THE UNIVERSITY OF MANITOBA

ACCEPTABILITY STUDIES ON FACTORS INVOLVED IN THE CHOICE AND TREATMENT OF WHITEFISH FOR CANNING

by

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ABSTRACT

A study of flavor and texture of canned lake whitefish (<u>Coregonus clupeaformis</u>) from 11 lots of fish caught in William Lake, Manitoba, between June, 1969 and June, 1970 showed high variability from month to month in hedonic responses from 60-member "consumer" panels, description by a 6-member trained panel and textural assessments with the Allo-Kramer shear press. No pattern of quality change was consistent with the calendar year but October-caught fish seemed inferior. Sensory and instrumental measurements indicated that, over the year, female fish were generally firmer than male fish.

Pre-canning freezing and partial drying applied to both sexes of fish within each catch, in a factorial arrangement, showed that freezing was beneficial to quality, while drying was detrimental. Compared with fish canned from the fresh state, frozen fish was firmer, had a better liked flavor and texture, had less free fluid but more expressible fluid and fewer textural disadvantages. Furthermore, freezing minimized textural differences attributable to month and sex.

Drying increased fish firmness, as detected by sensory and instrumental measurements. However, compared with not-dried fish, the texture and flavor of dried fish were less well liked. Dried fish had more off flavors, a less intense chickeny flavor, and a higher incidence of mealiness and tendency to felt along with decreased free fluid. Drying emphasized variability due to sex and month.

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INTRODUCTION

Whitefish (Coregonus clupeaformis) is the most important commercial catch from freshwater sources in Canada. In 1967, Canada's catch of freshwater fish was 1,302,600 metric tons, of which 8,400 metric tons were whitefish. During 1967 alone, 5,600 metric tons of whitefish were exported; 3,600 metric tons as fresh or chilled whole fish, 1,800 metric tons as frozen whole or dressed fish, and 200 metric tons as frozen fillets (FAO, 1969).

Because whitefish is a highly perishable product, several studies have been undertaken to determine methods of extending its storage life. The extension of storage life by freezing was studied by Osterhaug (1956) and by Awad et al. (1969). Gamma radiation was used to preserve both fresh (Ostovar et al., 1967) and smoked whitefish (Slusar and Vaisey, 1970).

Canning should extend the storage life of whitefish considerably longer than any of these methods, since the process excludes air, inactivates enzymes, and destroys spoilage organisms.

In a report to the Manitoba Department of Industry and Commerce, Arthur D. Little, Inc., reported that canned whitefish could compete cost-wise with canned salmon and tuna (Anonymous, 1965). Canada exported 28,200 metric tons of canned fish in 1968, of which 18,000 metric tons was canned salmon (FAO, 1969). Since canned fish is such an acceptable product, the market for canned whitefish looks promising, if the product is of sufficiently high quality.

It has been reported that the flavor of canned whitefish was desirable and mild, but that there were two main drawbacks to the product, its softness and the lack of uniformity even in fish canned from the same lot (Anonymous, 1966, Lantz, 1966).

One purpose of the present study, therefore, was to evaluate methods of firming the canned fish. Flavor was studied only to ascertain whether treatments designed to improve the texture of the fish had preserved the original flavor. The effect of sex of the fish and season of catch on the flavor and texture of the canned fish were studied to determine if either or both of these factors contributed to the variability of the canned product.

REVIEW OF LITERATURE

The Effects of Canning on Fish Characteristics

Canning may be defined as the preservation of food in sealed containers by the action of heat (Frazier, 1967; Van den Broek, 1964). Canning does not result in absolute sterility of the food since some organisms may remain viable even in adequately processed foods (Rowan, 1956). The heat treatment, however, must be sufficient to destroy the microorganisms most likely to cause spoilage. Temperatures in non-acid foods such as fish must be maintained at 115°C for several minutes in order to eliminate the hazards of surviving spores of the bacteria Clostridium botulinum, the most heat-resistant species of all food spoilage organisms (Triebold and Aurand, 1963). Bolton (1969) reported that, in canned salmon, more heat is required to soften the bones than to sterilize the product.

The temperature reached during the canning process is far in excess of that required to cook fish. Griswold (1962) indicated that fish is considered cooked when the myofibrillar proteins coagulate. This process reportedly begins at 30°C and is completed by 60°C in several species of fish (Koval'chuk, 1954; Simidu and Simidu, 1960).

Rasekh et al. (1970) in a study designed to measure tuna quality, reported that even though consumer panel members were instructed to consider texture preference, they were influenced in their ratings first by the appearance of the fish, second by its flavor and only third by its texture. Nevertheless, as a result of the extreme softness reported in canned whitefish (Lantz, 1966; Anonymous, 1966), it was felt that preference might well be more dependent on texture in this fish than it was in canned tuna.

Flavor of Canned Whitefish

The flavor of experimentally canned lake whitefish has been described as pleasant, desirable, mild, acceptable and containing sweet fish aromatics. Lower quality packs in this developmental work exhibited an undesirable sulfide note thought to be indicative of some spoilage in the fish before it was canned (Anonymous, 1966, 1967).

The origins of the desirable flavors in whitefish have yet to be defined chemically, although they may be partially dependent on ribonucleotide content. Hiltz et al. (1969) reporting on the work of many researchers, reviewed nucleotide degradation in many fish species. The usual sequence of events in fish muscle is as follows:

ATP - ADP - AMP - IMP - Inosine - Hypoxanthine

The speed of these reactions is species dependent. The usual method of measuring the rate of reaction is to measure hypoxanthine, the end product.

Woskow (1969) demonstrated the flavor modifying effects of a 50 : 50 mixture of 5' disodium inosinate (IMP) and 5' disodium guanylate (GMP). In his study, the ribonucleotides enhanced sweetness and saltiness and suppressed sourness and bitterness.

It may be suggested that the flavor of canned whitefish is at least partially dependent on its ribonucleotide content, especially since addition of these substances has been shown to enhance pleasant flavor of canned whitefish (Anonymous, 1967). Furthermore, unpublished work in these laboratories has shown that the chickeny flavor, measured by a panel trained in profile techniques, was enhanced by addition of ribonucleotides to the whitefish before canning.

In the absence of precise chemical information, the flavor of fish in general, and of whitefish in particular, is largely confined to sensory definition. Even within this area, most reports deal with the development of spoilage flavors, hence such work has been confined mainly to the description of negative characteristics. However, work by Shewan et al. (1953) gave some idea of what top quality fish flavor should be. It can be seen from Table I that loss of freshness is first evidenced by a loss of flavor rather than occurrence of off flavors, although sourness and bitterness do occur in later stages of deterioration.

As opposed to scalar analysis, the flavor profile method of descriptive analysis devised by Arthur D. Little, Inc., of Cambridge, Massachusettes and reported by Cairncross and Sjostrom (1950) demands more definition of positive flavor characteristics. This method described in detail by Caul (1957) has been designed for use with highly trained panelists who describe the order in which flavor notes are perceived, their intensity and the overall flavor impression (OAI) in relation to an agreed upon prototype. A "good" flavor described by this method of analysis will have several flavor notes occurring close together with desirable ones of high intensity.

In contrast to data obtained from other types of panels, data obtained by profile panels are not statistically analyzed. Instead, a composite profile is agreed upon by all panel members after discussion.

There are several disadvantages to the flavor profile method, including the length of time required for training, the possible dominance by one of the members of the group, and the fact that the final profile does not consist of independent observations and, therefore, results may not be statistically analyzed (Amerine et al. 1965). Nevetheless, a major advantage to the method, in addition to its sensitivity to small changes in flavor is its reproducibility (Caul, 1957). Discussion at the

TABLE I

FLAVOR SCALE FOR STEAMED FISH (SHEWAN *ET AL.*, 1953)

Flavor	Score
Fresh, sweet flavors characteristic of the species	10
Some loss of sweetness	9
Slight sweetness and loss of the flavor characteristic of the species	8
Neutral flavor, definite loss of flavor but no off flavors	7
Absolutely no flavor, as if chewing cotton wool	6
Trace of off flavors, some sourness but no bitterness	5
Some off flavors, and some bitterness	4
Strong bitter flavors, some rubber-like and slight sulphide-like flavors	3
Strong bitter flavors but not nauseating	1
Strong putrid flavors (e.g. sulphides) tasted with difficulty	0

end of the session is intended to stimulate panel members to increase their acuteness and reliability, and to foster interest and self-confidence (Cairncross and Sjostrom, 1950).

Texture of Canned Whitefish

As with other flesh foods, the texture of cooked fish hinges upon changes in proteins during heating. During cooking the myofibrillar proteins denature and coagulate. Coagulation of muscle proteins apparently begins at approximately 30°C and is completed at 60°C (Koval'chuk, 1954); Simidu and Simidu, 1960). The connective tissue protein, collagen, hydrolyzes to gelatin at a lower temperature than mammalian collagen (Connell, 1962, Connell, 1964).

As proteins denature they lose their ability to bind water (Van Den Broek, 1965; Lassen, 1965). Also, some of the fat which has been dispersed throughout the muscle is released (Stansby and Dassow, 1951). The net effect of thermal treatment on fish, then, is formation of free fluid made up of water released from the tissue, fat, and gelatin, together with coagulation of the myofibrillar proteins. In normal cooking, protein coagulation increases flesh firmness; however, the excessive heat of canning is known to induce softness in both salmon and whitefish (Mann, 1969; Lantz, 1966).

Textural quality of fish has been estimated instrumentally with various shearing devices such as the textometer used with canned salmon (Mann, 1969) and the shear press used with tuna (Rasekh et al., 1970). The disadvantage of these devices is that they measure mainly resistance to shear, while it is recognized that texture, as a sensory modality is relatively complex.

Rasekh *et al*. (1970) described certain mechanical aspects of tuna texture, firmness measured by compression, fiber strength measured by shearing, and mouth-melting quality measuring by noting the change in resistance to shear over repeated shearing actions. Moisture characteristics were measured by compression at various levels of force. These instrumental measurements were related to scalar analyses by a trained sensory panel and by consumer panels.

However, the bulk of the work in the literature described one or more of an assortment of textural differences. Therefore, this author attempted to group the observations made by many workers into the kind of classifications defined by Szczesniak (1963) in order to describe desirable fish texture.

Szczesniak (1963) sorted textural characteristics of foods in general into three distinct classes (Table II). Mechanical characteristics depend on the reaction of the food to stress. Geometrical characteristics are dependent on the constituents of the food, and are mainly sensed visually, although, if sufficiently pronounced, they may produce an oral sensation. "Other" characteristics are defined as factors which cannot be described as either mechanical or geometrical properties (Szczesniak, 1963).

Brandt *et al*. (1963) developed the concept of texture profiles, similar to flavor profiles, using the scales devised by Szczesniak *et al*.(1963). The texture profile was defined by Brandt *et al*. (1963) as the "organoleptic analysis of the texture complex of a food in terms of its mechanical, geometrical, fat and moisture characteristics, the degree of each present, and the order in which they appear from first bite through complete mastication" (Table III).

TABLE II

RELATIONS BETWEEN TEXTURAL PARAMETERS AND POPULAR NOMENCLATURE (SZCZESNIAK, 1963)

Primary Parameters	Secondary Parameters	Popular Terms
Mechanical characteristics		
Hardness		Soft-firm-hard
Cohesiveness	Brittleness	Crumbly-crunchy-brittle
	Chewiness	Tender-chewy-tough
	Gumminess	Short-mealy-pasty-gummy
Viscosity		Thin-viscous
Elasticity		Plastic-elastic
Adhesiveness		Sticky-tacky-gooey
Geometrical characteristics		
Particle size and shape		Gritty,grainy,coarse,etc.
Particle shape and orientation		Fibrous,cellular,crystalline,etc.
Other Characteristics		
Moisture content		Dry-moist-wet-watery
Fat content	Oiliness	Oily
	Greasiness	Greasy

TABLE III

PROCEDURE FOR EVALUATING TEXTURE (BRANDT *ET AL.*, 1963)

- Initial (perceived on first bite)
  - Mechanical
    - hardness
    - viscosity
    - brittleness
  - Geometrical
    - any, depending upon product structure
- Masticatory (perceived during chewing)
  - Mechanical
    - gumminess
    - chewiness
    - adhesiveness
  - Geometrical
    - any, depending upon product structure
- Residual (changes made during mastication)
  - rate of breakdown
  - type of breakdown
  - moisture absorption
  - mouthcoating

Using the appropriate textural characteristics as defined by Szczesniak (1963), and descriptions of fish texture made by other authors, a fairly accurate description of good canned fish texture can be formulated.

Hardness

The literature agrees that fish should be neither too hard nor too soft. Unlike meat in which tenderness is the ideal (Cover, and Hostetler, 1960), Dyer and Dyer (1949) said that cod muscle should be firm, tender, should flake well and should be moist. Vaisey et al. (1969) adapted scales used by Baines and Shewan (1965). Their judges agreed that a firm, resilient texture was ideal for smoked freshwater whitefish (Coregonus clupeaformis). Both mushiness and toughness were thought to be less than ideal. Excess softness was described as detrimental in canned salmon (Bolton, 1969) and in pilchards (Van Den Broek, 1965) while rubberiness, stringiness, and extreme chewiness were described as qualities attributed to lower quality cod (MacCallum et al., 1968). From these results, it appears that moderately firm fish flesh is desirable.

Flakiness

Flakiness in fish is a common test of doneness. Before cooking, the flakes of fish, i.e. the myotomes, are held together by thin strands of connective tissue. During the cooking process, the collagen in the connective tissue hydrolyzes to gelatin, the myotomes separate and the flaky texture characteristic of cooked fish is formed.

Fibrousness

Fibrousness has been found to be detrimental to the texture of several kinds of fish. Stansby and Dassow (1951) reported that freezing salmon before canning resulted in a firmer texture of the fish. This firmness was desirable when present only to a slight extent, but when the fish became dry, "woody" and excessively tough, it was no longer acceptable. Increased fibrousness also resulted in a lowering of texture scores for frozen cod (MacCallum et al., 1966).

Mealiness

Mealiness occurs as an undesirable textural characteristic in several animal protein foods. Cover and Hostetler (1960) described mealiness in beef. In their study, high scores for crumbliness were given to the meat when the fibers broke readily across their long axis into very small pieces. Cover said "high scores for crumbliness were associated with tiny, hard dry particles which seemed to roll out of the connective tissue network".

Mealiness in frozen cod results in a lowering of overall texture score. MacCallum et al. (1968) demonstrated that disappearance of mealiness in frozen-stored cod resulted in texture scores remaining the same or even increasing, even though at the same time, undesirable toughness increased. Mealiness in smoked goldeye can be so undesirable that Lantz and Iredale (1969) undertook a study to determine the effects on mealiness of smoking temperature and cooking method in an attempt to minimize this characteristic.

Moisture Characteristics

A moderate rate and amount of moisture release would appear to be desirable in fish. In canned fish, too much water released from the proteins during the sterilization process is undesirable since it results in unattractive packs by diluting sauces or oil. Also if fish shrinks excessively after it is packed in the can, it takes on a shrunken appearance. In addition, the fish cannot be packed tightly enough to prevent damage during shipping. Removal of some of the water is a common pre-canning treatment given to sardines (Meesemaecker and Sohier, 1959) and tuna (Lassen, 1959). In sardines, the amount of free water in the can must not exceed 2.5 - 3% for sardines labled "Extra" fancy (Fourgoux and Cheftel, 1956 and 1963).

Too little moisture in fish can also be detrimental. Kelly (1969) found that dryness in cod was related to lowered acceptability. Excess dryness is a problem which occurs along with toughness in salmon canned after freezing, (Stansby and Dassow, 1951). In appraising smoked whitefish, panelists in a study by Vaisey et al. (1969) agreed that the fish should be moist.

Oiliness

Too little rather than too much oiliness seems to be a problem with fish texture. One reason frozen salmon is unsuitable for canning is because freezing causes a decrease in the amount of desirable free oil (Stansby and Dassow, 1951). It has even been proposed that allowances be made for a large volume of free oil when grading canned salmon, even though increased oil is associated with softness (Bolton, 1969). The best sardines for canning are those containing 10 - 15% fat (Cheftel, 1965). In Scandinavia, sardines must have at least 7% fat to be canned, and the canned product must have a final oil content of at least 30% for fancy qualities and 28% for other grades (Stenstrom, 1965). Thus it appears that a high fat content is desirable in canned fish.

In conclusion, it appears that a canned whitefish product should:

1) retain the desirable flavor described by Arthur D. Little, Inc., especially if the sulfide note can be eliminated.

2) be moderately firm.

3) be flaky.

4) not be excessively fibrous.

5) not be mealy.

6) have a moderate rate and amount of moisture release.

7) contain a fair amount of oil.

To achieve these ends, fish can either be given pre-canning treatments which would change the flesh to meet these standards, or fish for canning can be selected on the basis of the presence of these attributes. In the present study, freezing and drying were used as pre-canning treatments. In addition, fish were sorted according to sex and season of catch in an attempt to explain the variability in canned whitefish.

Pre-Canning Treatments

Freezing

The process of freezing results in textural changes in fish flesh. Progressive toughening of frozen stored fish flesh accompanied by a decrease in protein soluble in cold, neutral, 5% NaCl has been demonstrated in many species of marine and freshwater fish, such as cod (Dyer, 1951), plaice (Dyer and Morton, 1956), rosefish (Dyer et al., 1956) and whitefish (Awad et al., 1969).

Tanaka (1965) demonstrated that this toughness was species dependent and seemed related to the amount of intracellular freezing, measured histologically. Studying frozen Alaska pollack and yellowtail, he demonstrated that development of toughness and rate of actomyosin denaturation was greater in Alaska pollack, which showed extracellular freezing, than in yellowtail, which showed intracellular freezing (Figure 1). Electron micrographs showed that, over the 12-month storage period, the myofilaments of Alaska pollack, only, became fibrous. This was thought to be due to dehydration of the myofilaments by the movement of the intracellular water to the extracellular field, since when

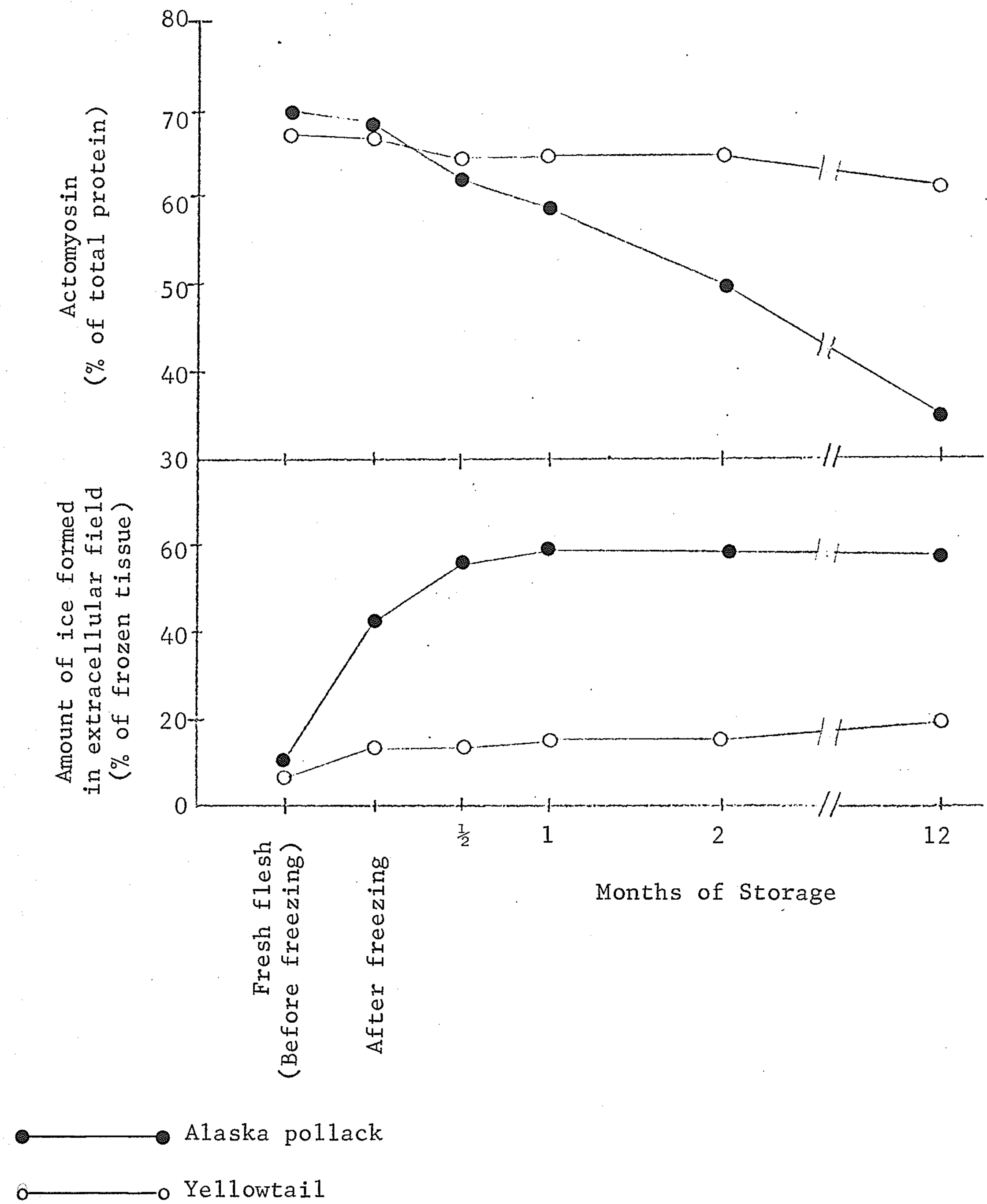


FIGURE 1

RELATION BETWEEN DENATURATION OF ACTOMYOSIN AND THE AMOUNT OF EXTRA-CELLULAR ICE IN FROZEN, STORED FISH FILLETS (TANAKA, 1965) actomyosin was extracted from the 2 kinds of fish and frozen stored, the rates of actomyosin denaturation were the same for both species of fish.

Awad et al. (1969) found that storage of whitefish fillets at $-10^{\circ}C$ resulted in increased toughness and decreased soluble protein. Since no fresh control was used, the effects of freezing followed by immediate thawing are not known. However, since the decrease in amount of soluble protein of whitefish flesh during frozen storage is comparable to that found by Love and Ironside (1958) in cod (Figure 2), it might be expected that changes in cod flesh during freezing and immediate thawing would be good predictors of changes in whitefish flesh given similar treatment.

The amount of protein soluble in cold, neutral 5% NaCl solution has been related to organoleptically evaluated toughness in cod (Dyer, 1951) and is known to decrease with freezing followed by immediate thawing (Love and Ironside, 1958). They reported that freezing and thawing cod fillets reduced soluble protein from 96% for unfrozen fish to approximately 87% for fish frozen and immediately thawed. The rate of freezing did not seem to have an effect on soluble protein.

Using the paired fillet technique, in which one fillet from a fish was frozen and thawed and then compared, in the same tasting session with the unfrozen fillet, Connell and Howgate (1968) demonstrated organoleptically evaluated differences between fresh and frozen fish. When fresh cod was compared with that which had been frozen and thawed immediately, the fresh fish was found to be significantly softer and more moist than that which had been frozen. These results are in agreement with those of Luijpen (1957) who stated that toughness in frozen fish is always greater than that of unfrozen fish.

