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Diversity and Justification of Quality Differences in Cultivated and Wild Fish – A Systematic Review

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Abstract

Fish provide essential nutrients—high-quality proteins, omega-3 fatty acids, and vital vitamins—making them a key component of human nutrition. Previous studies have indicated that consumers prefer wild over cultured fish; however, whether real nutritional differences exist remains unclear. This paper reviews 41 studies on quality differences between wild and cultured fish across 27 species, examining proximate composition, minerals, fatty acids, amino acids, color, and texture. Cultured fish had a significantly lower moisture content but a higher lipid content, while the protein and ash contents showed no significant differences. Cultured fish sometimes exhibited lower polyunsaturated fatty acid percentages. Both groups were mineral-rich, though wild fish contained significantly higher toxic element levels. Color and texture differed substantially by origin. These results suggest both cultured and wild fish possess valuable quality attributes. Variations likely depend on sex, diet, region, season, farming mode, and environmental conditions. Although the core synthesis covers literature until November 2019, selected key studies from 2020-2024 were integrated to reflect recent developments, corroborating and refining the overall conclusions. This review offers insights for sustainable aquaculture quality development.

Keywords

Proximate composition, fatty acids, amino acids, minerals, quality

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Introduction

Fish provide essential nutrients, including high-quality proteins, heart-healthy omega-3 fatty acids, and vital vitamins, making them a key component of human nutrition (Domingo, 2016). Consequently, fish and seafood consumption have increased significantly in recent decades (Tacon & Metian, 2013; Claret *et al.*, 2016). According to Food and Agriculture Organization data, global fish production reached approximately 223.2 million tonnes in 2022, and aquatic animal production is projected to reach 205 million tonnes in 2032 (FAO, 2024). Given the rising demand for seafood, wild-caught resources alone are unlikely to meet human needs; consequently, focus has been gradually shifting from capture fisheries to aquaculture, with fish being cultivated primarily for consumption.

Despite the increasing role of aquaculture, consumer perceptions have remained largely unchanged, with many still believing that farmed fish are of lower quality than their wild counterparts (Claret *et al.*, 2012; Polymeros *et al.*, 2015; Claret *et al.*, 2016). Since the scientific rationale behind consumer preferences remains unclear (Polymeros *et al.*, 2015), a comparative assessment of quality and safety between wild and cultivated fish is needed to inform evidence-based consumer choices (Reig *et al.*, 2019). Such evaluations are also valuable for farmers, as they provide insights into product quality and inform improvements in aquaculture practices. Therefore, synthesizing existing literature on the quality attributes of wild and cultivated fish is essential for understanding their nutritional value and guiding both producers and consumers.

Typically, the key parameters used to compare differences between cultivated and wild fish have included proximate composition, fatty acid and amino acid compositions, external appearance, organoleptic quality, and contamination levels (Orban *et al.*, 2003; Grigorakis *et al.*, 2011; Lenas *et al.*, 2011). Regarding commonly cultivated and wild sea bass, sea bream, and Mediterranean species, some authors have reviewed their compositional and organoleptic qualities (Grigorakis, 2007; Arechavala-Lopez *et al.*, 2013; Grigorakis, 2017). However, reviews for other fish species have never been attempted.

This paper reviews existing literature on the quality differences between cultured and wild fish to understand the characteristics shaping developments in the aquaculture industry. We focused on proximate composition, mineral contents, fatty acids, amino acids, color, and texture to provide a comprehensive understanding of the nutritional differences between cultured and wild fish. The review also examines the key factors influencing farmed fish quality, including geographical region, seasonal variations, rearing conditions, and feed composition.

Methods

The Web of Science and Google Scholar were searched in November 2019 using 'cultured/farmed/reared/cultivated fish', 'wild fish', 'proximate composition', and 'nutritional values of wild and cultivated fish'. We excluded articles examining only cultured or wild fish without comparison and restricted publications to 2001-2019, yielding 59 relevant articles. After screening the abstracts and full texts, 41 studies were included, with data limited to fish flesh/muscle/fillets and referenced in appropriate figures and tables.

Figure 1 categorizes the studies by the analyzed compositions. Fatty acids and/or lipids were the most reported (38/41 studies), followed by proximate composition (30/41), minerals/pollutants (12/41), amino acids (9/41), and color and texture (8/41). Other features—odor, flavor, cholesterol, muscle cellularity, and isotope analysis—were excluded, not because they lack importance, but because an insufficient number of studies reported them. We included all features reported in more than five studies and emphasize the need for more research on underrepresented parameters.

Additionally, peer-reviewed literature from 2020-2024 was systematically reviewed to provide updated context on nutritional composition, fatty acid profiles, mineral content, and meat quality differences between wild and farmed fish.

Statistical analysis

For the proximate composition analysis, radar plots were created in OriginPro (version 2018) to compare cultured and wild fish species. Heatmaps were produced using R 3.6.1 (R

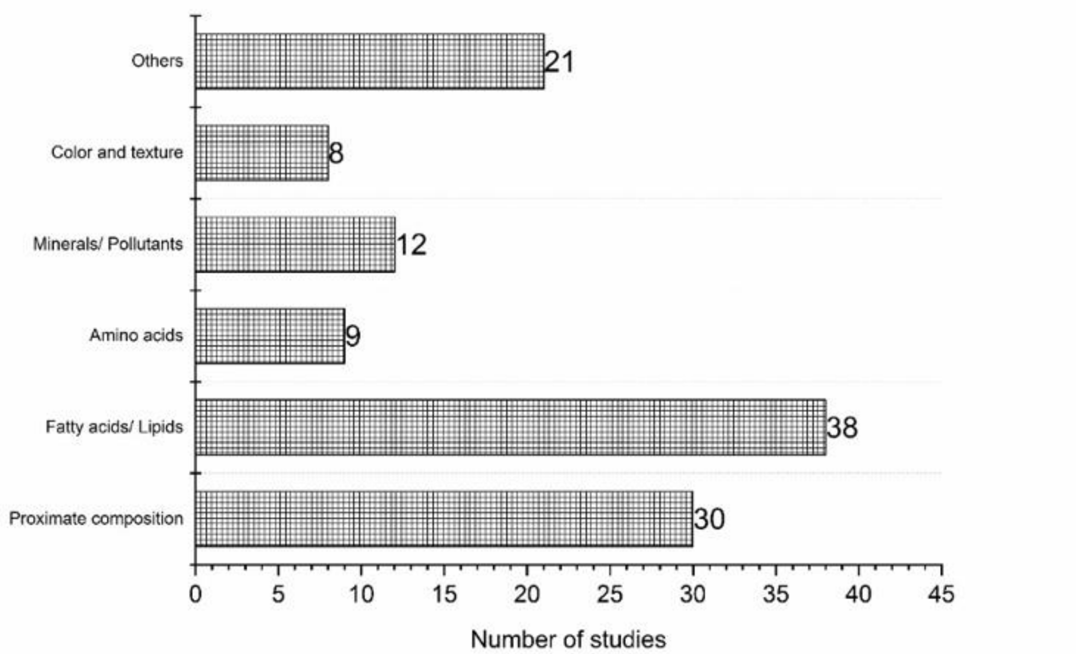

Figure 1. Numbers of studies reviewed in the present paper according to the analyzed nutritional compositions

Core Team, 2019) with the Heatmap package in the Complexheatmap function for variable clustering (Gu *et al.*, 2016).

Results and Discussion

Proximate composition

Proximate composition (moisture, ash, protein, and lipid content) provides general information for evaluating raw fish quality (Yeannes & Almandos, 2003). Therefore, many studies have examined proximate composition across different fish species (**Figure 2**).

Moisture, the principal component of fish composition, can affect the edible quality and processing of fish (Kent, 1985). A large number of studies (20/30 studies) reported that cultured fish have a lower moisture content than their wild counterpart (**Figure 2**). This is true for many varieties including meagre (Chaguri *et al.*, 2017; Saavedra *et al.*, 2017), red tail (Jiang *et al.*, 2017), sea bass (Alasalvar *et al.*, 2002; Orban *et al.*, 2002; Orban *et al.*, 2003; Fuentes *et al.*, 2010), sea bream (Piccolo *et al.*, 2007; Dincer *et al.*, 2010; Rincón *et al.*, 2016), and other species. However, in some species, the cultured fish showed a higher moisture content than their wild counterpart, including sea bass (Periago *et al.*, 2005; Baki *et al.*, 2015) and rainbow trout (Mustafa & Dikel, 2015).

