**Gaziosmanpaşa Üniversitesi Ziraat Fakültesi Dergisi**
*Journal of Agricultural Faculty of Gaziosmanpasa University*
https://dergipark.org.tr/tr/pub/gopzfd

Araştırma Makalesi/*Research Article*

JAFAG
ISSN: 1300-2910
E-ISSN: 2147-8848
(2023) 40(3) 125-129
**doi:10.55507/gopzfd.1326924**

# Analysis of the Relationship between Almond Production and Almond Price with the Koyck Model

**Tayfun ÇUKUR[1*], Figen ÇUKUR[2]**

[1]Muğla Sıtkı Koçman University, Milas Vocational School, Department of Marketing and Advertising, Muğla
[2] Muğla Sıtkı Koçman University, Milas Vocational School, Department of Management and Organization, Muğla
***Corresponding author's email:** tayfun.cukur@hotmail.com

Alındığı tarih (Received): 13.07.2023 Kabul tarihi (Accepted): 29.09.2023

**Abstract:** In the current study, the Koyck model was used to determine the effect of almond prices on almond production in Türkiye. In the study, the period of 1970-2021 was examined and almond production was used as the dependent variable and almond price was used as the independent variable. According to the results of the analysis, the correlation between almond prices and the amount of almond production was found to be 0.952. The study determined that almond production is influenced by almond prices, and that any change in almond prices can lead to a noticeable change in almond production within a time frame of 2.67 years. On the other hand, it was determined that for the examined period, a one TL increase in almond prices in the current year led to a production increase of 0.002771 tons, while a one TL increase in almond prices in the previous period resulted in a production increase of 0.002015057 tons.

**Keywords:** Almond production, distributed lag model, Koyck

## Bademde Üretim ile Fiyat İlişkisinin Koyck Modeli ile Analizi

**Öz:** Araştırmada Türkiye'de badem üretimi üzerinde badem fiyatlarının etkisini belirleyebilmek amacıyla Koyck modelinden yararlanılmıştır. Araştırmada 1970-2021 dönemi incelenmiş, badem üretimi bağımlı değişken, badem fiyatı ise bağımsız değişken olarak kullanılmıştır. Analiz sonuçlarına göre badem fiyatları ile badem üretim miktarı arasındaki korelasyon 0.952 bulunmuştur. Araştırmada badem üretiminin badem fiyatlarından etkilendiği, badem fiyatlarında meydana gelen değişikliklerin badem üretiminde hissedilebilir bir değişikliğe yol açabilmesi için gereken zamanın ise 2.67 yıl olduğu saptanmıştır. Diğer taraftan incelenen dönem için, cari yılda badem fiyatlarındaki bir TL'lik artışın üretim miktarında 0.002771 tonluk bir artış yarattığı, bir önceki dönemdeki badem fiyatlarındaki bir TL'lik artışın ise badem üretiminde 0.002015057 ton artırdığı belirlenmiştir.

**Anahtar kelimeler:** Badem üretimi, gecikmesi dağıtılmış model, Koyck

## 1. Introduction

The history of almond trees dates back to ancient Babylon, and it is reported by historians to be among the oldest cultivated fruits. It is also stated that almonds were found among the treasures in Egypt, specifically on the island of Pharos near Alexandria (Topçuoğlu and Yılmaz-Ersan, 2020). Almond is a tree species that produces hard-shelled fruits and is cultivated in climates characterized by dry and hot summers, as well as mild and rainy winters. Almond is an important agricultural product that has low soil selectivity and can even grow in arid lands. Almonds are a good source of vitamins and minerals, making them beneficial for human health. They are widely used as a snack, as well as in confectionery, chocolate and pastry products. Additionally, almond oil is widely used in the cosmetic industry and in the pharmaceutical industry (Aydoğdu and Şahin, 2020). From a commercial perspective, the desirable characteristics of a good almond variety include strong tree development, abundant flowering, late blooming, abundant and consistent fruit production, simultaneous fruit maturation, resistance to wind-induced fruit drop and ease of harvesting. Moreover, it should be resistant to environmental conditions, diseases, and pests (Eldoğan, 2020).

In the agricultural sector, for supply to adapt to price changes, it requires the passage of a production cycle. The length of a production cycle in the agricultural sector is typically one year. Sometimes, this duration can be even longer, as in the case of perennial plants. The necessity for a production cycle to pass in order for supply to respond to such demand and price changes stems from the fact that the quantity supplied is dependent on the price from the previous year (with a lag). In conclusion, the supply quantity of the product produced in period t is dependent on the price of the period t-1 (Karkacıer, 1999).

