

THE ROLE OF FEED ADDITIVES IN ENSURING OPTIMAL FISH FILLET QUALITY

Strategies to maintain the healthy image of fish consumption

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Consumption of fish can provide several health benefits. Fish fillet is an excellent source of high-quality protein, and essential for building and repairing tissues in the body. Additionally, fish, especially fatty fish like salmon and mackerel, are rich in omega-3 fatty acids. Omega-3 fatty acids support heart health, reduce inflammation, and may improve brain function. Fish fillet is low in saturated fat and calories, making it a nutritious choice for weight management. Additionally, they are packed with vitamins and minerals such as vitamin D, vitamin B12, selenium, and iodine, which contribute to overall well-being. However, with the increased production of aquatic species, challenges to maintain the healthy image of fish fillet occur.

Factors that decrease the quality of fish fillet

Whilst the benefits of eating fish are clear, the issues with decreasing fillet quality are threatening the healthy image of fish consumption. Decreased fillet quality is caused by a wide range of factors. The first and clear one is poor handling, storage and processing methods. Improper handling and storage of fish after harvest can lead to bacterial growth and spoilage, resulting in lower quality flesh, whilst using the wrong processing methods, such as improper filleting, excessive freezing, or inadequate packaging, can affect the texture, flavor, and overall quality of the fish flesh. Temperature control and proper hygiene practices are crucial in maintaining the freshness and quality of fish.

Secondly, the fish diet and living environment of the fish can impact the quality of their flesh. Fish that are raised in overcrowded or polluted environments, or fed a diet that lacks essential nutrients, may have lower-quality flesh, sensory and nutritionally. Next to that, fish can accumulate contaminants such as heavy metals and environmental pollutants from their habitat. Consuming fish with high levels of contaminants can impact the quality and safety of the fillet. Feed additives can play a vital role in ensuring that the quality of seafood stays at a high level. The goal of this article is to discuss some of these additives and explain how these can have a beneficial effect on seafood quality.



Selenium is an essential trace mineral that plays a vital role in the overall health and productivity of fish

Selenium – important for animal health and fillet quality

Selenium is an essential trace mineral that plays a vital role in the overall health and productivity of fish. It plays an important role in the antioxidant and immune system, protecting fish's cellular metabolism from oxidative stress, and reducing the risk of diseases. Selenium is, therefore, crucial for maintaining proper growth, reproduction, and overall resilience in aquatic environments. In humans, selenium is of equal importance. Selenium deficiencies in humans can lead to various health issues, such as weakened immune function, increased susceptibility to infections, and potential complications in thyroid function, as selenium is essential for the production of thyroid hormones. Traditionally seafood is a good source of selenium, but recently some issues with the selenium content of fish have risen.

Fishmeal and fish oil are known to contain high levels of selenium. Previously aquaculture practices used a lot of fishmeal and fish oil in their diets. However, these sources are limited, expensive and less sustainable. To maintain the growing aquaculture production, the industry was forced to look into other protein and fat sources such as plant materials. However, one of the issues with plant materials is that they often contain lower selenium levels. Since fish are adapted to high levels of selenium in the wild, their requirement is higher than terrestrial animals. So, with the change towards diets with less marine ingredients and more plant-based ingredients, selenium deficiencies occur. This causes decreased performance and health in the fish themselves, but it has a consequence for humans as well.

Since less selenium, in the form of L-selenomethionine, is in the diet, less selenium is stored in the animal protein, causing less healthy fish fillets (Figure 1; Betancor et al., 2006).

Selenium addition is thus a necessity in aquaculture, but a wide variety of available selenium sources exist. Selenium can be added in organic form, such as selenocysteine or L-selenomethionine, or inorganic form, such as sodium selenite. The addition of L-selenomethionine is known to be an excellent source of selenium to maintain fish health and performance, whilst having the unique property to, at the same time, improve the selenium status of the end products. L-selenomethionine is the only source of selenium that can be stored in animal protein, whilst other sources cannot be stored. This storage of selenium is good for animal health because it can use this selenium when stress is high and selenium from the diet is not-sufficient. L-selenomethionine is also beneficial for the transfer to offspring and the enrichment of end products. One example is the addition of selenium in Atlantic salmon as L-selenomethionine or sodium selenite, where it is observed that L-selenomethionine addition is causing better selenium storage (Figure 2; Prabhu et al., 2020).

