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Innovation & Investment

Assessing coloration in channel catfish fillets

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Digital photography method developed to gauge yellowness

In channel catfish fillets, a yellow color is mostly considered an undesirable defect rejected by some markets and has become a concern for the catfish industry.

In the seafood industry, skin and fillet color of fish – together with texture, flavor, and odor – are used as sensory attributes that establish value in seafood markets. Food color is one of its most sensory attributes, as it plays an important role in food quality and affects how consumers evaluate other sensory and non-sensory features. Product color can influence customer acceptability and price, and many food industries – including the seafood industry – consider it an important quality parameter.

Consumers typically pay appreciably more for Atlantic salmon fillets with normal or above-normal red coloration vs. paler salmon fillets in an experimental market of Atlantic salmon. In the channel catfish industry, lightly pink to ivory fillets are considered high quality and preferred by customers, and yellow color is mostly considered an undesirable defect rejected by some markets and has become a concern for the catfish industry. Carotenoids are the pigments responsible for the yellow color in catfish fillets, and xanthophyll is the main class of carotenoids found in catfish fillets.

The food industry has put significant efforts into controlling and standardizing the color of their products because of the importance of color in consumer decisions, and many industries have developed a color standard for food grading. In the seafood industry, the salmon segment is a good example of the use of well-developed grades for both skin and flesh color, using the Roche SalmoFan^{TM} chart. But other seafood segments have not adapted a color standard, including the catfish industry – the leading aquaculture fish industry in the United States – that needs to develop a fillet color standard.

We carried out this study to improve our understanding of the yellow coloration in catfish fillets, and to develop a correlation between yellowness in the color standard and xanthophyll content, and a consistent and unbiased color standard. This article is adapted and summarized from J. Aquatic Food Product Technology, 24:723-729, 2015. We are thankful to Harvest Select (Uniontown, Ala.) and SouthFresh (Eutaw, Ala.) for providing the catfish fillets, and Luke Roy for assistant in taking pictures. This project was supported in part by the Alabama Agriculture Extension Station.

Study setup

The catfish industry classifies discolored fillets as being dark yellow, medium yellow, or light yellow. A sample of 60 catfish fillets was collected directly from the processing line, intentionally selected based on their color variation to represent all three categories.

We used a method developed by Cline (2011) – and proposed as a tool to automate color sorting of fillets – with the CIELAB color space to measure catfish fillet color. The CIELAB values of the fillets in the commercial software were recorded, where L∗ represented lightness, a∗ redness, and b∗ yellowness, and the b∗ value was used to define the yellowness of fillets.

For the extraction and analysis of xanthophyll, we modified a method developed for channel catfish by Liu et al. (2012) and the general procedure described by Rodriguez-Amaya (2001).

The identification of carotenoids was confirmed by comparing their mass measurement and HPLC retention time to those of standard compounds. The total xanthophyll level in the catfish fillets was calculated as the sum of lutein, zeaxanthin, and alloxanthin.

Please refer to the original publication or contact the corresponding author for a detailed description of the techniques and equipment used for measurement of fillet color and xanthophyll analysis, as well as the statistical analyses used in this study.

Fig. 1: Photos of catfish fillets taken by a Canon 40D digital camera in the light box with set configurations and corresponding average colors of the whole fillets after blurred in Adobe Photoshop. The readings below the color cubes were formatted as identification number and CIELAB values.

Results and discussion

The major xanthophyll found in catfish fillets was lutein, followed by zeaxanthin and alloxanthin, and their composition varied in the catfish fillets. Lutein contributed 35 to 82 percent of the total xanthophyll, zeaxanthin 16 to 60 percent, and alloxanthin 0 to 31 percent. Total xanthophyll concentration in catfish fillets varied from 16 to 142 ng/g. No other carotenoid was identified in the catfish fillets studied.

We used the 1976 CIELAB color space to obtain a measurement of the yellow coloration in catfish fillets. This is the most complete color space to describe all the perceivable colors by the human eye, with a wider range than RGB or CMYK color spaces. In addition, a positive b∗ value in CIELAB indicates yellowness – which directly describes the yellow coloration of catfish fillets – should be convenient for the development of automated sorting technologies.

