

MENHADEN (BREVOORTIA TYRANNUS);
UTILIZATION AS A POTENTIAL FOOD RESOURCE

by

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(ABSTRACT)

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Thermally processed menhaden products were evaluated as potential food products. Nine canned menhaden products judged to be satisfactory in pilot studies were canned or pasteurized and evaluated by a six member semi-trained panel. Panelists scored product characteristics of menhaden products and commercially canned tuna in oil, tuna in water and mackerel. Three canned menhaden products were incorporated in "pizza" sauce and in fish salad recipes that were scored for preference by consumer panelists. Objective measurements for drained weight and total fluid were recorded.

Descriptive analysis of the nine canned menhaden products indicated that the dressed and filleted menhaden products were similar in the firmness, flakiness, chewiness, moisture, and fish flavor characteristics. Canned minced menhaden products were significantly different from the dressed and filleted fish products in the texture characteristics: firmness, flakiness and chewiness.

Plots drawn for comparison of mean characteristic scores of each menhaden product and the three comparison products (tuna in oil, tuna in water, mackerel) indicated that the canned filleted

menhaden in oil was judged by a semi-trained panel to be similar to the two commercially canned tuna products.

Consumer preference scores for the menhaden products were significantly different from the scores for comparison products used in the pizza sauces and fish salads. The menhaden fish salads and the menhaden pizza sauce were scored lower.

Objective measurements indicated that the use of an alum and citric acid brine increased percent weight loss and percent fluid loss. The minced menhaden product brined in alum and citric acid had the highest recorded percent weight loss and percent fluid loss. Pilot study and consumer preference panelists indicated that the alum and citric acid brine imparted a metallic aftertaste to the canned menhaden products.

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To the memory of my Mother,

"We must accept finite regret, but we
must never lose infinite hope."

(M.L. King)

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Chapter I
INTRODUCTION

Menhaden (Brevoortia tyrannus) is an abundant species of fish classified as an "industrial" fish. Menhaden has had limited use as a commercial food product because of the fishes high oil content and fine-branched bone structure. The production of food products from menhaden has not been researched extensively. Additional research is needed before menhaden can be considered for human consumption.

The goal of this research was to evaluate thermally processed menhaden as a commercial food resource. The objectives for the research were: 1) to objectively measure drained weight and fluid loss of nine thermally processed menhaden products; 2) to complete a descriptive sensory evaluation of the nine menhaden products using a semi-trained panel and, 3) to evaluate three canned menhaden products incorporated into recipes.

Chapter II

REVIEW OF LITERATURE

HISTORICAL NOMENCLATURE

Menhaden has a documented history beginning in the early 1800s, and a collection of names to rival its history in length. Goode (1884) attributed thirty names to menhaden which vary primarily with geographical region and secondarily with the local population's feelings toward certain of the fishes characteristics (McCay, 1980).

Menhaden, a name used in southern New England, and poggy, a name commonly used north of Cape Cod, originated from two American Indian words: "Pookagan" an Abnaki name that means "that which enriches the earth (Goode, 1884)." A Massachusetts Indian word "Munnawhutteaug", referring to several species of fish used to fertilize hills of corn, is also credited with being the forerunner of the name menhaden (June and Reintjes, 1976). Whatever the ancestral ties, menhaden is the common name G. B. Goode helped establish in the nineteenth century (McCay, 1980) and is the accepted common name today.

Still in use, the names bunker and mossbunker have geographical roots in New Jersey and New York with their heritage from the Dutch. The term mossbunker was "transferred by analogy from a European fish with similar surface-schooling behavior known to the Hollanders as 'marshbanker' (McCay, 1980)." Other names

that refer to menhaden's individual or analogous characteristics are fatback, bony-fish, green-tail, alewife, and pilcher (McCay, 1980; Goode, 1884).

Virginian's added three names in the 1800s that are no longer common but are nonetheless descriptive; bug-fish, bug-head and bud-shad. Like other menhaden aliases, these names have an origin, they refer to the parasitic crustacean that lives in the mouth of the southern menhaden (Goode, 1884).

CLASSIFICATION

Menhaden belong to the class of True or Bony fishes, Osteichthyes, and come under the herring family, Clupeidae. There are six closely related species of menhaden, genus Brevoortia, that are found along the North and South American coasts (Hildebrand and Schroeder, 1972; Perlmutter, 1961). Brevoortia aurea and Brevoortia pectinata are the South American species. Brevoortia smithi (yellow-fin menhaden), Brevoortia gunteri (fine-scaled menhaden), Brevoortia patronus (Gulf menhaden), and Brevoortia tyrannus (Atlantic menhaden) inhabit the North American coastal waters, with the latter two species being of primary importance in the United States fishing industry (June and Reintjes, 1976; June, 1961; Goode, 1887).

ANATOMY

Menhaden are dark blue to blue brown along the back and

sides, gradually changing to silver along the belly flap. A characteristic dark shoulder spot is found just behind the gill. A single fin is located midway along the back and the midline of the belly has a row of sharp-edged bony plates. Basically, menhaden appear similar to other members of the herring family, especially the alewife (Pomolobus pseudoharengus) and shad (Alosa sapidissima), but are recognizable by their exposed margin of nearly vertical scales which have serrated, rather than smooth edges (June and Reintjes, 1976; Perlmutter, 1961). Menhaden are filter feeders. The mouth of menhaden have about 1500 thread-like bristles from one-third to three-fourths of an inch long which serve as a strainer or filter (Goode, 1887). Plankton are the primary food source of juvenile and adult menhaden. Menhaden have a digestive system characteristic of herbivores with a muscular gizzard-like cardiac stomach, low peptase content and a long coiled intestine (Grosslein and Azarovitz, 1982).

Mean lengths of fish in successive age groups are used to estimate growth. The measurement is taken from the tip of the snout along the midline to the fork of the tail. Mean length for age groups 1 through 7 were reported by June, (1961), and Grosslein and Azarovitz, (1981) and are shown in Table 1.

Atlantic menhaden (Brevoortia tyrannus) mature sexually at two years of age. Spawning occurs annually in the middle of the Continental Shelf and also in certain bays and sounds. Females produce 60,000 to 600,000 eggs per year and evidence indicates that

Table 1-Mean lengths for menhaden for age groups 1 through 7.

Age years	Mean Length mm (inches)
1	135 (5.5)
2	215 (8.5)
3	250 (10.0)
4	270 (11.0)
5-7	300-350 (12.0-15.0)

major spawning takes place in late fall (Grosslein and Azarovitz, 1982; Hildebrand and Schroeder, 1972; June, 1961). Larvae ride the ocean currents, or swim, to inshore estuaries of lower salinity where they grow to juveniles. Juveniles then move toward more saline waters where they form schools and move out into the ocean in the autumn (Grosslein and Azarovitz, 1982).

June and Reintjes (1976) stated that "the Atlantic menhaden is a temperate species which occurs from Nova Scotia to the Central coast of Florida. The Gulf menhaden is a sub-tropical species which is distributed in the Gulf of Mexico from Southern Florida to Yucatan Peninsula."

Menhaden undertake extensive migrations and congregate in specific localities during certain periods of the year. In colder months, sometime during September or October, menhaden disappear and are rarely seen in surface coastal waters until the following April or May. During the warmer months, the fish concentrate in schools containing 1 to 75 tons of fish, in near-surface waters over the inner half of the Continental Shelf. Throughout the summer months, large schools are found in estuarine drainage systems, such as the Mississippi Delta and Chesapeake Bay (June and Reintjes, 1976; June, 1961). In autumn the fish withdraw and move southward. Schools are large, containing thousands of tons of fish, and at times covering a surface area of several square kilometers. The purse-seine fleet follow these large schools as they migrate (June, 1961).

ANNUAL YIELDS

Goode (1887) stated that in the 1880s menhaden were a major contributor to the total yields of fishery products in the United States. Maryland, Virginia, Delaware, New Jersey, New York, Connecticut, Rhode Island, Massachusetts and Maine all had menhaden fisheries. Approximately 243,059 tons of menhaden were reported by Goode (1887) for the year 1880. He gave the value of the menhaden products as 2,116,787 dollars. From 1950 to 1974, the total landings of menhaden in thousands of tons ranged from a low of 513,159 in 1950, to a high of 1,173,972 in 1962. The value to fishermen in thousands of dollars was 10,402 and 25,866 for the years 1950 and 1962 respectively. In 1974, the menhaden catch totaled 969,596,000 tons, with a value of 75 million dollars (June and Reintjes, 1976).

1983 was a record year for menhaden with an annual yield of almost 3 billion pounds, worth 119 million dollars (Gorman, 1984). The 1984 United States menhaden landings were 2.9 billion pounds with a dollar value of 117.3 million. Landings for the Atlantic states decreased by 22 percent and the Gulf states catch increased by 6 percent during 1984 (National Oceanic and Atmospheric Administration (NOAA), 1985).

Nearly half of the fish landed in the United States in any given year are menhaden (Gorman, 1984) but this species fluctuates greatly in both abundance and availability from year to year. The differences of survival rates for individual year broods of young

menhaden is responsible for annual variations in abundance. An unusually abundant or "dominant" year brood may result in excessive abundance of fish for up to two years in a particular locality. However, as their numbers become reduced by fishing, migration, and natural factors, the catch declines (June, 1961).

HISTORICAL USE OF MENHADEN

There is not a clear definition of an "industrial" fish but generally these fish are small, relatively oily and have dark as well as light muscle. Sizes for industrial fish range from the small anchovies to capeline, pilchards, horse mackerel and menhaden (Dreosti and Billy, 1983). Menhaden have had a long history as an industrial fish and have not been considered as a primary food product for human consumption.

The menhaden industry is one of the oldest industries in the United States. New Jersey Native Americans and early colonists used whole fish as fertilizer. The original source of this knowledge is disputed, but this industrial use of fish was well established in the colonial times (McCay, 1980; June and Reintjes, 1976; June, 1961). Menhaden was among the anadromous fishes caught in the coastal rivers, such as alewives, herring and other similar species used by the colonial farmers as fertilizer (McCay, 1980).

In 1801, Ezra L'Hommendieu published results from experiments using menhaden as a side dressing for potatoes on the depleted

soils of Long Island. L'Hommendieu's conclusions pointed toward increased yields, and wealth to farmers living along the seacoast who utilized this marine resource on their crops. Demands for menhaden as a fertilizer resulted in the development of an integrated farming-fishing industry (June and Reintjes, 1976; June, 1961).

The demand for menhaden as a fertilizer continued to increase and additional uses were explored, especially as a less expensive replacement for linseed and whale oil in curing leather, and making rope, soap, and paints. This market for menhaden grew slowly until 1860, when the mechanical screw-press and steam-power were introduced, and made practical an industrial level oil recovery process (June, 1961).

In the early nineteenth century, menhaden were used for human food and the fall catch, which had a high fat content, was valued (McCay, 1980). In 1888, a commission of the New Jersey legislature held hearings in response to a dispute over the primary uses of menhaden. The industries conversion of menhaden into fertilizer and oil exclusively was attacked because the fish were considered to be of value for direct human consumption (McCay, 1980). Although the outcome of this hearing was not reported, the use of menhaden for direct human consumption has not been a principal commodity in the past or present.

Today, menhaden is still used in the industrial production of oil, meal, and solubles with small quantities used for bait and pet food (NOAA, 1985). The primary market for menhaden meal and solubles is animal feed manufacturers. Most of the oil produced is exported to European countries where it is manufactured into margarine (June and Reintjes, 1976).

In 1984, forty-one percent of the United States coastal catch was menhaden. No direct human food uses are noted by NOAA in the 1985 Fishery Statistics bulletin, for this species. In 1983, thirty-three percent of the world's catch was industrial fish. This means approximately 25 million tons of fish were handled and processed in ways other than as fresh, frozen, smoked, canned, or fermented products consumed by humans. A majority of this industrial fish catch was processed into fish meal and oil (Dreosit and Billy, 1983).

Basic sensory objections to menhaden are the high oil content and the fine branched bone structure. Yet, as McCay (1980) pointed out, other fish such as mackerel are oily and have regional appeal. Relatives of menhaden, also in the herring family, tend to be small, bony and oily and have value as human food in canned, smoked and pickled products. Therefore menhaden's history as an industrial fish, especially as a fertilizer and in pet foods, as well as the sensory characteristics of the fish may account for lack of acceptance as a food product.

PROXIMATE COMPOSITION OF FISH

The variation of reported values for the composition of fish meat is dependent on species, size, maturity, sex, feed intake, activity level, season of year, and geographical location in which the fish was caught (Dunajski, 1979; Stansby and Olcott, 1976; Palmer and Bowers, 1972). Proximate composition of all fish varies from species to species, as well as within the same species, from individual to individual (Stansby and Olcott, 1976).

Proximate composition is based on the edible portion of fish which was defined by Stansby and Olcott (1976) as the fish fillet, free from skin and bone. Listed in Table 2 is the proximate composition for an average fish.

The average values of proximate composition have limited meaning as shown by the range statistics in Table 2. A partial solution to this problem was a classification of species of fish according to their oil and protein content, as shown in Table 3 (Stansby and Olcott, 1976; Palmer and Bower, 1972). The primary category for menhaden is B, medium oil and high protein. This is the second most common category for fish.

Composition of fish-water

The edible flesh of fish contains 53 to 81 percent water, making water the major compositional component of fish. An inverse relationship exists between the water and oil components of fish muscle, with the various ratios of oil and water totaling about 80 percent (Dunajski, 1979; Stansby and Olcott, 1976).

Table 2-Proximate composition of edible portion of fish

Measure- ment	Moisture %	Protein %	Oil %	Ash %
Average	74.8	19	5	1.2
Range	28-90	6-28	0.2-64	0.4-1.5
Ratio- High to Low	3.2	4.7	320	3.8

(Stansby and Olcott, 1976)

Table 3-Classification of fish by and protein content

Category	Type		Oil Content %	Protein Content %	Fish Type
	Oil	Protein			
A	Low	High	<5	15-20	Cod
B	Medium	High	5-15	15-20	Sockeye Salmon
C	High	Low	>15	<15	Lake Trout
D	Low	Very High	< 5	>20	Tuna
E	Low	Low	< 5	<15	Clams

(Stansby and Olcott, 1976; Palmer and Bower, 1972)

Bound and free water are found in fish muscle. Bound water assists in supporting the native protein structure by forming a monolayer which forms hydrogen bonds with the polar groups of the proteins. The percentage of bound water remains fairly constant throughout postmortem changes and during processing (Dunajski, 1979).

Approximately 80 percent of the total water content of fish muscle is free water. This water is loosely bound, or trapped, within the protein filament network and the cellular membranes (Dunajski, 1979).

Composition of fish-protein

The protein content of fish muscle ranges from 6 to 28 percent. The water soluble sarcoplasmic proteins comprise about 10 to 20 percent of the total protein. The salt soluble myofibrillar proteins (myosin, actin, and tropomyosin) in fish muscle comprise about 70 to 90 percent of the total protein, with myosin being the most abundant type of myofibrillar protein.

The insoluble fish muscle proteins are primarily collagen, the major component of myocommata, or connective tissue, found in fish muscle. The collagen of fish muscle contains less proline and hydroxyproline than mammalian collagen (Spinelli and Dassow, 1982; Dunajski, 1979; Stansby and Olcott, 1976; Palmer and Bowers, 1972).

