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Clustering of Counties of Samsun According to the Presence of Cattle Breeds

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Keywords:

Cattle breeds
3-D Clustering
Principal Component Analysis
Accuracy

ABSTRACT

In Samsun which is one of the leading provinces in cattle population, there is a great diversity in terms of cattle breeds. In this study, the cluster analysis method was used to examine the applicability of similar breeding policies for all districts when the statistical distribution of cattle in Samsun according to breeds was examined. The dimention reduction using PCA method was used to eliminate the variables that have no effect on the data set and to prevent the multicollinearity problem. As a result of the analysis, the explanatory power of the cluster analysis increased from 51.7% to 64.1% by using the dimention reduction. Different breeding policies should be developed for Bafra, Vezirköprü, Çarsamba and Tekkeköy districts compared to other districts, according to the results obtained by looking at the clustering graph formed when the ineffective variables are removed from the data set with the dimention reduction method. Policies for dairy cattle breeding can be proposed in these districts.

Samsun İlçelerinin Büyükbaş Irk Varlığına Göre Kümelenmesi

Anahtar Kelimeler:

Sığır ırkları
3-D Kümeleme
Temel Bileşenler Analizi
Etkinlik

ÖZET

Büyükbaş hayvan popülasyonunda önde gelen illerden biri olan Samsun'da sığır ırkları açısından büyük bir çeşitlilik bulunmaktadır. Bu çalışmada Samsun ilindeki büyükbaş hayvanların ırklara göre istatistiksel dağılımı incelendiğinde benzer yetiştirme politikalarının tüm ilçeler için uygulanabilirliğinin incelenmesi amacıyla kümeleme analizi yöntemi kullanılmıştır. Veri seti üzerinde etkisi olmayan değişkenlerin ortadan kaldırılması ve çoklu bağlantı sorununun önlenmesi amacıyla PCA yöntemi kullanılarak boyut indirgeme işlemi uygulanmıştır. Analiz sonucunda boyut indirgeme kullanılarak kümeleme analizinin açıklama gücü %51,7'den %64,1'e çıkmıştır. Boyut indirgeme yöntemiyle etkisiz değişkenlerin veri setinden çıkarılmasıyla oluşan kümelenme grafiğine bakılarak elde edilen sonuçlara göre Bafra, Vezirköprü, Çarsamba ve Tekkeköy ilçeleri için diğer ilçelere göre farklı yetiştirme politikaları geliştirilmelidir. Bu ilçelerde süt sığırcılığına yönelik politikalar önerilebilir.

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INTRODUCTION

The livestock sector has a strategic importance in the adequate and balanced nutrition of the rapidly increasing population in Turkey, as in the world, in using it as an industrial raw material and in realizing rural development (Aral, 1996; Yılmaz and Köknaroglu, 2007). The aim of livestock policies and supports is to increase the production required for a balanced diet in terms of animal protein, and to realize a higher quality and economical production (Demir, 2012).

The growing food crisis all over the world underlines the need to take important strategic steps in the field of agriculture and animal husbandry. It is important for countries to develop productive policies in line with their geography and food source. Since cattle breeding is used both in food and industrial areas in our country, where animal husbandry is also very common in agriculture, the implementation of priority policies in order to ensure its continuity will continue the development in these areas.

It is necessary to repeat some studies in order to identify and solve the problems in livestock enterprises, to monitor the changes in the sector and to make realistic plans for the future (Ören and Bakır, 2020).

Statistical methods are used for development policies in many fields such as agriculture. Appropriate statistical analyzes are applied according to the variable structures obtained as a result of the experiments. Cluster Analysis, one of these analysis methods, is a multivariate statistical method that aims to divide a set of observations into a limited number of groups or clusters. Separation is made so that while observations in the same group are similar to each other, observations in different groups are different from each other (Neil, 2002).

In this study, it is aimed to classify the provinces of Samsun city according to cattle breeds in Turkey by clustering analysis on the applicability of similar breeding policies for districts according to cattle breed existence.

MATERIALS AND METHODS

In this study, a total of 64 cattle breeds from 17 counties in Samsun (Ondokuz Mayıs, Alaçam, Asarcık, Atakum, Ayvacık, Bafra, Canik, Çarşamba, Havza, İlkadım, Kavak, Ladik, Salpazarı, Tekkeköy, Terme, Vezirköprü, Yakakent) 392,289 cattle were used for analysis.

The cattle breeds used in the study; Aberdeen Angus, Aberdeen Angus Crossbreed, Angler, Angler Crossbreed, Aubrac, Avrupa Kırmızısı, Bazadaise Crossbreed, Belçika Mavisi, Belçika Mavisi Crossbreed, Blonde D'aquitaıne, Blonde D'aquitaıne Crossbreed, Boz Irk, Boz Irk Crossbreed, Brangus, Brangus Crossbreed, Brown Swiss, Brown Swiss Crossbreed, Charolais, Charolais Crossbreed, Chıanına, Clavel Aleman, Clavel Aleman Crossbreed, Dogu Anadolu Kırmızısı, Dogu Anadolu Kırmızısı Crossbreed, Danimarka Kırmızısı Crossbreed, Eston Kırmızısı, Güney Anadolu Kırmızısı, Güney Anadolu Kırmızısı Crossbreed, Hereford, Hereford Crossbreed, Holstein KA, Holstein SA, Holstein KA M, Holstein SA, Holstein SA M, Isveç Kırmızısı, Isveç Kırmızısı Crossbreed, Jersey, Jersey Crossbreed, Leton Kırmızısı Crossbreed, Limousin, Limousin Crossbreed, Marchıgıana Crossbreed, Montbeliarde, Montbeliarde Crossbreed, Normande, Normande Crossbreed, Norveç Kırmızısı, Norveç Kırmızısı Crossbreed, Piedmentosa, Piedmentosa Melezi, Red Angus, Red Angus Crossbreed, Salers, Salers Crossbreed, Simental, Simental Crossbreed, Yerli, Yerli Güney Sarısı, Yerli Güney Crossbreed, Yerli Kara, Yerli Kara Crossbreed, Zavot, Zavot Crossbreed, Zebu variables consisting breeds were used.

Cluster analysis, which is accepted as one of the multivariate statistical methods, is applied to group many complex data and compare the resulting groups, and it is often preferred because it is easy and the results can be clearly understood (Tekin, 2015). Cluster analysis is a technique that allows data to be collected in discrete clusters in terms of their similarity to each other according to units or variables (Çakmak, 1999).

The main goal of cluster analysis is to classify and make sense of a group of data whose origin is unknown. Therefore, cluster analysis is used to classify units or objects according to their basic properties (Abonyi and Feil, 2007). In short, it can be stated that the general purpose of clustering analysis is to separate the similar from the different (Everitt et al., 2001).

In cluster analysis, the Nxp dimensional data matrix, in which p measurements are made in each of N observations, can be shown as follows.

$$\mathbf{X}=\begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1p} \\ x_{21} & x_{22} & \cdots & x_{2p} \\ \vdots & \vdots & \ddots & \vdots \\ x_{N1} & x_{N2} & \cdots & x_{Np} \end{bmatrix}$$

Here, x_{ij} represents the value taken by the j^{th} variable for the i^{th} individual or object (Çakmak, 1999).

The six steps of Cluster Analysis;

Obtain the data matrix,

Standardize the data matrix,

Compute the resemblance matrix,

Execute the clustering method,

Rearrange the data and resemblance matrices,

Compute the cophenetic correlation coefficient. All else is supplementary detail (Romesburg, 2004).

Principal component analysis (PCA), which is a transformation technique that enables the dimensions of the data set, which includes a large number of interrelated variables, to be reduced to a smaller size by preserving the existing changes in the data as much as possible, facilitates various evaluations (Çilli, 2007). The analysis aims to determine the best transformation that can express the available data with fewer variables. The variables obtained after the transformation are called the principal components of the initial variables. The first principal component has the largest variance value and the other principal components are ordered in descending order of variance values. (Alpar, 2003). To summarize briefly;

The data matrix of the p variable in the n measurement is standardized,

The correlation matrix of the standardized data matrix is found,

The eigen values and standardized eigen vectors of the correlation matrix are calculated,

From the eigenvalues, the explanation ratios of the principal components to the total variance are found,

Principal component values are found by multiplying the transpose of each eigenvector with the standardized data matrix (Ersungur, 2007).

Analysis R software version 4.2.2 (R Core Team, 2022) with *FactoMineR* and *factoextra* packages was used to develop breeding policies by using cluster analysis to group cattle breeds in Samsun according to districts.

RESULTS AND DISCUSSION

According to the results of the clustering analysis applied to examine the distribution of cattle breeds by districts, it was understood that the districts were divided into 5 classes. Looking at Figure 1, it is observed that Bafra, Çarşamba, Tekkeköy and Vezirköprü districts are clustered far from other districts. Therefore, it has been determined that a separate breeding policy can be followed in these districts compared to other districts. Looking at the hierarchical clustering map, it is understood that the explanatory power is 51.7%.

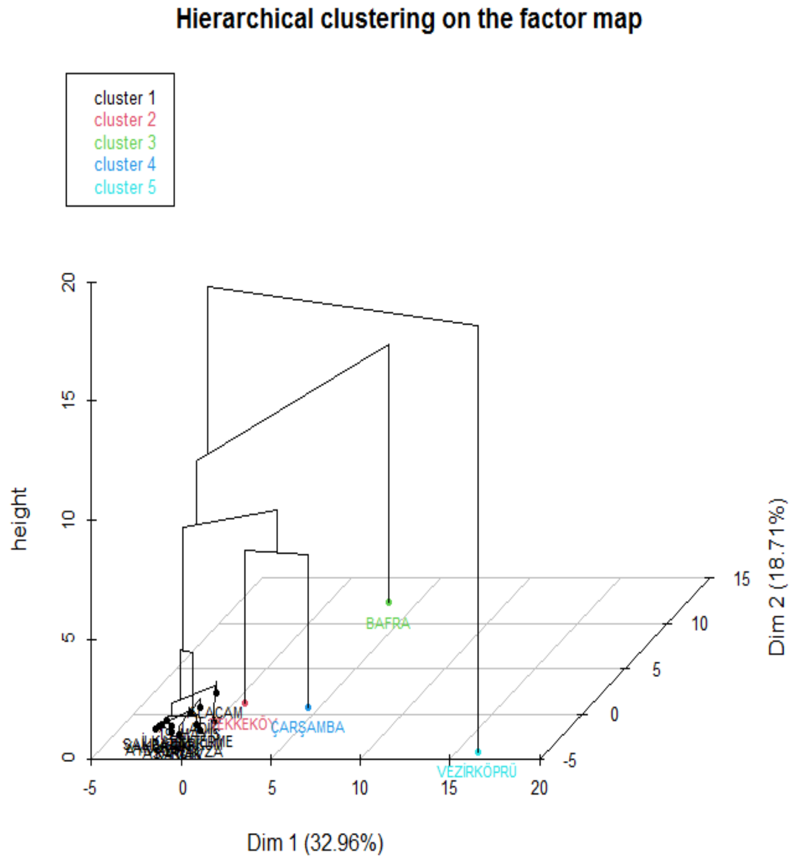

Figure 1. 3D clustering map of districts according to animal breeds.

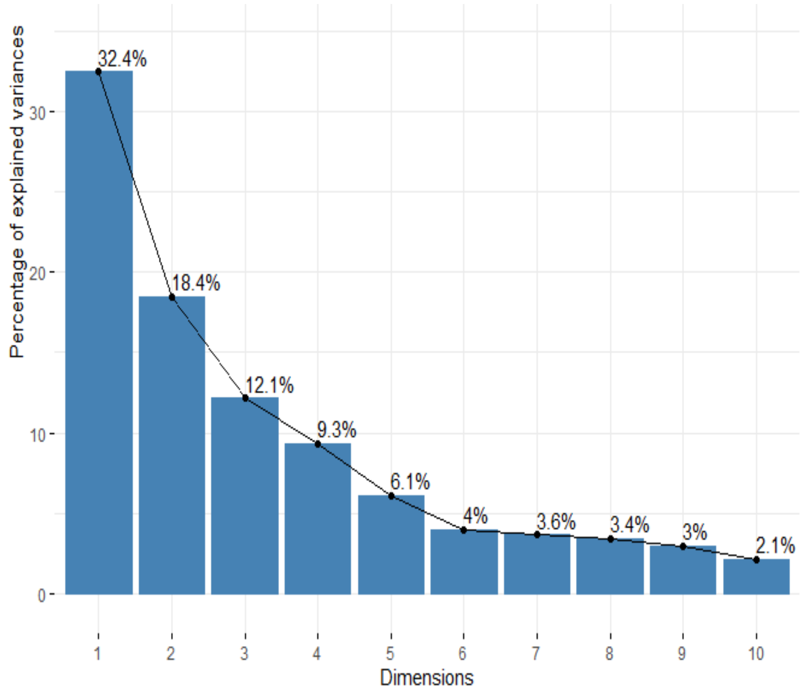

Figure 2. Variance explanatory power of dimensions.

When Figure 2 was evaluated, it was determined that the explanatory power of the dimensions for cluster analysis was 78%.

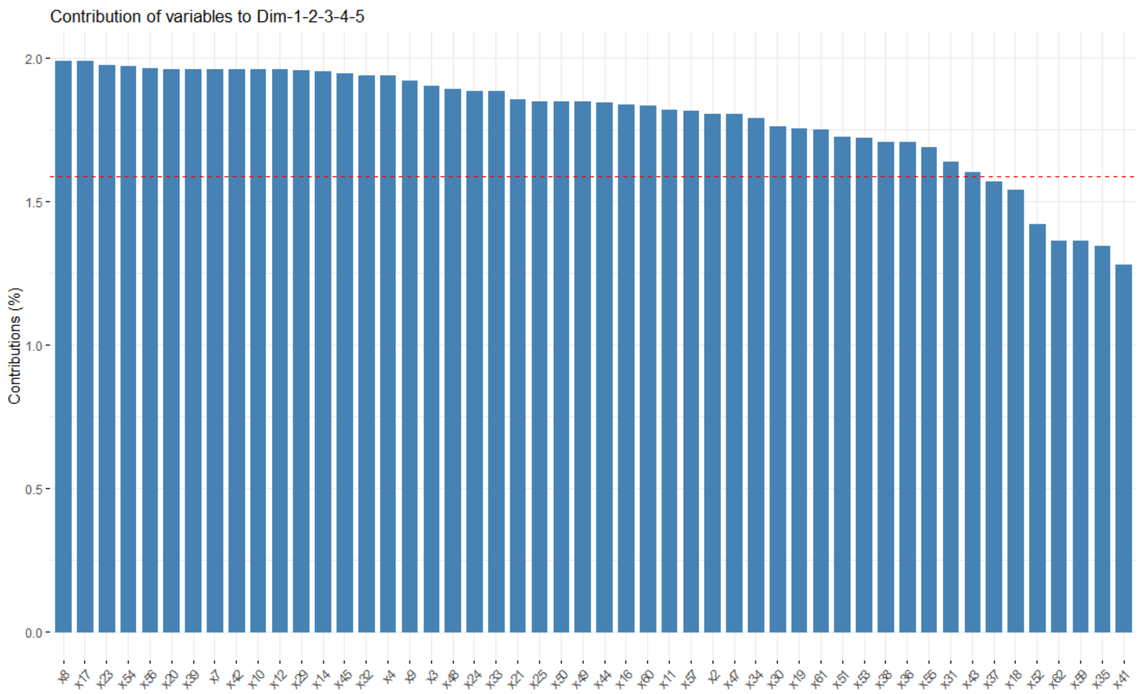

Figure 3. Variables that are significant for data after PCA.

After PCA is done, the variables of the remaining cattle breeds after the insignificant variables in the data set are eliminated are shown in the Figure 3. Animal breeds excluded from the data set in this study; Aberdeen Angus, Aubrac, Avrupa Kırmızısı, Boz Irk Crossbreed, Brangus Melezi, Charalails, Clavel Akman Crossbreed, Estan Kırmızısı, Güney Dogu Anadolu Kırmızısı, Güney Dogu Anadolu Kırmızısı Crossbreed, İsveç Kırmızısı, Jersey, Limosin, Limosin Crossbreed, Normande Crossbreed, Red Angus Crossbreed, Yerli Güney Sarısı, Yerli Güney Sarısı Crossbreed, Zavot, Zavot Crossbreed, Zebu are breeds that were not significant for analysis.

After the variable elimination method was applied, it was observed that all 5 clusters got closer to each other in the new clustering map, when the variables that were meaningless for the data set were removed. It has also been observed that a separate breeding policy can be applied for Bafra, Çarsamba, Tekkeköy and Vezirköprü districts according to the animal breeds raised between the districts. The explanatory power of cluster analysis after PCA increased from 51.7% to 64.1%. Therefore, the applicability of PCA is recommended for data sets with too many variables (Figure 4).

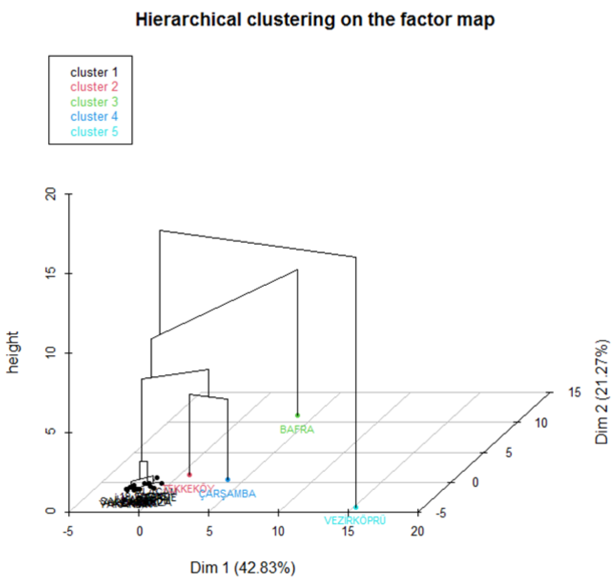

Figure 4. 3D clustering map formed after applying PCA.

