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RESEARCH ARTICLE ARAŞTIRMA MAKALESİ

Changes in the import dynamics of Atlantic mackerel and its economic implications for Türkiye in two last decades

Son yirmi yılda Atlantik uskumrusu'nun ithalat dinamiklerindeki değişimler ve Türkiye için ekonomik etkileri

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Abstract: The dynamics of Atlantic mackerel imports in Türkiye have undergone significant changes over the years. Initially, imports were predominantly sourced from high-cost suppliers such as Norway. However, rising costs prompted a shift toward more affordable alternative sources, including Morocco and Iceland. This diversification strategy reduced import costs, enabling lower consumer prices and decreased operational expenses for the aquaculture sector. Between 2005 and 2009, Türkiye's annual average fresh mackerel imports were approximately 0.3 tons, dropping dramatically to just 0.1 tons annually between 2020 and 2024. In contrast, frozen mackerel imports increased significantly, with annual averages rising from 14,209 tons in 2005-2009 to 27,032 tons in 2020-2024. This shift reflects a transition in import preferences toward frozen products due to logistical and storage advantages, as well as the availability of lower-cost alternatives. Although the reduction in import prices has provided notable economic benefits for both consumers and the aquaculture industry, it has also raised concerns about quality and labeling. For instance, products imported from Morocco are often marketed as "Atlantic mackerel," and different species, such as chub mackerel, are sometimes mislabeled as mackerel. These practices pose a risk of misleading consumers and highlight the need for stricter quality control and accurate labeling. The diversification of import sources and the accompanying price reductions have created significant economic advantages for Türkiye. However, sustaining these benefits requires the implementation of robust quality standards, proper labeling practices, and consumer protection measures. Such actions will enhance market confidence and ensure the long-term sustainability of these economic gains.

Keywords: Atlantic mackerel, import dynamics, price reduction, structural breakpoint

Öz: Türkiye'de Atlantik uskumrusu ithalat dinamikleri yıllar içinde önemli değişiklikler geçirmiştir. Başlangıçta ithalat, ağırlıklı olarak yüksek fiyatlı Norveçli tedarikçilerden yapılırken, artan maliyetler daha uygun fiyatlı alternatif kaynaklara, özellikle Fas ve İzlanda'ya yönelimi teşvik etmiştir. Bu çeşitlendirme stratejisi, ithalat maliyetlerini düşürerek tüketici fiyatlarının azalmasına ve su ürünleri yetiştiriciliği sektörünün operasyonel giderlerinin azalmasına imkân tanımıştır. 2005-2009 yılları arasında Türkiye'nin yıllık ortalama taze uskumru ithalatı yaklaşık 0,3 ton iken, 2020-2024 döneminde bu miktar yıllık ortalama sadece 0,1 tona kadar düşmüştür. Buna karşılık, dondurulmuş uskumru ithalatı önemli ölçüde artış göstermiş; yıllık ortalama ithalat miktarı 2005-2009 döneminde 14.209 ton iken, 2020-2024 yılları arasında 27.032 tona ulaşmıştır. Bu değişim, ithalat tercihlerinin, lojistik ve depolama avantajları ile daha düşük maliyetli alternatiflerin bulunabilirliği nedeniyle dondurulmuş ürünlere kaydığını göstermektedir. Her ne kadar ithalat fiyatlarındaki düşüş hem son tüketiciler hem de su ürünleri yetiştiriciliği sektörü için önemli ekonomik faydalar sağlamış olsa da kalite ve etiketleme konularında bazı endişeleri de beraberinde getirmiştir. Örneğin, İzlanda ve Fas'tan ithal edilen ürünler sıklıkla "Norveç Uskumrusu" hatta bazen farklı türler yanlış etiketlenerek sunulmaktadır. Bu tür uygulamalar, son tüketicilerin yanıltılma riskini artırmakta ve daha sıkı kalite kontrolü ile doğru etiketleme ihtiyacını ortaya koymaktadır. Sonuç olarak, ithalat kaynaklarının çeşitlendirilmesi ve beraberinde gelen fiyat düşüşleri Türkiye için önemli ekonomik avantajlar yaratmıştır. Ancak, bu kazanımların sürdürülebilirliğini sağlamak için sağlam kalite standartlarının uygulanması, doğru etiketleme uygulamalarının benimsenmesi ve tüketici koruma önlemlerinin hayata geçirilmesi gerekmektedir. Bu tür önlemler, piyasa güvenini artıracak ve söz konusu ekonomik kazanımların uzun vadede sürdürülebilirliğini sağlayacaktır.

