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An extensive review of human health benefits from consuming farmed or wild fish with special reference to gilthead seabream (*Sparus aurata*)

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ABSTRACT

In public, there is a significant concern regarding the safety and quality of farmed fish that poses problems for fish farmers in marketing. There is widespread recognition that farmed fish are less healthy than their wild equivalent, mostly attributed to unhealthy farm conditions or the ingredients used in artificial diets for aquaculture. However, the nutritional quality of farmed -or wild-caught fish may differ based on regional variation or a cultural environment's complex aspects. Whether farmed or wild fish provide better product quality is a long-standing matter for consumer preferences and marketing. Information was collected from a wide range of references through an extensive literature review, and detailed evaluations were made on the health levels of cultured fish and natural fish in human consumption. Therefore, the present study provides an extensive review to address the differences in the nutritional contribution of farmed and wild fish for human consumers. Addressing the questions arising from consumers' concerns will undoubtedly support farmers in their challenging marketing efforts.

Keywords: Consumer concern, Social awareness, Healthy food, Cultured fish, Food safety

Introduction

Limited freshwater resources and land available for agricultural production brought new challenges to seeking alternative food sources to meet the increasing demand from human consumers worldwide. With this respect, a common view is that the production of aquatic foods will need to expand globally to meet population-driven demand (Naylor et al., 2021). Capture fisheries can no longer meet the global demand for fish, making aquaculture the most possible alternative for supporting increased fish consumption (López-Mas et al., 2021). Stabilising fishing yields and using technological equipment such as sonars and eco-sounders in fishing vessels increase the pressure on wild populations that may not increase within the present state of fishing operations. World fish production was reported at around 180 million tons (Mt) in 2018, with a total first sale value estimated at USD 401 billion, of which 82 Mt (valued at USD 250 billion) was supplied by aquaculture production. Out of the total production, 156.4 Mt (FAO, 2020) were used for human consumption, equivalent to an estimated annual supply of 20.5 kg per capita (FAO, 2020) for a World population of 7.6 billion in 2018 (FAO, 2020). The production of aquatic animals in 2018 was dominated by finfish (54.3 Mt, valued 139.7 billion US$), harvested from inland aquaculture (46.9 Mt, valued 104.3 billion US$) as well as marine and coastal aquaculture facilities (7.3 Mt, valued 35.4 billion US$) (FAO, 2020). Cage aquaculture, the locomotive of the fish production sector, is in a rapid growth period and operates in more exposed sites nowadays (Bostock et al., 2010). Cage aquaculture in the Mediterranean was initiated in near-shore sites with wooden-framed floating constructions and shallow net depth in the early 80s with gilthead seabream and European seabass juveniles collected from the nature during the spring season when juveniles remain in shallow coastal waters. With the development of technological and innovative equipment, limitations of in-shore suitable sites, and increasing public concern about environmental impacts from fish farming, these farms have been moved to more exposed sites with the extension of cage size and net volumes. Since then, cage aquaculture has been in a rapid growth period and is considered the locomotive of the fish production sector that has recently been operating in more exposed sites (Bostock et al., 2010) with a production of over 7.3 Mt of fish in 2018 (FAO, 2021). Even though cage systems are operating in very exposed sites today, with strict control mechanisms of local governments in terms of environmental impact assessment and best management practices with the consideration of carrying capacity estimations, there is still remarkable concern in society with questions unclear for consumers in regards to the faster growth of farmed fish compared to the wild populations of same species and whether the farmed fish is safe for human consumption. The consumers' general belief that farmed fish grow faster than their respective equivalents caught from nature is mainly attributed to unfavourable conditions in the culture environment or even to dietary ingredients used in aqua-feeds, which is a set of problems for fish farmers in marketing. However, the nutritional quality of farmed -or wild-caught fish may depend on regional conditions or a complex of aspects in the cultural environment. Whether farmed or wild fish provide better flesh quality is a long-standing matter for consumer preferences and marketing challenges. The image of farmed fish among consumers is less positive compared to their respective wild-caught individuals, and images of food products are mainly affected by consumers' choices, which are highly advised to consider in marketing strategies of fishery products (López-Mas et al., 2021).

