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ARAŞTIRMA MAKALESİ **RESEARCH PAPER**

A Case Study on Economic Analysis of Sea Cage Farms in the Black Sea, Türkiye

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Abstract: The main aim of this research is to understand the value chains of enterprises engaged in aquaculture in sea cages in the Black Sea region of Türkiye, to determine production costs and to make a general analysis of the aquaculture sector. Random sampling method was used to ensure that farmers were equally represented in the survey. Data for the survey were randomly selected from 16 separate farms spread throughout 4 different marine cage locations. Furthermore, fish traders and sector stakeholders were interviewed. The businesses examined within the scope of the study are divided into 3 groups: small (250 -500 tons/year), medium (501-999 tons/year) and large (>1000 tons/year), according to their capacities. The most important expense items of enterprises consist of variable costs. Among the variable costs, the purchase of fry fish, feed purchase, and labor costs constitute the most important expenditure items. Among the fixed costs, the most important expense is depreciation costs. The unit cost of one kg of fish varies between 2.7 and 3.0 euros. Considering that the trout (*Oncorhynchus mykiss*) and seabass (*Dicentrarchus labrax*) in the Black Sea are at the level of 3.5 Euro, the profit rate of the enterprises is between these levels. Recently, since trout from the Black Sea has been exported to the Far East Country (particularly Japan), its price has also increased. In 2018, the average retail price (including VAT) and medium selling price of seabass and trout were at a level of 5.24 and 5.34 Euros respectively. Despite all these positive developments, climate change continues to pose a threat in terms of disease outbreak and marketing problems.

Keywords: Value chain, production coast, selling price, black sea, trout, seabass.

Türkiye'nin Karadeniz Kıyılarında Ağ Kafeslerde Yapılan Yetiştiriciliğin Değer Zinciri

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Öz: Bu araştırmanın temel amacı, Karadeniz Bölgesi'ndeki su ürünleri yetiştiriciliğindeki değer zincirlerini anlamak, üretim maliyetlerini belirlemek ve pazarın genel bir analizini yapmaktır. Bu amacı gerçekleştirmek için dört deniz kafesi lokasyonundan 16 üretici, balık tüccarları ve sektördeki paydaşlarla görüşmeler yapıldı. Karadeniz'in Türk kıyı sularında deniz kafeslerinde kafes yetiştiriciliğini büyüklüklerine göre 250 -500 ton/yıl kapasiteli (küçük), 501-999 ton arası (orta) ve 1000 tondan fazla/yıl (yüksek) kapasiteli olmak üzere 3 gruba ayrılmıştır. Değişken maliyetler arasında yavru balık alımı, yem alımı ve işçilik maliyetleri en önemli harcama kalemlerini oluşturmaktadır. Sabit giderler arasında en önemli gider amortisman giderleridir. Bir kg balığın birim maliyeti 2.7-3.0 Avro arasında değişmektedir. Karadeniz'de alabalık (*Oncorhynchus mykiss*) ve levrek balığı (*Dicentrarchus labrax*) üretiminin 3,5 Avro seviyesinde olduğu dikkate alındığında işletmelerin kar oranı bu seviyeler arasındadır. Son dönemde Karadeniz'den gelen alabalığın Uzak Doğu ülkelerine (özellikle Japonya'ya) ihraç edilmesi nedeniyle fiyatı da artış göstermiştir. 2018 yılında levrek ve alabalık ortalama perakende satış fiyatı (KDV dahil) ve orta satış fiyatı sırasıyla 5,24 ve 5,34 Avro seviyesinde gerçekleşti. Tüm bu olumlu gelişmelere rağmen iklim değişikliği, hastalıkların ortaya çıkması ve pazarlama sorunları açısından tehdit oluşturmaya devam ediyor.

Anahtar kelimeler: Değer zinciri, üretim maliyeti, satış fiyatı, karadeniz, alabalık, levrek.

INTRODUCTION

The concept of value chain was first used in the 1960s and 1970s. Since the 1990s, value chain analysis has begun to be widely applied. The value chain encompasses all the activities required from the design stage of a product or service to its final consumption by the end consumer (Bağci and Yavan, 2022). It consists of two main parts: primary activities such as incoming logistics and operations, and supporting activities such as outgoing logistics, marketing and sales, services and company infrastructure, human resources method, technology development and supply.