Lipid and moisture contents are inversely related (Shearer, 1994). Consistent with this, studies reporting a lower moisture content also reported a higher lipid content. Cultured fish generally have a significantly higher lipid content than wild fish (**Figure 2**), as observed in sea bass (Alasalvar *et al.*, 2002; Orban *et al.*, 2002; Fuentes *et al.*, 2010), yellow perch (González *et al.*, 2006), and rainbow trout (Mustafa & Dikel, 2015). However, exceptions exist: cultured tilapia was shown to have a lower lipid content than wild fish (0.70 vs. 0.97%) (Garduño Lugo *et al.*, 2007). Additionally, the lipid contents did not differ significantly between cultured and wild sea bass (Periago *et al.*, 2005), white sea bream (Cejas *et al.*, 2004), Atlantic cod (Jensen *et al.*, 2013), and yellowtail (O'Neill *et al.*, 2015).

Complete understanding of how the protein contents vary between cultivated and wild fish is still lacking, as the crude protein of cultivated and wild fish have been shown to have significant compositional differences (**Figure 2**). Some studies documented that there is a lower protein content in cultured fish than in wild fish (González *et al.*, 2006; Fuentes *et al.*, 2010;).

However, the cultured fish had significantly higher protein than that of their wild counterpart in cod, northern pike, sea bass, sea bream, and catfish (Periago *et al.*, 2005; Piccolo *et al.*, 2007; Wang *et al.*, 2012; Jensen *et al.*, 2013; Modzelewska-Kapituła *et al.*, 2017). Moreover, in some species there appears to be no significant difference in protein content between cultivated and wild fish (Alasalvar *et al.*, 2002; Orban *et al.*, 2002; O'Neill *et al.*, 2015; Rincón *et al.*, 2016). Such mixed results suggest that more studies are required, especially to document the protein contents in wild and cultivated fish.

Most of the studies demonstrated that the ash content does not differ significantly between wild and cultivated fish (**Figure 2**). A large number of papers did not mention the ash content of cultured/wild fish (**Figure 2**). A small number of studies showed that the ash content of cultured fish is substantially lower than wild fish (Mustafa & Dikel, 2015; Goebel *et al.*, 2017; Modzelewska-Kapituła *et al.*, 2017). Thus, whether ash content could be a good proxy to test the quality of fish is not clear (Arechavala-Lopez *et al.*, 2013).

Fatty acids profile

During the past two decades, fatty acid profiles have been commonly used in differentiating the origin of cultivated and wild fish (Hearn *et al.*, 1987; Arechavala-Lopez *et al.*, 2013; Murillo *et al.*, 2014). A heatmap showing the comparison of the fatty acid components between cultured and their corresponding wild fish species is presented in **Figure 3**.

Although most studies have indicated that cultured fish have a significantly higher lipid content than wild fish, the fatty acid profiles varied between cultured fish and their wild counterparts (**Figure 3**).

The majority of the studies (18/38) illustrated that wild fish have significantly higher total saturated fatty acid percentages (Mirmiran *et al.*, 2022) than those of cultivated fish (**Figure 3**). This has been observed in sea bass (Alasalvar *et al.*, 2002; Orban *et al.*, 2002; Orban *et al.*, 2003; Baki *et al.*, 2015), rainbow trout (Mustafa & Dikel, 2015), sea bream (Orban *et al.*, 2003), and meagre (Chaguri *et al.*, 2017).

Interestingly, cultivated fish seem to have significantly higher values of monounsaturated fatty acids (Mufas & Perera, 2013) than their wild counterpart (25/38 studies). This was observed in sea bass (Orban *et al.*, 2003; Fuentes *et al.*, 2010; Baki *et al.*, 2015), blackspot sea bream (Rincón *et al.*, 2016), whitefish (Goebel *et al.*, 2017), rainbow trout (Mustafa & Dikel, 2015), meagre (Chaguri *et al.*, 2017), and others. In contrast, a few studies (3/38) demonstrated that the MUFA contents of cultivated fish were lower than their wild counterparts, such as sea bass (Orban *et al.*, 2002) and sea bream (Orban *et al.*, 2003).

Substantial research (15/38 studies) documented significantly lower polyunsaturated fatty acid (PUFA) percentages in cultured versus wild fish (**Figure 3**). Similar trends occurred for total n-3 fatty acids and docosahexaenoic acid (DHA) (14 and 17/38 studies, respectively). Conversely, studies showing no significant differences were considerably fewer (13, 12, and 11/38 studies for PUFA, n-3, and DHA, respectively).

Considerable research (18/38 studies) underpinned that cultivated fish have significantly higher percentages of total n-6 fatty acids than their wild counterparts, such as yellowtail (O'Neill *et al.*, 2015), blackspot sea bream (Rincón *et al.*, 2016), sea bass (Orban *et al.*, 2003), and meagre (Chaguri *et al.*, 2017). Surprisingly, 8/38 studies reported significantly higher n-6 fatty acid percentages in wild versus cultured fish, while 10/41 cases found no significant differences. However, the n-3/n-6 ratio showed no clear trend, with cultured < wild, cultured > wild, and non-significant results occurring in 11, 7, and 10 of 38 studies, respectively (**Figure 3**).

Although the ratios of EPA/DHA were reported only in a small number of studies (**Figure 3**), some research proffered that cultivated fish have significantly lower percentages of EPA (eicosapentaenoic acid) and DHA (docosahexaenoic acid) than their wild counterparts (Alasalvar *et al.*, 2002; Chaguri *et al.*, 2017; Jiang *et al.*, 2017). For instance, the DHA percentage of cultivated *Pagrus pagrus* was significantly lower than wild fish (7.76 and 18.73% of total fatty acids, respectively) (Loukas *et al.*, 2010). Moreover, some research found

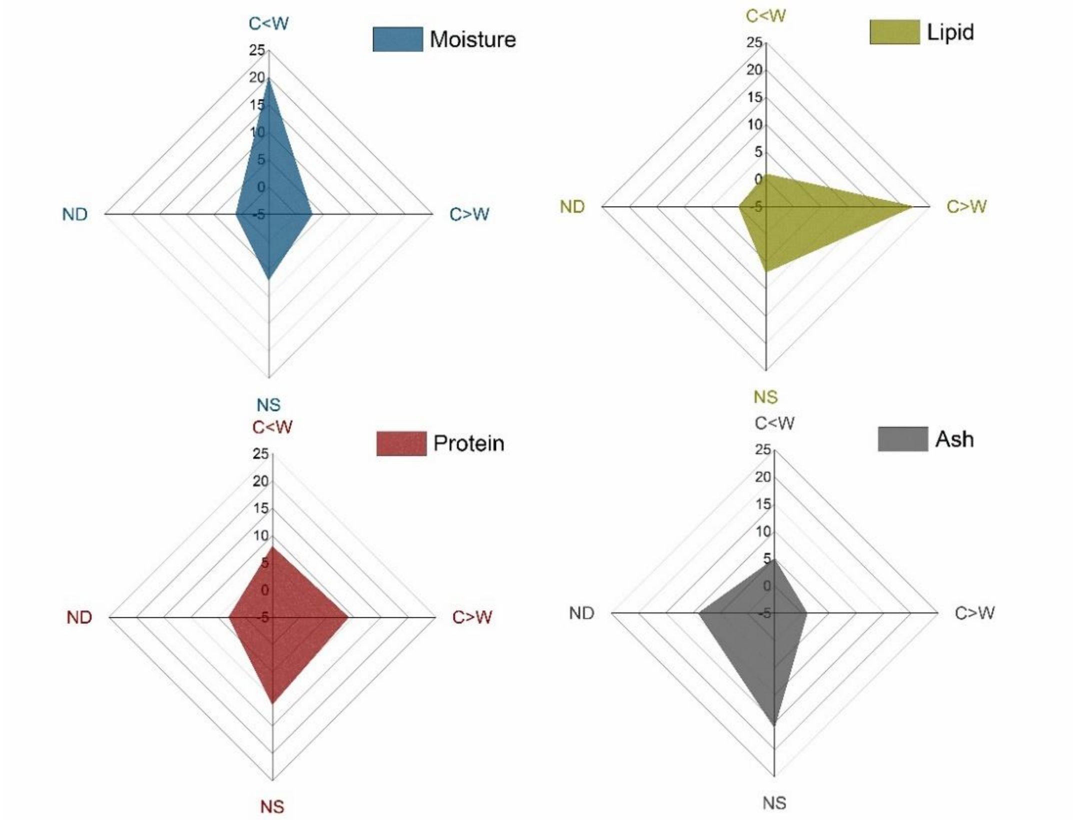

Figure 2. Number of studies featuring the proximate composition contents of cultured (C) and wild (W) fish species. C<W, cultured fish contents significantly lower than wild; C>W, cultured fish contents significantly higher than wild; NS, no significant difference; ND, no data.