The gilthead seabream (*Sparus aurata*) is one of the main fish species dominating the Turkish marine aquaculture industry, with a harvest yield of over 130.000 tons out of a total of 467.048 tons in 2021 (Yigit et al., 2023). Therefore, the present review aims to provide information for understanding the differences in fish growth between farmed individuals, particularly in seabream versus natural fish populations, with a comparative evaluation of age-growth relation and supply helpful information for fish farmers in challenging marketing efforts as well as for consumers relieve in terms concerning food safety and food quality.

Developing Resistant Cage Nettings: Reduced Risks of Net Ruptures and Fish Escapes

Among different fish production systems, marine aquaculture operating in exposed sites uses flexible but durable materials resistant to heavy storms and typhoons. Different from the early 80s, cage farming operating at the very edge of limits today is considered one of the most dangerous industrial activities with high safety risks forced by heavy storms and hurricanes (Holmen et al., 2017). Therefore, the strength, durability, and flexibility of the material used in cage construction are very important and need high technology. Offshore cage aquaculture, a rapidly growing industry in exposed sea conditions (Bostock et al., 2010), supplies high-quality food of over seven million tons of fish (FAO, 2021), covering an important amount of the food demand for the growing world population. Resistant offshore cage systems, successfully used in Mediterranean aquaculture today, result from long-term experience and know-how. However, remarkable public concerns remain about fish escaping from cage nets due to operational failures or technical damage to nettings, cage components and structures in heavy storms (Arechavala-López et al., 2012). However, based on technological developments, cage systems' strength and resistance have increased. Further, using ultrahigh molecular weight polyethene (UHMWPE) nets in aquaculture provided high performance in terms of resistance and strength. Nowadays, more and more farms replace traditional nylon nettings with strength UHMWPE nets (personal communications: Melih Geçgil, Operation and Logistics Director of Kılıç Co. 07.03.2021 (RIP 11.04.2021); Huseyin Cakir, Founder of Cakir Fishing Co. 20.10.2020; Huseyin Ek, CEO of Akuakare Co. 23.08.2021. Alternatively, during the last decade, research efforts have been made to introduce high-strength antimicrobial and anti-biofouling copper alloy mesh material for aquaculture economies (Yigit et al., 2017).

Growth Performance and Welfare of Farmed Versus Wild Fish: Conditions and Impacts

Numerous studies on age, growth, reproduction, feeding behaviour, etc., are available in farmed fish, in contrast to their respective wild-caught equivalents in the Mediterranean (Chaoui et al., 2006). Reports on farmed fish are more comprehensive, with consistent findings. In contrast, studies on wild-caught fish populations provide a wide range of results due to the characteristics of the environment at optimum -or near optimum levels in farm conditions versus year-around variations in the natural environment. A direct comparison of growth between farmed fish and wild populations might be misleading. It may not accurately focus on growth performance in two different environmental conditions.

Growth of fish, whether in farm conditions or the natural habitat, is a complex process depending on several biotic or abiotic factors of environmental conditions including photoperiod (Wendelaar-Bonga, 2011), temperature (Carriquiriborde et al., 2009), salinity (Tipsmark et al., 2004), dissolved oxygen, pH (Kestemont & Baras, 2001), elevated nitrogenous compounds of nitrite and ammonia (Schram et al., 2010), food intake, diet characteristics and quality, management practices, stocking densities, species and genetic differences (Lanari et al., 2002), predator effects, or a combination and interaction of all these factors (Imsland et al., 2001). Further, feed quality and feeding strategies may influence fish growth; in their comprehensive report, Hernández et al. (2003) underlined that ration size affected growth, reducing the time to reach market size. No significant differences were observed when fish were fed at 80 or 100% ration size. However, growth performance declined significantly when the feeding rate was reduced to 60% of the normal ration size. Further, the authors explained that the growth performance was strongly related to geographical areas. Regardless of the ratio size, it was noted that the time required for a seabream to reach any size was shorter in the Atlantic than in the Mediterranean area.