The approximate amino acid composition of fish is similar to the composition of mammalian flesh. Fish have significant quantities of the essential amino acids: lysine, leucine, isoleucine, valine and threonine. Fish are low in the essential amino acids methionine and tryptophan (Stansby and Olcott, 1976).

Composition of fish - non-protein nitrogen

The major non-protein nitrogen components; trimethylamine oxide, urea, taurine, peptides, amino acids, nucleotides and related purine-based compounds comprise 0.5 to 1.0 percent of the total weight of the fish muscle. The flavor of fish, whether fresh or spoiled, has been related to these compounds and to their degradative products (Spinelli and Dassow, 1982).

Composition of fish-lipids

The lipid content of fish ranges from 0.1 to 31 percent. Mixed triglycerides that have three principle types of fatty acids: saturated, monounsaturated and polyunsaturated, characterize fish oils and marine-animal oils (Gruger, 1967). Fish oils differ from animal and vegetable oils in the chain length and number of double bonds found in the fatty acid chains.

One third of the fatty acid chains in fish oil exceed eighteen carbons in length. Most of the long-chain fatty acids are twenty or twenty-two carbons in length, with a few twenty-four carbon chains (Stansby and Olcott, 1976; Palmer and Bowers, 1972; Gruger, 1967).

The fatty acids of fish contain more double bonds than are present in animal and vegetable oils. Five double bonds (pentaene)

are common in the C₂₀ fatty acids and six double bonds (hexaene) are normally found in the C₂₂ fatty acids (Stansby and Olcott, 1976; Palmer and Bowers, 1972). The fatty acid composition of menhaden oil as reported by Gruger (1967) is listed in Table 4.

STRUCTURE OF FISH MUSCLE

Fish have the three major types of muscle: smooth, cardiac, and skeletal. The skeletal muscle, which comprises the major portion of the fish structure, is arranged in segments. These segments, called myotomes, consist of muscle fibers which are the myofibrillar proteins. The myotomes are short muscle masses that are not more than 12 millimeters in length, even in large fish. The myotomes are separated by, and inserted in, the myocomma, or connective tissue, which is primarily collagen (Dunajski, 1979; Palmer and Bowers, 1972). This segmented structure of fish muscle accounts for the flakiness of cooked fish.

Two types of skeletal muscle, light and dark, are found in fish. The light muscle generally predominates in the fish structure, with the dark muscle occurring in limited areas close beneath the skin along the lateral line (Stansby and Olcott, 1976). The dark muscle contains less protein and more lipid than the light muscle (Dunajski, 1979). In lean fish, category A, (Table 3), 1 to 2 percent of the total muscle is dark muscle. Species found in category B, (Table 3), have up to 10 percent dark muscle (Spinelli and Dassow, 1982). The dark muscle of fish has an important role

Table 4-Fatty acid composition for body oil of menhaden (Brevoortia tyrannus).

Percentage Composition	
Fatty Acid ¹	Range% ²
14:0	7.2-8.0
15:0	0.5
16:0	17.0-28.9
16:1	6.7-9.8
17:0	0.4-1.0
18:0	3.1-4.0
18:1	13.4-15.4
18:2	1.1-2.7
18:3	0.0-1.6
18:4	1.9-4.0
20:1	0.9-2.1
20:4	0.6-2.0
20:5	10.2-12.5
22:1	1.7
22:5	1.6-2.3
22:6	8.9-14.0

¹ First two digits (left of colon) refer to number of carbon atoms in molecule; digits right of the colon refer to extent of unsaturation.

² Range includes values reported in three studies (Gruger, 1967).

in the physiology and biochemistry of the fish since fats, fatty acids, myoglobin, and enzymes such as succinic dehydrogenase, lecithinase and respiratory enzymes are found in higher concentrations in the dark muscle (Spinelli and Dassow, 1982; Palmer and Bower, 1972).

TEXTURE OF FISH MUSCLE

The texture of fish muscle is unique in that the myofibrillar, sarcoplasmic and collagen (connective tissue) proteins assume somewhat different roles than in land animals.

Collagen, or the connective tissues known as myocomma in fish, is found in relatively low amounts but still has a function in maintaining the structural integrity of the muscle in the raw state. Love, Lavety, and Vellas (1982), and Dunajski (1979), reported that mishandling of the muscle or severe rigor caused the muscle to pull apart, or gape, with resulting loss of raw appearance quality.

Fish collagen contains less proline and hydroxyproline than land animals, making fish collagen less stable. The lower stability of fish collagen results in thermal denaturation at relatively low temperatures with a total loss of binding properties of the connective tissue. The cooked fish muscle separates easily into flakes and the connective tissue has a negligible influence on the cooked texture (Love et al., 1982; Dunajski, 1979).

Sarcoplasmic proteins are water soluble and exist in a soluble form in the raw muscle. During heating, partial coagulation occurs

and the sarcoplasmic proteins form a soft mass which is not considered a significant contributor to the texture of cooked fish (Dunajski, 1979).

Myofibrillar proteins constitute 70 to 80 percent of the total protein content of fish. These proteins form the segmented structure, or myotomes, of the muscle and are also responsible for the rheological characteristics often denoted as tenderness or toughness and coarseness or fibrousness in fish (Dunajski, 1979; Palmer and Bowers, 1972). According to Goll, Robson and Stromer (1977) over 90 percent of the water holding capacity of muscle is attributed to the myofibrillar proteins. A breakdown of this protein structure will result in a reduced water holding capacity. Water holding capacity is perceived as moisture by sensory panels, with a low moisture content in fish related to increased toughness (Bremner, Laslett, and Olley, 1978).

Texture of fish depends primarily on species, with body size, chemical composition, and morphological structure affecting the principle differences. Within a species, post-mortem, physio-chemical, and mechanical factors that influence texture are: glycolysis, rigor mortis, skeletal attachment, temperature, pH, added sodium chloride, frozen storage, and alteration of muscle structure.

Fish muscle is neutral in pH immediately after death but decreases within several hours to a pH between 6.5 and 6.2, as lactic acid is produced from anaerobic glycogen degradation. As

the pH approaches the isoelectric point of the myofibrillar protein, molecular charges are neutralized, the protein structure tightens, and the product is increased in toughness (Dunajski, 1979).

Rigor mortis occurs at the same time as glycolysis and the textural results are similar. Rigor mortis is the actual contraction of the muscle caused by physiological changes at death. Dunajski (1979) reported that the relationship between muscle excised from the skeleton in prerigor or rigor, and tenderness after cooking, were similar after 10 days of storage.

The myofibrils and collagen are affected by heat. Collagen proteins solubilize at about 140°F (60°C). As temperature was increased to 194°F (90°C), the collagen became softer and the myofibrils were tougher. Above 194°F (90°C), fish muscle of a low pH reversed the temperature/texture relationship and was mushy in texture (Dunajski, 1979). Fish muscle with a neutral or slightly alkaline pH maintained a constant texture throughout the range of temperatures (Dunajski, 1979).

Dunajski (1979) found that fish muscle tenderness decreased as the pH decreased. In the range of pH 5.7 to 6.7, a one unit decrease in pH caused a 2.5 fold increase in toughness in terms of shear force values. When the pH was 6.7 or above, the effect of pH on texture gradually declined.

Sodium chloride increased the hydration of muscle proteins, reducing the amount of liquid released during cooking. Essentially the presence of sodium chloride increased the water content of the

cooked fish and therefore increased the perception of tenderness (Dunajski, 1979).

Fish freeze slowly and Palmer and Bower (1972) suggested that as the water content of the muscle was gradually frozen, the remaining moisture was concentrated with salts in the protein structure. Frozen storage affects the extractability, or solubility, by weak salt solutions, of the myofibrillar proteins. Myofibrillar protein extractability decreased during frozen storage and this loss of solubility was correlated with the development of toughness (Dunajski, 1979). The myofibrillar proteins lose the ability to reabsorb water from melted ice as the muscle is thawed. The loss of water, in the form of drip, resulted in a less tender muscle texture (Dunajski, 1979; Palmer and Bowers, 1972).

Mechanical alteration of fish muscle occurs when a fish-flesh separating machine (Appendix I) is used to produce minced fish. The minced products dark and light muscle had been broken down into small particles that are no longer characterized by the segmented fish muscle structure. Thus, the minced fish product lacks the typical flaky textural properties of cooked fish muscle (Wheaton and Lawson, 1985).

Minced products may be further processed in a wash solution containing sodium chloride and citric acid (National Marine Fisheries Service (NMFS), 1984). The washed product is lighter in color than the unwashed minced fish product. Unwashed minced menhaden, used as an extender in crab cakes, was reported by sensory panelists to have a rubbery texture (Cook, 1984).

SENSORY EVALUATION

One definition of sensory evaluation is reported by Stone and Sidel (1985), "sensory evaluation is a scientific discipline used to evoke, measure, analyze and interpret reactions to those characteristics of foods and materials as they are perceived by the senses of sight, smell, taste, touch, and hearing." Sensory evaluation can be categorized into three types; discrimination testing, descriptive analysis, and affective testing (Stone and Sidel, 1985; Larmond, 1977).

Discrimination testing is used to determine if two products are different. Included in this category are paired comparison, triangle, and dual-standard test methods (Stone and Sidel, 1985; Larmond, 1977).

Descriptive analysis is used to identify the difference between products by evaluating the sensory characteristics of the products. Descriptive analysis is divided into two methods; qualitative analysis which includes flavor profile and the expert panel, and quantitative analysis which includes texture profile and quantitative descriptive analysis. Key elements of the descriptive methods are the development of descriptive language and the use of trained panelists (Stone and Sidel, 1985; Stone, Sidel, and Bloomquist, 1980; Stone, Sidel, Oliver, Woolsey, and Singleton, 1974).

Quantitative Descriptive Analysis (QDA) is a multi-product sensory test that provides a word description of a product's sensory characteristics (Stone and Sidel, 1985). Panel training

involved development by the panel of a descriptive language for characteristics of the products being tested and definitions for the characteristics. In sensory evaluation of fish, definitions for characteristics such as hardness, flakiness, chewiness, fibrousness, moisture, oily mouthcoating, toughness, and mouthfeel have been developed by authors Madeira and Penfield (1985) Cardello, Sawyer, Maller, and Digman (1982), and Bremner, et al., (1978). A scoresheet with line scale and anchor words is used in the sensory training to familiarize the panel with the QDA scoring technique. Anchor words are the descriptive language developed by the panel (Stone and Sidel, 1985; Stone et al., 1980; Stone et al., 1974).

Affective testing can be referred to as acceptance, preference, or consumer testing. Discrimination testing and descriptive analysis reduced product alternatives and affective testing evaluated preference for a product by comparison of two or more products. Large scale market testing is often preceded by small scale affective testing. Paired comparison and hedonic scale are commonly used affective testing methods (Stone and Sidel, 1985; Larmond, 1977).

PREPARATION OF FISH FOR THERMAL PROCESSING

Dressed Fish

When raw fish such as salmon and mackerel are delivered to the processing plant they are washed, and dressed which includes removal of the viscera, head, tail, fins and scales. Some fish, for example salmon, are packed in cans in raw-dressed form, while fish

like tuna are precooked prior to being packed into cans (Wheaton and Lawson, 1985; Lopez, 1981b).

Fish Flakes

Fish flakes are prepared from fish that have been slightly brined, freshened and then cooked in steam until the flesh is opaque and flaky. The skin and bones are removed by hand and the muscle is broken apart and packed into enamel-lined cans in preparation for processing (Wheaton and Lawson, 1985).

Minced fish

A fish-flesh separating machine (Appendix I) is used to mince fish. The eviscerated fish, whole or filleted, are minced by passing the fish over a drum perforated with holes 1 to 7 millimeters in diameter. Pressure applied to the fish forces of the flesh through the perforations, leaving the skin, scales, fins and larger bones behind (Wheaton and Lawson, 1985; Steinburg and Spinelli, 1976). The minced product may be left as unwashed, or dark, mince or it may be washed in a sodium chloride and citric acid solution to give a washed, or light, minced fish product (NMFS, 1984).

THERMAL PROCESSING LOW ACIDS FOODS

Pasteurization

Each type of heat process has specific objective, with the severity of the thermal process directed by these objectives. Pasteurization is considered a mild heat treatment that will kill

part, but not all of the vegetable microorganisms present in food. By definition, pasteurized foods are not sterile and must be used in conjunction with: refrigeration, chemical additives, packaging or fermentation (Ward, Flick, Hebard, Townsend, 1982; Lund, 1975).

Two parameters need to be evaluated to determine the appropriate time/temperature relationship for a pasteurized food product: 1) the heat resistance of the specific micro-organism the process is designed to destroy and, 2) the heat stability of the product (Lund, 1975).

Pasteurized products are generally subjected to temperatures below 212°F (100°C). The process for pasteurized crab meat represents a generalized, and regulated, pasteurization method (Ward et al., 1982; Lopez, 1981b). Containers of product are heated until thermocouples located at the geometric center of the can reach a temperature of 185°F (85°C). This temperature is maintained for one minute and then the product is cooled to 55°F (13°C) within 180 minutes. A minimum cooking time is 110 to 115 minutes for a 401 x 301 can (Ward et al., 1982; Lopez, 1981b).

Commercial Sterilization

The use of heat to destroy bacteria and bacterial spores in hermetically sealed containers is the fundamental principal behind preservation of foods by canning (Lopez, 1981a; National Canners Association, 1976 and 1968).

Bacterial spores are more heat resistant than bacteria and of greatest concern from the public health point of view since the spores of Clostridium botulinum are included in this group. Thermal process determinations for low acid foods (pH above 4.6) are based on time/temperature relationships that will destroy C. botulinum spores and render a canned food product commercially sterile (Wheaton and Lawson, 1985; Lopez, 1981a; Food Processors Institute, 1980; Lund, 1975). A majority of the fishery products that are thermally processed are in the pH range 5.0 to 6.8 (Wheaton and Lawson, 1985), and are therefore considered low acid foods.

Lopez (1981a) defines commercial sterility in low acid foods as "that process by which all Clostridium botulinum spores and all other pathogenic bacteria have been destroyed, as well as more heat resistant organisms which, if present, could produce spoilage under normal conditions of non-refrigerated canned food storage and distribution." Commercial sterilization processes allow canned fishery products extended shelf life without the additional methods required for pasteurized products.

Fish and seafood products are most often precooked to specified temperatures prior to packing in cans (Wheaton and Lawson, 1985). A generalized canning operation was outlined by Wheaton and Lawson (1985) and included the following steps: 1) packing the prepared products into cans, 2) adding substances to enhance flavor, improve quality, or help preserve the product, 3)

exhausting or applying a vacuum, or other process, to remove air from cans, 4) closing and sealing the cans, 5) heating (retorting), 6) cooling and washing the processed cans, 7) labeling, packing, and storing the processed products.

Specific time/temperature canning processes are determined for individual products. The United States Food and Drug Administration has directed regulations for low acid canned foods in Good Manufacturing Practice (GMP) Regulations (U.S. Food and Drug Administration, 1979). GMP procedures specify that thermal processes must: be determined by appropriate authorities; must destroy C. botulinum spores; and must be under adequate control and delivery (Lopez, 1981b). GMP regulations outline equipment, procedures, controls and records that industry must follow to insure the safe production of low acid canned foods. Processors are responsible for determining process adequacy, the Food and Drug Administration does not approve process schedules (Lopez, 1981b). The National Food Processors Association will assist members in process determination for specific food products and will make available general processes for fishery products (Brooks, 1984).