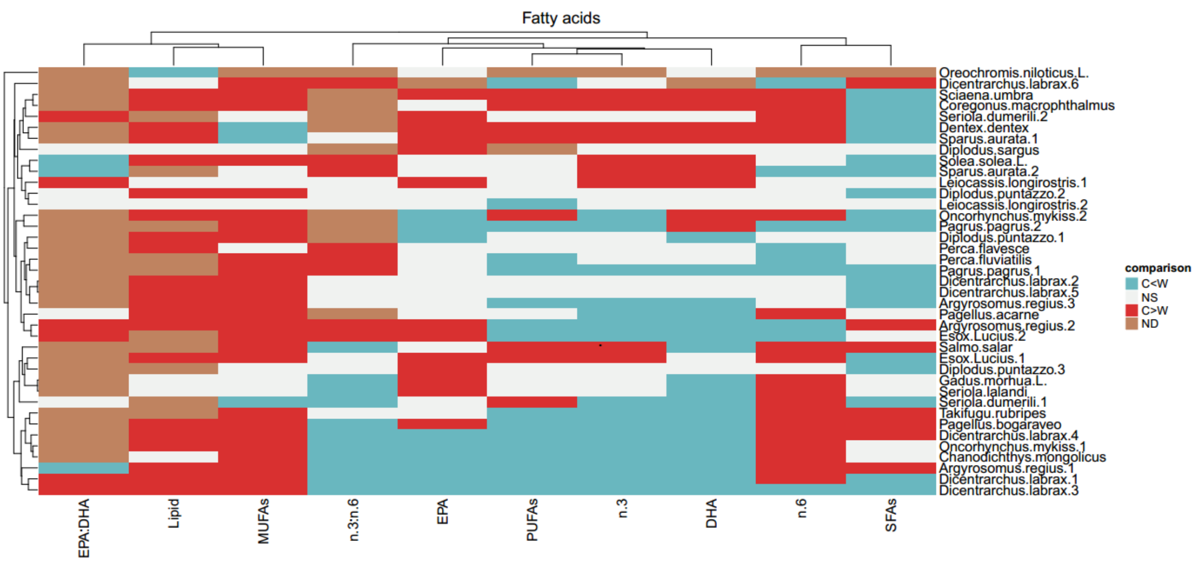

Figure 3. Heatmap comparing the fatty acid profiles of cultured (C) and wild (W) fish species from reviewed literature. Blue: cultured contents significantly lower than wild (C<W); white: no significant difference (NS); red: cultured contents significantly higher than wild (C>W); brown: no data (ND).

that cultivated fish had significantly higher EPA and DHA percentages than their wild counterparts, e.g. sea bream (Orban *et al.*, 2003; Sağglık *et al.*, 2003; Mnari *et al.*, 2007), sea bass (Orban *et al.*, 2002; Sağglık *et al.*, 2003), and cod (Jensen *et al.*, 2013).

Based on the WHO dietary guidelines recommending that the saturated fatty acid

(SFA) intake should be below 10% of total energy and should be replaced with polyunsaturated fatty acids (PUFAs), the fatty acid profiles of wild and cultured fish present distinct trade-offs. Wild fish contain higher SFAs but also superior PUFA proportions, particularly n-3 fatty acids and DHA—WHO-recommended SFA substitutes. Cultured fish offer lower SFAs and higher monounsaturated fatty acids (MUFAs), partially aligning with WHO recommendations; however, their elevated n-6 content and reduced n-3/n-6 ratios indicate less favorable profiles. From a public health perspective, consumption strategies should balance these differences: cultured fish reduce SFA intake, while wild fish provide more beneficial n-3 PUFAs, better aligning with WHO recommendations for replacing SFAs with PUFAs.

Amino acids profile

Fish proteins are nutritionally valuable due to their well-balanced amino acid composition, providing all nine essential amino acids in proportions meeting human dietary requirements (Petricorena, 2014). A heatmap comparing the amino acid profiles between cultured and wild fish is shown in **Figure 4**. Both groups were amino acid-rich; however, tryptophan, cysteine, asparagine, and taurine were infrequently reported across species (**Figure 4**).

Non-significant differences were dominant in the amino acid profiles of the cultured and wild counterparts (**Figure 4**). For example, there were no significant differences in the essential amino acid concentrations between cultivated and wild yellow perch (*Perca flavescens*) (González *et al*., 2006). Similarly, there were no significant differences found in cultivated (pond or cage-cultured) longsnout catfish (*Leiocassis longirostris)* and its wild counterpart, except for the higher glycine concentration of the wild fish than that of the cultivated fish (Wang *et al*., 2012).

The total amino acids in wild fish tended to be higher than in cultivated fish in some research (Fuentes *et al*., 2010; Wang *et al*., 2014). Particularly, the total amino acids of wild fish and cultivated fish were 379.29 mg kg^{-1} versus 355.38 mg kg^{-1} in sea bass (Fuentes *et al*., 2010) and 68.47 mg kg^{-1} versus 61.67 mg kg^{-1} in *Pseudobagrus ussuriensis* (Wang *et al*., 2014). Inaddition, some non-essential amino acids were deduced to have significantly higher concentrations in wild yellow perch than those of its cultivated counterpart (González *et al*., 2006). However, it was not consistent in some studies, as cultivated fish had significantly higher concentrations of total amino acids, total essential amino acids, and total non-essential amino acids than wild *Chanodichthys mongolicus* (Jiang *et al*., 2017). Similarly, Jensen *et al*. (2013) reported that 12 of 13 amino acids of cultivated cod were significantly higher than in wild cod (except for cysteine).

Amino acids play an important role in the taste and flavor of fish (Haard, 1992). Among them, aspartic acid, glutamic acid, alanine, and glycine are the main components of fish flavor characteristics (Özden & Erkan, 2008). These amino acids were significantly higher in cultivated fish than wild fish, such as sea bass (Fuentes *et al*., 2010), Atlantic cod (Jensen *et al*., 2013), and *Chanodichthys mongolicus* (Jiang *et al*., 2017). These results implied that it is possible to improve cultivated fish quality with qualified nutritional compositions; this will help to change the consumers' perception and cultivated fish consumption.

Mineral content

The results from the previous studies showed that both cultivated and wild fish are rich in essential minerals (P, K, Na, Ca, Mg, Fe, Zn, Mn, B, Co, Se, and Ni), especially P, K, Na, Ca, and Mg (**Figure 5**). Usually, the mineral levels were different between fish species (Özden *et al*., 2010; Qiu *et al*., 2011; Kalantzi *et al*., 2013). Moreover, the mineral concentrations significantly varied in different parts of fish body. Indeed, the concentration of mineral compositions showed significant differences in the vertebrae and muscle of haddock (*Melanogrammus aeglefinus*) (Roy & Lall, 2006), the ventral, dorsal, and tail of blackspot sea bream (*Pagellus bogaraveo*) (Alvarez *et al*., 2009), and the muscle, liver, intestine, kidney, and gonads of carp (*Cyprinus carpio*) (Alam *et al*., 2002).