Overall, the control of foraging and feed intake is related to interactions between the brain and the signal from the surrounding aquatic environment via sensory information transferred through hormones and nutrient molecules in the blood system that either stimulate or prevent food intake (Nguyen, 2015). Unlike wild individuals, fish in culture conditions are protected from the peripheral environment with easy access to abundant food and typically without predators (Arechavala-López, 2012). The wild individuals, however, have to protect themselves against circumjacent predators, leading to a significant amount of energy expenditure for sheltering or hiding efforts, tissue recovery and performance loss from wounds (Sinclair et al., 2011). Stressful conditions may decrease appetite and voluntary feed intake, which is reported as one of the main reasons for growth suppression in fish (Wendelaar-Bonga, 1997).

When estimating dietary energy requirements or tissue deposition and growth utilisation, a wide variation can be noted among different species or fish sizes within the same species based on tissue composition and utilisation efficiency (Lupatsch, 2005). Generally, fish in favourable conditions without stress, and the energy budget is partitioned into five parts (Tort, 2011). Removing the basic metabolic needs, the fish in a no-stress environment assign their energy to growth. Fish going through mating and reproduction may shift a significant part of the energy absorbed from food into use for reproduction rather than growth. When fish encounter stress, the requirement level for energy to maintain growth or reproduction will be increased (Tort, 2011). Reaching the highest growth rate at harvest with a minimum cost and per cent share of feed expenses, which comprises around 60% of the total operational and production costs (Ergün et al., 2020), is the main goal in aquaculture facilities. Hence, preventing stress factors or minimising stress levels is a challenge in aquaculture management for increased productivity on fish farms.

Unlike the wild populations, the only competition in farm conditions that fish encounter is due to the crowding effect strongly related to stocking densities, which is a matter of management practice. A fish stocking rate of around 20-25 kg per cubic meter is common in commercial seabream culture in Mediterranean cage farming. Sánchez-Muros et al. (2017) did not observe any differences in cortisol levels as an indicator of stress condition in fish kept at a biomass level of 20 kg/m^3 compared to those cultured at a lower density of 5 kg/m^3 stocking rate; however, fish reared at higher biomass densities presented a significantly reduced growth performance compared to the lower biomass condition. Batzina et al. (2014) reported less aggressive behaviour in seabream juveniles with more even distribution at higher stocking rates of 9.7 to 29.9 kg/m^3, compared to those kept in lower densities of 4.9 to 14.7 kg/m^3, attributed to a more favourable social environment in higher stocking rates, that probably provides an ambient similar to the natural habitat in terms of socialised fish schooling behaviour for farmed individuals.

In nature, wild fish are challenged in a competitive environment in many aspects, not only in foraging but also in hiding from predators, breeding and mating, habitat settlement or migration behaviours, which are under the severe influence of various environmental conditions. These matters affect the growth progress of natural fish populations if the fishermen do not capture them. Among different environmental impacts, marine currents or the availability of sufficient food resources, for example, may influence biological aspects of migration behaviour or habitat use, which is still a significant area of investigation, and there is a lack of information about the structural knowledge in general (Rossi et al., 2006).

Several reasons, such as biomass control, improved fish welfare, good feeding practices, and management regimes, might be the key to parasite-free fish under farm conditions. Besides, the anti-microbial and anti-fouling properties of the nettings are also important to ensure a parasite-free cage environment. Parasites, with their deleterious effects, may invade, move around or grow in -or on the fish and influence growth performance, survival, or even the reproductive efficiency and fitness of the farmed fish (Barber et al., 2000). Biofouling development on cage mesh may host parasites and other pathogens, which, in time, pass over and invade the fish, especially at reduced welfare conditions of physiological imbalance or general malaise, resulting in disease and severe losses at extreme conditions. Hence, nets used in cage farms are treated with antifouling coats to prevent biofouling and attachment of sessile organisms such as algae or mussels on the mesh. Therefore, the aquaculture industry's rapid growth, challenging the sustainability of coastal ecosystems and economies, can only reach high profits with good farm management set forward to produce disease-free fish with improved welfare.