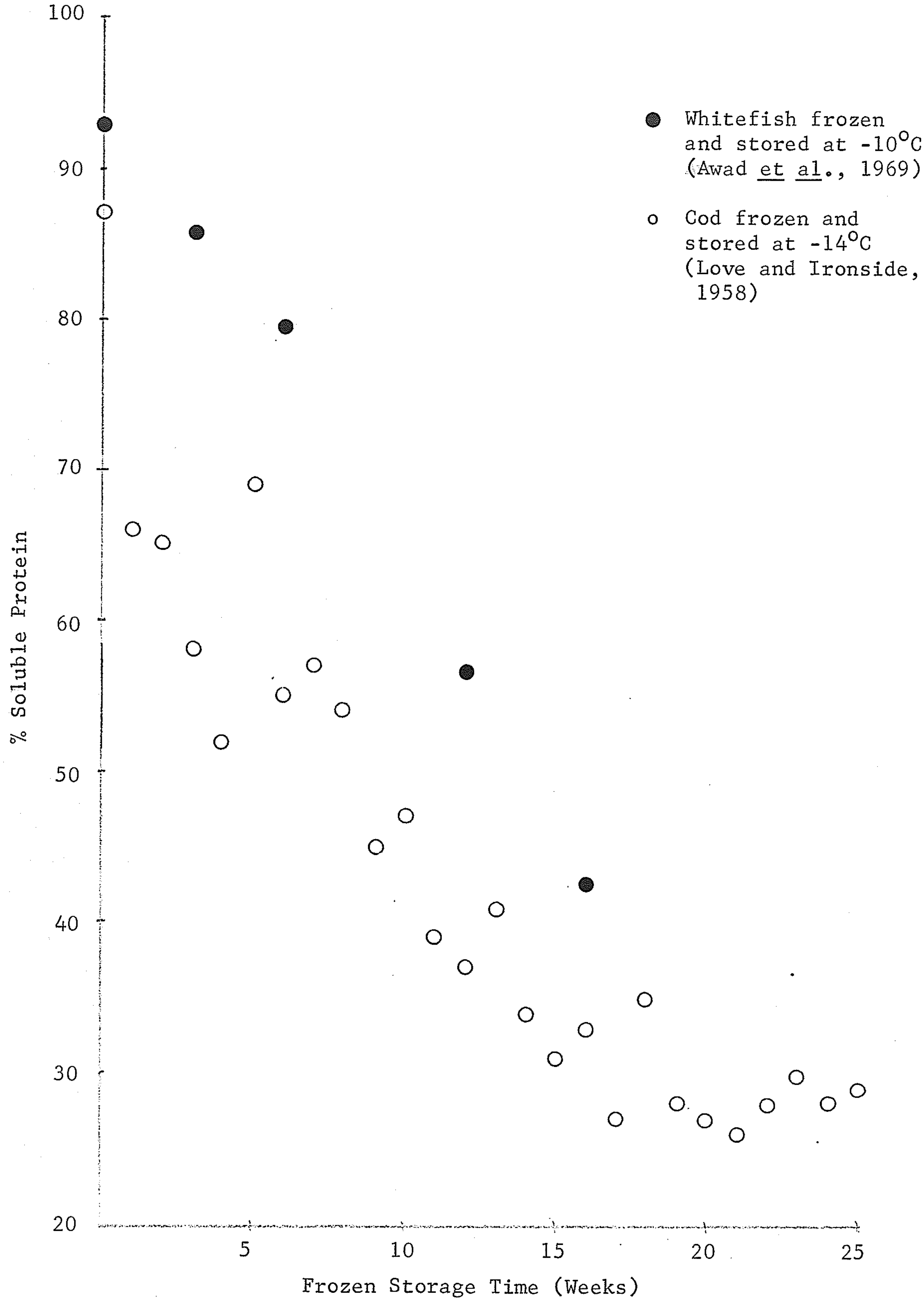


FIGURE 2

INFLUENCE OF FROZEN STORAGE ON PROTEIN SOLUBILITY IN WHITEFISH AND COD

Thus it seems possible that freezing before canning whitefish might result in a firmer product.

Freezing is commonly used as a method of preserving tuna before canning. The quality of the canned product is usually not affected. However, before canning, the fish receives a pre-cook treatment, unlike salmon which is cooked in the can. Since whitefish is canned much like salmon, the effect of freezing on canned salmon must be examined.

Stansby and Dassow (1951) reported that frozen, thawed salmon could not be successfully canned. During frozen storage, the fish deteriorated due to bacterial action and oxidation of pigments and oils, problems which could be overcome by proper handling techniques. In addition, increased curd formation occurred in the frozen, canned fish; however, this was a factor of small importance in lighter colored salmon. Curd formation would probably affect canned whitefish only to a small extent due to the pale color of whitefish flesh.

Stansby and Dassow (1951) also noted a decrease in free oil in the fish canned from frozen salmon, probably as a result of binding of the oil as described by Bilinski et al. (1966) and Bilinski and Clement (1967), who hypothesized that physical changes in proteins, resulting in a more fibrous texture, might be less favorable for the release of oil from the tissue during canning. This decrease in free oil is detrimental to salmon acceptability (Stansby and Dassow, 1951).

Increased firmness and dryness were associated with salmon canned from frozen fish (Stansby and Dassow, 1951). These changes were described as detrimental to canned salmon, but may be desirable in canned whitefish which is excessively soft.

For these reasons, the effect of pre-canning freezing on the characteristics of canned whitefish was studied.

Drying

Lantz (1966) reported that drying freshwater fish to a moisture loss of 20% resulted in a canned product with no free liquid in the cans and with a satisfactory appearance. Del Valle and Nickerson (1968) described the transport of water during drying as a two-stage process; diffusion of water from the interior of the fish, followed by evaporation from its surface.

Since dehydration of actomyosin is known to cause its insolubilization (Hunt and Matheson, 1958; Tanaka, 1965) and since insolubilization of myofibrillar proteins has been related to toughness in fish (Dyer, 1951; Tanaka, 1965) dehydration of fish should result in a firm canned product.

Causes of Variability in Fish

Sex Variation

Although protein content of fish flesh is not related to sex in such fish as Baltic herring (Kordyl, 1951), barracuda (Jowette and Davis, 1938), cod, haddock and coalfish (Lucke, 1949), it has been shown (Jowette and Davies, 1938) that in salmon, at least, the female fish contain proportionally more protein than the males (Table IV).

It has been suggested (Lantz, personal communication) that the flesh of female whitefish gapes more than that of male fish. Gaping in cod has been related to the biological condition of the fish. Cod fillets from healthy fish gaped much more than those from spent or starved fish (Love and Robertson, 1968). Fish which have been starved and are therefore in poor condition, tend to have a lower fat and protein content than fed fish (Love, 1958); for example, cod in poor condition were found to be extremely soft (Love, 1958). The higher incidence of gaping in female

TABLE IV

THE INFLUENCE OF SEX ON THE COMPOSITION OF FISH FLESH (JOWETT AND DAVIES, 1938)

Species	Stage of the Sexual Glands	Sex	Protein (% Fresh Weight)
Australian salmon	Immature	M	20.6 - 21.2
		F	22.8
	Mature	M	20.0
		F	20.6
Barracuda	At maturity	M	22.5
		F	21.8 - 22.2
Sea mullet	Immature	M	20.5
		F	18.4

whitefish suggests that their condition may be better than that of the male fish, that they may contain more protein and fat, and therefore, the female fish may have firmer flesh than the males.

Seasonal Variation

Variations in the composition of fish and factors affecting these variations have been studied by a number of workers. Dambergs (1964), working with uniform size Nova Scotia inshore cod, found that fat and protein contents of cod flesh were lowest during March and April, when the fish were spawning (Figure 3). Conversely, water content and water solubles content were at peak levels during spawning (Figure 4). Although starvation is known to increase the water content of cod (Love, 1958), spawning rather than feeding pattern appeared to account for the variation in Damberg's study since in the spawning cod the occurrence of empty stomachs did not exceed 20%, a figure considered by Dambergs to be normal for the size of fish studied. Similarly, Ironside and Love (1958) could find no shortage of food or loss of appetite during spawning of North Sea cod, although the fish did not accept bait.

Spawning cycle and not food consumption also determines the composition of Sockeye salmon flesh. Tomlinson et al. (1967) found that feeding the usually fasting Sockeye salmon after they had left the ocean to spawn had little effect on changes occurring in the flesh. As in cod, the principal change associated with spawning was an increase in water content of the flesh.

Variations in the water content of fish flesh result in textural changes. Love (1958) reported that the flesh of starved cod, containing more water than fed fish, was semi-liquid and sloppy. The flesh of starved fish did not develop any white curd when steamed.

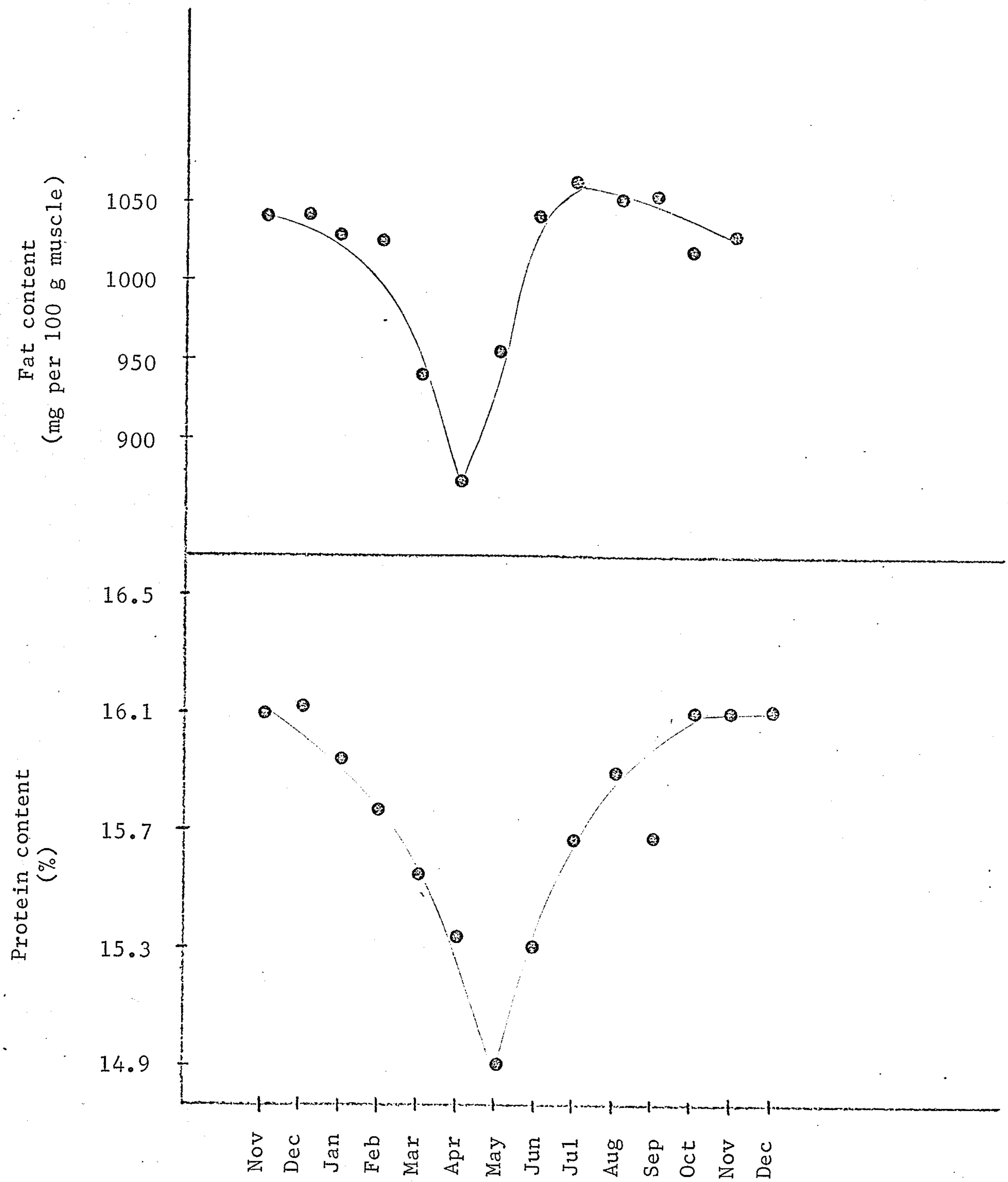


FIGURE 3

SEASONAL VARIATIONS IN THE FAT AND PROTEIN CONTENTS OF COD FILLETS (DAMBERGS, 1964)

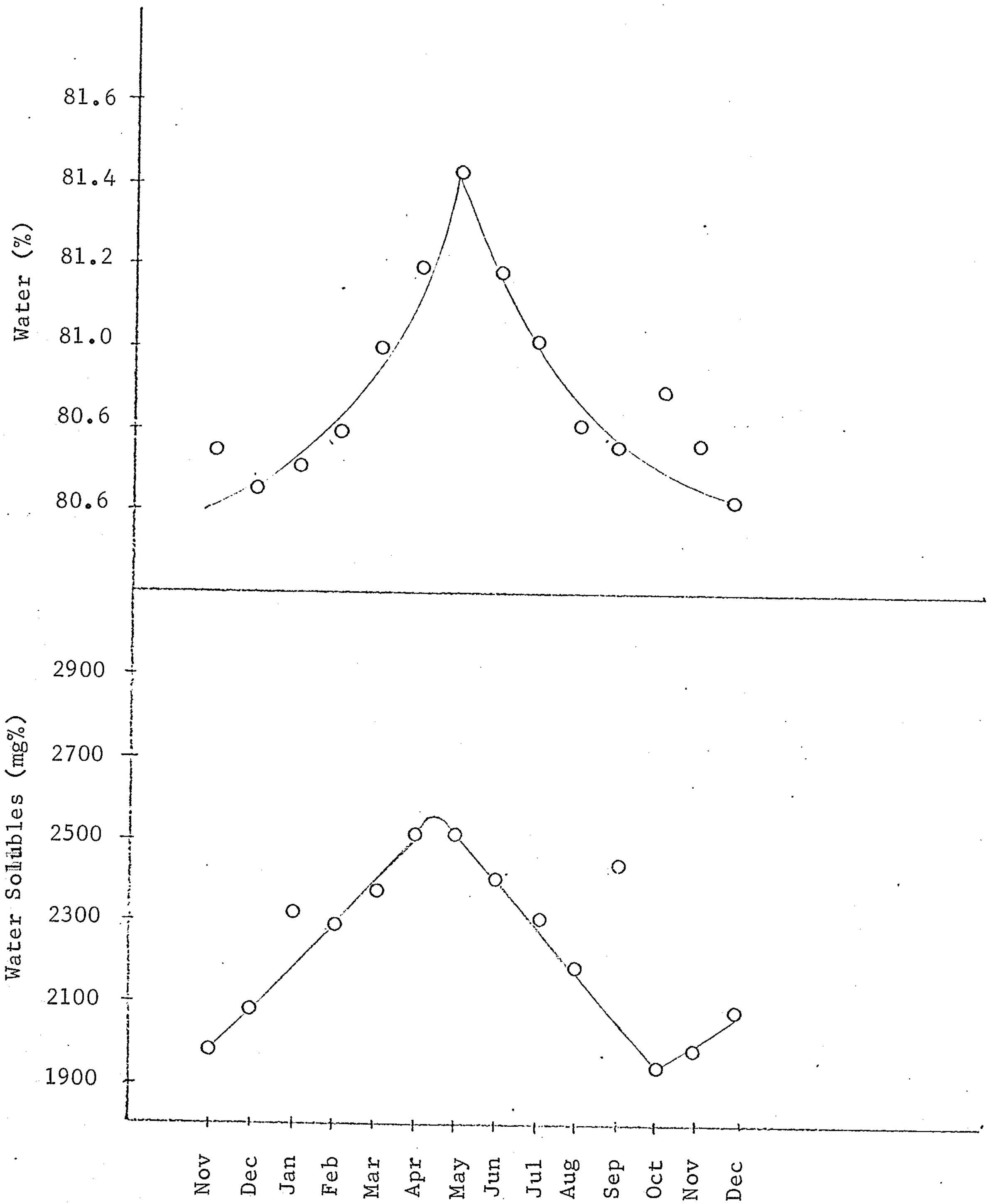


FIGURE 4

SEASONAL VARIATIONS IN THE WATER AND WATER SOLUBLES CONTENT OF COD FILLETS (DAMBERGS, 1964)

Whitefish are known to spawn in October and November when the water cools. During spawning the fish leave the bottom of the lake and stop feeding (Quadri, 1968). It might be expected that the fat and protein contents of the flesh are depleted during this time, giving rise to the soft flesh similar to that noted by Love (1958) in cod. Since excessive softness is a serious problem in any canned, freshwater fish (Lantz, 1966), autumn-caught whitefish might be a poor choice for canning.

METHOD

A factorial design as described by Steel and Torrie (1960) was used to determine the influences of two pre-canning treatments, freezing and partial drying, and two methods of selecting fish for canning, by sex and by month of catch on the flavor and texture of canned freshwater whitefish (Coregonus clupeaformis). These influences were assessed using both organoleptic and instrumental measurements. The experimental plan can be seen in Figure 5. The eight treatments per month were evaluated over eleven catches, giving rise to 88 treatment combinations.

Fish used for the study was caught by gill net at approximately one month intervals from June, 1969 to June, 1970 in William Lake, Manitoba. Whole, ungutted fish were packed in ice in styrofoam boxes and trucked to the Freshwater Institute, Fisheries Research Board, University of Manitoba campus for processing. Upon arrival at the Freshwater Institute laboratories, the fish were filleted and sorted by sex during filleting. Each group was further sorted into 4 lots of approximately equal weight, and assigned to the pre-canning treatments shown in Figure 5.

The drying times and temperatures varied slightly. Fish caught in June, July, August, September and October, 1969 were dried in a stainless steel kiln[1] where temperatures could be readily controlled. All fish caught during these months were dried for 60 minutes at 52°C. Smoky flavors were evident in fish dried by this method, even though there was no smoke introduced into the kiln, and inside walls were cleaned before the drying process began. However, in order to limit smoke flavor from latent tars in the kiln ducts, fish caught after October were dried in a

[1] Stainless steel kiln. Designed by Alkar-Rasmussen Engineering Ltd., Box 196, Lodi, Wisconsin.

Month of Catch	Sex	Freezing Treatment	Drying Treatment	Symbol
June, 1969- June, 1970 (11 catches)	Male	Fresh	Not dried	MFr
			Dried(2)	MFrD
		Frozen(1)	Not dried	MFo
			Dried(2)	MFoD
	Female	Fresh	Not dried	FFr
			Dried(2)	FFrD
		Frozen(1)	Not dried	FFo
			Dried(2)	FFoD

(1) Sharp frozen at -40°C, stored overnight at -37°C and thawed.

(2) Drying conditions varied as indicated in the text.

FIGURE 5

EXPERIMENTAL PLAN FOR EVALUATING THE EFFECTS OF MONTH OF CATCH, SEX, FREEZING AND PARTIAL DRYING ON CANNED WHITEFISH CHARACTERISTICS.

special drying chamber designed by the Freshwater Institute. The maximum and minimum temperatures occurring during the drying cycle were recorded. It can be seen in Table V that the drying times and temperatures varied considerably for fish dried in the drying chamber, although drying losses were no more variable than those fish dried in the kiln.

After being subjected to the appropriate pre-canning treatments, the fillets were cut into steaks, packed in ¼ lb. enamelled cans, a salt pellet (½ tsp.) was added, the cans were sealed under vacuum and sterilized at 115°C for 60 minutes. After cooling the cans were labelled and stored at room temperature for at least 30 days to obtain good flavor and aroma distribution (Anonymous, 1966). After this aging period, the cans of fish were refrigerated in household-type refrigerators until evaluation.

Organoleptic Evaluation

"Consumer" Panel Evaluation

The flavor and texture of whitefish from each catch with the exception of May, when there was insufficient sample, were evaluated separately by a consumer-type panel consisting of 60 untrained judges. Panelists were undergraduate and graduate students and staff members from various departments in the University of Manitoba. No attempt was made to obtain the same panelists every session.

Panel sessions were held in an air-conditioned foods laboratory. As a result of the large number of samples involved (8 for flavor evaluation and 8 for texture evaluation by each panelist) it was impossible to have all the panelists taste on the same day, so duplicate panels of 30 members each were held on Monday and Tuesday afternoons of the same week.

Small chunks of fish were portioned into ¾ oz. coded plastic

TABLE V

DRYING TEMPERATURES, TIMES, AND LOSSES OF WHITEFISH FILLETS

Catch	Drying Temperature (°C)	Drying Time (minutes)	Drying Losses (% original weight)			
			Male		Female	
			Fresh	Frozen	Fresh	Frozen
June, 1969	52	45	14.0	12.5	11.3	9.7
July	52	45	7.9	8.9	10.3	7.2
August	52	45	11.5	10.8	8.4	8.8
September	52	45	11.9	9.2	11.6	11.4
October	52	45	5.0	7.4	10.5	10.1
January	24 - 29	85	6.7	8.2	7.0	7.0
February	43 - 52	85	11.8	12.2	10.3	9.0
March	40 - 54	60	7.3	10.0	6.1	9.2
April	49 - 66	60	7.3	7.8	8.0	6.6
May	49 - 60	60	5.6	7.0	6.2	7.2
June	49 - 63	60	4.7	6.0	7.8	7.7

creamers*, covered with cardboard lids and refrigerated until evaluation. Panelists were asked to arrive at the taste panel area between 1 and 3 P.M. When each arrived, he was seated in an individual booth and served, in a randomized order, eight coded samples of whitefish for flavor evaluation. Questionnaires used were 9-point hedonic scales similar to those described by Larmond (1967). A sample questionnaire used for flavor evaluation can be seen in Figure 6. The eight samples evaluated consisted of fish from the same catch given the pre-canning treatments seen in Figure 5.

When the flavor judging was completed, both the tray containing the samples and the questionnaire were removed and panelists were given a second set of 8 samples and questionnaire (Figure 7), this time to evaluate fish texture. The samples for texture evaluation had different codes and were served in a different order than those for flavor evaluation. Different colored questionnaires, yellow for flavor and white for texture simplified service, since panelists were always given samples for flavor evaluation and yellow questionnaires first.

Unsalted soda crackers and water were provided, and panelists were requested to use both between samples. All samples and rinsing materials were swallowed or not, as desired. At the end of the session, panelists were given rewards of lemonade, candy and quarters and were thanked for participating.

The Profile Method

A 6-member panel consisting of graduate students and staff members of the Department of Foods and Nutrition, University of Manitoba who were willing to participate in the study were trained in flavor and texture profile techniques. All members of the group had previously taken part

* Lily brand.

FLAVOR HEDONIC SCALE

CANNED WHITEFISH

Name ______________ Date ______________

Taste these samples and check how much you like or dislike the FLAVOR of each one.
REMEMBER YOU ARE THE ONLY ONE WHO CAN TELL WHAT YOU LIKE.

Code ______	Code ______	Code ______	Code ______
Like Extremely ______	Like Extremely ______	Like Extremely ______	Like Extremely ______
Like Very Much ______	Like Very Much ______	Like Very Much ______	Like Very Much ______
Like Moderately ______	Like Moderately ______	Like Moderately ______	Like Moderately ______
Like Slightly ______	Like Slightly ______	Like Slightly ______	Like Slightly ______
Neither Like Nor Dislike ______	Neither Like Nor Dislike ______	Neither Like Nor Dislike ______	Neither Like Nor Dislike ______
Dislike Slightly ______	Dislike Slightly ______	Dislike Slightly ______	Dislike Slightly ______
Dislike Moderately ______	Dislike Moderately ______	Dislike Moderately ______	Dislike Moderately ______
Dislike Very Much ______	Dislike Very Much ______	Dislike Very Much ______	Dislike Very Much ______
Dislike Extremely ______	Dislike Extremely ______	Dislike Extremely ______	Dislike Extremely ______
Comments	Comments	Comments	Comments

For analysis of the data, the above terms were given numerical values from 1 = Dislike extremely to 9 = Like extremely.

FIGURE 6

QUESTIONNAIRES USED BY "CONSUMER" PANEL TO EVALUATE CANNED WHITEFISH FLAVOR

TEXTURE HEDONIC SCALE

CANNED WHITEFISH

Name ____________________ Date ____________________

Taste these samples and check how much you like or dislike the TEXTURE of each one.
REMEMBER YOU ARE THE ONLY ONE WHO CAN TELL WHAT YOU LIKE.

Code ________	Code ________	Code ________	Code ________
Like Extremely ______	Like Extremely ______	Like Extremely ______	Like Extremely ______
Like Very Much ______	Like Very Much ______	Like Very Much ______	Like Very Much ______
Like Moderately ______	Like Moderately ______	Like Moderately ______	Like Moderately ______
Like Slightly ______	Like Slightly ______	Like Slightly ______	Like Slightly ______
Neither Like Nor Dislike ______	Neither Like Nor Dislike ______	Neither Like Nor Dislike ______	Neither Like Nor Dislike ______
Dislike Slightly ______	Dislike Slightly ______	Dislike Slightly ______	Dislike Slightly ______
Dislike Moderately ______	Dislike Moderately ______	Dislike Moderately ______	Dislike Moderately ______
Dislike Very Much ______	Dislike Very Much ______	Dislike Very Much ______	Dislike Very Much ______
Dislike Extremely ______	Dislike Extremely ______	Dislike Extremely ______	Dislike Extremely ______
Comments	Comments	Comments	Comments

For analysis of the data, the above terms were given numerical values from

1 = Dislike extremely to 9 = Like extremely.

FIGURE 7

QUESTIONNAIRES USED BY "CONSUMER" PANEL TO EVALUATE CANNED WHITEFISH TEXTURE in various other sensory panels, although none had had previous experience with descriptive analysis.