Some studies have documented that there were significant differences in only a few mineral contents of cultivated and wild fish. This phenomenon has been observed for some minerals, such as Ca (Fuentes *et al*., 2010), Fe, and Zn (Orban *et al*., 2002) in sea bass, Ca and

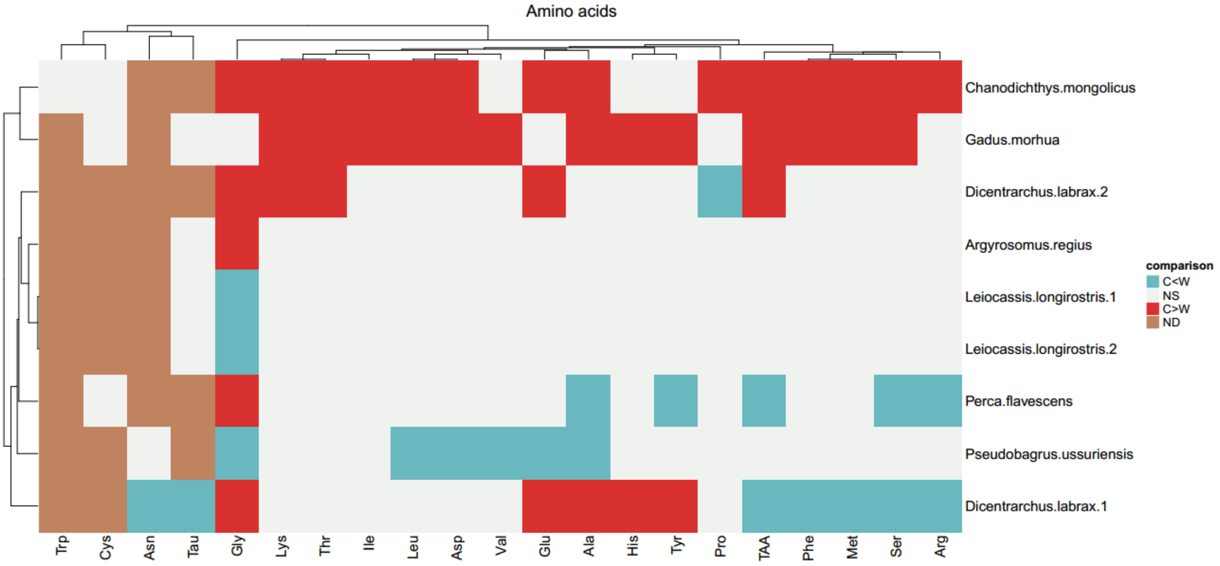

Figure 4. Heatmap comparing the amino acid profiles of cultured (C) and wild (W) fish species from reviewed literature. Blue: cultured contents significantly lower than wild (C<W); white: no significant difference (NS); red: cultured contents significantly higher than wild (C>W); brown: no data (ND). Amino acid abbreviations: Alanine (Ala), Arginine (Arg), Asparagine (Asn), Aspartic acid (Asp), Cysteine (Cys), Glutamic acid (Glu), Glutamine (Gln), Glycine (Gly), Histidine (His), Isoleucine (Ile), Leucine (Leu), Lysine (Lys), Methionine (Met), Phenylalanine (Phe), Proline (Pro), Serine (Ser), Threonine (Thr), Tryptophan (Trp), Tyrosine (Tyr), Valine (Val), and Total amino acids (TAA).

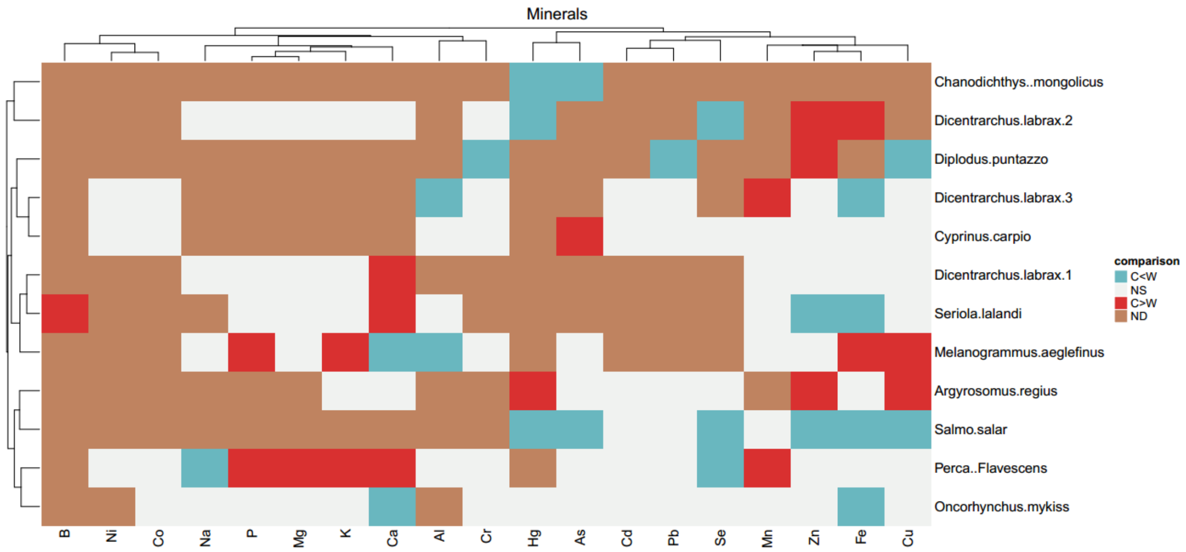

Figure 5. Heatmap comparing the mineral contents of cultured (C) and wild (W) fish species from reviewed literature. Blue: cultured contents significantly lower than wild (C<W); white: no significant difference (NS); red: cultured contents significantly higher than wild (C>W); brown: no data (ND).

Fe in rainbow trout (Fallah *et al.*, 2011), and Zn in meagre (Chaguri *et al.*, 2017). In addition, there were no significant differences in the contents of essential minerals between cultured and wild carp (*Cyprinus carpio*) (Alam *et al.*, 2002).

However, significant differences have been reported in most of the mineral contents of cultivated fish and their wild counterpart (González *et al.*, 2006; Roy & Lall, 2006; O'Neill *et al.*, 2015; Lundebye *et al.*, 2017). In addition,there were different trends for some minerals, where the significant higher value was in cultured fish or its wild specimen. For example, the Fe contents present in wild sea bass (*Dicentrarchus labrax*) (Alasalvar *et al.*, 2002) and yellowtail (*Seriola lalandi*) (O'Neill *et al.*, 2015) were significantly higher than their cultivated counterparts. In contrast, the Fe contents in the vertebrae and muscle of cultivated haddock (*Melanogrammus aeglefinus*) were significantly higher than in its wild origin (Roy & Lall, 2006). There are many reasons that could potentially explain the variations, such as age (Otwell & Rickards, 1981), size (Roy & Lall, 2006; O'Neill *et al.*, 2015), seasonal variations (Özden *et al.*, 2010), diet of fishes (Yildiz, 2008; Siano *et al.*, 2017) or environmental conditions at which those fish were grown (Lall & Milley, 2008; O'Neill *et al.*, 2015).

Excessive toxic elements (Cd, Hg, Pb, As, and Cr) in fish pose human health risks. Various governments have established threshold levels, including the Australian Food Standards Code (Alam *et al.*, 2002) and China's General Administration of Quality Supervision (Jiang *et al.*, 2017). While toxic element levels in most wild and cultured fish remain below legislative limits, wild fish generally contain higher levels than cultured fish (Orban *et al.*, 2002; González *et al.*, 2006; Jiang *et al.*, 2017). For example, As and Hg levels in wild *Chanodichthys mongolicus* significantly exceeded those in cultured groups, with Pb detected only in wild fish (Jiang *et al.*, 2017). Similarly, the Hg content in wild sea bass fillets (100.50 mg kg^{-1} wet weight) significantly exceeded cultured sea bass (7.0 mg kg^{-1}) (Orban *et al.*, 2002). In contrast, although all measured toxic trace metals remained well below international food safety standards, Chaguri *et al.* (2017) reported that cultivated meagre (*Argyrosomus regius*) contained significantly higher Hg concentrations than wild specimens (820.00 vs. 1.66 µg kg^{-1}). Therefore, it is believed that the surrounding aquatic environment can affect the contents of mineral compositions (Orban *et al.*, 2002).

Color and texture

Color plays a crucial role in a consumer's acceptability of fishery products (Haard, 1992; Goebel *et al.*, 2017). Color analysis showed significant differences in skin/fillets colors between cultivated and wild fish. Wild fish possessed more red hues with higher redness (a^*) values in the skin of blackspot sea bream (Rincón *et al.*, 2016) and fillets of yellow perch (González *et al.*, 2006) than those of their cultivated counterparts. However, cultivated Northern pike was detected with higher a^* (redness) and b^* (yellowness) values (Modzelewska-Kapituła *et al.*, 2017). In terms of lightness (L^*), wild fish had higher L^* values in the skin of blackspot sea bream (Rincón *et al.*, 2016) and fillets of Northern pike (Modzelewska-Kapituła *et al.*, 2017). However, cultivated fish showed significantly higher L^* values in the fillet color of yellow perch (González *et al.*, 2006). In addition, the organoleptic test of cooked whitefish fillets demonstrated that 79% of the panelists preferred the clear white flesh of cultivated fish compared to the pale, slightly grey flesh of wild fish (Goebel *et al.*, 2017). In contrast, Atlantic salmon showed no significant difference in the average flesh color between wild and cultivated fish (Johnston *et al.*, 2006).