Anahtar kelimeler: Atlantik uskumrusu, ithalat dinamikleri, fiyat düşüşü, yapısal kırılma analizi

INTRODUCTION

Global mackerel production is highlighted by the significance of the Northeast Atlantic Mackerel (NEA) stocks. NEA mackerel is widely harvested within the economic zones of countries such as Norway and Iceland, where it is recognized as one of the most valuable pelagic species (Bertheussen et al., 2020). Approximately 300,000 tons of mackerel are exported annually from Norway, positioning it as a leading exporter. Over the past decade, Iceland has exported an average of 100,000 tons of mackerel per year. On average, Norwegian exports achieve prices that are 0.23 USD/kg higher than those from Iceland, attributed to the superior fat content and muscle firmness of Norwegian mackerel (Bertheussen et al., 2020).

Export markets for Norwegian mackerel focus primarily on high-value Asian countries such as Japan, China, and South Korea, whereas Iceland's exports are directed toward Eastern European markets, particularly Lithuania and Poland. The quality requirements in Asian markets provide Norway with a significant competitive advantage (Bertheussen et al., 2020). By contrast, Icelandic exports are channeled toward markets preferring lower-quality products, which explains the price differences (Kristófersson et al., 2016). However, the sustainable management of NEA mackerel stocks has faced challenges due to disputes among coastal states, hindering the attainment of Marine Stewardship Council (MSC) certifications

(Totland, 2020). Additionally, it has been suggested that climate change could alter stock distributions, potentially impacting existing biological and economic dynamics (Astthorsson et al., 2012).

Mackerel production in Morocco holds significant importance, particularly with Atlantic mackerel (*Scomber colias*). This species ranks as the second most harvested small pelagic fish, following sardines. In 2019, approximately 281,000 tons of mackerel were caught along Morocco's coasts, representing 20% of the total small pelagic fish landings, while sardines accounted for 75% (Techetach et al., 2024).

Mackerel is harvested along both the Atlantic and Mediterranean coasts, with the Larache region and M'diq Bay being the most productive areas. In addition to local consumption, mackerel is regarded as an essential export commodity. Exports are directed to European and Asian markets, where demand remains high. However, stock assessments have indicated overfishing of mackerel along Morocco's Atlantic coast, underscoring the need for sustainable management strategies (Derhy et al., 2024). Indian mackerel is widely harvested across South and Southeast Asia, where it plays a critical role in both local food security and export markets. In India, 249,000 tons of Indian mackerel were caught in 2016. Production is concentrated in the coastal states of Karnataka, Kerala, Goa, Maharashtra, Andhra Pradesh, and Tamil Nadu. The average price of Indian mackerel in local markets was 1.50 USD/kg, while processed and frozen products fetched higher prices in international markets (Aswathy et al., 2020).

Approximately 26% of Indian mackerel production in India is exported, with major markets including Southeast Asia, the Middle East, and Europe. However, increasing export demand has led to price increases in domestic markets, making the species less accessible to local consumers (Aswathy et al., 2020).

Beyond India, the harvesting of Indian mackerel is also significant in other countries. Indonesia is among the largest producers, where mackerel is an essential economic resource for small-scale fisheries. In Sri Lanka, the species is heavily consumed domestically, while Thailand and Malaysia play prominent roles in mackerel harvesting and exportation. Additionally, Oman and Yemen focus on catching Indian mackerel along the Red Sea and the Indian Ocean coasts (Jayabalan et al., 2014; Al-Mahdawi & Mehanna, 2010).

The growing economic importance of Indian mackerel has been accompanied by concerns over overfishing, which poses risks to stock sustainability. This situation necessitates the development of effective management strategies in India and other producing countries (Al-Mahdawi & Mehanna, 2010).

Studies on fish consumption habits in Turkey indicate that large pelagic species such as mackerel are among the most preferred types, especially in coastal regions. Mackerel, anchovy, and sardine stand out as the most consumed fish species in these areas (Sagun & Saygı, 2021). In offshore tuna farms in Turkey, mackerel is prominently used as feed to increase the fat content of tuna over a 6-8-month period. This practice plays a crucial role in meeting the demands of high-value markets such as Japan, where specific fat levels are highly desired (Koçak, 2018). Turkey has long relied on the importation of mackerel, both as a fresh fish feed and as a food source for human consumption. The dynamics of trade in this segment have been analyzed to better understand the economic and sustainability aspects of the market.