According to Porter, who defines these activities as a chain, the method used to systematically identify, describe, and evaluate the strengths and weaknesses within the chain is referred to as the value chain (Porter, 1985). According to this model, business activities are divided into two parts: primary activities (inbound logistics, operations, outbound logistics, marketing and sales, and services) and support activities (firm infrastructure, human resource management, technology development, and procurement) (Eraslan, Kuyucu and Bakan, 2008).

The seafood industry may make a significant contribution to the world's food supply and serve as a significant source of animal protein (Kobayashi et al., 2015). The predictions made on this subject indicate that the demand will be 186 million tons by 2030, and the increase is completely linked to aquaculture. The total production of fisheries and aquaculture (excluding algae) reached 178 million tons in 2020 (Kobayashi et al., 2015). Aquatic animal production in 2020 was estimated to have a total first sale value of USD 406 billion, of which USD 265 billion came from aquaculture (FAO, 2023).

Fishery production fluctuates from year to year, and on the other hand, aquaculture production continues to increase. Similar to the situation in the world, aquaculture in Türkiye is constantly increasing. Türkiye is in a good position in the world in aquaculture. Compared to EU countries, Türkiye is one of the leading countries in aquaculture. Türkiye's annual aquaculture production varies from year to year due to the fluctuations in capture fisheries production. Similar to the world production, Türkiye's aquaculture production continues to increase and the share of aquaculture in total production is increasing. Türkiye's aquaculture production reached a record high of 849,808 tonnes in 2022, with fisheries production reaching 335,003 tonnes (39.4%) and aquaculture production reaching 514,805 tonnes (60.6%). The prices of small pelagic species such as anchovy, sprat, and sardine, consisting of a great majority of marine products fishing, marine products such as sand mussel and sea snail, and the species which is captured in inland waters such as tarek, Mediterranean sand smelt and prussian carp are generally low (TURKSTAT, 2023). Although the amount of capture fisheries is more dependent on these species, its value is lower than farming products. The total values of farming products depending on the production increase in farming are also rising every year. The aquaculture sector can be characterized by mainly three species: rainbow trout (*Oncorhynchus mykiss*), European seabass (*Dicentrachus labrax*), and Gilthead seabream (*Sparus aurata*). Trout, European seabass, Gilthead seabream, and mussels in aquaculture production have a 98% share in Türkiye (TURKSTAT, 2023).

The aquaculture products sector is one of the most important sectors in Türkiye's exports. The export value increases annually. In parallel with the developments in aquaculture farming production and processing technologies, there is a significant increase in aquaculture exports. In the period following 2000, the increase in exports continued and imports displayed a partially fluctuating and partially stagnant course. In terms of quantity, our imports in 2010 (80.7 thousand tons) were considerably higher than our exports (55.1 thousand tons), whereas in the following years exports were always higher than Türkiye imports. Looking at the monetary value in recent years; it is seen that the value of exports is always higher than the value of Türkiye imports.

Türkiye’s exports, which were 27 thousand tons in 2002, increased to 251 thousand tons in 2022, from 97 million dollars to 1.652 billion dollars in value. In terms of imports of aquaculture products in the same period; while it was 23 thousand tons in 2002, it reached 145.6 thousand tons in 2022 and the monetary value of imports increased from 19 million dollars to 189 million dollars (TURKSTAT, 2023). The most important export items in Türkiye consist of trout, sea bream, and seabass fish obtained by farming, and Atlantic bluefin tuna (*Thunnus thynnus*), with high commercial value grown and fed in net cages. Export is made to many countries in the world. Due to many factors such as climate change, changing environmental factors, human destruction in natural habitats, population growth, excessive fishing, and unconscious fishing, natural fish stocks have decreased and some species have come to the brink of extinction. Although some measures are tried to be taken against these circumstances, it has been acknowledged by the stakeholders in the sector that production through fishing will not increase anymore and production increase can only be provided by fish aquaculture (Boyd et al., 2022).

In parallel with the developments in aquaculture farming production and processing technologies, a significant increase is observed in aquaculture exports (Yılmaz et al., 2022; Ertör and Ortega-Cerdà, 2019).

Based on the study of measuring the network efficiency of the aquaculture value chain in Türkiye,

Yıldırım (2023) recommends conducting holistic education and training focused on fresh and processed fish. He reported that this education and training will increase both the overall efficiency of value chain networks and the individual efficiency of intermediaries.

In the study examining the trout farming value chain, Yüksel (2022) reported that the product price gained importance on the retailer side in the flow from producer to consumer and that there was a difference of approximately 100% between the producer price and retail price of trout.

