Nutrition and changes in fish body colouration in catfish

by Dong Qiufen, Yang Yong and Su Shi

Environment and physico-chemical factors influence fish skin and flesh colouration and dietary manipulation can overcome abnormal colouration.

In recent years, changes in body colour have been more frequently observed in many Asian farmed fish species. The colouration of the marine fish, Japanese flounder *Paralichthys olivaceus*, red snappers *Lutianus* spp and large mouth sea bass *Micropterus salmoides* may change to white or black from natural body colour. Some scaly freshwater fish, black carp, grass carp, common carp and black tilapia often show abnormal white, black or yellow colouration. The biggest worry for freshwater catfish farmers is a banana colouration in *Clarias fuscus* and *Pelteobagrus fulvidraco* and totally white or yellow colouration in *Ictalurus punctatus*, *Ameiurus nebulosus*, *Silurus asotus* and *Leiocassis longirostris*.

Fish with abnormal body colouration may fetch lower market prices, reducing profit margins of farmers. This article discusses the reasons leading to changes in fish body colouration and regulation of skin colour through nutrition.

Physiological basis for colour change

There are two chromatophore cell bands located in fish skin. More of these aggregate between the epidermis and the dermis, and less are found between the dermis and the muscle. Chromatophore cells in fish can be classified into six types according to colour: melanophores (black), xanthophores (yellow), erythrophores (red) iridophores (iridescent, blue, silvery white and golden yellow), leucophore (white and offwhite) and cyanophore (blue). With different distribution and quantities, these cells allow the fish to exhibit different body colouration and patterns.

Based on the chemical structure and composition, the pigments in the fish skin and muscle are known as carotenoid, bile pigment, benzoquinone, melanin, pteridine and others. Carotenoids and melanins are responsible for the catfish body colour expression. Through nervous system and hormonal control, the pigment granules of the chromatophore cells in fish body can be transported swiftly by kinesin giving rise to dark colouration and by cytoplasmic dynein to aggregate, leading to light colouration in microtubules.

Factors influencing body colouration

Environment

Temperature influences carotenoid deposition and is important in fish ingestion, metabolism and growth. From an experiment with the glass eel, we know that chromocytes move slower at low than at high temperatures. Illumination makes the fish adapt their colouration according to that of the environment. When fish are stocked at high density their body colour will darken. The colour of water can also affect fish body colour, and pollutants in the water can destroy the nervous system and lead to colour variation. When cultured in water with low dissolved oxygen and high ammonia nitrogen, the flesh of the pangasius can easily turn yellow. Changes in salinity will change fish body colouration.

Physiology

Inherited characters determine the way pigments are deposited. Different individuals in the same rainbow trout population show different deposition abilities. In addition, fish age, size, physical conditions, internal neuroendocrine and paracrine systems, and androgenic hormones are factors influencing pigment deposition.

Nutrition

The pigments in feed are important for fish body colour expression, and adding commercial colourants into the feed artificially can influence colouration. With low quantity and bad quality of fat and premix in the diet, the pigment granules in the fish body cannot be transported and absorbed normally. Protein quality is also an important factor, in particular the non-protein nitrogen (NPN).

Regulation of body colour through nutrition

Pigment sources

Pigments in the fish come from feed ingredients and commercial colourants as well as natural sources. There are rich xanthophylls in corn-based raw ingredients (corn with 15~25 mg/kg, corn gluten powder with 130~290 mg/kg, DDGS with 10.6~34 mg/kg) and the yellow pigment can be seen with the naked eye when the amount reaches 11mg/kg in the catfish. This is the cut off level for fillet value.

In China, the careless use of corn-based ingredients in tilapia feed often makes the fish skin and muscle colour yellow. However, for some other catfish, such as yellow catfish and white spotted freshwater catfish, some

Catfish Pelteobagrus fulvidraco. Normal (A) and various abnormal colouration (B,C,D) due to nutrition.

Catfish Ictalurus punctatus. Normal (A) and various abnormal colouration (B,C) due to nutrition. (D) Normal colour (white) and abnormal (Yellow) flesh

commercial colourants are used artificially to improve its economic value and cater to the market and consumer demand.

Some research results showed that the rainbow trout muscle was yellow from the carotenoid in natural food (algae with yellow pigments ingested by fish) but not from dietary intake from feed. Farmed sea bass showed yellow and red muscle tissue following daily feeding of shrimp and crab. It is necessary to monitor water quality to control the transparency, salinity, dissolved oxygen, ammonia nitrogen and the blue-green algae to avoid abnormal skin and muscle colour change.

