OKU Fen Bilimleri Enstitüsü Dergisi
8(3): 1169-1186, 2025

OKU Journal of The Institute of Science and Technology, 8(3): 1169-1186, 2025

Osmaniye Korkut Ata Üniversitesi Fen Bilimleri Enstitüsü Dergisi

Osmaniye Korkut Ata University Journal of The Institute of Science and Technology

Milk Production Curves Obtained from Cows Raised in Türkiye According to Years and Determination of Production Differences with the Help of Cluster Analysis and Friedman Test

Alper GÜVEN[1], Murat ÇİMEN[2*]

[1]Munzur University, Faculty of Fine Arts, Design and Architecture, Faculty, Department of Gastronomy and Culinary Arts, Tunceli, Türkiye
[2]CMN Statistics and Scientific Research Center, Çorum, Türkiye

[1]https://orcid.org/0009-0007-6698-9754
[2]https://orcid.org/0000-0003-4290-2718
*Corresponding author: mcimen19@gmail.com

Research Article

Article History:
Received: 16.10.2024
Accepted: 18.03.2025
Published online: 16.06.2025

Key words:
Cow
Cluster analysis
Friedman test
Milk production curve

ABSTRACT

In the study, cluster analysis and Friedman tests were used to create curves for cow milk yields in Türkiye between 2010-2023 and to determine yield differences. For this purpose, milk yield records obtained from TUIK for the years in question were used. Since data before 2010 could not be accessed, 2010 was taken as the starting date. When the figures obtained in the study are examined, it is striking that the years generally show similar curves. These curves generally show a decrease from January to February, then an increase until May. Milk yield values, which reach their peak in May, decrease again until November. After this month, a new increase is noted in December. The months showing maximum and minimum values in the graphs of 2016 and 2017 are different. Therefore, different curves were obtained for these years compared to other years. When the curves of all years, cluster analysis and Friedman test results are examined in general, it can be said that the highest production was determined in May and the lowest production in November. The reason for these differences should be investigated for the years 2016 and 2017, when different curve results were obtained. The findings of this study are important in terms of providing preliminary information for those who will conduct model studies on milk production in our country. In addition to the evaluation of curve graphs, it has been seen from the research findings that different statistical techniques such as cluster analysis and Friedman test give effective results in this type of data. Both cluster analysis and Friedman test methods are test methods that can be used safely in new studies where curve graphs will be made.

Türkiye'de Yetiştirilen İneklerden Elde Edilen Süt Verimi Eğrilerinin Yıllara Göre İncelenmesi ve Kümeleme Analizi ve Friedman Testi Yardımıyla Üretim Farklılıklarının Belirlenmesi

Araştırma Makalesi

Makale Tarihçesi:
Geliş tarihi: 16.10.2024
Kabul tarihi:18.03.2025
Online Yayınlanma: 16.06.2025

Anahtar Kelimeler
İnek
Kümeleme analizi
Friedman test
Süt verimi eğrisi

ÖZ

Araştırmada, Türkiye'de 2010-2023 yılları arasında inek sütü verimlerine ait eğrilerin oluşturulması ve verim farklılıklarının belirlenmesinde kümeleme analizi ve Friedman testleri kullanılmıştır. Bu amaçla söz konusu yıllara ait TUİK'ten elde edilen süt verimi kayıtları kullanılmıştır.2010 yılından önceki verilere ulaşılamadığı için başlangıç tarihi olarak 2010 yılı alınmıştır. Araştırmada elde edilen rakamlara bakıldığında yılların genel olarak benzer eğriler gösterdiği dikkat çekmektedir. Bu eğriler genel olarak Ocak ayından Şubat ayına kadar bir düşüş, ardından Mayıs ayına kadar bir artış göstermektedir. Mayıs ayında pike ulaşan süt verimi değerleri, Kasım ayına kadar tekrar düşüş göstermektedir. Bu aydan sonra Aralık ayında yeni bir artış dikkat çekmektedir.2016 ve 2017 yıllarına ait grafikte maksimum ve minimum değer

gösteren aylar farklılık göstermektedir. Bu nedenle bu yıllar için diğer yıllara göre farklı eğriler elde edilmiştir. Tüm yıllara ait eğriler, kümeleme analizi ile Friedman testi sonuçları genel olarak incelendiğinde en yüksek üretimin Mayıs ayında, en düşük üretimin ise Kasım ayında belirlendiği söylenebilir. Farklı eğri sonuçlarının elde edildiği 2016 ve 2017 yılları için bu farklılıkların nedeni araştırılmalıdır. Bu çalışmanın bulguları ülkemizde süt üretimi ile ilgilenen model çalışmaları yapacaklar için ön bilgi olması açısından önem taşımaktadır. Eğri grafiklerinin değerlendirilmesinin yanı sıra bu tip verilerde kümeleme analizi ve Friedman testi gibi farklı istatistiksel tekniklerin etkili sonuçlar verdiği araştırma bulgularından görülmüştür. Hem kümeleme analizi hem de Friedman testi yöntemi eğri grafiklerinin yapılacağı yeni çalışmalarda güvenle kullanılabilecek test yöntemleridir.

To Cite: Güven A., Çimen M. Milk Production Curves Obtained from Cows Raised in Türkiye According to Years and Determination of Production Differences with the Help of Cluster Analysis and Friedman Test. Osmaniye Korkut Ata Üniversitesi Fen Bilimleri Enstitüsü Dergisi 2025; 8(3): 1169-1186.

1. Introduction

To know milk production curve makes it possible valuable insights in planning optimum management models related to health, feeding, and breeding in dairy cows (Lee et al., 2020). By recognizing the curves, it becomes possible to intervene in the negativities observed. Milk production also varies depending on seasonal changes throughout the year (Cimen et al., 2010; Biswal et al., 2020). Periodic changes in milk production require different measures to be taken within the enterprise. It is possible to list many factors such as milk preservation, marketing, feeding patterns and maintenance work among these measures. Curves, in which changes in both milk production and milk biochemical parameters were shown, have been the subject of many studies (Piccardi et al., 2017). In this study, the curves formed by the monthly production amounts of cow milk produced in Turkey between 2010 and 2023 were tried to be shown separately for each year. Differences that can be seen in the curves according to years will constitute an important source for determining possible problems in the years when the differences are observed. It is of great importance to repeat similar studies not only across Turkey but also on a provincial basis and in other animal species. In addition, establishing the curves to be determined in these studies not only for milk yield but also for milk biochemical parameters will provide great gains for the sector working in the field of milk production. Prediction of milk yield through modeling plays an important role in improving the production efficiency and sustainability of the dairy industry. Methods and models developed according to lactation and milk production periods will be decisive for all kinds of improvement to be applied in the dairy industry (Oliveira et al., 2024). The results of the curves and cluster analysis determined by years in our study are thought to be of great importance in terms of providing insight and guidance in modeling that can be done for lactation and milk production periods in our country.At the same time, it will provide great benefits in terms of obtaining up-to-date information by looking at the curves formed by the fluctuations in annual milk productions in our country, as well as what kind of improvement should be made against possible disruptions. This study aims to show the efficiency of cluster analysis and Friedman test in this field in terms of showing the differences between treatment groups in the studies to be conducted on lactation curves and clearly revealing the differences seen while the curves are being formed. Because no studies

were found in the literature review that included comments made with these two test models on lactation curves.