When the relevant literature is examined, it is seen that there is very limited research using the Koyck model to determine the relationship between agricultural product prices and the production of agricultural products in Türkiye. Ağazade (2021) investigated the relationship between cotton production and cotton prices, Avcioğlu and Aksoy (2021) examined the relationship between pistachio production and pistachio prices, Berk (2017) studied the relationship between sunflower production and sunflower prices, Çelik (2014) explored the relationship between hazelnut shelled production and hazelnut shelled prices, Çelik (2015) analyzed the relationship between sheep milk production and sheep milk prices, Çobanoğlu (2010) examined the relationship between strawberry production and strawberry prices, Dikmen (2006) investigated the relationship between tobacco production and tobacco prices, Erdal and Erdal (2008) studied the relationship between dry onion production and dry onion prices, Özçelik and Özer (2006) explored the relationship between wheat production and wheat prices, Özsayın (2017) analyzed the relationship between cow milk production and cow milk prices, Doğan et al. (2014) examined the relationship between potato production and potato prices, Abdikoğlu and Unakıtan (2014) investigated the relationship between watermelon production and watermelon prices and Arısoy and Bayramoğlu (2017) attempted to determine the relationship between potato production and potato prices using the Koyck model.

The purpose of the current study is to reveal the relationship between almond production and almond prices in Türkiye using the Koyck model.

## 2. Materials and Method

### 2.1. Almond production in the world and in Türkiye

In the almond production, the United States ranks first with a share of 54.81%, followed by Spain in second place with a share of 9.14%, Australia in third place with a share of 7.15%, and Türkiye in fourth place with a share of 4.46% (Table 1) in 2021.

When almond production in Türkiye is examined, it is seen that almond production has been showing an increasing trend, particularly in recent years (Figure 1). It can be said that the increase in the number of fruit-bearing trees and productivity has played a significant role in this production increase. For example, in 2004, the number of fruit-bearing trees was 3450000, while in 2022, this number increased to 13616290. Similarly, the yield per tree increased from 11 kilograms in 2004 to 14 kilograms in 2022 (TÜİK, 2023).

**Table 1.** World almond production (2021)
***Çizelge 1.*** *Dünya badem üretimi (2021)*

| Country | Production (ton) | % |
|---|---|---|
| USA | 2189040.00 | 54.81 |
| Spain | 365210.00 | 9.14 |
| Australia | 285605.05 | 7.15 |
| Türkiye | 178000.00 | 4.46 |
| Morocco | 169255.00 | 4.24 |
| Iran | 163568.20 | 4.10 |
| Tunisia | 75000.00 | 1.88 |
| Italy | 71620.00 | 1.79 |
| China | 45000.00 | 1.13 |
| World | 3993998.06 | 100.00 |

Source: FAO, 2023.

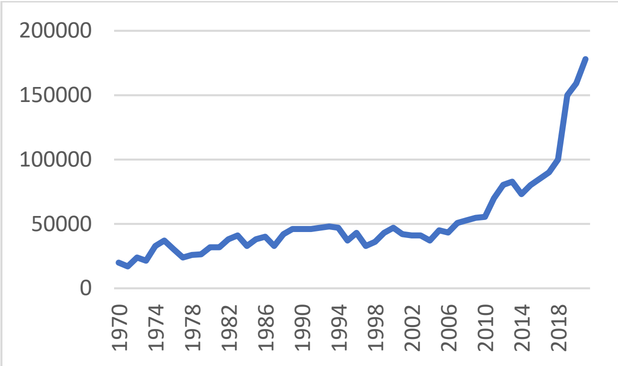


**Figure 1.** Almond Production in Türkiye by Years (tons)
***Şekil 1.*** *Türkiye'de yıllar itibariyle badem üretimi (ton)*

In Türkiye, in 2022, almond production reached 190000 tons. In almond production in Türkiye, Adıyaman province ranked first in production with a share of 17.80%, followed by Mersin province with a share of 13.82%, Antalya province with a share of 5.97% and Muğla province with a share of 5.59% (TÜİK, 2023).