Chapter III

MATERIALS AND METHODS

PILOT STUDIES

Objectives

Three pilot studies were completed using dressed, filleted, and washed (light) and unwashed (dark) minced menhaden. The purpose of the first pilot study was to determine the forms (dressed, filleted, minced) of menhaden most suitable for canning and pasteurization. The purpose of the second pilot study was to determine the suitability of an alum (potassium aluminum sulfate) and citric acid brine treatment of dressed and filleted menhaden. The third pilot study was based on the evaluation of products from the first two pilot studies. The purpose of the third pilot study was to make a final evaluation of the forms and treatments of canned menhaden to be used in the final processing run.

Raw product

Freshly caught menhaden (Brevoortia tyrannus) were obtained from pound-net fishermen at Kilmarnock, Virginia on the Chesapeake Bay in July, August and September of 1984. The fish were received at the boat and packed in ice in plastic ice chests. The fish were on ice for approximately six hours prior to being eviscerated, filleted or dressed, packaged in freezer bags, boxed and labeled. The boxed fish were kept frozen at a temperature of -20°F (-29°C) in a commercial freezer at Virginia Polytechnic

Institute and State University's Department of Food Science and Technology.

Minced menhaden were obtained in cooperation with the National Marine Fisheries Service (NMFS) Southeast center, Charleston, South Carolina. Freshly caught menhaden were purchased from pound-net fishermen at Hampton, Virginia. The menhaden were eviscerated, and headed and approximately 300 pounds of menhaden were transported on ice to the NMFS center in Charleston, within 24 hours after harvest.

A fish-flesh separating machine (Appendix I) was used to produce the unwashed, or dark, minced fish. Half of the unwashed mince was washed four times in water containing 0.1 percent sodium chloride and 0.04 percent citric acid, using a ratio of five parts water to one part mince. The final minced fish slurry was passed through a screw press to remove excess water. This product is referred to as washed, or light, minced menhaden.

The washed and unwashed minced fish products were packed into one and five pound waxed freezer boxes and enclosed in freezer bags for storage in a commercial freezer at a temperature of -20°F (-29°C).

Raw product preparation for thermal processing

Dressed, filleted and minced menhaden for all pilot studies were thawed in the refrigerator for 24 hours.

No brine treatment, seasonings, broth, or oil were used with the fish in the first pilot study. The three forms of fish were

packed raw into No. 1 Tall (301 X 411) USA salmon cans from the American Can Company. The cans of fish product were processed according to the procedures outlined in the canning and pasteurization sections.

In the second pilot study dressed and filleted menhaden were brined in an alum and citric acid brine prior to canning. The brine consisted of a 15 percent sodium chloride brine (weight to volume) with 1 percent alum (potassium aluminum sulfate) and 1 percent citric acid added (Nair, Madhavan, Balachandran, and Prabhu, 1974). The dressed and filleted menhaden were soaked in the brine for 20 minutes, packed into cans and processed according to the steps outlined in the canning section. Unbrined controls were processed for comparison. No seasonings, broth, or oil were added to the packs.

Dressed, unwashed minced menhaden and menhaden flaked fillets were used in the third pilot study. The method used to prepare the menhaden flaked fillets was modified from the fish flake process described by Wheaton and Lawson (1985). The menhaden fillets were refrigerator thawed for 24 hours, rinsed, and placed in a covered baking pan. The fillets were baked at 325°F (163°C) for 8 to 10 minutes, or until the flesh was opaque and flaky. The light muscle was separated from the skin, dark muscle and bones, and packed into cans. Samples of menhaden fillets that were preprocessed in the alum and citric acid brine, were brined prior to being baked, flaked and packed into cans.

The dressed and unwashed minced menhaden were packed raw into the cans. Each form of fish (dressed, filleted, and minced) had three treatments: oil pack, broth pack or pre-processing in alum and citric acid brine. The nine fish packs were processed following the steps outlined in the canning section.

Oil used in the packs was Puritan brand sunflower and soybean oil. The broth was prepared from Wyler's brand instant vegetable flavored bouillon, 2.8 grams of dry bouillon was mixed into 250 milliliters of boiling water. The amounts of oil and broth added to the nine packs are listed in Table 5. The alum and citric acid brine used in the third pilot study was described in the second pilot study.

Thermal processing procedures

The regulations for crab meat pasteurization (Ward et al., 1982; Lopez, 1981b) were followed for the pasteurized menhaden products of pilot study one. Thermocouples were placed in the geometric center of No. 1 Tall (301 X 411) USA salmon cans (American Can Company) prior to packing the fish into the cans. Cans were sealed with an Ives-Way Can Sealer and cans seams met the specifications for ideal seam measurements established by the American Can Company (Bailey, 1984).

The filleted, dressed or minced menhaden products were heated to 185°F (85°C) for one minute in a steam-heated water bath (Chester-Jensen Co., model 203) preheated to 195°F (91°C). Temperatures were recorded at 30 second intervals on a Data

Table 5—Amount of oil or broth added to nine menhaden packs

Form	Pack	
	Oil mL	Broth mL
Flaked Fillet	45	60
Dressed	30	30
Minced	15	15
Flaked Fillet/alum citric acid	--	60
Dressed/alum citric acid	--	30
Minced/alum citric acid	--	15

Logger (Monitor Labs Inc., model 9300). The cans were immediately cooled, at the end of the processing time, in an ice water bath, to less than 55°F (13°C) within 180 minutes. The pasteurized fish products were refrigerated and evaluated the following day.

The scheduled process outlined by Lopez (1981b) for salmon, water cooled, was followed for the canned menhaden products of all three pilot studies. Filleted, dressed, and minced menhaden products were packed into No. 1 Tall (301 X 411) USA Salmon cans and exhausted to an average internal temperature of 180°F (82°C). The cans were sealed on an Ives-Way Can Sealer and processed in a Presto pressure canner (model 0175001) at 250°F (121°C) for 85 minutes. At the end of the processing time the cans were placed in a sink filled with cold tap water. The water was changed frequently to facilitate rapid cooling of the contents of the cans to approximately 95°F (35°C). The cooled cans of menhaden product were refrigerated until the following day when the products were evaluated.

Product evaluation

A five member panel evaluated the pasteurized and canned menhaden products from the three pilot studies. The panel consisted of faculty, research associates and graduate students from Virginia Polytechnic Institute and State University. The panel subjectively evaluated the menhaden products for appearance in

can, appearance out of can, texture of muscle and bone, color, odor and flavor. This panel determined the nine menhaden products that were to be evaluated by a semi-trained panel.

FINAL PROCESSING

Raw product

The raw product for the final processing included dressed, filleted and dark minced menhaden. These forms of fish were obtained, handled and packaged in the manner discussed in the pilot studies.

Raw product preparation for canning

Dressed, filleted and minced menhaden were thawed in the refrigerator for 24 hours. Nine forms and treatments of menhaden were prepared for canning.

Samples of menhaden fillets were preprocessed in an alum and citric acid brine according to the treatment described in pilot study two. The brined fillets, along with the unbrined fillets that were to be packed in oil or in broth, were baked and flaked according to the procedure of Wheaton and Lawson (1985) discussed in pilot study three. The flaked menhaden were packed into No. 1/2 Flat (307 X 200.25) enamel-lined cans (American Can Company). Oil or broth was added to the cans as shown in Table 6. Six cans of each flaked fillet in oil, or in broth, or preprocessed in alum citric acid brine were prepared.

Samples of dressed menhaden were preprocessed in an alum and citric acid brine according to the treatment described in pilot study two. The brined dressed menhaden, along with the unbrined dressed menhaden that were to be packed in oil or in broth, were packed raw into No. 1/2 Flat (307 X 200.25) cans. Oil or broth was added to cans as shown in Table 6. Six cans of each dressed menhaden product were prepared.

Samples of unwashed minced menhaden were preprocessed in an alum and citric acid brine according to the treatment described in pilot study two. The brined minced menhaden, along with the unbrined minced menhaden that were to be packed in oil or in broth, were packed raw into cans (No. 1/2 Flat (307 X 200.25)). Six cans of each minced menhaden product were prepared.

Oil used in the packs was Puritan brand sunflower and soybean oil. The broth was prepared from Wyler brand instant vegetable flavored bouillon, 5.6 grams of dry bouillon was mixed into 1000 milliliters of boiling water. Table 6 lists the amount of oil or broth added to the nine packs for the final processing.

Canned procedure

All preparation and processing steps were completed in a food processing lab of the Department of Food Science and Technology, Virginia Polytechnic Institute and State University. The time and temperature guidelines (89 minutes at 250°F (121°C)) used for the final processing of the nine menhaden packs were obtained from the

Table 6-Can fill weights and amount of oil or broth added to nine menhaden packs

Form	Can Fill Weight g	Oil mL	Broth mL
Flaked Fillet	194.5	45	60
Dressed	223.9	30	30
Minced	207.8	15	15
Flaked Fillet/alum citric acid	194.5	--	60
Dressed/alum citric acid	223.9	--	30
Minced/alum citric acid	207.8	--	15

National Food Processors Association in Seattle, Washington (Brooks, 1984).

The fish for the nine packs were packed into No. 1/2 Flat (307 X 200.25) enamel-lined cans manufactured by the American Can Company. Can and product weights and milliliters of oil or broth added are listed in Table 6. Can weights ranged from 37.28 to 37.80 grams.

Packed cans of the menhaden products were exhausted in a commercial steam exhaust box to an average initial temperature of 125°F (52°C). Lids were attached as the cans left the exhaust box. The cans were sealed with an Ives-Way Can Sealer. Can seams met the specifications for ideal seam measurements established as guidelines by the American Can Company (Bailey, 1984).

A commercial vertical retort was used for processing the exhausted and sealed canned menhaden products. The time and temperature schedule for the final products was 89 minutes at 250°F (121°C). A process recorder verified the scheduled process.

The cans were water cooled in the retort to an approximate content temperature of 100°F (38°C) (Lopez, 1981b) and then removed from the retort and air dried. The canned products were boxed and stored at room temperature.

Mouse bioassay for *Clostridium botulinum*

Time and temperature schedules were not determined for each of the nine menhaden packs, therefore a mouse bioassay for

Clostridium botulinum (Holdeman, Cato, and Moore, 1977) was completed at the Department of Food Science and Technology three weeks after processing. One can from each of the nine packs was sampled for use in the assay. All tests for toxin were negative.

OBJECTIVE MEASUREMENTS

Drained weight

Drained weight was determined for each pack by emptying the contents of a No. 1/2 Flat (307 X 200.25) can of menhaden product onto a 10-mesh screen (Fisher Scientific) over a glass drain pan. The product was drained without spreading the product over the mesh, for two minutes and then procedure A outlined by Lopez (1981b) was followed. The screen and drained solids were weighed on a Mettler (model P1000) balance to 0.1 gram and then the weight of the draining screen was subtracted. The screen was cleaned and dried between samples.

Total fluid

Fluid caught in the glass drain pan was poured into a 100 milliliter graduated cylinder and the milliliters of fluid from the drained solids was measured. The graduated cylinder and glass drain pan were cleaned between samples.

SENSORY EVALUATION BY SEMI-TRAINED PANELISTS

Panel selection

Panelist selection was based upon an individual's interest,

willingness to participate in training, availability for training and panel sessions, and use of canned fish products. Six panelists were chosen from the faculty and graduate school population of both the Departments of Human Nutrition and Foods, and Food Science and Technology.

Panel training

The six member panel met for one, two hour training session. The objectives of the session were: 1) to come to a consensus on the fish characteristic anchor words and their definitions, and 2) to become familiar with the defined characteristics by sampling two canned fish products.

The author acted as group leader, while panelists worked together to develop the sensory language and definitions for the canned fish products (Stone and Sidel, 1985; Stone et al., 1980; Stone et al., 1974). Examples of sensory characteristics and definitions for fish products, used by other authors, were made available for reference (Madeira and Penfield, 1985; Cardello et al., 1978). The final score sheet format and list of characteristic definitions are shown in Appendix II and III.

Sample preparation

Cans of menhaden product were opened on the days selected for the response of the sensory panel, and drained weight and fluid loss were measured. The solid fish product was not spread over the mesh for these measurements. After the measurements were taken, the fish product was replaced in the can, without the

drained fluid. Samples for the sensory panel evaluation were taken from the drained product.

Samples of approximately 18 grams each were taken from the center portion of each pack and were placed in 4 ounce opaque plastic cups with lids. Samples were served at room temperature. Coded samples were placed on trays with a plastic fork, water, and unsalted crackers.

Sensory evaluation

The three by three randomized incomplete block design used for the sensory evaluation required the six panelists to sample three different canned menhaden products on each of three days (Appendix IV). Samples of Double Q brand chunk light tuna packed in oil, Double Q brand chunk light tuna packed in water, and Sweep Stakes brand jack mackerel packed in water were also evaluated by the six panelists.

Panelists were requested not to eat for at least one hour prior to the panel. Trays presented to panelists included samples, along with water and unsalted crackers for clearing the palate between samples. Samples were presented in a random order and panelists were instructed to evaluate the products in that order. Samples were evaluated in sensory sensory booths under cool white fluorescent light.

CONSUMER SENSORY PANELS

A nine point hedonic scale was used for the preference testing of three canned menhaden products that were incorporated into

recipes for fish salad and pizza sauce (Appendix V).

Three fish salad products were prepared using Double Q light chunk tuna packed in oil, dressed menhaden and filleted menhaden both preprocessed with alum and citric acid brine and packed in broth. Thirty-six panelists from both the Departments of Human Nutrition and Foods, and Food Science and Technology tasted these products and indicated a preference by using the questionnaire shown in Appendix VI.

Two pizza sauces were prepared using hamburger or minced menhaden canned in oil. Thirty-one panelists from both the Departments of Human Nutrition and Foods, and Food Science and Technology tasted these products and indicated a preference. The hedonic questionnaire in Appendix VI was used.

Chapter IV

RESULTS AND DISCUSSION

OBJECTIVES

Menhaden has been classified as an "industrial" fish with a low acceptance as a food product because of the high fat content and finely branched bone structure. The goal of this research was to evaluate thermally processed menhaden flesh as a commercial food resource. The objectives for the research were: 1) to objectively measure drained weight and fluid loss of nine menhaden products; 2) to complete a descriptive sensory evaluation of the nine menhaden products using a semi-trained panel and, 3) to evaluate three canned menhaden products incorporated into recipes.

PILOT STUDIES

First pilot study

The initial pilot study included menhaden in the following forms: dressed, filleted, washed (light) mince and unwashed (dark) mince. All forms of fish were canned and pasteurized according to procedures discussed in methods and materials (Ward et al., 1982; Lopez, 1981b). The products were evaluated by a five member panel that consisted of faculty, research associates, and graduate students. Subjective evaluation of the products included appearance in and out of the can, texture of flesh and bones, color, odor, and taste. Panelists discussed the products and

reached a consensus on the products to be accepted or rejected. The results are shown in Table 7.

Dressed, filleted, dark and light minced fish from the pasteurized products were all rejected. Although the minced and filleted products have many of the larger bones removed, many fine bones existed in the menhaden muscle of both forms of fish. The pasteurization process as outlined by Ward et al., (1982) did not provide an adequate time and temperature process to soften the fine menhaden bones. The bones were highly visible in all four pasteurized products when the cans were opened and when the products were removed from the can to a plate. The bones were also detectable when the products were tasted. The panel decided no further work would be completed on the pasteurized products.

