commercial heading and cleaning machines now available on the market shows them to be very expensive. Preliminary estimates of the cost for building a modified LaPine machine indicate that its selling price should be less.

Plans are underway to test the modified machine under commercial conditions. The unit will be put into a commercial fish processing plant where its efficiency, throughput, and quality of product will be determined.

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MFR PAPER 1234

Development of a Color Measuring System for Minced Fish Blocks

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ABSTRACT—The present interim grade standard for minced fish blocks has three categories of color styles, but it does not include a method for classifying a given block into one of these categories. This report describes a system for color classification. It is based on a reflectance spectrophotometer and Munsell neutral value standards. A set of color pictures is included to visualize what is measured by these Munsell "shades-of-gray" standards.

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The proposed Interim Standards for Grades of Frozen Minced Fish Blocks contain three color classifications: "white", "light", and "dark" (National Marine Fisheries Service, 1975). This is the first seafood grading standard which classifies color into styles. Previous seafood grading standards have included color only as a visual indication of deterioration in quality from the normal appearance of a product. In contrast to other graded seafoods, the normal appearance of freshly prepared minced fish blocks can vary widely. These blocks can be made from virtually all species, ranging from white flesh such as cod to dark flesh such as herring, or from a mixture of species. For some product applications, such as fish sticks or portions, a white appearance is desirable (King, 1973a). For other applications such as mixtures with ground beef, a dark appearance is appropriate (King, 1973b).

Such considerations led to classifying styles of color in the Proposed Interim Standards for Grades of Frozen Minced Fish Blocks. The present document (National Marine Fisheries Service, 1975) states that "color standards will be developed and incorporated in the final regulations." Since its publication, we have examined several methodologies for color classification. They are described in this report.

In present buyer-seller contracts, the appearance (color) of minced fish blocks is determined by mutual agreement, such as by limiting the source material which can be used or by using color photographs or chips. These methods have obvious advantages of flexibility and practicality when used by small groups. Their advantages become difficulties when considering them for a proposed U.S. standard. For example, the proposed interim standards of grades of frozen minced fish blocks is meant to include all source materials from which minced fish blocks might be derived. Color photographs have their disadvantages, such as fading and difficulty of duplicating or replacing an original with a color-correct copy. Color chips or models have been used in grading certain fruits and vegetables, but difficulties in using them or replacing them are being encountered (Agricultural Marketing Service, 1975; Magnuson[1], pers. commun.).

Pictorial color standards have been developed to show frozen beef of acceptable (normal) color and various degrees of brown, dark red, or bleached (whitened) discoloration (Kansas State University, undated). These eleven pictures have been used to visualize beef quality. They are useful in industry since most reflectance spectrophotometers or colorimeters are too unwieldy to use at the several points of frozen beef color evaluation (Kropf et al., 1976). Their usefulness in standardizing color styles is limited. For example, two copies from a single press run were found to have different instrumental tristimulus parameters and sometimes visual differences (Kropf et al., 1976). Further differences in color are expected as copies of these pictorial standards age, but the extent of such changes has not yet been measured.

An instrumental approach to classifying color styles might overcome problems associated with visual judgments. In a series of publications, Little (1969a, 1969b, 1969c, 1972) described an objective method for measuring color characteristics of canned tuna. Her study included measuring variations in instrumental performance against a selected "reference" instrument. It included six instruments and compared three different models against the "reference" instrument. Variations in instrument performance were reconciled by regression analysis techniques, but this method was considered impractical on an industry-wide basis.

Little (1969a) recommended developing material color standards to calibrate each instrument to insure uniform results. These color standards would mimic the color of canned tuna and thus define tuna color in terms of CIE-Y value as determined by tristimulus colorimetry. Although subsequent reports (Little, 1969b, 1969c) describe a chemical treatment for presenting uniformly colored tuna samples to an instrument, the goal of uniform color standards was not achieved. Others have had similar difficulties, for example the Agricultural Marketing Service (1975) and Magnuson (footnote one). The source of these difficulties is related to the chemical dyes used to make such standards. It is possible to make as many sets as desired of a series of uniform color standards when all are based on single mixtures of dyes. However, once these mixtures have been used up, it appears to be impractical to match these sets with another production of color standards.

Difficulties in preparing color standards for instrumental analysis can be avoided by using Munsell neutral value standards. This approach has been used for almost 15 years in the canned tuna standard (Food and Drug Administration, 1962). It requires an optical comparator fitted with a narrow band light filter (550-560 mμ). A sample of canned tuna appears gray when viewed under the specified conditions. Its shade of gray is compared to a Munsell neutral value standard. Each standard's appearance (shade of gray) is identified by a Munsell value between 10 ("pure" white) and 0 ("pure" black). The canned tuna standard defines "white" tuna as not darker than Munsell value 6.3; "light" tuna as not darker than Munsell value 5.3, and "dark" tuna as darker than Munsell value 5.3 (Food and Drug Administration, 1962).