MATERIALS AND METHODS

This study investigates the effects of changes in countries of origin on the price per ton of mackerel imports using mathematical and statistical methods. The analysis covers data from 2005 to 2024. Data were obtained from the Turkish Statistical Institute (TUIK Obtained from the Biruni foreign trade statistics page by chapter and country) and international trade databases. Missing or outlier values were addressed using multiple imputation and statistical outlier detection methods (Tukey, 1977; Wickham, 2016). Initially, descriptive statistics were applied to understand the overall distribution of prices over time, and average prices were compared across countries. To better understand price changes during the transition from high-cost sources like Norway to other countries such as Iceland, Morocco, and Asian nations, structural breakpoint analysis, local regression (LOESS), and multiple regression analysis were conducted.

Structural breakpoint analysis

Structural breakpoint analysis was employed to examine whether trends, levels, or variances in the time series changed at specific points. The time series: y_t, where t = 1, 2, t, is expressed as:

$$y_t = \{\beta_1 + \varepsilon_t \, if \; t \leq \tau; \; \beta_2 + \varepsilon_t \, if \; t > \tau\}$$

Here:

β_1: The average or trend coefficient before the breakpoint.

β_2: The average or trend coefficient after the breakpoint.

ε_t: The error term (normally distributed and independent).

Breakpoints were identified using the Bai-Perron multiple breakpoint algorithm, which tests for multiple structural changes in time series data (Bai & Perron, 2003).

Local regression (LOESS)

Local regression (LOESS) was used to flexibly model the price data. Instead of a global trend, LOESS analyzes local trends around data points. Mathematically:

$$f(x_i) = \sum w_i(x_i) \, y_i$$

Where:

f(x): The predicted value (local trend).

$w_j(x_i)$: The weight function, typically using the tricube function:

$$w_j(x_i) = [1 - (|x_i - x_j| / d)^3]^3, if\ |x_i - x_j| < d$$

d: The bandwidth (window size).

This method was used to visualize and interpret price changes over time.

RESULTS

Table 1 provides the five-year averages and standard errors of mackerel import and export data in Türkiye, categorized by product type, over the last two decades. The data covers the periods 2005–2009, 2010–2014, 2015–2019, and 2020–2024. Quantities are reported in tons, and values are expressed in millions of dollars. For canned mackerel, export quantities decreased from 5.5 ± 5.5 tons in 2005–2009 to 3.9 ± 1.3 tons in 2020–2024. Imports followed a similar declining trend, reducing from 3.7 ± 3.4 tons to 1.229 ± 1.2 tons. Export values fluctuated slightly, stabilizing at 0.028 ± 0.010 million dollars in the most recent period.

Table 1. Five-year averages and standard errors of mackerel import and export data in Türkiye by product type over the last two decades

Period	Product type	Amount (tons)		Value (million of dollars)	
		Export	Import	Export	Import
2005-2009	Canned	5.5 ± 5.4	3.7 ± 3.4	0.062 ± 0.061	0.008 ± 0.007
	Fresh	0.3 ± 0.1	47.7 ± 25.6	0.001 ± 0.000	0.053 ± 0.019
	Frozen	9.8 ± 6.3	14209.2 ± 2402.4	0.034 ± 0.018	18.725 ± 3.147
2010-2014	Canned	4.1 ± 2.0	-	0.035 ± 0.016	-
	Fresh	8.6 ± 4.4	8.8 ± 3.262	0.022 ± 0.010	0.033 ± 0.012
	Frozen	26.9 ± 12.4	24921.1 ± 1791.0	0.093 ± 0.040	40.893 ± 1.908
2015-2019	Canned	6.3 ± 2.1	1.9 ± 1.0	0.044 ± 0.015	0.013 ± 0.007
	Fresh	41.9 ± 26.1	1.2 ± 0.8	0.127 ± 0.078	0.004 ± 0.003
	Frozen	51.5 ± 5.3	31939.1 ± 3816.6	0.138 ± 0.015	44.272 ± 6.464
	Indian M.	875.7 ± 70.3	581.4 ± 285.2	1.875 ± 0.242	0.792 ± 0.419
2020-2024	Canned	3.9 ± 1.3	1.229 ± 1.2	0.028 ± 0.010	0.005 ± 0.005
	Fresh	13.5 ± 4.8	0.1 ± 0.1	0.053 ± 0.015	0.000 ± 0.000
	Frozen	85.4 ± 9.2	27032.1± 3416.3	0.244 ± 0.022	35.725 ± 4.255
	Indian M.	1082 ± 120.4	1364.5 ± 286.4	1.884 ± 0.200	2.136 ± 0.426