Yu et al. (2023) in their value chain analysis of Chinese gulf scallop farming suggest that increasing the horizontal integration of enterprises cannot make aquaculture production more efficient, but there is a need for vertical integration of different enterprises.

Exports continued to increase in the period after 2000, while imports remained partly fluctuating and partially stable. Despite the current level and fluctuation of capture production in the territorial waters of Türkiye, the fact that some of fishers have been fishing in Georgia and Mauritania and significant increases in farming production and exports are important indicators for the development of the industry. Black Sea aquaculture plays an important economic and social role in the region. The sustainability of the aquaculture sector in the region is increasingly challenged by emerging problems. To this end, innovative measures, including economic, social, environmental, and governance issues, should be addressed to ensure the sustainability of the sector (Fezzardi et al., 2013). However, when the current production and foreign trade amounts are compared with the population of the country; it is seen that especially per capita domestic consumption is below the world average. Potential that will ensure a further rise in production and consumption in Türkiye.

Fish farming in the sea cages in the Turkish coastal water of the Black Sea is carried out in 5 different locations: province of Sinop, Samsun, Ordu, Trabzon, and Rize. Regarding aquaculture production data, 75% of the fish produced in sea cages in the Black Sea is trout, and 25% is seabass. Apart from these species, the amount of species such as sturgeon, etc., which are grown for trial purposes, is at a negligible level. Among the major limitations, high summer temperatures and a lack of sheltered sites are the major ones. Compulsory harvesting during June due to rising temperature forces the farmers to drop prices. Although some farmers transfer, market-size fish to freshwater farms, the volume of fish transferred is very limited. After trout reach 30-50 or 350-500 grams in weight, the fish is transferred from the inland farmers and are placed in cages in the sea when sea water begins to cool down in the autumn season. It is imperative that the fish are sold or fed until the beginning of June when the water temperature increases (Figure 1).

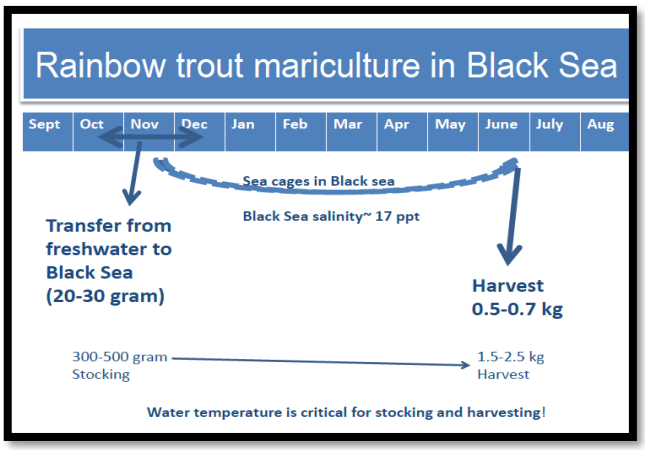

Figure 1. The aquaculture period of rainbow trout in the sea during the year.

The fry of seabass fish raised in cages in the Black Sea are taken from hatcheries in the Aegean or Mediterranean regions. In general, producers in the Black Sea prefer seabass fry weighing 4-5 grams.

The main objectives of this study were to understand the value chains of aquaculture products, identify production costs, and make a general analysis of the aquaculture market in the Black Sea region of Türkiye.

MATERIAL AND METHOD

This study was carried out in the Black Sea region of Türkiye based on fish farming in the sea cages in the Turkish coastal water of the Black Sea (Figure 2). Random sampling was used to ensure that farmers were equally represented in the survey. To fill this purpose, 16 farmers were interviewed from four sea cage location sites. Furthermore, fish traders and respected stakeholders were interviewed. The production data were obtained from provincial directorates of agriculture in the region and the Turkish Statistical Institute (TUİK). Cage farms were analysed into sizes with a capacity of 250 tons/year (small), between 501-999 tons (medium), and more than 1000 tons/year. In this study, farms engaged in sea cages in 2018 were evaluated. In the research, the unit cost of fish produced by the aquaculture method was calculated. Within the scope of fish costs, costs directly related to the fish production branch were separated from the production costs for fish production (Kıral et al., 1999). Feed costs, labor, energy expenses, medicine costs, interest on fish capital, insurance premiums, taxes, costs of tools and machines (repair, maintenance, depreciation, etc.) used in fish production were calculated. In determining fish production costs, Kıral et al. (1999) was used a table based on the classification of fixed and variable costs. Unit fish cost was found by dividing the total costs of fish production by the amount of fish production.