The canned light mince was rejected because of problems with the texture of the product. Light, or washed, minced fish had a dry, elastic texture that was judged to be unsatisfactory by the panel. Canned unwashed minced fish products had higher percent fluid loss and were evaluated by a semi-trained panel in later work to be tougher in texture than the dressed or filleted menhaden products.

The light and dark minced fish had an unacceptable in can appearance. These products form a circular, cohesive mass in the center of the can. The fluid lost from the product filled the margin between the inside of the can and the product.

Table 7-First pilot study: forms of canned and pasteurized menhaden accepted or rejected by five panelists for further study.

Form	Process	
	Canned	Pasteurized
Dressed	accepted	rejected
Fillet	accepted	rejected
Mince/dark	accepted	rejected
Mince/light	accepted	rejected

The dark minced fish was accepted for further study based on satisfactory evaluations of texture, odor, and flavor. The texture of the canned dark minced menhaden was noted by the panel to be similar in appearance and mouthfeel to cooked ground beef. Further evaluation of the characteristics of this product by a semi-trained panel and evaluation of the product in a recipe by a consumer preference panel, was judged to be warranted.

The dressed menhaden product was accepted for further study based on satisfactory evaluation of the texture, odor, and flavor of the canned product. The in and out of can appearance of the product was questioned due to the prominent backbone of the dressed fish, although the panelists noted that bones in canned salmon and mackerel were also visible in and out of the can. The backbone, and all other bones, were soft and communicated when pressed between the thumb and forefinger, or chewed.

Canned products from filleted menhaden were accepted for further study. The texture, odor, and flavor were satisfactory. Panelists noted that the fillets had a mild flavor. The canned menhaden fillets were not skinned or flaked and since the fillets were relatively thin the pack appeared to have an excess of skin. A canned product using a skinless, flaked menhaden was proposed (Wheaton and Lawson, 1985).

Second pilot study

The second pilot study was completed to evaluate the effect on the dressed and filleted menhaden of preprocessing in an alum and

citric acid brine (Nair, et al., 1974). An unbrined product was processed for comparison. The five member panel from the first pilot study evaluated the products from the second pilot study.

The panel agreed that the brined menhaden products were firmer than the unbrined product. A citric acid flavor from the brine treatment was detected but was considered acceptable by the panel. A metallic aftertaste was detected by two panel members and was considered unacceptable. The alum may have been responsible for this aftertaste since it was not detected in the unbrined products. The other panelists could barely detect, or did not detect, a metallic aftertaste. One panel member felt the alum and citric acid brine gave the product a milder fish flavor.

Third pilot study

Dressed, dark minced, and skinless, flaked fillets were the forms of menhaden processed in the third pilot study. Each form had three treatments; oil pack, vegetable broth pack, and preprocessing in alum and citric acid brine as shown in Table 5.

The five member panel evaluated the nine menhaden products in the same manner as the previous pilot studies. One product, minced menhaden in alum and citric acid, was rejected. This product was kept in the experimental design for statistical purposes. The remaining eight products were accepted for the final processing and evaluation by a semi-trained panel.

OBJECTIVE MEASUREMENTS

Drained weight and total fluid

Measurements of drained weight and total fluid in the can after processing are recorded in Table 8. Weight loss, percent weight loss, fluid loss and percent fluid loss for canned menhaden products are recorded in Table 9. Weight loss, percent weight loss, fluid loss, and percent fluid loss were calculated to allow comparison of menhaden products that had different fill weights and different amounts of oil or broth added to the pack.

The percent weight loss of the oil and the broth packs for the fillet, the dressed, and the minced menhaden products were close in values within a form. The fillet in oil and fillet in broth had percent weight losses of 19.2 percent and 19.4 percent respectively. The dressed fish in oil and the dressed fish in broth showed percent weight losses of 17.6 percent and 17.8 percent respectively, and the minced fish in oil and the minced fish in broth had percent weight losses of 20.9 percent and 20.6 percent.

Between forms the oil and broth packs of the dressed menhaden lost an average of 1.6 percent less than the fillet in oil and the fillet in broth packs, and lost 3.1 percent less than the mince in oil and the mince in broth packs. The percent weight loss was less when compared among packs than when compared among forms.

The major fish muscle components that would be lost during a canning process would be the free water, the water soluble

Table 8-Drained weight and total fluid from canned menhaden products¹

Product ²	Measurement after Processing	
	Drained Weight (g)	Total Fluid (mL)
Fillet/oil	157.1	55.2
Fillet/broth	156.7	68.8
Fillet/alum citric acid	155.7	65.3
Dressed/oil	184.4	50.2
Dressed/broth	184.0	51.0
Dressed/alum citric acid	175.8	50.8
Mince/oil	164.3	54.3
Mince/broth	161.7	58.2
Mince/alum citric acid	111.4	96.6

¹ Mean values from 3 cans of each product.

² Form of fish (fillet, dressed, mince)/treatment (alum citric acid) or pack (oil or broth).

Table 9-Weight loss, percent weight loss, fluid loss and percent fluid loss of canned menhaden products.^{1,2,3,4}

Product	Measurement			
	Weight Loss (g)	Percent Weight Loss	Fluid Loss (mL)	Percent Fluid Loss
Fillet/oil	37.4	19.2	10.2	18.5
Fillet/broth	37.8	19.4	8.8	12.8
Fillet/alum citric acid	38.8	19.9	5.3	8.1
Dressed/oil	39.5	17.6	20.2	40.2
Dressed/broth	39.9	17.8	21.0	41.2
Dressed/alum citric acid	48.1	21.5	20.8	40.9
Mince/oil	43.5	20.9	39.3	72.4
Mince/broth	46.1	20.6	43.2	74.2
Mince/alum	96.4	46.4	81.6	84.5

¹ Weight loss = fill weight - drained weight

² Percent weight loss = $\frac{\text{fill weight} - \text{drained weight}}{\text{Fill weight}} \times 100$

³ Fluid loss = total fluid - oil or broth added

⁴ Percent fluid loss = $\frac{\text{total fluid} - \text{oil or broth added}}{\text{Fluid loss}} \times 100$

⁵ Form of fish (fillet, dressed, mince)/treatment (alum citric acid) or pack (oil or broth).

sarcoplasmic proteins and the heat soluble collagen protein (Love, et al., 1982; Dunajski, 1979). From the data in Table 9 it would seem that an increased amount of mechanical alteration of the fish muscle prior to canning would result in an increased amount of percent weight loss. Although a difference in percent weight loss between forms is evident, the amount does not seem significant.

The dressed, filleted and minced menhaden products preprocessed in the alum citric acid brine, all showed larger percent weight loss within forms. The fillet in alum and citric acid brine had a loss of 0.7 percent and 0.5 percent greater than the fillet in oil and the fillet in broth packs respectively. The minced menhaden in alum and citric acid had a percent weight loss of 25.5 percent and 25.8 percent greater than the losses for the minced products packed in oil and the minced products packed in broth respectively.

Between forms the minced in alum citric acid product lost 24.9 percent and 26.5 percent more in percent weight loss than the dressed and filleted fish in alum and citric acid products. The percent weight loss of the minced fish in alum and citric acid was on the average 25 percent higher than any other treatment.

As suggested previously, part of this increased loss for the minced fish in alum and citric acid, could be accounted for by the form of this fish muscle. The minced products tended to have higher percent weight losses. The preprocessing in alum and citric acid brine also increased the percent weight losses for all forms of

fish, although the increased losses for the filleted and dressed packs were relatively small. The combined effects of the minced form and the alum and citric acid brine seem to have a significant effect on the solids and fluids measured after processing.

The alum and citric acid brine consisted of a 15 percent sodium chloride brine to which 1 percent citric acid and 1 percent alum (aluminum potassium sulfate) were added (Nair, et al., 1974). Samples of dressed, filleted and minced menhaden were soaked in this brine for 20 minutes prior to packing the products into cans and processing. Minced fish products, because of the small particle size of the muscle, had more muscle surface area exposed to the brine than did the filleted or dressed products.

Sodium chloride, acid, water, and heat all affect fish muscle proteins. Sodium chloride and water would seem to have the major effect on percent weight loss in the minced menhaden in alum and citric acid product. The sarcoplasmic proteins are water soluble and the myofibrillar proteins are salt soluble (Palmer and Bowers, 1972; Stansby and Olcott, 1976; Spinelli and Dassow, 1982, 1979, 1976, 1972; Dunajski, 1979). The increased exposure of the fish muscle to the alum and citric acid brine in the minced fish product may have allowed larger amounts of the sarcoplasmic and myofibrillar proteins to be solubilized resulting in increased percent weight loss of the minced product preprocessed in alum and citric acid.

According to Goll et al., (1974), over 90 percent of the water-holding capacity of muscle is attributed to the myofibrillar proteins.

An unfolding of the protein structure will result in reduced water-holding capacity. If the myofibrillar structure of the minced fish in alum and citric acid product had been disrupted by the mincing, brining, and processing, this may account for the 84.5 percent fluid loss of this product. The minced products, as shown in Table 9, had the largest percentage fluid loss.

Percent fluid loss for the three fillet packs may be low due to the prepacking baking and flaking of the fillets. The fillets were baked and the white muscle was flaked from the skin, dark muscle and bones (Wheaton and Lawson, 1985). This flaked fish was packed into the cans for processing. The moisture lost during baking was not measured.

The three dressed products had similar percent weight losses.

Percent weight loss and percent fluid loss were highest for the minced fish in alum and citric acid product. The mincing process, brine treatment, and processing may have a combined effect that resulted in the high losses but the alum and citric acid brine seemed to be the significant variable.

SENSORY EVALUATION BY THE SEMI-TRAINED PANEL

Menhaden products

Three pilot studies of canned and pasteurized menhaden products resulted in nine canned fish products that combined different forms, treatments, and packs of menhaden. The nine products are listed in Table 10.

Table 10—Mean scores for characteristics of canned menhaden products as scored by six semi-trained panelists^{1,2}

Product ³	Characteristics				
	Firmness	Flavor	Flakiness	Chewiness	Moisture
Fillet/oil	5.44 _c	3.20	6.74	4.87	4.53
Fillet/broth	3.57 _e	3.26	7.04 _e	3.90	5.65
Fillet/alum citric acid	3.98 _d	5.83	8.18 _d	2.72 _d	7.84
Dressed/oil	1.96 _b	4.61	8.61 _b	2.01 _b	6.86
Dressed/broth	1.66 _c	3.79	9.06 _c	2.07 _c	6.72
Dressed/alum citric acid	4.34 _a	3.82	8.39 _a	2.46 _a	7.19
Mince/oil	6.66 _{bc}	7.12	3.05 _{abc de}	5.63	6.68
Mince/broth	5.20	6.93	3.77 _{ab cd}	4.89	4.15
Mince/alum	8.01 _{abc de}	6.31	2.95 _{abc de}	6.74 _{abcd}	4.45

¹ Means of 6 scores. Firmness:0=very soft, 10=firm; Flavor:0=mild, 10=strong; Flakiness:0=low, 10=high; Chewiness:0=least, 10=most
Moisture:0=low, 10=high.

² Panelists from faculty and graduate students at VPI&SU. 1 training session.

³ Form of fish (dressed, fillet, mince)/treatment or pack (oil, broth, or alum citric acid).

⁴ Means in a column followed by the same letter are significantly different ($p < .002$). All possible comparisons were made for each product.

Panelists scored canned menhaden products, canned tuna in oil, canned tuna in water and canned mackerel in water. All possible comparisons were made among the mean scores of the five characteristics for the nine menhaden products. The mean characteristic scores for the tuna and mackerel products were not included in these comparisons.

Mean scores of the menhaden products are listed for each product and characteristic in Table 10. The notation used in Table 10 was: mean scores in a column that are significantly different ($p < 0.002$) are followed by the same letter. Same letters were used, rather than different letters, to indicate significance because the number of comparisons made for each product and characteristic made the alternative method unmanageable in a table format.

Mean characteristic scores for flavor and moisture

The characteristic, fish flavor, was scored so that statistical analysis of the data showed no significant difference among the nine products (Table 10). A score of 0 indicated a mild fish flavor and a score of close to 10 indicated a strong fish flavor. The canned minced products were scored the highest for fish flavor (6.32, 6.93, 7.12) and the fillet products packed in oil and in broth were scored the lowest for fish flavor (3.20, 3.26).

The filleted products were similar to the fish flake product described in Wheaton and Lawson (1985). The product was baked and the light muscle was removed in flakes. The dark muscle content of this product with its high concentration of fats, fatty

acids, myoglobin and enzymes (Spinelli and Dassow, 1982; Palmer and Bower, 1972) was kept to a minimum and this may account for the lower, although not significantly lower, scores for fish flavor of canned fillets.

The mean scores for moisture were not significantly different among the nine products. The lowest moisture perception scores for a product were given a numerical value of 0, and the highest moisture perception scores were given a numerical value close to 10. Filleted menhaden packed in alum citric acid was scored the highest for moisture (7.84) and the minced fish in broth, minced fish in alum and citric acid and the fillet in oil, were scored the lowest (4.15, 4.45, 4.53).

The panel scores for moisture for the minced products were not as low as percent weight loss and percent fluid loss (Table 9), would lead one to expect. The minced fish products had percent weight losses of about 72 to 84 percent, yet this loss did not result in scores for moisture perception of minced fish products that were significantly different from the scores for the dressed or filleted products.

Mean characteristic scores for firmness, flakiness, and chewiness

Scores for firmness in the nine canned products did show significant product differences ($p < 0.002$). In filleted and dressed products only, the scores differed significantly for firmness for the fillet in oil and the dressed fish in broth. The fillet in oil was scored as significantly firmer than the dressed fish in broth. The

scores for firmness differed significantly for the dressed and filleted menhaden products when compared with the firmness scores of the minced fish in oil and the minced fish in alum and citric acid brine. The minced products were scored as significantly firmer than the dressed and filleted products. The minced fish product packed in broth was not scored as significantly different in firmness from any other product. The minced menhaden in alum and citric acid brine differed significantly from all products except the minced fish in broth product. The minced fish in alum citric acid was scored as significantly firmer than all other products.

Statistical analysis of the scores for the flakiness characteristic of the canned menhaden products indicated significant differences. The three minced products were not significantly different from one another but the minced fish in oil and the minced fish in alum and citric acid were significantly different from all other fillet and dressed products, with the exception of the filleted product packed in oil. The minced fish in broth were different from the three dressed products and the fillet in alum and citric acid. The minced products were all significantly less flaky. The dressed products were scored highest for flakiness.

Statistical analysis of the scores for the chewiness characteristic indicated significant differences between products. The minced fish product in alum and citric acid was significantly more chewy than the fillet in alum and citric acid and the three dressed fish products. Differences were slight among any of the

other products for the chewiness characteristic.

Firmness, flakiness and chewiness were three texture characteristics evaluated. For all three characteristics statistical analysis of the scores indicated that the significant product differences were between the minced products versus the dressed and filleted products, with the exception of the scores for firmness between the fillet in oil and the dressed in broth menhaden products. Other than this exception, differences were slight in scores for firmness, flakiness, or chewiness among the dressed or filleted fish products. The semi-trained panel determined that the dressed and filleted products had similar textural characteristics regardless of form (dressed or filleted), treatment (alum citric acid), or pack (oil or broth).