Although the flavor and texture profile panels will be discussed together, panelists were not trained for flavor and texture evaluation at the same time. No rigid schedule was followed because different types of training took different amounts of time. For example, it took several days to become acquainted with all the texture scales, but the basic tastes, sweet, sour, salt and bitter could easily be tasted the same day.

Training Sessions. Training sessions for flavor and texture evaluation took place between September, 1968 and October, 1969. There were five relatively separate stages in training the profile panel members. The first stage was to have panelists became familiar with the terms which might later be useful in evaluating the fish. In order to acquaint them with terms used in texture description, panelists were presented with the various texture scales devised by Szczesniak *et al.* (1963) and examples of the geometrical characteristics as defined by Brandt *et al.* (1963). Samples of the four basic tastes and examples of food irritants, including astringency, pungency, tickling, tingling and cooling were presented to panelists in order to acquaint them with terms used in flavor description.

During the second stage of training, either the texture scales or the examples of taste and feeling factors were presented along with samples of fish. The texture scales were presented with samples of canned whitefish and other canned fish and meat products, including turkey, chicken, salmon, tuna and sardines, to acquaint panelists with the range of textural characteristics occurring in canned fish and meat products. For flavor training, panelists were provided with whitefish from two different lakes, Lake Winnipeg and Cedar Lake, which had been given various pre-canning treatments, along with examples of taste and feeling factors.

After panelists had become familiar with both the rating scales and whitefish, the third stage of training was begun. During this time, practice profiles were drawn up by the panelists, and the descriptive terms used were clarified by discussion. The scales which were felt to be useful in describing fish texture and flavor were retained; those which were not useful were discarded. Several terms not found in the original scales were added. Texture terms which were retained included hardness, chewiness, flakiness, fibrousness, mealiness and oiliness. Chewiness was later discarded because of the great variability among judges in its evaluation. The term fibrousness was later called tendency to felt, because this phrase was thought to convey more clearly, the concept of amount of fibrousness present rather than the size of the fibers. It was decided that moisture characteristics of the fish could best be described in two terms; the rate at which the moisture was released from the fish and the total amount of moisture present (RMR and AMR respectively).

It was agreed that the four basic tastes were all useful in describing fish flavor, but several other associative terms were also needed for accurate flavor description, including chickeny, fishy and smoky.

During the fourth stage of training, anchored scales for as many of the texture and flavor terms as possible were formulated. The points on the scales were)((threshold) 1, 2, and 3. The anchored scales used for texture evaluation are shown in Table VI, and two verbal scales, for flakiness and texture overall impression (OAI) are shown in Table VII. The agreed-upon methods of evaluating each of the texture characteristics are

TABLE VI

ANCHORED SCALES USED BY PANELISTS FOR TEXTURE PROFILES

Parameter	Intensity	Food Product[1]	Brand	Particulars
Hardness	)(	Cream cheese	Philadelphia	-
	1	Gelatin gel[2]	Carmel Kosher	10.5 g. gelatin + 1 tbsp. sugar + 1 c. water
	2	Gelatin gel[2]	" "	14.0 g. gelatin + 1 tbsp. sugar + 1 c. water
	3	Gelatin gel[2]	" "	17.5 g. gelatin + 1 tbsp. sugar + 1 c. water
Tendency to Felt	)(, 1, 2	-	-	-
	3	Canned tuna	Gold Leaf	Flaked, white tuna
Mealiness	)(	Green Pea Soup	Campbell's	Diluted 1:3 (v/v) with water
	1	" " "	"	" 1:2 " " "
	2	" " "	"	" 1:1 " " "
	3	" " "	"	Undiluted
Rate of Moisture Release	)(	Gherkin	McLaren's	Sweet pickled midget gherkin
	1	Gherkin	Catelli's	Sweet pickled gherkin
	2	Olive	McLaren's	Manzanilla Spanish-Pimento removed
	3	Pineapple chunk	Libby's	-
Amount of Moisture Release	)(, 1, 2			Same as Rate of Moisture Release standard
	3	Pineapple tidbit	Libby's	-
Oiliness	)(	Soda cracker	Weston's	Unsalted
	1	Carleton cracker	Christie's	-
	2	Shortcake biscuits	Peek Frean's	-
	3	Triscuit wafers	Christie's	-

(1) All foods were served at room temperature.

(2) Made by combining gelatin and ¼ C. cold water, adding sugar and ¾ C. boiling water, pouring into a 6-inch round pan, covering with plastic film and refrigerating overnight.

TABLE VII

DEFINITIONS OF FLAKINESS AND TEXTURE OVERALL IMPRESSION OF WHITEFISH USED BY THE PROFILE PANEL

Parameter	Level	Definition
Flakiness	)(	Fish flakes slightly, only. Instead it tends to be mushy.
	3	Flakes separate distinctly and hold their shape.
Texture Overall Impression	)(	Fish is soft, with a rapid rate of moisture release; it felts on mastication to the point of being difficult to swallow and is very mealy.
	3	Fish is fairly firm, with sustained moderate moisture release and minimum tendency to felt and be mealy.

shown in Table VIII.

Anchored scales for flavor evaluation are given in Table IX and descriptions of color, which was evaluated at the same time as flavor, and flavor overall impression (OAI) are given in Table X. In subsequent sessions, profile panel members evaluated the canned whitefish using these anchor points in much the same way as Tilgner's panelists evaluated hot smoked fish against established standards (Tilgner, 1962).

At this time, the questionnaires which would be used for flavor and texture evaluation (Figures 8 and 9, respectively) were drawn up. As can be seen, the questionnaire used for flavor profiles (Figure 8) was much less structured than the one used for texture profiles (Figure 9). This was because flavor notes do not necessarily appear in the same order in different fish samples, but textural characteristics occur in a fairly ordered manner.

During the fifth and final stage of training, canned whitefish flavor and texture were evaluated using all the scales developed in previous training sessions. The fish used was caught in either Cedar Lake or Lake Winnipeg. All the fish evaluated was given the same pre-canning treatments as the fish from William Lake.

Evaluation Sessions. In early work, panel sessions were held in an air-conditioned foods' laboratory, but this area was found to be unsatisfactory because noise and interruptions made it difficult for panelists to concentrate. It was found that an empty class room where the door could be closed and interruptions could be kept to a minimum was more suitable for profile work.

Descriptive analysis panel sessions were held on four days each week at 11:30 A.M. Either the flavor or the texture of two samples of

TABLE VIII

PROCEDURES USED BY PROFILE PANEL TO EVALUATE TEXTURAL PARAMETERS

Parameter	Method of Evaluation
Hardness	Place food between the molar teeth and bite down evenly, evaluating the force required to compress the food.
Flakiness	Judge the ease with which the fish flakes by eye and by gentle separation of flakes with a fork.
Tendency to Felt	Note the compactness of the mass formed during mastication.
Mealiness	Note during mastication the extent of the coating of the mouth with very tiny particles that cling. The number, rather than the size of the particles is to be evaluated.
Rate of Moisture Release	Note the speed with which moisture leaves the food in response to initial pressure of the tongue to palate (for fish) or of force exerted by molars when chewing (for reference standards).
Amount of Moisture Release	Note the amount of moisture released from the food after 3 - 5 chews.
Oiliness	During mastication, look for film formation in the mouth.

TABLE IX

ANCHORED SCALES USED BY PANELISTS FOR FLAVOR PROFILES

Parameter	Chemical	% Concentration in Water (1) Intensity 1	2	3
Sweet	Sucrose (2)	0.2	0.4	0.6
Sour	Citric acid (3)	0.008	0.014	0.016
Salty	Sodium chloride (4)	0.52	1.00	1.50
Bitter	Quinine sulphate (5)	0.0006	0.0012	0.0018
Chickeny	Monosodium glutamate (6)	0.10	0.20	0.30
Smoky	Liquid smoke (7)	0.01	0.02	0.06

(1) All percentages were calculated on a weight/volume basis except liquid smoke which was calculated on a volume/volume basis.

(2) Household type.

(3) Source; Rexall drugs.

(4) Household type, iodized.

(5) Source; T. Eaton Company, Drug Department.

(6) Accent Brand.

(7) Colgin Hickory Liquid Smoke.

TABLE X

DEFINITIONS OF COLOR, AND FLAVOR OVERALL IMPRESSION OF WHITEFISH USED BY THE PROFILE PANEL

Parameter	Level	Definition
Color	3	White to slightly pink Uniform No serious discoloration
	2	Yellow tinge Fairly uniform Slight discoloration
	1	Atypical color (Dark yellow or reddish tinge) Not uniform Discolored
	)(	Very atypical Serious discoloration
Flavor Overall Impression	3	Well blended flavor Strong, pleasant chickeny flavor Other notes typical of fresh canned whitefish No off flavor - (including smoky)
	2	Less well blended flavor Weaker chickeny note Other notes typical of fresh canned whitefish - perhaps a smoky note if still pleasant Very slight off flavors (fishy)
	1	Less well blended flavor Weak chickeny note Other notes masking chickeny flavor - especially smoke. Appreciable off flavors.
	)(	Poorly blended flavor Very weak chickeny note Strong flavors masking chickeny note Very unpleasant off flavors

Name ______________________ Month of Catch ________________

Date ______________________ Lake ________________

Sample Code		
Color		
Flavor Overall Impression		
Initial		
On Mastication		
Residual		

FIGURE 8

QUESTIONNAIRE USED FOR FLAVOR PROFILE ANALYSIS OF CANNED WHITEFISH

Name ______________________ Month of Catch ______________

Date ______________________ Lake ______________

Sample Code		
Flakiness by Eye		
Texture Overall Impression		
<u>First Bite</u> Hardness Rate of Moisture Release		
<u>On Mastication</u> Tendency to Felt Amount of Moisture Release Oiliness		
<u>Residual</u> Mealiness		

FIGURE 9

QUESTIONNAIRE USED FOR TEXTURE PROFILE ANALYSIS OF CANNED WHITEFISH

fish per session were evaluated. All treatments from one catch were evaluated on successive days, but within each catch, treatments were evaluated in random order. To eliminate any sample bias, fish was identified by 3-digit codes. The treatment was made known to the panelists only after evaluation was completed.

Depending on the type of evaluation which was to take place, either the anchored texture rating scales or the anchored flavor rating scales were provided along with the appropriate verbal scales and questionnaires.

Texture reference scales were served in individual portions in fluted paper cups* as can be seen in Appendix Plate A. Sufficient solution of flavor notes for the entire panel were served in small brown bottles. Panelists poured individual samples into fluted paper cups*. Cups of the same type were used to hold individual portions of fish.

The drained contents of each can of fish were served intact to the panel as a whole in coded pyrex custard cups. At least 10 minutes elapsed between the time the cans were opened and the color and flavor were evaluated since a small, unpublished study in these laboratories indicated that within this time, the color of the fish changed from pink to tan. Also during this period, some of the chickeny flavor was lost, and a slight fishiness became apparent. This 10-minute delay was not necessary before texture evaluation.

After each panelist had drawn up either a flavor or a texture profile independently, the panel leader led the discussion to formulate the composite profile. When agreement on the order of appearance or intensity of any parameter of the profile could not be reached, the sample was re-evaluated in later sessions until the composite profile was agreed

* Lily brand.

upon by all panel members.

Instrumental Methods of Evaluation

Force to Shear

An estimate of fish firmness was obtained by measuring the force required to shear drained, individual cans of fish weighing approximately 134 g. (range = 133.0 - 139.0 g.). An Allo-Kramer shear press (Model SP-12 IMP) equipped with a recorder/indicator (Model E2) was used. Measurements were taken using a 5000 lb. proving ring with range set at 10%, so that 100 chart units represented 500 pounds of force.

The drained contents of each can were placed intact in a horizontal position on the floor of the sample cell box assembly of the standard shear-compression cell. The maximum peak height obtained during a 15 second stroke was measured in chart units, which were then transformed into pounds of force. Ten replicates of this measurement were taken for each of the eight treatments every month.

Moisture Characteristics

The moisture characteristics, free, expressible and total fluid of 5 cans of fish from each of the eight treatments were measured for every catch except April and May, when only expressible fluid was measured.

Free Fluid. To measure free fluid, each can of fish, weighing approximately 134 grams was opened and inverted for 20 seconds over a funnel draining into a 25 ml graduated cylinder, Care was taken not to compress the contents of the can.

Expressible Fluid. An estimate of expressible fluid was obtained by placing the drained fish in the succulometer cell of the Allo-Kramer shear press. The 5000 lb. proving ring was used and the recorder was set on the 20% range. The fish was pressed during a 4 min. 30 sec. stroke until the pen reached a reading of 100 chart units (i.e. total force = 1000 lb.). When 1000 lb. force was reached, the piston was stopped. The fluid expressed through the port in the succulometer cell was collected during compression and for 30 seconds after the plunger had been stopped. Fluid collected by this method was termed expressible fluid.

Total Fluid. The volume of total fluid in the fish was obtained by adding the volume of free fluid to the volume of expressible fluid.

Analyses of the Data

Because each composite profile was arrived at by group discussion rather than as independent observations, no statistical analysis could be applied to the data. However, the intensities of each of the parameters measured were recorded from the composite profiles and means of these values were used to compare the effects of the various treatments on flavor and texture of the fish. The sum of the intensities of each off flavor (e.g. fishy, sour, etc.) or each undesirable textural characteristic (tendency to felt and mealiness) were calculated for each composite profile and reported as off flavor and undesirable textural characteristics, respectively.

Analyses of variance were applied to the consumer panel and instrumental data using a computer program written by Dr. C. F. Shaykewich, Department of Soil Science, University of Manitoba. When the calculated F values were significant at $p \leq .01$, Duncan's multiple range test as described by Larmond (1967) was used to determine significant differences between means.

Simple correlation coefficients as described by Steel and Torrie (1962) gave an estimate of the relationship between different variables measured. A t-test was used to determine the level of significance of these correlation coefficients.

RESULTS AND DISCUSSION

For ease of discussion, results in the text have been summarized according to main effects and interactions. Individual flavor and texture profiles, along with mean flavor and texture hedonic scores and instrumental measurements for each of the eight treatments from each catch are shown in Appendixes A - H.

Correlation Between Variables

Simple linear correlation coefficients as described by Steel and Torrie (1960) were calculated and results are given in Table XI. The values shown were calculated on a minimum 72 pairs of values (8 treatments per month X 9 months). While many of these correlation coefficients were statistically significant at $p < .01$, only those with coefficients of determination (r^2) greater than 0.15, that is when more than 15% of the variation in the values of Y is accounted for by a linear relationship with X, will be discussed.

Flavor

Examination of Table XI indicates that the profile panel's flavor OAI scores were correlated with chickeny note as well as with off flavor, indicating that the evaluation of flavor OAI was based on both positive and negative attributes. Both of these correlation coefficients were high ($r = .777$ and $-.726$ respectively), which was expected since the best flavor OAI was defined as having a strong chickeny note and no off flavor.

On the other hand, of all the flavor variables, flavor hedonic scores were correlated only with off flavors. These data suggest that the "consumer" panel members were determining how much they liked the flavor of the fish by the intensity of the off flavor. The correlation between flavor hedonic scores and texture hedonic scores ($r = .441$) indicates that

TABLE XI

CORRELATION COEFFICIENTS(r) BETWEEN PARAMETERS

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
(1) Flavor Hedonic Scores		.324	.328	-.502	.441	-.065	-.265	-.249	.281	.256	.527	-.204	.520	-.408
(2) Flavor OAI			.777	-.726	.174	.035	-.161	-.001	.217	.213	.385	-.091	.451	-.281
(3) Chickeny Note				-.670	.324	.015	-.227	-.176	.320	.238	.453	-.103	.493	-.370
(4) Off Flavor					-.363	-.033	.213	.246	-.350	-.376	-.495	.161	-.503	.387
(5) Texture Hedonic Scores						.288	.07	-.398	.115	.293	-.013	.238	.188	-.069
(6) Texture OAI							.750	-.24	-.304	-.097	-.279	.564	.153	.40
(7) Hardness								.105	-.554	-.339	-.417	.563	-.032	.59
(8) Undesirable Textural Characteristics									-.209	-.277	-.079	.019	-.002	.301
(9) RMR										.663	.348	.288	.175	-.468
(10) AMR											.292	-.190	.163	-.355
(11) Free Fluid												-.708	.693	-.654
(12) Expressible Fluid													.019	.684
(13) Total Fluid														-.193
(14) Force to Shear														

how much the panelists liked the flavor of the fish was also influenced by how much they liked its texture. The lack of correlation between hedonic scores and chickeny note suggest that these panelists were not judging the flavor of the fish on the basis of its positive flavor attributes.

There is some evidence in the literature indicating that when "off" or "abnormal" flavors occurred in the odd sample of a triangle test, the odd sample was identified without difficulty. This was true whether the test product was beer, (Helm and Trolle, 1946) irradiated and non-irradiated whole egg magma, (Grim and Goldblith, 1965) or smoked and unsmoked frankfurters (Wasserman and Talley, 1969). When there were 2 samples with "off" or "unfamiliar" flavor, the odd sample, in this case the "familiar" one was difficult to identify. It seemed that the panelists in these studies looked for "off" flavors to help them pick out the odd sample, and became confused when these flavors appeared in 2 of the samples. They did not seem to look for positive characteristics. Perhaps the consumer panel members in the present study looked for off flavors to help them judge how much they liked the fish. When off flavors occurred in the fish, panelists knew they did not like it. However, when there was no off flavor, panelists did not look for positive characteristics like chickeny note to determine how much they liked the fish. For example, fish from the February catch had low off flavors (0.47) but also had low chickeny note (1.72). "Consumer" panelists, not finding any reason to dislike it, gave it a high flavor hedonic score (6.29). The profile panel, which was influenced by the chickeny note as well as off flavor, realized that fish from this catch had low flavor impact and thus gave it a lower flavor OAI than, for example, fish from the April catch which had both low off flavor (0.38) and high chickeny note (2.06). Flavor OAI scores were 1.94 and 2.22 for February and April caught fish, respectively.

The explanation for this phenomenon may lie in the characteristics of the panel evaluating the food product. Panelists involved in the triangle tests reported in the literature cited, were trained to look for differences between samples. Likewise, since all fish samples were presented simultaneously in the present study, it is reasonable to assume that "consumer" panel members were looking for a difference between samples to help them evaluate how much they liked each one.

Profile panel members, on the other hand, were trained not to look for differences between samples, but to judge each sample according to a given set of standards. The flavor OAI was defined in terms of positive and negative aspects. Therefore, it is likely that this panel would consider both chickeny note and off flavors when assigning flavor OAI score. This may account, in part, for the lack of correlation between flavor hedonic scores and flavor OAI.

It is clear from Table XI that flavor and texture of the fish are closely related. Flavor hedonic score, flavor OAI and chickeny note, all of which are positive attributes, were all negatively correlated with off flavor ($r = -.502$, $-.726$ and $-.670$ respectively) and were, as well, all positively correlated with total fluid content ($r = .520$, $.451$ and $.493$ respectively). That is, fish which had low flavor hedonic scores, flavor OAI and chickeny notes tended to have high off flavors and low total fluid content. Of the two pre-canning treatments and the two methods of selection of fish for canning examined in the present study, drying seems to be implicated since it was the only treatment which significantly decreased the total fluid content in the fish ($\overline{X} = 26.4$ ml and 23.9 ml total fluid in not dried and dried fish, respectively). Drying also resulted in increased off flavors and decreased flavor hedonic scores and flavor OAI.

Flavor hedonic scores and chickeny note were both positively correlated with free fluid (r = .527 and .453 respectively), and flavor hedonic scores were negatively correlated with force to shear values (r = -.408).

Texture

Texture hedonic scores were positively correlated with flavor hedonic scores, suggesting that how much panelists liked the texture of the fish was influenced by how much they liked its flavor. These results are in agreement with those obtained by Rasekh et al. (1970) who reported that even when untrained panelists were asked to consider texture preference, the best single correlations were between these texture scores and expert panel scores for odor and taste (r = .616 and .578 respectively). As with flavor hedonic scores, texture hedonic scores also were correlated with negative attributes of the fish, in this case undesirable textural characteristics (r = -.398). These results are in contrast with those obtained by the highly trained profile panel's evaluation of texture OAI which correlated highly with its evaluation of hardness (r = .75) and less well, but still positively with the instrumental measurement of fish firmness (r = .40). Hardness and force to shear values were well correlated (r = .59) and both these measurements of fish firmness were negatively correlated with RMR (r = -.554 and -.468 respectively) and free fluid (r = -.417 and -.654 respectively) and positively correlated with expressible fluid (r = .563 and .684 respectively), suggesting that treatments which firm the fish decrease RMR and free fluid and increase expressible fluid.

RMR correlated fairly well with AMR (r = .663) but AMR was not correlated with any other variable. Hence, RMR may be a more useful measurement than was AMR. Free fluid was highly negatively correlated with expressible fluid (r = -.708) and highly positively correlated with total fluid (r = .693).

The Effect of Freezing

Flavor

Flavor hedonic scores were significantly higher ($p<.01$) for frozen fish than for fresh fish. However, since freezing had no effect on flavor OAI, chickeny note or off flavors (Table XII) these data may reflect the effect of freezing on the texture of the canned whitefish, since there was a correlation coefficient of 0.441 between flavor hedonic scores and texture hedonic scores (Table XI).

Texture

The texture quality of frozen fish was higher than that of fresh fish. Texture hedonic scores were significantly higher ($p<.01$) for frozen fish than for fresh fish. The texture OAI was higher, and undesirable textural characteristics were lower in frozen fish than in fresh fish (Table XII).

Freezing firmed the canned fish. The profile panel's evaluation of hardness was appreciably higher for frozen fish than for fresh fish. Analysis of variance revealed that force to shear values of frozen fish were significantly higher ($p<.01$) than those of fresh fish.

However, significant interactions of freezing with other variables in the force to shear data revealed that freezing did not affect the texture of the fish from all catches uniformly over all treatments. A significant month x freezing interaction in the force to shear data (Table XIII) revealed that although in all months there was a significant freezing effect, the direction of the effect was reversed in 1 of the 11 catches examined. In contrast with results obtained from fish from all other catches, June, 1970- caught fresh fish had significantly higher force to shear values than frozen fish from the same catch. When the force to

TABLE XII

THE EFFECT OF FREEZING ON FLAVOR AND TEXTURE VARIABLES

Variable	Number of Observations Contributing to the Mean	Fish Form	
		Fresh	Frozen
Flavor Profile Scores (Max.=3.0)			
- Flavor OAI	44	2.03	2.05
- Chickeny note	44	1.85	1.86
- Off flavors	44	0.70	0.76
Texture Profile Scores(1) (Max.=3.0)			
- Texture OAI	40	1.64	2.01
- Hardness	40	1.83	2.16
- RMR	40	1.34	1.18
- AMR	40	1.09	1.00
- Undesirable textural characteristics	40	0.88	0.65
"Consumer" Panel Scores (Max.=9.0)			
- Flavor Hedonic Scores**	2400	5.90	6.04
- Texture Hedonic Scores**	2400	5.70	6.00
Instrumental Data			
- Force to shear (lb.)**	440	227	264
- Free fluid (ml)**	180	15.0	11.8
- Expressible fluid (ml)**	220	10.3	13.1
- Total fluid (ml)	180	25.2	24.7

(1) Parameters measured by the profile panel were not statistically analyzed.

** Values in the same row are significantly different at $p<.01$.

shear data were sorted according to the significant ($p < .01$) month x sex x freezing interaction (Table XIII), it was found that in fish from several of the catches, only one of the sexes exhibited a significant freezing effect. From the data shown in Figure 10, it can be seen that of the fish from the July, September, October and May catches, only the males exhibited a significant freezing effect, while of the fish from the February and June 1970 catches, only the females exhibited a significant freezing effect. Both sexes of fish from the remaining 5 catches exhibited a significant freezing effect. Female fish were responsible for the directional difference in response to freezing in the June, 1970 caught fish. There was no significant difference between force to shear values of male fresh and frozen fish from this catch.

From these data it is clear that, while there were exceptions, in general, freezing increased force to shear values of both sexes of canned whitefish. When fish of 1 sex only, exhibited a freezing effect, it usually occurred in the males, suggesting that male fish were slightly more susceptible to the effect of freezing than female fish.

