Salmon Color and the Consumer

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Abstract: It is generally accepted that the color of salmon products is one of the most important quality parameters. Therefore, color plays a decisive role when evaluating the quality of the product at point-of-sale. The colors resulting from the deposition of carotenoids are considered to be of significant behavioral importance to animals. However, in addition to their coloration properties, the carotenoids have major biological functions. The species-specific pink flesh color provided only by astaxanthin has always been associated with salmonids and has differentiated the salmonids from other fish species. Studies have shown that when it comes to making purchasing decisions about salmon, consumers have stated that color is very important. Consumers perceive that redder salmon is equated to these characteristics: fresher, better flavor, higher quality and higher price.

Keywords: salmon, coloration, carotenoids, consumer color preference

1. CAROTENOIDS IN FISH

Coloration plays a role in social structure as well as defence of fish in the wild. Fish depend a great deal on vision as a source of sensory information. All but a few species (mainly cave dwellers) have well-developed eyes. As is the case in many other groups of animals, the body colors of fish are predominantly dependent on the presence of special cells in the skin, called chromatophores. These contain pigments or light-scattering or light-reflecting organelles. In biology, any substance that can impart color to the tissues or cells of animals or plants can be called a pigment.

There are four main groups of pigments that can be used to provide color in these cells: melanins, carotenoids, pteridines, and purines. Melanins are responsible for the dark coloration seen in fishes. Carotenoids, which are lipid soluble, dominate in giving the yellow to red colors. Pteridines are water-soluble compounds and result in bright coloration like the carotenoids. Pteridines play a small role in coloration when compared to carotenoids. In the purine compounds, guanine predominates, and large amounts of guanine can be found in the silvery belly skin of most species of fish. These basic compounds can be combined with other components, like proteins, to produce the blue, violet, and green color ranges seen in fishes. In the flesh (muscle), the carotenoids are the dominant pigment. In lobsters and shrimps, astaxanthin is attached to a protein to produce the carotenoprotein, crustacyanin. This carotenoprotein imparts a blue color in living Crustacea; in the presence of heat the carotenoprotein molecule is cleaved, which subsequently results in the characteristic astaxanthin red color of cooked lobsters and shrimps.

"Carotenoid" is the generic name for one of the most common groups of naturally occurring pigments found in the animal and plant kingdoms. To date, over 600 carotenoids have been identified in nature, varying in color from yellow to red. Most carotenoids are polyunsaturated hydrocarbons, containing 40 carbon atoms, and comprising two terminal ring systems. Carotenoids that are composed entirely of carbon and hydrogen are known as carotenes, while those that contain oxygen are termed xanthophylls. Carotenoids are the major pigmenting compounds and cannot typically be synthesized by fish. In contrast, most other pigmenting compounds can be made by the fish.

Carotenoids are used in aquaculture feeds to provide the color associated with consumer products, such as the bright vibrant colors of ornamental fish. The same carotenoid, astaxanthin, found in wild salmon is used in aquafeeds to impart this natural, pink-red color to farmed salmon fillets. Color matters, particularly in regards to consumer preference for aquaculture products.

As is the case with other carotenoids, salmonids cannot endogenously synthesize astaxanthin; therefore, it must be supplemented in the fish's ration. Research also indicates additional benefits from dietary carotenoids beyond the resulting coloration. Astaxanthin, for example, has biological functions related to growth, reproduction and tissue health in salmonids and shrimp, possibly due to the compound's strong antioxidant properties (Bell et al., 2000).

Only a small number of plants and micro-organisms can synthesize carotenoids. Higher animals, including fish, cannot produce the carotenoids themselves and are reliant upon a dietary source. They absorb the carotenoids from the feed and deposit them in their tissues.

Astaxanthin is the pigment that provides salmon flesh with its characteristic rich pink-red color. Astaxanthin accounts for more than 90% of the total carotenoid content found in the flesh of wild salmonids (salmon and trout). In the wild, salmonids absorb astaxanthin from the crustaceans they eat. The absorbed carotenoid is then transported in the blood to the muscles and skin where it is deposited.

In other fishes and to a limited extent in salmonids, additional carotenoid compounds are the source of other bright colors. Research results indicate that tunaxanthin is a rather common pigment in marine fish. This carotenoid is especially abundant in yellow-colored fishes. Astaxanthin, by contrast, seems to be dominant in red marine fish. Lutein is also widely found in many marine species. Carotenoids commonly occurring in freshwater fish include beta-carotene, lutein, taraxanthin, astaxanthin, tunaxanthin, alpha-, beta-doradexanthins, and zeaxanthin.

1.1 Additional functions of carotenoids

The colors resulting from the deposition of carotenoids are considered to be of significant behavioral importance to the animal. However, in addition to their coloration properties, the carotenoids have major biological functions. Recent research suggests that astaxanthin plays an important role in salmonid growth and health (Christiansen et al., 1995). Astaxanthin has also been shown to increase the survival of crustaceans (Chien and Jeng, 1992; Nègre-Sadargues et al., 1993). It has been suggested that *Penaeus semisulcatus*, requires astaxanthin and not retinol, per se (Dall, 1995). Yet, it is important to stress that carotenoids do not replace the requirement for vitamin A in fish diets.