The resulting CIELAB b∗ values of catfish fillets ranged from 15 to 30, and a significant correlation between b∗ values and xanthophyll levels was determined for the catfish fillets studied (Fig. 2). The linear regression equation between b∗ values and xanthophyll levels in catfish fillets was y = 6.65x – 81.85, with an R-square value of 0.646, with the x-values for b∗ and the y-values for xanthophyll concentrations in catfish fillets (ng/g).

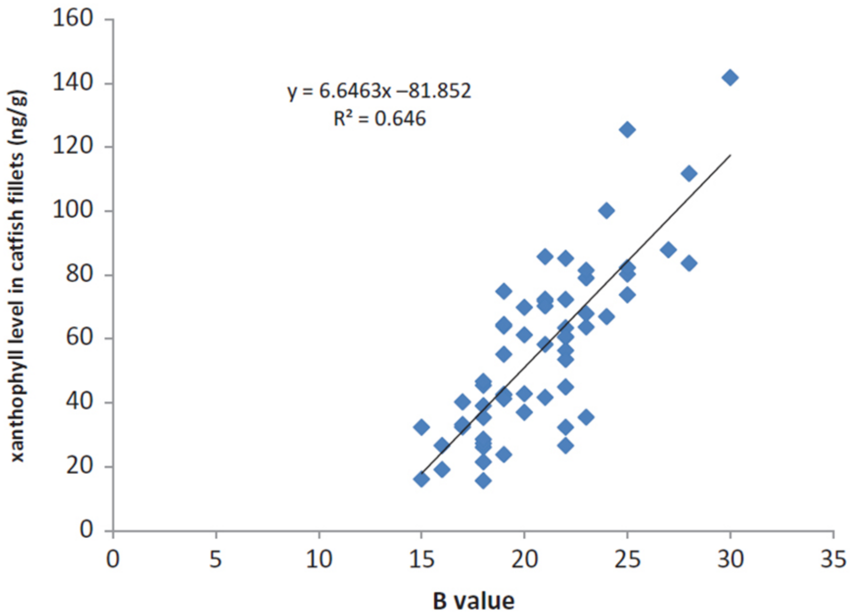

Fig. 2: Relationship determined between CIELAB b∗ values and xanthophyll levels in the catfish fillets studied.

A group of pigments called xanthophylls gives its yellow coloration to catfish flesh, with lutein and zeaxanthin as the major xanthophylls in channel catfish. We also identified alloxanthin in catfish fillets, together with lutein and zeaxanthin, in our study. Up to 31.5 percent of the total xanthophyll in the 60 catfish fillets was contributed by alloxanthin, one of the principal xanthophyll in the fillets of channel catfish.

We found that using the total xanthophyll (the sum of lutein, zeaxanthin, and alloxanthin) produced a better indication of the yellowness of catfish fillets. The correlation between xanthophyll (the sum of lutein and zeaxanthin) and b∗ values (R-square = 0.60) was weaker than that between b∗ values and xanthophyll as a sum of all the three pigments (R-square = 0.65).

There was a positive linear relationship between xanthophyll levels and CIELAB b∗ values of the catfish fillets. This result is associated with the fact that all three main xanthophylls in catfish fillets are yellow in color. For a fast estimate of the xanthophyll levels based on the b∗ values, the linear equation in Fig. 2 could be used.

Perspectives

This study developed a consistent and unbiased color standard. To warrant the accuracy of this color standard, we used a specific photograph configuration and color calibration software. We developed a correlation between the xanthophyll contents in catfish flesh and the b* values, which could be used for a swift estimation of the xanthophyll content.

The development of this color standard allows the sorting of fillets into different categories for different markets, and supports the standardization of quality in the catfish industry. Catfish fillet grades based on consumer preference can be established using this color standard, which helps support color management practices and product quality assurance.

References available from corresponding author.

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