

# Sensory Methodology for the Classification of Fish According to "Edibility Characteristics"

Armand V. Cardello, F. Miles Sawyer, P. Prell, O. Maller and J. Kapsalis

Armand V. Cardello, O. Maller and J. Kapsalis: Science and Advanced Technology Laboratory, U.S. Army Natick Research and Development Laboratories, Natick, MA 01760 (U.S.A.)

F. Miles Sawyer: Department of Food Science and Nutrition, University of Massachusetts, Amherst, MA 01003 (U.S.A.)

P. Prell: Food Engineering Laboratory, US Army Natick Research and Development Laboratories, Natick, MA 01760 (U.S.A.)

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*As part of a research project funded by the National Marine Fisheries Service of the U.S. Department of Commerce (NMFS/USDC), a standardized sensory methodology for evaluating the flavor, texture, and appearance of fin fish was developed by the U.S. Army Natick Research & Development Laboratories. The ultimate goal of the NMFS/USDC project is to develop a nationwide seafood nomenclature system that is based upon similarities and dissimilarities in "edibility" characteristics among species. This new system will enable consumers and commercial processors to make informed choices among unfamiliar or non-traditional species by providing the comparative sensory data necessary to select a desired texture, flavor, etc., of fish. The present report summarizes the development of the sensory methodology and its initial application in establishing a data base on the sensory properties of traditional and non-traditional fish species.*

## Introduction

The National Marine Fisheries Service (NMFS), with consumer, industry, and regulatory agency support, has undertaken to develop a new system for establishing market names for fisheries' products. The need for such a program has arisen from: 1) the increased use of fisheries resources that have not been previously marketed and for which no common names exist, 2) the fact that many marketed species of fish are known and marketed by different names in different areas of the country, and 3) because the marketing of many nutritious species of fish has been severely limited as a consequence of aesthetically-objectionable common names (1). The primary goal of the new nomenclature system is to identify groups of similar fish species so that similar species can be assigned similar names. However, while ichthyologists use anatomical characteristics to name and group species, such zoological groupings have little relevance to the consumer, who usually purchases a species for its particular sensory qualities. When a consumer encounters a novel fish species in the market place, his/her first question is "What does it taste like?" (Here, the word "taste" is usually used in the generative sense to mean taste, smell, texture, etc.). The common reply of the retailer is to compare the taste of the novel fish to that of a better known fish, e.g. "it's similar to flounder, but has a stronger taste," or "it tastes like mackerel, but isn't as oily." This method of comparing unfamiliar species to more familiar species is very useful to consumers who are looking to substitute less expensive fish for the more costly fish in their diet.

In order to develop a sensory methodology for use in this consumer-oriented approach to marketing fish, four requirements had to be met. First, the important sensory attributes

of fish had to be identified. Although various sets of terminology for describing the sensory characteristics of fish have been developed for purposes of quality control and inspection (2-6), no comprehensive set of terminology is available that has established meaning and usefulness to consumers or that would be useful for the purpose of making inter-species comparisons. Second, a reliable scaling method had to be identified so that reliable sensory profiles could be established. Third, a valid statistical method for grouping species on the basis of similarities and dissimilarities in their sensory profiles had to be identified. Lastly, although not a requirement for the nomenclature project itself, it would be useful to identify procedures for representing the sensory relationships among species in retail locations and for assisting future consumer-education programs.

The present report summarizes the approach developed for NMFS by the U.S. Army Natick Research & Development Laboratories (NLABS) and its application to 17 species of North Atlantic fish.

## Methods

The research program was divided into two phases. The first was devoted to the development of methodology, and the second was devoted to the application of the methodology to 17 species of fish.

### *Harvesting, Identification and Preparation of Samples*

Test samples consisted of traditional and non-traditional species of North Atlantic fin fish. All were harvested by "day boats" and landed the night before or early in the morning of the day that they were to be filleted. After filleting, boxes of

fillets were packed with ice in insulated shipping containers and transported to NLABS. The quality of fish was assessed by Military Veterinary Personnel and by NMFS/USDC personnel using standardized appearance and odor criteria. Fillets were trimmed by removing the skin, the belly flap, the edge of the nape, and the tail. The rest of each fillet was cut into approximately 56 g pieces. Portions of the fillet trimmings, representing at least six different fillets, were taken to the Gloucester Laboratory, Northeast Fisheries Center, for positive identification of species using thin layer-isoelectric focusing (7, 8).