Various reliable data are available on wild seabream's age-length or length-weight relations. However, most of these studies are on a regional and local basis. Also, different fish species show different genetic patterns, such as the case of seabream compared to seabass (Arechavala-López, 2012). Some earlier studies reported that wild seabream displayed a slight genetic variation among the Mediterranean populations, but these differences were unrelated to geographical factors (Palma et al., 2001; Rossi et al., 2006). However, a genetic variation between the wild populations from the Atlantic and the Mediterranean and within the wild individuals from the Mediterranean has been identified using fine-scale differences (De Innocentiis et al., 2004). Seasonal migration of wild populations and consequences of inter-crossing between neighbour populations might be a reason for the slight genetic variation (Palma et al., 2001), which can explain the discrepancies among earlier studies. Despite some divergences, these studies prove the differentiation between wild populations and farmed specimens (Arechavala-López, 2012).

Considering the findings of Al-Zahaby et al. (2018), a 3-year wild seabream weighing around 390 g would correspond to the harvest size of a farmed seabream grown in a cage farm for a year and a half, depending on water temperature (Lupatsch, 2005). Clear evidence for the significant influence of water temperature on gilthead seabream growth was presented by Hernández et al. (2003). According to the growth prediction of Lupatsch (2005), seabream was reported to have higher growth potential than seabass. It may attain 380 g after 12 months, starting from an initial stocking size of 1 g. In contrast, seabass reached an average body weight of 325 g within the same production period while feeding on the same diet as the seabream (45% protein, 19% lipid, 21.2 gross energy). Similarly, in a comparative study carried out in a commercial earth pond facility supplied with ground brackish water of 7‰ salinity, Altan (2020) reported that both seabream and seabass with an initial body weight of 1.6 g reached over 300 g after 20 months at 19 °C water temperature, with slightly higher harvest weight for the seabream (369.1±24.1 g) compared to seabass (328.4±22.9 g).

Nutritional Quality -and Contribution of Farmed Versus Wild Fish

The nutritional quality of farmed -or wild fish differs according to the complex aspects of the cultural conditions and regional characteristics of the marine environment. Profiles of amino acids (AAs) and fatty acids (FAs) in fish meat are important sources of high-quality protein and lipid with health potentials for human consumers (Öztekin et al., 2018, 2020).

Nutritional Quality Level of Amino Acids

The protein quality can be addressed with the availability of amino acids, especially essential amino acids (Jiang et al., 2017). Fish feeds used in aquaculture facilities depend on fishmeal and fish oil processed from wild fisheries. These two commonly used marine resources are scarce due to the increasing demand for aquaculture's rapid growth worldwide. The aquaculture sector is forced to replace fishmeal and fish oil with other sources rich in the amino acid pattern but low in cost, which can reduce feed expenses and increase competition in global marketing. Plant proteins are the strongest candidates for replacing fishmeal and oil (Dubois et al., 2007). Among them, soybean meal is one of the strongest alternatives for the replacement of fish-based protein and oil sources (Alam et al., 2014), which eventually helps to reduce feed costs comprising around 60% of the total production costs in fish farms, as stated earlier by Ergün et al. (2020). The substitution of fishmeal with plant-based proteins might differentiate the amino acid composition of the diet and change body composition as well as the nutritional quality of farmed fish in general.

A wide range of amino acid profiles in farmed fish are reported with discrepancies in several studies, that could be attributed to the different fish species (Mohanty et al., 2014), diet quality and processing techniques of ingredients (Kim et al., 2012; Wang et al., 2014), or even to the water quality changes in the culture environment, as well as feed storage conditions (Wang et al., 2014). Among essential amino acids, methionine, lysine, tyrosine, histidine, and tryptophan may show antioxidant effects (Saito et al., 2003). Others, such as glycine, proline, leucine, glutamine, and aspartic acid, play an important role in cytotoxic activity against cancer cells (Kim et al., 1999). Arginine improves disease resistance when fish are exposed to stress conditions (Costas et al., 2011), while methionine is a stimulator for protein synthesis, supporting cell survival (Belghit et al., 2014).

Earlier reports provided interesting findings in terms of higher concentrations of glutamic acid and serine and lower levels of methionine, lysine, isoleucine, valine, threonine, glycine, and aspartic acid levels in fish-fed soybean meal incorporated diets compared to those fed on fishmeal-based diets (Kim et al., 2012). Wild fish schooling around cage farms might change their body amino acid profiles by feeding on the abundant pellets around the cage systems (Skog et al., 2003). This was supported by Fernandez-Jover et al. (2008), who underlined that wild fish aggregating around fish farms significantly consume pellets lost from fish cages, which might differentiate their feeding behaviour and affect natural fish populations through a slight change in their amino acid profiles. Therefore, it is likely that wild fish schooling around fish cages consume remarkable amounts of pellets lost from the pens, which might change the amino acid profiles in wild fish captured from marine sites dominated by cage farms (Oztekin et al., 2020).