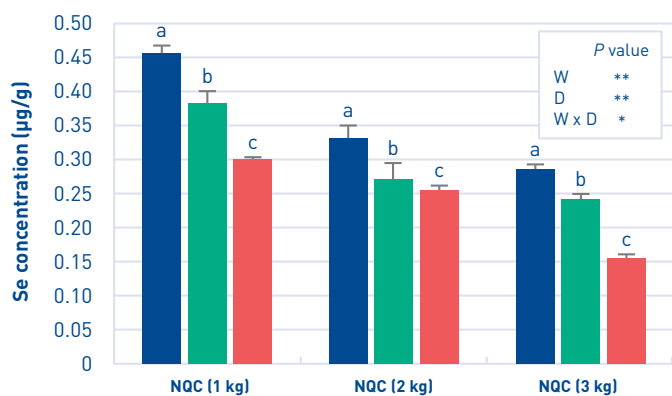


Figure 1: Selenium levels in the body of Atlantic salmon fed diets with levels of plant protein (blue), medium levels of plant protein (green) and high levels of plant protein (red) at different fish sizes. Betancor et al. (2006)

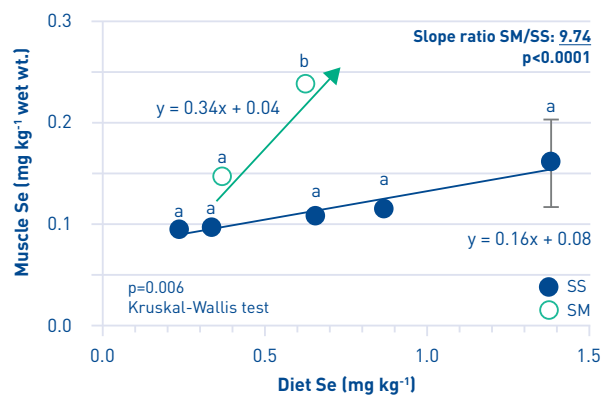


Figure 2: Muscle selenium deposition of Atlantic salmon fed diets with sodium selenite (SS) or L-selenomethionine (SM). Prabhu et al. (2020)



Atlantic salmon is a carnivorous species, but also in omnivorous and herbivorous fish a beneficial effect of selenium on fish flesh quality was observed. In Nile tilapia, for example, it is observed that addition of selenium has a similar effect as in salmon. In general growth, health and disease resilience of Nile tilapia is improved upon the addition of selenium, with the best results observed by the addition of L-selenomethionine. After addition of selenium to the diet it was observed that increased dry matter content of the fish fillet was observed (Figure 3; Sharaf Al-Din et al., 2022). Next to that, it was observed that addition of selenium increased the protein, fat and ash content, whilst decreasing the frozen leakage rate. Indicating that the addition of selenium increases the quality of fish fillet.

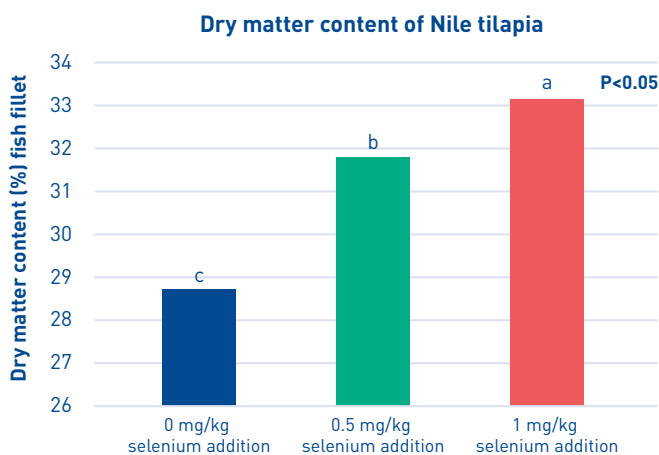


Figure 3: Dry matter content of Nile tilapia fish fillet fed different levels of selenium. Sharaf Al-Din et al. (2022)