There was also a significant interaction of freezing with month and drying in the force to shear data (Table XIII). Freezing significantly increased the force to shear values of both not-dried and dried fish in only 5 of the 11 catches, June, 1969, August, September, January and April (Figure 11). Fish from the remaining 6 catches reflected a significant freezing effect in one of the drying treatments, only. Freezing increased the force to shear values of not-dried fish, only, from the July, October and February catches and of dried fish, only, from the March and May catches. Results from the June, 1970 catch were erratic; freezing resulted in significantly lower force to shear values in the dried fish, but this

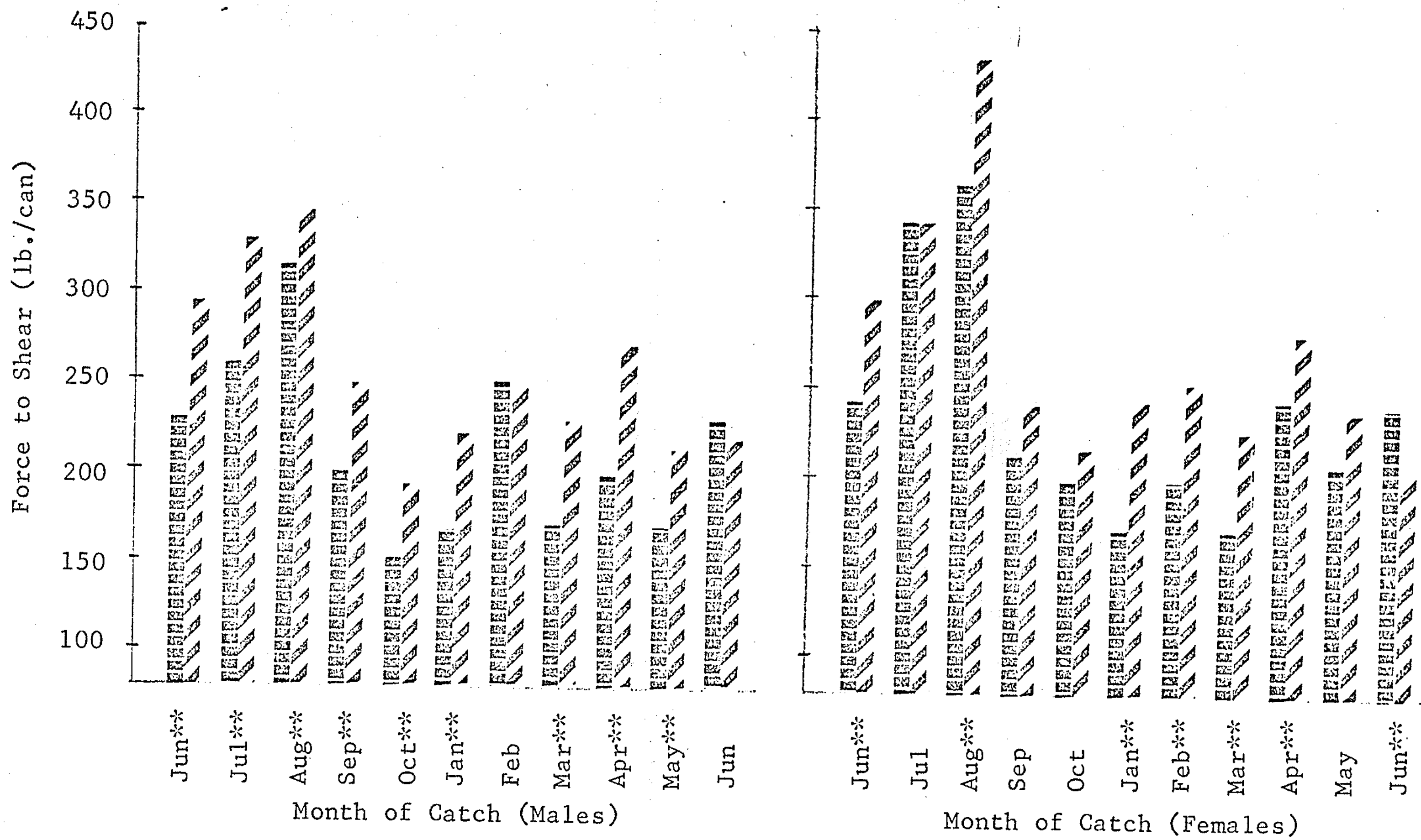
TABLE XIII

SUMMARY OF ANALYSES OF VARIANCE

Source of Variation	Consumer Panel Data			Instrumental Data						
	df	F Values		df	F Values	df	F Values	df	F Values	
		Flavor Hedonic Scores	Texture Texture Scores		Force to Shear		Expressible Fluid		Free Fluid	Total Fluid
Total	4799	-	-	879	-	439	-	359	-	-
Month(M)	9	6.82**	5.02**	10	195.13**	10	10.29**	8	30.60**	19.05**
Sex(S)	1	0.20	1.10	1	63.62**	1	7.92**	1	1.96	4.52*
Drying(D)	1	102.06**	11.86**	1	1226.37**	1	80.54**	1	346.76**	70.74**
Freezing(F)	1	7.30**	29.71**	1	253.55**	1	141.52**	1	182.44**	3.61
M x S	9	2.50**	1.18	10	10.95**	10	3.24**	8	1.54	2.59**
M x D	9	2.21*	3.92**	10	18.13**	10	1.65	8	1.81	1.81
M x F	9	2.09*	1.88	10	9.53**	10	2.83**	8	4.66**	2.47*
S x D	1	2.49	2.62	1	0.00	1	0.00	1	0.77	2.97
S x F	1	0.18	0.95	1	3.18	1	0.02	1	1.34	2.53
D x F	1	3.45	0.31	1	0.14	1	3.46	1	1.72	0.02
M x S x D	9	0.30	1.08	10	7.37**	10	1.47	8	0.94	1.72
M x S x F	9	1.15	1.00	10	5.16**	10	1.14	8	1.67	1.13
M x D x F	9	1.21	1.03	10	3.60**	10	3.72**	8	3.69**	2.87**
S x D x F	1	0.00	0.58	1	0.39	1	1.03	1	0.04	0.84
Error	4729	-	-	802	-	362	-	296	-	-

** Significant at p<.01.

* Significant at p<.05.



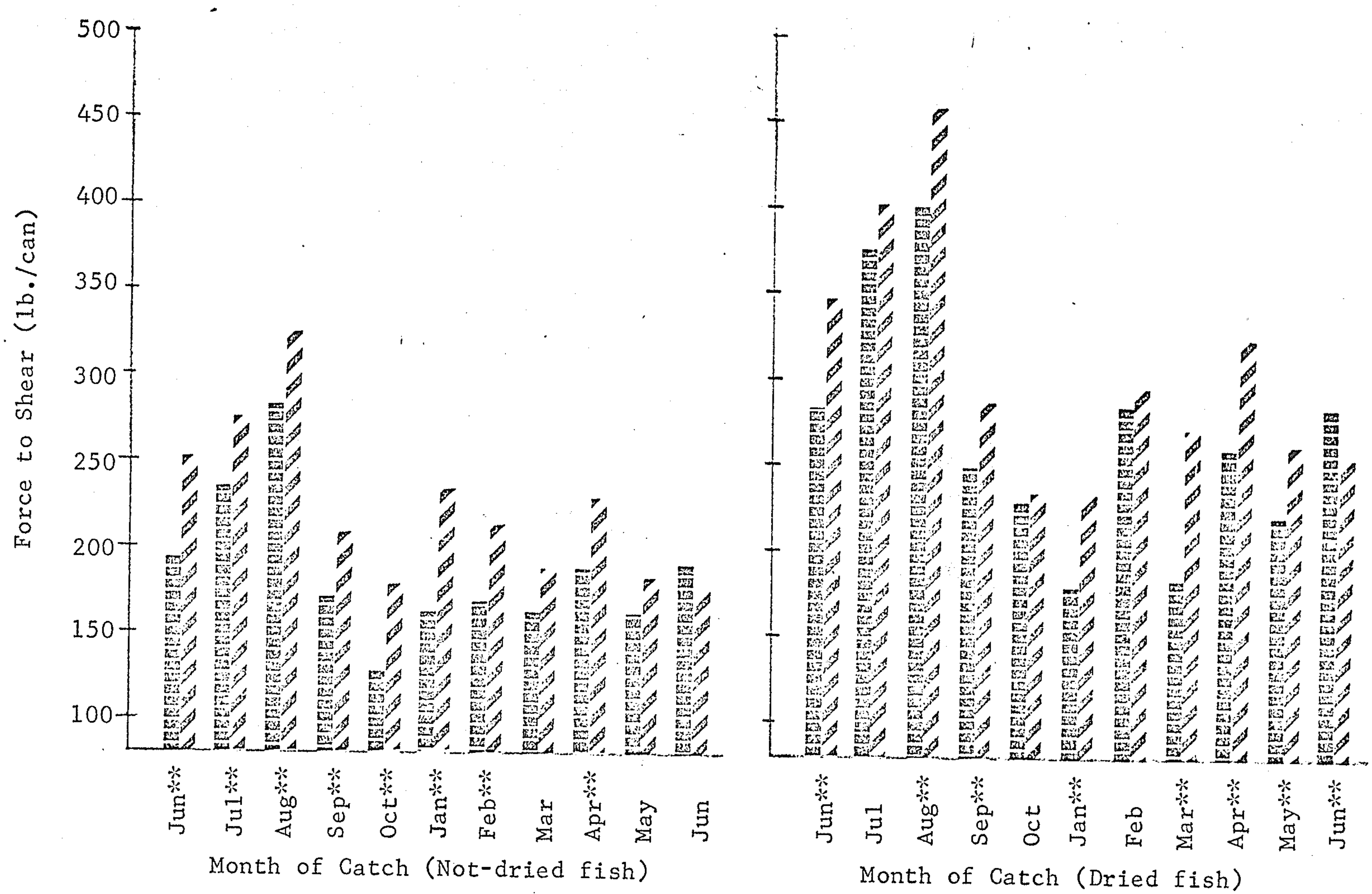
Each bar represents the mean of 20 observations (2 treatments x 10 replicates).

** In these months, values for fresh and frozen fish were significantly different at $p < .01$.

Fresh fish   Frozen fish

FIGURE 10

THE EFFECT OF FREEZING ON FORCE TO SHEAR VALUES OF MALE AND FEMALE WHITEFISH EACH MONTH



Each bar represents the mean of 20 observations (2 treatments x 10 replicates).
** In these months, values for fresh and frozen fish were significantly different at $p < .01$.

Fresh fish   Frozen fish

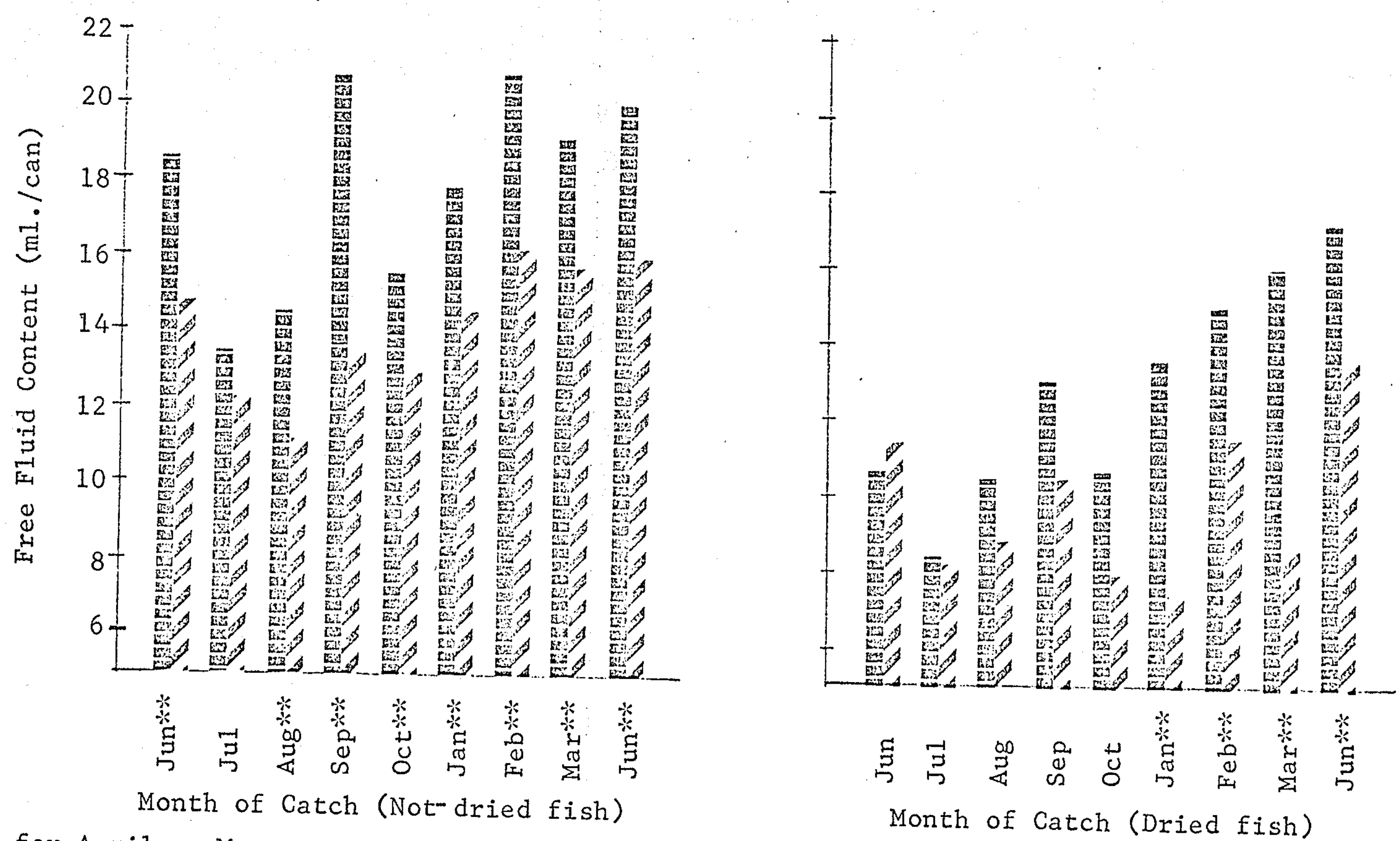
FIGURE 11

THE EFFECT OF FREEZING ON FORCE TO SHEAR VALUES OF NOT-DRIED AND DRIED FISH EACH MONTH treatment had no significant effect on the not-dried fish from this catch (Figure 11). Thus, except for fish from the June, 1970 catch, force to shear values were always higher for frozen fish than for fresh fish, even though the differences were not always significant.

Freezing also affected the moisture characteristics of the fish, decreasing both the RMR and the AMR (Table XII). Frozen fish also had significantly ($p<.01$) less free fluid than fresh fish (Table XII). The significant month x drying x freezing interaction in the free fluid data (Table XIII) revealed that this decrease was not uniform over all months of catch and drying conditions. The effect of freezing on free fluid content was much more apparent in not-dried fish than in dried fish. Data in Figure 12 indicate that freezing significantly decreased free fluid content in not-dried fish from 8 of the 9 catches examined, but the free fluid content of dried fish was significantly decreased in only 4 catches. It may be seen from these data that drying tended to minimize the effect of freezing on the free fluid content of the fish.

If the more acceptable not-dried fish, only, are examined for the effect of freezing, it is readily seen that for 8 of the 9 catches examined, freezing significantly lowered the free fluid content. These results are in agreement with those obtained by Tarr (1941) who found that cooking losses were less for frozen, thawed halibut than for fresh halibut. Work with salmon has revealed that the free oil content of the canned product is lower in fish stored in a frozen (Stansby and Dassow, 1951) or partially frozen (Bilinski et al., 1966) condition before canning. A decrease in free oil would result in lower free fluid content as measured in the present experiment.

Freezing resulted in significantly higher ($p<.01$) expressible



No values for April or May.

Each bar represents the mean of 10 observations (2 treatments x 5 replicates).

** In these months, values for fresh and frozen fish were significantly different at $p<.01$.

Fresh fish   Frozen fish

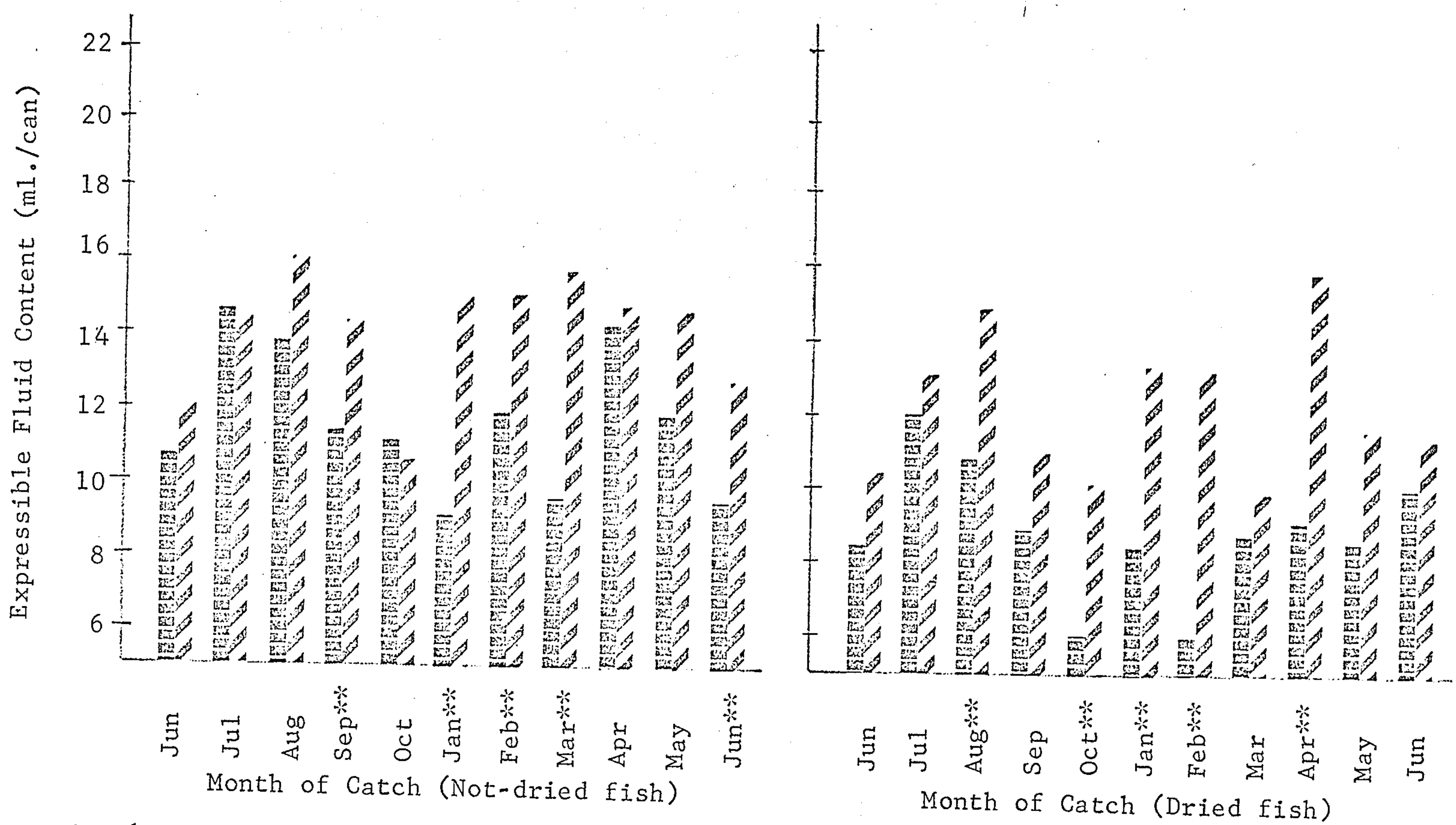
FIGURE 12

THE EFFECT OF FREEZING ON FREE FLUID CONTENT OF NOT-DRIED AND DRIED FISH EACH MONTH fluid content in the canned whitefish (Table XII) to an extent varying with month of catch and drying treatment. The significant interaction of freezing with month and drying (Table XIII) shows that freezing increased the expressible fluid content of both not-dried and dried fish in only 2 of the 11 catches examined, January and February (Figure 13). Freezing had no significant effect on the expressible fluid content of either not-dried or dried fish from 3 catches, June, July and April.

For the remaining 6 catches, the effects of freezing on the expressible fluid content varied with the drying treatment. For 3 of these catches, September, March and June, 1970, freezing did not significantly affect the expressible fluid content of the not-dried fish, but it significantly increased the expressible fluid content of dried fish. In the other 3 catches, August, October and April, freezing did not affect the expressible fluid content of the dried fish, but it resulted in significantly higher expressible fluid content of the not-dried fish.

If data from the not-dried fish, only, are examined (Figure 13), it is evident that freezing significantly increased the expressible fluid in only 5 of the catches, although even in the remaining catches, the expressible fluid content of frozen fish was higher in every case. Thus it appears that freezing increased the expressible fluid content of canned whitefish. Stansby and Dassow (1951) reported that freezing salmon before canning decreased the free oil in the cans but did not affect the total oil content. Therefore, freezing must result in more oil being held within the tissue of the fish. This oil, which could be removed by centrifuging intact cans of fish, (Bilinski and Clement, 1967) probably was responsible for the increase in expressible fluid of the canned whitefish.

A significant month x drying x freezing interaction for the total



Each bar represents the mean of 10 observations (2 treatments x 5 replicates).

** In these months, values for fresh and frozen fish were significantly different at p<.01.

Fresh fish   Frozen fish

FIGURE 13

THE EFFECT OF FREEZING ON EXPRESSIBLE FLUID CONTENT OF NOT-DRIED AND DRIED FISH EACH MONTH fluid content of canned whitefish (Table XIII) revealed that in only 2 of the 9 catches examined, did a significant difference between the total fluid content of fresh and frozen fish exist (Figure 14). Moreover, this difference occurred for only one of the drying treatments. In fish from the September catch, freezing significantly decreased the total fluid content of the not-dried fish but did not affect the dried fish while for the October catch, freezing increased the total fluid content of the dried fish but did not affect the not-dried fish. For the remaining 7 catches, freezing had no significant effect on the total fluid content. Therefore, it may be assumed that the total fluid content of the fish was not markedly affected by freezing.

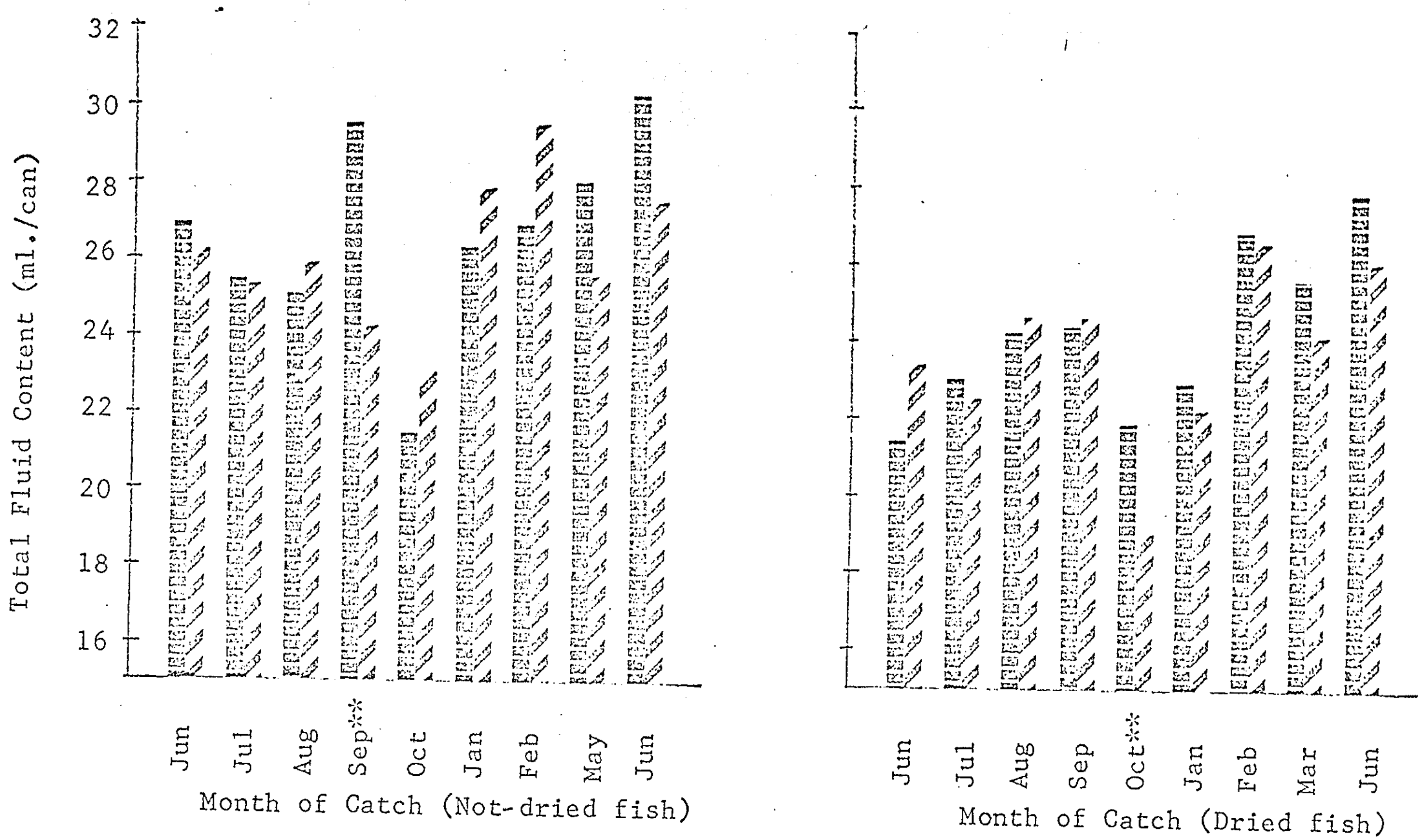
It has been shown that the decrease in free fluid and increase in expressible fluid of frozen canned whitefish may be due to translocation of oil, as it occurs in canned salmon. The influence of freezing on total fluid content of cans of whitefish is in agreement with results obtained on canned salmon by several workers (Stansby and Dassow, 1951; Bilinski et al., 1966; and Bilinski and Clement, 1967). That is, freezing has no effect on total oil (or total fluid) content of canned fish.