Higher levels of essential amino acids (valine, threonine, isoleucine, and phenylalanine) and non-essential amino acids (glycine, alanine, and tyrosine) were found in the muscles of wild seabream compared to the caged fish or those aggregating around the pens (Oztekin et al., 2020). However, these differences were insignificant ($p<0.05$) except for the methionine among all three populations, namely caged fish, cage-aggregated wild and wild captured from a distance from the cage facility. In contrast, the authors reported higher levels of non-essential amino acids of serine, glutamic acid, and hydroxylysine in caged -and cage-aggregated seabream than those captured from wild populations from a distant area (Oztekin et al., 2020).

Higher total essential amino acids (∑EAA) and lower total non-essential amino acids (∑NEAA) compared to farmed or farm-aggregated individuals axillary seabream (*Pagellus et al.* et al., 2020), in meagre (*Argyrosomus regius*, Saavedra et al., 2017), ussuri catfish (*Pseudobagrus ussuriensis*, Wang et al., 2014), beluga sturgeon (*Huso huso*, Hamzeh et al., 2015), and barramundi (*Lates calcarifer*, Manthey-Karl et al., 2016). However, higher levels of EAAs were found in farmed seabass, turbot (*Scophthalmus maximus*), and red tail (*Chanodichthys mongolicus*), compared to wild-caught fellows by Baki et al. (2015), Manthey-Karl et al. (2016), and Jiang et al. (2017), respectively. In fish species captured from different marine sites and culture conditions, Manthey-Karl et al. (2016) pointed out differences in amino acid profiles between turbot captured from wild populations in the Atlantic Ocean and those cultured in fish farms in Spain or Chile. Manthey-Karl et al. (2016) also investigated amino acid levels for wild-caught. They farmed barramundi in Australia and Vietnam, where the authors stated that the environmental conditions of water quality or feed storage conditions could affect amino acid profiles in fish meat.

Several earlier reports provided similar ratios of total essential amino acids to total amino acid levels (∑EAA/∑AA) for farmed versus wild marine fishes; namely, 43.02, 50.81, 39.84, 45.10, 44.3% for farmed -and 42.78, 51.35, 40.33, 45.77, 46.5% for wild unsure catfish (Wang et al., 2014), Beluga sturgeon (Hamzeh et al., 2015), red tail (Jiang et al., 2017), meagre (Saavedra et al., 2017), and axillary seabream (Öztekin et al., 2020) respectively. These ratios of ∑EAA/∑AA were comparable with the ratio given for Egg (50%) as a reference value in reports of FAO/WHO (1989) or even higher than the recommended reference value of 40% for ∑EAA/∑AA by FAO/WHO (1991).

The recommended reference value for the total essential amino acids to total non-essential amino acids (∑EAA/∑NEAA) has been reported as 40% by FAO/WHO

(1991). Oztekin et al. (2020) reported ∑EAA/∑NEAA ratio as 79.6% in cage-farmed seabream in the Northern Aegean Sea, whereas a slightly higher ratio of 86.8% was noted in wild-caught fish, which was higher than the which was higher than the recommended reference value of >60% in FAO/WHO (1991) reports, underlining that seabream either farmed in fish pens or caught from natural populations provide a remarkable high level of nutritional contribution in terms of a high-quality-protein-source for human consumers.

Any source of protein showing an amino acid score less than 1 (AAS <1), the reference amino acid level reported by FAO/WHO (1973), needs further supplementation from another protein source in order to meet the sufficient level of protein in the human diet. Overall, higher levels of AASs were recorded in wild unsure catfish (Wang et al., 2014) and red tails (Jiang et al., 2017). In axillary seabream, however, Oztekin et al. (2020) found AASs higher than "1" (>1.00) in both farmed and wild individuals, except for lysine and leucine, indicating that both farmed and wild seabream provide sufficiently high nutritional quality in terms of amino acid profiles as a favourable protein source, with the only exception for lysine and leucine, indicating that lysine and leucine are the "first limiting" amino acids in seabream and the requirements of lysine and leucine in human diets, estimated below "1", need to be supplied by another source of protein.

