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EDITORIAL DECLERATION

Dear authors and readers,

First of all, we would like to thank you for being our travel companion by writing, evaluating, and reading us about this broadcasting life we started six years ago. With these thoughts, we are especially thankful for researchers and academicians honoring with the articles, valuable scientists involved in editorial boards, and reviewers for their contributions to the evaluation processes through their opinions/ideas/contributions/criticisms. With this article, we wanted to inform you, our valuable stakeholders, about the development of The Black Sea Journal of Agriculture (BSJ Agri). The statistics of the BSJ Agri for the last five years are given below. Hope you will be with us in future issues.

Year	Articles	Cites	Cite Index*	CNA	CNC	CCI
2018	23	6	0.26	23	6	0.26
2019	36	19	0.53	59	25	0.42
2020	49	40	0.82	108	65	0.6
2021	23	79	3.43	131	144	1.1
2022	72	111	1.54	203	255	1.26

CNA= cumulative number of articles, CNC= cumulative number of cite, CCI= cumulative cite index

*According to Scholar Google

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Average review time (days): 54

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Volume 6, Issue 1 (2023)

Table of Contents

Research Articles

Review Articles

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Research Article
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VERMICOMPOST ENHANCES SALINE TOLERANCE IN PEANUT (*Arachis hypogaea* L.)

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Abstract: Peanut is an oilseed legume plant with multi-purpose uses that contains many bioactive components, including polyphenols, phenolics, and flavonoids. It is one of the main foodstuffs, both in meeting protein deficiencies and in meeting high energy needs. This study investigated the effects of vermicompost fertilizer application on chlorophyll content and yield parameters of peanuts grown under saline stress in climate room conditions. Root weight, root length, stem weight, stem length, leaf weight, leaf number, and chlorophyll content values were determined in the first developmental period of the plant in the experiment, which was established with three replications according to the randomized plots experimental design. As a result of the study, statistical differences were determined between control and vermicompost treatments under high saline stress conditions (300 mM). The results obtained from the vermicompost treatment, especially in stem and root weights, prove this treatment's usefulness. The principal component analysis (PCA) clustered all parameters according to applications. Correlation analysis revealed significant relationships, especially for vermicompost treatment. It is thought that the information obtained from the experimental results will be helpful to entrepreneurs investigating the saline stress resistance of peanuts.

Keywords: Abiotic stress, Salt, Chlorophyll, Physiological characteristics, *Arachis hypogaea*

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1. Introduction

The rapid increase in the world population causes insufficient food in terms of calories and other nutritional values (Ali et al., 2020). Food safety cannot be ensured, and the yield values of the plants decrease with the changing climatic conditions worldwide (Yılmaz et al., 2022). If economically sustainable agriculture is to be provided and farmers are to be given a chance to survive on the farm, agricultural management and production paradigms should be changed, while modern agrarian practices should be implemented (Yılmaz et al., 2021a).

Oilseed crops rich in primary and secondary metabolites (minerals, vitamins, carbohydrates, protein, fat, antioxidants, and phenolics) constitute an essential raw material source for animal and human nutrition and the industrial sector (Yılmaz et al., 2021a). They are also economically, socially, and environmentally significant as they provide food, feed, and raw materials (Can et al., 2021). These crops can adapt to different agricultural conditions of the world, from temperate to tropical regions (Yılmaz et al. 2021b). Approximately 8% of the world's oilseed needs are met by peanut agriculture (Yılmaz et al., 2021c). Peanut (*Arachis hypogaea* L.) is an oil-producing legume plant grown in subtropical and semi-arid tropical regions of the world, especially between 40° north and 40° south locations (Yılmaz and Çiftçi, 2021). Peanuts are among the world's leading oilseed crops, with an annual production of forty-five million tons, cultivated on 26 million hectares of land in approximately 120 countries (Singh et al., 2021). Peanuts are a source of antioxidants, vitamins, minerals, and health-improving bioactive compounds such as arginine, tocopherol, resveratrol, etc., and hence are touted as a functional food (Variath and Janila, 2017). Peanut seeds contain an excellent rate of protein (16-36%), oil (35-54%), and carbohydrates (10-20%). They also contain high levels of Ca, Mg, P, vitamin E, folic acid, niacin, riboflavin, amino acids, and resveratrol (Singh et al., 2021). In this respect, it is highly important for human nutrition.