2. Material and Methods

2.1. Obtaining Data

The data used in obtaining cluster analysis results and creating curves of milk production data were taken from TUIK (2024). The data between 2010-2023 examined in the current study represents the total of Turkey's provinces. Since data before 2010 are not available within TUIK, they could not be included in the research. Data in Excel format was downloaded by entering the TUIK data page via the internet connection of Çorum Hitit University Library.

2.2. Shaping of the Curves

In shaping the curves, the graphs were obtained by entering the Graphs>Chart Builder menu from the SPSS package program. SPSS 18.0 package program was used to form the graphics. The results seen in the SPSS output were copied and transferred to a word file.

2.3. Cluster Analysis Application

In the first clustering chart, the month factor was eliminated by combining and a clustering chart was formed by years. In the second clustering chart, the year factor was eliminated by combining and a clustering chart was formed by months. SPSS 18.0 package program was used to apply cluster analysis to the research data. Euclidean distance and Ward method were used in Hierarchical clustering analysis (HCA) performed with the help of SPSS. The algorithm measures the similarity between objects using Euclidean distance, and groups them into cluster. The Euclidean distance measure calculates the distance as a "straight line" between two clusters (Anonymous, 2024).

2.4. Application of Friedman Test Analysis

For Friedman analysis, first the years were eliminated and the analysis was done according to months, then the months were eliminated and the analysis was done according to years. The differences that could be seen according to months and years were reached in this way. For the analysis, the SPSS 18.0 package program was entered from the non parametric test > legacy dialogs > k related samples section. Then, the Friedman test analysis button was marked and the analysis results were reached.

To find the test statistic in the Friedman test, it is used the following formula (Riffenburg, 2006):

$$F = \left[\frac{12}{[N * k * (k+1)]}\right] * \Sigma R^2 - [3 * N * (k+1)]$$

Where N is the blocks, groups (number of lines), k is the transactions (number of columns), and R is the total ranks for each of the columns of data (Karagöz, 2014).

3. Results and Discussion

3.1. Monthly Milk Production Curves

Monthly curves of milk production are shown in the relevant figures (Figure 1-14) for each year respectively. It is possible to see the fluctuations of the curves according to months from the figures (Figure 1-14).

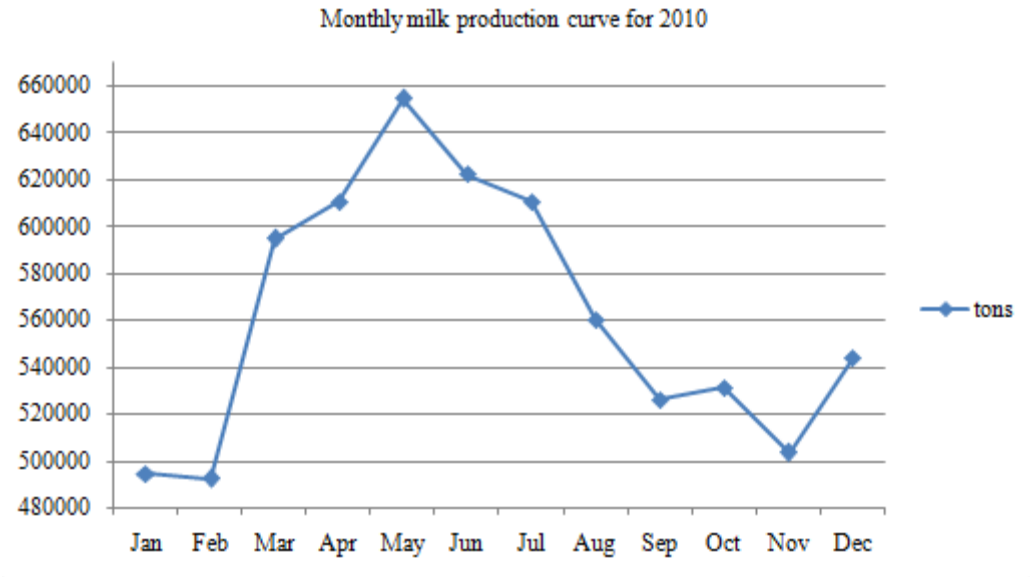

Figure 1. Monthly cow milk production in Turkey for 2010 (tons)

When Figure 1 was examined, raw milk production, which was 490 thousand tons in January, peaked in May (654 thousand tons). Production decreased in the following months, falling to 500 thousand tons in November. It was seen that production started to rise again in December. When the milk production curve is examined, a curve that increases until May and then decreases is noteworthy.

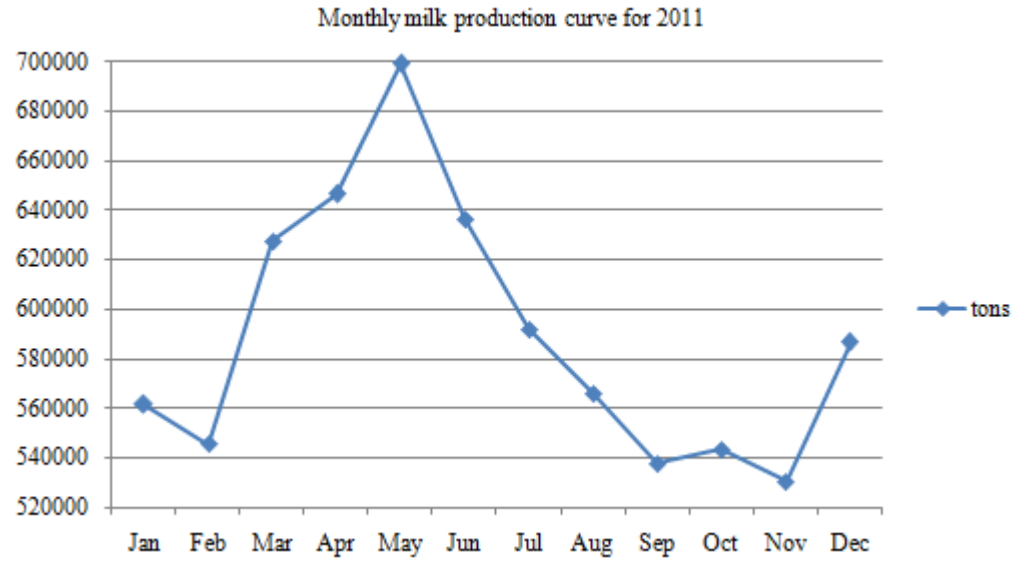

Figure 2. Monthly cow milk production in Turkey for 2011 (tons)

Figure 2 shows a curve similar to Figure 1. There was an increase until May (700 thousand tons) and then a decrease until November (530 thousand tons).