#### Cooking Method

Consideration was given to the effect that cooking method might have on judgments of the sensory characteristics of the fish. The major criterion for choice of a suitable method was that it have minimal sensory impact of the "innate" characteristics of the species. This criterion eliminated such methods as frying and cooking with seasoning. As a result, a method of the Association of Official Analytic Chemists for cooking seafood was adopted. This method required heating the samples in pouches (laminates of  $5.0 \times 10^{-2}$  mm polyethylene and  $2.5 \times 10^{-2}$  mm polyester) immersed in 71°C water. The method was subsequently improved by introducing a compartmentalized pouch into which juices that were produced during cooking could drain away from the fish tissue, through perforations separating the compartments. This prevented samples from cooking in their own juices. Heat-penetration studies were also conducted to establish precise cooking times for samples of different thicknesses.

#### Sensory Panels

Three different types of sensory panels were used throughout this research:

- 1 A trained texture profile panel, comprised of 6–8 individuals trained in the General Foods Texture Profile Method (9–11).
- 2 A trained flavor profile panel, comprised of 6–8 individuals trained in the Authur D. Little Flavor Profile Method (12–13).
- 3 Consumer panels drawn from a population of 450 untrained volunteer employees of the U.S. Army Natick Laboratories.

All panel test procedures conformed to accepted practices for sensory evaluation (14–15).

#### Development of Sensory Attributes to Describe Fish

Initial research focused on the development of a comprehensive list of sensory attributes that could be applied to the wide range of commercially available, edible fish species. For this purpose, a diverse sample of fish species ( $\approx 25$ ) was examined by the trained profile panels, and a set of descriptive flavor and texture terms was developed. Simultaneously, an extensive series of tests and interviews were conducted with approximately 300 consumers. In the first of these tests, a written survey was administered to consumers in which they were asked to list all descriptive terms that they felt were applicable to the description of the edibility characteristics of fish. In subsequent tests they were presented with various species of cooked fish, asked to taste them, and then asked to list descriptive terms that came to mind. All terms were freely generated and no guidance or influence was provided by persons involved in the conduct of the study. Lastly, consumers were interviewed to ascertain personal definitions of the terms that they had used.

A combined tabulation of the descriptive terms generated by the trained and consumer panels yielded a total of 153 descriptors. Since many terms were similar in meaning (e.g., tart, sour, sharp), polar opposites (e.g., salty vs. unsalty and

**Tab.1 Twenty-seven sensory attributes identified by consumers and trained panelists as important to the characterization of fish.**

Asterisks indicate the thirteen attributes that were subsequently found to be significant discriminators on the basis of stepwise discriminant analysis.

Flavor	Texture
* Overall flavor intensity	* Flakiness
Delicate or fresh fish	* Firmness
* Heavy or gamey fish	* Moistness
Fish (old fish)	* Chewiness
Sweet	Mouth-drying
* Briny, salty	* Fibrousness (stringiness)
* Sour	* Oily mouth coating
Seaweed	Adhesiveness (sticks to teeth)
Bitter	Cohesiveness of the mass (chewed sample holds together in mouth)
* Fish oil	
Buttery	
Nutty	
Musty	Appearance
Ammonia	
Metallic	Whiteness
* Shellfish	* Darkness

soft vs. hard), or inappropriate (e.g., healthy, boneless, sickly, non-fattening), the list was reduced to 27 terms, as shown in Tab.1.

Due to the consumer-oriented nature of the NMFS/USDC project, the usefulness of this initial set of attributes to consumers for discriminating among species of fish was assessed. This was accomplished by conducting tests in which consumer panelists rated different species of fish on all 27 attributes. Participants in these tests were selected randomly in groups of 40 panelists each. The data were analyzed by stepwise multiple discriminant analysis to identify those attributes that best discriminated among the various species of fish. Complete details of this multi-phased evaluation can be found in SAWYER, *et al.* (16). In brief, the data showed that 13 descriptors were significant discriminating variables ( $p < 0.001$ ). These 13 attributes were adopted for further use in this project and are asterisked in Table 1. In addition, since the subtleties of flavor differences prevented the enumeration of a fixed set of flavor attributes to be encountered in all fish, certain other flavor attributes that were deemed important by the flavor profile panel for a particular species were included for further use.