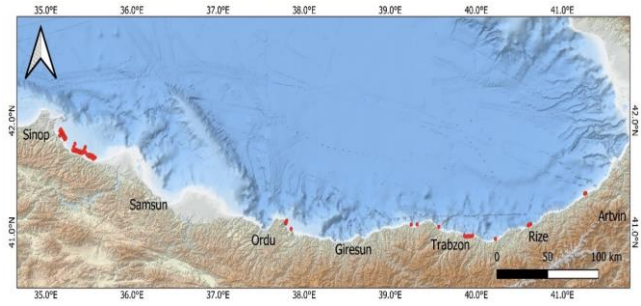

Figure 2. Enterprises areas of marine cages in the Black Sea.

RESULTS AND DISCUSSION

It is possible to divide the cage farming in the sea cage in the Black Sea into 3 groups according to their size with a capacity of 250 tons/year (small), between 501-999 tons (medium), and more than 1000 tons/year. The production capacity of enterprises is high. However, there are enterprises that produce below their actual capacity by years. Costs of production considering their size for trout and seabass sea cage farming in the Black Sea were given in Table 1. The most important expense items of enterprises consist of variable costs. Among the variable Costs, the purchase of fry fish, feed purchase, and labor costs constitute the most important expenditure items. Among the fixed costs, the most important expense is depreciation costs. The unit cost of one kg of fish varies between 2.7-3.0 Euros (Table 1). Considering that the trout and seabass in the Black Sea are at the level of 3.5 Euro, the profit rate of the enterprises is between these levels.

Table 1. Cost of production for sea cage farming (Euro) in the study area.

Cost items	**Categories**		
	Small-scale 250-500 tons	**Medium-scale (501-999 tons)**	**Large-scale>=1000 tons**
Variable costs			
Fry	70,299	351,494	562,390
Labor	33,022	89,158	99,065
Energy	4,576	17,388	18,303
Marketing (incl. packing)	14,792	52,068	59,169
Others (feed and vaccinal, vet)	418,278	1,463,972	1,581,722
Sub total	540,966	1,974,080	2,320,649
Fixed Costs			
Management	7,833	28,201	31,334
Depreciation	40,235	112,657	202,783
Financial	10,768	31,226	43,071
Maintenance	3,181	9,287	12,086
Costs for insurance	8,238	28,833	32,953
Fees & Rents (costs per license/concession)	395	1,582	1,670
Others	12,358	44,735	49,431
Subtotal	83,008	256,521	373,327
Total	623,974	2,230,602	2,693,976
Unit Production Cost	**2.84**	**2.97**	**2.69**

The most important expenses in aquaculture consist of feed prices. Feed prices are still at a high level (1.4 Euros for salmon). In Black Sea conditions, an average of 1.5 kg of feed is used for 1 kg of trout. For seabass, 2.3 kg of feed is used for 1 kg of fish meat weight. While the size of the enterprise increases, the unit cost does not change much in the most important expenditure items such as feed, energy, and the price of fry. However, unit cost decreases in labor costs due to an increase in production capacity. Enterprises purchase trout which they buy on land for an average of 3.5 Euros. After bringing the fish to 3 times as much weight at the end of 6 months, they export it at a price of 3.25-3.75 Euros. Although the price of fish does not show much change in kg, the fact that the weight increases in this way within 6 months makes the rearing of this species profitable.

It is also a great advantage that live weight increase is experienced as much as feed given. With the shift of the Japanese market to Türkiye in recent years, the producer has come to a strong position in marketing. Since salmon has to be processed in fillet form, manufacturers market their products to Japan through processing plants. Although some producers have partnerships with processing plants, they do not directly export the products themselves. Although the VAT rate for other animal products is 1%, VAT for fish in Türkiye is 8%. In fact, this situation constitutes a handicap for the manufacturer. In 2018, the average retail price (including VAT) and the Medium selling price were at 5.34 Euros (Table 2).

Table 2. Value chain for trout reared in the sea cages in the study area.