Fresh mackerel exports showed an upward trend initially, increasing from 0.3 ± 0.1 tons in 2005–2009 to a peak of 41.9 ± 26.1 tons in 2015–2019, before decreasing to 13.5 ± 4.8 tons in 2020–2024. In contrast, import quantities dropped significantly from 47.7 ± 25.6 tons to 0.1 ± 0.1 tons over the same period. Export values exhibited gradual growth, while import values nearly disappeared by the latest period.

Frozen mackerel exports experienced steady growth, starting at 9.8 ± 6.3 tons in 2005–2009 and reaching 85.4 ± 9.2 tons in 2020–2024. Imports, already substantial, increased from 14,209.2 ± 2402.4 tons to 27,032.1 ± 3416.3 tons. Export values rose from 0.034 ± 0.018 million dollars to 0.244 ± 0.022 million dollars, while import values saw a slight decline from 18.725 ± 3.147 million dollars to 35.725 ± 4.255 million dollars.

For Indian mackerel, a product type recorded in the later periods, export quantities increased from 875.7 ± 70.3 tons in 2015–2019 to 1,082 ± 120.4 tons in 2020–2024. Similarly, imports grew from 581.4 ± 285.2 tons to 1,364.555 ± 286.4 tons. Export values rose from 1.875 ± 0.242 million dollars to 1.884 ± 0.200 million dollars, while import values increased from 0.792 ± 0.419 million dollars to 2.136 ± 0.426 million dollars.

Figure 1 identifies key structural breakpoints in the trends of mackerel import quantities, values, and unit prices in Türkiye, focusing on imports from Norway, Morocco, and Iceland. The structural breakpoints highlight periods of significant shifts in the data across the studied years (2005–2024). For Türkiye's total imports, breakpoints are observed around 2010 and 2015, with a marked shift in the rate of change for both import quantities and values. Unit prices also exhibit variations during these periods, with notable fluctuations aligning with the identified breakpoints. In imports from Norway, breakpoints are detected around 2013 and 2018. These points correspond to significant changes in import quantities and values, with a steady increase in unit prices over the years. For Morocco, the analysis indicates breakpoints around 2011 and 2016. These points reveal a steep rise in import quantities and values, particularly around 2011, followed by a stabilization in later years. Unit prices show variability, particularly during the identified breakpoints. Iceland exhibits structural breakpoints around 2012 and 2017. These points correspond to sharp increases in import quantities and values, followed by declines or stabilization. Unit prices display substantial fluctuations, particularly around these breakpoints.

Figure 2 presents the LOESS evaluation results of mackerel imports in Türkiye over the years, including a general overview as well as data specific to Norway, Iceland, and Morocco. The evaluations illustrate the trends in both quantity (tons) and value (million USD) of mackerel imports from 2005 to 2024. In the total panel, a consistent upward trend is observed in both the quantity and value of imports, with a noticeable stabilization in recent years. The LOESS curves smooth out annual fluctuations, revealing long-term patterns in Türkiye's overall mackerel import dynamics. The Norway panel indicates a rapid increase in both quantity and value of imports

until around 2014, followed by a decline and stabilization in subsequent years. The trends suggest a shift in import dynamics after a period of substantial growth. The Iceland panel shows a steady and continuous increase in both quantity and value of imports over the observed years. The LOESS curves suggest a consistent upward trajectory without significant disruptions, indicating growing trade between Türkiye and Iceland in mackerel. In the Morocco panel, a gradual rise in both quantity and value is observed, with a more pronounced increase beginning in the mid-2010s. The LOESS curves highlight the steady growth in Türkiye's mackerel imports from Morocco.