Regarding the protein content, similar results were observed in rainbow trout, where crude protein content of the fish fillet was significantly increased by addition of selenium to the diet, leading to higher nutritional fish. Also, an improved hardness or sturdiness of the fish fillet was measured after selenium addition, accompanied by a decreased drip loss (Wang et al., 2018), all indicating higher quality fish products with a longer shelf-life.

All these examples show that selenium addition to the diet of aquatic animals can have a beneficial effect on fillet quality. Orffa offers **Excential Selenium 4000**, which is a selenium source with 100% L-selenomethionine. This is an excellent form

of selenium ensuring good quality fish fillet and fish productivity. Excential Selenium 4000, being solely L-selenomethionine, is a better source of selenium compared to other organic or inorganic source to ensure this high-quality fish.

Betaine – Osmoregulator to increase fillet quality

Betaine, or trimethylglycine, is found in a variety of organisms, including plants, microorganisms, and marine animals. It serves various functions in these organisms, such as osmoregulation, protection against osmotic stress, and as a methyl donor in metabolic reactions. Betaine is often used as a feed additive in fish diets. Addition of betaine in aquaculture diets, is often linked to better osmoregulation, stress reduction, growth improvement, immune system enhancement and increased reproductive performance. Additionally, betaine is widely known as a beneficial compound to improve meat quality in terrestrial animals and fillet quality in seafood.

One example is the effect of betaine on the fillet quality of red Pacu fish. Red Pacu fish, or the vegetarian piranha, is a species native to the Amazon river in South America and in recent years this species has gained significance in aquaculture, mainly due to its large harvesting size, easy handling and wide acceptance of variable diets. Another important aspect of the red Pacu is the fillet quality. Red Pacu is considered to be a good quality fish for consumption. Since fillet quality is of such importance it is interesting to see that addition of betaine in the form of betaine hydrochloride increases the dry matter content of the meat, leading to higher-quality fish fillet. Additionally, higher free carnitine levels were observed in fish fed levels of betaine (Figure 4; Lu et al., 2003). Higher free carnitine levels are associated with fish fillet with better preservation of freshness, better texture and firmness of the fillet, positive effects on the flavor and increased nutritional value. Moreover, decreased cholesterol levels were observed in fish fed betaine, leading to healthier fillet (Figure 4; Lu et al., 2003).

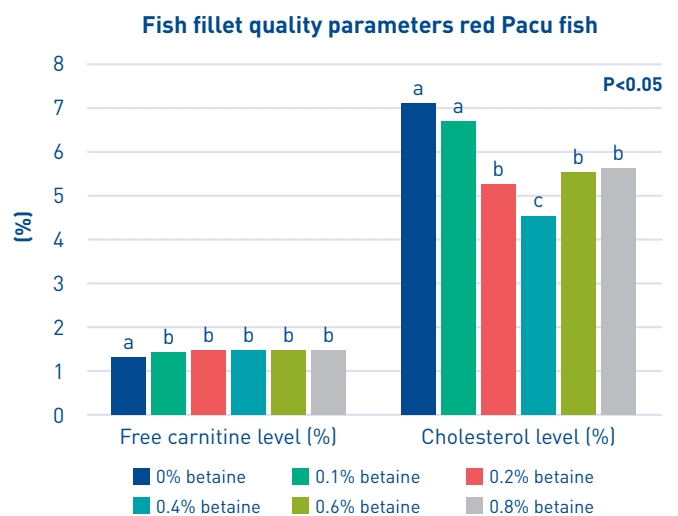


Figure 4: Free carnitine level and cholesterol level of red Pacu fish fed different levels of betaine. Lu et al. (2003)

In rainbow trout, similar results have been observed. In an experiment where betaine was tested at dietary levels 0%, 0.9% and 1.63%, increased dry matter content of the fish fillet was observed. Besides, betaine levels were significantly improved in the fillet with dietary betaine, increasing the health benefits for humans.