	Euro/kg		**% of**
Items	**Interval**	**Average**	**Retailer price**
Production cost (including producer margin)	3.2-3.8	3.6	67.4
Labor transport and material cost	0.26	0.26	4.9
Wholesaler margin			
Ex-Wholesaler price			
Retailer cost and margin		1.08	20.2
Retail price (excluding VAT)		4.94	92.5
VAT		0.4	7.5
Retail price (including VAT)		5.34	100
Medium selling price		5.34	100

Data based on 3-5 kg fish for marketing size, Source: face-to-face interviews

The situation is slightly different in seabass production. The fry individuals are purchased from enterprises in the Aegean Sea. Currently, the fry seabass in the Black Sea is sold at a price of 0.15 Euro + VAT. Enterprises lose approximately 35% of their juvenile individuals purchased under the Black Sea conditions. An

enterprise needs to purchase approximately 3.3 juvenile seabass to reach 400 g portions of size. Losses are very low in trout as individuals are taken as a portion (Table 3).

Table 3. Value chain for seabass reared in the sea cages in the study area.

Items	Euro/kg Interval	Average	% of Retailer price
Production cost (including producer margin)	3.25-3.75	3.5	66.8
Labor transport and material cost	0.25-0.26	0.25	4.8
Wholesaler margin			
Ex-Wholesaler price			
Retailer cost and margin		1.1	21
Retail price (excluding VAT)		4.85	92.6
VAT		0.39	7.4
Retail price (including VAT)		5.24	100
Medium selling price		5.24	100

Data based on 350 gr fish for marketing size, Source: face-to-face interviews

In the early years in the cages in the Black Sea, the focus was on seabass rearing. Although experiments with sea bream were made, this species was abandoned because it was not profitable. In recent years, salmon farming has started to become widespread in the Black Sea. Salmon farming has become attractive in the Black Sea. The production capacity of enterprises is high. After 2018, seabass is no longer attractive in the Black Sea. Because the selling price of seabass is around 3.5/Kg Euros (Table 3). Since the production amount of the Black Sea bass is not as high as the amount per enterprise, the enterprises cannot export the fish. The fish have to be sold in the domestic market. Seabass prices have not experienced much change in the domestic market, either. Marketing is carried out through brokers. Sales to big shopping markets are preferred. Both competitions cannot be made with the Aegean Sea and the price these centers receive is below the market. In fact, in many previous studies conducted it is stated that seabass farming is profitable (Dawson et al. 2018). But, it was noticed that the production of seabass in the sea cages in the Turkish coastal water of the Black Sea which was started as a second species was limited, because of disease and marketing problems together with difficult natural conditions (Baki and Dalgıç, 2009).

In the coming years, we can foresee that Black Sea cage farming can be completely shifted to trout farming. Because the trout reaches the desired weight in 6 months in the Black Sea, the producer will not wait 18 months for the seabass. On the other hand, while the surface water temperature of the Black Sea is suitable for growing trout for 6 months, seabass growing can be done for 12 months. For this reason, it is seen that the producers try to apply the trout rearing techniques in the best way in order to make maximum use of the sea for trout production. Akbulut et al (2002) reported that the growth rate is higher in small fish (50 gr) than in bigger fish (100 gr) in the study which is to assess the effect of initial size on the growth rate of rainbow trout cultured in the sea cage in the Black Sea. Another study carried out by Öz et al (2016) emphasized the need for grading the trout growth in the sea cages, and it was stated that the growth and feed evaluation was better in small fish compared to the older ones. In another study on trout rearing in sea cages in the Black Sea reported that FCR was 1.40-1.65 for trout and 1.90-2.50 for seabass (Yıldırım, 2014).

CONCLUSION

In conclusion, the average retail price (including VAT) and Medium selling price were at a level of 5.24 Euros in 2018. It is useful to state that the price changes according to the weight of the trout. The fish, which are exported abroad as salmon, are marketed after being processed as fillets. The sales prices of these firms are around 8-9 Euros. Due to the fact that the demand is high, the level of risk is low and the price is attractive, it is foreseen that salmon production in the Black Sea will increase significantly. Investments are made only in the Eastern part of the Turkish coast. The main reason for this is that it is more sheltered than the Western Black Sea. Fishmeal feed requirements will be a big problem in the future. It is understood that approximately 25% of fish feed in Japan is utilized from residues. Enterprises in Turkey also need to transition to this structure in a holistic manner. It will be useful to cultivate in these regions with the use of different technology. In the purchase of fry and eggs, the spread of the disease from one region to another region may be possible. For this, traceability should be ensured. It would be useful to switch to geotagging in the sector.

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