### 2.2. Koyck model

The Distributed Lag Koyck Model was used in the current study. In the study, the amount of almond production is taken as the dependent and the price of almonds as the independent variable. The variables used in the study cover the period from 1970 to 2021. The unit of almond price is taken as the price paid the producer (TL/kg), while the unit of the amount of almond production is taken as ton. The time series data for the amount of almond production and almond prices were obtained from the TÜİK (Turkish Statistical Institute) database (TÜİK, 2023; TÜİK, 2014).

In regression models that use time series data, if the models include not only the current values of explanatory variables but also their past (lagged) values, such models are referred to as distributed lag models (Gujarati, 1999). The model used in the study is as follows, given in Equation 1.

$$Q_t = \alpha + \beta_0 P_t + \beta_1 P_{t-1} + \beta_2 P_{t-2} + ....... + \beta_k P_{t-k} + u_t \quad (1)$$

Koyck proposed a method for estimating distributed lag models. Koyck assumes that all the β coefficients have the same sign and that they geometrically decline as follows (Gujarati and Porter, 1999).

$$\beta_k = \beta_0 \lambda^k \quad k=0,1\ldots \quad (2)$$

In the formula;
$\lambda$ ($0<\lambda<1$): The rate of decline or decay of the distributed lag
($1-\lambda$): Speed of adjustment

As we go back into the distant past, each successive β coefficient numerically decreases even more. This implies that the impact of this lag on $Y_t$ gradually diminishes, which is a reasonable assumption (Gujarati, 1999).

Attention should be paid to the following characteristics of the Koyck scheme (Gujarati and Porter, 1999): (1) By assuming negative values for λ, Koyck rules out the β's from changing sign (2) by assuming that $\lambda < 1$, he gives lesser weight to the distant β's than the current ones, and (3) he ensures that the sum of the β's, which gives the long-run multiplier, is finite. Namely,

$$\sum_{i=0}^{\infty} \beta_k = \beta_0 \left(\frac{1}{1-\lambda}\right) \quad (3)$$

As a result, the infinite lag model may be written as in Eq. 4 (Gujarati and Porter, 1999).

$$Y_t = \alpha + \beta_0 X_t + \beta_0 \lambda X_{t-1} + \beta_0 \lambda^2 X_{t-2} + \ldots..+ \beta_0 \lambda^k X_{t-k} + u_t \quad (4)$$

When the model is lagged by one period, the following is obtained:

$$Y_{t-1} = \alpha + \beta_0 X_{t-1} + \beta_0 \lambda X_{t-2} + \beta_0 \lambda^2 X_{t-3} + \ldots..+ u_{t-1} \quad (5)$$

When the model is multiplied by λ, the following is obtained.

$$\lambda Y_{t-1} = \lambda\alpha + \beta_0 \lambda X_{t-1} + \beta_0 \lambda^2 X_{t-2} + \beta_0 \lambda^3 X_{t-3} + \ldots..+ \lambda u_{t-1} \quad (6)$$

When $Y_t$ is subtracted from $\lambda Y_{t-1}$, the Eq. 7 is obtained.

$$Y_t - \lambda Y_{t-1} = (1-\lambda)\alpha + \beta_0 X_t + (u_{t-1} - \lambda u_{t-1})$$
$$Y_t = (1-\lambda)\alpha + \beta_0 X_t + \lambda Y_{t-1} + v_t \quad (7)$$

## 3. Results and Discussion

In the study, first, the relationship between the amount of almond production and almond price was examined. As a result of the analysis, the correlation coefficient between almond price and the amount of almond production was calculated to be 0.952. This high correlation indicates that the variables are suitable for the Koyck model. In studies related to the subject, correlation coefficients between production and price were found to be 0.790 in garlic by Hasan and Khalequzzaman (2015), 0.850 in cow's milk by Özsayın (2017), 0.997 in sheep's milk by Çelik (2015), 0.940 in strawberries by Çobanoğlu (2010), 0.920 in dry onions by Erdal and Erdal (2008), 0.645 in shelled hazelnuts by Çelik (2014) and 0.638 in wheat by Özçelik and Özer (2006).