CONCLUSION

It has been determined that the same breeding policies cannot be applied in all districts for cattle breeds in Samsun. Accordingly, as a result of the analyzes made, the sustainability of dairy cattle is important for Bafra district, where dairy breeds such as Holstein, Jersey, and Montofon are mostly raised. When we look at Çarşamba county, in addition to dairy breeds, the Yerli Kara Crossbreeds which is a meat breed, is mostly seen, and it may be more suitable for breeding both dairy and meat breeds for this county. Considering the ratio of beef cattle to dairy cattle, it can be said that beef cattle breeds such as Charolais Crossbreeds are suitable for breeding policies as well as dairy breeds for Tekkeköy district. n terms of separate breeding policies, it can be suggested that dairy cattle and beef cattle breeds should be preferred in Vezirköprü district, as the district where the Yerli Kara which is one of the beef cattle breeds, is outnumbered. Traceability of the same cultivation policies is appropriate for other districts, which we can define as cluster 5.

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The Lentil Market and Türkiye's Comparative Advantage

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Keywords:

Lentils
Competitive situation
Comparative advantages
Balassa index
Vollrath index

ABSTRACT

In this study, the lentil market and comparative advantage in the world and Türkiye between 2000 and 2021 were examined to elucidate Türkiye's competitive position. For the purpose of calculating comparative advantage, Balassa and Vollrath indices were utilized. In the global lentil market, Canada, India, and Australia are significant producer countries. Canada and Australia predominantly export their lentil production, while India, despite being a major producer, holds the position of an importer. Türkiye, on the other hand, while nearly dominant in the global lentil market during the 1990s, has lost this role in the 2000s. Despite ranking fourth in lentil production worldwide, Türkiye stands as the second-largest importer. The price gap between producer prices in Türkiye and globally is widening against Türkiye. This trend may lead to a disengagement of producers from lentil cultivation. Necessary support measures are imperative to safeguard producers economically. To enhance Türkiye's competitiveness in the global lentil market, it should consider market demands, engage in branding, undertake promotional activities, and explore new markets. According to the Balassa index, Australia, Egypt, Canada, Kazakhstan, Nepal, Sri Lanka, Syria, Türkiye, and the UAE exhibit comparative advantage in the global lentil market. When compared to countries with comparative advantage in the global lentil market, Türkiye holds an advantage against Australia, Egypt, Kazakhstan, Sri Lanka, and the UAE, but a disadvantage against Canada, Nepal, and Syria. According to the Vollrath LnRXA index, Australia, Canada, Kazakhstan, Nepal, Russia, Sri Lanka, Syria, Türkiye, and the UAE hold superiority in the global lentil market. According to the RTA index, Australia, Canada, China, Kazakhstan, Nepal, Portugal, Russia, Syria, Uganda, and the UAE hold superiority. According to the RC index, Australia, Canada, China, Kazakhstan, Nepal, Portugal, Russia, Syria, Uganda, the UAE, and the USA hold superiority.

Mercimek Piyasası ve Türkiye'nin Karşılaştırmalı Üstünlüğü

Anahtar Kelimeler:

Mercimek
Rekabet durumu
Karşılaştırmalı üstünlükler
Balassa indeks
Vollrath indeks

ÖZET

Bu çalışmada 2000-2021 yılları arasında dünyada ve Türkiye'de mercimek piyasası ve karşılaştırılmalı üstünlüğü incelenip, Türkiye'nin rekabet durumu ortaya konmak istenmiştir. Bu amaçla karşılaştırmalı üstünlük hesaplanması için Balassa ve Vollrath indeksleri kullanılmıştır. Dünya mercimek piyasasında Kanada, Hindistan ve Avustralya önemli üretici ülkelerdir. Kanada ve Avustralya ürettiği mercimeğin çoğunu ihraç etmekte, Hindistan ise önemli bir üretici olmasına rağmen ithalatçı ülke konumundadır. Türkiye ise 1990'lı yıllarda dünya mercimek piyasasında neredeyse hâkim konumda iken 2000'li yıllarda bu rolünü kaybetmiştir. Türkiye, dünyada mercimek üretiminde 4. Sırada yer almasına karşın en çok ithalat yapan 2. ülke konumundadır. Türkiye'deki ve dünyadaki üretici fiyatları arasındaki makas Türkiye aleyhinde açılmaktadır. Bu durumun devam etmesi üreticileri mercimek üretiminden uzaklaştıracaktır. Üreticilerin ekonomik açıdan korunması için gerekli desteklerin verilmesi gerekmektedir. Türkiye'nin dünya mercimek piyasasındaki rekabet gücünü artırması için pazar taleplerini dikkate alması, markalaşması, reklam çalışmaları yapması ve yeni pazarlar araması gerekmektedir. Ballasa indeksine göre dünya mercimek piyasasında Avustralya, Mısır, Kanada, Kazakistan, Nepal, Sri Lanka, Suriye, Türkiye ve BAE karşılaştırmalı üstünlüğe sahiptir. Türkiye dünya mercimek piyasasında üstünlüğe sahip ülkelerle karşılaştırıldığında Avustralya, Mısır, Kazakistan, Sri Lanka ve BAE karşısında avantaja sahip olup Kanada, Nepal ve Suriye karşısında dezavantaja sahiptir. Vollrath LnRXA indeksine göre dünya mercimek piyasasında Avustralya, Kanada, Kazakistan, Nepal, Rusya, Sri Lanka, Suriye, Türkiye ve BAE üstünlüğe sahiptir. RTA indeksine göre Avustralya, Kanada, Çin, Kazakistan, Nepal, Portekiz, Rusya, Suriye, Uganda ve BAE üstünlüğe sahiptir. RC indeksine göre ise Avustralya, Kanada, Çin, Kazakistan, Nepal, Portekiz, Rusya, Suriye, Uganda, BAE ve ABD üstünlüğe sahiptir.

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GİRİŞ

İnsanlığın en eski besin kaynaklarından biri olan Mercimek bitkisinin M.Ö 8000-8500 yılları arasında yetiştirildiği bulgusuna yapılan arkeolojik kazılarda rastlanılmıştır. Mercimek Mısırlılar, Yunanlar, Romalılar gibi birçok medeniyette, insan ve hayvan beslenmesinde kullanılan önemli bir baklagildir (Şahin, 2016).

Günümüzde protein değerinin yüksek olması nedeniyle, gelişmekte olan birçok ülkede düşük gelir grubundaki insanların önemli besin kaynağı arasında baklagiller bulunmaktadır. Baklagiller grubunda ise mercimek yüksek protein kaynağı olmasının yanı sıra vitamin (B) ve mineral maddeler bakımından da zengin içeriği ile öne çıkmaktadır (Gülaç, 2022).

İnsanlığın beslenme tarihinde böylesine önemli bir yeri olan Mercimek bitkisinin tarımı dünya üzerinde ılıman ve subtropik iklim bölgelerinde yapılmaktadır. Türkiye'de ise Karadeniz bölgesi hariç hemen hemen her yerde ama özellikle İç Anadolu ve Güneydoğu Anadolu bölgesinde yetiştiriciliği yapılmaktadır (Kaya, 2010).

1990'lı yıllarda Dünya mercimek piyasasında neredeyse hâkim konumda olan Türkiye 2000'li yıllarda bu rolünü kaybetmiştir (Aslan, 2023). Mercimek üretiminde yaşanan sıkıntılar, artan nüfus ve kişi başına tüketimde gözlemlenen değişimlerle birleşince, Türkiye'nin uluslararası alanda rekabet üstünlüğünü kaybettiği söylenebilir (Berk ve ark., 2019). Türkiye'nin mercimek üretimindeki sorunların çözümü ve eskiden sahip olduğu uluslararası konuma yeniden gelebilmesi için bu alandaki çalışmalar arttırılmalıdır. Özellikle rakip ülkeler ile karşılaştırmaya olanak sağlayan analizlere ihtiyaç vardır.

Türkiye'de karşılaştırmalı üstünlükle ilgili yapılan çalışmalarda daha çok ürün grupları ele alınarak hesaplanmaktadır. Bu durum tarım sektöründe ya da ürün grubunda dünyadaki rekabet durumumuzu göstermesi açısından önemli ancak, ürün grubu içerisindeki rekabetçi durumda olmadığımız ürünleri rekabetçiymişiz gibi göstereceğinden sakıncalıdır. Bu durumda, tek bir ürünün rekabet durumunu ortaya koyacak çalışmalar daha yararlı olacaktır. Yapılan bu çalışmanın amacı Türkiye'nin mercimekte dünyadaki rekabet durumunu ortaya koymaktır. Bu amaç, Balassa ve Vollrath yöntemleri karşılaştırılarak ortaya konacaktır.

MATERYAL VE METOT

Bu çalışmada mercimek piyasasındaki durumu global düzeyde ortaya koymak ve Türkiye'nin karşılaştırmalı üstünlüğünü hesaplamak için ikincil verilerden yararlanılmıştır. Dünya piyasası için gerekli veriler FAO'dan elde edilmiştir. Türkiye piyasası için TÜİK, FAO ve Tarım ve Orman Bakanlığı gibi kurumlardan elde edilen veriler kullanılmıştır. Dünya geneli için kırmızı ve yeşil mercimek verileri birlikte verilmektedir. Türkiye için ise, kırmızı mercimek ve yeşil mercimek verileri ayrı ayrı verilmektedir. Çalışmada Türkiye'nin mercimekte karşılaştırmalı üstünlüğünün belirlenmesi için Bela Balassa tarafından geliştirilen Balassa Endeksi (RCA) ve Vollrath tarafından geliştirilen Nispi Ticaret Avantajı (RTA), Nispi İhracat Avantajının Logaritması (LnRXA) ve Açıklanmış Üstünlük (RC) endeksleri karşılaştırmalı olarak kullanılmıştır.

Balassa Endeksi

Bela Balassa uluslararası ticarette ülkeler arası farklılıkların oluşmasında fiyat tarifeleri ve miktar sınırlandırmalarının kullanıldığını belirtmiştir. Ayrıca fiyat dışı faktörlerin de bu farklılıkları yaratacağını eklemiştir. Bunun yanında göreceli maliyetlerin de ülkeler arası farkların belirlenmesinde kullanılabileceğini ifade etmiştir. Ancak fiyat farklılıkları ülkeler arası karşılaştırmalı üstünlükleri hesaplarken zorluk çıkartmaktadır. Bunun yanında fiyat dışı etkenlerin de fazla olması durumu zorlaştıran diğer durumlardandır. Tüm bu sebeplerden dolayı karşılaştırmalı üstünlükler hesaplanırken ülkelerin ticaret sonrası verilerinin kullanılması gerekmektedir. Bela Balassa endeksi bir ülkenin karşılaştırmalı üstünlüğünün nedenlerini açıklamak yerine, ülkenin karşılaştırmalı üstünlüğe sahip olup olmadığını açıklar. Ayrıca endeks, ülkelerin ihraç ettiği ürünlerdeki nispi faktör yoğunluğunun ve verimliliğinin belirlenmesinde de kullanılır (Kılıç, 2018).

Balassa tarafından geliştirilen indeks aşağıdaki gibidir.

1) $RCA = \frac{Xia\ /\sum Xi}{Xwa\ /\sum Xw}$

Xia → i ülkesinin a ürünündeki ihracat değeri
$\sum Xi$ → i ülkesinin ürünlerdeki toplam ihracat değeri
Xwa → Ülke veya ülke grubunun, dünyanın a ürünündeki ihracat değeri
$\sum Xw$ → Ülke veya ülke grubunun, dünya ürünlerindeki toplam ihracat değeri

$0 < RCA < 1$ ülke ilgili sektörde karşılaştırmalı dezavantaja sahiptir.
$1 < RCA < 2$ ülke ilgili sektörde karşılaştırmalı üstünlüğü zayıftır.
$2 < RCA < 4$ ülke ilgili sektörde orta derecede karşılaştırmalı üstünlüğe sahiptir.
$4 < RCA$ ülke ilgili sektörde güçlü karşılaştırmalı üstünlüğe sahiptir.

Vollrath Endeksi

Vollrath endeksi ile Balassa endeksinde bir ülkenin verisini dünya verisinin dışında tutulmaması yani çifte hesaplama olması ve ithalatı göz ardı etmesi nedeniyle eleştirilmiştir (Çakan ve Turhan, 2022).
Vollrath endeksleri aşağıdaki gibidir;

Nispi ihracat avantajı;

2) $RXA = \frac{Xia\ /\sum Xin}{Xra\ /\sum Xrn}$

Xia → i ülkesinin a malı ihracat değeri
$\sum Xin$ → i ülkesinin a malı dışındaki ürünlerin toplam ihracat değeri
Xra → i ülkesi dışındaki dünyanın a malı ihracat değeri
$\sum Xrn$ → i ülkesi dışındaki dünyanın a malı dışındaki ürünlerin toplam ihracat değeri

Nispi ithalat avantajı;

3) $RMA = \frac{Mia\ /\sum Min}{Mra\ /\sum Mrn}$

Mia → i ülkesinin a malı ithalat değeri
$\sum Min$ → i ülkesinin a malı dışındaki ürünlerin toplam ithalat değeri
Mra → i ülkesi dışındaki dünyanın a malı ithalat değeri
$\sum Mrn$ → i ülkesi dışındaki dünyanın a malı dışındaki ürünlerin toplam ithalat değeri

Nispi ticaret avantajı;
4) $RTA = RXA - RMA$

Nispi ihracat avantajı ile nispi ithalat avantajı arasındaki farktır.
Açıklanmış üstünlük;

5) $RC = LnRXA - LnRMA$

RXA ve *RMA* endekslerinin logaritmasının alınmasının sebebi hükümetlerin tarım sektörüne müdahalelerinden dolayı ülkelerin dış ticaret verilerinde bozulma yaşanmasıdır. Bu bozulma sonucunda endekslerde meydana gelen asimetrik durumu çözmek için logaritmaları alınır.
RC, *LnRXA* ve *RTA* değerlerinin 0 ‘dan büyük olması rekabet durumunun olduğunu gösterir.

BULGULAR VE TARTIŞMA

Dünyada Mercimek Piyasası

Dünya mercimek üretimine bakıldığında 2000 yılında 3 394 605.79 ton üretim gerçekleşmiştir. Üretim miktarı 2021 yılında yaklaşık %65 artarak 5 610 103,65 ton seviyesine çıkmıştır. En düşük üretim 2008 yılında 2 835 379,78 ton olarak gerçekleşmiştir. En yüksek üretim ise 2017 yılında 7 130 547,84 tondur. Dünyada mercimek ekimi 2000 yılında 3 881 715 ha alanda yapılmıştır. Ekim alanı 2021 yılında yaklaşık %44 artarak 5 585 879 ha seviyesine çıkmıştır. En az ekim alanı 2008 yılında 3 337 466 ha ile gerçekleşmiştir. En yüksek ekim alanı ise 2017 yılında 6 156 884 ha ile yapılmıştır. Dünya mercimek verimine bakıldığında 2000 yılında 87.45 kg/da iken 2021 yılında yaklaşık %15 artarak 100.43 kg/da’a çıkmıştır. En düşük verim 2002 yılında 79,27 kg/da olarak gerçekleşmiştir. En yüksek verim 2020 yılında 130,49 kg/da olmuştur (Tablo 1) (FAO, 2023a).

Dünya mercimek üretici fiyatları 2000-2021 yılları arasında bazı yıllar düşüş olsa da artış eğilimindedir. Dünya mercimek üretici fiyatları 2000 yılında 493,05 $/ton seviyesindedir. 2021 yılında yaklaşık %156 artarak 1 266,94 $/ton seviyesine kadar çıkmıştır. En düşük üretici fiyatı 2001 yılında 442,81 $/ton olmuştur. En yüksek üretici fiyatı ise 2021 yılında 1 266,94 $/ton olmuştur (Tablo 1) (FAO, 2023b).

Tablo 1. Dünya mercimek üretimi, ekim alanı, verimi ve fiyatı 2000-2021.

DÜNYA MERCİMEK ÜRETİMİ, EKİM ALANI VE VERİMİ 2000-2021				
YILLAR	**MİKTAR (ton)**	**EKİM ALANI (ha)**	**VERİM (kg/da)**	**FİYAT (USD/TON)**
2000	3 394 605,79	3 881 715	87,45	$493,05
2001	3 276 527,73	4 008 915	81,73	$442,81
2002	2 909 283,91	3 669 999	79,27	$470,01
2003	3 005 654,93	3 574 158	84,09	$525,59
2004	3 615 205,11	3 873 878	93,32	$653,99
2005	4 164 721,66	4 151 018	100,33	$622,39
2008	2 835 379,78	3 337 466	84,96	$1 019,21
2017	7 130 547,84	6 156 884	115,81	$1 226,52
2018	6 580 218,62	5 512 261	119,37	$1 129,55
2019	5 787 579,49	4 863 292	119,01	$931,49
2020	6 471 039,20	4 958 876	130,49	$1 031,80
2021	5 610 103,65	5 585 879	100,43	$1 266,94

Kaynak: FAO, 2023

Dünyada yıllar içerisindeki mercimek ihracat ve ithalat miktarlarına bakıldığında bir artış eğilimi olduğu yani Dünya genelinde mercimek dış ticaret hacminin gelişme gösterdiği görülmektedir. 2000 yılında dünya ithalat miktarı 1 074 175,56 ton olarak gerçekleşmiştir. 2021 yılında ise ithalat miktarı %279,10 artarak 4 072 186,16 ton olarak gerçekleşmiştir. En düşük ithalat miktarı 2004 yılında 1 030 364,00 ton olarak gerçekleşirken en yüksek ithalat miktarı ise 2020 yılında 5 050 784,82 ton olarak gerçekleşmiştir. 2000 yılında dünya ihracat miktarı 1 098 203,27 tondur. 2021 yılında ise ihracat miktarı %245,04 artarak 3 789 288,87 ton olarak gerçekleşmiştir. En düşük ihracat miktarı 2002 yılında 1 018 923,00 ton olarak gerçekleşirken en yüksek ihracat miktarı ise 2020 yılında 5 087 273,95 ton olarak gerçekleşmiştir (Tablo 2) (FAO, 2023c).

Tablo 2. Dünya mercimek dış ticareti 2000-2021.