Scores for the minced products showed significant differences in firmness, flakiness and chewiness when compared to the dressed and filleted products but the minced fish products were scored as similar for these characteristics. The three minced fish products differed most frequently from the dressed and filleted menhaden products in the textural characteristic of flakiness. This result is in agreement with Wheaton and Lawson (1985) who stated that structural breakdown of the muscle resulted in a minced product that lacked the typical flaky textural property of cooked fish muscle. The panelists noted that the definition for flakiness was difficult to apply to the minced fish product but the author and the panelists decided that the anchor words, "low flakiness" and "high

flakiness" would allow appropriate scoring of the characteristic in the minced products.

Scores for the minced menhaden in alum and citric acid were significantly different from the scores for five other menhaden products for the firmness and flakiness characteristics and were significantly different from the scores for four other products for the chewiness characteristic. Minced menhaden in alum and citric acid was scored as significantly firmer and chewier and was scored lowest in flakiness. These scores indicate that the minced menhaden in alum and citric acid had a tougher texture than the other canned products. Bremner et al., (1978) found a strong negative correlation between sensory panel evaluation of toughness and moisture which indicated that as the fish became drier they were sensed as also being tougher. This study did not show significant differences in moisture perception among the nine menhaden products, but the minced product in alum and citric acid did have an average percent fluid loss that was 25 percent higher than the other products. This loss of moisture may have been sensed by the panel as increased firmness and chewiness and decreased flakiness.

The firmness, flakiness, and chewiness characteristics of the dressed and filleted fish products were scored to indicate the products were softer, higher in flakiness, and lower in chewiness than the minced fish products. The mean scores for these characteristics indicate that the dressed and filleted menhaden

products were similar in firmness, fish flavor, flakiness, chewiness and moisture.

Tuna and mackerel products

The six member semi-trained panel evaluated fish characteristics of canned tuna packed in oil (Q Brand), canned tuna packed in water (Q brand), and canned jack mackerel packed in water (Sweep Stakes brand). Mean scores for product characteristics are recorded in Table 11.

The mean characteristic scores for each tuna and mackerel product were plotted with the mean characteristic scores of one of the canned menhaden products (Table 10). These plots are shown in Figures 1 through 9. Significance of the differences between the products was not statistically analyzed because of an error in the experimental design.

The purpose of these plots is to give a general idea of the similarities and differences in characteristics of canned fish products currently on the market and the nine menhaden products. The intensity of a characteristic increases from the center to the periphery of the plot.

Figure 1-Menhaden fillet in oil

Firmness The mean score for the firmness of the menhaden product was similar to the firmness scores of both tuna packed in water and mackerel. The menhaden fillet was scored as firmer in texture than the tuna in oil product.

Table 11-Mean scores for characteristics of commercially canned tuna and mackerel products as scored by six semi-trained panelists^{1,2}

Product ³	Characteristic				
	Firmness	Fish Flavor	Flakiness	Chewiness	Moisture
Tuna/oil	4.72	4.24	8.14	3.99	6.98
Tuna/water	5.64	4.32	6.34	5.89	8.70
Mackerel/water	5.47	6.54	4.24	6.03	6.24

¹ Mean of 6 values. Firmness: 0=very soft, 10=firm; Flavor: 0=mild, 10=strong; Flakiness: 0=low, 10=high; Chewiness: 0=least, 10=most
Moisture: 0=low, 10=high.

² Panelists from faculty and graduate students at VPI&SU. 1 training session.

³ Species of fish/pack (oil, water).

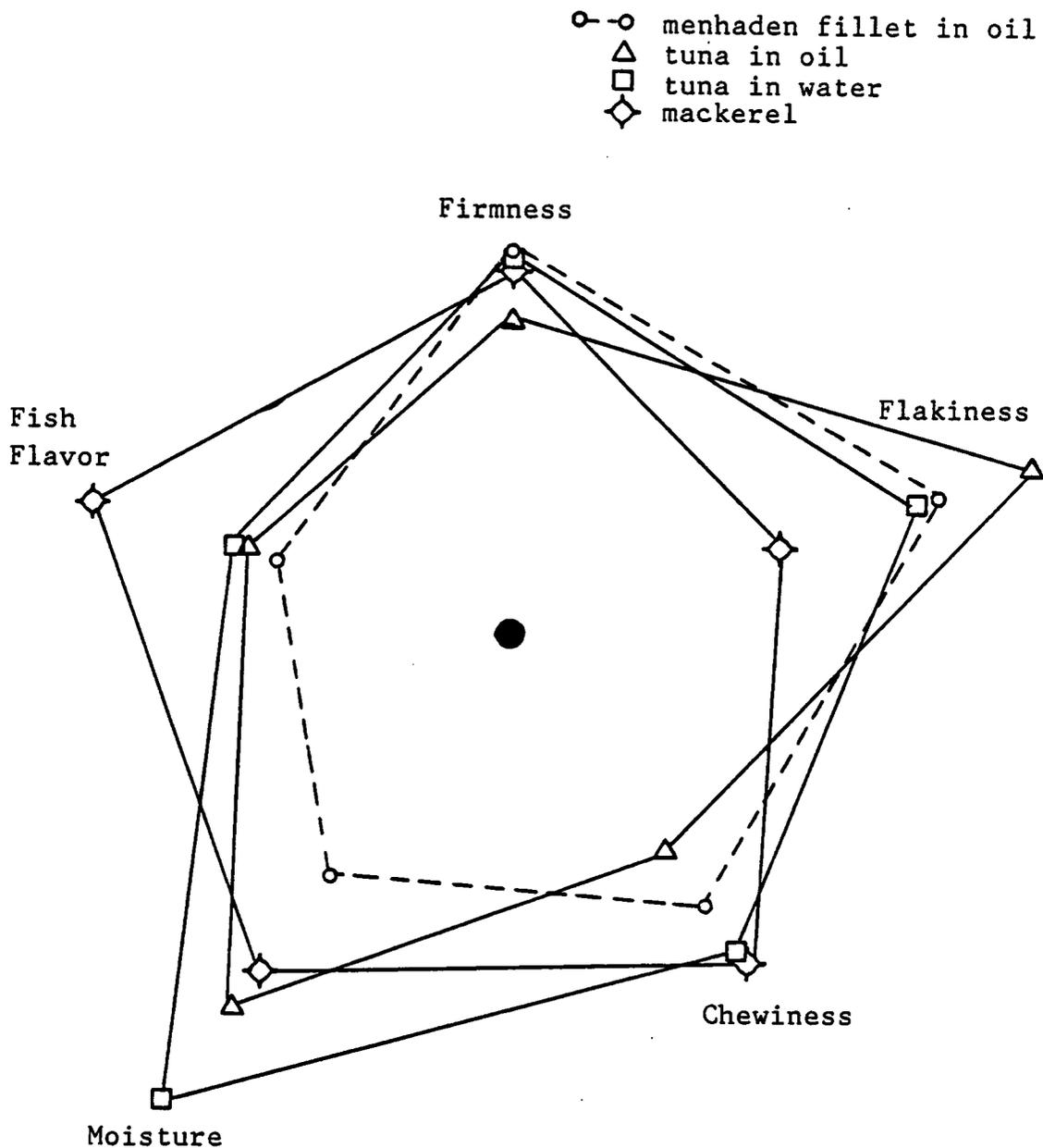


Figure 1-Plot of mean characteristic scores for menhaden fillet in oil, tuna in oil, tuna in water and mackerel canned products.

Flakiness The fillet in oil was slightly more flaky than the tuna in water. Mean scores for the menhaden fillet were between the scores for tuna in oil and mackerel.

Chewiness This menhaden product was scored for chewiness as between the scores for tuna in oil and tuna in water.

Moisture The menhaden fillet in oil was judged to be less moist than the tuna and mackerel products.

Fish Flavor The menhaden fillet in oil was scored as mildest in fish flavor when compared to the tuna and mackerel products. The fillet in oil was scored closest in fish flavor to the tuna products.

Figure 2-Menhaden fillet in broth

Firmness Menhaden fillets canned in broth were scored as less firm than the tuna and mackerel products which indicated the menhaden product had a softer texture.

Flakiness The menhaden fillet in broth was scored as similar to the flakiness of the tuna in oil. This menhaden product was scored higher for flakiness than the tuna in water or the mackerel product.

Chewiness The menhaden fillet in broth was scored as similar in chewiness to the tuna in oil product and as less chewy than the tuna in water or mackerel products.

Moisture The menhaden fillet in broth was scored lower for moisture than were the tuna or mackerel products.

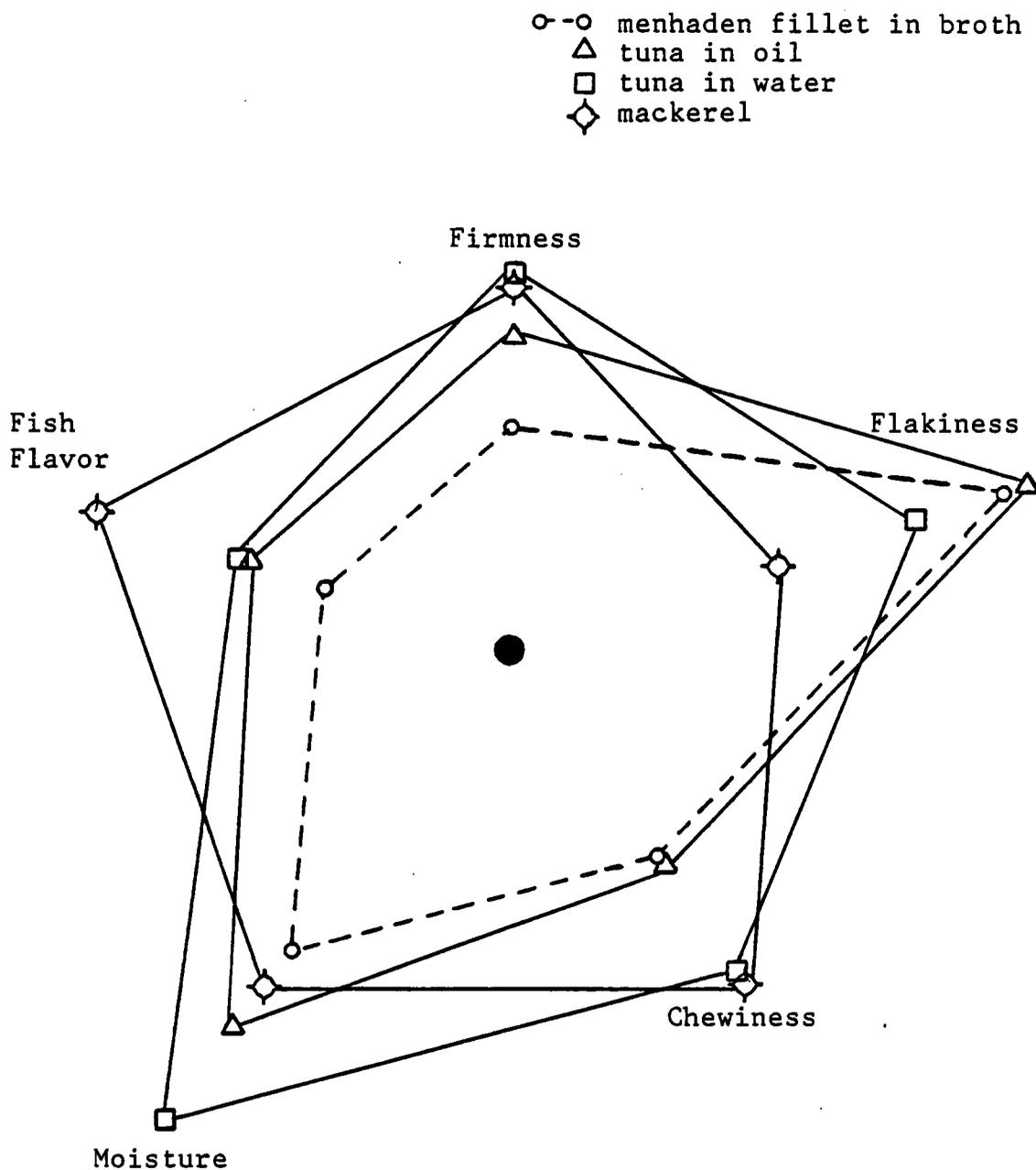


Figure 2-Plot of mean characteristics scores for menhaden fillet in broth, tuna in oil, tuna in water and mackerel canned products.

Fish Flavor The menhaden fillet in broth was scored as milder in fish flavor than the tuna or mackerel products.

Figure 3-Menhaden fillet in alum and citric acid

Firmness The menhaden fillet preprocessed in alum citric acid was scored as having a softer texture than the tuna and mackerel products.

Flakiness The menhaden fillet was scored high for flakiness, similar to tuna in oil. The tuna in water and mackerel products were scored as less flaky than the menhaden product.

Chewiness The menhaden fillet required the least effort to chew of the tuna and mackerel products according to the mean scores.

Moisture The mean score for moisture release of the menhaden fillet was between the mean scores for the tuna in oil and the tuna in water products.

Fish Flavor The menhaden fillet was scored as having a milder fish flavor than the tuna or mackerel products. The mean scores for fish flavor of the menhaden fillet was closest to the mean scores of the tuna products.