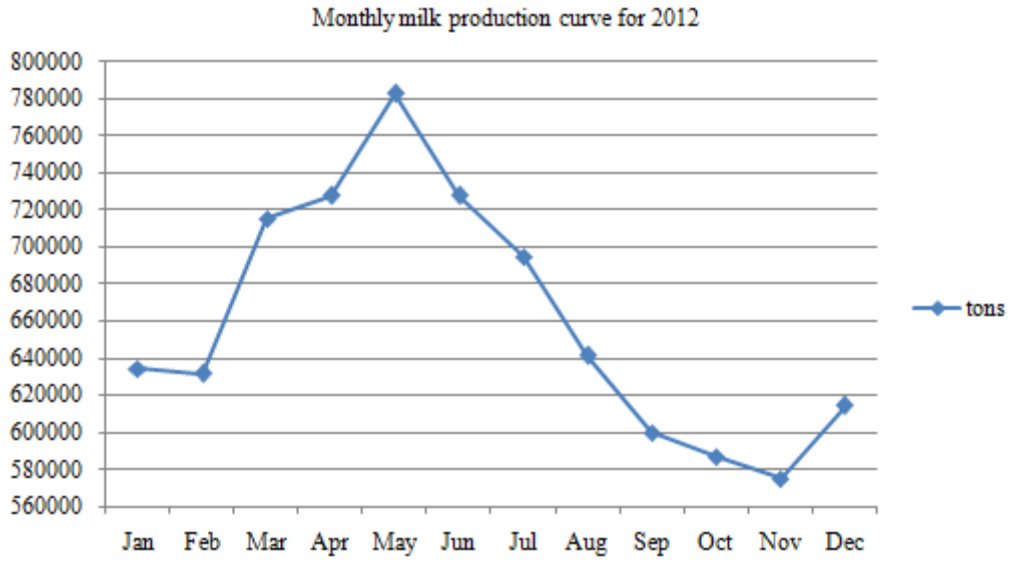

Figure 3. Monthly cow milk production in Turkey for 2012 (tons)

Figure 3 shows a distribution similar to the previous figures. While milk yield was at its peak in May (783 thousand tons), it was found to be at its lowest in November (575 thousand tons).

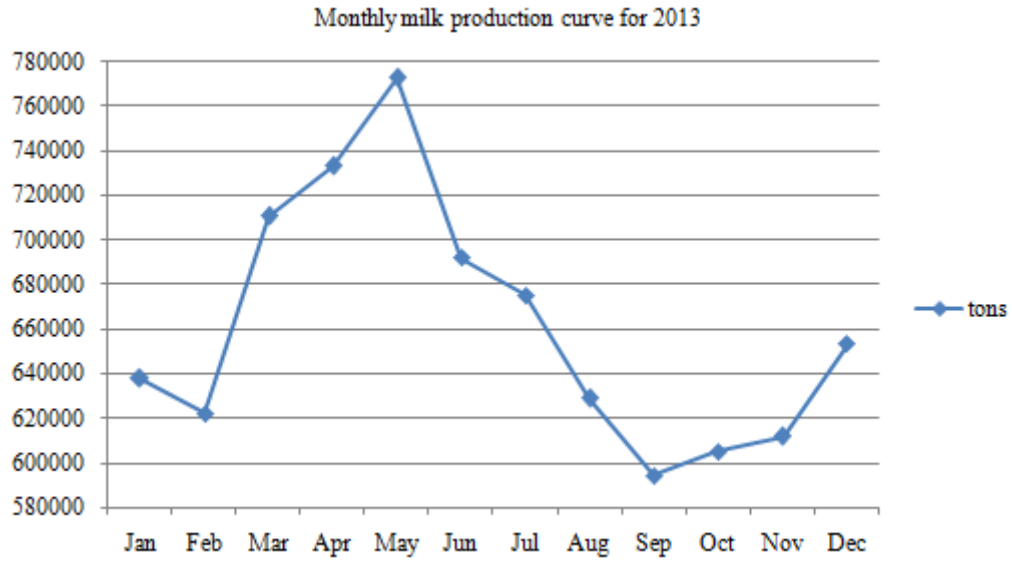

Figure 4. Monthly cow milk production in Turkey for 2013 (tons)

The maximum milk production amount, which was 773 thousand tons in May, decreased to the lowest level with 594 thousand tons in September, unlike other figures (Figure 4).

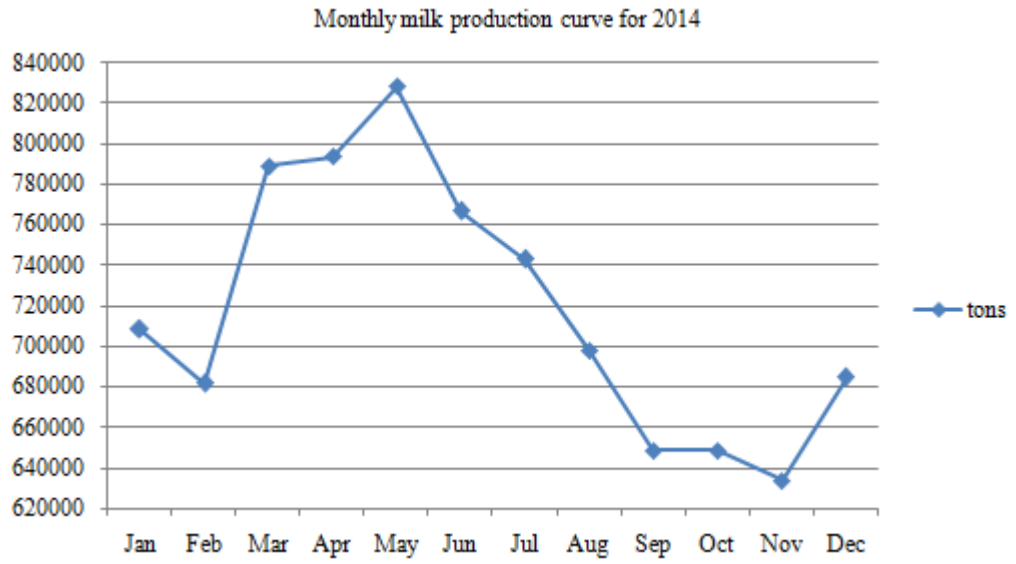

Figure 5. Monthly cow milk production in Turkey for 2014 (tons)

Figure 5 has a similar structure to the curves from other years, except Figure 4. Again, the highest (828 thousand tons) milk production amounts were achieved in May and the lowest (634 thousand tons) in November.