DÜNYA MERCİMEK DIŞ TİCARETİ (ton) 2000-2021				
YILLAR	**İTHALAT (ton)**	**Bİ**	**İHRACAT (ton)**	**Bİ**
2000	1 074 175,56	100,00	1 098 203,27	100,00
2001	1 138 504,03	5,99	1 177 013,00	7,18
2002	1 076 922,00	0,26	1 018 923,00	-7,22
2003	1 118 432,00	4,12	1 041 169,00	-5,19
2004	1 030 364,00	-4,08	1 127 666,00	2,68
2017	3 863 637,27	259,68	3 520 882,65	220,60
2018	2 947 573,49	174,40	3 152 051,41	187,02
2019	4 032 607,71	275,41	3 908 444,55	255,89
2020	5 050 784,82	370,20	5 087 273,95	363,24
2021	4 072 186,16	279,10	3 789 288,87	245,04

Kaynak: FAO, 2023

Dünya genelinde 2021 yılında üretilen toplam 5 610 103,65 ton mercimeğin büyük bir kısmını 3 ülke üretmektedir. 2021 Dünya mercimek üretiminin %70,41'lik kısmını Kanada, Hindistan ve Avustralya tarafından gerçekleştirmiştir. Dünya mercimek üretiminde Kanada, 1 606 411,00 ton ile toplam üretimin %28,63'lük kısmını karşılamaktadır. İkinci sırada Hindistan 1 490 000.,00 ton ile toplam üretimin %26,56'lık kısmını karşılamaktadır. Üçüncü sırada Avustralya 853 641,68 ton üretim ile toplam üretimin %15,22'lik kısmını karşılamaktadır. Türkiye 263 000,00 ton üretim ile dünya üretiminin %4,69'luk kısmını karşılayarak 4'üncü sırada yer almaktadır. Ardından Nepal 264 092,00 ton üretim ile Dünyadaki mercimek üretiminin %4,39'luk kısmını karşılayarak 5'inci sırada yer almaktadır (Tablo 3) (FAO, 2023a).

Tablo 3. Dünyada en çok mercimek üreten 10 ülke 2021.

DÜNYADA EN ÇOK MERCİMEK ÜRETEN 10 ÜLKE 2021		
ÜLKELER	**MİKTAR (ton)**	**%**
KANADA	1 606 441,00	28,63
HİNDİSTAN	1 490 000,00	26,56
AVUSTRALYA	853 641,68	15,22
TÜRKİYE	263 000,00	4,69
NEPAL	246 092,00	4,39
BANGLADEŞ	185 500,00	3,31
RUSYA	176 131,80	3,14
ÇİN	165 158,18	2,94
AMERİKA	150 910,00	2,69
ETİYOPYA	122 766,45	2,19
DİĞER	350 462,54	6,25
TOPLAM	5 610 103,65	100

Kaynak: FAO, 2023

Dünyada 2021 yılında üretilen 5 610 103,65 ton mercimeğin %67,54'lük kısmı yani 3 789 288,87 tonu ihraç edilmiştir. Bu ihracatın %73,07'lik kısmını Kanada ve Avustralya yapmaktadır. Dünyada mercimek ithalatına baktığımızda ise Hindistan, Türkiye ve Bangladeş toplam ithalatın %42,15'lik kısmını yapmaktadır. Kanada 2021 yılında hem üretim hem de ihracat miktarı bakımından ilk sırada yer almaktadır. Kanda 1 928 932,69 ton ile dünya ihracatının %50,90'lık kısmını yapmaktadır. Avustralya 840 229,52 ton ihracat miktarı ile Kanada'nın ardından %22,17'lik payla ikinci sırada yer almaktadır. Türkiye 289 418,31 ton ihracat miktarı ile Avustralya'nın ardından %7,64'lük oranla üçüncü sırada yer almaktadır (Tablo 4) (FAO, 2023c).

Dünyada mercimek ihracat fiyatlarına baktığımızda, ortalama 1 ton mercimeğin ihracat fiyatı 746,03 $'dır. Bu fiyat Kanada için, 724,85 $ iken Avustralya için, 599,00 $'dır. Türkiye ise ortalama 1 ton mercimeği 940,29 $'a ihraç etmiştir ve bu fiyat dünya ortalamasının üzerindedir. 2021 yılında Dünya genelinde toplam ithalat 4 072 186,16 tondur. Hindistan 2021 yılında 724 536,72 ton ithalat ile toplam ithalatın yaklaşık %17'lik kısmıyla ilk sırada yer almaktadır. Türkiye 536 702,49 ton ithalat ile toplam ithalatın yaklaşık %13'lük kısmıyla ikinci sırada yer almaktadır. Bangladeş 455 298,43 ton ithalat ile toplam ithalatın yaklaşık %11'lik kısmıyla üçüncü sırada yer almaktadır. Dünya toplam ithalatının %42,15'lik kısmını Hindistan, Türkiye ve Bangladeş yapmaktadır. Dünyada mercimek ithalat fiyatlarına baktığımızda, ortalama 1 ton mercimeğin ithalat fiyatı 775,24 $'dır. Bu fiyat Hindistan için, 725,70 $ iken Türkiye için, 707,92 $'dır. Bangladeş ise ortalama 1 ton mercimeği 625,86 $'a ithal etmiştir (Tablo 4) (FAO, 2023c).

Tablo 4. Dünyada en çok mercimek ithal ve ihraç eden 10 ülke 2021.

DÜNYADA EN ÇOK MERCİMEK İTHAL VE İHRAÇ EDEN 10 ÜLKE (ton) 2021								
SIRALAMA	**İHRACAT**				**İTHALAT**			
	ÜLKELER	**MİKTAR**	**%**	**$/TON**	**ÜLKELER**	**MİKTAR**	**%**	**$/TON**
1	KANADA	1 928 932,69	50,90	₺724,85	HİNDİSTAN	724 536,72	17,79	₺725,70
2	AVUSTRALYA	840 229,52	22,17	₺599,00	TÜRKİYE	536 702,49	13,18	₺707,92
3	TÜRKİYE	289 418,31	7,64	₺940,29	BANGLADEŞ	455 298,43	11,18	₺625,86
4	BAE	268 968,89	7,10	₺890,77	BAE	244 420,41	6,00	₺719,66
5	AMERİKA	201 673,51	5,32	₺687,98	SRİ LANKA	205 280,95	5,04	₺745,44
6	RUSYA	80 979,33	2,14	₺1 206,32	PAKİSTAN	164 910,56	4,05	₺644,54
7	KAZAKİSTAN	48 082,88	1,27	₺651,42	MISIR	145 851,55	3,58	₺694,26
8	MISIR	15 272,38	0,40	₺893,25	ETİYOPYA	102 999,80	2,53	₺562,22
9	BELÇİKA	12 219,08	0,32	₺1 096,97	VENEZUELLA	100 000,00	2,46	₺1 280,00
10	SURİYE	9 935,55	0,26	₺522,87	KOLOMBİYA	85 232,33	2,09	₺807,52
	DİĞER	93 576,73	2,47	₺1 215,15	DİĞER	1 306 952,92	32,09	₺899,05
	TOPLAM	3 789 288,87	100,00	₺746,03	TOPLAM	4 072 186,16	100,00	₺775,24

Kaynak: FAO, 2023

Türkiye'de Mercimek Piyasası

2000 yılında Türkiye'de toplam mercimek üretimi 353 000 ton 'dur. Bunun %20,67'lik kısmını yeşil mercimek üretimi oluştururken geriye kalan %79,33'lük kısmını da kırmızı mercimek üretimi oluşturmaktadır. 2022 yılında üretim miktarı 445 000 tona kadar çıkmıştır. Bu üretimin %10,11'lik kısmını yeşil mercimek oluştururken geriye kalan %88,89'luk kısmını kırmızı mercimek üretimi oluşturmaktadır. 2022 yılında 2000 yılına göre toplam mercimek üretimi %26,06 artış göstermiştir (FAO, 2023a).

2000 yılında mercimek ekim alanı toplam 4 720 000 da iken 2022 yılına bakıldığında 3 426 367 da seviyesine gerilemiştir. 2022 yılında 2000 yılına göre toplam ekim alanı %27,41 azalmıştır. Yeşil mercimek verimi 2000 yılında 89,02 kg/da iken 2022 yılında 105,08 kg/da 'a yükselmiştir. Kırmızı mercimek verimi ise 2000 yılında 71,79 kg/da iken 2022 yılında 133,42 kg/da 'a yükselmiştir (FAO, 2023a).

Türkiye'de mercimek üretici fiyatları, 23 yıllık süreçte inişli çıkışlı bir durum izlemiştir. 2000-2009 yılları arasında fiyatlar yükseliş eğilimindedir. 2010-2022 yılları arasında ise fiyatlar düşüş eğilimindedir. Türkiye'de mercimek üretici fiyatları 2000 yılında 609,20 $/ton seviyesindedir. Bu durum 2022 yılında bir miktar arışla 716,95 $/ton seviyesine çıkmıştır (FAO, 2023b).

Türkiye dünya mercimek piyasasında hem ihracatta hem de ithalatta önemli bir ülke konumundadır. Son 23 yıllık verilere bakıldığında 2001-2007 ve 2012 dönemlerinde Türkiye'nin mercimekte net ihracatçıdır. Ancak 2013 yılından itibaren bu konumu tersine dönmüştür. 2013-2022 döneminde Türkiye mercimekte net ithalatçı olmuştur. Özellikle 2018-2021 yılları arasında ithalat-ihracat makası ihracatın aleyhinde giderek açılmıştır. Türkiye 2000 yılında 140 913,92 ton mercimek ithal etmiştir. 2022 yılında ise 2000 yılına göre mercimek ithalatı %260,92'lik artışla 508 591,02 ton olmuştur. Türkiye 2000 yılında 99 729,63 ton mercimek ihraç etmiştir. 2022 yılında ise 2000 yılına göre mercimek ihracatı %400,57'lik artışla 499 220,05 ton olmuştur (FAO, 2023c).

Araştırma konumuz gereğince Türkiye'nin mercimek dış ticaretine daha yakından bakmak faydalı olacaktır. Bu araştırmanın yapıldığı sırada 2022 yılı dış ticaret verileri ayrıntılı olarak yayınlanmadığından 2021 yılı verilerini incelemiş bulunmaktayız. 2021 yılında Türkiye 536 702,49 ton mercimek ithal etmiştir. Bu ithalat için ton başına ortalama 707,92 $ ödeme yapmıştır. Türkiye ithalatının %74,90'lık kısmını Kanada'dan yapmış olup bu ithalat için ton başına ortalama 696.33 $ ödeme yapmıştır. Türkiye'nin en çok ithalat yaptığı ikinci ülke ise Rusya'dır. Türkiye Rusya'dan 49 009,39 ton mercimek ithal etmektedir ve bu ithalat için ortalama ton başına 513,74 $ ödeme yapmaktadır. Üçüncü sırada ise Kazakistan yer almaktadır. Türkiye Kazakistan'dan 35 423,98 ton mercimek ithal etmekte ve ton başına ortalama 710,76 $ ödeme yapmaktadır. 2021 yılında Türkiye 289 353,12 ton mercimek ihraç etmiştir. Bu ihracat için ton başına ortalama 940,33 $ ödeme almıştır. Türkiye'nin ihracat yaptığı ülkelerin başında %21,07'lik kısımla Irak gelmektedir. Irak Türkiye'den 60 980,87 ton mercimek ithal etmiştir ve bu ithalat için Türkiye'ye ton başına ortalama 870,03 $ ödeme yapmıştır. Türkiye'nin en çok ihracat yaptığı ikinci ülke Mısır'dır. Türkiye Mısır'a 25 901,62 ton mercimek ihraç etmiş olup bu ihracattan ortalama ton başına 961,06 $ ödeme almıştır. Türkiye'nin en çok ihracat yaptığı üçüncü ülke ise Sudan'dır. Sudan Türkiye'den 25 684,84 ton mercimek ithal etmiştir. Sudan bu ithalat için Türkiye'ye ton başına ortalama 926,54 $ ödeme yapmıştır (FAO, 2023c).

Türkiye'de mercimek üretimi belli bölgelerde yapılmaktadır. Kırmızı mercimek üretimi Güneydoğu Anadolu bölgesinde yaygın olarak yapılırken yeşil mercimek üretimi yaygın olarak İç Anadolu bölgesinde yapılmaktadır. İllerin son 5 yıldaki (2018-2022) üretimlerine baktığımızda kırmızı ve yeşil mercimek üretiminin büyük kısmı 3'er ilde gerçekleşmektedir. Kırmızı mercimek için bu iller Diyarbakır, Şanlıurfa ve Batmandır. Yeşil mercimek için ise Yozgat, Konya ve Kırşehir'dir (TÜİK, 2023).

Dünya Ticaretinde Üstünlükler

Balassa indeksine göre, dünyada son 10 yılda (2012-2021) Avustralya, Kanada, Mısır, Kazakistan, Nepal, Sri Lanka, Suriye, Türkiye ve BAE'nin Dünya mercimek ticaretinde üstünlüğü olduğu görülmektedir.

Çizelge 1. Balassa indeksine göre dünya mercimek piyasasında ülkelerin rekabet durumu.

Ülkeler	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Avustralya	5,47	4,12	3,63	2,44	3,21	7,42	4,34	4,84	5,83	7,28
Kanada	15,97	19,90	19,38	20,18	18,24	14,28	15,13	16,03	16,79	14,71
Mısır	2,07	1,45	0,56	0,57	0,25	0,31	2,19	1,41	0,53	1,35
Kazakistan	0,63	0,33	0,75	0,98	7,73	10,87	14,96	12,49	3,98	6,00
Nepal	138,92	56,16	51,28	19,84	34,51	24,53	42,94	21,58	3,72	2,82
Sri Lanka	3,15	2,29	5,23	1,84	3,77	2,02	0,90	1,75	3,69	1,70
Suriye	25,73	18,13	15,91	11,61	9,11	16,64	16,09	16,91	7,77	4,60
Türkiye	10,84	7,90	7,62	7,33	8,70	8,25	10,21	8,14	8,00	7,10
BAE	5,14	5,73	4,01	6,63	7,17	12,00	7,80	7,61	7,19	10,12

Kaynak: FAO, 2023 verileri kullanılarak hesaplanmıştır.

Nepal, Suriye ve Türkiye'nin rekabet durumuna bakıldığında yıllar içerisinde yükselişler olsa da genel olarak düşüş eğiliminde olduğu görülmektedir. Hindistan, dünya mercimek üretiminde ikinci, mercimek ithalatında ise ilk sırada yer almasına rağmen, mercimeği öz tüketimde kullanmasından dolayı dünya mercimek piyasasında dezavantajlı durumdadır. Rusya, 2012-2016 yılları arasında dünya mercimek piyasasında dezavantajlı konumda iken, 2017 yılından sonra bazı yıllarda zayıf, bazı yıllarda orta derecede rekabet durumundadır.

Avustralya'nın rekabet durumuna bakıldığında, 2012 yılında 5,47'lik değer ile güçlü rekabet durumunda olduğu görülmektedir. 2013-2015 yılları arasında rekabet durumu düşerek 2015 yılında 2,44 değer ile orta derecede rekabet durumuna düşmüştür. 2016 ve 2017 yılında rekabet değeri artarak 7,42'lik değerle tekrar güçlü rekabet durumuna gelmiştir. 2018 yılında rekabet durumunda düşüş olsa da daha sonraki yıllardaki artışla 2021 yılında 7,28'lik değerle, Avustralya dünya mercimek piyasasında güçlü rekabete sahip bir ülkedir. Kanada'nın rekabet durumuna bakıldığında 2012-2021 yılları arasında bazı yıllarda düşüşler olsa da güçlü rekabete sahip olduğu görülmektedir. Mısır'ın rekabet durumuna bakıldığında, 2012 yılında 2,07'lik değerle orta derecede rekabete sahiptir. 2021 yılında ise 1,35'e gerilemiştir. Mevcut durumda Mısır, dünya mercimek piyasasında zayıf üstünlüğe sahiptir. Kazakistan'ın rekabet durumuna bakıldığında, 2012-2015 yılları arasında dünya mercimek piyasasında dezavantajlı olduğu görülmektedir. Kazakistan 2016 yılından itibaren ciddi bir yükselişle dünya mercimek piyasasında güçlü rekabet durumuna yükselmiştir. Nepal'in rekabet durumuna bakıldığında, yıllar geçtikçe dünya mercimek piyasasındaki rekabet durumunun düştüğü görülmektedir. Özellikle Nepal 2012 yılında 138,92 gibi çok yüksek bir değerle güçlü rekabet durumuna sahiptir. Ancak bu durumun sebebi, Nepal'in ihraç ettiği toplam tarım ürünlerinin içerisinde mercimeğin payının çok yüksek olmasından kaynaklıdır. Nepal en son 2021 yılında 2,82'lik değer ile orta derecede rekabet durumuna düşmüştür. Sri Lanka'nın rekabet durumuna bakıldığında, yıllar içerisinde dalgalı bir durum görülmektedir. Sri Lanka dünya mercimek piyasasında 2012 yılında 3,15'lik değer ile orta derecede rekabet durumuna sahiptir. 2014 yılında ise 5,23'lük değer ile güçlü rekabet durumuna gelmiştir. Sri Lanka'nın 2021 yılındaki rekabet durumu ise 1,7'lik değer ile zayıf karşılaştırmalı üstünlüğe sahiptir. Suriye'nin rekabet durumuna bakıldığında, 2012-2016 yılları arasında sürekli azalarak 2016 yılında 9,11'lık değer gerilemiştir. 2017-2019 yılları arasında tekrar yükselerek 2019 yılında 16,91'lik değer ile güçlü rekabet durumundadır. Suriye 2020 ve 2021 yıllarında rekabet gücünü kaybetse de 2021 yılında 4,60'lık değerle hala güçlü rekabete sahiptir denebilir. Türkiye'nin rekabet durumuna bakıldığında, Dünya mercimek piyasasında, 2012 yılında 10,84'lük değer ile güçlü rekabete sahiptir. 2013-2015 yılları arasında rekabet durumunda düşüş olsa da 2015 yılında 7,33'lük değer ile güçlü rekabet durumundadır. 2016-2018 yıllarında rekabet durumu yükselerek 2018 yılında 10,21 seviyesine çıkmıştır. 2019-2021 yıllarında ise tekrar düşerek 2021 yılında 7,10'luk değere gerilemiştir. Türkiye 10 yıllık ortalama 8,41'lik değer ile dünya mercimek piyasasında güçlü rekabete sahip ülke konumundadır. BAE'nin rekabet durumuna bakıldığında, 2012-2017 yılları arasında bazı yıllar düşüş olsa da genel olarak yükseliş eğilimindedir. BAE'nin dünya mercimek piyasasındaki en yüksek rekabet durumu 2017 yılında 12,00'lık değerle gerçekleşmiştir. 2018-2020 yılları arasında düşüş olsa da 2021 yılında tekrar yükselerek 10,12'lik değerle güçlü rekabet durumundadır.