#### Selection of a Reliable Scalar Method

The second phase of research focused on the selection of a psychophysical method for scaling the magnitude of each sensory attribute. Since the new nomenclature system would ultimately require evaluation of numerous species of fish over several years of testing, the chosen criterion for an optimal scaling method was its reliability over time. The reliability of five different scalar methods was examined by the texture profile panel. These methods consisted of 5-point, 7-point and 9-point category scales, a magnitude estimation scale (17) and a 9-point difference-from-control scale (18). Complete details of the procedures and results can be found in CARDELLO, *et al.* (19). In brief, the outcome of these tests was the selection of a 7-point category scale of intensity, of which three of the points had verbal labels, i.e. "1 = slight", "4 = moderate" and "7 = extreme". Since the traditional flavor profile scale  $\{(\text{threshold}, 1 = \text{slight},$



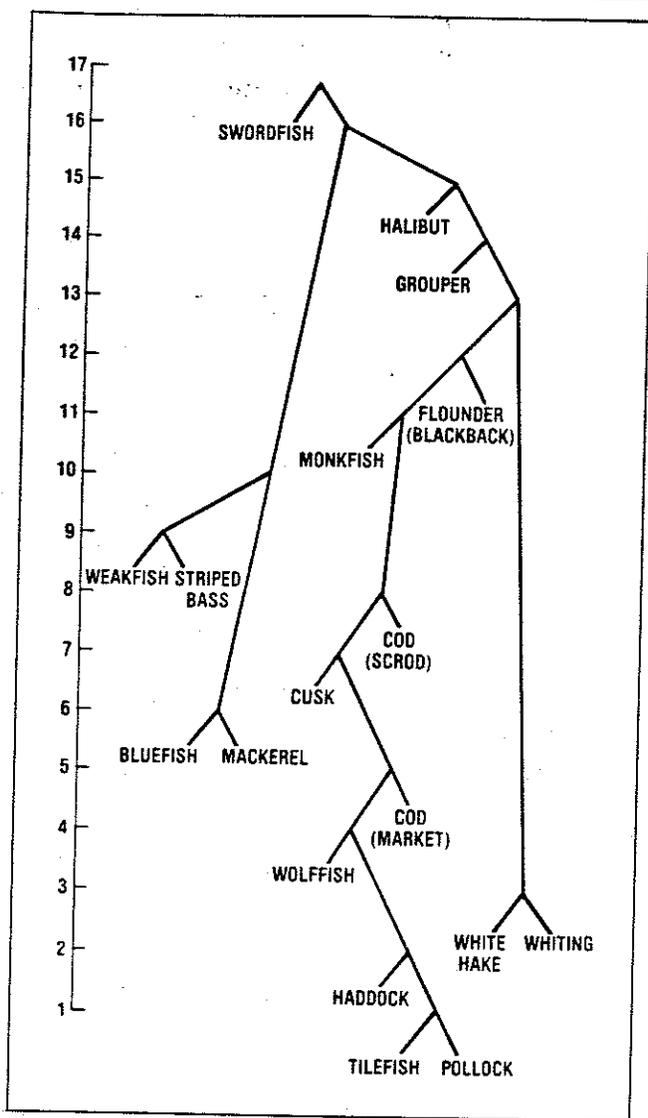


Fig. 2 Tree-diagram depicting the results of the cluster analysis of the data for 17 species of North Atlantic fish

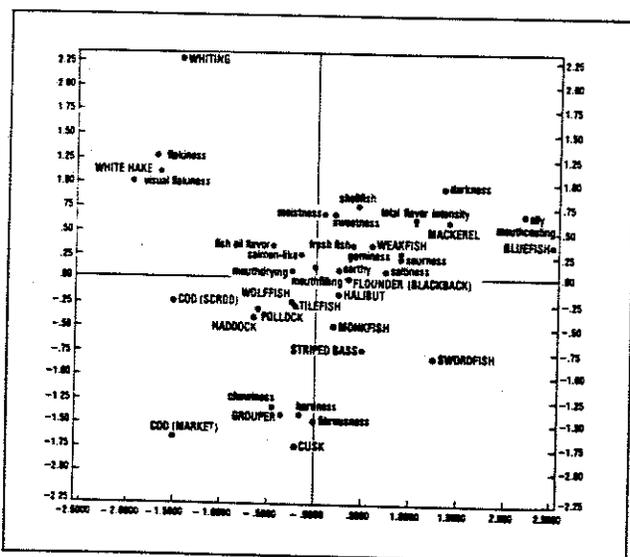


Fig. 3 Two-dimensional solution resulting from the multi-dimensional unfolding of the sensory data for 17 species for North Atlantic fish

attribute in that fish. (Note that certain relationship among data points may be distorted by the necessity to achieve a best representation with lowest dimensionality).