Abiotic stress factors are significant physiological events that negatively affect crop productivity (Yılmaz et al., 2022). Numerous studies have been conducted to reduce the harmful effects of abiotic stress factors on plants (Yavaş et al., 2020). Soil salinity can reduce plants' growth rate (Doğru and Canavar, 2020). Saline stress is one of the most important abiotic factors limiting agricultural productivity worldwide. Saline stress also reduces photosynthetic capacity because of causes the part affinity and stomata osmotic pressure. Plants can also suffer from general nutrient uptake and metabolic disorders due to saline stress (Yılmaz and Kulaz, 2019).

Maintaining and developing a quality soil structure is one of the most important goals for sustainable agriculture

(Ayhan and Kulaz, 2016). Vermicompost fertilizers contain worm secretions, mycorrhizal fungi, asymbiotic, symbiotic microorganisms, and actinomycetes. The production and use of vermicompost have become a new trend today (Sönmez and Gülser, 2021). It has been reported that vermicompost treatments positively affect product quantity and quality in many field crops such as corn (Durukan et al., 2020), potato (Yourtchi et al., 2013), and chickpea (Uçar et al., 2020). This situation manifests itself in the form of significant increases in yield criteria as a reflection of the enhancements in the chemical and physical characteristics of the soils with vermicompost treatments (Sönmez and Gülser, 2021). Thanks to these benefits, it has also been seen in some studies that the plant provides tolerance against saline stress (Liu et al., 2019; Ding et al., 2021; Beyk-Khormizi et al., 2022). The primary purpose of this study is to prove that vermicompost fertilizers are an alternative factor in preventing saline stress in the peanut.

2. Materials and Methods

This research was carried out at Bolu Abant İzzet Baysal University, Faculty of Agriculture, Department of Field Crops. Seeds were sowed in pots and grown under controlled climate room conditions. Plants were harvested after a 3-week growing period. The study was set up in a randomized plot design with three replications.

2.1. Plant Material

The seeds of the EFSANE registered peanut variety were supplied from the Progen seed company.

2.2. Saline Application

Peanuts were gradually exposed to saline stress for five days with 150 mM and 300 mM NaCl after a 2-week growing period (Yılmaz and Çiftçi, 2021).

2.3. Vermicompost Treatment

Niksolfarm brand liquid vermicompost, supplied from Dost Organic Tarım (Bolu, Türkiye) (Table 1), was diluted 50% and applied twice, one week before and two days after saline application in the form of a spray to leaves and stems.

2.4. Physical Analyses

2.4.1. Stem length

The distance from the soil level to the top leaf extension of the plants was measured as stem length in cm.

2.4.2. Root length

After the plant was removed from the soil, the part of the root zone up to a point on the soil surface was cut. The root zone was measured in cm from this point to the lowest root extension.

2.4.3. Stem weight

The part of the plant above the ground was considered the stem region and was weighed on a precision scale and calculated in g/plant.

2.4.4. Root weight

The part of the plant under the ground was considered as the root zone and was weighed on a precision scale and calculated in g/plant.

2.4.5. Number of leaves

All leaves of plants were counted as pieces/plant calculated.

2.4.6. Leaf weight

The weights of the counted leaves were weighed on a precision scale and calculated in g/plant.

2.5. Chlorophyll Content

Chlorophyll content measurements were made from the middle leaves of the plant with the 'spad' unit using the 'Apogee MC 100 Chlorophyll Concentration Meter' device.

2.6. Statistical Analysis

Statistical analyzes of the findings were made with the R studio program. The student's t-test ($\alpha = 0.05$) was used to determine the difference between applications.

3. Results and Discussion

There were statistical differences in terms of all parameters between saline doses in the study. Statistical differences were in all parameters except leaf number and chlorophyll in vermicompost treatment. Additionally, only chlorophyll content, leaf, and stem weights were statistically different in vermicompost saline interaction (Table 2).