Balassa İndeksine göre Türkiye, dünya mercimek piyasasında güçlü rekabete sahip ülkeler arasındadır. Son 10 yıllık verilere göre Türkiye, Dünya'da Nepal, Kanada ve Suriye'nin ardından en rekabetçi 4. ülke konumundayken son 2 yıllık verilere göre Kanada ve BAE'nin ardından en rekabetçi 3. ülke konumundadır. Türkiye 2012-2021 yılları arasında Suriye ve Nepal karşısında rekabet gücünü artırırken, aynı dönemde BAE, Kazakistan ve Avustralya karşısında rekabet gücünde azalma olmuştur. Türkiye, 2012-2021 yılları arasında Kanada, Mısır ve Sri Lanka karşısındaki rekabet durumunda bazı yıllar artış ve azalışlar olsa da gözle görülür bir değişim olmamıştır.

Çizelge 2. Balassa indeksine göre Türkiye'nin dünya mercimek piyasasındaki rekabet durumu.

Yıllar	Türkiye-Avustralya	Türkiye-Kanada	Türkiye-Mısır	Türkiye-Kazakistan	Türkiye-Nepal	Türkiye-Sri Lanka	Türkiye-Suriye	Türkiye-BAE
2012	1,98	0,68	5,23	17,27	0,08	3,45	0,42	2,11
2013	1,92	0,40	5,44	23,85	0,14	3,44	0,44	1,38
2014	2,10	0,39	13,49	10,14	0,15	1,46	0,48	1,90
2015	3,00	0,36	12,77	7,45	0,37	3,99	0,63	1,10

Çizelge 2. (Devamı)

Yıllar	Türkiye-Avustralya	Türkiye-Kanada	Türkiye-Mısır	Türkiye-Kazakistan	Türkiye-Nepal	Türkiye-Sri Lanka	Türkiye-Suriye	Türkiye-BAE
2016	2,71	0,48	34,89	1,13	0,25	2,31	0,95	1,21
2017	1,11	0,58	26,42	0,76	0,34	4,08	0,50	0,69
2018	2,35	0,67	4,67	0,68	0,24	11,30	0,63	1,31
2019	1,68	0,51	5,77	0,65	0,38	4,65	0,48	1,07
2020	1,37	0,48	15,02	2,01	2,15	2,17	1,03	1,11
2021	0,98	0,48	5,25	1,18	2,52	4,18	1,55	0,70

Kaynak: FAO, 2023 verileri kullanılarak hesaplanmıştır

Türkiye-Avustralya arasındaki rekabet durumuna bakıldığında, Türkiye Avustralya karşısında bazı yıllar düşüşler olsa da genel itibariyle üstünlüğe sahip olduğu görülmektedir. Türkiye 2012 ve 2013 yıllarında zayıf karşılaştırmalı üstünlüğe sahipken 2014-2016 yılları arasında orta derecede karşılaştırmalı üstünlüğe sahiptir. 2017 yılından sonra Türkiye'nin rekabet durumunda artışlar ve azalışlar olmuştur. 2021 yılında ise Türkiye Avustralya karşısında rekabet durumunda dezavantajlı bir duruma gelmiştir. Türkiye-Kanada arasındaki rekabet durumuna bakıldığında, Türkiye'nin dünya mercimek piyasasında Kanada karşısında dezavantajlı bir durumda olduğu görülmektedir. Genel duruma bakıldığında, son 10 yıllık süreçte Türkiye'nin Kanada karşısındaki rekabet durumunda artış ya da azalış eğilimi görülmemektedir. Türkiye-Mısır arasındaki rekabet durumuna bakıldığında, Türkiye'nin Mısır karşısında güçlü rekabet durumunda olduğu görülmektedir. 2016 ve 2017 yıllarında Türkiye'nin rekabet durumu ciddi miktarda yükselmiştir. Genel duruma bakıldığında son 10 yıllık süreçte Türkiye'nin Mısır karşısında rekabet durumunda artış ya da azalış eğilimi görülmemektedir. Türkiye-Kazakistan arasındaki rekabet durumuna bakıldığında, 2012-2015 yılları arasında Türkiye'nin Kazakistan karşısında güçlü rekabet durumunda olduğu görülmektedir. 2016 yılından sonra ise Türkiye'nin rekabet durumunda ciddi düşüşler olarak bazı yıllarda Kazakistan karşısında dezavantajlı durumu düşmüştür. Türkiye-Nepal arasındaki rekabet durumuna bakıldığında, yıllar içerisinde Türkiye'nin rekabet durumunda artış eğilimi olduğu görülmektedir. 2012-2019 yılları arasında Türkiye Nepal karşısında dezavantajlı durumdayken 2020 ve 2021 yıllarında Türkiye Nepal karşısında avantajlı konuma gelmiştir. Türkiye-Sri Lanka arasındaki rekabet durumuna bakıldığında, Türkiye'nin Sri Lanka karşısında rekabette avantajlı durumda olduğu görülmektedir. Türkiye'nin 2018 yılında Sri Lanka karşısında Rekabet durumu ciddi oranda yükselmiştir. Türkiye-Suriye arasındaki rekabet durumuna bakıldığında, 2012-2019 yılları arasında Türkiye'nin dezavantajlı olduğu görülmektedir. 2020 ve 2021 yıllarında ise Türkiye'nin rekabet durumu yükselerek Suriye karşısında avantajlı konuma gelmiştir. Son 10 yılda Türkiye'nin Suriye karşısındaki rekabet durumu yükseliş eğilimindedir. Türkiye'nin BAE karşısında rekabet durumuna bakıldığında, 2012-2021 yılları arasında, 2017 ve 2021 yılları hariç rekabette avantajlı durumdadır. 2017 ve 2021 yıllarında ise Türkiye dezavantajlı durumdadır. Türkiye son 10 yılda BAE karşısındaki rekabet durumu düşüş eğiliminde olduğu görülmektedir.

Balassa indeksinin ardından, dünyadaki mercimek piyasasındaki bazı ülkelerin rekabet gücü Vollrath indeksine göre de incelenmiştir. İncelenmek üzere ülkelerin 2021-2021 yılları arasındaki ihracat ve ithalat verileri kullanılmıştır. Karşılaştırmalı üstünlükleri hesabında ise Vollrath'ın LnRXA (nispi ihracat avantajının logaritması), RTA (nispi ticaret avantajı) ve RC (açıklanmış üstünlük) indeksleri kullanılmıştır.

Çizelge 3. Vollrath indeksine göre dünya mercimek piyasasında ülkelerin rekabet durumu (2012-2021 yılları ortalaması).

Ülkeler	LnRXA	RTA	RC
Avustralya	1,69	5,32	3,98
Kanada	3,67	38,74	4,41
Çin	-2,05	0,11	1,91
Kazakistan	1,76	5,63	3,55

Çizelge 3. (Devamı)

Ülkeler	LnRXA	RTA	RC
Nepal	3,19	14,98	0,95
Portekiz	-1,54	0,08	0,45
Rusya	0,01	0,97	3,26
Sri Lanka	1,02	-27,89	-2,41
Suriye	2,59	7,73	0,87
Türkiye	2,21	-0,77	-0,08
Uganda	-1,27	0,08	0,32
BAE	2,1	2,91	0,44
ABD	-0,41	0,47	1,24

Kaynak: FAO, 2023 verileri kullanılarak hesaplanmıştır

Vollrath LnRXA indeksine göre, Avustralya, Kanada, Kazakistan, Nepal, Rusya, Sri Lanka, Suriye, Türkiye ve BAE dünya mercimek piyasasında nispi ihracat üstünlüğüne sahiptir. Vollrath RTA indeksine göre, Avustralya, Kanada, Çin, Kazakistan, Nepal, Portekiz, Rusya, Suriye, Uganda, BAE ve ABD dünya mercimek ticaretinde nispi ticaret üstünlüğüne sahiptir. Vollrath RC indeksine göre, Avustralya, Kanada, Çin, Kazakistan, Nepal, Portekiz, Rusya, Suriye, Uganda ve BAE dünya mercimek piyasasında açıklanmış üstünlüğe sahiptir. Tabloya göre dünya mercimek piyasasında Kanada'nın 3 indekste de rekabet gücü en yüksek ülke olduğu görülmektedir. Türkiye dünya mercimek piyasasındaki durumuna bakıldığında, LnRXA indeksine göre rekabetçi bir ülke iken, RTA ve RC indeksine göre dünyada dezavantajlı durumdadır.

Bu bölümde Türkiye'nin Vollrath indeksine göre yıllar içerisindeki rekabet gücünün değişimi incelenmiştir. Türkiye mercimekte önemli ihracatçı ülke olmasına karşın, son yıllarda ihracatında düşüş olması, aynı zamanda son zamanlardaki ithalatının artması RTA ve RC indekslerin de ciddi düşüşlere neden olmuştur.

Çizelge 4. Vollrath İndeksine Göre Türkiye'nin Mercimek Piyasasındaki durumu.

Yıllar	RTA	LnRXA	RC
2012	3,81	2,51	0,37
2013	0,74	2,16	0,09
2014	-2,53	2,13	-0,26
2015	-1,52	2,09	-0,17
2016	-2,08	2,28	-0,19
2017	0,81	2,21	0,09
2018	1,67	2,45	0,16
2019	1,57	2,20	0,19
2020	-1,43	2,19	-0,15
2021	-4,51	2,06	-0,45

Kaynak: FAO, 2023 verileri kullanılarak hesaplanmıştır.

Türkiye'nin rekabet durumuna bakıldığında, RTA (nispi ticaret avantajı) indeksine göre 2012'de 3.81 değerinde iken yıllar içerisindeki düşüş eğilimiyle 2021 yılında -4,51 değerine kadar düşmüştür. LnRXA (nispi ihracat avantajının logaritması) indeksine göre, 2012'de 2,51 değerinde iken yıllar içerisindeki düşüş eğilimiyle 2021 yılında 2.06 değerine kadar düşmüştür. RC (açıklanmış üstünlük) indeksine göre, 2012 yılında Türkiye'nin rekabet değeri 0.37 iken yıllar içerisindeki düşüş eğilimiyle 2021 yılında -0,45 değerine kadar düşmüştür. Türkiye'nin RTA (nispi ticaret üstünlüğü) ve RC (açıklamış üstünlük) indeksleri 2018-2021 yılları arasında sürekli düşmüştür. Bu indeksler RXA (nispi ihracat avantajı) ve RMA (nispi ithalat avantajı) indekslerine bağlıdır. 2018-2021 yılları arasında RXA ve RMA indeksleri arasındaki fark Türkiye'nin aleyhine açılmıştır. Bu durum da RTA ve RC indekslerinin düşmesine neden olmuştur.

SONUÇ

Bu çalışmada 2000-2021 yılları arasında Dünya'da ve Türkiye'de mercimek piyasası ve karşılaştırmalı üstünlüğü incelenmiştir. Dünya mercimek piyasasına bakıldığında, mercimek üretiminde dalgalı bir durum olmasına rağmen genel olarak artış eğilimi vardır. Mercimek üretimde Kanada, Hindistan ve Avustralya ilk 3 sırada yer almaktadır. Dünya mercimek dış ticaretine bakıldığında ithalatta ve ihracatta artış eğilimi olduğu görülmektedir. Özellikle 2018-2020 yılları arasında ithalat %71,35'lik, ihracatta ise %61,39'luk artış olmuştur. Dünya'da en çok mercimek ihracatını Kanada, Avustralya ve Türkiye yapmaktadır. En çok ithalatı ise Hindistan, Türkiye ve Bangladeş yapmaktadır. Türkiye mercimek piyasasına bakıldığında, yeşil mercimek üretiminde 2000-2006 yılları arasında sürekli düşüş vardır. 2007-2016 yılları arasında ise mercimek üretimi durağın bir seyir izlemekle beraber 2017-2022 yılları arasında artışa geçmiştir. Genel duruma bakıldığında ise yeşil mercimek üretiminde düşüş eğilimi vardır. 2022 yılı iller bazında üretim miktarına bakıldığında, ilk 3 sırada sırasıyla Yozgat, Konya ve Kırşehir yer almaktadır. Kırmızı mercimek üretiminde bakıldığında dalgalı bir durum olmasına rağmen genel olarak düşüş eğilimi vardır. Özellikle 2008 yılında üretim ciddi miktarda düşmüştür. 2022 yılı iller bazında üretim miktarına bakıldığında, ilk 3 sırada sırasıyla Şanlıurfa, Diyarbakır ve Batman yer almaktadır. Türkiye mercimek dış ticaretine bakıldığında, ithalatta ve ihracatta artış eğilimi olduğu görülmektedir. 2021 yılında Türkiye en çok ihracatını sırasıyla Irak, Mısır ve Sudan'a yapmaktadır. İthalatta ise sırasıyla Kanada, Rusya ve Kazakistan yer almaktadır. Karşılaştırılmalı üstünlüğe bakıldığında, Ballasa indeksine göre dünya mercimek piyasasında Avustralya, Mısır, Kanada, Kazakistan, Nepal, Sri Lanka, Suriye, Türkiye ve BAE karşılaştırmalı üstünlüğe sahiptir. Türkiye dünya mercimek piyasasında üstünlüğe sahip ülkelerle karşılaştırıldığında Avustralya, Mısır, Kazakistan, Sri Lanka ve BAE karşısında avantaja sahip olup Kanada, Nepal ve Suriye karşısında dezavantaja sahiptir. Vollrath LnRXA (nispi ihracat avantajı) indeksine göre dünya mercimek piyasasında Avustralya, Kanada, Kazakistan, Nepal, Rusya, Sri Lanka, Suriye, Türkiye ve BAE üstünlüğe sahiptir. RTA (nispi ticaret avantajı) indeksine göre Avustralya, Kanada, Çin, Kazakistan, Nepal, Portekiz, Rusya, Suriye, Uganda ve BAE üstünlüğe sahiptir. RC indeksine göre ise Avustralya, Kanada, Çin, Kazakistan, Nepal, Portekiz, Rusya, Suriye, Uganda, BAE ve ABD üstünlüğe sahiptir.

Türkiye'de mercimek ekim alanları ve üretimi düşüş eğilimindedir. Uzun vadede mercimek üretiminin daha da düşmemesi için ARGE çalışmalarıyla mercimek verimliliğinin artırılması gerekmektedir. Türkiye Dünya'da mercimek üretiminde 4. Sırada yer almasına karşın en çok ithalat yapan 2. ülke konumundadır. Türkiye mercimek üretimini destekleyerek ya da üretim maliyetlerini düşürücü desteklerle mercimek üretimini artırıp tüketim amaçlı ithalatı azaltma yoluna gitmelidir. Türkiye'deki ve Dünya'daki üretici fiyatları arasındaki makas Türkiye aleyhinde açılmaktadır. Bu durumun devam etmesi üreticileri mercimek üretiminden uzaklaştıracaktır. Üreticilerin ekonomik açıdan korunması için gerekli desteklerin verilmesi gerekmektedir. Türkiye'nin dünya mercimek piyasasındaki rekabet gücünü artırması için pazar taleplerini dikkate alması, markalaşması, reklam çalışmaları yapması ve yeni pazarlar araması gerekmektedir. Dünya mercimek piyasasında Kanada gibi rekabet gücü olan ülkelerin mercimek politikasına bakılıp Türkiye için uygulanabilir olup olmadığı incelenmelidir. Uygun olan politikalar Türkiye'de de denenmelidir.

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Forecasting Soybean Production in Türkiye: A Comparative Analysis of Automated and Traditional Methods

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Keywords:

Soybean production
Türkiye
Time series forecasting
ARIMA algorithm
NNAR
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ABSTRACT

Türkiye's climate and soil are well-suited for the cultivation of oilseed crops, which are of vital importance to various industries and human and animal diets. Among oilseeds, soybeans, a legume, possess a distinctive nutritional profile. While existing research covers soybean production in Türkiye, this study aims to: a) evaluate production levels using different forecasting algorithms to identify the most accurate model, and b) based on the chosen model, forecast future production and assess the current and future entrepreneurial potential of the soybean industry in Türkiye.

Soybean production data (1990-2022) from TURKSTAT was divided into training (n=25) and test (n=8) sets for cross-validation. By applying univariate time series methods, including ARIMA, SES, NNAR, MN, and Naive to the training dataset, it was found that ARIMA (1,1,1) performed best according to test set RMSE values. The performance ranking (in terms of RMSE) was as follows: ARIMA (13019) < SES (13888) < Naive (14240) < NNAR (58393) < MN (80418). Notably, for this dataset, the performance of automated processes was relatively worse than that of manual methods, suggesting that relying solely on automated methods may lead to suboptimal forecasting results. These findings underscore the importance of human oversight in the use of automated algorithms for time series forecasting and highlight the need for caution when employing automated methods.

The ARIMA (1,1,1) model predicts a flat trend in production from 2023 to 2032, with an initial production volume of 154 516 tonnes and a slight decline to 153 607 tonnes. This predicted stagnation implies that, in the context of economic and population growth, soybean production will fall further behind domestic demand, leading to increased import reliance. These findings are of serious importance to farmers and policymakers alike, as they can assist in the formulation of informed decisions pertaining to resource allocation, crop planning, and market strategies. Local producers may potentially benefit from increased production efficiency, improved competitiveness, and potential revenue growth by catering to both domestic and export markets. Furthermore, an understanding of these trade dynamics can assist stakeholders in identifying potential avenues for collaboration or investment within the Turkish soybean industry. Further analysis of these results is ongoing in order to gain deeper insights into the factors influencing soybean production trends in Türkiye.

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INTRODUCTION

Fats, known as triglycerides of fatty acids, are an important source of energy in the human diet and serve as crucial industrial raw materials. Due to the high cost and insufficiency of animal oil production, a large proportion (91.7%) of the oils needed for human nutrition is supplied by vegetable oils. Many crops contain oil in their seeds, with some of the most important oil-producing crops being annual plants such as soybean, sunflower, rapeseed, peanut, sesame, and safflower. Additionally, perennial crops like olives, dates, and coconuts also play a significant role in crude oil production (Arıoğlu, 2016).

Soybean, scientifically known as *Glycine max* L. Merrill, is a legume that holds significant importance due to its dual role as a source of protein and oil (Pagano and Miransari, 2016). It is the world's leading oil crop, with soybean oil valued not only for human consumption but also for various industrial applications beyond food preparations and animal nutrition (Pratap *et al.*, 2012; Tiwari, 2017). Soybean oil accounts for 53% of global oilseed production, making it an essential component in the agricultural systems of major countries such as the USA, China, Brazil, Argentina, and India (Pratap *et al.*, 2012). The majority of soybeans undergo industrial processing to create value-added products like soymeal for animal feed and edible oil. The strong connection between soybean farming and industries, particularly the food and feed industries, makes it a highly desirable global trading commodity (Tiwari, 2017).

