the three severely chalky halibut were below pH 6.0, and the three slightly chalky halibut were above pH 6.0.

In evaluating the texture of these chalky halibut, we found that hydraulic shear (toughness) values were in about the 60-70 pounds force range, as we would expect from their low pH.

CHALKY CONDITION

The industry continues to be concerned about the chalky condition from both a quality and an economic standpoint. The precise cause and control of the condition is not completely known. The condition varies in degree from barely perceptible to excessive.

OBSERVATIONS: The condition is not immediately apparent but develops within at least 2 days after the halibut are caught. In normal halibut, the meat is semitranslucent; whereas in chalky halibut, it takes on a flat-chalky-white opaque color. Other main abnormal characteristics of chalky halibut are its low pH and its great tendency to lose water (the water literally flows out of the tissue when it is cut). Its ready tendency to lose water is illustrated in figure 9 for the 2- to 30-day iced halibut.

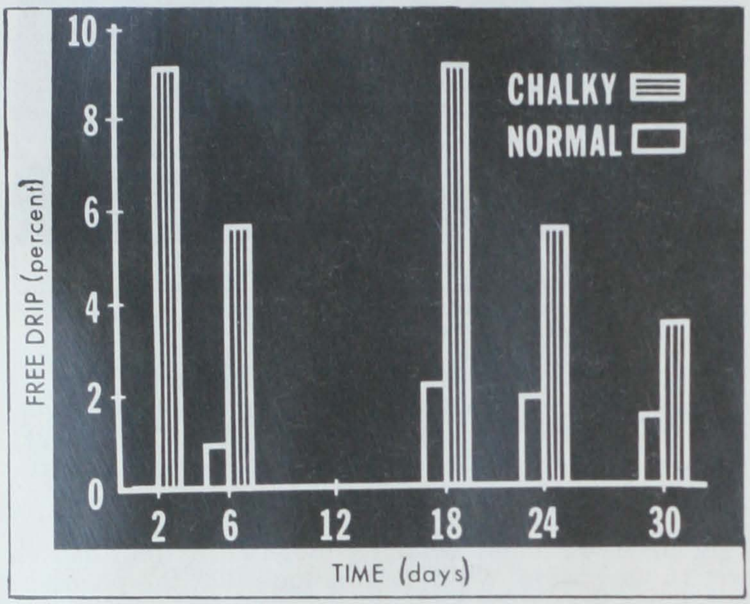

Fig. 9 - A comparison of the free drip from chalky and normal halibut during iced storage at 38° F. (Note: No measurable free drip was formed in the normal 2-day halibut.)

In examining chalky halibut, we find a lower protein solubility (in high- and low-ionic-strength extractions) and a lower protein content in the free and cooked drip than are found in normal halibut. The cooked meat of chalky halibut becomes dry and tough but is otherwise acceptable. No identifiable parasites have been found associated with this condition.

EXPLANATION OF CHALKY CONDITION: Based on our tests, on studies of meat products, and on studies in Canada at the Vancouver Technological Laboratory (Tomlinson, Geiger, and Dollinger 1964), it appears that the predisposition to the chalky condition involves (1) feeding halibut that have high glycogen energy reserves in the muscle, (2) halibut that die in a frenzy of activity or are extremely exhausted, causing an accumulation of fatigue-produced lactic acid in the muscle, (3) halibut that are, for one reason or another, unable to get rid of the relatively high lactic acid accumulation, and (4) halibut held at a relatively high temperature--the higher the temperature of holding, the more rapidly the condition develops. The muscle proteins under these conditions appear to be sufficiently injured or altered to give rise to the readily apparent abnormality. This represents a preliminary working hypothesis subject to further test evaluation and modification.

The condition observed is similar to that found in "watery meat" or so-called "muscle degeneration." This condition may be "found in nearly every case when rigor is allowed to occur rapidly at a relatively high temperature, whether in the rabbit, pig, beef, or whale" (Bendall 1963). A well-fed animal killed under severe physical struggle or stress conditions is more subject to this condition than one killed without struggle.

APPLICABILITY OF INFORMATION ON CHALKY HALIBUT: Provisionally, the following practice for minimizing the chalky condition may be recommended:

At Fishermen's Level: (1) Kill or stun halibut immediately to stop all physical activity. (Physical activity may increase the tendency toward chalky condition, and it may also lower the pH sufficiently to affect the texture of the meat adversely.) (2) Chill halibut immediately, as holding the fish at higher deck temperatures favors the earlier development of the chalky condition.

At Processors' Level: In fletching operations, avoid the use of halibut that may be potentially chalky as evident by trial examination of a meat cut or by pH measurement. Freeze these segregated halibut immediately and handle and use them only frozen. (Thawing for later use results in an intensification of the condition.)

SUMMARY

The principal aim of this study was to define the initial quality of fresh halibut when landed in subjective and objective terms. The need for simple rapid objective quality tests was simultaneously considered in the evaluation of the quality attributes: freshness, raw-fish elasticity, cooked texture, and abnormal chalky condition.

The chemical criteria for freshness (hypoxanthine content of meat and magnesium content of drip) and the physical criteria for freshness (difference in pH between surface and interior meat and surface measurement by electronic fish tester) all show promise but will require further testing. The use of the electronic fish tester appears to be the most practical because of its speed and operational simplicity.

The loss in elasticity of halibut during iced storage did not cause a related loss in cooked textural quality, immediately after freezing, or after 1-year of storage at -20° F.

The variability in cooked halibut texture was more directly related to the pH of the landed halibut than to the days of storage on ice--the lower the pH, the poorer the texture.

The main adverse characteristics of the abnormal chalky condition (white-opaque meat color) in halibut involved a lower than normal pH, poor water retentivity of the raw and cooked meat, and an associated poor texture. A preliminary hypothesis for this condition was set forth.

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Note: Acknowledgment: R. Nelson (Chemical Engineer, U. S. Bureau of Commercial Fisheries Technological Laboratory, Seattle, Wash.) procured the halibut used in this study. R. Nelson and Harold Barnett (Chemist, Bureau of Commercial Fisheries Technological Laboratory, Seattle, Wash.) obtained the electronic-fish-tester and hypoxanthine data.