Lastly, betaine is known to be a feed additive with the capacity to reduce oxidative stress in fish. One of the benefits of decreasing oxidative stress is better pigmentation of fish fillets. Decreased pigmentation is often linked to higher stress in the animals. During this same experiment with betaine in rainbow trout, a significantly increase in redness was observed in the trout fed higher levels of betaine. This redness is desired by consumers, increasing the quality and perception of the fish fillet (Pinedo-Gil et al., 2017).

To conclude, it can be said that the addition of betaine has a beneficial effect on fish fillet quality. For humans, especially the increase in beneficial compounds such as carnitine and pigments in fish fillets, whilst decreasing cholesterol content is a positive aspect of betaine addition to fish diets. Besides, the increased dry matter content of the fish fillet when betaine was added is also positive for the fillet quality. Orffa offers a wide range of **Excential Betaine** products, that can ensure high-quality fish flesh.



The addition of **betaine** has a **beneficial effect** on fish fillet quality



Essential oils: plant derivatives to improve seafood quality

Essential oils, or phytochemical feed additives, are highly concentrated extracts derived from various plants that contain the natural aroma and properties of the plant. When used in the diets of fish, essential oils can enhance feed palatability, stimulate feed intake, improve digestion and nutrient absorption, enhance immune response, and exhibit antimicrobial properties. Garlic and cinnamon are examples of such plant derivatives used in aquaculture, which are known to improve feed efficiency and animal health.

When used appropriately, essential oils, or phytochemical feed additives, can have positive effects on fillet quality. They may exhibit antioxidant properties, which can help to reduce lipid oxidation and maintain the freshness and shelf life of the fillets. Feed additives with antimicrobial properties can also help inhibit the growth of spoilage bacteria, reducing the risk of bacterial contamination and improving the microbial quality of the fillets. One example of this was observed in common carp, where cinnamon was added at levels ranging from 0% to 1%. Not only was the growth performance of fish improved, but the texture and taste of the fish were also improved (Figure 5; Dedi et al., 2016),

indicating that addition of a plant derivative such as cinnamon can improve fillet quality. Again, increased dry matter content was observed in the fish fillet, which is linked to the improved perception by the consumer.

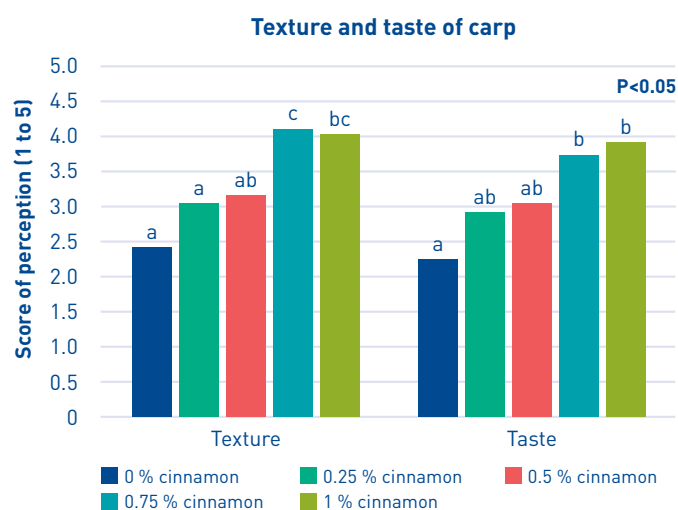


Figure 5: Texture and taste of common carp fillet fed different levels of cinnamon. Dedi et al. (2016)



The scoring of the **sensory attributes** of the fillets was higher in diets with **essential oils**

Seafood is often processed, and frozen or refrigerated. This is frequently linked to an increase in bacteria in the end product and a decrease of product appearance, odor and texture. In another trial with common carp, it was observed that the use of essential oils, such as rosemary, cinnamon, fennel and cardamom in the diets, caused a smaller increase in *Staphylococcus aureus*, *E. coli*, and *Bacillus cereus* growth compared to control, with rosemary and cinnamon being the most effective. Next to that, the scoring of the sensory attributes were higher in diets with essential oils, again with dietary cinnamon and rosemary giving the best results (Figure 6; Abdeldaiem et al., 2016).