As a result of the possible improvement of flavor, and the obvious improvement of texture, freezing appears to be a useful pre-canning treatment for whitefish.

The Effect of Drying

Flavor

Drying had a deleterious effect on the flavor of canned whitefish. The flavor hedonic scores of not-dried and dried fish were 6.23 and 5.71 respectively (Table XIV). These values were significantly different at $p<.01$ (Table XIII). The profile panel indicated that flavor OAI and



No values for April or May.

Each bar represents the mean of 10 observations (2 treatments x 5 replicates).

** In these months, values for fresh and frozen fish were significantly different at $p < .01$.

Fresh fish   Frozen fish

FIGURE 14

THE EFFECT OF FREEZING ON TOTAL FLUID CONTENT OF NOT-DRIED AND DRIED FISH EACH MONTH chickeny notes were lower, and off flavors were higher in the dried fish than in the not-dried fish (Table XIV).

Since fish caught from June, 1969 to October was dried in a kiln which had previously been used to smoke fish, an increase in off flavors, which included smoky, might be expected, even though no smoke was generated, and the tunnel was cleaned before the drying process took place. However, even in fish caught after October, off-flavors increased on drying. Oxidation of the highly unsaturated fatty acids at the elevated temperatures involved during the drying process is probably responsible for at least some of the off flavors. Since flavor notes described as smoky appear even in fish caught after October, it is probable that the profile panel used the term, smoky, to describe the flavor of the oxidized oils.

Texture

Drying also influenced the texture of the fish, as can be seen from the profile panel data, "consumer" panel data, and instrumental data given in Table XIV. The profile panel found that dried fish had higher hardness scores and a higher incidence of undesirable textural characteristics than not-dried fish. According to this panel's definition, firmness was the most important characteristic of textural quality. Therefore, in spite of the increased undesirable textural characteristics observed in the dried fish, the profile panel gave it high texture OAL scores.

Analysis of variance of the "consumer" panel data indicated that there was a significant ($p=.01$) drying effect (Table XIII) but the significant ($p<.01$) month x drying interaction indicated that the effect of drying was not the same over all catches. Although the main effect of drying was to decrease texture hedonic scores (Table XIV), the significant month x drying interaction revealed that in only 2 of the 10 months

TABLE XIV

THE EFFECT OF DRYING ON FLAVOR AND TEXTURE VARIABLES

Variable	Number of Observations Contributing to the Mean	Fish Form	
		Not-Dried	Dried
Flavor Profile Data(1) (Max.=3.0)			
- Flavor OAI	44	2.30	1.78
- Chickeny Note	44	2.02	1.69
- Off Flavors	44	0.36	1.10
Texture Profile Data(1) (Max.=3.0)			
- Texture OAI	40	1.73	1.93
- Hardness	40	1.74	2.25
- RMR	40	1.41	1.11
- AMR	40	1.17	0.91
- Undesirable Textural Characteristics	40	0.66	0.87
"Consumer" Panel Data (Max.=9.0)			
- Flavor Hedonic Score**	2400	6.23	5.71
- Texture Hedonic Score**	2400	5.94	5.76
Instrumental Data			
- Force to Shear (lb.)**	440	204	287
- Free Fluid (ml)**	180	15.6	11.2
- Expressible Fluid (ml)**	220	10.6	12.8
- Total Fluid (ml)**	180	26.1	23.8

(1) Parameters measured by the profile panel were not statistically analyzed.

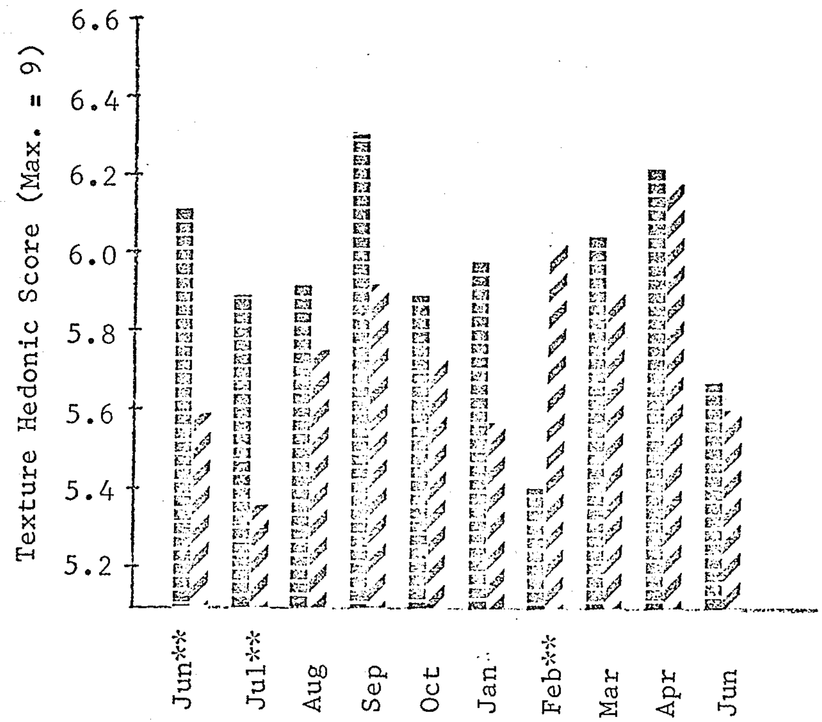
** Values in the same row are significantly different at $p < .01$.

examined, June, 1969 and July, were texture hedonic scores significantly higher for the not-dried fish (Figure 15). Dried fish from the February catch, only, had significantly higher texture hedonic scores than not-dried fish from the same catch (Figure 15). There was no significant difference between the texture hedonic scores of dried and not-dried fish for the remaining 7 catches, although in all cases, scores for not-dried fish were higher than for dried fish. Thus it appears that the texture of the dried fish was generally liked less than the texture of not-dried fish.

Although there were significant interactions of month x drying, month x sex x drying, and month x drying x freezing in the force to shear data, the F values of the 3-way interactions, in particular, were small when compared with the F values of the simple effects (Table XIII). An examination of the effects of drying by month for each sex separately (Figure 16) and for each freezing condition separately (Figure 17) show that fish from the January catch behaved differently from fish from the other catches. Of the 11 catches examined, with the exception of January, the dried fish always had higher force to shear values than not-dried fish. In these 10 months, the drying effect was always significant except in fresh fish from the March catch; this inconsistency accounts in part for the 3-way interaction. Even though the magnitude of the drying effect from month to month varied with the sex of the fish and freezing condition, drying increased force to shear values.

Drying also affected the moisture characteristics of the fish. The profile panel determined that dried fish had a lower RMR and less AMR than not-dried fish (Table XIV).

Of the 3 instrumental estimates of moisture characteristics, free,



No values for May.

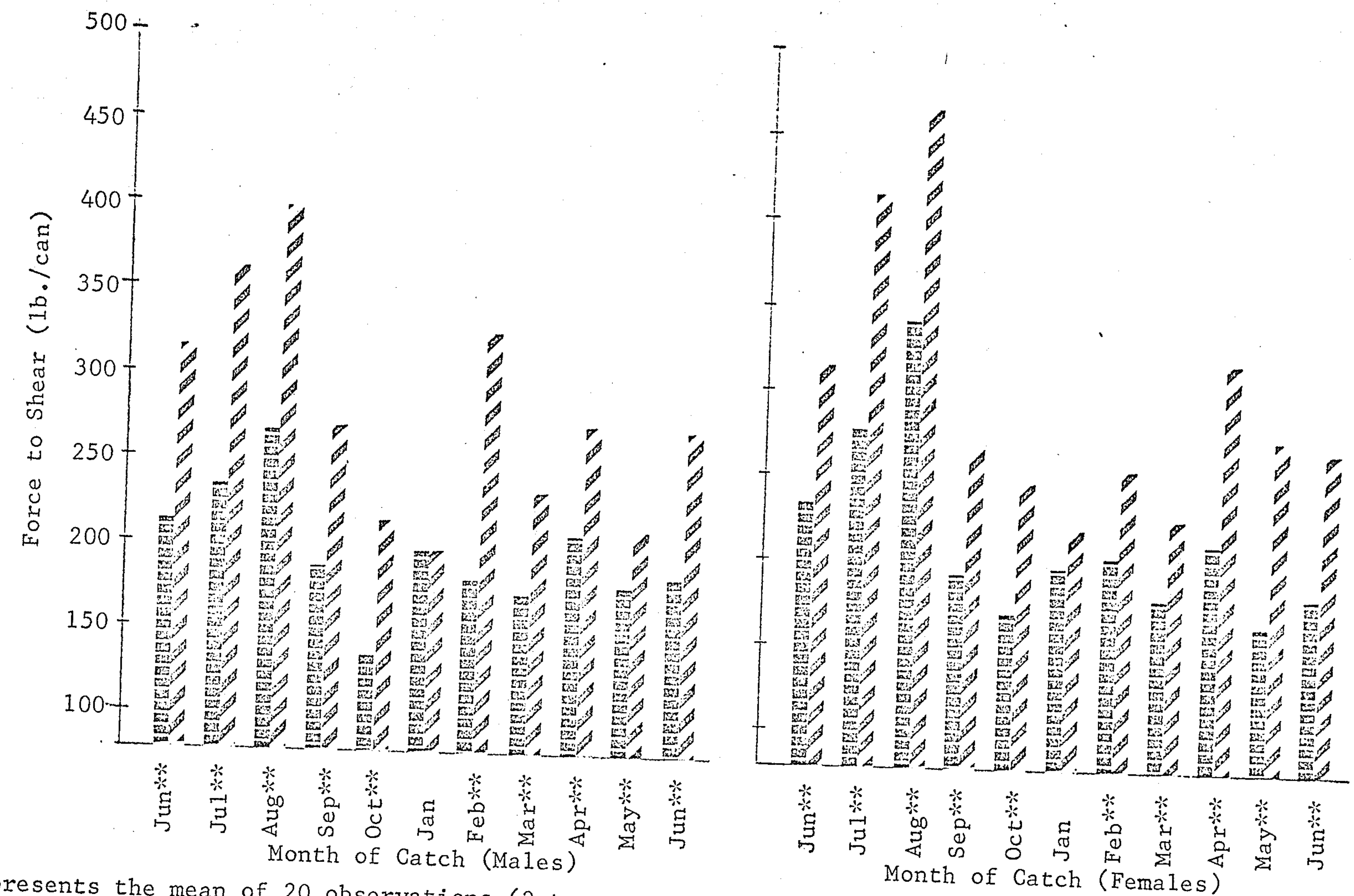
Each bar represents the mean of 240 observations (4 treatments x 60 judges).

** In these months, values for not-dried and dried fish were significantly different at $p<.01$.

Not-dried fish   Dried fish

FIGURE 15

THE EFFECT OF DRYING ON TEXTURE HEDONIC SCORES EACH MONTH



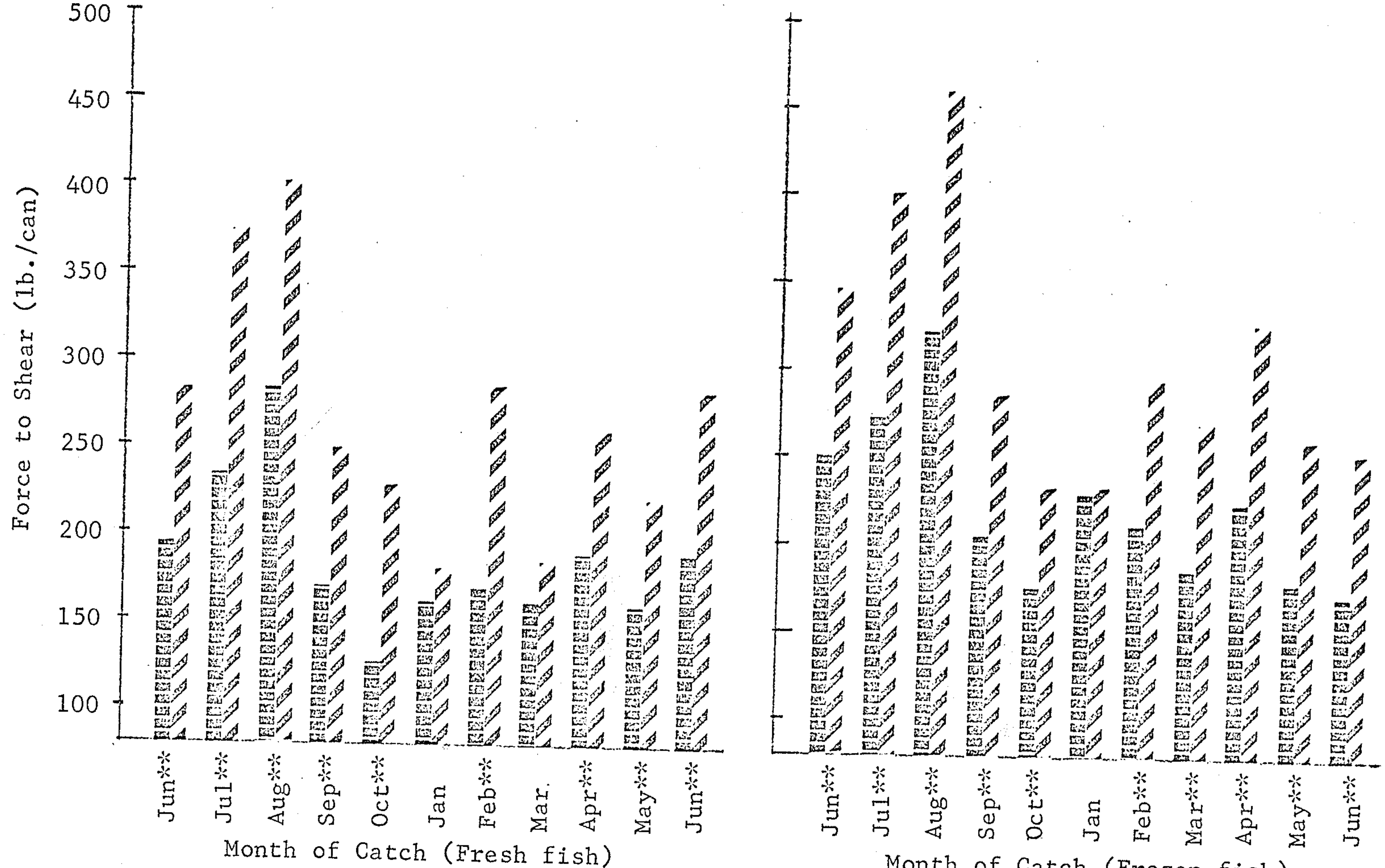
Each bar represents the mean of 20 observations (2 treatments x 10 replicates).

** In these months, values for not-dried and dried fish were significantly different at $p < .01$.

Not-dried fish   Dried fish

FIGURE 16

THE EFFECT OF DRYING ON FORCE TO SHEAR VALUES OF MALE AND FEMALE FISH EACH MONTH



Each bar represents the mean of 20 observations (2 treatments x 10 replicates).
** In these months, values for not-dried and dried fish were significantly different at $p<.01$.

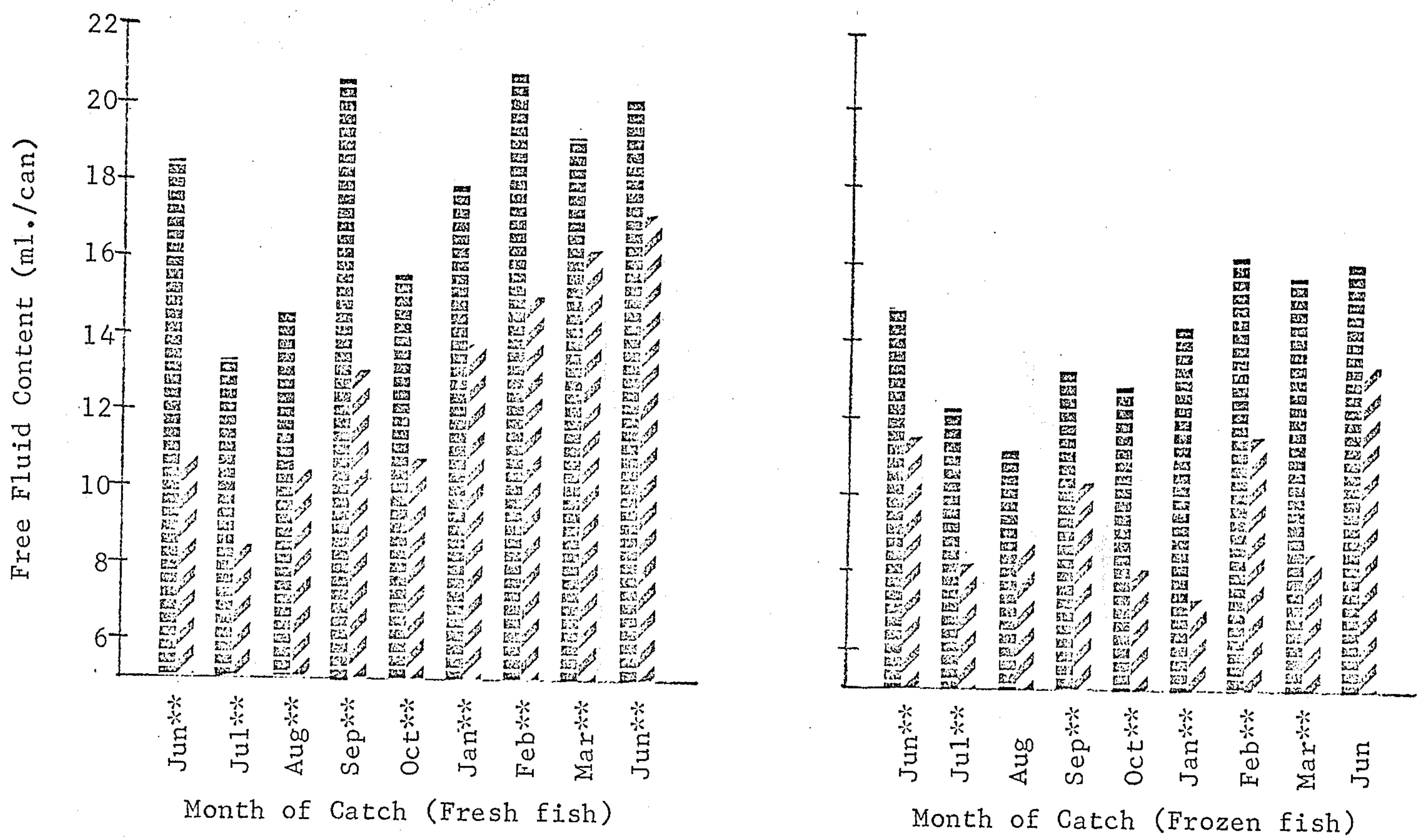
Not-dried fish Dried fish

FIGURE 17

THE EFFECT OF DRYING ON FORCE TO SHEAR VALUES OF FRESH AND FROZEN FISH expressible and total fluid content, free fluid content showed the effect of drying most clearly. The drying effects on the other measurements were more obscured by the confounding effects of month and freezing condition.

Dried fish had significantly less free fluid than not-dried fish (Table XIV) but a significant month x drying x freezing interaction (Table XIII) indicated that the effect of drying was not uniform over all treatments all months. For 7 of the 9 catches examined, dried fish had significantly less free fluid, whether or not the fish had been frozen (Figure 18). For the remaining 2 catches, August and June, 1970, only the fresh fish exhibited a significant drying effect. Nevertheless, dried frozen fish from these 2 catches had less free fluid than not-dried frozen fish from the same catches, although the differences were not significant (Figure 18). Thus, it may be stated, without reservation, that drying significantly lowered the free fluid content of cans of whitefish.

Drying resulted in a significant increase in the expressible fluid content of the fish (Table XIV). However, a significant month x drying x freezing interaction (Table XIII) revealed that for 5 of the 11 catches examined, there was no significant drying effect for either fresh or frozen fish (Figure 19). Furthermore, in the remaining 6 catches, the drying effect was significant only in fresh fish or only in frozen fish. For 2 of the catches, September and March, only the frozen fish exhibited a drying effect, and for the remaining 4 catches, October, February, April and May, only the fresh fish exhibited the drying effect. Nevertheless, except for the June, 1970-caught fresh fish and the April-caught frozen fish, dried fish had higher expressible fluid content than not-dried fish, even when the differences were not significant. From these data, it appears that drying may have increased the expressible fluid content of



No values for April or May.

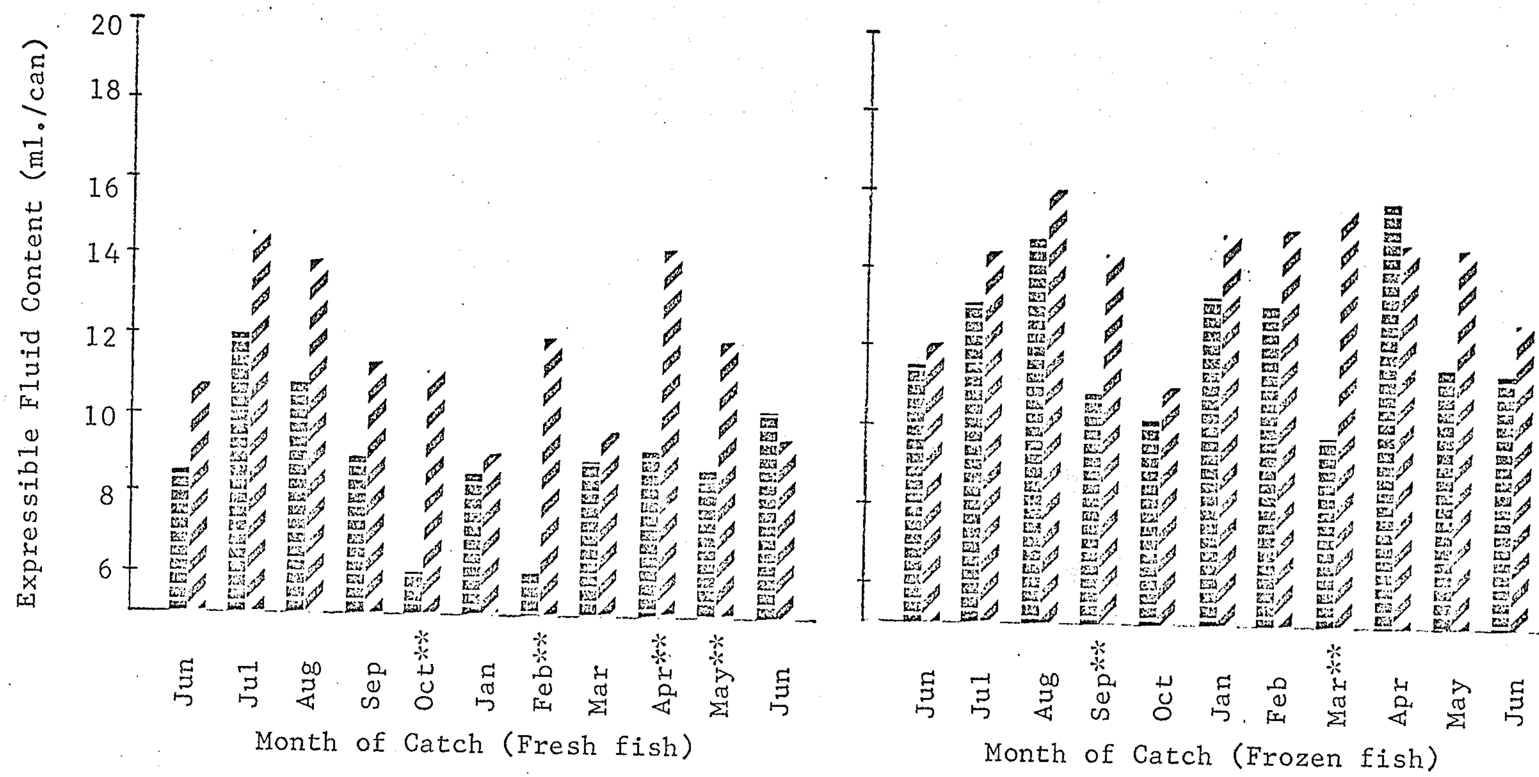
Each bar represents the mean of 20 observations (2 treatments x 10 replicates).