Figures 1 through 3-Summary

The menhaden fillet in oil (Fig. 2) was scored close to, or between, the two tuna products in all characteristics except moisture, where the menhaden fillet in oil was scored as less moist than the tuna products. The menhaden fillet product in broth and

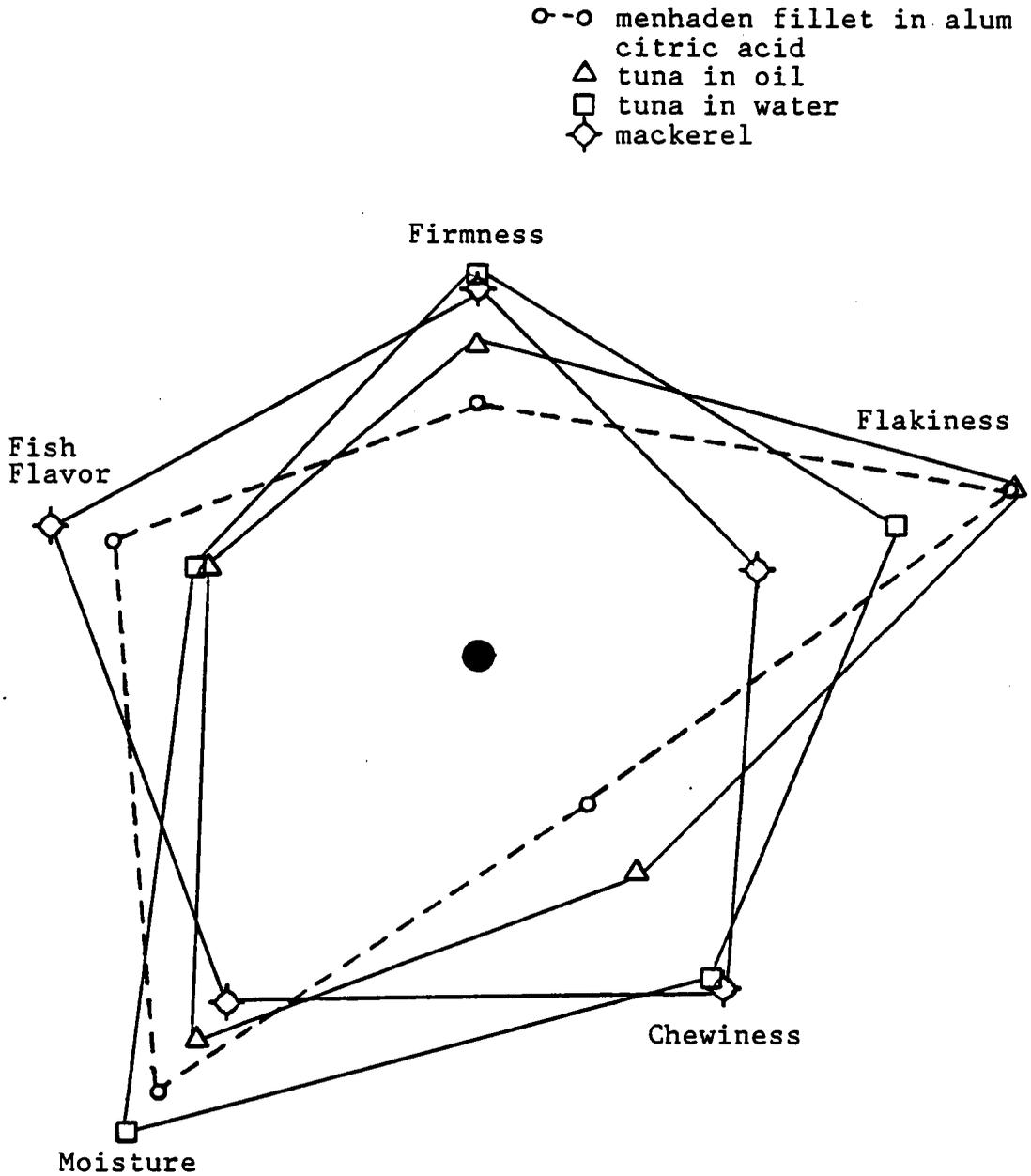


Figure 3-Plot of mean characteristic scores for menhaden fillet in alum citric acid, tuna in oil, tuna in water and mackerel canned products.

the menhaden fillet preprocessed in alum and citric acid were less firm and more flaky than the tuna products. The menhaden fillets in broth and in alum and citric acid were less firm and more flaky than the menhaden fillet in oil.

Mean scores for all characteristics of the menhaden fillet in broth were lower, or less intense, than the tuna in oil product.

The plots showed the tendency, among the scores for three menhaden products for flakiness to increase as firmness and chewiness decreased, and for flakiness to increase as moisture increased. Moisture release showed a tendency to decrease as firmness and chewiness increased.

Figure 4-Dressed menhaden in oil

Firmness The dressed menhaden in oil was scored as softer in texture than the tuna or mackerel products. The mean scores for this menhaden product were not at all similar to the tuna or the mackerel products.

Flakiness The dressed menhaden in oil was scored as being flakier than the comparison products. The dressed menhaden had a flakiness score that was close to the score of tuna in oil.

Chewiness The dressed menhaden in oil required the least effort to chew when scores were compared to the scores for tuna and mackerel products. The means scores for this menhaden product were not at all similar to the tuna or mackerel products.

Moisture The mean scores for moisture perception for the dressed menhaden in oil were most similar to the mean scores for tuna in oil.

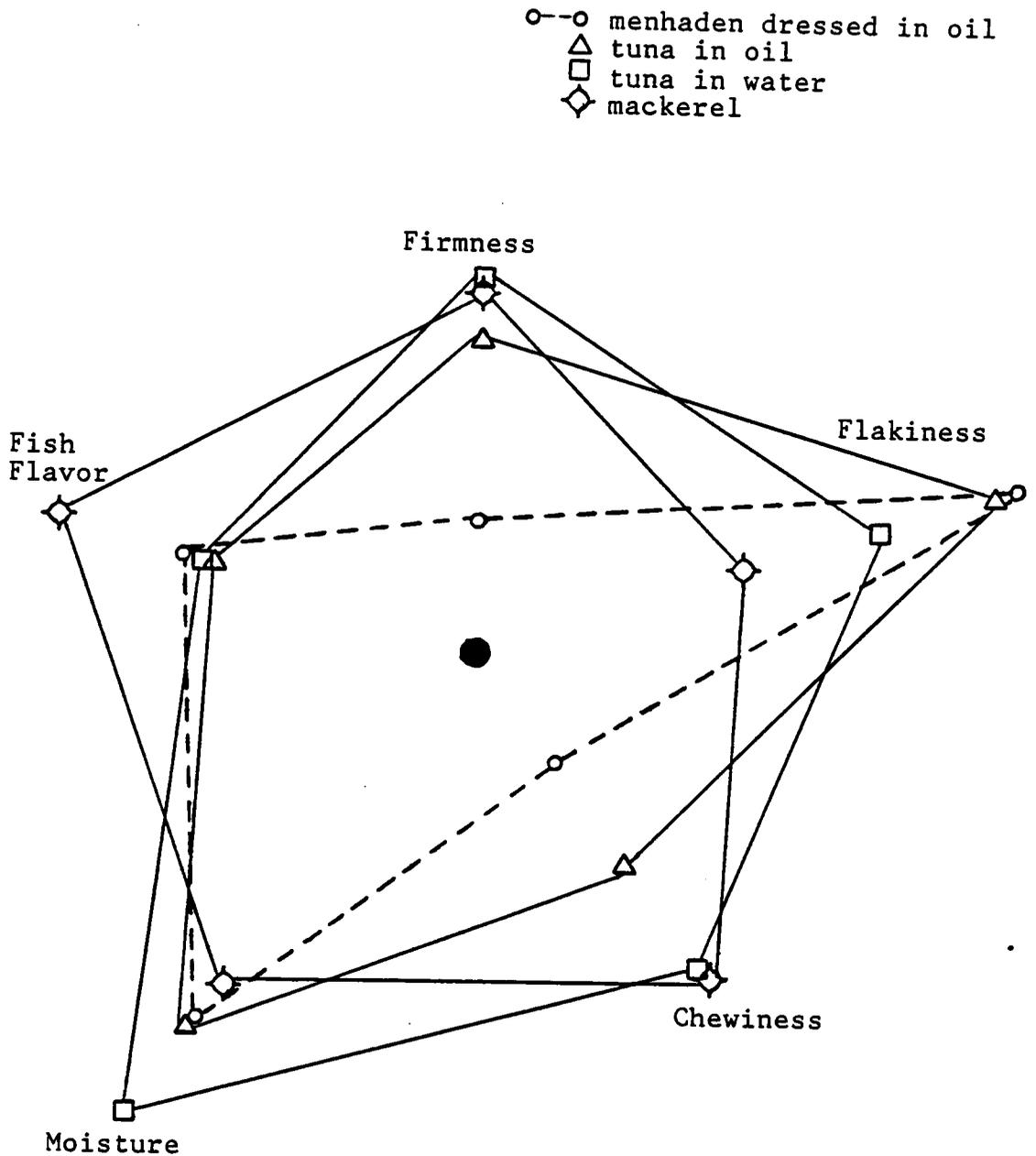


Figure 4-Plot of mean characteristic scores for menhaden dressed in oil, tuna in oil, tuna in water and mackerel canned products.

Fish Flavor The dressed menhaden in oil was scored as having slightly stronger fish flavor than the tuna products. Scores for this menhaden product indicated that it was milder in flavor than the mackerel products.

Figure 5-Dressed menhaden in broth

Firmness The dressed menhaden in broth was scored as softer in texture than the tuna or mackerel products. These scores for the menhaden product were not at all similar to the tuna or mackerel products.

Flakiness The dressed menhaden was scored higher for flakiness than the tuna or mackerel products. The flakiness scores for the menhaden product were closest to the scores for the tuna in oil product.

Chewiness The dressed menhaden in broth was scored as requiring the least effort to chew when compared to the tuna and mackerel products. The mean scores of the menhaden product and the tuna and mackerel products were not at all similar.

Fish Flavor The dressed menhaden in broth was scored as having a milder fish flavor than the tuna or mackerel products. The flavor scores for the menhaden product were closest to the flavor scores of the tuna products.

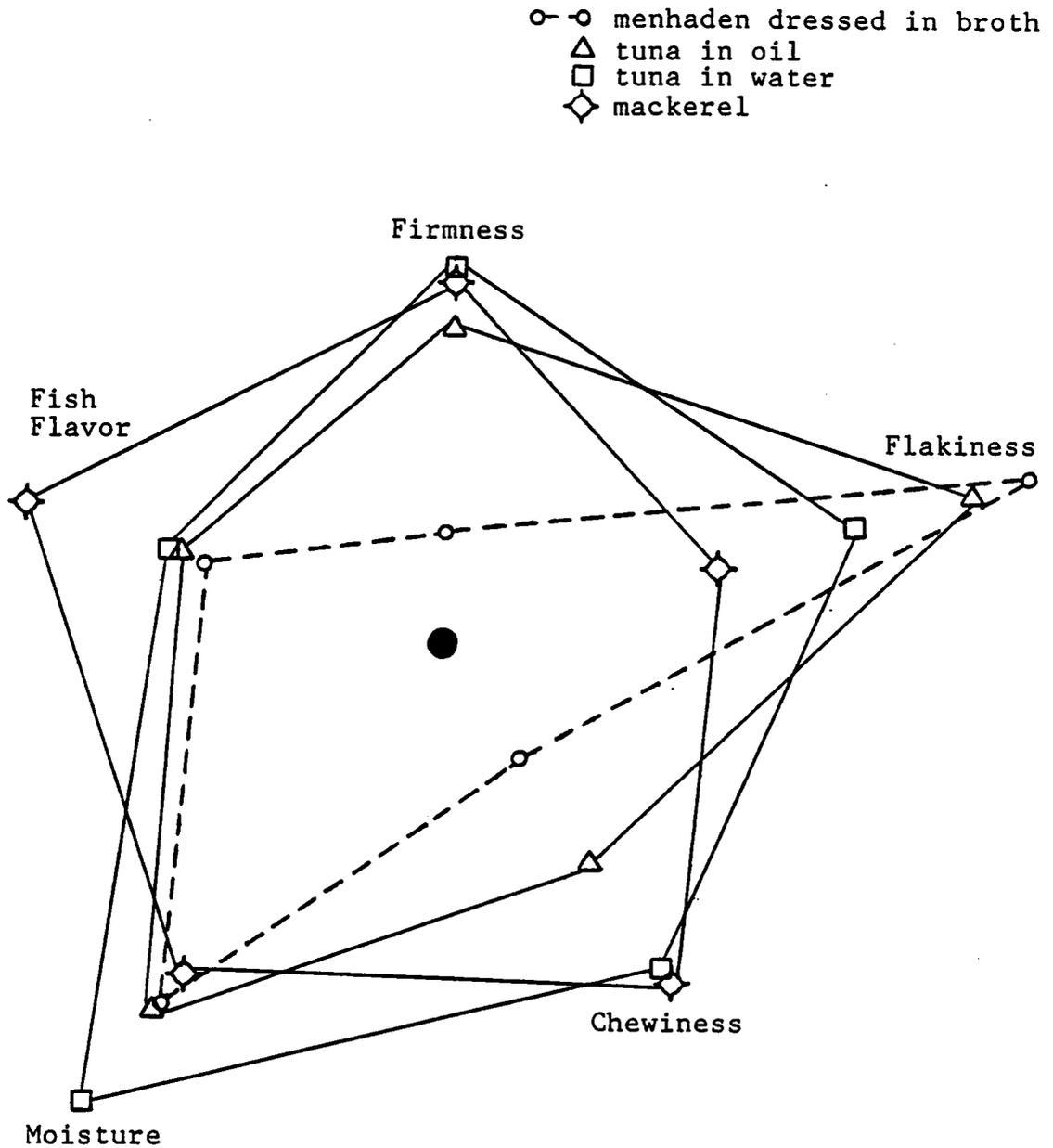


Figure 5-Plot of mean characteristic scores for menhaden dressed in broth, tuna in oil, tuna in water, and mackerel canned products.

Figure 6-Dressed menhaden in alum citric acid

Firmness The dressed menhaden was scored as slightly softer than the tuna and mackerel products. The mean scores for firmness of tuna in oil were closest to the mean scores of the menhaden in alum and citric acid.

Flakiness The dressed menhaden preprocessed in alum and citric acid was scored as similar in flakiness to the tuna in oil product. Both products received high scores for flakiness.

Chewiness The dressed menhaden required the least effort to chew. The mean scores for the menhaden product were not similar to the tuna or mackerel product scores.

Moisture The mean scores for moisture perception for the dressed menhaden product were most similar to the mean scores for the tuna in oil.

Fish Flavor The dressed menhaden was scored as having a slightly milder fish flavor than the tuna or mackerel products. The flavor scores for the menhaden product were closest to the flavor scores of the tuna products.

Figures 4 through 6-Summary

The dressed menhaden in oil, in broth and in alum and citric acid was scored high for flakiness and the mean score was close to the scores of tuna in oil. The dressed products had low chewiness scores that were not similar to any of the comparison products. The moisture scores for all three dressed products indicated a

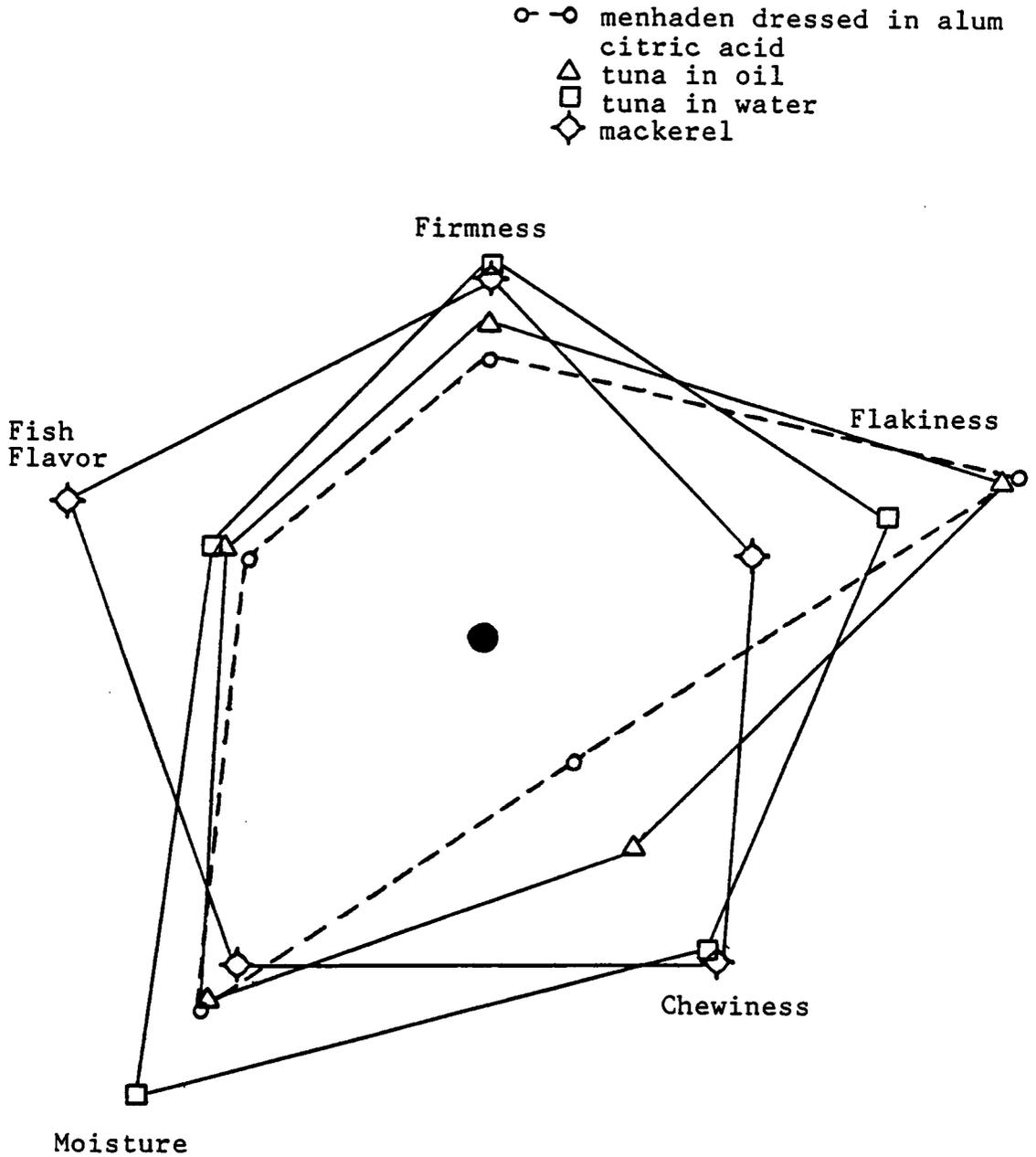


Figure 6-Plot of mean characteristic scores for menhaden dressed in alum citric acid, tuna in oil, tuna in water and mackerel canned products.

moisture release similar to tuna in oil. Fish flavor scores for the menhaden products were similar in intensity to the scores for tuna products. The firmness scores for the dressed menhaden in broth and dressed menhaden in oil were similar and indicated canned menhaden products that were very soft, unlike either tuna or mackerel products. The dressed menhaden preprocessed in alum and citric acid was the firmest of the three menhaden products and had firmness scores closest to tuna in oil.