Farmed fish seems to be a reliable marine food in terms of a high-quality protein source for human consumers. Based on recommended reference levels by FAO/WHO (1973, 1991), its nutritional contribution of amino acid profiles is not less but even higher than that of their wild representatives.

Nutritional Quality Level of Fatty Acids

Higher lipid levels in caged axillary seabream compared to wild individuals were reported by Oztekin et al. (2018). Twice more lipid levels in farmed fish over their wild representatives were reported in axillary seabream. Similar findings were reported in farmed versus wild salmon (Johnston et al., 2006), seabream (Grigorakis, 2007), and meagre (Saavedra et al., 2017). Johnston et al. (2006) reported that the higher fat levels in farmed fish compared to the wild fellows could be linked to the higher fat concentrations in the aquadiets as well as the feeding frequency or a wide range of several factors such as plenty food availability in farm conditions, dietary ingredients, and the higher energy consumption of fish in culture conditions over the wild populations (Grigorakis et al., 2002), which was also supported by Öztekin et al. (2018). The fatty acid profile of fish can differ based on several factors, such as the lipid source used in the diet, water temperature, salinity, or seasonal changes (Yildiz et al., 2008), as well as a combination of all these factors (Öztekin et al., 2018).

In terms of polyunsaturated fatty acids (PUFAs), higher concentrations of linoleic acid (LA) were reported in caged axillary seabream compared to their wild representatives captured from the same area (Öztekin et al., 2018). Increased LAs were noted in fish fed diets supplemented with soybean oil (60%) compared to those fed diets prepared with fish oil as the sole source. Further, Fountoulaki et al. (2003) reported that substituting fish oil with soybean oil showed a significant increase in linoleic acid and linolenic acid contents with increased levels of n-6/n-3 ratio in the farmed fish. Nevertheless, when the fatty acids are converted into mg/100 g wet weight basis, all fatty acids presented higher levels in farmed axillary seabream, with twice higher arachidonic acid (ARA, C20:4n6) and eicosapentaenoic acid (EPA, 20:5 n- 3) in farmed fish compared to their wild representatives from the same aquatic environment, and 1.5 to 4 times higher alpha(α)-linolenic acid (ALA, C18:3n3), EPA, and docosahexaenoic acids (DHA, 22:6*n*-3) in cage-farmed fish over the wild-caught seabream (Öztekin et al., 2018).

When converting fatty acid levels into mg/100 g, based on lipid levels in fish meat, it was recorded that ARA, ALA, EPA and DHA were higher in farmed fish than in the wild-captured individuals from the same marine environment. Additionally, the nutritional contribution of LA and ALA from farmed seabream were higher than their wild representatives, which was also supported by Dubois et al. (2007), underlining that the dietary incorporation level of plant oil could result in an increased level of LA in fish meat, supporting the hypothesis of improved nutritional contribution of LA or ALA in cage-farmed seabream compared to the wild-caught individuals. Additionally, Öztekin et al. (2018) reported a higher nutritional contribution for EPA+DHA in farmed axillary seabream compared to the wild populations, which met the recommended daily intake levels of EPA+DHA (250 to 500 mg/day) reported by the European Food Safety Authority (EFSA, 2010) for the prevention of primary cardiovascular disease in human beings. This is in line with the report of the American Dietetic Association and Dietitians of Canada, suggesting 500 mg/day intake of EPA+DHA for the prevention of cardiovascular disease in humans, which is around 112 g per serving and could be gained by consuming oily fish twice a week (Kris-Etherton & Innis, 2007). In light of these recommendation levels and the nutritional contribution of EPA+DHA in seabream reported recently by Oztekin et al. (2018), 227 g of farmed seabream would be more than sufficient (140.3%) to meet the 500 mg level recommendation by EFSA (2010). In contrast, the wild-captured fish from the same area was just enough (99.9%) to cover the recommended daily intake level of EPA+DHA with a serving of 227 g of fish to prevent human cardiovascular diseases. Similarly, Saavedra et al. (2017) reported that a daily intake of 160 g of farmed meagre (A. regius) could cover the recommended level of 500 mg for EPA+DHA. In contrast, wild meagre could meet some recommended daily intake levels daily intake levels, according to Saavedra et al. (2017).