Fish muscle texture plays an important role in sensory acceptability and quality (Haard, 1992; Rincón *et al.*, 2016). Wild fish generally exhibited significantly higher instrumental texture values than cultured fish (Periago *et al.*, 2005; Johnston *et al.*, 2006; Rincón *et al.*, 2016; Saavedra *et al.*, 2017). For example, raw wild blackspot sea bream fillets showed higher hardness and fracturability than cultured fish (Rincón *et al.*, 2016). Similarly, wild Atlantic salmon had higher instrumental texture values than cultured salmon (Johnston *et al.*, 2006). Additionally, wild sea bass dorsal muscles showed significantly higher values ($P < 0.001$) for all textural properties (hardness, springiness, chewiness, cohesiveness, and gumminess) than cultured fish (Periago *et al.*, 2005). Wild meagre fillets also exhibited significantly higher hardness than cultured meagre; however, cultured meagre scored higher for cohesiveness, springiness, firmness, and oiliness (Saavedra *et al.*, 2017). Notably, muscle fiber area and density showed no significant differences between wild and cultured meagre, indicating these parameters cannot explain fillet texture differences (Saavedra *et al.*, 2017).

Factors affecting the quality differences of cultivated fish

Several factors have been proposed to explain nutritional and sensory differences between cultured and wild fish, which we discuss below.

First, fish sex (female versus male) affects the chemical composition, fatty acids, and fresh fillet properties (Goebel *et al.*, 2017; Modzelewska-Kapituła *et al.*, 2017). In northern pike (*Esox lucius*), males exhibited higher expressible water and fillet redness, while females showed higher pH values and C20:0 fatty acid concentrations (Modzelewska-Kapituła *et al.*, 2017). Thus, sex significantly influences cultured fish quality within a season. In some cases, sex exerts greater influence on fish quality than origin (cultured versus wild). For example, in whitefish, sex significantly affected body height, fillet yield, proximate composition, fatty acids, and color (Goebel *et al.*, 2017).

Second, diets can potentially affect the fatty acid compositions of the fish flesh (Suzuki *et al.*, 1986; Cahu *et al.*, 2004; Webb & O'neill, 2008; Wood *et al.*, 2008). Especially, total n-3 and n-6 fatty acid amounts can be affected by diets (Hossain, 2011). In addition, fishmeal is one important element affecting the quality of fish fillets in terms of texture, appearance, smell, taste, and color (Cahu *et al.*, 2004; Hossain, 2011). Moreover, the feeding rates also affect the fish quality. Increased feeding rates raised the percent carcass fat and visceral protein in rainbow trout (Storebakken *et al.*, 1991). Overall, the relationship between feeding diets and fish quality is complicated due to the impacts of feeding strategies, and the quality of fish product can be improved through supplemental dietary nutritional compositions and feeding rates.

Third, geographical region can remarkably affect the fish quality (Mairesse *et al.*, 2006; Tkaczewska *et al.*, 2014; Ørnholt-Johansson *et al.*, 2017). The importance of cultivated region was mentioned in research about the quality of carp cultivated in six various Polish regions (Tkaczewska *et al.*, 2014). The authors suggested the necessity of legal regulations to label the place and method of cultivation of freshwater fish in consumer markets. Moreover, the effects of regions, rearing temperature, and rearing companies were confirmed in the quality of cultivated Atlantic salmon in Norway (Ørnholt-Johansson *et al.*, 2017). There were significant correlations between the water holding capacity and geography, and between the water holding capacity and company.

Fourth, seasonal variations significantly impact cultured and wild fish quality across species. For example, Atlantic halibut quality parameters (water holding capacity, muscle pH, and fatty acid composition) were investigated from May to December in Norway (Olsson *et al.*, 2003). Cultured halibut had a higher lipid content and lower pH than wild fish. Similarly, seasonal effects (rainy and dry) influenced the chemical composition of cultured and wild cachara (*Pseudoplatystoma fasciatum*) (Sant'Ana *et al.*, 2010). Notably, DHA proportions in both cultured and wild whitefish fillets were considerably higher in the spring. Therefore, seasonality effects warrant attention, and farmers should optimize cultivation timing to achieve better post-mortem fish quality.

Lastly, farming modes and environmental conditions also play important roles in the quality of cultivated fish. Particularly, there were significant differences in the nutritional quality of sharpsnout sea bream (*Diplodus puntazzo*) reared in cages and in tanks (Orban *et al.*, 2000). Moreover, in an effort to differentiate aquaculture products, Valente *et al.* (2011) studied the quality differences of gilthead sea bream raised in distinct production systems (integrated, intensive, semi-intensive, and extensive systems) in southern Europe. The results showed that fish reared in an intensive system had a higher lipid content, and firmer and denser texture than the values of fish reared extensively. Furthermore, rearing conditions and water type, freshwater or seawater, can make differences in the sensory characteristics and nutritional value of red drum (Klanian & Alonso, 2015). Therefore, investigations in the farming modes should be considered to decide the ultimate quality of cultured fish.

Recent literature update (2020-2024)

Since the cutoff of our main literature review was November 2019, a number of comparative studies between wild and farmed fish have emerged (2020-2024), further reinforcing and refining our core findings.

Comparative studies on proximate composition reveal clear differences between farmed and wild fish, reflecting the influence of diet, environment, and metabolic activity. Wild-caught species generally exhibit higher protein and ash contents, consistent with greater muscular activity and natural dietary diversity, whereas farmed fish often show elevated lipid and moisture levels due to formulated feeds and reduced energy expenditure. For instance, wild tilapia demonstrated higher protein (16.90 ± 0.50%) and ash (9.22 ± 1.27%) contents, whereas farmed tilapia showed increased fat (3.55 ± 0.05%) and energy density (94.5kcal $100g^{-1}$) (Francis *et al.*, 2024). Similarly, seasonal studies from South Asia highlighted that protein, lipid, and amino acid levels tended to be higher in pre-monsoon periods, while moisture levels increased during spawning migrations, underscoring the role of environmental and biological factors in shaping proximate profiles (Rasul *et al.*, 2021).

Mineral composition also varies significantly between wild and farmed species, influenced by feeding practices, water quality, and ecological exposure (Thanh *et al.*, 2024). Evidence suggests that wild fish contain higher concentrations of essential micronutrients such as iron, zinc, calcium, and phosphorus, attributed to natural feeding on mineral-rich prey and sediments. For example, zinc was only detected in wild tilapia, whereas iron concentrations, although present in both wild and farmed tilapia, were slightly higher in the wild but remained within safe consumption limits (Francis *et al.*, 2024). In contrast, farmed Asian sea bass displayed a higher overall ash content (21.04 ± 2.1%), suggesting substantial mineral deposition, though this may reflect differences in feed formulation rather than environmental uptake (Francis *et al.*, 2024).

Fatty acid composition differs markedly between farmed and wild fish, largely reflecting the diet and rearing environments. Farmed species generally contain higher total lipid levels, as seen in sardines (14.52% vs. 2.37%) (Scheuer *et al.*, 2024) and salmon (8.97% vs. 2.14%) (Molversmyr *et al.*, 2022), while wild fish typically present leaner profiles with greater proportions of long-chain omega-3 polyunsaturated fatty acids (LC-PUFA). Wild sardines, for example, showed elevated EPA and DHA (2560 mg/100 g), whereas their farmed counterparts were enriched in n-6 PUFA due to vegetable oil-based feeds (Scheuer *et al.*, 2024). Similarly, wild salmon exhibited a higher proportion of SFA and a more balanced n-3/n-6 ratio, despite farmed salmon having a greater absolute PUFA content (Molversmyr *et al.*, 2022). In Mediterranean sea bass and sea bream, cultivated fish contained more PUFA, mainly linoleic acid, while wild fish showed relatively higher MUFA and SFA (Amoussou *et al.*, 2022). Overall, wild fish provide leaner tissue and superior LC-PUFA quality, whereas farmed fish offer higher fat yields but are more influenced by feed composition.