Soybean cultivation in Türkiye began in the 1930s, primarily in the Black Sea Region. The introduction of the second crop project subsequently facilitated the expansion of soybean farming into the Mediterranean Region. Today, soybean ranks as the second most important crop in the Mediterranean Region in terms of both cultivated area and production volume. Notably, the Çukurova sub-region exhibits a particularly strong emphasis on soybean cultivation. Irrigation has significantly contributed to the successful establishment of soybeans in this region due to its ease of cultivation under irrigated conditions (Özcan, 2023). However, Türkiye's soybean trade pattern is characterized by a heavy reliance on imports. This is primarily due to insufficient domestic production to meet the high domestic consumption demands and market requirements for soybeans and soybean meal. Consequently, Türkiye is a net importer of soybeans, which is the country's most imported oilseed crop (Tüfekçi, 2019).

Considering the significance of soybean production within a national economy, numerous studies have been initiated with the primary focus on estimating soybean production levels, consumption patterns, and market trends. The outcomes of these analyses are expected to provide essential market intelligence for agricultural decision makers. This valuable information can help them anticipate potential opportunities and threats within the soybean market. Uçum (2016), for example, employed the ARIMA (1,1,1) model to analyze and forecast both current and future soybean production trends in Türkiye. Güler *et al.* (2017), compared the performance of ARIMA and Artificial Neural Networks (ANNs) in forecasting import quantities of various oilseed crops, including soybean, chickpea, sunflower, and rapeseed.

Turkey's climate and soil are well-suited for cultivating oilseed crops, vital for various industries and human and animal diets. Among oilseeds, soybeans, a legume, have a distinctive nutritional profile. While existing research explores soybean production in Turkey, this study aims to: (a) evaluate production levels using different forecasting algorithms to identify the most accurate model and (b) forecast future production based on the chosen model to assess the current and future entrepreneurial potential of Turkey's soybean industry. This study will evaluate and compare the performance of various soybean production projection models to identify the most accurate one. Utilizing the outputs of the most successful model, the study will then forecast soybean production for the next decade. This information will be a valuable resource for agricultural decision-makers, enabling them to anticipate potential market opportunities and threats.

MATERIALS AND METHODS

This study utilized datasets from FAOSTAT to determine the current status of soybean production (Anonymous, 2022a) and trade (Anonymous, 2022b; Anonymous, 2022c) worldwide in 2022. Additionally, a 33-year soybean production dataset (in tonnes) compiled by TurkStat (Anonymous, 2022d) for the period 1990-2022 was used. The TurkStat data was divided into training and testing sets, with the first 25 years used for model training and the remaining 8 years for model evaluation based on goodness-of-fit criteria. This process facilitated the identification of the most effective model.

Within the domain of time series forecasting, two prominent methodologies dominate: Exponential Smoothing (ES) and Autoregressive Integrated Moving Average (ARIMA) models. ES approaches target the trend and seasonality inherent in the data, while ARIMA models prioritize capturing the autocorrelations within the series. These distinct techniques offer complementary strengths, enabling effective forecasting solutions (Hyndman, 2021).

The seminal work by Box and Jenkins (1970) in their publication "Time Series Analysis: Forecasting and Control" marked a pivotal turning point in time series forecasting. Known as the Box–Jenkins (BJ) methodology or ARIMA methods, these techniques represent a shift from constructing single-equation or simultaneous-equation models towards analyzing the stochastic properties of time series data independently. In contrast to regression models where the dependent variable Y_t is explained by independent variables $X_1, X_2, X_3, \dots, X_k$ ARIMA models enable Y_t to be influenced by past (lagged) values of itself and random error terms (Gujarati and Porter, 2009).

The Box–Jenkins method for ARIMA model building is a widely-used technique but poses challenges when implemented on a large scale, requiring both expertise and substantial time investment (Mélard and Pasteels, 2000). In business environments where over a thousand product lines necessitate monthly forecasts and trained personnel are in short supply, automatic forecasting algorithms prove indispensable (Hyndman and Khandakar, 2008). These methods must identify suitable models, estimate parameters, generate predictions, accommodate unusual patterns, and function efficiently without user intervention for vast numbers of series. To make time series analysis accessible to individuals lacking the necessary expertise, software vendors have introduced automated time series forecasting methods as alternatives (Mélard and Pasteels, 2000). For instance, R's "auto.arima" function in the "forecast" package determines all ARIMA model parameters automatically (Hyndman and Khandakar, 2008). This study employed the 'auto.arima' algorithm to identify the optimal ARIMA model based on the minimum Bayesian Information Criterion (BIC) score. The performance of the selected model was then compared to manually chosen ARIMA models.

ES techniques, including popular variants such as the Holt-Winters methods, trace their origins to the work of Robert G. Brown for the US Navy around 1944. Brown developed these methods to address trend and seasonality in discrete time series. Concurrently, Charles Holt was developing a different version of ES at the US Office of Naval Research (ONR). The work of these pioneers was further refined by the researchers, leading to the development of various statistical models for forecasting using exponential smoothing. The success of these methods in both forecasting and inventory control has inspired extensive research aimed at deriving equivalent point forecasts from other models. Many of these models are state space models that yield minimum mean squared error forecasts identical to those of simple ES (Hyndman *et al.*, 2008). In this study, we compare the performance of Simple Exponential Smoothing (SES), Holt's Linear Trend Method (HLT) (Holt, 2004), and Damped Holt's Trend Method (DHLT) (Gardner and Mckenzie, 1985).

This study utilized artificial neural networks (ANNs) for time series forecasting. ANN models, such as Neural Network Autoregression (NNAR), are employed for their ability to handle complex nonlinear relationships between variables. These networks use lagged time series values as inputs and have a single hidden layer with an automatic determination of nodes based on optimal performance. The

R package fits NNAR(p,k) models where p represents the number of lagged inputs and k is the number of nodes in the hidden layer. For non-seasonal data, the default is the optimal number of lags for a linear AR model. ANNs are iteratively applied to generate forecasts one step at a time using historical inputs as well as previous forecasts until all required forecasts have been computed (Hyndman *et al.,* 2008). In this study, while the ‘p’ value is determined by an automatic algorithm, the ‘k’ value is set to 5, 10, 25, and 50.

To establish a baseline for comparison with more sophisticated models, we included two simple forecasting methods: the mean method and the naive method. The mean method forecasts future values by setting them equal to the average of the historical data. Conversely, the naive method forecasts future values by setting them equal to the most recent observation in the time series.

Stationarity is a crucial concept in statistical analysis and modeling, particularly when working with time series data or performing econometric analyses. Its importance lies in the assumptions made by various analytical methods and models, which rely on stationary data to ensure accurate results. Stationarity refers to a property of a time series where its statistical characteristics, such as mean, variance, and covariance, remain constant over time. When dealing with non-stationary data, these properties may change over the observation period, leading to biased or misleading conclusions when applying certain analytical techniques (Gujarati and Porter, 2009).

In this study, the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test is employed to examine the stationarity of the soybean production time series. Kwiatkowski et al. (1992) introduced this approach to assess whether an observable time series follows a deterministic trend while being stationary around it. The proposed model includes deterministic trend, random walk, and stationary error components. The null hypothesis assumes the random walk has zero variance, which is tested using the LM test statistic. Asymptotic distributions under both the null and alternative hypotheses (difference-stationarity) are derived.

Root Mean Square Error (RMSE), Mean Absolute Error (MAE), and Mean Absolute Percentage Error (MAPE) are commonly employed metrics to evaluate the accuracy of time series forecasting models. RMSE measures the difference between observed and predicted values, while MAE calculates the absolute differences between them. MAPE represents the average percentage error across all observations. Equations for these goodness-of-fit criteria (Hyndman *et al.*, 2008; Akın *et al.*, 2021):

- Forecast Error (FE): $\epsilon_{T+h} = y_{T+h} - \hat{y}_{T+h|T}$ where ϵ_t is the forecast horizon, y is the observation and $\hat{y}$ is the forecast. The training data is given by $\{y_1, y_2, \dots, y_T\}$ and the test data is given by $\{y_{t+1}, y_{T+2}, \dots, y_{T+H}\}$.
- Root Mean Square Error (RMSE): $\frac{1}{n}\sqrt{\sum(\epsilon_t{}^2)}$ where ϵ_t is the forecast error.
- Mean Absolute Error (MAE): $\frac{1}{n}\sum|\epsilon_t|$ where ϵ_t is the forecast error.
- Mean Absolute Percentage Error (MAPE): $\frac{1}{n}\sum|P_t|$ where P_t is the percentage error for the t-th prediction ($P_t = 100 \times \frac{\epsilon_t}{y_t}$)

In this study, RMSE was used as the primary goodness-of-fit criterion to assess model performance; however, MAE and MAPE were also reported for a comprehensive evaluation of the forecasting models.

This study used the R statistical environment, version 4.2.2, developed by R Core Team (2022). The tidyverse meta-package, version 2.0.0, created by Wickham *et al.* (2019), was employed for data manipulation and cleaning. For time series data extension, the tsibble package (version 1.1.3), developed by Wang *et al.* (2020), was utilized. To build forecasting models, the fable package (version 0.3.3) created by O’Hara-Wild *et al.* (2023a) was employed. For feature extraction and statistical analysis, the feasts package (version 0.3.1), developed by O’Hara-Wild *et al.* (2023b), was utilized. To create world maps, rnaturalearth version 0.3.4 by Massicotte and South (2023), rnaturalearthdata version 0.1.0 by South (2017), sf package version 1.0.14 by Pebesma (2018), and sp package version 2.1.2 with contributions from Pebesma and Bivand (2005) and Bivand *et al.* (2013), were employed.

RESULTS AND DISCUSSION

This study begins by examining the production and trade dynamics of soybeans. Soybeans are a vital component in various industries, including food processing, animal feed production, and industrial applications. Understanding worldwide trends in soybean production and trade can provide valuable insights into market conditions, price fluctuations, potential investment opportunities, threats, and strategic partnerships.

According to data from the year 2022 (Anonymous, 2022a), Brazil is the leading producer of soybeans, with an impressive volume of approximately 120.7 million tons. The United States of America follows closely behind, with an estimated production of approximately 116.4 million tonnes during the same year. Argentina ranks third with a reported production of approximately 43.9 million tonnes, while China contributes approximately 20.3 million tonnes to the global market. India is the fifth-largest producer of soybeans, with an estimated annual production of approximately 12.6 million tons. Conversely, Türkiye's reported production volume was approximately 155,000 tonnes, placing it in the lower part of the ranking at position 32 (see Figure 1).

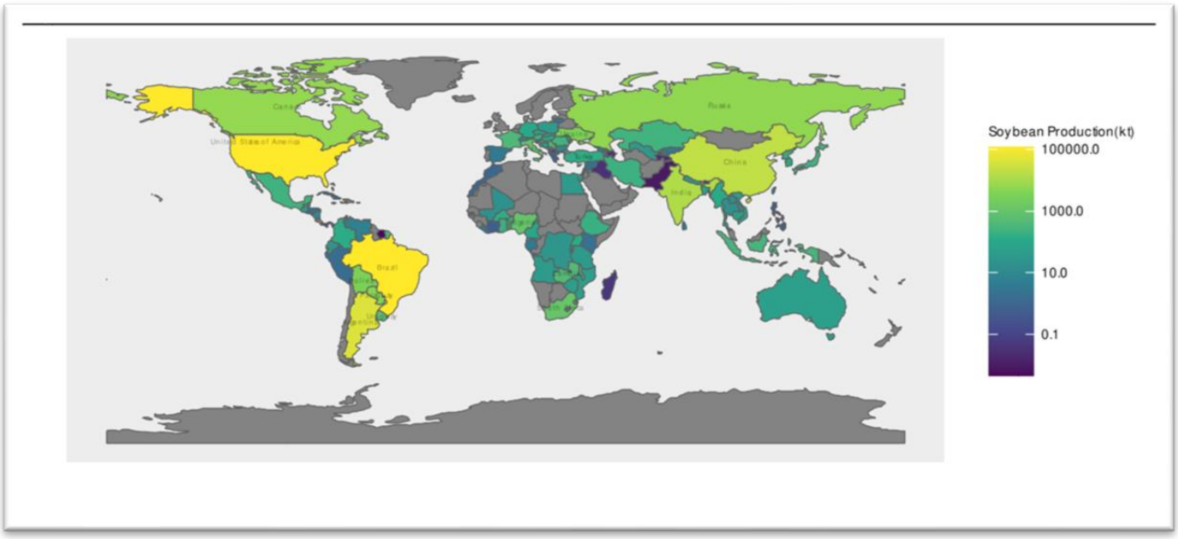

Figure 1. Soybeans Production by Countries (2022) (Data source: Anonymous (2022a)).

As indicated by the data (Anonymous, 2022b), China occupies the leading position as the largest importer of soybeans, with approximately 91.1 million tonnes imported during that period. The Netherlands follows with approximately 4.0 million tonnes imported, while Mexico ranks third with a reported import volume of approximately 3.9 million tonnes. Japan is in fourth place with estimated annual soybean imports of approximately 3.5 million tonnes, while Germany holds the fifth position with approximately 3.4 million tonnes imported. Türkiye's reported soybean imports during this period were approximately 3 million tonnes, placing it ninth in this comparison (Figure 2).

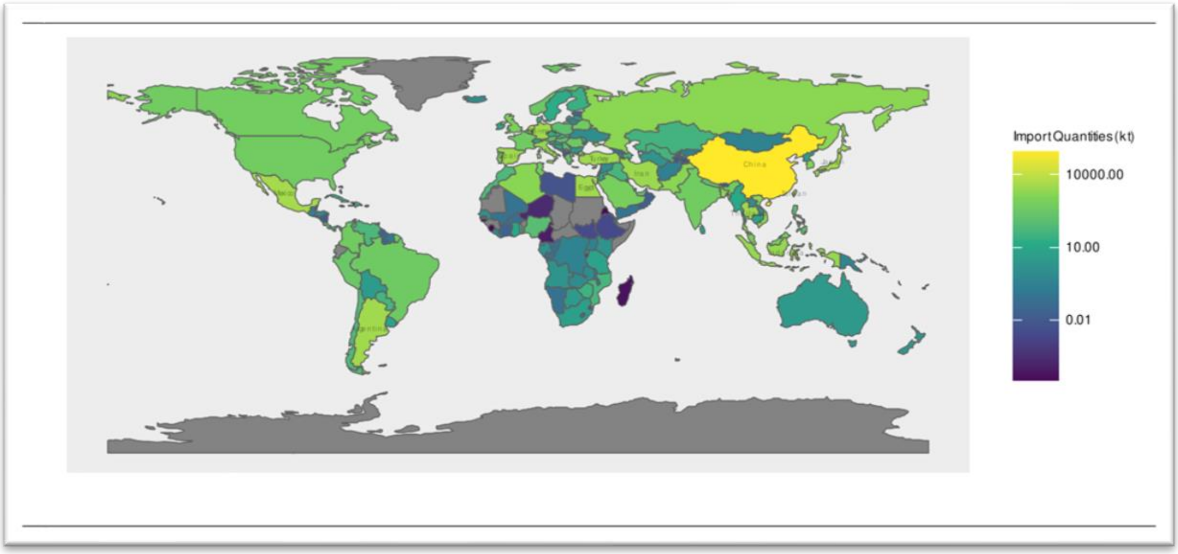

Figure 2. Soybeans Import Quantities by Countries (2022) (Data source: Anonymous (2022b)).

The data, presented by Anonymous (2022b), indicates that Brazil holds the leading position as the largest exporter of soybeans. During that period, approximately 78.9 million tonnes were exported from Brazil. The United States of America follows closely behind, exporting approximately 57.3 million tonnes, while Argentina ranks third with a reported export volume of approximately 5.2 million tonnes. Canada is in fourth place with estimated annual soybean exports of approximately 4.3 million tonnes, while Uruguay holds the fifth position with approximately 3.1 million tonnes exported. Türkiye’s reported soybean exports during this period were approximately 106,907 tonnes, placing the country in nineteenth position in this comparison (Figure 3).

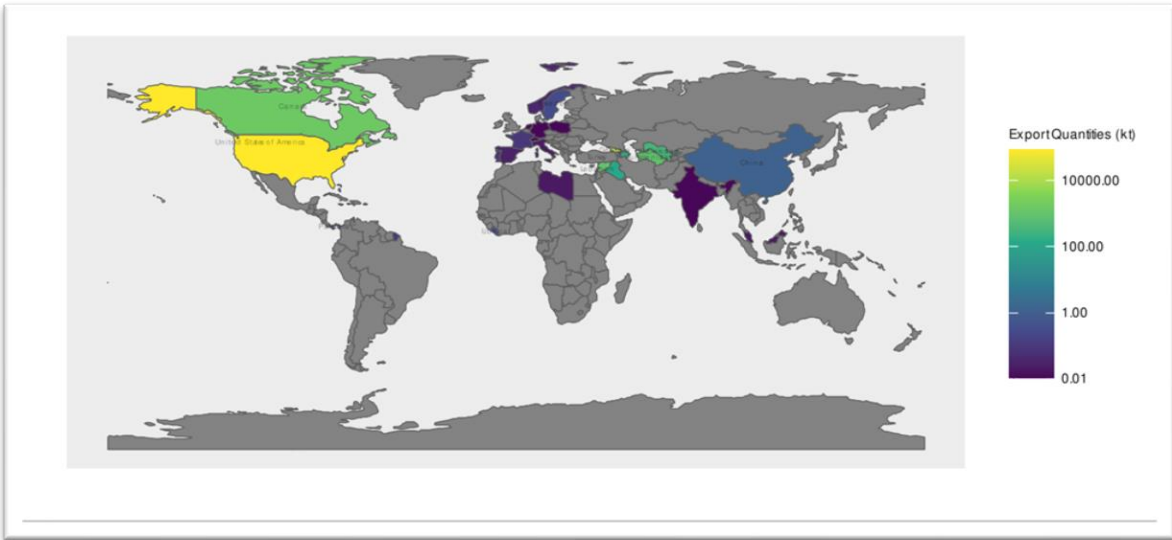

Figure 3. Soybeans Export Quantities by Countries (2022) (Data source: Anonymous (2022b)).