These results clearly indicate that addition of plant derivatives, especially cinnamon, improves the sensory quality of fish fillets. Orffa offers **Excential Alliin Plus**, a product which is a combination of garlic and cinnamon. Excential Alliin Plus can improve fish health and productivity, whilst at the same time ensuring high-quality fish flesh.

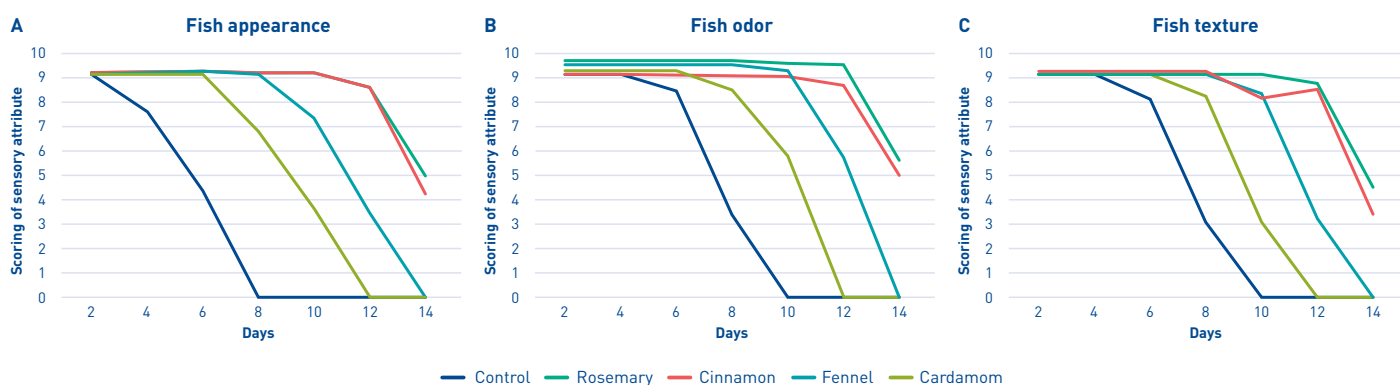


Figure 6: Sensory scoring attribute of fish for the texture (A), odor (B) and texture (C) of common carp after being refrigerated over 14 days. Abdeldaiem et al. (2016)

The use of clinoptilolite to improve fish fillet quality

Clinoptilolite is a natural zeolite that is commonly used in various applications due to its unique structure and properties. It is a microporous aluminosilicate with a 3D structure that can selectively adsorb certain molecules, such as ammonia and heavy metals. Clinoptilolite is known for its high cation exchange capacity, high surface area, and ability to adsorb and retain toxic substances such as heavy metals and ammonia, making it useful in water treatment, soil remediation, and feed additives. In general, addition of clinoptilolite in the diet or in the water can improve the health, growth performance and feed efficiency of fish. At the same time, addition to the diet or water can improve the water quality as well, by the absorption of these toxic compounds.

One of the most significant concerns regarding fish fillet quality is heavy metal accumulation in the flesh, due to its potential

negative impact on both human health and fish health. Heavy metals such as mercury, lead, cadmium, and arsenic can be present in water sources and can be absorbed by fish through their gills or by ingesting contaminated or wrongly supplemented feed. These metals can accumulate in fish tissues, including the fillets, over time. Consuming fish with high levels of heavy metals can pose health risks to humans, as these metals are toxic and can have detrimental effects on various organ systems. Additionally, heavy metal accumulation in fish fillets can negatively impact their fillet quality. It can cause off-flavors, unpleasant odors, and changes in texture, making the fillets less desirable to consumers. Therefore, it is crucial for aquaculture practices to act properly to reduce heavy metal content in the water and to avoid contamination of feed by these heavy metals. One of the solutions to reduce the effect of heavy metals is the use of clinoptilolite.