Furthermore, the amino acid profile of fish muscle exhibits notable variation between farmed and wild individuals, reflecting differences in feeding regimes, habitat conditions, and growth dynamics. In pirarucu (*Arapaima gigas*), muscle amino acid composition was influenced by both origin (wild vs. farmed) and size class, with estimated amino acid requirements providing a basis for diet formulation in aquaculture, while simultaneously confirming pirarucu fillets as a rich source of essential amino acids for human nutrition (Rodrigues *et al.*, 2022). In European plaice (*Pleuronectes platessa*), farmed individuals displayed significantly higher free amino acid (FAA) concentrations, particularly glutamate, glycine, alanine, and tyrosine, which contribute to umami and sweet tastes, although substantial intra-group variation was observed (Kendler *et al.*, 2024). Otherwise, comparative analysis of pangasius catfish species demonstrated that wild *Pangasius pangasius* contained higher essential amino acid (EAA) ratios than farmed *Pangasius hypophthalmus*, however both exceeded the FAO/WHO minimum standard, thereby ensuring nutritional adequacy (Chakma *et al.*, 2022). Collectively, these studies indicate that while both wild and farmed fish provide sufficient amino acids for human consumption, wild fish generally demonstrate superior amino acid balance, whereas farmed fish may exhibit elevated FAA content due to dietary influences and metabolic factors.

Overall, recent investigations reinforce pre-2019 conclusions: farmed fish contain more lipids but similar protein and ash contents, the fatty acid profiles vary predictably, contaminant differences depend on the environment, and sensory differences reflect biological and environmental factors. These newer findings add mechanistic and multi-species depth, strengthening interpretive power.

Conclusions

This review provides novel comparative insights into quality differences between cultured and wild fish regarding proximate composition, fatty acids, amino acids, mineral contents, and sensory characteristics. Although cultured fish showed significantly lower moisture and higher lipid contents, some studies detected remarkably higher EPA and DHA percentages than in wild fish. Moreover, fish reared under controlled aquaculture conditions may offer greater culinary safety. Therefore, we reject the prejudice against cultured fish quality.

Internal factors (sex) and external factors (diet, region, season, farming mode, and environmental conditions) significantly influence these quality differences, explaining variations within species and across companies, regions, and countries. Future research should consider additional factors such as exercise levels and rearing conditions. To improve cultured fish quality, aquaculture practices should optimize feeding strategies, geographical regions, farming modes, and cultivation seasons. Recent studies (2020-2024) reinforce these conclusions, adding mechanistic insights on feed composition, carotenoids, and gut microbiota in shaping fish quality, confirming that our core interpretations remain valid while reflecting current advancements.

References

Alam M. G., Tanaka A., Allinson G., Laurenson L. J., Stagnitti F. & Snow E. T. (2002). A comparison of trace element concentrations in cultured and wild carp (*Cyprinus carpio*) of Lake Kasumigaura, Japan. Ecotoxicology and Environmental Safety. 53(3): 348-354.

Alasalvar C., Taylor K. D. A., Zubcov E., Shahidi F. & Alexis M. (2002). Differentiation of cultured and wild sea bass (*Dicentrarchus labrax*): total lipid content, fatty acid and trace mineral composition. Food Chemistry. 79(2): 145-150.

Alvarez V., Medina I., Prego R. & Aubourg S. P. (2009). Lipid and mineral distribution in different zones of farmed and wild blackspot seabream (*Pagellus bogaraveo*). European Journal of Lipid Science and Technology. 111(10): 957-966.

Amoussou N., Marengo M., Iko Afe O. H., Lejeune P., Durieux É. D. H., Douny C., Scippo M.-L. & Gobert S. (2022). Comparison of fatty acid profiles of two cultivated and wild marine fish from Mediterranean Sea. Aquaculture International. 30(3): 1435-1452.

Arechavala-Lopez P., Fernandez-Jover D., Black K. D., Ladoukakis E., Bayle-Sempere J. T., Sanchez-Jerez P. & Dempster T. (2013). Differentiating the wild or farmed origin of Mediterranean fish: a review of tools for sea bream and sea bass. Reviews in Aquaculture. 5(3): 137-157.

Baki B., Gönener S. & Kaya D. (2015). Comparison of food, amino acid and fatty acid compositions of wild and cultivated sea bass (*Dicentrarchus labrax* L., 1758). Turkish Journal of Fisheries and Aquatic Sciences. 15(1): 175-179.

Cahu C., Salen P. & de Lorgeril M. (2004). Farmed and wild fish in the prevention of cardiovascular diseases: Assessing possible differences in lipid nutritional values. Nutrition, Metabolism and Cardiovascular Diseases. 14(1): 34-41.

Cejas J. R., Almansa E., Jérez S., Bolaños A., Samper M. & Lorenzo A. (2004). Lipid and fatty acid composition of muscle and liver from wild and captive mature female broodstocks of white seabream, *Diplodus sargus*. Comparative Biochemistry and Physiology Part B: Biochemistry and Molecular Biology. 138(1): 91-102.

Chaguri M. P., Maulvault A. L., Costa S., Gonçalves A., Nunes M. L., Carvalho M. L., Sant'ana L. S., Bandarra N. & Marques A. (2017). Chemometrics tools to distinguish wild and farmed meagre (*Argyrosomus regius*). Journal of Food Processing and Preservation. 41(6): e13312.

Chakma S., Rahman M. A., Siddik M. A., Hoque M. S., Islam S. M. & Vatsos I. N. (2022). Nutritional profiling of wild (*Pangasius pangasius*) and farmed (*Pangasius hypophthalmus*) pangasius catfish with implications to human health. Fishes. 7(6): 309.

Claret A., Guerrero L., Aguirre E., Rincón L., Hernández M. D., Martínez I., Peleteiro J. B., Grau A. & Rodríguez-Rodríguez C. (2012). Consumer preferences for sea fish using conjoint analysis: Exploratory study of the importance of country of origin, obtaining method, storage conditions and purchasing price. Food Quality and Preference. 26(2): 259-266.

Claret A., Guerrero L., Gartzia I., Garcia-Quiroga M. & Ginés R. (2016). Does information affect consumer liking of farmed and wild fish? Aquaculture. 454: 157-162.

Dİncer T., Caklİ S. & Cadun A. (2010). Comparison of proximate and fatty acid composition of the flesh of wild and cultured fish species. Archiv Für Lebensmittelhygiene. 61(1): 12-17.

Domingo J. L. (2016). Nutrients and chemical pollutants in fish and shellfish. Balancing health benefits and risks of regular fish consumption. Critical Reviews in Food Science and Nutrition. 56(6): 979-988.

Fallah A. A., Siavash Saei-Dehkordi S. & Nematollahi A. (2011). Comparative assessment of proximate composition, physicochemical parameters, fatty acid profile and mineral content in farmed and wild rainbow trout (*Oncorhynchus mykiss*). International Journal of Food Science & Technology. 46(4): 767-773.

FAO (2024). The State of World Fisheries and Aquaculture: Opportunities and Challenges. Rome: Food and Agriculture Organization of the United Nations.

Francis L. G., Aming M. F., Idris S. I. M., Mazlan N., Othman R., Fui C. F., Shapawi R. & Shah M. D. (2024). Comparison of nutritional compositions and heavy metals analysis between wild and farmed Tilapia (*Oreochromis* sp.) and Asian Seabass (*Lates* sp.) in Sabah, Malaysia. Journal of Food Composition and Analysis. 133: 106467.

Fuentes A., Fernández-Segovia I., Serra J. A. & Barat J. M. (2010). Comparison of wild and cultured sea bass (*Dicentrarchus labrax*) quality. Food Chemistry. 119(4): 1514-1518.

Garduño Lugo M., Herrera Solís J. R., Angulo Guerrero J. O., Muñoz Córdova G. & la Cruz Medina D. (2007). Nutrient composition and sensory evaluation of fillets from wild-type Nile tilapia (*Oreochromis niloticus, Linnaeus*) and a red hybrid (*Florida red tilapia× red O. niloticus*). Aquaculture Research. 38(10): 1074-1081.