** In these months, values for not-dried and dried fish were significantly different at $p < .01$.

Not-dried fish   Dried fish

FIGURE 18

THE EFFECT OF DRYING ON FREE FLUID CONTENT OF FRESH AND FROZEN FISH EACH MONTH



Each bar represents the mean of 10 observations (2 treatments x 5 replicates).

** In these months, the values for not-dried and dried fish were significantly different at $p<.01$.

Not-dried fish   Dried fish

FIGURE 19

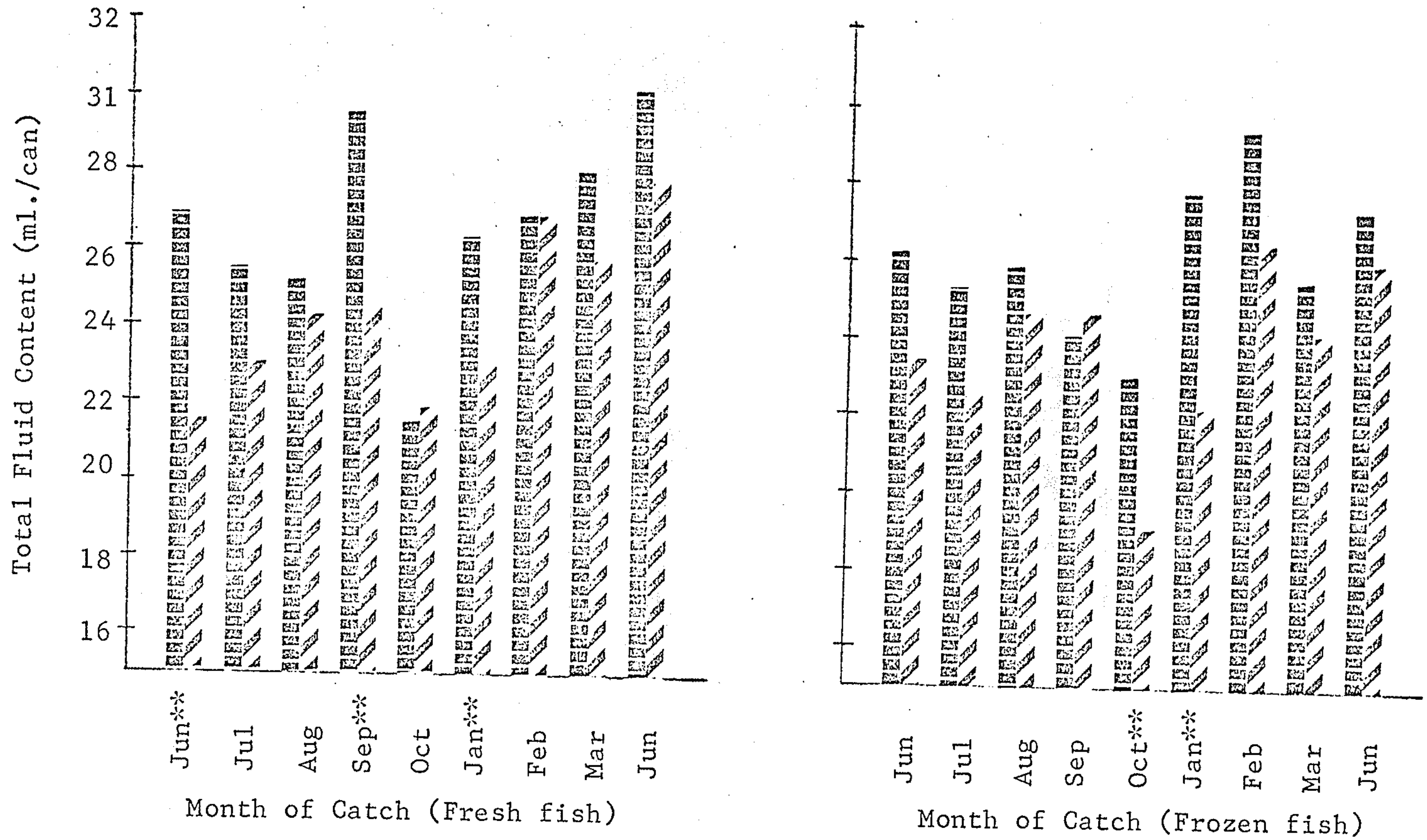
THE EFFECT OF DRYING ON EXPRESSIBLE FLUID CONTENT OF FRESH AND FROZEN FISH the fish, but more testing is needed to confirm the validity of these observations.

The simple effect of drying was to decrease the total fluid content of the fish (Table XIV) although a significant month x drying x freezing interaction (Table XIII) indicated that for 5 of the 9 catches, drying did not significantly affect the total fluid content of either fresh or frozen fish (Figure 20). Only fish from one catch, January, exhibited a significant decrease in total fluid content of both fresh and frozen fish. Two of the catches, June, 1969 and September exhibited a significant drying effect in fresh fish, only, and one catch, October, exhibited a significant drying effect in frozen fish, only. However, except for October-caught fresh fish and September-caught frozen fish, not-dried fish consistently had higher total fluid than dried fish, even though differences were not significant. Thus it seems that drying did decrease the total fluid content as measured by this method. Since the drying process was designed to remove approximately 10% of the moisture from the fish, these results are reasonable.

The Effect of Sex

Flavor

The sex of the fish did not have any simple effects on any of the parameters of flavor measured (Table XV). Examination of results sorted according to the significant ($p<.01$) month x sex interaction of flavor hedonic scores (Table XIII) revealed that the scores for male fish appeared to be slightly more consistent over months than were those for female fish (Figure 21). A comparison of scores of male and female fish for each of the 10 catches examined revealed that for 5 of the catches, scores for female fish were slightly higher than for male fish, while for the



No values for April or May.

Each bar represents the mean of 10 observations (2 treatments x 5 replicates).

** In these months, values for not-dried and dried fish were significantly different at $p<.01$.

Not-dried fish   Dried fish

FIGURE 20

THE EFFECT OF DRYING ON TOTAL FLUID CONTENT OF FRESH AND FROZEN FISH EACH MONTH

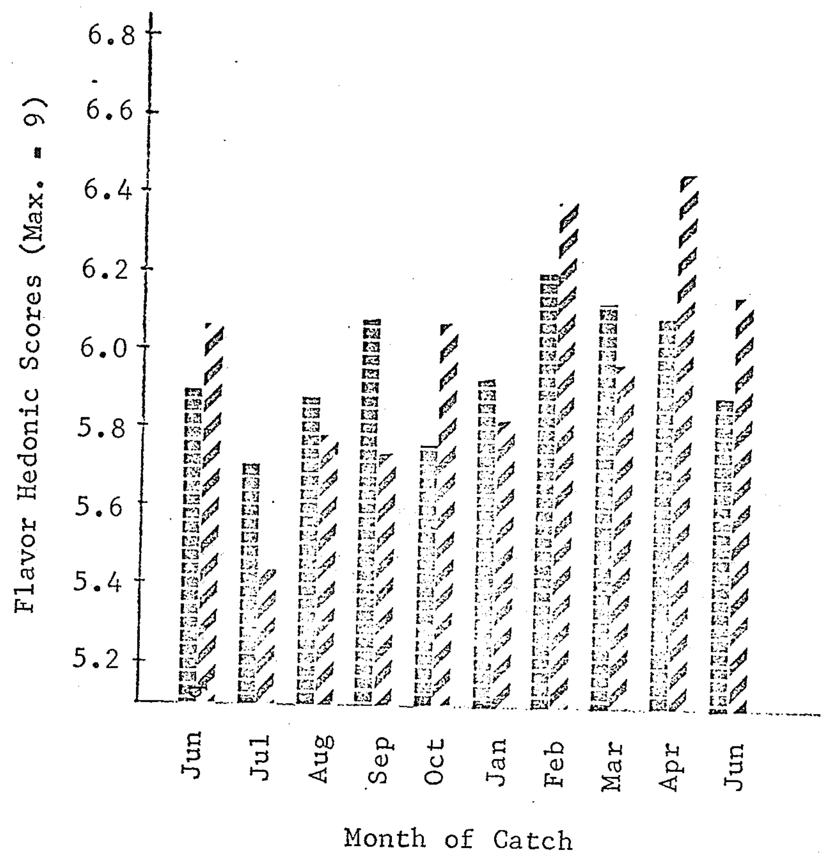
TABLE XV

THE EFFECT OF SEX OF THE FISH ON FLAVOR AND TEXTURE VARIABLES

Variable	Number of Observations Contributing to the Mean	Fish Sex	
		Male	Female
Flavor Profile Data[(1)] (Max.=3.0)			
- Flavor OAI	44	2.02	2.06
- Chickeny Note	44	1.83	1.88
- Off Flavors	44	0.72	0.74
Texture Profile Data[(1)] (Max.=3.0)			
- Texture OAI	40	1.80	1.85
- Hardness	40	1.95	2.05
- RMR	40	1.28	1.23
- AMR	40	1.07	1.01
- Undesirable textural characteristics	40	0.74	0.80
"Consumer" Panel Data (Max.=9.0)			
- Flavor Hedonic Scores	2400	5.96	5.98
- Texture Hedonic Scores	2400	5.82	5.88
Instrumental Data			
- Force to Shear (lb.)**	440	236	255
- Free Fluid (ml)	180	13.4	13.4
- Expressible Fluid (ml)**	220	11.4	12.1
- Total Fluid (ml)	180	24.4	25.5

(1) Parameters measured by the profile panel were not statistically analyzed.

** Values in the same row are significantly different at $p \leq .01$.



No values for May.

Each bar represents the mean of 240 observations (4 treatments x 60 judges).

Male fish   Female fish

FIGURE 21

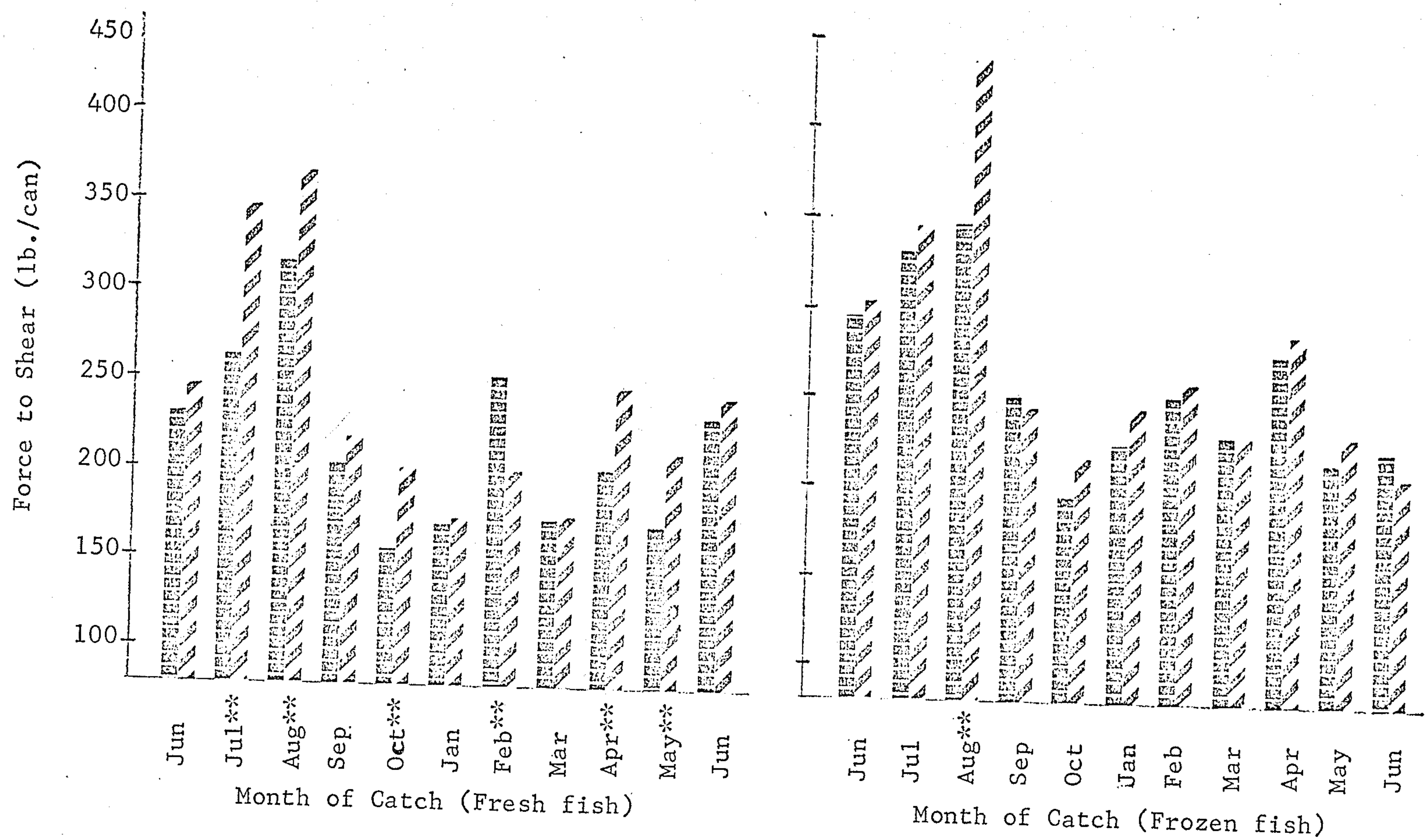
THE EFFECT OF SEX ON FLAVOR HEDONIC SCORES EACH MONTH remaining catches the reverse was true. These differences were not significant in any of the catches. Thus it appears that the sex of the fish did not appreciably affect any parameter of flavor.

Texture

The sex of the fish did not affect the texture hedonic scores of the fish, nor did it appear to affect texture OAI or the incidence of undesirable textural characteristics as determined by the profile panel (Table XV). However, female fish did seem to be firmer than male fish, as estimated by the profile panel's evaluation of hardness and by the force to shear values (Table XV).

The occurrence of interactions between sex and other variables in the force to shear data (Table XIII) revealed that sex did not have a uniform effect over all treatments and all months. A significant ($p<.01$) month x sex interaction among force to shear values showed that there was a significant difference between males and females only in fish from 6 of 11 catches examined; July, August, October, February, April and May. Of these 6 catches where a significant difference existed, female fish had higher force to shear values than male fish in all catches with the exception of February. However, the significant ($p<.01$) interactions of sex with month and freezing and with month and drying (Table XIII) indicated that the effect of sex over the 2 freezing conditions and over the 2 drying conditions was not the same for all catches.

Examination of the data of the month x sex x freezing interaction revealed that the effect of sex was evident to a much greater extent in fresh fish than in frozen fish (Figure 22). Results from fresh fish were similar to those obtained from the month x sex interaction. That is, there was a significant difference between male and female fish in the



Each bar represents the mean of 20 observations (2 treatments x 10 replicates).

** In these months, values for male and female fish were significantly different at $p < .01$.

Male fish   Female fish

FIGURE 22

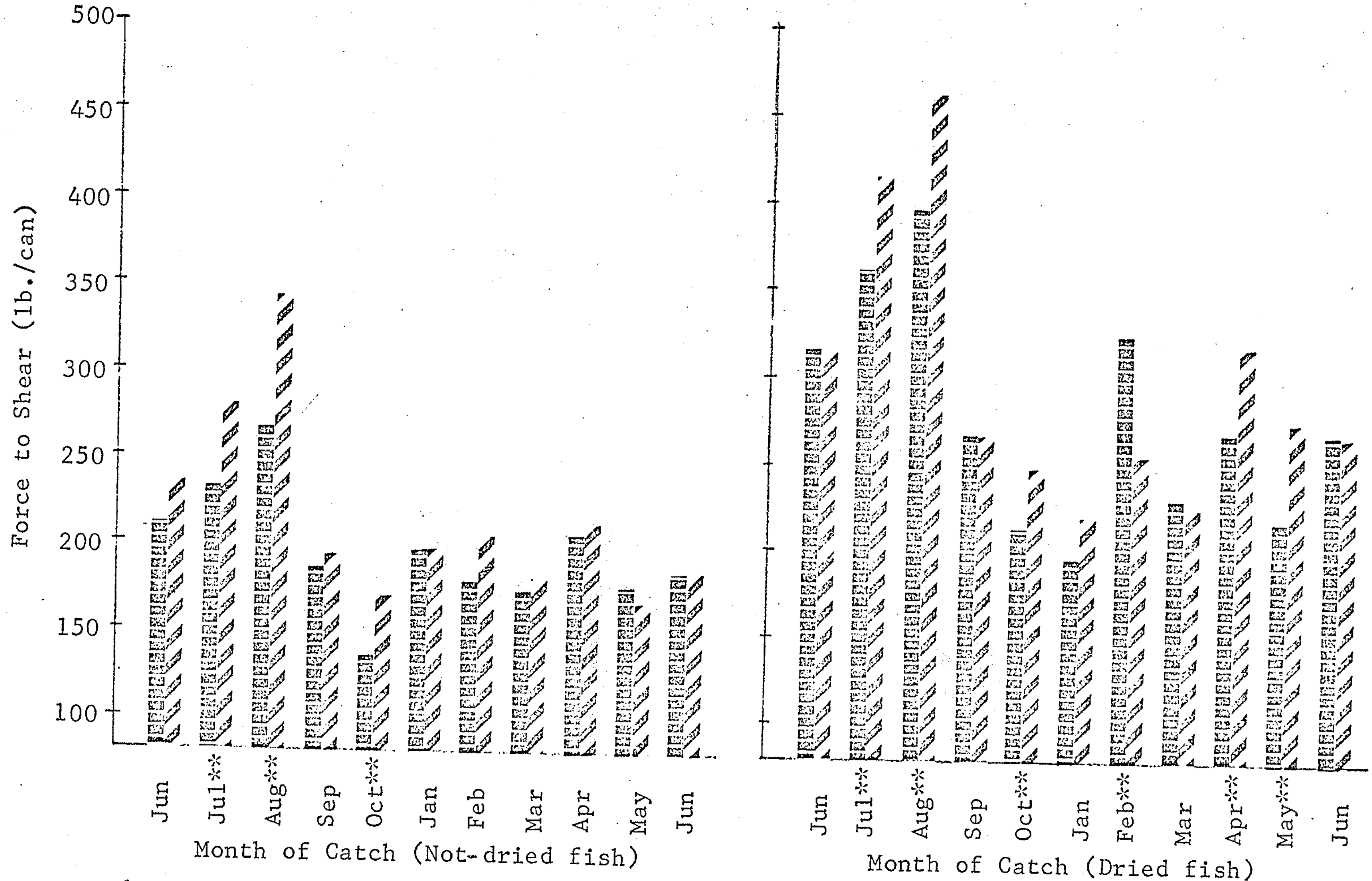
THE EFFECT OF SEX ON FORCE TO SHEAR VALUES OF FRESH AND FROZEN FISH EACH MONTH same 6 catches; July, August, October, February, April and May. In all cases except February catch, female fish had significantly higher force to shear values than male fish. In contrast to these results, among the frozen fish, only the August catch exhibited a significant sex effect. Again, female fish from this catch had higher force to shear values than male fish from the same catch.

These results suggest that when there is a difference in firmness attributable to sex, freezing before canning helps to obliterate it. Thus, in addition to its ability to improve fish texture, freezing appears to be useful in minimizing variability attributable to the sex of the fish.

The significant interaction of sex with month and drying in the force to shear values showed that dried fish exhibited the same variability due to sex as occurred in the month x sex interaction; that is, male and female dried fish had significantly different force to shear values in 6 of the catches, July, August, October, February, April and May (Figure 23). In all these catches except February, the female fish had significantly higher force to shear values ($p < .01$). In contrast to this effect of sex on dried fish over months, not-dried female fish had significantly different force to shear values in only 3 of the catches, July, August and October. Female fish from these catches had higher force to shear values than male fish from the same catch. There were no significant differences attributable to sex for the remaining 8 catches.

These data suggest that whereas the effect of freezing was to obscure the differences in force to shear values between the 2 sexes of fish, drying accentuated them.

None of the estimates of moisture characteristics, with the exception of expressible fluid, appeared to be affected by the sex of the



Each bar represents the mean of 20 observations (2 treatments x 10 replicates.

** In these months, values for male and female fish were significantly different at p<.01.

Male fish   Female fish

FIGURE 23

THE EFFECT OF SEX ON FORCE TO SHEAR VALUES OF NOT-DRIED AND DRIED FISH EACH MONTH fish (Table XV).

The amount of expressible fluid was higher for female fish examined over all months collectively, but examination of the data sorted according to the significant month x sex interaction (Table XIII) revealed that female fish had significantly more expressible fluid in only 3 of the catches, June, 1969, August and October (Figure 24). For all other months, sex of the fish did not significantly affect the expressible fluid content. Therefore, it is questionable whether or not there was a real difference between the expressible fluid contents of the two sexes of fish.

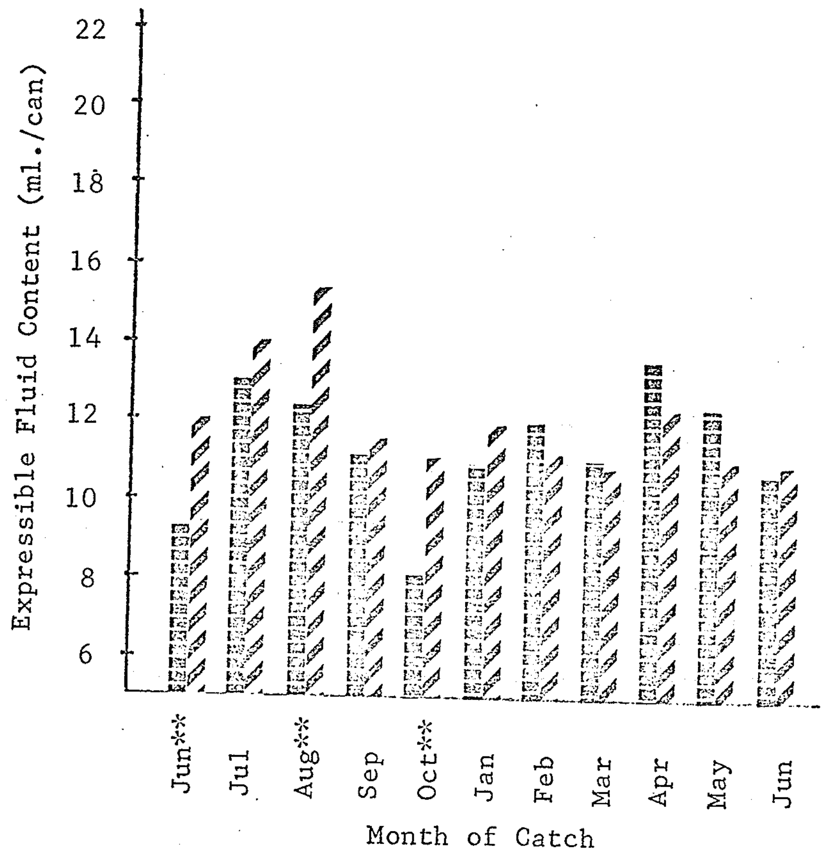
These data suggest that while there seemed to be a difference in firmness attributable to sex, it is doubtful whether any of the other textural parameters measured were affected by this variable. It is of practical interest that the variability attributable to sex in the force to shear data can be almost eliminated by freezing the fish before canning.

Thus it appears that the two sexes of whitefish can be canned successfully.

The Effect of Month of Catch

Flavor

Flavor hedonic scores did not vary a great deal from month to month (Table XVI). Data in this table have been sorted according to the significant month x sex interaction (Table XIII). It can be seen in Table XVI that February and April-caught male and female fish were well liked, while July and August-caught male and female fish were not as well liked; however, there were few clear cut differences between fish from different catches. On the whole, male and female fish had fairly similar scores, although the extent to which September and October-caught fish were liked varied with the sex of the fish.