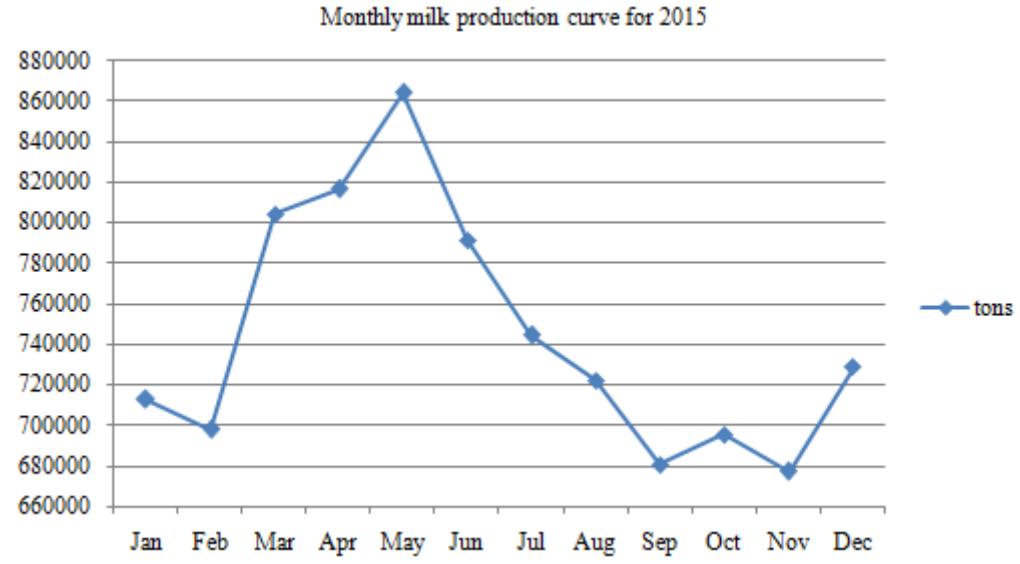

Figure 6. Monthly cow milk production in Turkey for 2015 (tons)

When the values of 2015 were examined, the highest values in May (864 thousand tons) and the lowest values in November (677 thousand tons) were found to be noteworthy as depicted in Figure 6.

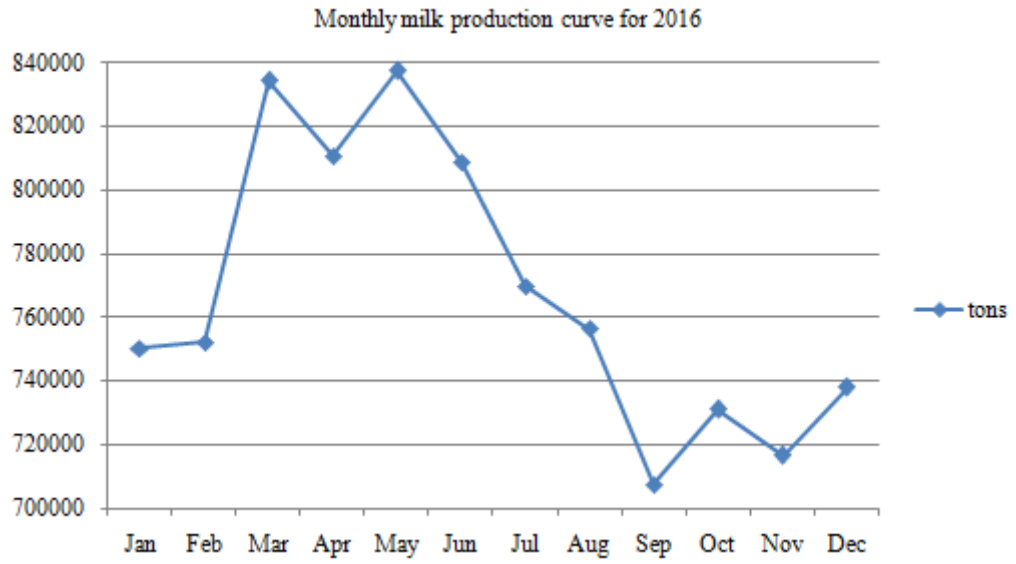

Figure 7. Monthly cow milk production in Turkey for 2016 (tons)

The curve expressing the milk production amount in Figure 7 differs from the previous curves. While the highest values in the previous curves were seen only in May, it is noteworthy that the months of March (834 thousand tons) and May (837 thousand tons) showed similar values in Figure 7. In addition, unlike the previous figures, the minimum values were seen in September (707 thousand tons) of this year.

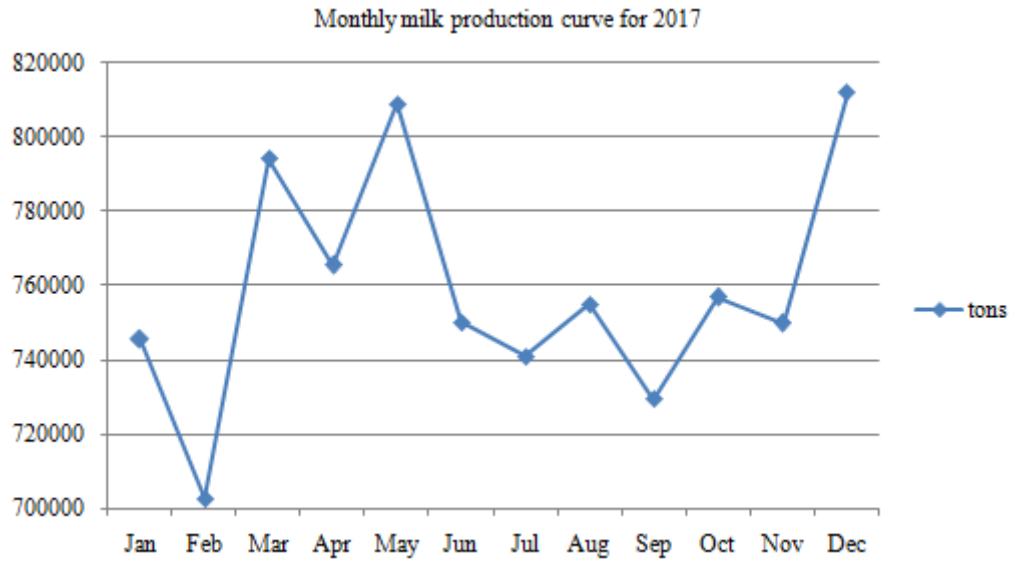

Figure 8. Monthly cow milk production in Turkey for 2017 (tons)

The curve of the production quantities shown in Figure 8 has had a completely different structure from the curves seen in other figures. Interestingly, the lowest milk production was observed in February (702 thousand tons), while the highest production was determined as 812 thousand tons in December.