Goebel S. E., Gaye-Siessegger J., Baer J. & Geist J. (2017). Comparison of body composition and sensory quality of wild and farmed whitefish (*Coregonus macrophthalmus [Nüsslin, 1882]*). Journal of Applied Ichthyology. 33(3): 366-373.

González S., Flick G. J., O'keefe S. F., Duncan S. E., McLean E. & Craig S. R. (2006). Composition of farmed and wild yellow perch (*Perca flavescens*). Journal of Food Composition and Analysis. 19(6-7): 720-726.

Grigorakis K. (2007). Compositional and organoleptic quality of farmed and wild gilthead sea bream (*Sparus aurata*) and sea bass (*Dicentrarchus labrax*) and factors affecting it: A review. Aquaculture. 272(1-4): 55-75.

Grigorakis K. (2017). Fillet proximate composition, lipid quality, yields, and organoleptic quality of Mediterranean-farmed marine fish: A review with emphasis on new species. Critical Reviews in Food Science and Nutrition. 57(14): 2956-2969.

Grigorakis K., Fountoulaki E., Vasilaki A., Mittakos I. & Nathanailides C. (2011). Lipid quality and filleting yield of reared meagre (*Argyrosomus regius*). International Journal of Food Science & Technology. 46(4): 711-716.

Gu Z., Eils R. & Schlesner M. (2016). Complex heatmaps reveal patterns and correlations in multidimensional genomic data. Bioinformatics.

Klanian M. G. & Alonso M. G. (2015). Sensory characteristics and nutritional value of red drum *Sciaenops ocellatus* reared in freshwater and seawater conditions. Aquaculture Research. 46(7): 1550-1561.

Haard N. F. (1992). Control of chemical composition and food quality attributes of cultured fish. Food Research International. 25(4): 289-307.

Hearn T. L., Sgoutas S. A., Hearn J. A. & Sgoutas D. S. (1987). Polyunsaturated fatty acids and fat in fish flesh for selecting species for health benefits. Journal of Food Science. 52(5): 1209-1211.

Hossain M. A. (2011). Fish as source of n-3 polyunsaturated fatty acids (PUFAs), which one is better-farmed or wild. Advance Journal of Food Science and Technology. 3(6): 455-466.

Jensen I. J., Larsen R., Rustad T. & Eilertsen K. E. (2013). Nutritional content and bioactive properties of wild and farmed cod (*Gadus morhua L.*) subjected to food preparation. Journal of Food Composition and Analysis. 31(2): 212-216.

Jiang H., Cheng X., Geng L., Tang S., Tong G. & Xu W. (2017). Comparative study of the nutritional composition and toxic elements of farmed and wild *Chanodichthys mongolicus*. Chinese Journal of Oceanology and Limnology. 35(4): 737-744.

Johnston I. A., Li X., Vieira V. L. A., Nickell D., Dingwall A., Alderson R., Campbell P. & Bickerdike R. (2006). Muscle and flesh quality traits in wild and farmed Atlantic salmon. Aquaculture. 256(1-4): 323-336.

Kalantzi I., Black K. D., Pergantis S. A., Shimmield T. M., Papageorgiou N., Sevastou K. & Karakassis I. (2013). Metals and other elements in tissues of wild fish from fish farms and comparison with farmed species in sites with oxic and anoxic sediments. Food Chemistry. 141(2): 680-694.

Kendler S., Yilmaz O., Jakobsen A. N., Mangor-Jensen A. & Lerfall J. (2024). European plaice (*Pleuronectes platessa*) in aquaculture–Nutritional, chemical, and physicochemical quality compared to wild stocks. Aquaculture. 592: 741163.

Kent M. (1985). Water in fish: Its effects on quality and processing. In: Simatos D. & Multon J. L. (Eds.). Properties of Water in Foods. The Netherlands: Martins Nijhoff Dordrecht: 573-590

Lall S. P. & Milley J. E. (2008). Trace mineral requirements of fish and crustaceans. In: Schlegel P., Durosay S. & Jongbloed A. W. (Eds.). Trace elements in animal production systems. Wageningen: Academic Press: 203-214

Lenas D., Chatziantoniou S., Nathanailides C. & Triantafillou D. (2011). Comparison of wild and farmed sea bass (*Dicentrarchus labrax L*) lipid quality. Procedia Food Science. 1: 1139-1145.

Loukas V., Dimizas C., Sinanoglou V. J. & Miniadis-Meimaroglou S. (2010). EPA, DHA, cholesterol and phospholipid content in *Pagrus pagrus* (cultured and wild), *Trachinus draco* and *Trigla lyra* from Mediterranean Sea. Chemistry and physics of lipids. 163(3): 292-299.

Lundebye A.-K., Lock E.-J., Rasinger J. D., Nøstbakken O. J., Hannisdal R., Karlsbakk E., Wennevik V., Madhun A. S., Madsen L. & Graff I. E. (2017). Lower levels of persistent organic pollutants, metals and the marine omega 3-fatty acid DHA in farmed compared to wild Atlantic salmon (*Salmo salar*). Environmental Research. 155: 49-59.

Mairesse G., Thomas M., Gardeur J.-N. & Brun-Bellut J. (2006). Effects of geographic source, rearing system, and season on the nutritional quality of wild and farmed *Perca fluviatilis*. Lipids. 41(3): 221-229.

Mirmiran P., Hosseini-Esfahani F., Esfandiar Z., Hosseinpour-Niazi S. & Azizi F. (2022). Associations between dietary antioxidant intakes and cardiovascular disease. Scientific reports. 12(1): 1504.

Mnari A., Bouhlel I., Chraief I., Hammami M., Romdhane M. S., El Cafsi M. & Chaouch A. (2007). Fatty acids in muscles and liver of Tunisian wild and farmed gilthead sea bream, *Sparus aurata*. Food Chemistry. 100(4): 1393-1397.

Modzelewska-Kapituła M., Pietrzak-Fiećko R., Zakęś Z. & Szczepkowski M. (2017). Assessment of Fatty Acid Composition and Technological Properties of Northern Pike (*Esox lucius*) Fillets: The Effects of Fish Origin and Sex. Journal of Aquatic Food Product Technology. 26(10): 1312-1323.

Molversmyr E., Devle H. M., Naess-Andresen C. F. & Ekeberg D. (2022). Identification and quantification of lipids in wild and farmed Atlantic salmon (*Salmo salar*), and salmon feed by GC-MS. Food science & nutrition. 10(9): 3117-3127.

Mufas A. & Perera O. (2013). Study on development of pitaya fruit (Hylocereus undatus) incorporated ice cream; an alternative solution to the pitaya cultivators in Sri Lanka.

Murillo E., Rao K. S. & Durant A. A. (2014). The lipid content and fatty acid composition of four eastern central Pacific native fish species. Journal of Food Composition and Analysis. 33(1): 1-5.

Mustafa O. Z. & Dikel S. (2015). Comparison of body compositions and fatty acid profiles of farmed and wild rainbow trout (*Oncorhynchus mykiss*). Food Science and Technology. 3(4): 56-60.

O'Neill B., Le Roux A. & Hoffman L. C. (2015). Comparative study of the nutritional composition of wild versus farmed yellowtail (*Seriola lalandi*). Aquaculture. 448: 169-175.

Olsson G. B., Olsen R. L., Carlehög M. & Ofstad R. (2003). Seasonal variations in chemical and sensory characteristics of farmed and wild Atlantic halibut (*Hippoglossus hippoglossus*). Aquaculture. 217(1-4): 191-205.

Orban E., Di Lena G., Ricelli A., Paoletti F., Casini I., Gambelli L. & Caproni R. (2000). Quality characteristics of sharpsnout sea bream (*Diplodus puntazzo*) from different intensive rearing systems. Food Chemistry. 70(1): 27-32.

Orban E., Lena G. D., Nevigato T., Casini I., Santaroni G., Marzetti A. & Caproni R. (2002). Quality characteristics of sea bass intensively reared and from lagoon as affected by growth conditions and the aquatic environment. Journal of Food Science. 67(2): 542-546.

Orban E., Nevigato T., Lena G. D., Casini I. & Marzetti A. (2003). Differentiation in the lipid quality of wild and farmed seabass (*Dicentrarchus labrax*) and gilthead sea bream (*Sparus aurata*). Journal of Food Science. 68(1): 128-132.