As can be seen in Fig. 3, starting in quadrant I, mackerel and bluefish fall closest to the points labeled "oily mouthcoating", "total flavor intensity" and "darkness", reflecting the high degree of these attributes present in these fish. Weakfish also lies relatively close to these three points, reflecting the fact that it also has a significant degree of these attributes. On the opposite pole of the diagonal axis (in quadrant III) are found the white-fleshed, low-oil fish, such as cod, haddock, pollock, grouper and cusk. Between these extremes are such species as wolffish, tilefish, monkfish and flounder. In the bottom half of quadrant III, a triad of sensory attributes consisting of "hardness", "chewiness", and "fibrousness" can be seen. Falling closest to this triad of sensory variables are the cusk and grouper species, both of which are very firm, chewy and fibrous.

In quadrant II are found the extremely flaky fish - white hake and whiting. Whiting is also extremely soft, forming a polar extreme to the hardness, chewiness, fibrousness triad. Swordfish is well separated from the remainder of the fish, falling in the middle of quadrant IV.

Discussion

The current market confusion in the common names assigned to fish and fisheries products is likely to continue or worsen as more non-traditional species are introduced to the marketplace. Need for the establishment of a standardized nomenclature system for fish and fisheries products is evident, and NMFS's proposed nomenclature system will well serve the fish-consuming public by basing nomenclature on the "edibility" characteristics of the fish, rather than on anatomical differences that have no market relevance.

The sensory methods developed here provide a standardized method for comparing different species of fish on the basis of their sensory characteristics. The descriptive attributes, being selected both on the basis of trained profile evaluations of their importance and for their discriminative usefulness to consumers (16), have practical validity. Similarly, the adoption of a 7-point category scale for establishing sensory profiles is justified on the basis of its simplicity and the reliability studies that were conducted.

Through the use of the above methods, a nationwide data bank on the sensory ("edibility") characteristics of fish can be established. Such a data bank, developed through government and industry cooperation, will enable the grouping of numerous commercial fish species on the basis of these characteristics. Of course, implementation of the new nomenclature system will not end with the establishment of a data bank and groupings. Useful names will still need to be identified, and consumers will need to be educated in the use of the edibility data, so that they can understand the sensory relationships among various species and groups of fish. The two-dimensional "fish map" seen in Fig. 3, can serve as a useful part of this consumer education program. Such a map can easily be made into wall posters and placed in fish markets or supermarkets for use by consumers. Using such a map, consumers could readily perceive the sensory relationships among species of fish. For example, if a consumer knows from prior experience that he/she likes mackerel, then he/she could look at a map (e.g., as shown in Fig. 3) and by observing the proximity of both flounder and weakfish to mackerel, know that both of the former fish were similar in appearance, flavor and texture to mackerel. Although bluefish is a species of moderate cost, weakfish is a non-traditional species of lower cost. Thus, the consumer who wanted

to try a less costly, yet somewhat similar tasting fish to mackerel, could purchase weakfish. In this way, the consumer who may never have tried weakfish previously, could still be confident that it will have similar edibility characteristics to mackerel. Similarly, the consumer who has tried mackerel and does not like its oiliness or its strong flavor would know that he/she should select fish species that are far removed from mackerel in the fish map. If he/she likes very flaky fish, white hake or whiting (quadrant II) would be very good selections. If, on the other hand, he/she prefers firmer, more chewy fish, then cusk, grouper or market-size cod would be better choices.

The successful establishment of a nationwide data bank on the edibility characteristics of fish, coupled with a new nomenclature system for fish and a viable consumer education program, should lead the way to an increased demand for fish and fisheries products. Such increased consumption of fish will serve the nutritional goals of the nation, as well as reduce the cost of this important source of protein by distributing demand for fish over the plentiful, non-traditional species.

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