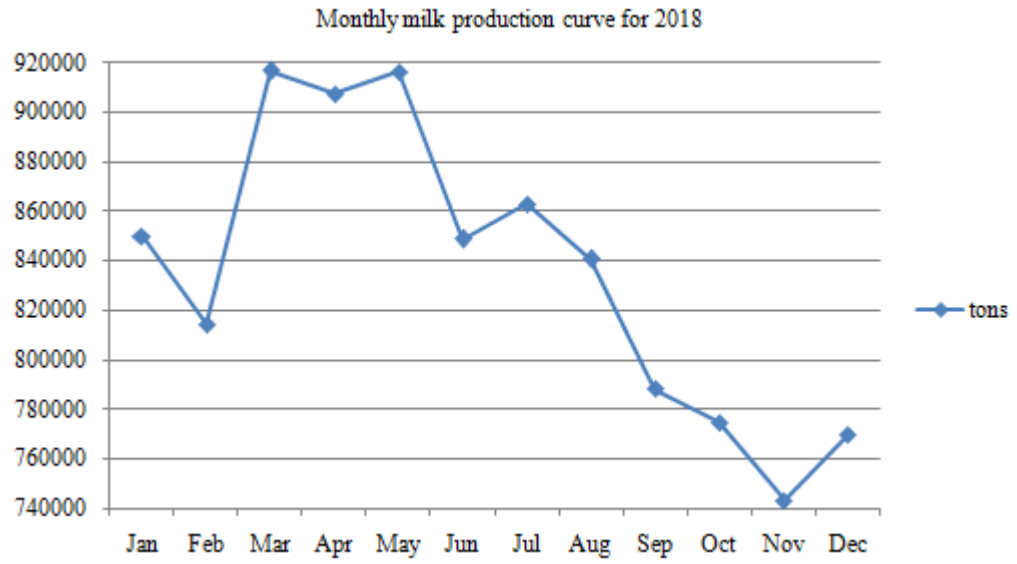

Figure 9. Monthly cow milk production in Turkey for 2018 (tons)

When Figure 9 is examined, it is seen that the highest milk production (916 thousand tons) in 2018 was achieved in March and May. The lowest milk production was obtained in November (743 thousand tons).

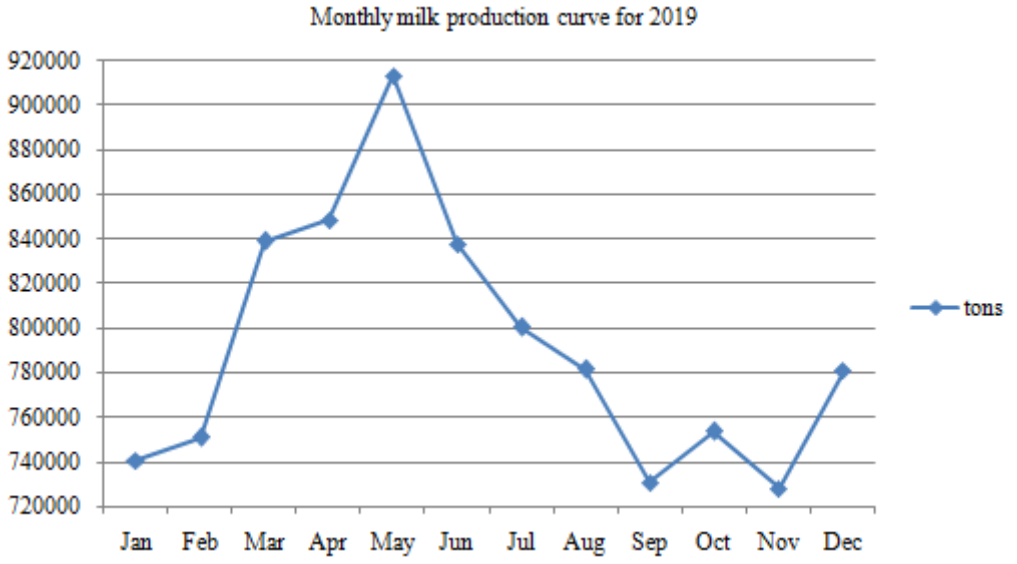

Figure 10. Monthly cow milk production in Turkey for 2019 (tons)

The highest milk production in 2019 was observed in May (913 thousand tons). The lowest milk production was obtained in November (728 thousand tons) (Figure 10).

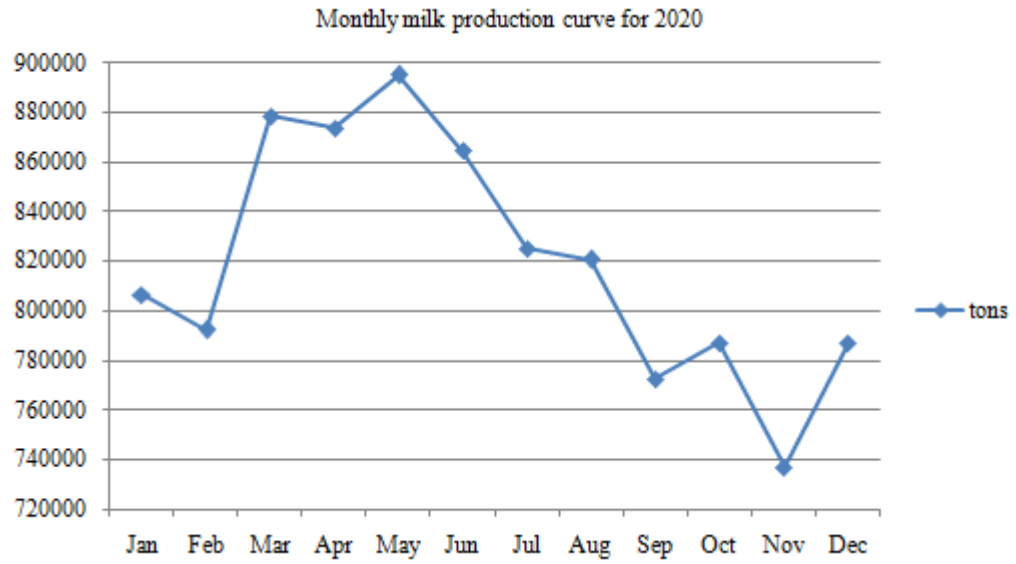

Figure 11. Monthly cow milk production in Turkey for 2020 (tons)

Looking at Figure 11, it is seen that the highest milk production (895.000 tons) in 2020 was achieved in May. The lowest milk production was obtained in November (737.000 tons).