The quantity and quality of fat

The fat content in the feed influences pigment absorption, transportation and deposition in the fish cells. Almost all farmed fish need fat soluble carotenoids, to express body colouration. Fish cannot synthesize carotenoids internally and must assimilate them from the feed ingredients, such as corn gluten meal, cottonseed meal, rapeseed meal and some others with high carotenoid content. A shortage of fat not only influence growth rate, but also affects the absorption of the pigment materials especially the carotenoid in fish gut (enteron) and optimal fat content can ensure a good absorption of pigments. The carotenoid deposition efficiency in the fish chromatophore cells and muscle is directly correlated with the adipose cells and fat deposition level in the fish. Lipid sources from soybean oil, rapeseed oil, pork oil or fish oil without oxidation with a level no less than 5% in the feed shows good pigment absorption in fish such as *Clarias leather*, rice field eel, loach, yellow catfish and ornamental fish with high level carotenoid content.

Fat quality decreases with oxidation. In the fish body, oxidised fat can generate more oxygen free radicals and some other free radicals. This causes fragmentation of the unsaturated bond in the carotenoids,

Tilapia. Normal (A), abnormal (B) skin colour of tilapia. C. Normal colour (white) and abnormal colour (yellow) in tilapia flesh

allowing it to lose pigment function and lead to fish body colour degeneration. On the other hand, oxidised fat also affects physiological functions. Chromatophore cells especially melanophores will not differentiate, grow and mature normally and decrease notably in the skin and scale with lower density. The result is that farmed fish show white or yellow colouration. Thus it is prudent to avoid oxidised lipid sources, in the feeds for fish with changeable body colouration such as yellow catfish, *Clarias leather*, blunt-snout bream, black carp, tilapia and pangasius.

Antioxidants

Many anti-nutrient factors in the plant ingredients, soybean meal/cake, rapeseed meal/cake, can influence the fish to make use of the nutritive materials in the feed. Adding enough antioxidant in the ingredients and feed products can prevent the carotenoid from oxidation with lipoxygenase and prevent fat oxidation and body colour change.

Premix

Vitamins act as coenzymes to facilitate chemical reactions in fish metabolism to ensure the normal cell structure and function of the tissues and organs, and maintain good health condition and biophysical activities. Research reported that Vitamin A and Vitamin E can improve carotenoid absorption but we should ensure that the vitamins perform their nutritive functions in a holistic manner.

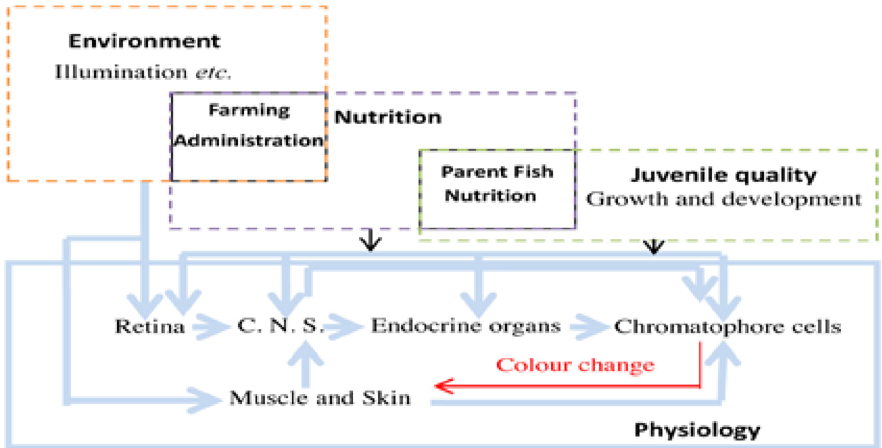
Taking into consideration fish body colouration, the requisite amount of 13 types of vitamins should be set as the basis for premixes and feed formulations to maintain a holistic biophysical function and to keep the normal fish colouration. This is also a nutritional technique in aquaculture health management. Some fish, *Clarias leather* and yellow catfish, can show normal body colour when fed with pelleted feed. In contrast, they show 'banana colour' when fed with extruded feed with the same feed formulation, as the high temperature during the extrusion destroys some of the vitamins. In turn, this reduces the number of melanophores and affects body colouration.

When developing the premix formulation for farmed fish, normally it is suggested to increase the vitamin volume at 30% to ensure good fish body colour and body surface mucus remains in normal physiological status. Increasing vitamin supplements is a good way to recover the farmed fish body colour when the colour is abnormal.

Mineral substances act as coenzymes in the regulation metabolism in the fish to maintain the normal functions and metabolisable actions of chromatophore cells. As mineral elements can influence the fish body colour by osmotic pressure, we should try to avoid high salt content in fish feed.

Catfish should be fed with feeds with a premix formulation different from fish with scales, as the latter have different requirements for vitamins and trace elements, iron, copper, manganese, zinc, etc.


Pangasius catfish. A. Normal skin colour. B. Varying flesh colour with increasing value from left: yellow, pink and white.



Pathway controlling fish colour

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