Each bar represents the mean of 20 observations (4 treatments x 5 replicates.

** In these months, values for male and female fish were significantly different at p<.01.

Male fish   Female fish

FIGURE 24

THE EFFECT OF SEX ON EXPRESSIBLE FLUID CONTENT EACH MONTH

TABLE XVI

MEAN FLAVOR HEDONIC SCORES[1] OF MALE AND FEMALE FISH EACH MONTH[2]

Month of Catch	Fish Sex	
	Male	Female
June, 1969	5.89^{ab}	6.06^{abc}
July	5.71^{b}	5.42^{cd}
August	5.88^{ab}	5.78^{cd}
September	6.08^{ab}	5.72^{cd}
October	5.76^{ab}	6.07^{abc}
January	5.93^{ab}	5.82^{cd}
February	6.20^{a}	6.38^{ab}
March	6.13^{ab}	5.96^{bc}
April	6.10^{ab}	6.45^{a}
June, 1970	5.90^{ab}	6.15^{abc}

(1) Each value is the mean of 240 observations (4 treatments x 60 replicates) when 1 = Dislike extremely; 9 = Like extremely.

(2) No values for May.

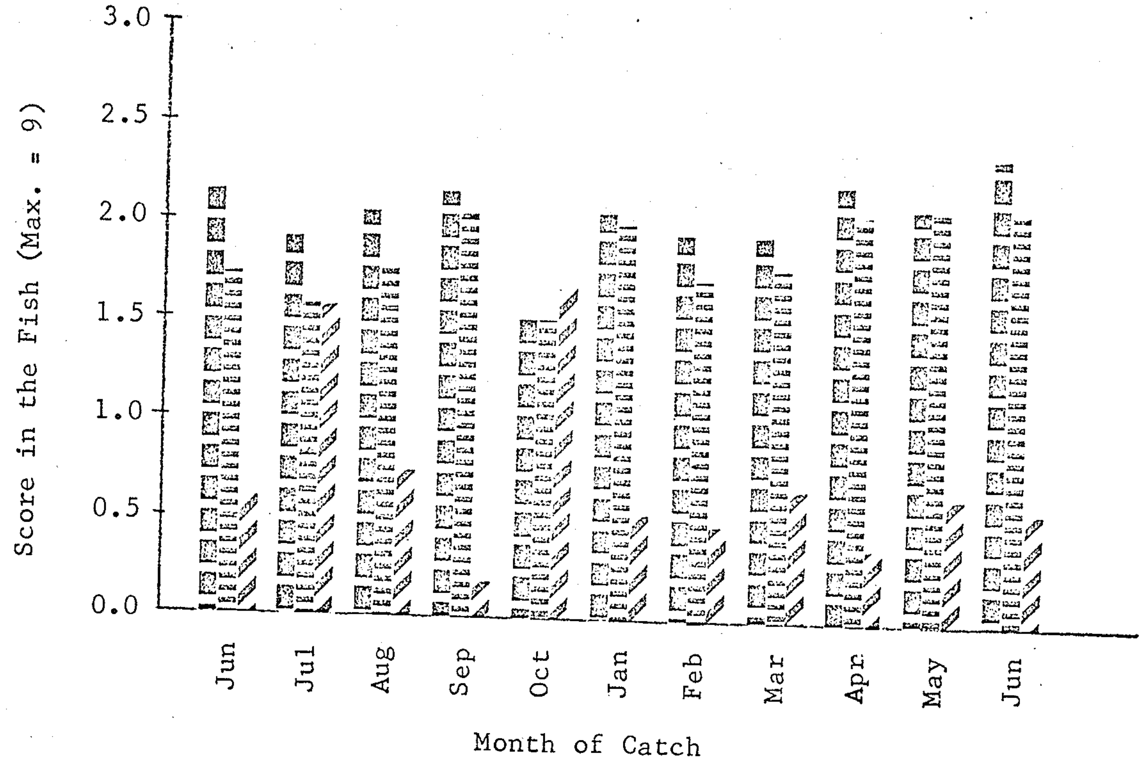
abcd Values in the same column with the same superscript are not significantly different at $p<.01$.

Flavor profiles from the trained panel showed that July-caught fish had poor flavor characteristics (Figure 25). A low chickeny note and a high degree of fishy and smoky off flavors (Appendix Table A) contributed to a lower flavor OAI for fish from this catch. The profile panel considered the October-caught fish to be the poorest of the year. A higher "livery" off flavor (Appendix Table A) in the October- caught fish penalized its score in all 3 flavor categories. This "livery" note apparently was not as objectionable to the consumer panel (Table XVI) as to the small trained panel (Figure 25). In all other months, relatively low levels of off flavors occurred.

Texture

There was a significant month x drying interaction (p .01) in the texture hedonic scores (Table XIII), so the data in Table XVII have been sorted according to the drying treatment. It is evident that there were few clear differences between how much the texture of the fish from different catches was liked. Scores of both not-dried and dried fish indicate that the texture of fish from the September and April catches was liked quite well. The texture of not-dried fish from the June, 1970, July and February catches was liked least, but scores for fish from these months were not significantly different from those of many other catches.

Rasekh et al. (1970) recently found that even when the 80 members of their consumer panels were asked to score canned tuna for texture preference, their scores were best correlated with odor and taste, rather than any of the texture variables measured. This was also found to be true in the present study where how much "consumers" liked the texture of the fish was correlated with how much they liked its flavor (r = .441). In addition, texture hedonic scores were well correlated with undesirable



Each bar represents the mean of 8 composite values (8 treatments)

Flavor Overall Impression | Chickeny note | Off flavors

FIGURE 25

MEAN FLAVOR OVERALL IMPRESSION, CHICKENY NOTE AND OFF FLAVORS IN FISH FROM EACH CATCH

TABLE XVII

MEAN TEXTURE HEDONIC SCORES[(1)] OF NOT-DRIED AND DRIED FISH EACH MONTH[(2)]

Month of Catch	Fish Form	
	Not-Dried	Dried
June, 1969	6.12[ab]	5.58[bc]
July	5.89[ab]	5.35[c]
August	5.92[ab]	5.75[abc]
September	6.30[a]	5.92[ab]
October	5.90[ab]	5.72[abc]
January	5.98[ab]	5.57[bc]
February	5.40[c]	6.02[ab]
March	6.05[ab]	5.90[ab]
April	6.22[a]	6.18[a]
June, 1970	5.67[bc]	5.60[bc]

(1) Each value is the mean of 240 observations (4 treatments x 60 replicates) when 1 = Dislike extremely; 9 = Like extremely.

(2) No values for May.

abc Values in the same column with the same superscript are not significantly different at $p<.01$.

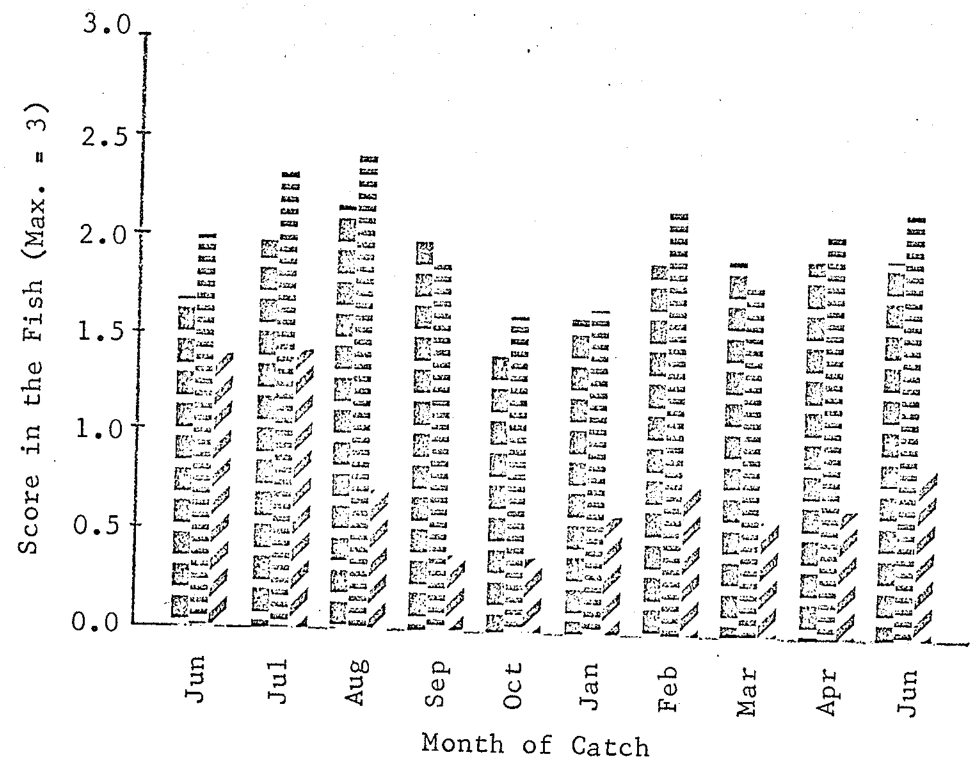
textural characteristics (r = .398), but were correlated only to a very small extent (r = .07) with hardness.

As a result of these influences in the consumer panel's evaluation of fish texture, the profile and instrumental data may be more useful in describing the texture of the fish from the various catches.

Examination of the texture profile data reveals that there were 2 obviously poor catches, January and October (Figure 26). Fish from both had low texture OAI and hardness scores, although undesirable textural characteristics were low in both cases. The three catches with the highest texture OAI were July, August and September, even though undesirable textural characteristics were high in the July catch and moderate in the August catch. Fish from the September catch had high texture OAI although hardness and force to shear values were only moderate (Table XVIII). The high texture OAI may have been a reflection of the low undesirable textural characteristics (Figure 26).

In the force to shear data there were many significant interactions of month with other variables; month x sex, month x drying, month x freezing, month x sex x drying, month x sex x freezing and month x drying x freezing (Table XIII). The implications of these interactions have been discussed in the sections dealing with sex, drying and freezing. In this section, results from all treatments have been combined, and mean values for each month are shown in Table XVIII. Fish caught in the summer of 1969 had high force to shear values, and October and January-caught fish had low force to shear values. Since no fish caught in November or December was evaluated, it is not known whether this softness is characteristic of winter-caught fish.

Although softness did not seem to lower the "consumer" panel's



[1]No values for May.

Each bar represents the mean of 8 composite values (8 treatments).

Texture Overall Impression   Hardness   Undesirable textural characteristics

FIGURE 26

MEAN TEXTURE OVERALL IMPRESSION, HARDNESS AND UNDESIRABLE TEXTURAL CHARACTERISTICS IN FISH FROM EACH CATCH

TABLE XVIII

FORCE REQUIRED TO SHEAR INDIVIDUAL CANS OF WHITEFISH EACH MONTH(1)

Month of Catch	Force to Shear (lbs. per can)
June, 1969	268[c]
July	321[b]
August	367[a]
September	228[ef]
October	191[g]
January	202[g]
February	241[de]
March	201[g]
April	251[d]
May	206[g]
June, 1970	226[f]

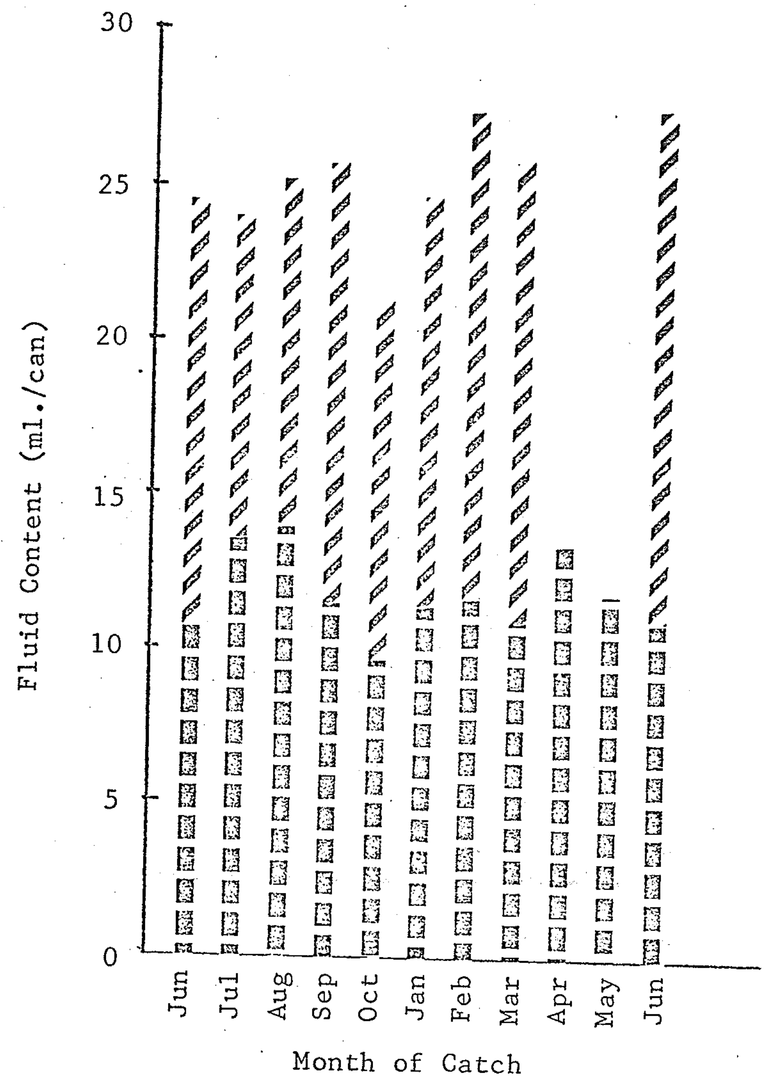
(1) Each value is the mean of 80 observations (8 treatments x 10 replicates).

abcdefg Values with the same superscript are not significantly different at $p<.01$.

evaluation of whitefish texture (Table XVII), softness was still felt to be a problem. Unpublished work in this department using canned whitefish in recipes indicated that its softness and friability definitely limited the usefulness of the fish. For these reasons, it was felt that fish from the October and January catches was less desirable for canning.

Examination of the moisture characteristics data (Figure 27) indicates that the free and expressible fluid content varied only to a small degree from month to month, although the sum of the free and expressible fluid, defined as total fluid, was considerably lower in October-caught fish than in fish from other catches.

Thus the texture data indicates that the fish was firmest during the summer months of 1969; June, July and August, although the "consumer" panel did not especially like fish from these catches. Both the "consumer" panel and the profile panel indicated that September-caught fish had desirable texture. October and January-caught fish are probably not useful for canning, due to the excessive softness in fish from these catches.



Each bar represents the mean of 40 observations (8 treatments x 5 replicates.

Total fluid = Free fluid + Expressible fluid

Free fluid of April and May-caught fish was not measured.

Expressible fluid   Free fluid

FIGURE 27

MEAN FREE, EXPRESSIBLE AND TOTAL FLUID CONTENT OF FISH FROM EACH CATCH

SUMMARY AND CONCLUSIONS

The effects of 2 pre-canning treatments, freezing and partial drying, and 2 methods of selecting fish for canning, by sex and month of catch on the characteristics of canned freshwater whitefish (Coregonus clupeaformis) were evaluated. Eleven catches of fish were obtained from William Lake, Manitoba, from June, 1969 to June, 1970.

Panels of 60 untrained judges provided an estimate of the consumer acceptance of the fish by evaluating both the flavor and the texture of all treatments from each catch. Although flavor and texture were evaluated on different fish samples, consumer scores from 9-point hedonic scales were significantly correlated (r = .441) showing that judges were unable to dissociate these two impressions. Consumer scores generally reflected the incidence of negative attributes expressed by a 6-member sensory panel trained in profile techniques. Correlation coefficients between consumer scores and undesirable fish characteristics were - .502 and - .398 for flavor and texture, respectively.

The profile panel also contributed descriptions of positive characteristics of the fish which were less related to "consumer" scores. The positive fish characteristics were correlated with the quality ratings assigned by the profile panel; chickeny note with flavor OAI (r = .777) and hardness with texture OAI (r = .750). The instrumental measurement of firmness, force required to shear the fish using the Allo-Kramer shear press, was also correlated with texture OAI (r = .40).

Free fluid in the cans was measured by draining the fish. Expressible fluid was measured by compressing the drained fish in the succulometer cell of the Allo-Kramer shear press and measuring the volume of fluid released during compression. The sum of free fluid and expressible fluid was termed total fluid. These intrumental measurements of moisture characteristics did not correlate well with the profile panel's description of moisture characteristics.

Freezing was definitely advantageous as a pre-canning treatment for whitefish. Consumer panels liked both the flavor and the texture of canned whitefish more if it had been frozen than if it was canned without prior freezing. Profile descriptions suggested that the main effects of freezing were an increase in fish firmness together with a decrease in the amount and rate of release of moisture. Force to shear data supported the panel's observation of increased firmness due to freezing. Free fluid was lower in fish frozen before canning, but expressible fluid was higher.

Partial drying before canning had a deleterious effect on fish quality, especially with regard to flavor. Consumer panels liked both the flavor and the texture of fish less if it had been dried before canning. In comparing dried and not-dried fish, the profile panel noted that dried fish had a higher incidence of off flavors and a less intense desirable chickeny flavor; however, dried fish was clearly firmer both from profile panel and force to shear measurements. Dried fish seemed to have lower amounts of moisture and a lower rate of moisture release in the mouth. Free and total fluid was appreciably decreased by pre-canning drying, but expressible fluid was increased.

Compared with the marked differences associated with the pre-canning treatments, variability attributable to the sex of the fish was small. Female fish were slightly firmer than males, but freezing before canning was found to minimize the difference in firmness of the 2 sexes of fish.

The fish was extremely variable from month to month, but seasonal patterns were not readily apparent. Fish caught in the summer of 1969 was firm, and October and January-caught fish was soft. Fish from the October catch had a "livery" flavor which resulted in a low flavor overall impression rating, but this flavor did not seem to influence how much the flavor of the fish was liked.

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APPENDIXES

APPENDIX TABLE A

FLAVOR PROFILES

June, 1969 Catch

	Treatment							
	MFr	MFo	MFrD	MFoD	FFr	FFo	FFrD	FFoD
Color	2-2½	2½	2½	2½-3	2½	2½	2½	2
Overall Impression	2½	1½-2	2-2½	1½	2½-3	2½-3	1½-2	2
Initial	Sa 1	Sa 1	Sa 1	Sa 1	Sa 1	Sa 1-1½	Sa 1½	Sa 1½
Mastication	Ch 1½-2 Sw ½	Ch 1½-2 Sw)(Fi 1	Ch 1½-2 Sw ½ So ½	Sm 1 Ch 1-1½ Sw)(	Ch 2-2½ Sw ½-1	Ch 2 Sw ½	Ch 1½ Sw ½ Fi ½ Sm)(	Ch 1½ Sw)(Sm)(So)(
Residual	Ch)(	Fi)(	Ch½	Fi)(	Ch ½	Ch ½	Fi)(Ch)(	Ch)(Fi)(

July Catch

	Treatment							
	MFr	MFo	MFrD	MFoD	FFr	FFo	FFrD	FFoD
Color	2½-3	2	2	1½	2½	2	1½-2	1½
Overall Impression	2½	2-2½	1½-2	1½	2½	1½-2	1½	1½
Initial	Sa 1	Sa 1	Sm 1 Sa 1½	Sm 1 Sa 1½	Sa 1½	Sa 1	Sm 1-1½ Sa 1	Sm 1-1½ Sa 1½
Mastication	Ch 2 Sw 1	Ch 1½-2 Sw ½	Ch 1½ Sw)(So)(	Ch 1 Sw)(So)(Fi 1-1½	Ch 2 Sw ½	Ch 2 Sw ½ So 1 Fi ½	Ch 1-1½ Sw)(-½ So ½ Fi ½	Ch 1-1½ Fi 1
Residual	Ch ½	Fi)(-½ Ch)(	Fi)(Ch)(	Fi)(	Ch ½ Fi)(	Ch ½ Fi ½	Sm)(Fi)(	Fi ½

APPENDIX TABLE A (CONTINUED)

August Catch

	Treatment							
	MFr	MFo	MFrD	MFoD	FFr	FFo	FFrD	FFoD
Color	2	3	1½	1½-2	1½-2	2½	2-2½	2
Overall Impression	2-2½	2½-3	1½	1½	2	2½	2	2
Initial	Sa 1-1½	Sa 1	Sm 1 Sa 1	Sa 1	Sa 1	Sa 1	Sa 1-1½	Sm 1 Sa 1
Mastication	Ch 2 Sw ½ Me)(	Ch 2 Sw ½	Ch 1-1½ Sw)(Fi ½-1	Ch 1½ Sm)(Sw)(So ½ Fi ½	Ch 1½ Sw)(	Ch 2 Sw)(	Ch 2 Sw)(Fi)(So ½ Me ½	Ch 2 Sw)(
Residual	Ch)(	Ch ½-1	Fi)(	Fi)(Ch ½	Ch)(Fi)(	Ch ½	Ch)(	Ch ½ Sm)(

September Catch

	Treatment							
	MFr	MFo	MFrD	MFoD	FFr	FFo	FFrD	FFoD
Color	2½	2½	2½-3	1½-2	2½	2½	2½	2
Overall Impression	2-2½	2½	2	1½	2½	2½	1½-2	2-2½
Initial	Sa 1	Sa 1-1½	Sa 1	Sa 1	Sa 1	Sa 1-1½	Sa 1-1½ Sm)(	Sa 1-1½
Mastication	Ch 2½ Sw ½ Fi)(	Ch 2 Sw ½-1	Sm ½ Ch 2 Sw ½ So)(	Sm)(Ch 1½ Sw)(Fi)(	Ch 2-2½ Sw ½	Ch 2½ Sw ½	Ch 1½-2 Sw)(-½ Fi)(	Ch 2 Sw ½
Residual	Ch ½	Ch)(	Ch ½	Ch)(	Ch)(	Ch ½	Ch)(	Ch)(-½

APPENDIX TABLE A (CONTINUED)

October Catch

	Treatment							
	MFr	MFo	MFrD	MFoD	FFr	FFo	FFrD	FFoD
Color	2½	2½-3	2	1½	2	2½	2½	2
Overall Impression	1-1½	2½	1½	1½	1½	1½	1-1½	1-1½
Initial	Sa ½	Sa 1-1½	Sm 2 Sa 1	Sm 2 Sa 1	Sa 1	Sa 1	Sm 2-2½ Sa 1-1½	Sm 2 Sa 1
Mastication	Ch 1½ Li 1	Ch 2 Sw)(-½ Li ½	Ch 1½ Sw)(So)(	Ch 1½ Sw)(	Ch 1½ Sw)(Fi)(	Ch 1-1½ Sw)(So ½ Li)(	Ch 1-1½ Sw)(Bi)(	Ch 1½ Sw ½
Residual	Li ½ Ch)(	Ch)(	Sm ½ Ch)(	Sm)(-½ Ch)(	Ch)(	Ch)(	Sm ½ Ch)(	Ch)(Sm ½

January Catch

	Treatment							
	MFr	MFo	MFrD	MFoD	FFr	FFo	FFrD	FFoD
Color	2-2½	2½	2½	2	2	2½	2½	2
Overall Impression	2-2½	2½-3	2	2	1½	2½	1½-2	1½-2
Initial	Sa 1-1½	Sa 1½	Sa 1½	Sa 1-1½	Sa 1-1½	Sa 1½	Sa 1½	Sa 1½
Mastication	Ch 2 Sw)(So)(	Ch 2-2½ Sw)(	Ch 1½-2 Sw)(Fi)(Li)(	Ch 2 Sw)(So)(	Ch 2 Sw)(Fi ½ So ½ Li)(	Ch 2½ Sw)(	Ch 2 Fi ½ Sm)(	So 1 Ch 1½ Sw)(
Residual	Ch)(	Ch)(	Ch)(	Ch)(Fi)(	Ch)(Fi)(	Ch)(	Fi)(Ch)(	Ch ½

APPENDIX TABLE A (CONTINUED)

February Catch

	Treatment							
	MFr	MFo	MFrD	MFoD	FFr	FFo	FFrD	FFoD
Color	2½-3	2½-3	2-2½	1½-2	2½-3	2	1½-2	2
Overall Impression	2½	2	2	1½	2	2-2½	1½-2	1½
Initial	Sa 1-1½	Sa 1	Sa 1-1½	Sa 1-1½	Sa 1	Sa 1½	Sa 1½	Sa 1-1½
Mastication	Ch 2 Sw)(Li)(	Ch 1½ So ½ Sw)(	Ch 2 Sw)(Li)(	Sm)(Ch 1½ Sw)(	Ch 1½ Sw)(So)(	Ch 2 Sw)(So)(Fi)(	Sm ½ Ch 1½-2 Sw)(Fi)(	Ch 1½ So)(Sm)(Fi)(
Residual	Ch)(	Ch)(	Ch)(	Ch)(Fi)(	Fi)(	Ch)(	Ch)(	-