Ørnholt-Johansson G., Frosch S. & Jørgensen B. M. (2017). Variation in some quality attributes of Atlantic salmon fillets from aquaculture related to geographic origin and water temperature. Aquaculture. 479: 378-383.

Otwell W. S. & Rickards W. L. (1981). Cultured and wild American eels, Anguilla rostrata: fat content and fatty acid composition. Aquaculture. 26(1-2): 67-76.

Özden Ö. & Erkan N. (2008). Comparison of biochemical composition of three aqua cultured fishes *(Dicentrarchus labrax, Sparus aurata, Dentex dentex*). International Journal of Food Sciences and Nutrition. 59(7-8): 545-557.

Özden Ö., Erkan N. & Ulusoy Ş. (2010). Determination of mineral composition in three commercial fish species (*Solea solea*, *Mullus surmuletus*, and *Merlangius merlangus*). Environmental Monitoring and Assessment. 170(1): 353-363.

Periago M. J., Ayala M. D., López-Albors O., Abdel I., Martinez C., García-Alcázar A., Ros G. & Gil F. (2005). Muscle cellularity and flesh quality of wild and farmed sea bass, *Dicentrarchus labrax* L. Aquaculture. 249(1-4): 175-188.

Petricorena Z. C. (2014). Chemical Composition of Fish and Fishery Products. In: Cheung P. C. K. & Bhavbhuti M. M. (Eds.). *Handbook of Food Chemistry*. Verlag Berlin Heidelberg: Springer: 1-28.

Piccolo G., De Riu N., Tulli F., Cappuccinelli R., Marono S. & Moniello G. (2007). Somatic indexes, chemical-nutritive characteristics and metal content in caught and reared sharpsnout seabream (*Diplodus puntazzo*). Italian Journal of Animal Science. 6(4): 351-360.

Polymeros K., Kaimakoudi E., Schinaraki M. & Batzios C. (2015). Analysing consumers' perceived differences in wild and farmed fish. British Food Journal. 117(3): 1007-1016.

Qiu Y.-W., Lin D., Liu J.-Q. & Zeng E. Y. (2011). Bioaccumulation of trace metals in farmed fish from South China and potential risk assessment. Ecotoxicology and Environmental Safety. 74(3): 284-293.

Rasul M. G., Jahan I., Yuan C., Sarkar M. S. I., Bapary M. A. J., Baten M. A. & Shah A. A. (2021). Seasonal variation of nutritional constituents in fish of South Asian Countries: A review. Fundamental and Applied Agriculture. 6(2): 193–209-193–209.

Reig L., Escobar C., Carrassón M., Constenla M., Gil J. M., Padrós F., Piferrer F. & Flos R. (2019). Aquaculture perceptions in the Barcelona metropolitan area from fish and seafood wholesalers, fishmongers, and consumers. Aquaculture. 510: 256-266.

Rincón L., Castro P. L., Álvarez B., Hernández M. D., Álvarez A., Claret A., Guerrero L. & Ginés R. (2016). Differences in proximal and fatty acid profiles, sensory characteristics, texture, colour and muscle cellularity between wild and farmed blackspot seabream (*Pagellus bogaraveo*). Aquaculture. 451: 195-204.

Rodrigues A. P. O., Bicudo Á. J. A., Moro G. V., Gominho-Rosa M. d. C. & Gubiani É. A. (2022). Muscle amino acid profile of wild and farmed pirarucu (*Arapaima gigas*) in two size classes and an estimation of their dietary essential amino acid requirements. Journal of Applied Aquaculture. 34(2): 441-455.

Roy P. K. & Lall S. P. (2006). Mineral nutrition of haddock *Melanogrammus aeglefinus* (L.): a comparison of wild and cultured stock. Journal of Fish Biology. 68(5): 1460-1472.

Saavedra M., Pereira T. G., Carvalho L. M., Pousão-Ferreira P., Grade A., Teixeira B., Quental-Ferreira H., Mendes R., Bandarra N. & Gonçalves A. (2017). Wild and farmed meagre, *Argyrosomus regius*: A nutritional, sensory and histological assessment of quality differences. Journal of Food Composition and Analysis. 63: 8-14.

Sağglık S., Alpaslan M., Gezgin T., Çetintürkc K., Tekinay A. & Güven K. C. (2003). Fatty acid composition of wild and cultivated gilthead seabream (Sparus aurata) and sea bass (Dicentrarchus labrax). European Journal of Lipid Science and Technology. 105(2): 104-107.

Sant'Ana L. S., Ducatti C. & Ramires D. G. (2010). Seasonal variations in chemical composition and stable isotopes of farmed and wild Brazilian freshwater fish. Food Chemistry. 122(1): 74-77.

Scheuer F., Sterzelecki F. C., Wagner R., Xavier A. C., de Souza M. P., Brasil E. M., Fracalossi D. & Cerqueira V. R. (2024). Proximate and fatty acids composition in the muscle of wild and farmed sardine (*Sardinella brasiliensis*). Food Chemistry Advances. 4: 100637.

Shearer K. D. (1994). Factors affecting the proximate composition of cultured fishes with emphasis on salmonids. Aquaculture. 119(1): 63-88.

Siano F., Bilotto S., Nazzaro M., Russo G. L., Di Stasio M. & Volpe M. G. (2017). Effects of conventional and organic feed on the mineral composition of cultured European sea bass (*Dicentrarchus labrax*). Aquaculture Nutrition. 23(4): 796-804.

Storebakken T., Hung S. S. O., Calvert C. C. & Plisetskaya E. M. (1991). Nutrient partitioning in rainbow trout at different feeding rates. Aquaculture. 96(2): 191-203.

Suzuki H., Okazaki K., Hayakawa S., Wada S. & Tamura S. (1986). Influence of commercial dietary fatty acids on polyunsaturated fatty acids of cultured freshwater fish and comparison with those of wild fish of the same species. Journal of Agricultural and Food Chemistry. 34(1): 58-60.

Tacon A. G. J. & Metian M. (2013). Fish matters: importance of aquatic foods in human nutrition and global food supply. Reviews in Fisheries Science. 21(1): 22-38.

Thanh C., Mith H., Peng C., Servent A., Poss C., Laillou A., Phal S. & Avallone S. (2024). Assessment of the nutritional profiles and potentially toxic elements of wild and farmed freshwater fish in Cambodia. Journal of Food Composition and Analysis. 133: 106357.

Tkaczewska J., Migdał W. & Kulawik P. (2014). The quality of carp (*Cyprinus carpio* L.) cultured in various Polish regions. Journal of the Science of Food and Agriculture. 94(14): 3061-3067.

Valente L. M. P., Cornet J., Donnay-Moreno C., Gouygou J.-P., Berge J.-P., Bacelar M., Escórcio C., Rocha E., Malhão F. & Cardinal M. (2011). Quality differences of gilthead sea bream from distinct production systems in Southern Europe: Intensive, integrated, semi-intensive or extensive systems. Food Control. 22(5): 708-717.

Wang F., Ma X., Wang W. & Liu J. (2012). Comparison of proximate composition, amino acid and fatty acid profiles in wild, pond-and cage-cultured longsnout catfish (*Leiocassis longirostris*). International Journal of Food Science & Technology. 47(8): 1772-1776.

Wang Y., Yu S., Ma G., Chen S., Shi Y. & Yang Y. (2014). Comparative study of proximate composition and amino acid in farmed and wild *Pseudobagrus ussuriensis* muscles. International Journal of Food Science & Technology. 49(4): 983-989.

Webb E. C. & O'neill H. A. (2008). The animal fat paradox and meat quality. Meat Science. 80(1): 28-36.

WHO guideline (2023). Saturated fatty acid and trans-fatty acid intake for adults and children. Geneva: World Health Organization; 2023. Licence: CC BY-NC-SA 3.0 IGO.

Wood J. D., Enser M., Fisher A. V., Nute G. R., Sheard P. R., Richardson R. I., Hughes S. I. & Whittington F. M. (2008). Fat deposition, fatty acid composition and meat quality: A review. Meat Science. 78(4): 343-358.

Yeannes M. I. & Almandos M. E. (2003). Estimation of fish proximate composition starting from water content. Journal of Food Composition and Analysis. 16(1): 81-92.

Yildiz M. (2008). Mineral composition in fillets of sea bass (*Dicentrarchus labrax*) and sea bream (*Sparus aurata*): a comparison of cultured and wild fish. Journal of Applied Ichthyology. 24(5): 589-594.