AMERICAN JOURNAL OF AQUACULTURE AND ANIMAL SCIENCE (AJAAS)

VOLUME 1 ISSUE 1 (2022)

Indexed in

PUBLISHED BY: E-PALLI, DELAWARE, USA

American Journal of Aquaculture and Animal Science (AJAAS)

Volume 1 Issue 1, Year 2022
ISSN: 2835-8945 (Online)
DOI: https://doi.org/10.54536/ajaas.v1i1.851
https://journals.e-palli.com/home/index.php/ajaas

Melanin: Definition, Cause and its Role in Atlantic Salmon- A Review

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Article Information

Received: October 29, 2022

Accepted: October 30, 2022

Published: November 07, 2022

Keywords

Melanin, Pigmentation, Fillet, Atlantic Salmon, Loss of Production

ABSTRACT

Atlantic salmon (*Salmo salar* L) is the major important species in salmonid families. But for the disease issue, farmers are losing a large number of fish and income. Melanin in fillet is one cause for the loss of the processing industries. The cause of melanin spot are related to the use of vaccines containing oil adjuvants (Fagerland *et al*., 2013), but other factors such as environmental conditions, genetics and diseases (Bjerkeng, 2000) also appear to play a role. The pigmentary and the immune systems are related each other. Larsen *et al.* (2012) reported that the melanogenesis occurs in muscle-located granulomas, which represents an association between the immune and pigmentary systems. Melanin spot in fish fillet or organs create many problems to farmers and processing industries. Consumers do not prefer spotted fillet so processing industries need to cut off the defected part of the fillet, as a result, they face some loss in their product production. Addition of Vitamin C, E and selenium in feed can contribute to reduce the number and size of the melanin spot (Wang, 2016).

INTRODUCTION

Atlantic salmon (*Salmo salar* L) is the major important species in salmonid families. Norway, Chile, UK, Canada are the major countries in world to the salmon farming and production. Among them, Norway ranks at top to produce and export of Atlantic salmon (NSC, 2017). Norway's long shoreline and cold, clean seawater provides excellent conditions for aquaculture activities of salmonids. But for the disease issue, farmers are losing a large amount of fish and income and Norway losing huge amounts of foreign exchanges.

A successful salmon culture depends on various factors such as fry quality, water and soil quality, culture method, vaccination, feed quality and regime, operation management etc. There is increasing salmon processing industries in world. Consumers choice deep pink coloured flesh as it appears fresh and healthful. Melanin spot in fillet is a major issue for processing industries. Malanin spot is occurring in salmon flesh due to vaccination, diseases, genetical or other factors. Industries loss high economics as they need to deduct the melanin- localized parts and sometimes they throw away the whole fillet. Mackintosh (2001) mentioned that dark pigmentation appears normally in fillet, visceral organs and peritoneum of ectothermic vertebrates. The dark spot of melanin occurs in the frontal part of the fillet compared to other parts of the fillet (Mathiassen *et al*., 2007). Sommerset *et al.* (2005) suggested that melanin can occur at sites of injury or infection as the melanin and its quinine precursors have anti- infection properties. Koeteng (1992) stated that the appearance of melanin in fillet indicates a serious quality damage compared to other food products where melanin is added as a healthy food supplement (NPS, 2013). In this mini- review document, we will observe about the cause of melanin deposition in salmon, and its role in the Atlantic salmon.

Melanin

Any of a set of polymers, derived from the amino acid tyrosine that cause pigmentation of eyes, skin, and hair in vertebrates (Figure. 1). The term "melanin" is a purely descriptive one, which simply denotes a black pigment of biological origin (Swan, 1974). Melanin is produced by specialized epidermal cells called melanophores (or melanocytes); their dispersion in these cells is controlled by melanocyte- stimulating hormone and melatonin. There are three basic types of melanin: eumelanin, pheomelanin, and neuromelanin but only eumelanin has been identified in teleosts (Adachi *et al*., 2005). Eumelanin is the most common type and it is either brown or black (Hearing & Tsukamoto, 1991). It is primarily a light-absorbing pigment (Leclercq *et al*., 2010). The melanin spots are commonly 1- 4 cm of diameter, but they may also be large (Norsk Fiskeoppdrett, 2008).