The Munsell neutral value standards described in the canned tuna standard (Food and Drug Administration, 1962) can be replicated uniformly. Each shade of gray is based on page 406 of Newhall et al. (1943) which relates Munsell values to percent magnesium oxide. These standards can be used with reflectance spectrophotometers or with colorimeters. Their "color" does not fade.

The disadvantage of Munsell neutral value standards is that it is difficult to relate a shade of gray to visual appearance of most seafoods. A set of pictorial standards helps one to visualize their appearance even though the pictures lack precision in classifying sample colors, especially those that are close to a previously specified Munsell neutral value.

To illustrate the construction of a color classification system for minced fish blocks, we prepared a series of "white", "light", and "dark" blocks. They were photographed using a "color-correct" process to illustrate a pictorial standard. Their reflectances were measured using Munsell neutral value standards to illustrate objective standards. In this illustration, we also compared frozen, thawed, and cooked samples because each state has advantages and disadvantages for color classification. The frozen state is the normal condition for most uses of fish blocks (e.g., fish sticks and portions). It is also used extensively in grading fish blocks. The thawed state eliminates frost interference with visual or objective measurements, but chemical reactions in a sample during thawing may alter its appearance. The cooked state relates directly to appearance when eaten, but cooking may add a second set of chemical reactions to alter appearance (color) compared to the original frozen state.

The minced fish blocks were made from mixtures of minced cod ("white") and herring ("dark"). The minced cod was prepared by passing skinless cod fillet flesh ("V-cuts") through a meat-bone separator (King, 1973b). The minced herring was prepared similarly from headed and gutted herring. The mixtures were prepared by weighing the cod and herring components, mixing them thoroughly by hand, and forming 16½-pound blocks using conventional molds in a plate freezer. Portions for the thawed and cooked state measurements were sawed from each block, battered and breaded, then frozen-stored from 1 to 5 days until used. The remainder of the block was used for frozen-state measurements. Thawed portions were held at ambient temperature until defrosted. Cooked samples were deep fat fried (King, 1976) using frozen portions. A serrated-blade meat-slicing knife was used to remove batter-breading cover from one side of thawed and cooked portions.

The samples were photographed using Kodak[2] Type L, Ektacolor pro-

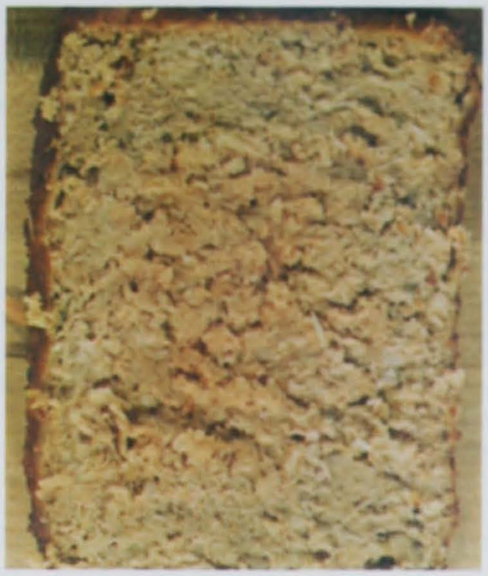
[1] Robert M. Magnuson, Magnuson Engineers, Inc., San Jose, CA 95150. 1974. Pers. commun.

[2] Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

Figure 1.—Color and reflectance measurements on frozen, thawed, and cooked minced fish block samples. Relative reflectance values are based on full scale calibration of spectrophotometer (0 to 90 percent reflectance).

52%

48%



42%

47%

41%

31%

57%

55%

48%

fessional film, 6102 under Tungsten (3200 K) illumination. Kodak neutral test cards (gray side-18 percent reflectance, white side-90 percent reflectance) were included in each exposure. The negatives were developed by a "color-correct" process based on the appearance of these test cards. Frozen samples were tempered to minimize frosting during the photography.

To measure reflectance, we used an Agtron M-400 spectrophotometer with a M-30-A wide area viewer operated in the red mode (640 mμ). The photometer was calibrated with Agtron mineral pigmented polystyrene discs. The appearance (shades of gray) of these calibration discs and their numerical identifications are based on a Munsell neutral value scale from 0 to 10 as described on page 406 of Newhall et al. (1943). For frozen samples, a sheet of 0.003-inch thick Herculene drafting film (Keuffel and Esser No. 19-1153) was placed frosted side down on the viewer underneath the tempered block sample. For thawed and cooked samples, a Meat Stick Adapter (Agtron No. 20519) with a Positioning Ring (Agtron No. 18379) was placed on the viewer. The thawed and cooked samples covered the 3.25- by 3.50-inch opening of this adapter.