In the study, the lowest Schwarz criterion value was reached at 1 lag length (Table 2). This result indicates that the impact of almond price on almond production will last for one year, and after the first year, the effect of almond price on almond production will be zero. In the studies conducted by Özsayın (2017) and Hasan and Khalequzzaman (2015), the lag length was also found to be 1. On the other hand, there are studies where the lag length is found to be more than 1 year. The lag length was found to be 9 years in the study conducted by Çelik (2015) and 4 years in the study conducted by Çobanoğlu (2010). Similarly, in a study conducted by Ağazade (2021), the lag length was found to be 2 years, while in the study conducted by Doğan et al. (2014), it was also found to be 2 years. Similarly, in the studies conducted by Mbise (2016) and Turğut et al. (2023), the lag length was found to be 2 years. However, in the study conducted by Erdal and Erdal (2008), the lag length was found to be 5 years, and in the study conducted by Özçelik and Özer (2006), it was found to be 3 years. Furthermore, in the study where the Almon Lag Model was used, Özbay and Çelik (2016) found a lag length of 8 years. In the study that employed Koyck and Almon models, Dikmen (2006) found a lag length of 3 years. In another study that employed the Koyck and Almon models, Gürer (2020) found a lag length of 6 years.

In Table 3, the relationship between almond production and almond price according to the 1 lag length was determined by the least squares method. The model obtained in the study is statistically significant (p=0.000000) and $R^2$ was found to be 0.908552. The correlation between almond production and almond price is shown in Equation 9.

**Table 2.** Schwarz values for lag numbers
***Çizelge 2.*** *Gecikme sayıları itibariyle schwarz değerleri*

| Lag Length | Schwarz Criterion Value |
|---|---|
| **k=1** | **21.48251** |
| k=2 | 21.53162 |
| k=3 | 21.55929 |
| k=4 | 21.60366 |
| k=5 | 21.60823 |

In Table 3, the relationship between almond production and almond price according to the 1 lag length was determined by the least squares method. The model obtained in the study is statistically significant (p=0.000000) and $R^2$ was found to be 0.908552. The correlation between almond production and almond price is shown in Equation 9.

$$Q_t = \alpha_0 + \beta_0 P_t + \beta_1 P_{t-1} + u_t \quad (8)$$

$$Q_t = 32682.72 + 0.004408P_t + 0.003072P_{t-1} \quad (9)$$

**Table 3.** The relationship between almond production and almond price according to the lag numbers
***Çizelge 3.*** *Gecikme sayılarına göre badem üretimi ve badem fiyatı ilişkisi*

| Variables | Coefficient | Standard error | t-statistics | Probability value |
|---|---|---|---|---|
| Constant | 32682.72 | 1710.828 | 19.10345 | 0.0000 |
| $P_t$ | 0.004408 | 0.002833 | 1.556113 | 0.1263 |
| $P_{t-1}$ | 0.003072 | 0.003227 | 0.951944 | 0.3459 |

$R^2$= 0.908552 F= 238.4453 p= 0.000000

**Table 4.** The results of the Koyck model obtained
***Çizelge 4.*** *Elde edilen Koyck modelinin sonuçları*

| Variable | Coefficient | Standard error | t-statistics | Probability value |
|---|---|---|---|---|
| Constant | 8790.566 | 3509.144 | 2.505046 | 0.0157 |
| $P_t$ | 0.002771 | 0.000637 | 4.349928 | 0.0001 |
| $Q_{t-1}$ | 0.727195 | 0.100305 | 7.249843 | 0.0000 |

$R^2$= 0.955526 F= 515.6362 p= 0.000000

According to the results of the Koyck model, it can be observed that all the variables (constant, $P_t$, $Q_{t-1}$) are statistically significant (P<0.05). When the results of the model are examined, it is seen that a 1 TL increase in almond price leads to a 0.002771 ton increase in almond production, while a 1-ton increase in the almond production in the previous period results in a 0.727195 tonnes increase in almond production (Table 4).

The mean lag was calculated using the formula $\lambda/(1-\lambda)$. The values were put into their places in the formula and the following result was obtained; 0.727195/(1-0.727195)=2.67. This result shows that it takes 2.67 years for the change in almond price to affect almond production. The average lag length was found to be 1.46 in the study conducted by Turğut et al. (2023), 1.75 in the study conducted by Çukur et al. (2023), 2.70 in the study conducted by Avcioğlu and Aksoy (2021), 0.1885 in the study conducted by Berk (2017), 2.27 in the study conducted by Abdikoğlu and Unakıtan (2014), 1.19 in the study conducted by Erdal and Erdal (2008) and 12.33 in the study conducted by Erdal et al. (2009).

Based on the Koyck model, the following operations are performed to reach the equation (9).