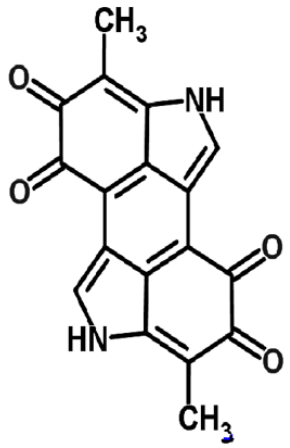

Figure 1: Melanin [Systematic name: 3, 8- Dimethyl- 2, 7 dihydrobenzo (1, 7) isoindolo (6, 5, 4- cd) indole- 4, 5, 9, 10- tetrone; Molecular Formula: C18H10N2O4] (World of Chemicals, 2022)

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Cause of melanin formation in salmon

The synthesis of melanin occurs through enzymes encoded by the tyrosinase gene family, of which Dopachrome tautomerase (Dct) is considered to be melanocyte specific (Slominski *et al.*, 2004). In Atlantic salmon, these genes are expressed in secondary lymphatic organs, where melanin-containing cells, termed melanomacrophages, reside (Mackintosh J.A., 2001). Expression of the tyrosinase gene family occurs in melanomacrophages during chronic inflammation of Atlantic salmon, indicating a de novo melanin synthesis (Larsen *et al.*, 2012). Histological investigations of pigmented muscle lesions show that they are dominated by inflammation and pigmented cells (Figure. 2) (Larsen *et al.*, 2012; Koppang *et al.*, 2005), regularly termed 'melanomacrophages' in piscine morphological characterization (Agius & Roberts, 2003).

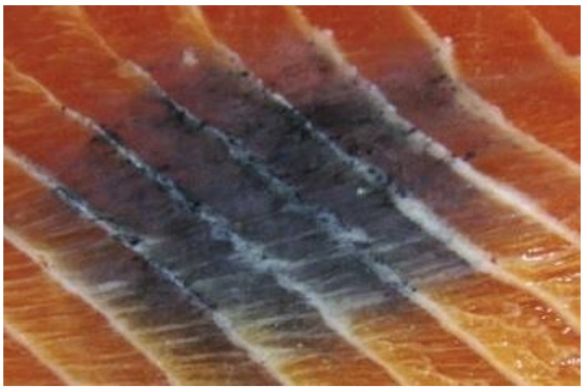

Figure 2: Melanin spot in fillet (Larsen *et al.*, 2012)

The cause of melanin spot are related to the use of vaccines containing oil adjuvants (Fagerland *et al.*, 2013), but other factors such as environmental conditions, genetics and diseases (Bjerkeng, 2000) also appear to play a role.

Koppang *et al.* (2005) reported that melanin spot in fillet were seen as a result of vaccination. Koppang *et al.* (2010) stated that melanization of the abdominal wall is linked to vaccination. They also observed that the intensity of melanization also depends on the quality of vaccination such as injection point and penetration depth. Another study discovered that there is no significant difference of melanin spot deposition in vaccinated and unvaccinated salmon (Berg *et al.*, 2012). Hossain K Z (2015) found that there is no significant difference in the melanin in fillet means score between the sampled vaccinated and unvaccinated salmon.

There is a clear association between temperature and fish size at vaccination, and side effects like abdominal adhesions and melanization, where smaller size and higher temperature increases the risk of such side effects (Berg *et al.*, 2006; Grini *et al.*, 2011). Barton *et al.* (2000) observed that fish exposed to stressors such as water quality variation and handling during the production, were more prone to exhibit menlanosis.

Different diseases such as Pancreatic Disease (PD), Heart Skeletal Muscle Inflammation (HSMI), Cardiomyopathy Syndrome (CMS) can also lead to form melanosis in salmon. Bjerkeng (2004) found that PD influences dark pigmentation in salmon fillet. Bjørgen *et al.* (2015) discovered that dark pigmentation in salmon tissues containing Piscine orthoreovirus (PRV) which create HSMI disease in salmonid. Fagerland *et al.* (2013) observed a link between black discoloration and processes of repair and scar tissue formation from the heart of salmon suffering from CMS disease.