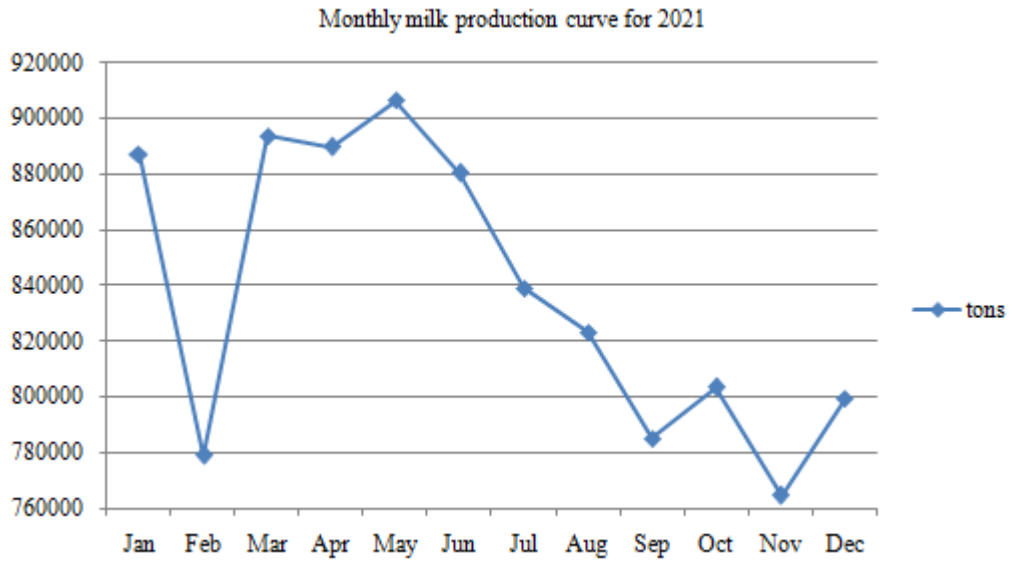

Figure 12. Monthly cow milk production in Turkey for 2021 (tons)

When the curve for 2021 is examined (Figure 12), it is noted that the highest milk production (906 thousand tons) was achieved in May. The lowest milk production was observed in November (764 thousand tons).

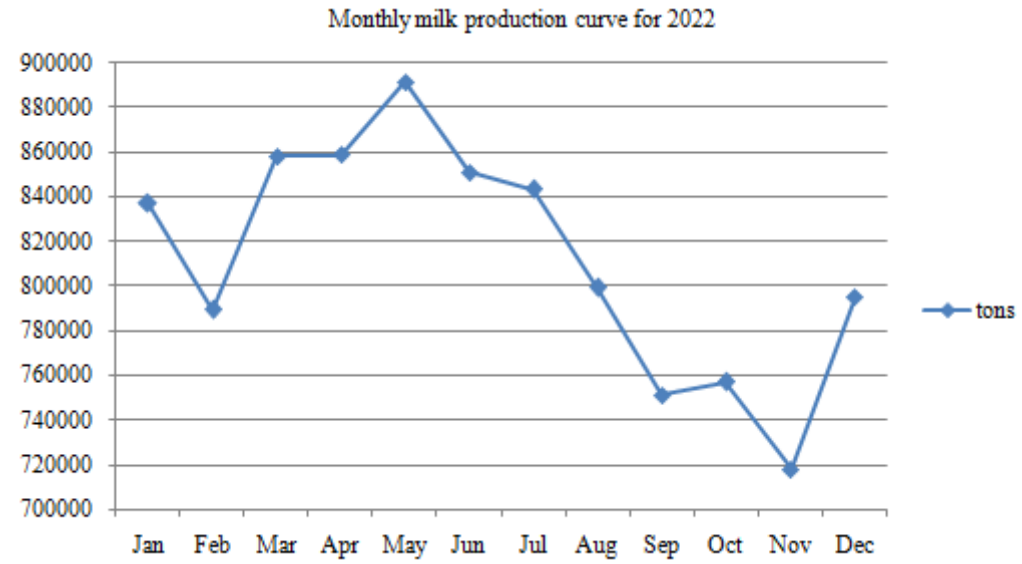

Figure 13. Monthly cow milk production in Türkiye for 2022 (tons)

Looking at Figure 13, the highest milk production (891.000 tons) was achieved in May. The lowest milk production was observed in November (718.000 tons).

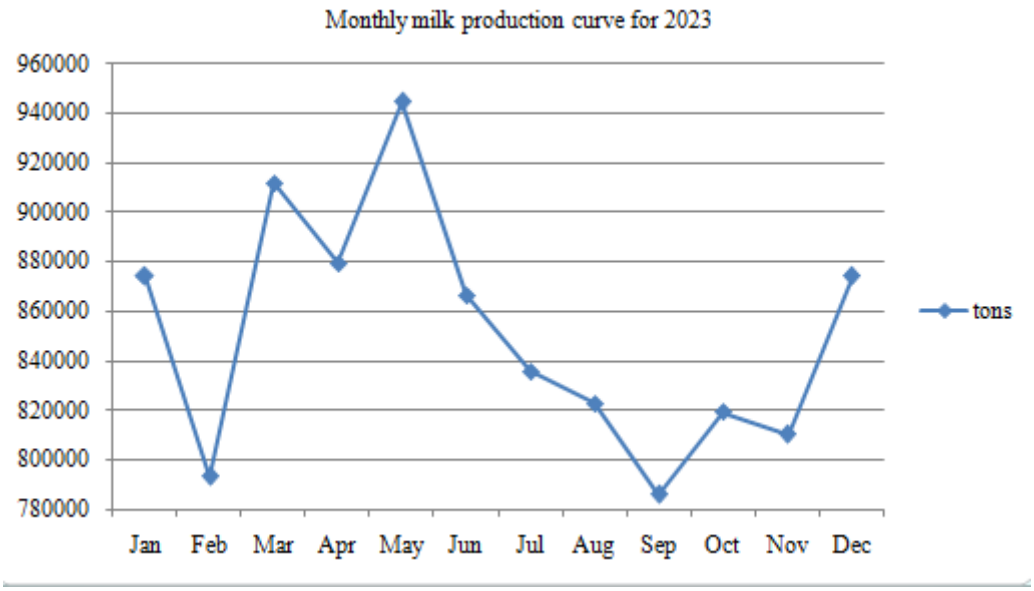

Figure 14. Monthly cow milk production in Türkiye for 2023 (tons)

As can be seen in Figure 14, it was found that the highest milk production (944 thousand tons) in 2023 was achieved in May. However, the lowest milk production was seen as 786 thousand tons in September. When we look at the figures given in the research, it was found to be noteworthy that the years generally show similar curves. These curves generally have shown a decrease from January to February and then an increase until May.

The milk production amount, which peaks in May, has decreased again until November. After this month, a new increase was noticeable in December. Although the months showing maximum and

minimum values may have varied in the graphs of some years, in general the highest production was determined in May and the lowest production was observed in November.