The mobilisation of carotenoids, and their transport from the flesh to the skin and ovaries during maturation has led to the hypotheses that carotenoids have a function in reproduction. Possible carotenoid functions included: a fertilisation hormone, a source of pigments for chromatophores, a function in cellular respiration, protection from light, resistance to elevated temperature and ammonia, and as provitamin A.

Carotenoids also have excellent antioxidative characteristics. Cold-water fishes, like salmon, have a high level of polyunsaturated fat in their membranes, and protection of lipid tissue from peroxidation seems to be a metabolic function for astaxanthin (Bell et al., 2000). Astaxanthin has been shown to be one hundred times more effective than vitamin E as an antioxidant (Miki, 1991).

2. HOW IS THE COLOR OF SALMON FLESH MEASURED?

When it comes to the objective measurement of color, electronic instruments may be used. These instruments use three elements to define color: a* value - red/green; b* value - yellow/blue; and L* value – lightness. Other important calculated values are the Hue (H*) and Chroma (C*) (or the intensity or clarity (saturation) of a color). These five elements, visualized in three dimensions (Figure 1), are used to objectively define all colors.

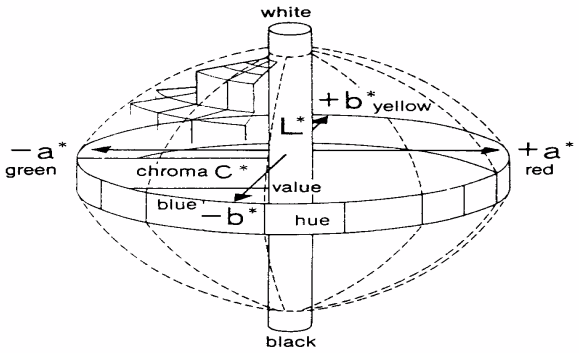

Figure 1. Three-dimensional color wheel.

For the "everyday" color assessment of salmonid flesh, the Roche *Salmo*Fan™ (Figure 2) is the internationally recognized method for color measurement.

Figure 2. The Roche *Salmo*Fan™

Color matching is preferably carried out in North facing daylight. This is not usually possible in processing plants and therefore to ensure consistent color assessment, fluorescent light conditions within a controlled environment are often preferred. For this purpose its is recommended that color cabinets are used.

When it come to salmon flesh, astaxanthin results in a redder hue than canthaxanthin at equal flesh concentrations. In addition to color, stability of the pigment in the flesh is very important. The astaxanthin molecule has two bonding locations in the muscle, where canthaxanthin only has one. This results in increased stability of pigment and color of astaxanthin over canthaxanthin. This stability is especially important during further processing of fish flesh such as smoking and freezing.

3. CONSUMERS PERCEPTION ABOUT SALMON AND ITS COLOR

It is generally accepted that the color of salmon products is one of the most important quality parameters. Therefore, color plays a decisive role when evaluating the quality of the product at point-of-sale. The species-specific pink flesh color provided only by astaxanthin has always been associated with salmonids and has differentiated the salmonids from other fish species. Studies have shown that when it comes to making purchasing decisions about salmon, consumers have stated that color is very important.

Focus groups, three in Seattle and three in Boston, were held with consumers who consumed salmon an average of once per month. When asked about salmon the top-of-the-mind associations are: rich taste, nice texture, color, equated to red meets, and versatile.

When purchasing salmon, color is one of the first things a consumer will consider. To a consumer, color indicates: species, age, origin, price, expected flavor/texture, freshness and quality. But an over-riding concern is that the consumer needs to have confidence in the store where they shop.

When the focus groups were shown pictures representing different levels of coloration, a 33 (on the *Salmo*Fan™) was preferred by a 2:1 margin. This research suggest a gap in the market place, as most retailers feel they receive salmon of a score of 27 on the *Salmo*Fan™ and consumers indicate they prefer a color of 33.

Consumers perceive that redder salmon is equated to these characteristics: fresher, better flavor, higher quality and higher price. Even though color does not impact on these characteristics. When asked about pricing, consumers felt that a salmon with a color of 22-24 should be less expensive and a well colored salmon, 33-34, would be the most expensive.

4. CONCLUSIONS

Astaxanthin is the major carotenoid responsible for the pink-red pigmentation of fish and crustaceans. Aquatic animals cannot synthesize astaxanthin and therefore it must be supplemented in the diet. As well as being a pigment, astaxanthin has been shown to have other biological and nutritional functions essential for fish growth and health.

Consumer research has suggested that consumers will pay more for redder salmon, acknowledging that a redder salmon commands a premium price. Yet, there is an over-riding need to present salmon in the most appealing fashion. Color is key to consumer purchasing decisions.

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