The dressed products were similar to the tuna in oil products for flakiness and moisture and were similar to tuna in oil and tuna in water for fish flavor. The dressed products were dissimilar to the comparison products in chewiness and firmness.

Figure 7-Minced menhaden in oil

Firmness The minced menhaden in oil was scored as firmer than the tuna or mackerel products.

Flakiness The minced menhaden in oil was scored as the least flaky of the products compared.

Chewiness This minced product was scored for chewiness between the scores of tuna in oil and tuna in water.

Moisture The minced product in oil was scored as similar to the score for mackerel for moisture perception.

Fish Flavor The minced product was scored as having stronger fish flavor that was similar to that of mackerel.

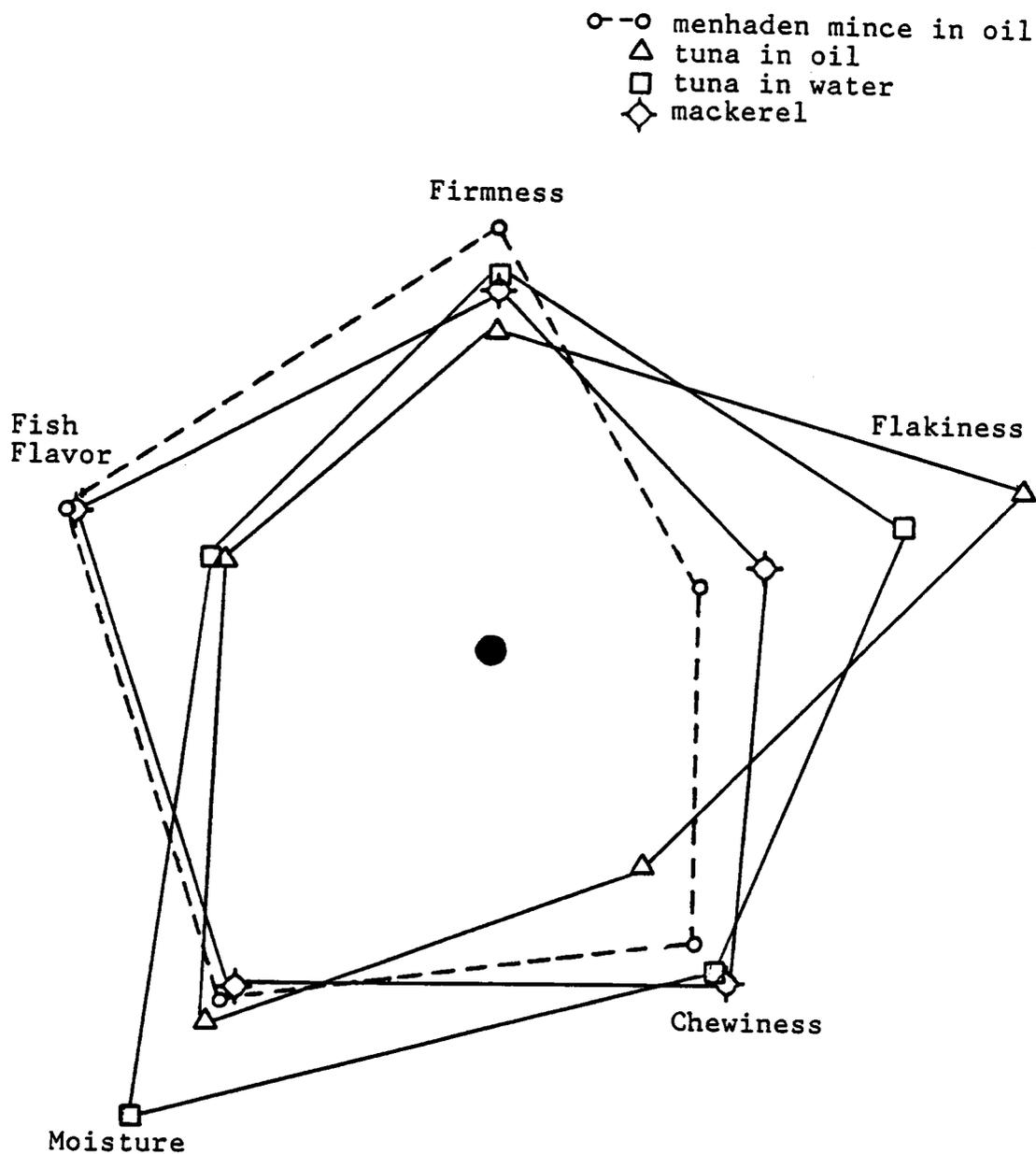


Figure 7-Plot of mean characteristic scores for menhaden mince in oil, tuna in oil, tuna in water, and mackerel canned products.

Figure 8-Minced menhaden in broth

Firmness The firmness of the minced product in broth was scored as similar to that of the tuna in water and mackerel products.

Flakiness The minced menhaden in broth was scored as less flaky than the tuna and mackerel products.

Chewiness The minced menhaden in broth was scored for chewiness between the scores of tuna in oil and tuna in water.

Moisture The minced product in broth was scored the lowest for moisture perception when compared to the scores for tuna and mackerel products.

Fish Flavor The minced product was scored as having stronger fish flavor than mackerel.

Figure 9-Minced menhaden in alum citric acid

Firmness The minced menhaden received a high score for firmness. The minced product was not similar in firmness to the tuna or mackerel products.

Flakiness The minced menhaden was scored as the least flaky product. The minced product was not similar in flakiness to the tuna or mackerel products.

Chewiness The minced menhaden was scored as requiring the most effort to chew of the products compared.

Moisture The minced product was scored the lowest for moisture perception of the products compared.

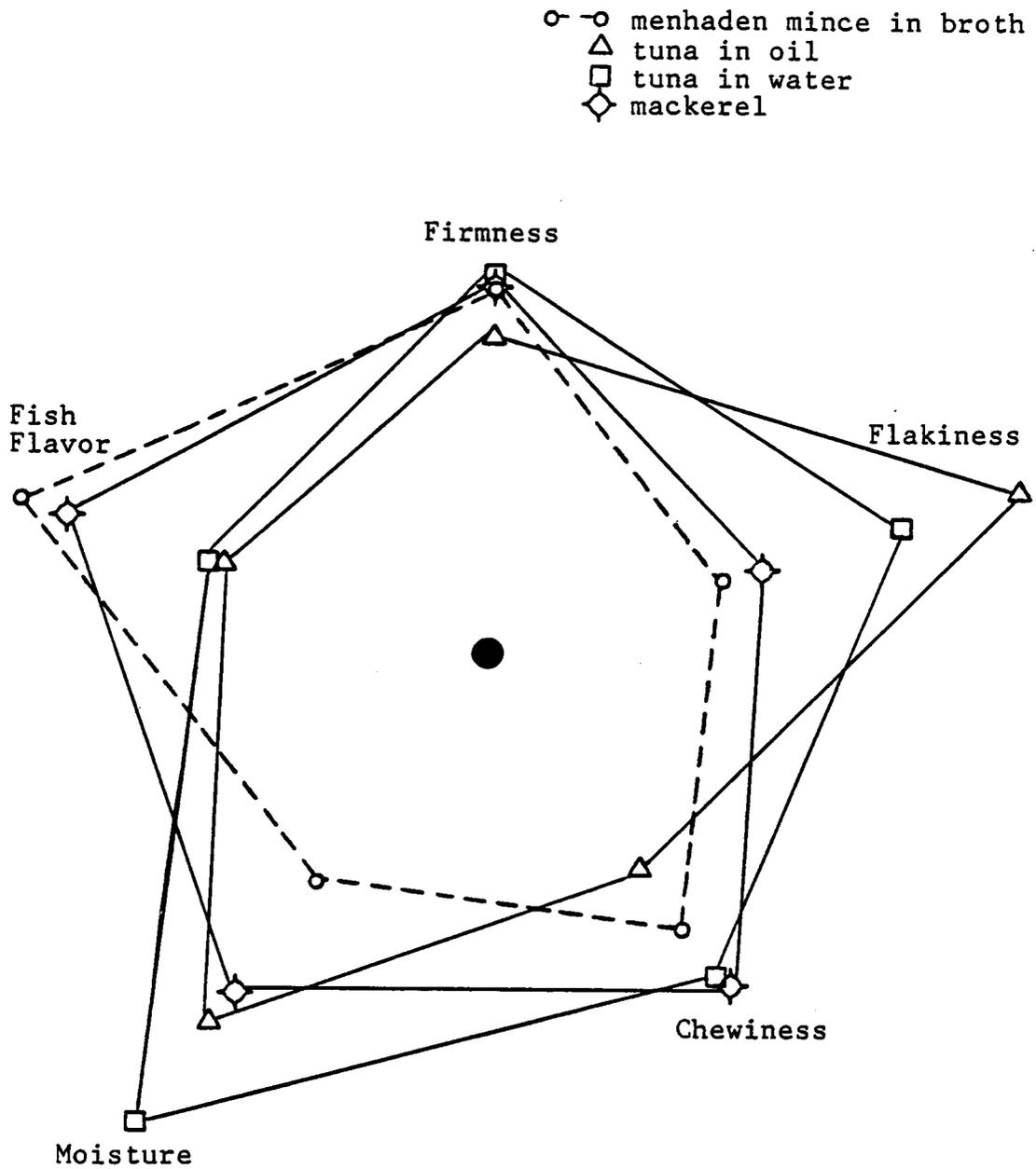


Figure 8-Plot of mean characteristic scores for menhaden mince in broth, tuna in oil, tuna in water, and mackerel canned products.

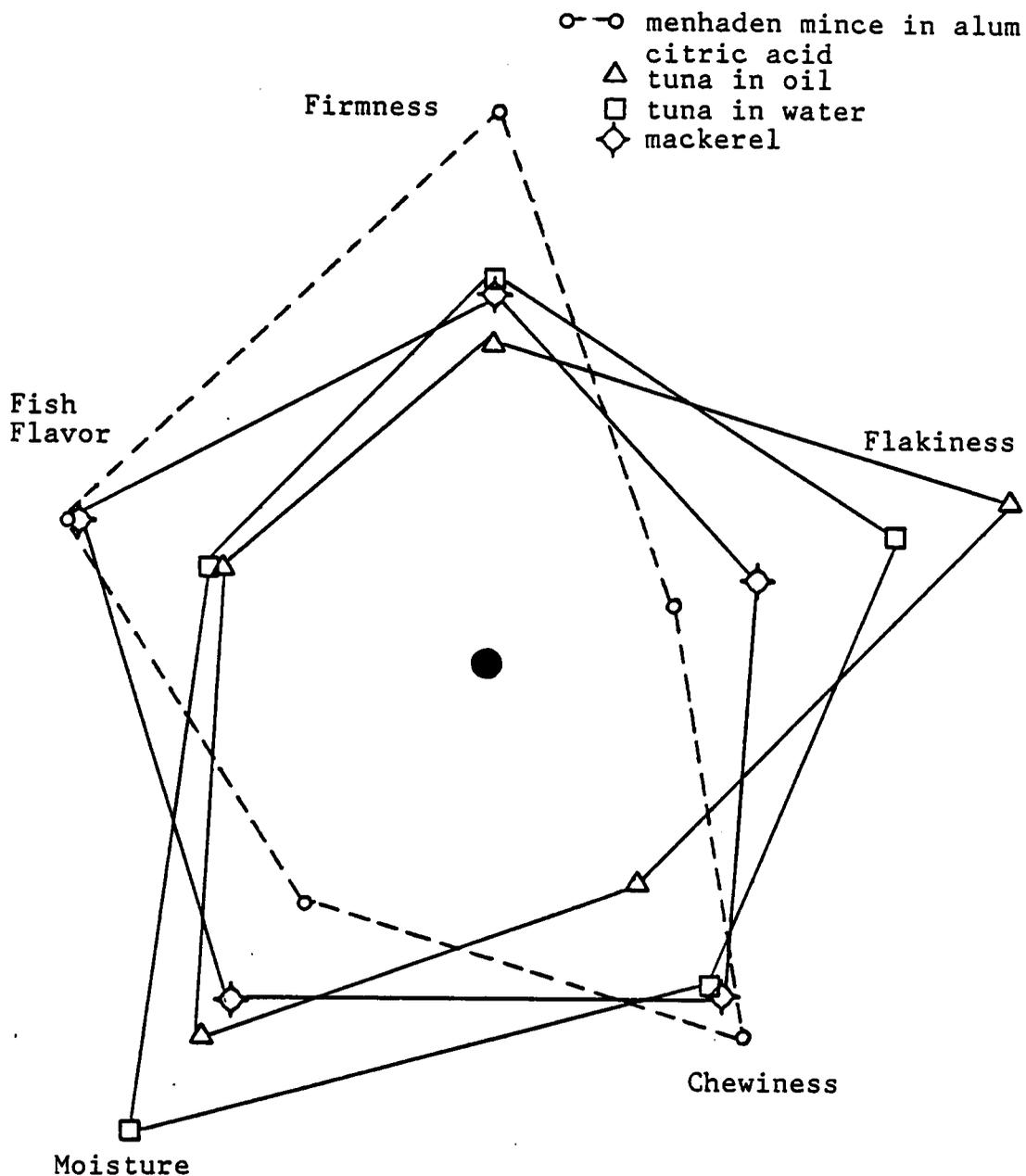


Figure 9-Plot of mean characteristic scores for menhaden mince in alum citric acid, tuna in oil, tuna in water, and mackerel canned products.