March Catch

	Treatment							
	MFr	MFo	MFrD	MFoD	FFr	FFo	FFrD	FFoD
Color	2½	2½	2	2	3	3	2½	2
Overall Impression	1-1½	2	1-1½	1½-2	3	2½	1½-2	2
Initial	Sa 1	Sa 1½	Sa 1	Sa 1-1½	Sa 1	Sa 1	Sa 1	Sa 1
Mastication	Ch 1-1½ Sw)(Li 1	Ch 2-2½ Sw)(Li)(	Sm ½ Ch 1-1½ So)(	Ch 1½ Sw)(Sm)(So)(Fi)(	Ch 2 Sw ½	Ch 2 Sw)(	Ch 2 Sw)(Li ½ So)(	Ch 2 Sw)(So)(Sm)(
Residual	Li)(	Ch)(	Fi ½	Fi)(Me ½	Ch ½	Ch ½	Ch)(	Ch)(

APPENDIX TABLE A (CONTINUED)

April Catch

	Treatment							
	MFr	MFo	MFrD	MFoD	FFr	FFo	FFrD	FFoD
Color	3	2½	2½-3	2½	2½-3	2½-3	2½	2½
Overall Impression	2½-3	2½-3	2-2½	1½	2-2½	2-2½	2½	1½
Initial	Sa 1	Sa 1½	Sa 1-1½	Sa 1	Sa 1-1½	Sa 1½	Sa 1	Sa 1½
Mastication	Ch 2½ Sw ½	Ch 2½ Sw)(-½	Ch 2 Sw)(Fi)(	Cu ½-1 Mo ½-1 So)(Ch 1½-2 Sw)(	Ch 2 Sw)(Bi)(	Ch 2 Sw)(Fi)(	Ch 2 Sw)(Fi)(	Ch 1½-2 Sw)(Sm)(Fi ½ So ½
Residual	Ch)(-½	Ch)(-½	Ch)(	Ch)(	Ch)(	Ch)(-½	Ch)(	Fi)(Ch)(

May Catch

	Treatment							
	MFr	MFo	MFrD	MFoD	FFr	FFo	FFrD	FFoD
Color	2½	2½	2½-3	2½	2½-3	2½-3	2-2½	2
Overall Impression	2½	2-2½	1½	2-2½	2-2½	2½	1½-2	1½-2
Initial	Sa 1	Sa 1	Sa 1-1½	Sa 1-1½	Sa 1	Sa 1	Sa 1	Sa 1-1½
Mastication	Ch 2-2½ Sw)(Li)(	Ch 2-2½ Sw)(Li ½	Ch 1½-2 Sw)(Li)(Fi ½	Ch 2-2½ Sw)(Fi)(	Ch 2 Sw)(So ½	Ch 2½ Sw)(So)(Li)(	Fi ½ Ch 2 Sw ½ Sw)(	Sm ½ Ch 1½-2 Sw)(Fi ½
Residual	Ch ½	Ch)(	Ch)(	Ch)(	Ch)(	Ch)(	Ch)(Fi)(	Ch)(Fi)(

APPENDIX TABLE A (CONTINUED)

June, 1970 Catch

	Treatment							
	MFr	MFo	MFrD	MFoD	FFr	FFo	FFrD	FFoD
Color	2-2½	2½	2	2	2½-3	2½-3	2-2½	2½
Overall Impression	2	2-2½	1½-2	2	2½	2-2½	2	1
Initial	Sa 1½	Sa 1½	Sa 1½	Sa 1-1½	Sa 1-1½	Sa 1-1½	Sa 1-1½	Sa 1-1½
Mastication	Ch 2-2½ Sw)(Li ½ Fi)(	Ch 2-2½ Sw)(So)(Li)(	Ch 1½-2 Sw)(Fi)(	Ch 2 Sw)(Sm)(Li)(	Ch 2½ Sw)(Bi)(So)(	Ch 2-2½ Sw)(Fi)(	Ch 2 Sw)(So)(Li)(	Ch 1½-2 Sw)(So ½ Li)(Fi)(-½
Residual	Ch)(	Ch)(	Ch)(	Ch)(	Ch)(	Ch)(	Ch)(	Ch)(Fi)(

Abbreviations

Sw - Sweet
So - Sour
Sa - Salt
Bi - Bitter
Ch - Chickeny
Fi - Fishy
Sm - Smoky
Me - Metallic
Li - Livery
Mo - Mouldy
Cu - Cucumber-like

Each profile is a composite from discussion of judgements by 4 - 6 panelists.

APPENDIX TABLE B

TEXTURE PROFILES

June, 1969

Parameters	Treatments							
	MFr	MFo	MFrD	MFoD	FFr	FFo	FFrD	FFoD
Flakiness	2 - 2½	2	1½ - 2	1½ - 2	2	2	1½	1½
Texture Overall Impression	2	1½	1½	1½	1½	2	1	2 - 2½
Hardness	3	1	2	2 - 2½	1½	2 - 2½	1½ - 2	2 - 2½
Rate of Moisture Release	1	1	½ - 1	½ - 1	1	½ - 1	1 - 1½	1
Tendency to Felt	½	)(	1	½	)(- ½	1½	½	½
Amount of Moisture Release	1 - 1½	1	½	½	1	½	1	1
Oiliness	½ - 1	1	1½	½	½	½	1	1
Mealiness	1	)(	)(	1 - 1½	½	)(	2	½

July

	Treatments							
	MFr	MFo	MFrD	MFoD	FFr	FFo	FFrD	FFoD
Flakiness	2	2½	2½	2	2½	2½	2	2 - 2½
Texture Overall Impression	2½	2	1½ - 2	2	2	2	1½ - 2	1½ - 2
Hardness	2½	2	1½ - 2	2½	2 - 2½	2½	2½	2½
Rate of Moisture Release	1	1	½ - 1	½	1½	1	1	½
Tendency to Felt	)(	½	½ - 1	)(- ½	½ - 1	1	1½	1
Amount of Moisture Release	1	1½	1	½ - 1	1 - 1½	½ - 1	1	½
Oiliness	½	1 - 1½	½ - 1	½ - 1	½	1	½ - 1	½ - 1
Mealiness	)(	)(- ½	)(- ½	½ - 1	)(	1½	0	1½

APPENDIX TABLE B (CONTINUED)

August

Parameters	Treatments							
	MFr	MFo	MFrD	MFoD	FFr	FFo	FFrD	FFoD
Flakiness	1½ - 2	2	2 - 2½	2 - 2½	2½	2 - 2½	2 - 2½	2
Texture Overall Impression	1½ - 2	1½ - 2	2 - 2½	2	2½	2½	2	1½ - 2
Hardness	1½ - 2	2	3	2½	2½ - 3	2½	2	2½ - 3
Rate of Moisture Release	2	1½ - 2	1	1 - 1½	1½	1½ - 2	1	½
Tendency to Felt	0	)(	)(	1	0	)(	0 -)(	)(
Amount of Moisture Release	1½	1	1	1	1 - 1½	1	½ - 1	½
Oiliness	½	1	½ - 1	1	1	1	1	½
Mealiness	1	½	)(	)(- ½	0 -)(	)(	½	½

September

	Treatments							
	MFr	MFo	MFrD	MFoD	FFr	FFo	FFrD	FFoD
Flakiness	2	2 - 2½	2½	1½ - 2	2½	1½ - 2	1½	2½ - 3
Texture Overall Impression	1½	1½ - 2	2½	2½	1½ - 2	1½	2	2 - 2½
Hardness	1	1 - 1½	3	2½ - 3	1½	1½	1½ - 2	2
Rate of Moisture Release	1½	1½ - 2	1 - 1½	1	1	2	1½	1
Tendency to Felt	0 -)(	0	½ - 1	0	)(	)(	0	0
Amount of Moisture Release	1 - 1½	1	1	1	1	1½	1 - 1½	1
Oiliness	½	½ - 1	½	½	½	½	½	½
Mealiness	)(	)(	)(	½	0 -)(	0	)(- ½	0

APPENDIX TABLE B (CONTINUED)

October

Parameters	Treatments							
	MFr	MFo	MFrD	MFoD	FFr	FFo	FFrD	FFoD
Flakiness	1½	2½	2	2½ - 3	1 - 1½	2½ - 3	1½ - 2	1½ - 2
Texture Overall Impression	½	1 - 1½	1½	2	½ - 1	1½	2	1½ - 2
Hardness	1	1	1½	2	½ - 1	1½	2	3
Rate of Moisture Release	1½	1	1½	1½	2	1½	1½	)(
Tendency to Felt	0	0	)(	0 -)(	0	0	½	)(
Amount of Moisture Release	1	1	½ - 1	1 - 1½	1½ - 2	1	1	)(- ½
Oiliness	½	½	½ - 1	1	½	½	1	1
Mealiness	0	)(	1	0	)(	)(	)(	0

January

	Treatments							
	MFr	MFo	MFrD	MFoD	FFr	FFo	FFrD	FFoD
Flakiness	1½	2½	2½	2½	1½	2½	1½ - 2	2½ - 3
Texture Overall Impression	1	1½ - 2	2	2	1	2	1	2
Hardness	1 - 1½	1½	2	2	1	2	1½	1½ - 2
Rate of Moisture Release	1½ - 2	2	1 - 1½	1½	2	1½	1	1½
Tendency to Felt	)(	½	0 -)(	0 -)(	0	)(	)(	)(
Amount of Moisture Release	1	1½	1	1	1½	1	1	1
Oiliness	½	½ - 1	1	½ - 1	½	½ - 1	½	1
Mealiness	½	)(	½	)(	)(	)(	½ - 1	)(

APPENDIX TABLE B (CONTINUED)

February

Parameters	Treatments							
	MFr	MFo	MFrD	MFoD	FFr	FFo	FFrD	FFoD
Flakiness	2	2	2	2	1½ - 2	2	2	2
Texture Overall Impression	1 - 1½	1½	2	2	1 - 1½	2½	2 - 2½	2 - 2½
Hardness	1	1½	2½	3	1½	2 - 2½	3	2½
Rate of Moisture Release	1½	1 - 1½	½ - 1	1	1½	1½	½ - 1	1
Tendency to Felt	)(	)(	0	)(	)(	)(	½	½
Amount of Moisture Release	1	1½	½ - 1	1	1	1	½	½ - 1
Oiliness	½	½ - 1	½ - 1	1	½	½	½ - 1	1
Mealiness	)(	)(	1	½	1 - 1½	0	)(	)(

March

	Treatments							
	MFr	MFo	MFrD	MFoD	FFr	FFo	FFrD	FFoD
Flakiness	2½	2½	1½ - 2	2½	1½ - 2	2	2 - 2½	1½ - 2
Texture Overall Impression	2	2½	1½	2½	1½	1½	1½ - 2	2
Hardness	2	2	1½ - 2	2 - 2½	1 - 1½	1½	1½	2
Rate of Moisture Release	1½	1 - 1½	1½	1	1½	1	1½	1 - 1½
Tendency to Felt	)(	0	)(- ½	0	)(	½	½	)(
Amount of Moisture Release	1	1½	1 - 1½	1	1 - 1½	1	1	½
Oiliness	½	½	½ - 1	1	½ - 1	½ - 1	½	1
Mealiness	)(	)(	)(- ½	0	½ - 1	)(	)(- ½	)(

APPENDIX TABLE B (CONTINUED)

April

Parameters	Treatments							
	MFr	MFo	MFrD	MFoD	FFr	FFo	FFrD	FFoD
Flakiness	2	2½	2	2½	2 - 2½	2½	2 - 2½	2 - 2½
Texture Overall Impression	1	2½	1	2½	1 - 1½	2½	2	2½
Hardness	1	2½	1	2½	1 - 1½	2½ - 3	3	2½
Rate of Moisture Release	2	1½	1½ - 2	1	1½	1	1 - 1½	1½
Tendency to Felt	)(	)(	½	0	)(	0	1	)(
Amount of Moisture Release	1½	1½	1 - 1½	1	1½	1 - 1½	1	1 - 1½
Oiliness	½ - 1	½	½ - 1	½	½	½	½ - 1	½
Mealiness	1	0	½ - 1	0	½	0	)(	0

June, 1970

	Treatments							
	MFr	MFo	MFrD	MFoD	FFr	FFo	FFrD	FFoD
Flakiness	1½ - 2	2½ - 3	1½	2½	2	2½ - 3	2½	2
Texture Overall Impression	1½	2	1½	2 - 2½	2	2	2 - 2½	1½ - 2
Hardness	1½	2	1½ - 2	3	2	2 - 2½	2 - 2½	2½
Rate of Moisture Release	1	1½	1½	1	1½	1	1½	1
Tendency to Felt	½	)(	1	)(	1	)(- ½	½	)(
Amount of Moisture Release	½	1	1	1	1	1	1½	½ - 1
Oiliness	½ - 1	½	½ - 1	½	½ - 1	1	½ - 1	½ - 1
Mealiness	½	)(	½ - 1	)(	0	0	)(	½ - 1

Each profile is a composite from discussion of judgements by 4 - 6 panelists.

APPENDIX TABLE C

FLAVOR HEDONIC SCORES BY MONTH AND TREATMENT(1)

Month of Catch	Treatments							
	MFr	MFo	MFrD	MFoD	FFr	FFo	FFrD	FFoD
June, 1969	5.82	6.60	5.33	5.80	6.13	6.75	5.45	5.92
July	5.62	6.32	5.38	5.52	5.57	5.83	5.27	5.03
August	5.83	6.40	5.32	5.97	5.90	6.43	5.65	5.13
September	6.53	6.48	5.63	5.68	6.45	6.00	5.37	5.08
October	5.93	6.32	5.57	5.22	6.33	6.45	5.35	6.13
January	6.05	6.32	5.77	5.58	6.13	6.22	5.20	5.72
February	6.10	6.47	6.27	5.98	6.17	6.68	6.47	6.20
March	6.32	6.13	5.87	6.20	6.08	6.37	5.93	5.45
April	6.65	5.85	5.97	5.95	6.72	6.62	6.18	6.27
May	-	-	-	-	-	-	-	-
June, 1970	5.62	6.18	5.98	5.80	6.28	6.50	5.82	5.00

(1) Each value is the mean of 60 individual judgements where

1 = Dislike extremely; 9 = Like extremely.

APPENDIX TABLE D

TEXTURE HEDONIC SCORES BY MONTH AND TREATMENT(1)

Month of Catch	Treatments							
	MFr	MFo	MFrD	MFoD	FFr	FFo	FFrD	FFoD
June, 1969	6.13	6.00	4.93	5.87	5.92	6.52	5.43	5.87
July	5.60	6.10	5.47	5.27	6.03	5.83	5.23	5.43
August	5.52	5.73	5.32	5.85	6.32	6.08	5.88	5.95
September	6.33	6.32	5.90	5.72	6.13	6.38	5.82	6.23
October	5.95	5.83	5.50	5.77	5.63	6.18	5.60	6.02
January	5.67	6.52	5.82	5.58	5.83	5.92	5.22	5.67
February	4.63	6.35	5.75	6.20	4.93	5.67	5.72	6.40
March	5.87	6.63	5.47	5.92	5.73	5.97	6.13	6.08
April	6.37	6.45	5.95	6.15	6.03	6.03	6.07	6.53
May	-	-	-	-	-	-	-	-
June, 1970	5.43	5.75	5.38	5.92	5.53	5.95	5.73	5.38

(1) Each value is the mean of 60 individual judgements where

1 = Dislike extremely; 9 = Like extremely.

APPENDIX TABLE E

FREE FLUID CONTENT OF CANNED WHITEFISH BY MONTH AND TREATMENT(ML.)[(1)]

Month of Catch	Treatments							
	MFr	MFo	MFrD	MFoD	FFr	FFo	FFrD	FFoD
June, 1969	18.5	17.2	10.8	11.5	18.4	12.4	10.6	11.2
July	15.4	11.6	9.0	7.9	11.4	12.9	7.7	8.3
August	15.8	11.1	11.1	9.7	13.1	11.1	9.7	7.6
September	21.6	12.3	14.7	10.8	19.8	14.4	11.3	9.9
October	14.3	12.3	11.8	6.7	16.8	13.2	9.5	9.3
January	17.0	15.0	15.0	7.4	18.7	14.0	12.4	7.2
February	20.3	15.4	13.9	12.2	21.3	17.0	15.8	10.9
March	19.1	15.5	15.3	8.3	19.2	16.0	16.9	8.6
April	-	-	-	-	-	-	-	-
May	-	-	-	-	-	-	-	-
June, 1970	20.2	15.7	17.3	13.8	20.0	16.3	16.9	12.9

(1) Each value is the mean of readings on 5 cans of whitefish.

APPENDIX TABLE F

EXPRESSIBLE FLUID CONTENT OF CANNED WHITEFISH BY MONTH AND TREATMENT(ML.)[1]

Month of Catch	Treatments							
	MFr	MFo	MFrD	MFoD	FFr	FFo	FFrD	FFoD
June, 1969	8.0	10.0	9.5	9.6	9.0	12.8	14.4	12.0
July	10.5	11.7	14.1	16.1	13.6	14.4	15.2	12.6
August	9.7	13.3	12.6	14.1	11.9	16.3	15.0	17.9
September	9.2	10.8	10.8	13.8	8.5	10.9	11.8	14.8
October	4.5	9.0	9.4	9.6	7.5	11.4	12.8	12.5
January	8.9	12.1	9.6	13.4	8.0	14.5	8.5	16.3
February	6.0	13.9	12.8	15.2	6.1	12.5	11.0	14.9
March	8.2	10.1	9.8	16.2	9.4	9.4	9.2	15.0
April	8.9	17.0	13.7	15.0	9.2	14.5	14.7	14.4
May	9.5	13.6	11.9	14.1	7.8	9.6	11.7	15.1
June, 1970	8.6	11.7	10.2	12.8	11.6	11.1	8.5	12.5

(1) Each value is the mean of readings on 5 cans of whitefish.

APPENDIX TABLE G

TOTAL FLUID CONTENT OF CANNED WHITEFISH BY MONTH AND TREATMENT(ML.)[1]

Month of Catch	Treatments							
	MFr	MFo	MFrD	MFoD	FFr	FFo	FFrD	FFoD
June, 1969	26.5	27.2	20.3	21.1	27.4	25.2	25.0	23.2
July	25.9	23.3	23.1	24.0	25.0	27.3	22.9	20.9
August	25.5	24.4	23.7	23.8	25.0	27.4	24.7	25.5
September	30.8	23.1	25.5	24.6	28.3	25.3	23.1	24.7
October	18.8	21.3	21.2	16.3	24.3	24.6	22.3	21.8
January	25.9	27.1	24.6	20.8	26.7	28.5	20.9	23.5
February	26.3	29.3	26.7	27.4	29.5	29.5	26.8	25.8
March	27.3	25.6	25.1	24.5	28.6	25.4	26.1	23.6
April	-	-	-	-	-	-	-	-
May	-	-	-	-	-	-	-	-
June, 1970	28.8	27.4	27.5	26.6	31.6	27.4	25.4	25.4

(1) Each value is the mean of readings on 5 cans of whitefish.

APPENDIX TABLE H

FORCE REQUIRED TO SHEAR CANNED WHITEFISH BY MONTH AND TREATMENT(LB.)(1)

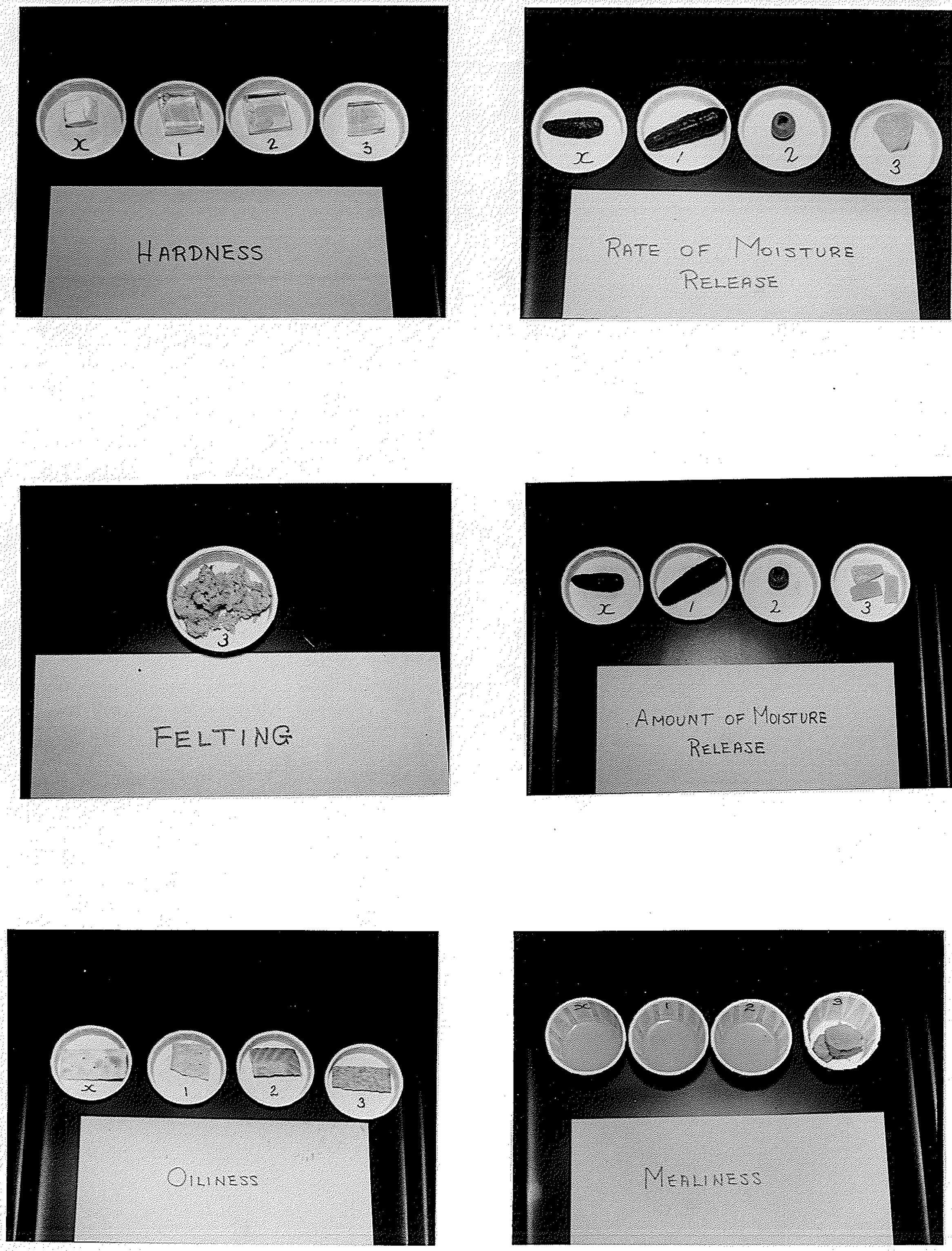
Month of Catch	Treatments							
	MFr	MFo	MFrD	MFoD	FFr	FFo	FFrD	FFoD
June, 1969	180	245	280	350	210	260	285	345
July	210	255	315	405	260	295	435	395
August	250	280	380	415	315	365	420	510
September	165	205	240	295	175	205	255	280
October	110	160	200	225	145	195	255	240
January	170	225	170	225	155	240	195	245
February	160	195	345	305	180	230	225	285
March	160	185	185	275	165	190	185	265
April	180	230	225	315	200	225	295	345
May	155	200	190	230	165	165	255	295
June, 1970	185	180	280	260	195	170	290	245

(1) Each value is the mean of readings on 10 cans of whitefish.

APPENDIX TABLE I

GLOSSARY OF ABBREVIATIONS

Treatments	
MFr	- Male fish canned from fresh state
MFo	- Male fish frozen, thawed, then canned
MFrD	- Male fish partially dried, then canned
MFoD	- Male fish partially dried, frozen, thawed, then canned
FFr	- Female fish canned from fresh state
FFo	- Female fish frozen, thawed, then canned
FFrD	- Female fish partially dried, then canned
FFoD	- Female fish partially dried, frozen, thawed, then canned
Terms Used by Profile Panels	
Flavor OAI	- Flavor overall impression
Texture OAI	- Texture overall impression
RMR	- Rate of moisture release
AMR	- Amount of moisture release



APPENDIX PLATE A

ANCHORED SCALES USED FOR TEXTURE PROFILE ANALYSIS