Farmed fish seems promising and reliable marine food with high quality and health potential for human consumers. Its nutritional contribution of EPA+DHA is not less but even higher than that of its wild representatives, especially for people with coronary health risks.

Results and Discussion

The discrepancies among earlier reports regarding age-growth relations of seabream either in farm conditions or wild populations can be attributed to the complexity of fish growth performance irrespective of farm -or wild conditions (Wendelaar-Bonga, 2011), which is significantly correlated to various environmental factors of water temperature (Carriquiriborde et al., 2009), food availability, species and genetic differences, predator effects, habitat selection, sheltering or hiding conditions, breeding, mating etc. Other notable factors in the culture environment, such as photoperiod (Wendelaar-Bonga, 2011), temperature, salinity, dissolved oxygen, pH (Kestemont & Baras, 2001), nitrogenous compounds (nitrite, ammonia) (Schram et al., 2010), voluntary food intake and food quality (Lanari et al., 2002), feeding strategies (Hernández et al., 2003) and operational management practices, stocking densities, or a combination and interaction of all these factors together may influence the growth performance in farmed fish (Imsland et al., 2001). All these biological activities are linked to significant energy expenditure in fish. In farmed fish, a bigger part of the energy consumed is allocated for growth. In contrast, in wild individuals, higher energy expenditure stands for various efforts for competition in repeated food search and foraging, hiding, tissue recovery, performance loss, habitat selection, mating and reproduction efforts, or even area-specific short-term habitat change and seasonal migrations. Beyond all, it is important to consider that farmed fish are kept under controlled conditions, apart from all the risks and harsh competition that wild fish face. Fish welfare in farm conditions is highly linked to sufficient oxygen and water flow through the system, biomass control and optimum stocking density, and biofouling-free netting that prevents pathogen attachments. Hence, if environmental conditions are optimum, cultured fish probably compete with their fellows only during feeding.

Apart from cormorant or seagull attacks, owing to the development of high-strength net materials, fish in cage farms are no longer in danger of predator attacks except for a few incidents of monk aggressions (Güçlüsoy & Savas, 2003) or possible shark attacks in certain areas. High-technology new-generation cage systems and innovative net materials improve strength against net failures at storms and typhoons, preventing fish escapes. Considering the nature of the Mediterranean ecosystem, however, seabream is among the endemic species that naturally and locally inhabit the Mediterranean. Hence, negative consequences regarding genetic or ecological influences, such as interbreeding or predation effects, are still uncertain for Mediterranean escapees with few reports (Thorstad et al., 2008). An existing complex environmental interaction between escaped fish and wild individuals through food, habitat, and mating competition, or disease transmission to nearby farms or the transmission of pathogens to native fish stocks have been investigated by Thorstad et al. (2008), who indicated "low probability" for impact of genetic interaction between escapees and endemic wild populations (Arechavala-López, 2012). Some studies underlined that the escapees may aggregate around cages and swim away from one farm to nearby cage farms or even to local fishing grounds and coastal habitats for foraging (Arechavala-López et al., 2012). Alternatively, legal measures can be set at the earliest to encourage the use of high-strength nettings such as ultrahigh molecular weight polyethene (UHMWPE) nets or the innovative copper alloy mesh (CAM) nets in cage facilities in order to reduce or even prevent escapes from marine cage farms at all. In general, fish farms operating in exposed marine sites show reduced environmental impacts (Utne et al., 2015), and the level reached by the Mediterranean aquaculture sector today is promising for sustainable production of healthy seafood for human consumers.

Conclusion

The information provided in this review prepared based on currently available knowledge, underlines that the nutritional contribution of farmed fish in terms of amino acids and fatty acid profiles is not less but even higher than that of their wild representatives. Accordingly, it might be underlined that farmed fish is a reliable source of seafood with high nutritional value, just like natural fish.

Compliance with Ethical Standards

Conflict of interest: The authors declare no actual, potential, or perceived conflict of interest for this article.

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