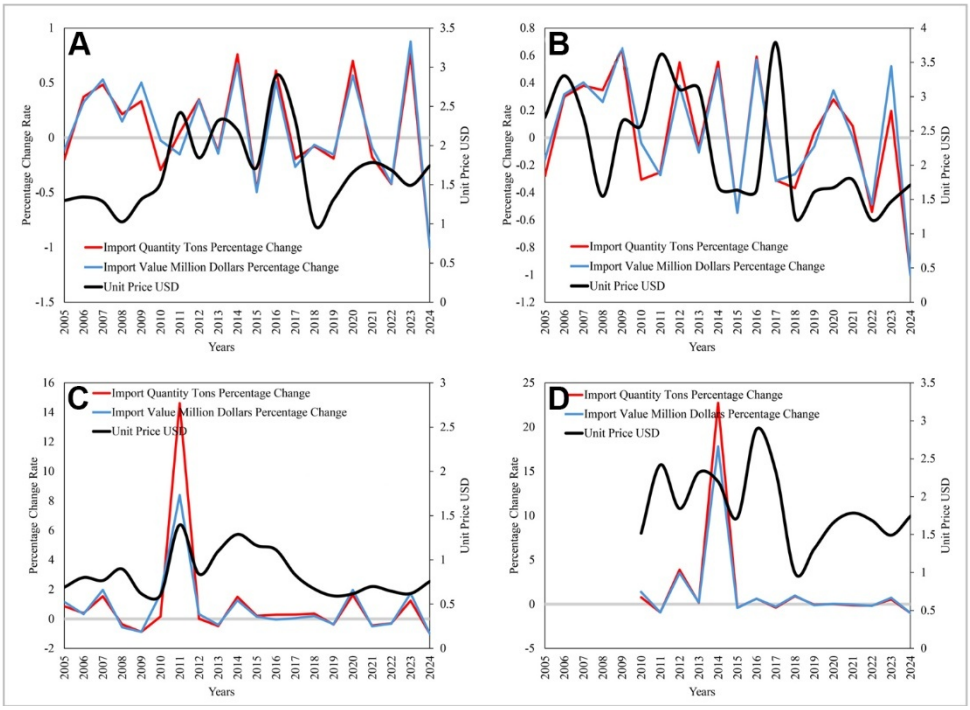

Figure 1. Annual variation rates of quantity and value, and unit prices of mackerel imports in Türkiye (A: Total, B: Norway, C: Morocco, D: Iceland)

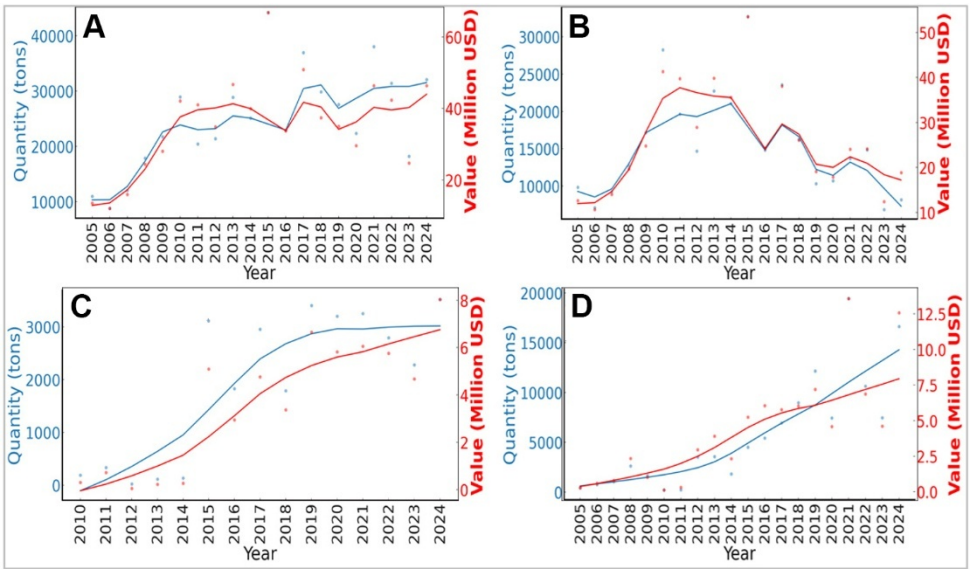

Figure 2. LOESs evaluation results of mackerel imports in Türkiye over the years (A: Total, B: Norway, C: Morocco, D: Iceland)