This study compares the quantities of soybeans imported into Türkiye from five major supplying countries as of recent data (Anonymous, 2022c). Brazil holds the first position with a substantial volume of 2,015,828 tonnes exported to Türkiye, followed closely by Ukraine in second place with an export quantity of 699,865 tonnes. The United States of America ranks third with soybean exports totalling 229,817 tonnes, while Argentina occupies the fourth position with a relatively smaller volume of 39,387 tonnes exported. Uruguay completes the list in fifth place with an export quantity of 14,194 tonnes. These findings highlight the significant role these countries play in Türkiye's soybean imports (Figure 4).

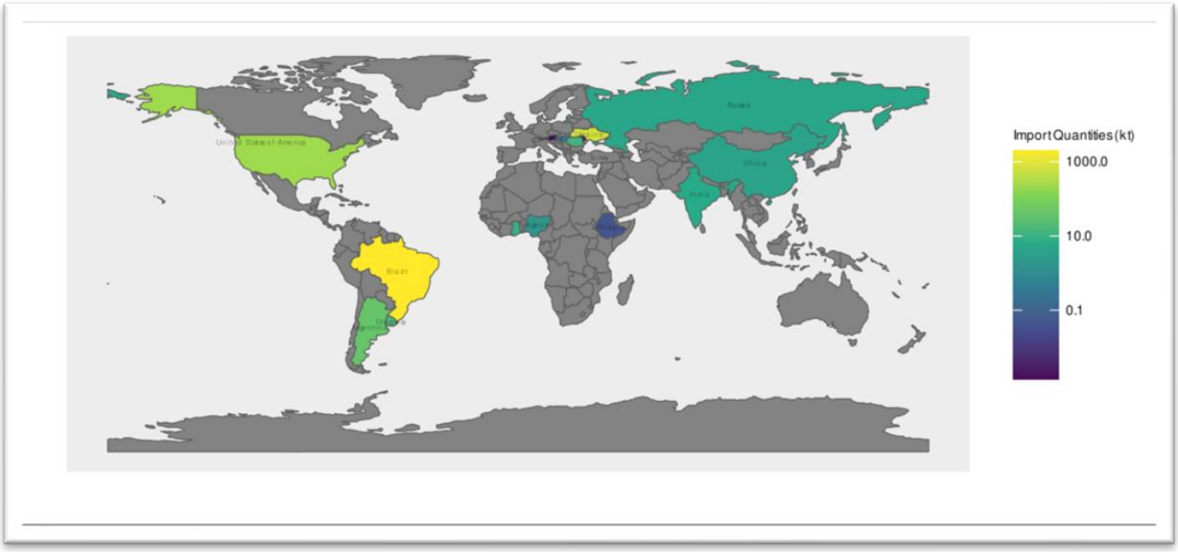

Figure 4. Total Soybean Imports into Türkiye in 2022 (kilo tonne) (Data source: Anonymous (2022c)).

The data (Anonymous, 2022c) on the export quantities of soybeans from Türkiye to various countries indicates that the United States of America is the leading importer of Turkish soybeans, with a significant volume of 88,376 tonnes. Georgia occupies the second position in this ranking with an import quantity of 12,102 tonnes, followed by Northern Cyprus (Cyprus), with 2,350 tonnes. Canada completes the top four list with a relatively smaller import volume of 1,541 tonnes (Figure 5).

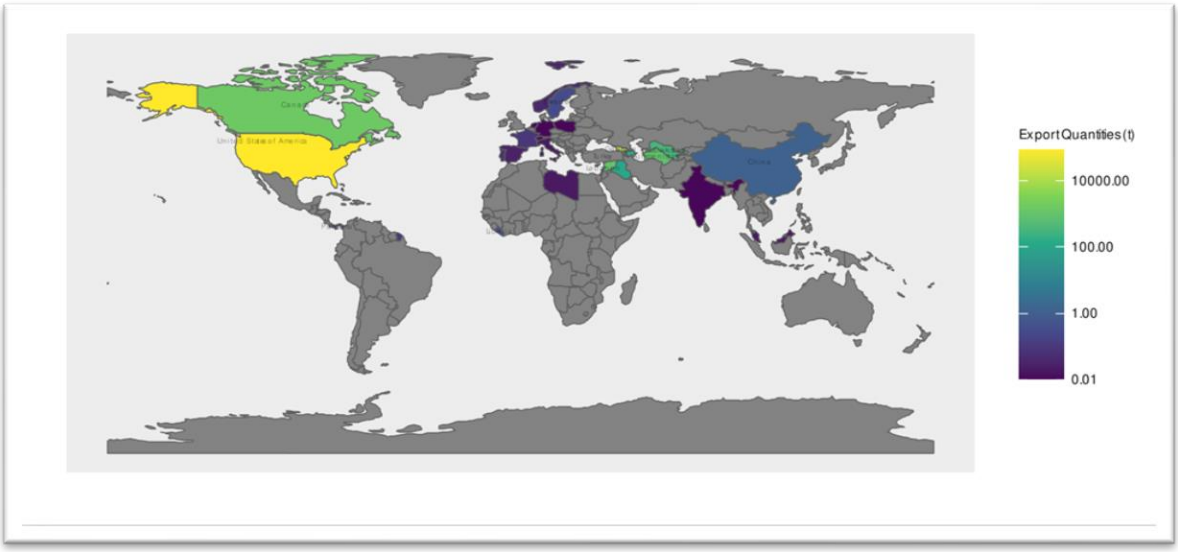

Figure 5. Total Soybean Exports from Türkiye in 2022 (tonnes) (Data source: Anonymous (2022c)).

Figure 6 presents the annual quantities of soybean production in Türkiye from 1990 to 2022. The KPSS test for stationarity yielded a test statistic of 0.48, which did not reject the null hypothesis of stationarity at the 5% significance level (p = 0.046). Nevertheless, the first differences of the series were found to be stationary (p = 0.10).

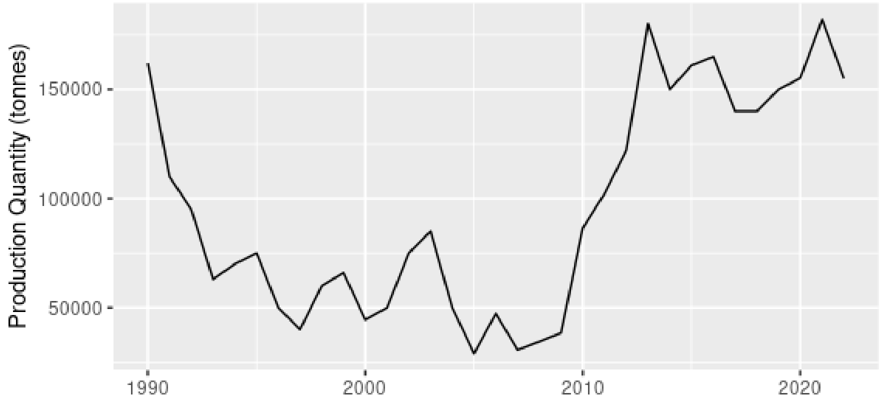

Figure 6. Annual Soybean Production in Türkiye (tonnes, 1990-2022) (Data source: Anonymous (2022d)).

The dataset utilized in this analysis is divided into two subsets. The first subset of data, designated as the training set, encompasses the period from 1990 to 2014. This portion of the data is employed for the development and calibration of statistical models and machine-learning algorithms. The second subset of data, designated as the test set, comprises observations from the years 2015 to 2022. The primary objective is to assess the performance and accuracy of the developed model using data that was not included during its development or training phase. This assessment provides insights into the model's ability to generalize new information and make reliable predictions for future time points.

By separating the dataset into a training set and a test set, researchers ensure an objective evaluation of their models while minimizing potential overfitting issues that may arise when using all available data for both development and testing purposes (Kuhn and Johnson, 2013).

Table 1. ARIMA Models Test Dataset Results Comparison.

Models	**RMSE**	**MAE**	**MAPE**
ARIMA (1,1,1)	13 019	10 363	6.6
ARIMA (0,1,0)	14 240	11 028	6.8
ARIMA (1,1,0)	16 367	13 033	7.9
ARIMA (0,1,1)	17 230	13 724	8.4
AUTOARIMA	49 096	42 202	28.0

ARIMA models are popular statistical tools used in time series forecasting. Among the various ARIMA models tested, the ARIMA (1,1,1) model demonstrated the highest performance based on three commonly used goodness-of-fit metrics: RMSE, MAE, and MAPE (Table 1). Specifically, the RMSE value for this model was 13 019, MAE was 10363, and MAPE was a relatively low 6.6%. On the other hand, the application of AutoARIMA, an automatic algorithm used to select optimal ARIMA parameters, did not yield successful results in this particular study. This observation underscores the importance of careful consideration and validation when using automated methods for model selection.

ES techniques are another popular class of time series forecasting models that adaptively revise previous predictions based on new data points. In the context of this study, 3 ES models were evaluated using an internal test dataset to assess their goodness-of-fit performance. Among these methods, SES emerged as the top performer. The SES model achieved impressive results in terms of RMSE, which was 13 888; MAE, with a value of 10 806; and MAPE at a relatively low rate of 6.7% (Table 2).

Table 2. ES Models Test Dataset Results Comparison.

Models	RMSE	MAE	MAPE
SES	13 888	10 806	6.7
DHLT	14 033	10 896	6.7
HLT	25 351	19 958	12.0

Four neural network (NNAR) models were trained with different numbers of nodes in their hidden layers: 5, 10, 25, and 50. As shown in Table 3, among these models, the one with only 5 nodes in the hidden layer achieved the best goodness of fit values (RMSE = 58 393, MAE = 56 135, MAPE = 45). However, the model's performance was found to be significantly inferior compared to the ARIMA and ES methods. As with the results from the auto-ARIMA process, a potential reason for the inferior performance could be that the automated processes used to determine the AR(p) value in the NNAR model might have been less accurate or optimal than manual methods. In some cases, manually selecting an appropriate order (p) can lead to better results and improved overall performance of the NNAR model. Furthermore, the suboptimal performance of the NNAR models may be attributed to the distinctive characteristics of the data. In the event that the data exhibits non-linearity, seasonality, or intricate patterns that are inadequately captured by the automated AR(p) selection process, this could result in suboptimal model performance.

Table 3. NNAR Models Test Dataset Results Comparison.

Models	RMSE	MAE	MAPE
NNAR_5	58 393	56 135	35
NNAR_10	87 658	86 643	55
NNAR_50	107 494	105 733	67
NNAR_25	108 472	107 395	69

In order to establish a baseline for comparison against more advanced forecasting models, two fundamental time series prediction techniques were included: the mean method and the naive method. The mean method postulates that future values can be approximated by the average of historical data points. In contrast, the naive method assumes that future observations will be consistent with the most recent value. The performance metrics were as follows: The mean method exhibited a RMSE of 80 418, a MAE of 79 377, and a MAPE of 50.5%. In contrast, the naive method exhibited a RMSE of 14 240, a MAE of 11 028, and a MAPE of 6.8%. These straightforward techniques serve as a foundation for evaluating more intricate models, such as NNAR. Notably, the significantly superior performance of the naive method indicates that the dataset may not be optimally suited for automated selection algorithms utilized in NNAR or Auto-ARIMA. This suggests a necessity for manual tuning to achieve optimal results. The forecasted values (each model represented in different colors) and the observed values (shown as a black line) for the test set are depicted in Figure 7.

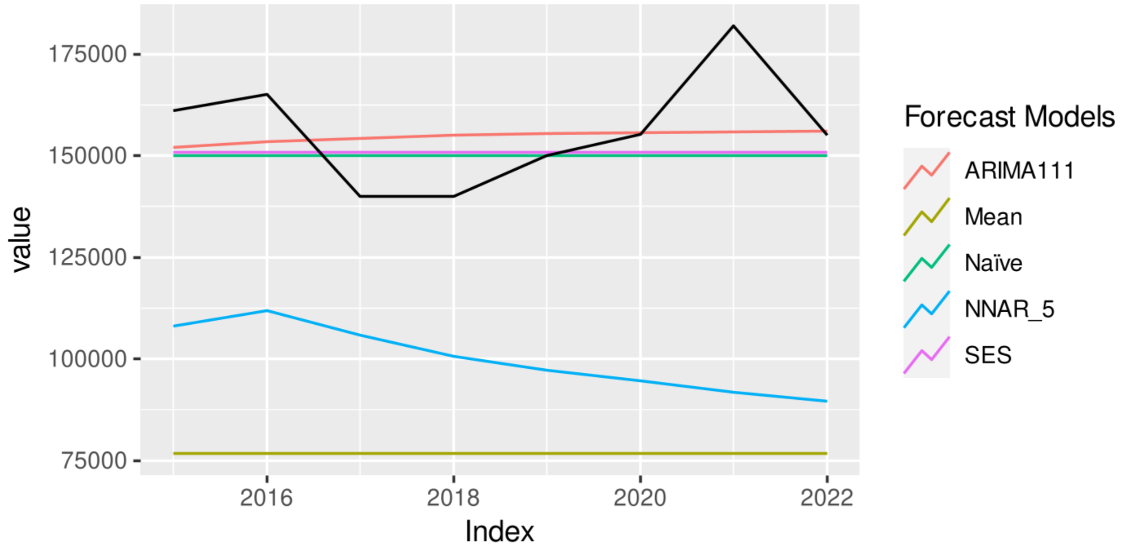

Figure 7. Visual Comparison of Forecast Models in the Test Set.

'The analysis of time series data revealed that the ARIMA (1,1,1) model provided the optimal fit to the historical soybean production data. Although neither the Autoregressive (AR) coefficient nor the Moving Average (MA) coefficient were statistically significant as shown in Table 4, the ARIMA (1,1,1) model demonstrated superior performance during cross-validation. These estimates enabled the forecasting of soybean production over the next ten years, as illustrated in Figure 8.

Table 4. Coefficients and Standard Errors for ARIMA (1,1,1) Model.

Parameter	Value	Standard Error	P Values
ar[1]	0.66	0.85	0.44^{ns}
ma[1]	-0.60	0.88	0.50^{ns}

^{ns} not significant

A reliable forecasting method is expected to exhibit residual errors that adhere to the following characteristics: the residual errors should be uncorrelated and their mean value should be zero. If the mean value deviates from zero, the forecasts are biased. In addition to these fundamental characteristics, it is beneficial, though not essential, for the residuals to exhibit constant variance (homoscedasticity) and to follow a normal distribution (Hyndman *et al.*, 2008).

In evaluating the quality of our forecasts, it is essential to examine the characteristics of the residual errors. The mean value of the residual errors was found to be -189.41. The applied Ljung-Box test indicated no autocorrelation problem among the residual errors, with a Q statistic of 4.84, degrees of freedom (df) equal to 10, and a p-value of 0.90. This result suggests that there is no evidence of correlation between successive residuals, which is an essential characteristic for unbiased forecasts. The Shapiro-Wilk test suggested that the residual errors follow a normal distribution with a W statistic value of 0.97 and a p-value of 0.49. This result indicates that there is no significant deviation from normality in the residuals, which is beneficial but not essential for accurate forecasts. These findings provide strong evidence that the ARIMA(1,1,1) model produces unbiased and robust forecasts for soybean production in Türkiye over the next decade (Table 5).

Table 5. Soybean Production Forecast in Türkiye (Tonnes, 2023-2032)[*].

Year	Mean	CI % 80[l]	CI % 80[u]	CI % 95[l]	CI % 95[u]
2023	154 490	125 616	179 988	102 870	209 806
2024	154 536	110 309	194 480	89 919	221 663
2025	154 396	100 011	207 434	71 617	236 583
2026	154 507	91 682	218 100	55 951	251 647
2027	154 231	83 321	226 654	44 841	264 794
2028	153 965	75 264	234 520	34 537	275 546
2029	153 443	67 461	240 257	24 237	284 888
2030	153 801	61 545	244 421	14 334	296 458
2031	154 157	54 988	252 841	6 828	306 411
2032	153 968	51 074	258 312	-5 327	313 024

[l] lower bound, [u] upper bound, CI = Confidence Interval, [*] the results obtained using the ARIMA(1,1,1) model

The obtained forecasts indicate that soybean production in Türkiye will continue to follow a horizontal trend, with only slight fluctuations observed over the next decade. These findings are crucial for farmers and policymakers as they can help inform decisions related to resource allocation, crop planning, and market strategies. Further analysis of these results is ongoing to gain deeper insights into the factors influencing soybean production trends in Türkiye (Figure 8).

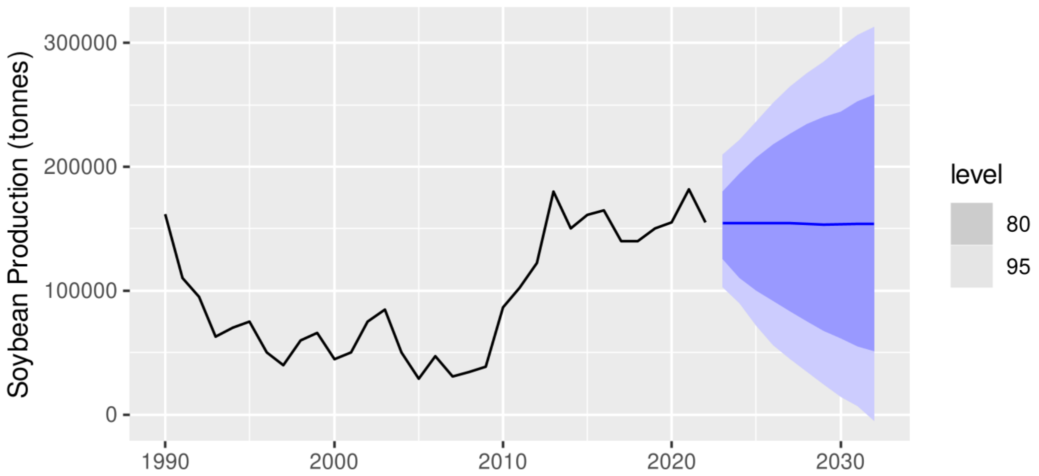

Figure 8. Forecasted Soybean Production in Türkiye (Thousand Tonnes, Next Decade).

CONCLUSION

For this time series dataset, the ARIMA (1,1,1) model was found to be the most effective. The SES model followed closely but performed slightly worse, though the difference was not significant. It is important to note that the performance of automated processes was relatively worse than that of the manual methods, suggesting that relying solely on automated methods may lead to suboptimal forecasting results. These findings underscore the importance of human oversight in the use of automated algorithms for time series forecasting and the need for caution when employing automated methods.