Role of melanin in immunization

The pigmentary and the immune systems are related each other. Larsen *et al.* (2012) reported that the melanogenesis occurs in muscle-located granulomas, which represents an association between the immune and pigmentary systems.

Burkhart C. G. & Burkhart C. N. (2005) discovered that the melanin producing leukocytes in salmon represents that melanin has active role in inflammation in fish and the melanin has a role in immune functions such as antimicrobial defense and the immune modulation is exerted by the pigmentary system. Melanocytes respond to cytokines, including interferons, interleukins and tumor necrosis factor (Slominski A. *et al.*, 2004).

Meredith and Sana (2006) found that melanin is photoprotective pigment. Melanin is considered a powerful protector against UVR and HEV (High Energy Visible) light. Melanin is a powerful antioxidant and an anti-secretory agent acts against excessive secretion of acids in the stomach (Mørkøre *et al.*, 2013). Melanin also protects against parasites (NPS, 2013).

Erlend Haugarvoll (2008) observed that melanomacrophages in salmon produce their own melanin. It has been assumed that they play an important role in the defence of fish against microbes (Norwegian School of Veterinary Science, 2008).

Impacts of Melanin in Salmon

Melanin spot in fish fillet or organs create many problems to farmers and processing industries. Consumers do not prefer spotted fillet so processing industries need to cut off the defected part of the fillet, as a result, they face some loss in their product production. Large amount of discarded fillets also cause loss to farms and the economy of the nation.

Berg *et al.* (2012) and Koeteng (1992) reported that melanin spots in fillet, organs are quality deviations during the secondary processing and it represents a critical quality problem (Figure. 3)

Although melanin is a natural ingredient for many types of food and create no side- effects from the food (FAO, 2013) but consumers do not accept discoloured or spotted fish fillet as a quality product (Mathiassen *et al.*, 2007). Melanin spot do not disappear even by the smoking process and they create a big cosmetic problem (Norsk Fiskeoppdrett, 2008).

The processing industries treat the defected part of the fillet or they remove the affected part or just thrown out the fillet, as a result, the quality of the product downgrades. Thus, it results a great economic loss to the producers and

Figure 3: A comparative picture between a healthy fillet and a melanin deposited fillet of Atlantic salmon (Larsen *et al*., 2012)

the extra labour cost is also a problem for the industry (Mathiassen *et al*., 2007; Kiessling *et al*., 2006).

This issue exists in most salmon farming countries like Norway, Denmark, UK, Ireland, USA, Canada, Chile. The problem costs to the Norwegian fish processing industries around one hundred million Euros per year (Risbråthe, 2015).

It was reported that approximately 30% and 20 % salmon fillet with melanin spot were found in the fish processing industries in 2006 and 2007 respectively (Thorsen, 2006; Mathiassen *et al*., 2007). FAO (2013) reported that approximately 2% of dark melanin spot in fillet with a diameter bigger than 3 cm were observed in 2013.

To solve the problem of melanin deposition in fillet, scientists are trying to find out many ways such as adding vitamins and antioxidant in feed, safe and side- effect free vaccine, safe biosecurity parameters etc. Addition of Vitamin C, E and selenium in feed can contribute to reduce the number and size of the melanin spot (Wang, 2016). Vit E in feed can sustain the oxidative stability in tissue and prevent discoloration related to lipid peroxidation (Peng *et al*., 2009; Sahoo & Mukherjee, 2002).

CONCLUSION

As melanin spot in flesh is seen as a defect and low quality, it needs to find out a complete solution to prevent the creation of the melanin in Atlantic salmon. All kinds of stakeholders and researchers need more work to discover the method to produce fresh, healthy and melanin-free Atlantic salmon.

Conflicts of Interests

Author declares there are no conflicts of interests.

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