In Figure 15, it was reported that the highest yields of dairy cattle are obtained in May and the lowest yields were obtained in November (USDA, 2024).

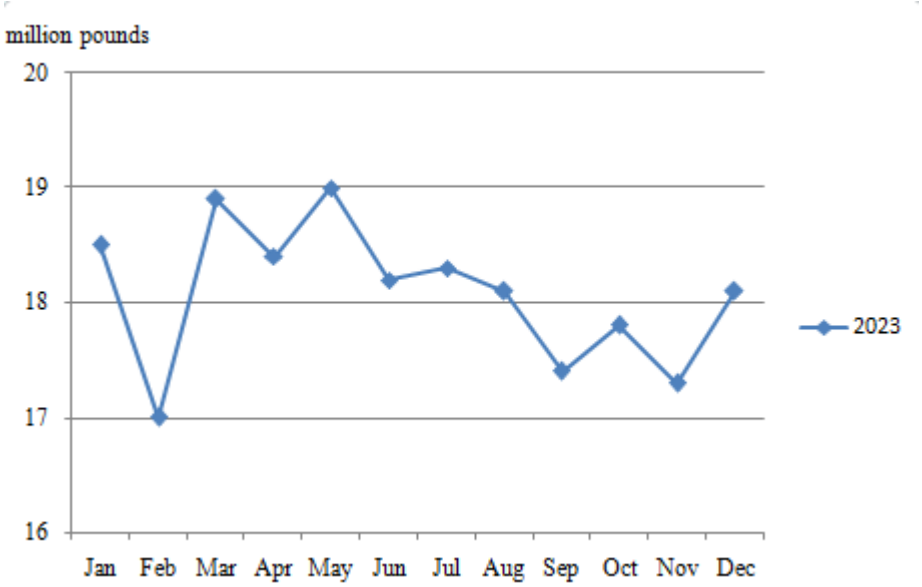

Figure 15. Monthly milk production of 24 states in America in 2023 and 2024 (USDA, 2024)

The curve showing the monthly milk production distributions reported for America in Figure 15 has been found to be very similar to the curves in our research. As seen in Figure 15, the USA has determined a common milk production curve for its 24 states. However, no milk yield curve study has been found in the literature showing the distribution of total milk yields obtained from provinces in our country for each months of recently years. For this reason, our study was believed to be of great importance in terms of showing the monthly distribution of milk obtained from all over Türkiye in each year. The current study was aimed to provide an advantage as a reference to other studies.

3.2. Cluster Analysis Results

When looking at Figure 16, two main clusters attracted attention. Data on milk production amounts from 2014 to 2023 constituted the first main cluster. Whereas data on milk production amounts from 2010 to 2013 constituted the second main cluster. The data forming the second main cluster was found to be lower than the data belonging to the years forming the first main cluster. In other words, milk yields in 2010-2013 were lower than the following years. If the second main cluster is evaluated within itself, the years 2010 and 2011 had lower milk yields than the years 2012 and 2013. It can be seen that the first main cluster was similarly distributed into 2 sub-clusters. The years 2018, 2020, 2021, 2022, 2023 are in the first subset of the first main cluster. The years 2014, 2015, 2016, 2017 and 2019 formed the second

subset under the first main cluster. Milk yield values of the first sub-cluster among the clusters under the first main cluster were found to be higher than the values of the second sub-cluster.

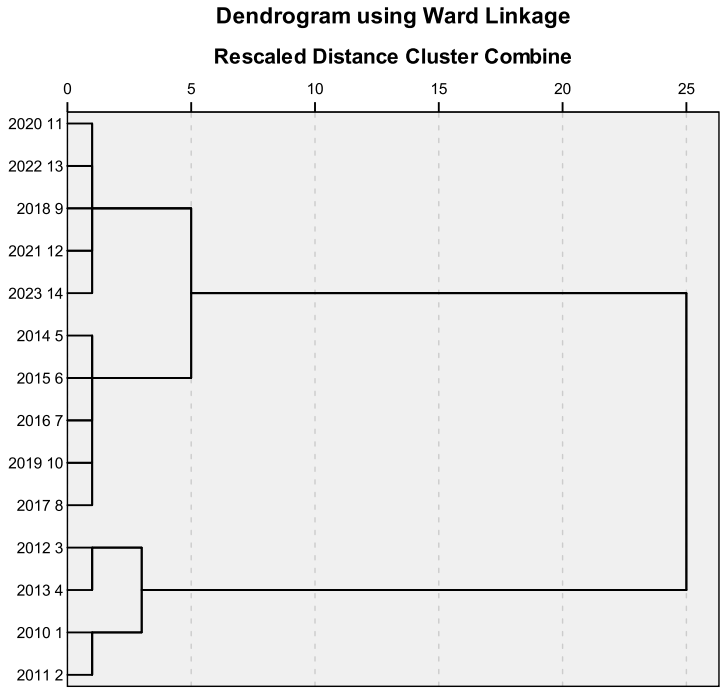

Figure 16. Distribution chart of main and sub-clusters by years

When the distribution of milk production amounts by month is examined in Figure 17, two main clusters are seen. The distributions seen in the subgroups in the monthly cluster graph have a more complex structure compared to the distributions in the annual cluster graph. September, October and November constitute the first subcluster of the second main cluster, while February, August, January and December constitute the second subcluster. September, October and November, which constitute the first subcluster of the second main cluster, have the lowest milk amounts. March, April, June and July constitute the first subcluster of the first main cluster. May constitutes the second subcluster of the first main cluster and has the highest milk yield values.

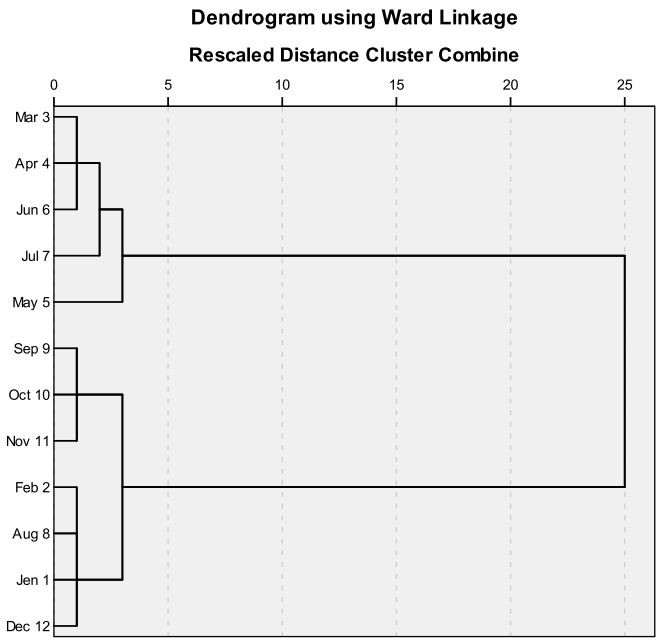

Figure 17. Distribution chart of main and sub-clusters by months

It was noteworthy that cluster graphs were more advantageous in terms of seeing quantitative differences compared to curve graphs. While in the curve charts the distribution of months for each year can be seen, in the cluster chart it was not possible to see such a monthly distribution statistically since there was only one data for each month of each year. Lactation curves are shaped according to time. It is understood from the results of previous studies that cluster analysis is a useful method in the evaluation of lactation cycles (Lee et al., 2020; Pereiera et al., 2021).