When the Koyck model is rewritten,

$$Q_t = \alpha_0 + \beta_0 P_t + \lambda Q_{t-1} + u_t \quad (10)$$

$$\beta_k = \beta_0 \lambda^k \quad (11)$$

As $0 < \lambda < 1$

$\beta_0$= 0.002771 $\lambda$= 0.727195

$\beta_1 = \beta_0\lambda^1$ =(0.002771)(0.727195) = 0.002015057

$\alpha_0 = \alpha/(1-\lambda)$= 8790.566/(1-0.727195)= 32222.89

When the data obtained through the calculations above are substituted into the equation generated using the Koyck model, Equation (13) is obtained.

$$Q_t = \alpha_0 + \beta_0 P_t + \beta_1 P_{t-1} + u_t \quad (12)$$

$$Q_t = 32222.89 + 0.002771P_t + 0.002015057P_{t-1} \quad (13)$$

As evident from Equation (13), a 1% change in prices leads to a 0.002771 increase in production. It was determined that when there is 1 lag ($P_{t-1}$), a 1% change in price will increase production by 0.0002015057%.

## 4. Conclusion

In the study, the relationship between the amount of almond production and almond price in the period from 1970 to 2021 was examined with the help of Koyck model. The Schwarz criterion was used to determine the lag length and the lag length was found to be 1. In the Koyck model, in which the interaction between the amount of almond production and almond price was examined, the coefficient of determination was found to be 95%, and it was significant at the 1% level. It was determined that the time required for the change in almond prices to cause a significant effect in almond production is 2.67 years. According to the results of the model, a 1 TL increase in almond prices leads to a 0.002771 ton increase in almond production, while a 1-ton increase in the almond production in the previous period results in a 0.727195 tonnes increase in almond production.

It is seen that almond production in Türkiye has been showing an increasing trend in recent years. Almond productivity has also increased over the years. The average yield per tree increased from 11 kilograms in 2004 to 14 kilograms in 2022 in Türkiye (TÜİK, 2023). On the other hand, domestic almond consumption in Türkiye has also increased in recent years. As seen, both almond supply and almond demand have increased in recent years in Türkiye. In the study conducted by Aydoğdu and Şahin (2020), it is stated that there will be continued increases in almond production areas, production quantities, consumption and prices. Therefore, the implementation of effective marketing policies is considered highly important for almond farmers in terms of market security.

## References

Abdikoğlu, D.İ., & Unakıtan, G. (2014). Türkiye'de karpuz üretimi ile karpuz fiyatı arasındaki ilişkinin ekonometrik analizi. *XI. Ulusal Tarım Ekonomisi Kongresi,* Türkiye, 854-859.

Ağazade, S. (2021). Türkiye'de pamuk üretimi ile fiyatı arasındaki ilişkinin koyck yaklaşımı ile analizi. *Tekirdağ Ziraat Fakültesi Dergisi,* 18(3), 386-399. DOI: 10.33462/jotaf.681808

Arısoy, H., & Bayramoğlu, Z. (2017). Determination of the effect of price fluctuations on producer income the case of potatoes. *Turkish Journal of Agriculture-Food Science and Technology,* 5(11), 1342-1349. DOI: https://doi.org/10.24925/turjaf.v5i11.1342-1349.1356

Avcioğlu, U., & Aksoy, A. (2021). Analysis of correlation of pistachio production and income with the koyck models in Turkey. *Alinteri Journal of Agriculture Sciences*, 36(1), 71-76. DOI:10.47059/alinteri/V36I1/AJAS21012

Aydoğdu, M.H., & Şahin, Z. (2020). Türkiye badem üretimi: son dönemlerdeki değişimlerin genel analizi. *Euroasia Journal of Mathematics-Engineering Natural & Medical Sciences*, 8, 63-72.

Berk, A. (2017). The analysis of relationship between sunflower production and its price by using Koyck model in Turkey. *Custos e Agronegocio On Line*, 13(4), 42-53.

Çelik, Ş. (2014). Türkiye'nin kabuklu fındık üretiminde üretim-fiyat ilişkisinin Koyck yaklaşımı ile analizi. *Türk Tarım ve Doğa Bilimleri Dergisi*, 1(4), 524-530.

Çelik, Ş. (2015). Koyck ve Almon gecikme modeli ile koyun sütü üretiminde üretim- fiyat ilişkisinin analizi: Türkiye örneği. *Akademik Bakış Dergisi*, 50, 137-149.