Brazil and the United States collectively dominate both the production and export markets for soybeans, while China plays a significant role in the import market. Türkiye occupies a relatively minor position in terms of production (32nd) and exports (19th). Brazil is the largest supplier of soybean imports into Türkiye, with a substantial volume of 2 015 828 tonnes. Ukraine follows closely in second place, while the United States holds the third position as both a significant importer and exporter. The findings underscore the significant role that Brazil, Ukraine, and the United States play in both Turkish soybean imports and exports.

Local producers in Türkiye have a significant opportunity to thrive in the market. This opportunity arises from Türkiye's reliance on imports due to insufficient domestic production capacity. While ARIMA (1,1,1) forecasts indicate stagnant production growth in Türkiye over the next decade, despite an anticipated increase in demand, this situation presents potential benefits for local producers. However, local producers need to compete with international competitors by supplying both domestic and export markets. In this context, policymakers have a role to play in supporting local producers.

This study underscores the pivotal role of soybeans in a multitude of industries, including food processing, animal feed production, and industrial applications. A comprehensive understanding of these trade dynamics can also assist stakeholders in identifying potential avenues for collaboration or investment within the Turkish soybean industry. An understanding of the global trends in soybean production and trade provides valuable insights into several key areas, including market conditions, price fluctuations, potential investments, threats, and strategic partnerships. Further analysis is currently being conducted in order to gain a more profound understanding of the factors that are influencing the trends in soybean production in Türkiye.

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Statement : This research was orally presented at the Silk Road 2023 International Scientific Research Conference on September 26-27, 2023, at Iğdır University, and its abstract was published in the conference proceedings.

Statement : During the preparation of this work the author used ChatGPT, Gemini and DeepL in order to improve readability and language. After using this tool/service, the author reviewed and edited the content as needed and takes full responsibility for the content of the publication.

Statement : The GitHub repository, which includes the source code, data and code references is available at https://github.com/hakan-duman-acad/article-soybeans-forecasting

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Review/Derleme

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Effects of Fish on Human Health and Nutrient Content

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Keywords:

Fish
Health
Diet
Nutrition
Seafood

ABSTRACT

Fish holds a crucial place in our diet, serving as an excellent source of minerals and vitamins for human nutrition. Renowned for its high-quality protein, minerals, vitamins, and fat content, fish is considered an outstanding food source. On average, it provides approximately 19.5 grams of protein per 100 grams. Other seafood and fish have been among the oldest food sources for humans. Consuming fish is generally part of a balanced nutrition program, supporting a healthy lifestyle. Fish are rich in omega-3 fatty acids, high-quality protein, vitamin D, vitamin B-12, minerals, low fat, low saturated fat, antioxidants, and vitamins with anti-inflammatory properties. It is known that at least 13 vitamins are essential for the human body, and a significant portion of these vitamins is found in fish, although their distribution in tissues is uneven and varies based on the fish species. Compared to land animals, fish have higher amounts of fat-soluble vitamins such as A, D, E, and K. Due to its content of essential fatty acids, fish is a vital food source for strengthening the immune system. The purpose of this study is to explain the effects of fish consumption on health and to examine fish consumption-related dietary recommendations, policies, or regulations in order to develop more effective strategies for public health. Additionally, it aims to provide guidance on fish consumption for a balanced diet program.

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INTRODUCTION

The utilization of seafood in human nutrition dates back to prehistoric times. Throughout ancient civilizations, fish has been regarded as an excellent food for maintaining health. Until recent years, many consumers were unaware of the nutritional value of fish, highlighting the importance of understanding the effects of nutrients on our health and investigating food components (Ruxton et al. 2004).

With the rapidly increasing population, nutritional needs are also on the rise. In contemporary times, people strive to make optimal use of seafood to minimize nutritional problems and meet dietary requirements. Seafood is effective in balanced nutrition, easy to digest, and has high nutritional value, making fish one of the preferred food groups (Sivri et al. 2011). Scientific studies have confirmed that regular consumption of seafood and fish has positive effects on human health. Beyond being a source of protein, the main benefits of fish consumption include reducing the incidence of cardiovascular disease, decreasing the risk of sudden cardiac death, lowering the risk of high blood pressure, and reducing the incidence of depressive symptoms and Alzheimer's disease (Morales et al. 2018).

Changing consumer preferences, increased income, and technological advancements have led to a noticeable increase in seafood consumption over the last 60 years. In 2019, 72% of the consumed seafood, totaling 157 million tons, was consumed in the Asian continent. Looking at global seafood consumption, Indonesia, India, China, Japan, and the United States rank highest. Globally, in 2019, 17% of the need for animal protein was met by fish, accounting for 7% of all consumed proteins (FAO, 2022).

Fish consumption worldwide increased from 9 kg per capita in 1961 to 20.2 kg in 2020. In 2019, 75% of per capita seafood consumption came from fish, 12% from mollusks, and 13% from crustaceans. Fish consumption varies between countries due to factors such as consumer income levels and dietary culture. In low-income countries, per capita fish consumption was 5.4 kg in 2019, while in middle-income countries, it was 15.2 kg, and in high-income countries, it was 26.5 kg. Approximately 178 million tons of seafood were produced globally in 2020, with 157 million tons directly used for food supply and the remaining 20 million tons utilized in the production of various non-food items, including fish oil and fishmeal (FAO, 2022).

The contribution of a food item to the intake of specific micronutrients is influenced by both the composition of the food item and the consumption of that food item. This implies that extensively consumed foods are the most suitable targets for enrichment unless there is a significant change in dietary habits. There are substantial differences in the per capita intake of docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA) between countries. DHA+EPA intake values are five times higher in fish consumers compared to non-fish consumers (Givens et al. 2008).

Nutrient Values in Fish

The chemical composition of fish varies significantly based on factors such as gender, age, species, season, and habitat. The quantity of proteins, which play a crucial role in human nutrition, in fish depends on factors such as age, species, gender, feeding environment, and the amount of fat and water in the flesh. Generally, the renewable part of the muscle contains approximately 18 to 22 grams of protein per 100 grams (Dean 1990). Unlike plant foods that contain indigestible substances like fiber or cellulose, and land animal meats that contain materials such as cartilage and nerves, which are hard to digest, fish do not contain these components. Therefore, fish is easily digestible, making it a recommended food, especially for individuals who need to be more cautious in their diet (Gorga, 1998).

Nutrients are substances that provide nourishment to the body, promote growth, and sustain body parts. Nutrients can be divided into micro and macro nutrients, both of which are vital for health. Fish contains macro nutrients such as proteins, lipids, ash, and carbohydrates. Micro nutrients like vitamins and minerals are essential dietary elements required in very small amounts and must be supplied from external sources to the body. Fish has played a significant role in providing nutrition for many animals, including humans. It is a valuable food source with high nutritional value that enhances health. Daily consumption of fish also plays a role in preventing heart diseases. Moisture, proteins, fats, minerals, and vitamins are important micro and macro nutrients that contribute to the nutritional value of fish meat. Compared to other protein sources, the macro and micro nutrients present in fish make it a superior choice. Fish provides essential nutrients, particularly high-quality proteins and fats. Proteins and fats are the primary nutrients that determine the nutritional value of fish. Fish is an excellent food with a rich nutritional value, providing various vitamins and minerals such as vitamins A and D, magnesium, and phosphorus. The micro and macro nutrients in fish are of better quality than those from other animal protein sources. In addition to being a food source, fish also helps prevent various diseases in humans. Fish protein constitutes 15-20% of its total live body weight. Fish protein contains essential amino acids that enhance the overall nutritional quality of a mixed diet. A portion of 140g of fish can provide approximately 50-60% of the daily protein requirement for an adult human. Fish is also rich in micro nutrients that are more readily available than those from plant foods. Compared to land animals, fish are a rich source of protein and have a high content of omega-3 long-chain polyunsaturated fatty acids (Balami *et al.* 2019).

At least 13 vitamins are essential for humans, and these vitamins are found in fish. The distribution of these vitamins in tissues is irregular, and all of them are present in fish. The amount of vitamins varies depending on the fish species. Fat-soluble vitamins A, D, E, and K are abundant in fish (Pigott *et al*. 1990). Vitamins are divided into two groups: fat-soluble (A, D, E, and K) and water-soluble (B and C). Although all vitamins necessary for humans and domestic animals are present in fish to a certain extent, their quantities vary widely from species to species and throughout the year. For instance, some freshwater species like carp have low thiamine content due to their high thiaminase activity. Regarding minerals, fish meat is a valuable source of calcium and phosphorus, as well as copper, iron, and selenium. Marine fish, in particular, contains high levels of iodine. The nutritional properties of fish, including essential amino acids and proteins, are related to the quality of lipids and the content of vitamins and minerals (FAO, Fisheries and Aquaculture Department publications).

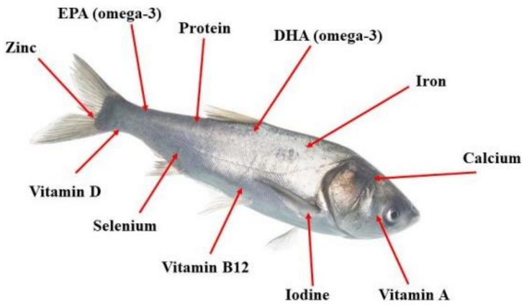

Figure 1. Beneficial effects of fish food on human health (Phogat 2022).

Fatty Acids in Fish

The nutritional content of fish is predominantly categorized into oily and lean based on its fat content. Fish classified as oily has a fat content exceeding 5%, while lean fish, as the name suggests, has a fat content of less than 2%. The majority of the fat in fish is found as triglycerides, compounds composed of glycerol and three molecular fatty acids. Triglycerides consist of fatty acids with varying carbon chain lengths, indicating the degree of saturation of fats (Pigott, 1990). Unsaturated fatty acids found in nature are named omega-9, omega-6, and omega-3, known as oleic, linoleic, and linolenic acids, respectively. Two essential fatty acids, eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), belonging to the linolenic series of omega-3 fatty acids, are not present in other food products and are crucial components found in seafood. These two fatty acids induce significant physiological and biochemical changes in the body (Gordon 1992). Fats in fish are more valuable in terms of nutrition compared to fats found in land animals. Polyunsaturated fatty acids are formed by unsaturated fatty acids. Fish oil is the sole source of n-3 group fatty acids, namely EPA and DHA (Mol, 2008).

It is highly important for the prevention of various chronic diseases to maintain a specific ratio of α-linolenic acid (n-6), found in green leafy vegetables; linoleic acid (n-3), found in vegetable oils and various plants; and EPA and DHA, found in fish and other seafood, in the diet. Countries that consume abundant fish and other seafood, such as Japan and China, have a dietary ratio of linoleic acid to α-linolenic acid of 1:5, while in Western societies, this ratio is 100:1. Studies suggest that for a healthy lifestyle, the dietary ratio of linoleic acid to α-linolenic acid should be 1:5-1:10. To maintain this ratio, it is recommended to increase the consumption of fish and other seafood to 2-3 servings (450 grams) per week, as advised by the American Heart Association (AHA) (Brown, 2000).

Table 1. Fat Content in Seafood (g/100 g Edible Fish Flesh) (Pigott 1990).

Type	*Oil*	*Saturated*	*Monounsaturated*	*Very unsaturated*	*EPA*	*DHA*	*Cholesterol(mg)*
Herring	9.0	2.0	3.7	2.1	0.7	0.9	60
Anchovy	4.8	1.3	1.2	1.6	0.5	0.9	-
Carp	5.6	1.1	2.3	1.3	0.2	0.1	67
Mackerel	13.0	2.5	5.9	3.2	1.0	1.2	53
Tuna	6.6	1.7	2.2	2.0	0.4	1.2	38
Channel Catfish	4.3	1.0	1.6	1.0	0.1	0.2	58
Barramundi	1.6	0.3	0.3	0.6	0.2	0.2	-
Halibut	2.3	0.3	0.8	0.7	0.1	0.3	32
Pollock	1.0	0.1	0.1	0.5	0.1	0.4	71
Sole	1.2	0.3	0.4	0.2	Tr	0.1	50
Pink Salmon	3.4	0.6	0.6	1.4	0.4	0.6	-
King Salmon	10.4	2.5	4.5	2.1	0.8	0.6	-
Rainbow Trout	3.4	0.6	1.0	1.2	0.1	0.4	57
Shrimp	1.1	0.2	0.1	0.4	0.2	0.1	147
Crab	1.3	0.2	0.2	0.5	0.2	0.2	78
Oyster	2.5	0.6	0.2	0.7	0.2	0.2	47
Herring Oil	100.0	19.2	60.3	16.1	7.1	4.3	766
Salmon Oil	100.0	23.8	39.7	29.9	8.8	11.1	485
Cod Liver Oil	100.0	17.6	1.2	25.8	9.0	9.5	570

The Balanced and Adequate Nutrition Importance of Fish Oil

In a healthy diet program for humans, the calories derived from saturated fats should be less than 10%, and the calories from fats should not exceed 30%. Many people living in urban areas consume more fat than these amounts, increasing the risk of heart diseases, certain types of cancer, and diabetes (Lau et al. 1993). According to these guidelines, the recommended daily average intake should be:
Linoleic acid: Females 13.0 g, Males 17.0 g.
Alpha-linolenic acid: Females 2.0 g, Males 3.0 g.
EPA and DHA: Females 1.1 g, Males 1.4 g (Eritsland et al. 1995).

The initial focus of the heart-protective mechanism has been on serum lipids. In healthy individuals, there is a positive correlation between the decrease in triglyceride concentrations in serum and the increase in the consumption of long-chain n-3 fatty acids. Low-density lipoprotein cholesterol concentration has increased with supplements prepared with fish oil.
Fish oil affects the interaction between platelets and vessel walls, as well as lipid and lipoprotein metabolism (Prichard et al. 1995).

The Impact of Fish Meat on Human Health

Deaths due to cardiovascular diseases are the leading cause of death worldwide, although the rates vary among countries. Despite significant advances in treatment that extend patients' lives, they have not made a substantial contribution to reducing the risk of heart disease. Therefore, preventive measures termed primary prevention, which aim to prevent the onset of the disease, have gained more importance in recent years. The relationship between heart diseases and the foods consumed by individuals has long been one of the most studied topics in medicine. Studies indicate that the amount of fish consumed is effective in the development of coronary artery disease. An increase in fish consumption has been associated with a decrease in complications and deaths related to heart and vascular diseases (Çömez, 2020).

Looking at the studies conducted, regular consumption of fish has been shown to reduce the risk of heart attacks, strokes, or heart diseases. The protective effect of fish on cardiovascular health is attributed to its high omega-3 content. Omega-3 fatty acids help regulate blood pressure by reducing plaque formation in the arteries. Lowering blood pressure prevents the heart from working excessively, reducing the risk of developing cardiovascular diseases. Two important fatty acids found in fish, EPA and DHA, have been revealed to have disease-treating properties in studies. These fatty acids are essential nutrients and protect the body against conditions such as migraines, joint rheumatism, diabetes, some types of cancer, high blood pressure, high cholesterol, some allergies, and cardiovascular diseases. DHA is a structural component of the retina, brain, sperm, and testis, and its proper function is related to tissue functions. Studies have shown that the level of DHA in the tissues of premature babies is lower than that of babies born at term. Babies born without omega-3 fatty acids in their diet have insufficient development of vision and nerve tissues. Omega-3 fatty acid levels in human milk are high in women who consume fish and low in vegetarians (Nettleton, 2000). Omega-3 polyunsaturated fatty acids (PUFAs) in humans help improve many metabolic problems by reducing hypertension and plasma triglyceride levels and insulin resistance (Berry, 1997). Some studies have shown that omega-3 PUFAs can slow down the progression of prostate cancer (Rose, 1997).

Fish is important for human nutrition and highly beneficial for our health. The proteins, lipids, vitamins, and minerals found in fish are essential nutrients for a healthy life. The recommendation of dieticians for daily consumption of fish or animal protein supports the nutritious value and health benefits of fish. Consuming fish can help maintain muscle mass, aid in weight loss, and regulate appetite. Additionally, fish is rich in omega-3 fatty acids such as EPA and DHA, which are important for a healthy heart. This can be effective in preventing various health problems, including cardiovascular diseases. Overall, fish is a nutritious food source that provides essential nutrients for the body despite being low in calories. Therefore, regularly consuming fish is important for a healthy lifestyle (Mishra 2020).

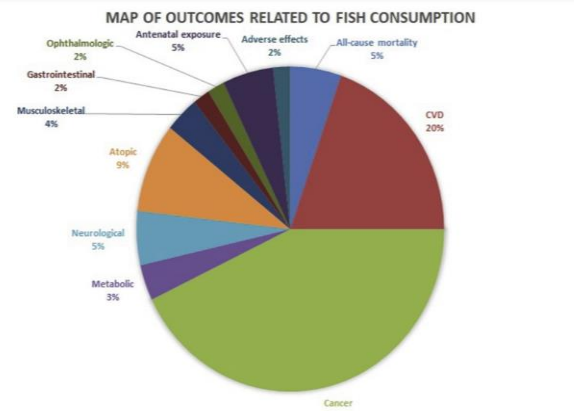

Fig. 2. Map of outcomes related to fish consumption (Li 2020).

CONCLUSION

Based on the conducted studies, it has been revealed that fish meat is highly beneficial for human health. Being a high-quality protein source, rich in omega-3 fatty acids, B-12 vitamin, D vitamin, low in fat, minerals, and antioxidants are just a few of the features found in fish. It is quite effective in preventing various diseases such as cardiovascular diseases, migraines, diabetes, rheumatic diseases, and some types of cancer. The studies suggest an increased consumption of fish and other seafood, emphasizing that it should be a primary component in a healthy diet program. Fish contains a balanced variety of nutrients while being a low-calorie food source. However, these values and benefits are often unrecognized and undervalued by people. Despite its many health benefits, many individuals are unaware of them. Therefore, it is important to educate people about the health benefits of consuming fish. Comparative studies between the consumption of meat and fish can highlight the differences, encouraging people to consume more fish. These studies can help increase fish consumption and steer people towards a healthier lifestyle.