Figure 1 illustrates a color classification system for minced fish blocks using pictures and reflectance measurements. It does not include "break-points" to separate "white" versus "light" versus "dark" color styles. Where to set "break-points" is more of a problem for minced fish blocks than for canned tuna. For example, "white" canned tuna is limited to albacore (Food and Drug Administration, 1962). Other species of tuna cannot be made into "white" canned tuna. In contrast, the scope and product description of the present minced fish block standard allows single or mixed species (National Marine Fisheries Service, 1975). A wide variety of species is available for manufacture of minced fish blocks so one can visualize a virtually continuous range of colors from "white" through "light" to "dark".

Setting "break-points" to distinguish color styles in a minced fish block standard involves agreements between producers and users of the blocks and consumers of products made from these blocks. If this report is useful to discussions on where to set these "break-points", it will have achieved its purpose. In the following paragraphs, we illustrate one way color styles might be classified in a grade standard. This illustration includes "break-points" as well as mention of a specific spectrophotometer and measurements based on cooked samples for purposes of discussion between producers, users, and consumers; no final recommendations are implied.

Add new section at end of standard as follows:

278.7 Appendix 1. Definition and method of measuring color classifications cited in section 278.2(b).

Introduction. Although the method described below is based on an Agtron instrument, any make of reflectance spectrophotometer may be used provided that it can be calibrated with neutral value standards based on the Munsell notation system as defined in terms of the CIE (International Commission on Illumination) standard observer and coordinate system for color specification. This method is based on an Agtron M-30-A Wide Area Viewer, a M-31-A Control Console, and its set of calibration discs (Magnuson Engineers, Inc., San Jose, Calif.) merely to simplify the technical description for users of other makes of reflectance spectrophotometers. Although Agtron calibration discs are numbered to approximate reflectance levels based on Munsell neutral value intervals, the description below uses Agtron designations for simplicity. Other calibration standards may be used if they provide equivalent results when used with a suitable reflectance spectrophotometer. Chip or swatch samples based on Munsell notation and percent reflectance for CIE illuminant "C" can be obtained from Munsell Color, Inc., Baltimore, Md., or made as given by the relationship between Munsell value and luminous reflectance derived by a subcommittee of the Optical Society of America and published in the *Journal of the Optical Society of America*, vol. 33, p. 406 (1943).

Sample preparation. The color of the sample must represent the average color of the block when it is cut from that block. At least one of its sides must be large enough and flat enough to completely cover the spectrophotometer's viewing area. It is cooked by the Bake Procedure or by the Deep Fat Frying Procedure as given in *Journal of Official Analytical Chemists*, vol. 59, no. 1, p. 225-226 (1976). If the sample is covered with batter and breading for cooking, this cover is removed with a sharp serrated knife so that the viewing area surface remains flat. The cooked sample must also be thick enough to prevent transmission of external, ambient light into the viewing area of the reflectance spectrophotometer.

Measurement of color. An Agtron or equivalent reflectance spectrophotometer is used. Its light source and filters are designed to view a sample primarily in the red region of the spectrum, at or near 640 nanometers. The viewing area is at least 6 square inches. Its borders are designed to allow placement of calibration discs or fish samples without entrance of external ambient light into the viewing area.

Definition of "white" samples. Calibrate the spectrophotometer to 0 percent reflectance using a number 00 ("black") calibration disc, then to 90 percent using a number 90 ("white") calibration disc. Place a sample on the viewing area and measure its reflectance. Samples from "white" blocks have a relative reflectance greater than 63 percent; but if a particular sample has a relative reflectance between 56 percent and 68 percent, its reflectance is measured again using an expanded scale before defining it as "white". Recalibrate the spectrophotometer using a number 56 calibration disc to set 0 percent reflectance and a number 68 calibration disc to set 100 percent reflectance on its scale. With these calibration settings, a "white" sample is defined as having a greater relative reflectance than a number 63 calibration disc[3].

Definition of "dark" samples. Calibrate the spectrophotometer to 0 percent re-

[3]A number 63 or a number 53 calibration disc is not presently available as standard equipment for the Agtron M-30-A Wide Area Viewer. Number 63 and number 52 calibration discs are presently available for the Agtron M-30A Spectrophotometer. These discs are much smaller (2.5-inch diameter) than the 6.5-inch diameter discs used with the Wide Area Viewer. We are assuming that the larger discs could be manufactured if a demand existed.

flectance using a number 00 ("black") calibration disc, then to 90 percent reflectance using a number 90 ("white") calibration disc. Place a sample on the viewing area and measure its reflectance. Samples from "dark" blocks have a relative reflectance less than 53 percent; but if a particular sample has a relative reflectance between 44 percent and 56 percent, its reflectance is measured again using an expanded scale before defining it as "dark". Recalibrate the spectrophotometer using a number 44 calibration disc to set 0 percent reflectance and a number 56 calibration disc to set 100 percent reflectance on its scale. With these calibration settings, a "dark" sample is defined as having a lower relative reflectance than a number 53 calibration disc (footnote 3).

Definition of "light" samples. If a sample does not satisfy the criteria given above for "white" or "dark" samples, it is classified as "light".

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