3.3. Friedman Test Analysis Results

When the rank values in Table 1 are examined, it is striking that the highest rank value of 11.86 belongs to May, and the lowest rank value of 1.79 belongs to November. Accordingly, when all months are evaluated together, it is seen that there is a significant difference between the months according to the Friedman test analysis results ($p<0.01$). In order to compare measurement scores belonging to more than 2 different times, the Friedman Test should be applied. If a significant difference is found as a result of this test, the measurements should be compared in pairs. For this, the Wilcoxon Signed Rank Test should be used. Thus, it can be determined between which measurements the difference is (Kolassa, 2022). In order to determine which months the difference found between the months as a result of the Friedman analysis is between, firstly the month with the lowest Average rank (1.79) value (November) was compared with the following month with the lowest Average rank (2.61) value (September) using the Wilcoxon Signed Rank Test, and it was determined that the month with the lowest measurement score was November ($p=0.048$). Since November showed statistically lower results than September, which had the lowest measurement score, it was not necessary to make a comparison with other months. The aim of the research was to reveal the months with the lowest and highest measurement scores.

Table 1. Friedman test results for months

Months	Mean Ranks
Jan	5.79
Feb	3.64
Mar	10.14
Apr	10.29
May	11.86
Jun	8.79
Jul	7.64
Aug	6.29
Sep	2.61
Oct	3.79
Nov	1.79
Dec	5.79

Table 2. Test statistics[a]

N	14
Chi-square	129.253
df	11
Asymp. Sig.	.000

a. Friedman Test

When the rank values given in Table 3 are examined, it is seen that the highest rank value of 13.00 belongs to 2023, and the lowest rank value of 1.08 belongs to 2010. Accordingly, when all years were evaluated together, it was seen from the Friedman test analysis results that there were significant differences between the years ($p<0.01$).Since a significant difference was found as a result of the Friedman analysis in the current study, the year with the lowest Mean rank (1.08) value (2010) was compared with the year with the next lowest Mean rank (1.92) value (2011) with the help of the Wilcoxon Signed Rank Test, and it was determined that the year with the lowest measurement scores was 2010 ($p=0.008$). Similarly, the year (2023) with the highest mean rank value (13.00) was compared with the year (2021) with the next highest mean rank value (12.12) using the Wilcoxon Signed Rank Test, and it was determined that the year with the highest measurement scores was 2023 ($p=0.049$).

The increase in milk production in May may have been influenced by the switch from feeding the cows with dry grass in the barn in the winter to green grass in the spring (Ulaş and Cimen, 2019). It has been reported that seasonality affected changes in milk parameters and production amounts (Lowe et al., 1999). The increasing insufficiency of pasture grass towards November may have caused a decrease in milk production. When cows start consuming pasture plants, their milk production increased (Ribeiro-Filho et al., 2003; Lüscher et al., 2014). The nutritional value of pasture plants and the chemical structure of nutrients were important factors in increasing milk production (Roca Fernandez et al., 2016). Pasture plants with high nutritional value encourage an increase in milk production (Chjapman et al., 2008). Heat stress and the drying of pasture grasses were found to be effective in the decrease in milk yield towards the summer months (Harris et al., 1997). In addition, in summer, stress occurred as the animal's body temperature increased and feed intake decreased. This situation caused an effect that reduced milk

production (Pragna et al., 2017). In cold weather, more energy was spent to maintain body temperature (Fu et al., 2022).

Table 3. Friedman test results for years

Years	Mean Ranks
2010	1.08
2011	1.92
2012	3.58
2013	3.42
2014	5.33
2015	6.58
2016	7.67
2017	7.50
2018	12.11
2019	8.92
2020	10.83
2021	12.12
2022	10.33
2023	13.00

Table4. Test statistics[a]

	14
Chi-square	143.771
df	11
Asymp. Sig.	.000

a. Friedman Test

Accordingly, the amount of energy to be spent on milk production reduces and milk production decreased. In addition, the cooling of water in winter negatively affects water intake, thus milk yield decreases. In addition, since animals were fed with dry grass in winter, they were deprived of pasture grass with high nutritional content in the spring (Lim et al., 2021). When the graphs presented in our research are examined, the curves formed to show maximum and minimum production in other years except 2016 and 2017 have a similar structure. The reason for the differences in milk production in 2016 and 2017 is unknown. In the following years, when new milk production curves are created, if different curves are obtained from the normal curve, the reason for this should be investigated. Milk yield amounts that are outside the expectations by month are a sign that there are some problems. For example, while the highest yields should be obtained in May, another month showing higher values makes it necessary to know what type of problem exists in May. In order for milk production facilities, animal farms and all related units to operate optimally, milk production curves must be determined on a monthly basis every year and any seen negative effects must be intervened (Ehrlich, 2011; Cole et al., 2023).

4. Conclusion

When we look at the results obtained in the research, it is noteworthy that the years generally show similar curves. These curves generally show a decrease from January to February, followed by an increase until May. The current study should be repeated not only across Türkiye but also on a provincial basis and in other animal species. In addition, curves should be created not only for milk yields but also

for milk biochemical parameters. The findings of the curves, cluster analysis and Friedman test determined in our work are of great importance in terms of providing insight in modeling and similar studies that can be done for lactation and milk yield periods in our country. In addition to the evaluation of curve graphs, it has been observed from the research findings that different statistical techniques such as cluster analysis and Friedman test give effective results in this type of data. This study shows that both cluster analysis and the Friedman test method are test methods that can be used safely in new studies where curve graphs will be made. In the literature reviews, it has been seen that unfortunately cluster analysis and Friedman test method are not applied in this type of curve analysis studies. Both in curve analysis studies like this research and in studies where other treatment group data will be compared, these two statistical methods should definitely be taken into consideration. With this study, not only the current situation analysis was made by showing milk production curves according to years and months, but also the efficiency of cluster analysis and Friedman test were tried to be shown in group comparisons.

Conflicts of Interest Statement: All authors declare that there is no conflict of interest related to this article.

Contribution Rate Statement Summary of Researchers: Alper Güven: planning and design of the study, article writing, editing, literature review, Murat Çimen: Obtaining data, analyzing of data.

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