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Babesiosis As a Potential Hazard in Animal Production and Its Global Emerging Zoonotic Threat for One Health

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ABSTRACT

Babesiosis is a lethal illness spread by ticks that affects both humans and animals globally. The livestock industry is severely impacted and is experiencing severe financial losses. The common species that cause babesiosis in cattle are Babesia B. bovis and B. bigemina. Rhipicephalus (Boophilus) species are the primary vectors for B. bovis and B. bigemina. The two main mechanisms that Babesia species use to cause acute illness are circulatory disruption and hemolysis. Animals with the infection experience an increase in body temperature, anorexia, trouble breathing, weakness, anemia, and jaundice. The complicated link between the causal agent, host, and vector has made the development of a vaccine for bovine babesiosis difficult because the condition is transmitted by ticks. Another recent problem that needs to be addressed is human babesiosis. In numerous regions of the world, zoonotic babesiosis represents a significant health danger. Due to its development, it is imperative that effective control measures be put in place to stop it from spreading over this area. This study demonstrates the sharp rise in the disease's prevalence around the globe and the urgent necessity for developing efficient plans and early detection techniques. This review also examines zoonotic Babesia species and provides a thorough overview of those species that have been linked to both animal and human infections. There have been 11 investigations that have found zoonotic Babesia species in animals, while 16 have found them in people. To ensure one health approach, this ailment must be effectively controlled.

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INTRODUCTION

Babesiosis is a widespread disease that poses significant public health implications and affects a variety of mammalian species (Bock, Jackson, De Vos, & Jorgensen, 2004; Waked & Krause, 2022), and it has also had a significant negative economic impact on the cattle sector due to the occurrence of the two most significant babesiosis species in cattle, B. bovis and B. bigemina (Zintl et al., 2014). Babesia, a genus of intra-erythrocytic parasites, are the culprits behind this ailment (Bajer et al., 2022; Hunfeld, Hildebrandt, & Gray, 2008). According to (Jacob et al., 2020; Sahinduran, 2012), they are apicomplexan protozoan parasites from the family Babesiadae and suborder Piroplasmida. Piroplasmosis, Texas cattle fever, Red-water, and Nantucket Tick fever are additional names for the illness that are used internationally (Ozubek et al., 2020; Sahinduran, 2012). After trypanosomiasis, it is the second most prevalent blood-borne parasite disease (Hamsho, Tesfamarym, Megersa, & Megersa, 2015). The movement of animals and the habitat of ticks in various locations both affect disease transmission. B. divergens is another typical species that is frequently seen in cattle. According to (Bock et al., 2004), the three most significant and well-studied species that have an impact on the cattle sector are B. bovis, B. bigemina, and B. divergens.

According to a different study, B. mymensingh, a new species of Babesia that can induce clinical illness in cattle, has been found. The species B. major, B. ovata, B. occultans, and B. jakimovi can also infect cattle. These Babesia species-specific strains all require ticks as their vectors and ideal environmental circumstances in order to spread. According to (Fakhar et al., 2012), B. ovis and B. motasi are known to be pathogenic pathogens in sheep and goats, respectively. These species infect nearly every type of mammal, and as a result of zoonotic infections, they eventually spread to humans (Waked & Krause, 2022). In many regions of the world, zoonotic babesiosis is largely brought on by three species: B. divergens, B. microti, and B. venatorum (Homer, Aguilar-Delfin, Telford III, Krause, & Persing, 2000). While B. microti primarily spreads through rodents in North America and Asia (Control & Prevention, 2012), Babesia divergens originated from cattle and has been documented in cases of human babesiosis in Europe (Gray, Zintl, Hildebrandt, Hunfeld, & Weiss, 2010). Babesia venatorum is widespread throughout the world and frequently originates in Europe (Control & Prevention, 2012). The principal carriers of babesiosis are ticks from the genus Ixodes, and the geographic distribution of these ticks affects the prevalence of the pathogens implicated (Young et al., 2019).

Babesiosis Zoonotic Incidence and Clinical manifestations

Babesiosis can affect both wild and domesticated animals, and its severity varies depending on a number of variables. The immunological health of the animal, the infectious dose, the virulence of the strain, and the degree of tick infestation all affect how severe a *B. divergens* infection in cattle will be (Purnell, Brocklesby, Kitchenham, & Young, 1976). The ticks that carry zoonotic Babesia species during their intricate life cycles, spreading these diseases either mother to offspring via infectious egg or by vector, are known to infect a variety of mammals and a few avian species as hosts. The reservoirs for B. divergens, B. venatorum are cattle, roe deer, and other ruminants, while the reservoirs for B. are white-footed mice, cottontail rabbits, and other small mammals (Silaghi et al., 2012).

Bovine babesiosis poses the greatest financial risk to the livestock sector, endangering 500 million cattle globally (Onoja et al., 2013). The illness has the worst consequences on the cattle industry because it kills allinfected animals having low immunity since it affects adult animals at the point of production rather than young animals (Onoja et al., 2013). Due to its high mortality rate, particularly among dairy cattle imported from Babesia-free regions e.g Ireland, this disease also makes it difficult to raise the production of local animals (Zintl et al., 2014). As it is blood parasite and host-specific illness, is common in tropical nations of the world and is characterized by anemia, hemoglobinuria, progressive weakness, jaundice, mortality, particularly in large ruminants. Anal sphincter spasms caused by B. divergens infection may allow feces from pipe stems to flow through. In endemic locations, the frequency of clinical cases is quite low due to repeated exposure to infections, and the immune-deficient animals that have recently been brought or who have not had early exposure to pasture are typically the ones who are harmed (Zintl et al., 2014). A recent meta-analysis and comprehensive review on the occurrence of bovine babesiosis worldwide was conducted by Jacob et al. (2020), which comprised a total of 163 pertinent papers from 63 different countries with a total of 81099 samples. The results of a continent-by-continent research showed that South America (64% of cases) had the maximum occurrence of bovine babesiosis. However, the prevalence was 61% in Australia, 52% in North America, 27% in Africa, 22% in Europe, and the lowest was 19% in Asia as shown in figure 1. The research of the years 2016 to 2019 revealed a growth in the prevalence of bovine babesiosis (25%) that should act as a red flag for the future health of the cow herd (Jacob et al., 2020). Based on the Babesia species, (Jacob et al., 2020) also performed subgroup analysis for estimating the occurrence of individual species and discovered that B. bigemina had the highest prevalence, which was 22%, followed by B. bovis with 20%, B. occultans with 16%, B. major with 15%, and B. divergens with the lowest prevalence, which was 12%.

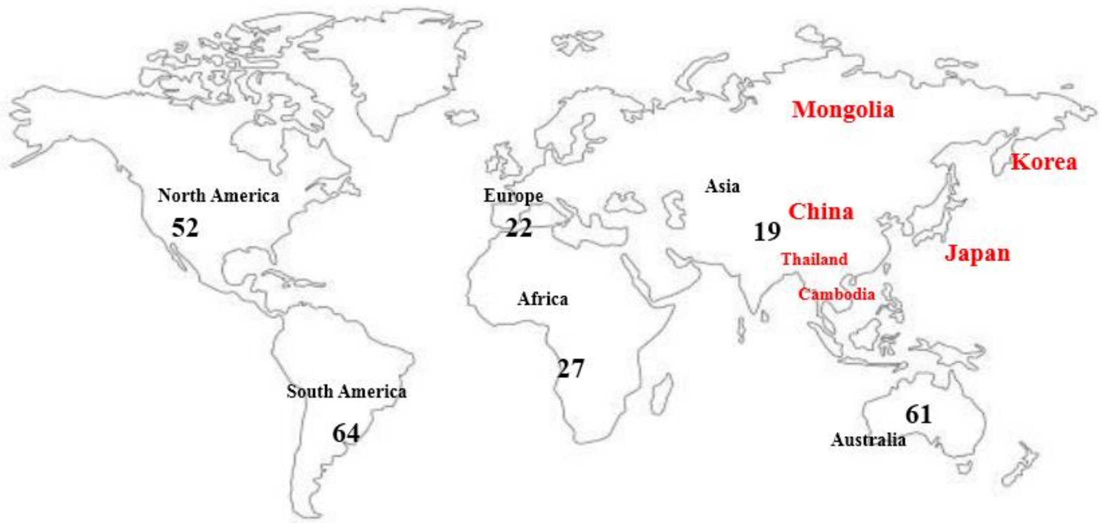

Figure 1. Screening geographical prevalence of babesiosis in animal and human populations. Countries marked with red showing zoonotic babesiosis occurrence (Rar et al., 2016) whereas in black displaying bovine babesiosis incidence (Jacob et al., 2020).

It is transmitted to humans through infected tick bites (Piesman & Spielman, 1980), but it can also be transferred between mothers during pregnancy (Asante et al., 2013) and through blood transfusions (Nzenze et al., 2013). It shows symptoms include headache, exhaustion, appetite loss, temperature. The elderly is more vulnerable to developing severe symptoms like enlargement of liver, loss of kidney function, hemolytic anemia, enlargement of spleen, and splenic complications, which can be fatal (Sanchez, Vannier, Wormser, & Hu, 2016). Acute babesiosis's splenic consequence is interestingly unrelated to the host immune system or the rise in parasitemia, unlike other serious complications. Blood smear examination is frequently employed as an identifying implementation (Dumic et al., 2020; Krause et al., 2003).

Babesiosis is consequently spreading zoonotically in Asia, which is made worse by a dearth of molecular identifying tools, clinical applicable testing skills, inadequate medical knowledge, and low throughput capacity to identify the pathogens at fault (Zhou et al., 2014). Human babesiosis is under-represented in Asia due to its low incidence, and its existence in this continent has not been adequately explored. However, it is understood that specific Babesia species are to blame for babesiosis spreading throughout Asia. For instance, Babesia microti and *Babesia sp*. KO1 appear to be the main disease-spreading agents in Japan (Tsuji et al., 2001), Korea (Kim et al., 2007), Taiwan (Shih, Liu, Chung, Ong, & Wang, 1997), and Mainland China, respectively. B. venatorum and Babesia sp. XXB/Hang Zhou have also been identified as potential disease-causing agents (Zhou et al., 2013). Additionally, it was noted that rodents and the ticks that live on them are important sources of Babesia spp. throughout Asia, including B. microti and B. microti-like as shown in figure 1(Rar et al., 2016). There is a dearth of data on the real occurrence and frequency of zoonotic babesiosis throughout world especially in Asia, as well as its species distribution and reservoir diversity.

Epidemiology of babesiosis

Victor Babes, who detected illness outbreaks with the typical characteristics of hemoglobinuria in cattle in Romania in 1888, is credited with being the first person historically to detect Babesia and Theileria in bovine blood. Following Victors' finding, Smith and Kilborne in 1893 discovered that Rhipicephalus annulatus was the vector for transferring B. bigemina (Smith & Kilborne, 1893). (Agoulon et al., 2012) confirmed and published the first case of human babesiosis in 1956, demonstrating the zoonotic significance of bovine babesiosis and the role of B. divergens as the causative agent.

Bovine babesiosis is more common in subtropical and tropical regions and can be found where tick vectors are abundant (Esmaeilnejad et al., 2015). Tick populations significantly increase during hot weather or the summer months as a result of temperature rise (Mohamed & Ebied, 2014)epidemiology of B. divergens in Europe has changed significantly during the past several years, with considerable declines in illness incidence in Norway (Hasle et al., 2010), Ireland (Zintl et al., 2014)and Hungary (Hornok, Edelhofer, Szotáczky, & Hajtós, 2006). Significant populations of *B. bovis* and *B. bigemina* can be found in Asia, Africa, Central and South America, Southern Europe, and Austria. The occurrence of Babesia species across the globe is shown in Table 1.

Table 1. Geographical distribution of Babesia species.

Babesia spp.	Affected spp.	Major tick vector	Global distribution	References
Babesia major	Cattle	*Haemaphysalis punctate*	Asia, Africa, Europe, and Northwest Africa	(L'Hostis & Seegers, 2002; Zintl et al., 2014)
Babesia divergens	Cattle	*Ixodes persulcatus and Ixodes ricinus*	Great Britain, Northwest Europe, Spain, Ireland	(Edelhofer, Müller, Schuh, Obritzhauser, & Kanout, 2004)
Babesia bovis	Buffalo and Cattle	*Boophilus annulatus, Boophilus microplus, and Boophilus geigyi*	Asia, Australia, Southern Europe, Central and South America, Africa but it is less prevalent in Africa	(Silva et al., 2009)
Babesia bigemina	Buffalo and Cattle	*Boophilus geigyi, Boophilus microplus, Boophilus decoloratus, and Boophilus annulatus*	Africa, Asia, Central and South America, Australia, and Southern Europe	Altay et al. 2008

For human babesiosis, more than 100 individuals from different areas in China have tested positive for B. microti. In 2011, in Zhejiang province, Babesia microti was identified for the first time in the Chinese population. This was verified using PCR (Yao et al., 2012). Babesia crassalike has also been linked to human babesiosis in China, where it was initially discovered in 2015. Since then, evidence from a sample size of 1125 participants with tick bite histories suggests that it is a novel Babesia species that caused 58 instances of babesiosis in Heilongjiang between 2015 and 2016 (Jia et al., 2018). The human population in China is also infected by Babesia venatorum, which is a common parasite. 48 positive cases of this species were identified from a sample of 2912 people who had a history of tick bites in a research conducted in the province of Heilongjiang, according to that study's findings (Jiang et al., 2015). According to PCR amplification and sequencing results, B. divergens, a different species that has only been described in two instances from the Shandong area, seems to be less frequently linked to Chinese human babesiosis infection (Qi et al., 2011). Babesia sp. XXB/Hangzhou, a different unique species of Babesia that can cause human babesiosis, was also identified in China in 2015, albeit only in one instance in a 42-year-old man in Hangzhou, Zhejiang province (S.-Q. Man et al., 2016). The assessment of zoonotic babesiosis in Korea discovered that small mammals and wild mammals that had been rescued from the area had tested positive for B. microti, which was verified using PCR in two studies with a prevalence of 2.1% and 5.7%, respectively (Table 2). Four investigations in Japan have identified zoonotic Babesia species from animals, with the findings confirmed by PCR. A total of three studies found that B. microti was present in wild rats, with prevalence rates of 13.4%, 45.2%, and 14.6%, respectively. *B. divergens*, another significant zoonotic Babesia species, was discovered in Japan's wild sika deer, with a prevalence of 6.6%. In Japan, there was just one case of PCR-confirmed human babesiosis where patient received around 2 liters of blood via transfusion after being taken to the hospital for a gastrointestinal issue and bleeding. The gastrointestinal ulcer was healed after one month, however the patient also had anemia and black urine. Following the discovery of Babesia-like intraerythrocytic parasites on a blood smear stained with Giemsa, *B. microti* was subsequently identified using IFA and PCR (Wei et al., 2001). With a prevalence of 5.3%, *Babesia microti* has been found in wild rats and has been recorded in Cambodia, Laos, and Thailand. 7% of 100 asymptomatic farmers in the Mongolian province of Selenge who underwent screening for the B. microti pathogen were found to have antibodies to the pathogen, and 3% of them had detected B. microti DNA in their blood.

Table 2. Some recent Zoonotic cases of Babesia.

Year of Study	Country	Method of Identification	Host	Species	Prevalence %	Reference
2008–2009	Korea	PCR/Seq	Rescued wild Animals	*B. microti*	5.7	(Hong et al., 2017)
2008–2009	Cambodia, Laos, Thailand	Nested PCR	Wild rodents	*B. microti*	5.3	(Karnchanabanthoeng, Morand, Jittapalapong, & Carcy, 2018)
2009–2011	China	PCR/Seq	Small mammals	*B. microti*	2.4	(Gao et al., 2017)
2012–2018	Japan	PCR	Wild Sika deer	*B. divergens*	6.6	(Zamoto-Niikura et al., 2020)

Prevention Measures

The spread of tick vectors and their rising prevalence in favorable circumstances make it difficult for the dairy and cattle industries and one health approach to control babesiosis. It can be prevented and controlled using three major strategies: immunization, restrict the vector, and chemoprophylaxis. (Y. Man et al., 2022) To attain and preserve enzootic stability, appropriate integration of these three techniques is crucial. In order to treat iron insufficiency, oral supplementation is also a viable option (Y. Man et al., 2022). Globally, it is also common practice to use acaricidal medications on a regular basis to eradicate tick habitats from farms. A way forward to manage the virus is to maintain biosecurity measures with good hygiene and to regularly immunize susceptible herds (Asrar et al., 2022). However, in order to safeguard the existing herd,vaccination has been reccomendedstringent quarantine is used for freshly purchased animals that are imported from locations where ticks are prevalentalso recommend the use of live attenuated vaccinations in all uninfected animals. (Jackson, Waldron, Weier, Nicoll, & Cooke, 2001).

Future Strategies

To minimize the financial losses resulting from that disease, there are a lot of gaps in the research and use of tick-control measures that need to be filled. Babesiosis prevention does not currently have a sub-unit vaccination, thus this is a possible topic that has to be covered in future research. Another area of interest would be the application o techniques to the identification of structural protein variations in *Babesia spp.*, genetically modified parasitic organisms grown in a lab environment can produce potential vaccine candidates. Another plan for the management of this illness is the creation of subunit vaccines made up of multiple antigens from sexual and asexual life stages of Babesia spp. Additional investigation is needed to understand the various *reservoirs* that could be involved in the growth of the tick population. In order to reduce the use of animals and humans for researching the impacts of pathogenic Babesia species, artificial feeding mechanisms for ticks should be created (Hatta, 2020; Vimonish et al., 2020). The development of effective vaccines against tick populations may also be facilitated by the use of nanoparticle technologies (de la Fuente, Estrada-Peña, & Contreras, 2020).

CONCLUSION

China and Korea have conducted a thorough search and discovered that the maximum number of zoonotic species of babesiosis in animals and human case reports, with *B. microti* and *B. divergens* appearing to be the most prevalent zoonotic species circulating in Asia. Rodents and other wild mammals were the most frequent zoonotic hosts found.in Asia where these zoonotic species are occurring, guiding management actions of stopping the spread of illness., The primary developing health concern is the spread of the disease, which is transmitted by a vector to several hosts before spreading among people. To effectively manage and prevent this disease, this public health perspective must be considered, especially for people under the one health concept.

AUTHOR'S CONTRIBUTION

Sara Ijaz and Muhammad Hussain Ghazali planned research and wrote paper, Asim Faraz revised the manuscript, Farena Khan, Sehrish Tariq, Nida Irshad and Sitwat Tahira helped in writeup and research, Shama Jamil, Raheel Khan and Ayesha Sharif helped in write-up.

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