DISCUSSION

The structural breakpoint analysis and the LOESS curves provide a detailed understanding of the significant shifts in import dynamics across these countries, emphasizing changes in both quantity and value trends. It can be observed that Türkiye's mackerel imports have shown continuity over time (Pekmezci et al., 2023). This decline was influenced by the

search for alternative markets other than Norway, starting from 2013. The involvement of new markets, particularly Morocco and Iceland, has contributed to a significant decrease in the unit price of mackerel imported from Norway, which has been favorable for Türkiye. However, this favorable situation should not come at the expense of product quality. Therefore, necessary precautions must be taken. For instance, mackerel imported from Morocco is a different species, and there are opinions suggesting that the mackerel produced in Iceland is of lower quality compared to the Norwegian mackerel product (Bertheussen et al., 2020; Gottschalk, 2022).

The import of mackerel to Türkiye is likely to continue supporting the aquaculture industry (Koçak, 2018; Hougaard, et al., 2020), both in terms of fresh feed and fish meal production. Mackerel, like other small pelagic species, is a necessity for aquaculture in Türkiye, especially mackerel imported from North African countries. However, mackerel is also widely consumed as human food in the country, which poses a potential risk of misleading the end consumer. It is a common practice in Türkiye to sell chub mackerel under the name "mackerel." Additionally, products often imported from Morocco under the name "Atlantic mackerel" may potentially be offered to consumers. Similarly, Indian mackerel is also considered to have such potential. Necessary measures should be taken into account to protect end consumers.

Mackerel is a globally popular fish due to its high protein content and healthy fats (Bae et al., 2011). However, improper storage and handling can lead to serious public health issues, such as histamine poisoning. This is especially problematic when proper storage conditions and supply chain management are not maintained (Visciano et al., 2014). Histamine poisoning occurs when histidine in the fish is converted to histamine by bacteria. Bacteria such as *Pseudomonas spp.*, *Proteus spp.*, *Escherichia coli*, and *Morganella morganii* are commonly responsible for this process (Kovacova-Hanuskova et al., 2015; Schirone et al., 2017). High temperatures above 15°C accelerate bacterial growth and histamine production (Abuhlega & Ali, 2022). Symptoms of poisoning include rashes, itching, nausea, vomiting, low blood pressure, and headaches (Anusha et al., 2021). Proper cold chain management is essential throughout the supply chain to ensure the safety of mackerel and similar fish. Adherence to hygiene standards during processing, storage, and transportation is critical (Bedane et al., 2022). Storing fish at low temperatures, either frozen or chilled, minimizes bacterial activity and reduces toxin production (Shamsan et al., 2019). Preventing histamine poisoning requires strict monitoring and control at all stages of the supply chain. Compliance with national and international food safety standards must be enforced (ICMSF, 2018). Additionally, consumers should be educated on proper storage and cooking practices to further reduce risks (Madejska et al., 2022).

CONCLUSION

Mackerel imports in Türkiye hold critical importance for both aquaculture and human consumption. The diversification of import sources has led to a decrease in mackerel prices over time, creating a positive economic impact. By shifting from high-cost suppliers like Norway to more cost-effective sources such as Morocco and Iceland, the unit prices of mackerel imported into Türkiye have been reduced, enabling consumers to access products at more affordable prices. The reduction in prices has provided significant advantages, including lowering costs in aquaculture and allowing consumers to access quality products at more reasonable prices. However, maintaining quality standards and ensuring accurate labeling of different species should not be overlooked in this process. For instance, the importation of different species under the name "Atlantic mackerel" or the sale of chub mackerel under the name "mackerel" poses a risk of misleading consumers.

In this context, while the economic benefits of low-cost imports are preserved, increasing inspections and regulations to protect consumers is of great importance. Moreover, strengthening national and international cooperation for the sustainable management of mackerel stocks will ensure the long-term continuity of these benefits.

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AUTHOR CONTRIBUTIONS

Sevil Demirci: Conceptualization, methodology, investigation, data collection, writing-reviewing and editing.

CONFLICT OF INTEREST

The author declares that there is no conflict of interest.

ETHICS APPROVAL

No specific ethical approval was necessary for the study.

DATA AVAILABILITY

All relevant data is in the article. Even so, for any questions, the author should be contacted.

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