Addition of **clinoptilolite** in the diet or in the water can **improve the health, growth performance and feed efficiency** of fish

One clear example is the addition of clinoptilolite to the water of Nile tilapia. The addition of 1, 2 or 3 g/L improved fish survival, growth performance and heavy metal concentration in the water. Additionally, the heavy metal content in the fish fillet was also significantly decreased (Figure 7; Hamed et al., 2022).

Similar results are observed in other fish species and also when the clinoptilolite is added to the diet instead of directly in the water. Orffa offers a wide range of clinoptilolite products to improve animal health and water quality. **Excential AmmoSAN** is Orffa's solution to be added directly to the water, whilst **Excential Toxin A** and **Excential AmmoMIN** can be added to the feed. Both increase water quality and health of the animals, whilst ensuring fish end products with a high quality and increased food safety.

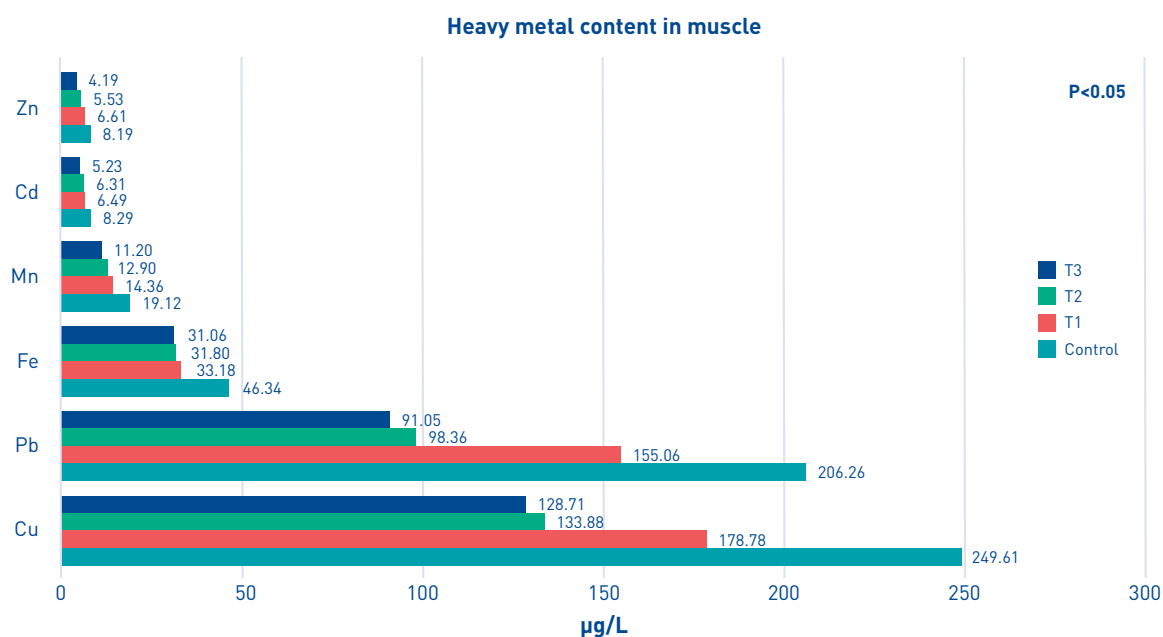


Figure 7: Heavy metal content in muscle of Nile tilapia grown in systems with 0 g/L (control), 1 g/L (T1), 2 g/L (T2) and 3 g/L (T3). Hamed et al. (2022)



FEED ADDITIVES

The way to improve fish fillet quality

Orffa's feed additives, in this case Excential Selenium 4000, Excential Betaine, Excential Alliin Plus, Excential Toxin A and Excential AmmoSAN, can in their own way act as a solution or part of a solution to improve or maintain high-quality fish fillet. With the increasing aquaculture production and the increasing world population, this is necessary to maintain the healthy image of fish consumption.