Fish Flavor The minced menhaden was scored as similar in fish flavor to the mackerel product. Both products had relatively strong fish flavors.

Figures 7 through 9-Summary

The three minced menhaden products had flakiness scores that were less than mackerel, the comparison product with the lowest flakiness score. The minced products were similar in their high scores for fish flavor. The plots for the minced menhaden products indicated a tendency for firmness to increase as chewiness increased.

CONSUMER PREFERENCE PANELS

Fish Salad

Dressed and filleted canned menhaden preprocessed in alum and citric acid brine and canned tuna packed in oil were used in three fish salad products. The fish salads were scored on a nine point hedonic scale by thirty-four member consumer panel. A numerical score was given to descriptive expressions listed on the panelists score sheet. The mean scores for the three fish salad products are listed in Table 12. Both menhaden salad products had mean scores of approximately 6, which translated into the expression "like slightly". The tuna salad had a mean score of approximately 7, which is translated into the expression "like moderately". The menhaden salads were not significantly different

Table 12-Mean scores for consumer preference of fish salad products made with canned tuna and with canned menhaden^{1,2}

Salad Product	Preference Scores ³	
	Mean	± S. D.
Tuna/oil	7.24 _a	± 0.22
Menhaden, dressed/alum citric acid	6.09 _b	± 0.22
Menhaden, fillet/alum citric acid	6.03 _b	± 0.22

¹ Means of 34 consumer preference scores.

² 1=dislike extremely; 2=dislike very much; 3=dislike moderately; 4=dislike slightly; 5=neither like nor dislike; 6=like slightly; 7=like moderately; 8=like very much; 9=like extremely.

³ Means with the same subscript letter are not significantly different (p < 0.05). S.D. = standard deviation.

from one another but both menhaden products were significantly different, ($p < 0.05$), from the tuna salad.

Several of the panelists who commented on the products indicated the presence of an aftertaste in the salad products made from the menhaden. This may be the same metallic aftertaste noted in the second pilot study.

The dressed fish product did have skin removed prior to being incorporated into the fish salad, but pieces of skin and dark muscle were still visible in the final product. One fish salad using the fillet in broth or oil packs should have been prepared to determine the significance of the alum citric acid brine on the preference score.

"Pizza Sauce"

"Pizza" sauces were made using dark minced menhaden packed in oil and using hamburger. The pizza sauces were used as a topping on quartered english muffins. Thirty-one consumer panelists tasted the products and scored them on a nine point hedonic scale. Mean preference scores are listed in Table 13.

The "pizza" made with menhaden mince received a mean score of approximately 4, which translates into the expression "dislike slightly". The hamburger "pizza" received an approximate mean score of 7, which translates into the expression "like moderately".

Panelists made comments on the score sheets concerning the products tested. One comment that was repeated, in writing and verbally, was that a fish pizza sauce was not expected and that if the hamburger had not been there for comparison, the fish "pizza" would have been given a higher score.

The author noted, and the panelists commented, that the appearance of the two "pizza" sauces were similar.

This preference test would indicate that minced menhaden products may not be suited as a substitute in food products that have a consumer standard of identity. The minced menhaden product may have a use in a new fish product, where a fish muscle, that is similar in texture and appearance to cooked ground beef, is desired.

Table 13—Mean scores for consumer preference of pizza products made with hamburger and with canned minced menhaden packed in oil^{1,2}

Pizza Product	Preference Scores ³	
	Mean	± S. D.
Hamburger	7.03 _a	± 0.27
Menhaden mince/oil	4.10 _b	± 0.27

¹ Means of 31 consumer preference scores

² 1=dislike extremely; 2=dislike very much; 3=dislike moderately; 4=dislike slightly; 5=neither like nor dislike; 6=like slightly; 7=like moderately; 8=like very much; 9=like extremely.

³ Means with the same subscript letter are not significantly different (p < 0.05). S.D. = standard deviation.

Chapter V

SUMMARY AND CONCLUSIONS

Menhaden (Brevoortia tyrannus) is an abundant species classified as an "industrial" fish. Limited use has been made of menhaden as a commercial food product. This study evaluated the acceptability of canned and pasteurized menhaden food products.

In the pilot studies the pasteurized menhaden in dressed, filleted, unwashed (dark) minced and washed (light) minced forms did not produce an acceptable food product. The large and small bones in menhaden muscle were not adequately softened by the pasteurization process. The longer time and higher temperature of the canning process did provide adequate softening of the bones. The dressed, filleted, and unwashed (dark) minced menhaden products were judged to be acceptable in bone softness, appearance, texture, odor, and flavor. The washed (light) minced product developed an unacceptable dry, elastic texture in the canning process.

An alum and citric acid brine was tested in a pilot study on the dressed and filleted forms of menhaden. The pilot study products were judged to be firmer but the brine treatment was also responsible for an unacceptable metallic aftertaste and an acceptable citric flavor.

Dressed, flaked filleted, and unwashed minced menhaden with an oil or broth pack, or preprocessed in alum and citric acid were

the pilot study products judged to have potential as canned food products for further evaluation.

Two objective measurements, drained weight and total fluid were recorded for the nine menhaden products used in the final processing and evaluation. When percent weight loss and percent fluid loss were calculated, the differences between the oil and broth packs appeared to be a function of the form of the fish rather than of the type of pack. All three forms of fish preprocessed in the alum and citric acid brine had higher percent weight losses. The combined effects of the minced form and the alum and citric acid brine produced the highest recorded percent weight loss and percent fluid loss. Minced fish products, because of the small particle size of the muscle, had more muscle area exposed to the brine than did the filleted or dressed fish products.

The characteristics of the menhaden products were determined by sensory evaluation using a descriptive method and a semi-trained panel. The panel scores indicated that in general the dressed and filleted menhaden products were similar in the characteristics of firmness, fish flavor, flakiness, chewiness, and moisture. The scores for minced menhaden products were similar to one another in all characteristics and similar to the dressed and filleted fish products in flavor and moisture. Scores for the minced products were significantly different from the dressed and filleted products in the firmness, flakiness, and chewiness characteristics. The canned minced menhaden was judged to have textural characteristics

that were different from the dressed and filleted fish products.

The characteristics determined by the scores of the semi-trained panel for the menhaden products were compared to the scores for characteristics given to commercially canned tuna in oil, tuna in water and mackerel products. Each menhaden product and the three comparison products were plotted to give a visual representation of the similarities and differences between the products. The menhaden fillet in oil seemed to be the most similar to the tuna comparison products. The mean scores indicated the filleted menhaden in oil was: similar in firmness and flakiness to tuna in water; between tuna in oil and tuna in water in chewiness; and less moist and milder in fish flavor than all three comparison products.

Statistical analysis of the scores for the characteristics of the menhaden products indicated the dressed and filleted menhaden products were similar. Therefore, although the plots show variations in the comparisons of characteristic scores of dressed and filleted menhaden products and the tuna and mackerel products, these variations would not necessarily be significant.

The plots allowed the mean characteristic scores to be viewed in a picture form. The plots, when placed on top of one another, indicated a tendency, among the three filleted menhaden products, for flakiness scores to increase as firmness and chewiness scores decreased; and for flakiness scores to increase as moisture scores increased. Moisture perception scores showed a tendency to

decrease as firmness and chewiness increased.

The descriptive sensory tests were followed with consumer preference testing of three canned menhaden products. The minced menhaden in oil "pizza" sauce was scored as "dislike slightly", when paired with a hamburger pizza sauce which was given a score of "like moderately". Three fish salad products prepared with filleted and dressed menhaden in alum and citric acid and with tuna in oil received scores of "like slightly" for the menhaden fish salads and "like moderately" for the tuna salad. The menhaden products tested were significantly less acceptable than the comparison products.

The dressed and filleted menhaden products were scored as satisfactory after the canning process. These products received scores that were similar to scores for currently marketed tuna and mackerel products. Additional recipe testing using consumer panels is warranted. Based on the data in this study the filleted menhaden products had the highest potential as a canned food product with the dressed menhaden product also showing a high potential as a canned food product.

The filleted menhaden packed in oil were scored by a semi-trained panel as similar in all characteristics to the filleted menhaden packed in broth. The dressed menhaden in oil were scored as similar to the dressed menhaden in broth in all characteristics. The canned menhaden in oil and in broth packs were not scored as significantly different in sensory characteristics

and major variations could not be detected from the product comparison plots. No differences were indicated between the oil and broth packs for the filleted and dressed products.

The minced menhaden products were significantly different in product characteristics from the dressed and filleted menhaden products and were dissimilar to the comparison tuna and mackerel products. Further evaluation is required to determine if the minced menhaden products are different in an acceptable or unacceptable manner when used in a food product.

The alum and citric acid brine did not improve the texture or flavor of the canned menhaden product in a consistent or significant manner. Therefore the added expense of completing this process would not seem warranted. Comments from the pilot study and consumer panelists were frequent enough to indicate the brine treatment did impart an unacceptable aftertaste to the canned product.

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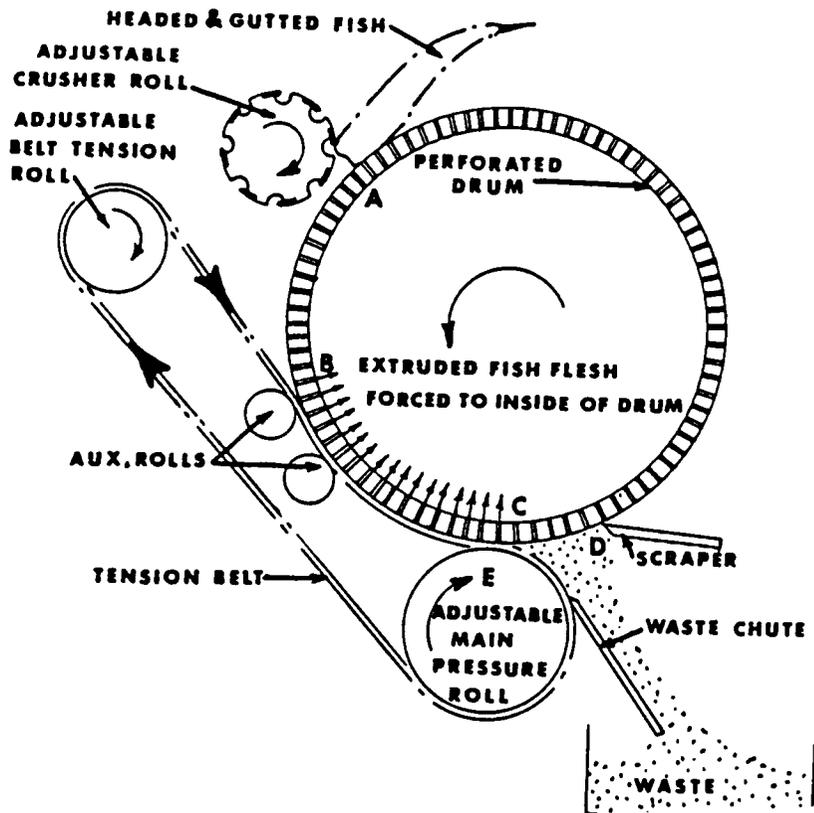
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APPENDIX I



(Steinberg and Spinelli, 1976)

APPENDIX II

Score Sheet Used By Semi-Trained Panelists
For Characteristics of Canned Menhaden Products

Panelist Name _____ Panelist Number _____

Date _____ Day _____ Sample Code _____

Evaluate the sample according to the definition and instructions for each characteristic. Record your score by making a vertical mark through the line under each characteristic.

FIRMNESS [_____]
 VERY SOFT FIRM

FISH FLAVOR [_____]
 MILD STRONG

FLAKINESS [_____]
 LOW FLAKINESS HIGH FLAKINESS

CHEWINESS [_____]
 LEAST EFFORT MOST EFFORT

MOISTURE [_____]
 LOW MOISTURE RELEASE HIGH MOISTURE RELEASE

APPENDIX III

Definitions of characteristics for canned menhaden products

FIRMNESS: The perceived force required to compress a $\frac{1}{2}$ -inch cube of the sample using the molar teeth.

FISH FLAVOR: The perceived flavor noted during mastication and after swallowing.

FLAKINESS: The perceived degree of separation of the sample into individual flakes when manipulated with the tongue against the palate.

CHEWINESS: The total perceived effort required to prepare a $\frac{1}{2}$ -inch cube of the sample to a state ready for swallowing. Count the approximate number of chews required prior to swallowing.

MOISTURE: The perceived degree of oil and/or water in the sample after 3 to 4 chews.

APPENDIX IV

Three day sensory evaluation schedule for nine menhaden products
judged by six semi-trained panelists

Judge 1:

<u>Day 1</u>	<u>Day 2</u>	<u>Day 3</u>
4	6	7
2	1	3
9	8	5

Judge 2:

<u>Day 1</u>	<u>Day 2</u>	<u>Day 3</u>
1	4	5
6	9	7
8	2	3

Judge 3:

<u>Day 1</u>	<u>Day 2</u>	<u>Day 3</u>
1	3	9
6	7	4
8	5	2

Judge 4:

<u>Day 1</u>	<u>Day 2</u>	<u>Day 3</u>
1	4	6
9	8	2
5	3	7

Judge 5:

<u>Day 1</u>	<u>Day 2</u>	<u>Day 3</u>
1	3	6
9	8	7
5	4	2

Appendix IV
continued:

Judge 5:

<u>Day 1</u>	<u>Day 2</u>	<u>Day 3</u>
3	5	6
8	9	7
4	1	2

APPENDIX V

Fish Salad

- 1 c. cooked fish, cut or flaked into small pieces*
- 1 egg, hard cooked and sliced
- 1 c. celery, diced
- ½ c. mayonnaise

* Fish used in the 3 samples were filleted and dressed menhaden preprocessed in alum and citric acid brine, commercially canned tuna in oil, and tuna in water

Pizza Sauce

- 1- 32 ounce jar Ragu brand spaghetti sauce
- ½ c. onion, chopped
- 1 lb. ground beef or canned fish
- Cheddar cheese, grated
- English muffins

1. brown onions in 2-3 tablespoons of oil.
2. add meat and brown; or add canned fish.
3. add spaghetti sauce and simmer for 20 minutes.
4. toast halved english muffins, then cut into fourths.
5. place 1 rounded teaspoon of pizza sauce on each quartered muffin and sprinkle top with cheese.
6. place muffins under broiler until cheese melts.

APPENDIX VI

Hedonic questionnaire used for consumer preference evaluation of fish salads and pizza sauces

NAME _____ DATE _____ PRODUCT _____

Taste these samples and check how much you like or dislike each one. Thank you.

_____ like extremely	_____ like extremely	_____ like extremely
_____ like very much	_____ like very much	_____ like very much
_____ like moderately	_____ like moderately	_____ like moderately
_____ like slightly	_____ like slightly	_____ like slightly
_____ neither like nor dislike	_____ neither like nor dislike	_____ neither like nor dislike
_____ dislike slightly	_____ dislike slightly	_____ dislike slightly
_____ dislike moderately	_____ dislike moderately	_____ dislike moderately
_____ dislike very much	_____ dislike very much	_____ dislike very much
_____ dislike extremely	_____ dislike extremely	_____ dislike extremely

Comments:

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the scanned document**