Çobanoğlu, F. (2010). Koyck – Almon yaklaşımları ile çilek üretimi ve fiyat ilişkisinin analizi. *Türkiye IX. Tarım Ekonomisi Kongresi*, Türkiye, 72-79.

Çukur, T., Işın, F., & Çukur, F. (2023). Cevizde üretim ile fiyat ilişkisinin analizi. *Gaziosmanpaşa Bilimsel Araştırma Dergisi*, 12(1), 101-106.

Dikmen, N. (2006). Koyck-Almon yaklaşımı ile tütün üretimi ve fiyat ilişkisi. *Çukurova Üniversitesi Sosyal Bilimler Enstitüsü Dergisi*, 15(2), 153-168.

Doğan, H.G., Gürler, A.Z., Ayyıldız, B., & Şimşek, E. (2014). Patates üretiminde üretim-fiyat ilişkisinin koyck yaklaşımı ile analitik olarak değerlendirilmesi (TR 71 bölgesi örneği). *Türk Tarım – Gıda Bilim ve Teknoloji Dergisi*, 2(1), 42-46.

Eldoğan, Ü. (2020). Dünya'da ve Türkiye'de badem. *Antep Fıstığı Araştırma Dergisi*, 8, 44-45.

Erdal, H., Erdal, G., & Esengun, K. (2009). An analysis of production and price relationship for potato in Turkey: a distributed lag model application. *Bulgarian Journal of Agricultural Science*, 15(3), 243-250.

Erdal, G., & Erdal, H. (2008). Kuru soğanda üretim fiyat etkileşimi. *Gaziosmanpaşa Üniversitesi Ziraat Fakültesi Dergisi*, 25(1), 33-39.

FAO. (2023). Crops and livestock products, https://www.fao.org/faostat/en/#data/QCL.

Hasan, M.K., & Khalequzzaman, K.M. (2015). Relationship between production and price of garlic in Bangladesh: an analysis by using distributed lag model. *Bull. Inst. Trop. Agr., Kyushu Univ.*, 38, 31-38.

Gujarati, D.N. (1999). Temel Ekonometri. (Çevirenler: Ü. Şenesen, G.G. Şenesen). İstanbul: Literatür Yayınları.

Gujarati, D.N., & Porter, D.C. (1999). Basic Econometrics. New York: McGraw-Hill/Irwin.

Gürer, B. (2020). Investigation of the lagged effects of livestock supports on the animal production value in Turkey. *Eurasian Journal of Agricultural Research*, 4(2), 144-156.

Karkacıer, O. (1999). Genel Ekonomi (İktisada Giriş). Tokat: Gaziosmanpaşa Üniversitesi Ziraat Fakültesi Yayınları.

Mbise, M. (2016). Influence of expected farm-gate price on maize production in Ludewa district of Njombe region, Tanzania: estimation of koyck lag model. *International Journal of Advanced Research*, 4(12), 292-299. DOI:10.21474/IJAR01/2393

Özbay, N., & Çelik, Ş. (2016). Türkiye'de karpuz üretiminde üretim-fiyat ilişkisinin almon gecikme modeli ile incelenmesi. *Kahramanmaraş Sütçü İmam Üniversitesi Tarım ve Doğa Dergisi*, 19(2), 141-146.

Özçelik, A., & Özer, O.O. (2006). Koyck modeliyle Türkiye'de buğday üretimi ve fiyat ilişkisinin analizi. *Tarım Bilimleri Dergisi*, 12(4), 333-339. DOI: 10.1501/Tarimbil_0000000398

Özsayın, D. (2017). Investigation of production and price relationship in cow milk production by koyck model approach. *Turkish Journal of Agriculture - Food Science and Technology*, 5(6), 681-686. DOI: https://doi.org/10.24925/turjaf.v5i6.681-686.1164

Topçuoğlu, E., & Yılmaz-Ersan, L. (2020). Fonksiyonel beslenmede bademin önemi. *Bursa Uludağ Üniversitesi Ziraat Fakültesi Dergisi*, 34(2), 427-441.

Turğut, U., Güler, D., & Engindeniz, S. (2023) The analysis of the relation between production and price in sunflower by koyck model. *Tarım Ekonomisi Dergisi*, 29 (1), 57-64.

TÜİK. (2023). Bitkisel Üretim İstatistikleri, https://data.tuik.gov.tr/Kategori/GetKategori?p=tarim-111&dil=1.

TÜİK. (2014). İstatistik Göstergeler 1923-2013, Ankara.