Table 1. Chemical and physical ingredients of Niksolfarm vermicompost fertilizer

Property	Unit	Value	Property	Unit	Value
Organic matter	%	6.88	Organic nitrogen	%	0.84
Total phosphorus pentaoxide	%	0.85	Organic carbon	%	5.29
pH		5.20	Nickel (Ni)	mg/kg	0.03
Water soluble potassium oxide	%	0.17	Cadmium (Cd)	mg/kg	0.15
Total nitrogen	%	0.93	Zinc (Zn)	mg/kg	0.18
Carbon/nitrogen determination	%	5.69	Lead (Pb)	mg/kg	0.21
Total humic+Fulvic acid	%	7.58	Quicksilver (Hg)	mg/kg	<0.01
Electrical conductivity (EC)	ds/m	2.52	Chromium (Cr)	mg/kg	0.19
Total free amino acid	(%)	1.00	Tinnen (Sn)	mg/kg	<0.01
Alginic acid	%	0.20	Copper (Cu)	mg/kg	0.05

Table 2. Statistical difference reflections of vermicompost treatment and saline doses to parameters

Trait	$F_{vermicompost}$	F_{saline}	$F_{vermicompost \times saline}$
Leaf area index	60.47****	276.03****	2.05ns
Leaf number	0.44ns	50.78****	2.11ns
Leaf weight	29.31***	488.99****	91.18****
Root length	60.06****	21.76****	1.18ns
Root weight	16.78**	16.45***	0.26ns
Stem length	7.95*	69.62****	1.04ns
Stem weight	5.13*	240.77****	5.16*
Chlorophyll content	4.26 ns	59.17****	13.15***

3.1. Physical Analyses

The images and numerical data of the physical analysis findings obtained in the study are given in Figure 1 and Table 2. According to the results, the highest mean value in stem length was obtained from vermicompost/0 mM with 19.4 cm, and the lowest mean value was obtained from 300 mM/NaCl with 10.1. For each salt dose, there was no statistically significant difference in stem length between the vermicompost and control groups. However, it was observed that stem length numerically increased with vermicompost treatment under high saline stress conditions. The highest mean value in stem weight was obtained from control/0 mM NaCl with 5.9 g/plant, and the lowest mean value was obtained from control/300 mM NaCl with 2.4 g/plant (Figure 1). A statistical difference was between the 300 mM saline doses of only vermicompost and control groups regarding stem weights. Therefore, it can be said that even though stem weight dropped in response to increasing saline stress, vermicompost treatment significantly affected stem weight compared to the control.

The highest mean value in root length was obtained from vermicompost/0 mM NaCl with 32.7 cm, and the lowest mean value was obtained from control/300 mM NaCl with 23.5 cm. There was a statistically significant difference in root lengths for each saline dose of vermicompost and control groups. With this result, it should be stated that root length increased thanks significantly to vermicompost treatment under saline stress conditions. Root weight values were obtained between 3.3 g/plant and 4.4 g/plant (Figure 1). There was a statistical difference between the 300 mM saline doses of only vermicompost and control groups regarding root weights. Therefore, it can be said that root weight increases significantly with vermicompost treatment under high saline stress conditions.

The application with the highest mean in leaf weight values was control/0 mM NaCl (3.7 g/plant), and the application with the lowest mean was control 300 mM NaCl (1.4 g/plant). In leaf weight, the saline-stress-free application of the control group was statistically superior to the saline-stress-free application of the vermicompost group. It may be explained by the fact that the plants may not be able to respond to vermicompost in terms of yield as soon as possible due to the short vegetation period.

On the other hand, as expected from the application, it was observed that the resistance to saline stress, which is the study's primary aim, gave statistically logical results at the highest saline doses. In this respect, it should be said that vermicompost treatment increased leaf number significantly under high saline stress conditions. The highest mean value in the leaf number obtained from the application of vermicompost/0 mM NaCl with 9.7 pieces/plant, and the lowest mean value was obtained from the application of control/300 mM NaCl with 5.0 pieces/plant (Figure 1). No statistically significant difference was detected in all dose comparisons. However, despite there being no statistical difference, it was observed that the leaf number was relatively higher in vermicompost treatment under 300 high saline stress conditions compared to the control. The highest mean value for leaf area index was obtained from vermicompost/0 mM NaCl with 7.84 cm^2, and the lowest mean value was obtained from control/300 mM NaCl with 3.92 cm^2. There was a statistical difference in the leaf area index for each saline dose of the vermicompost and control groups. With this result, it should be noted that the leaf area index increased thanks significantly to vermicompost treatment under saline stress conditions.

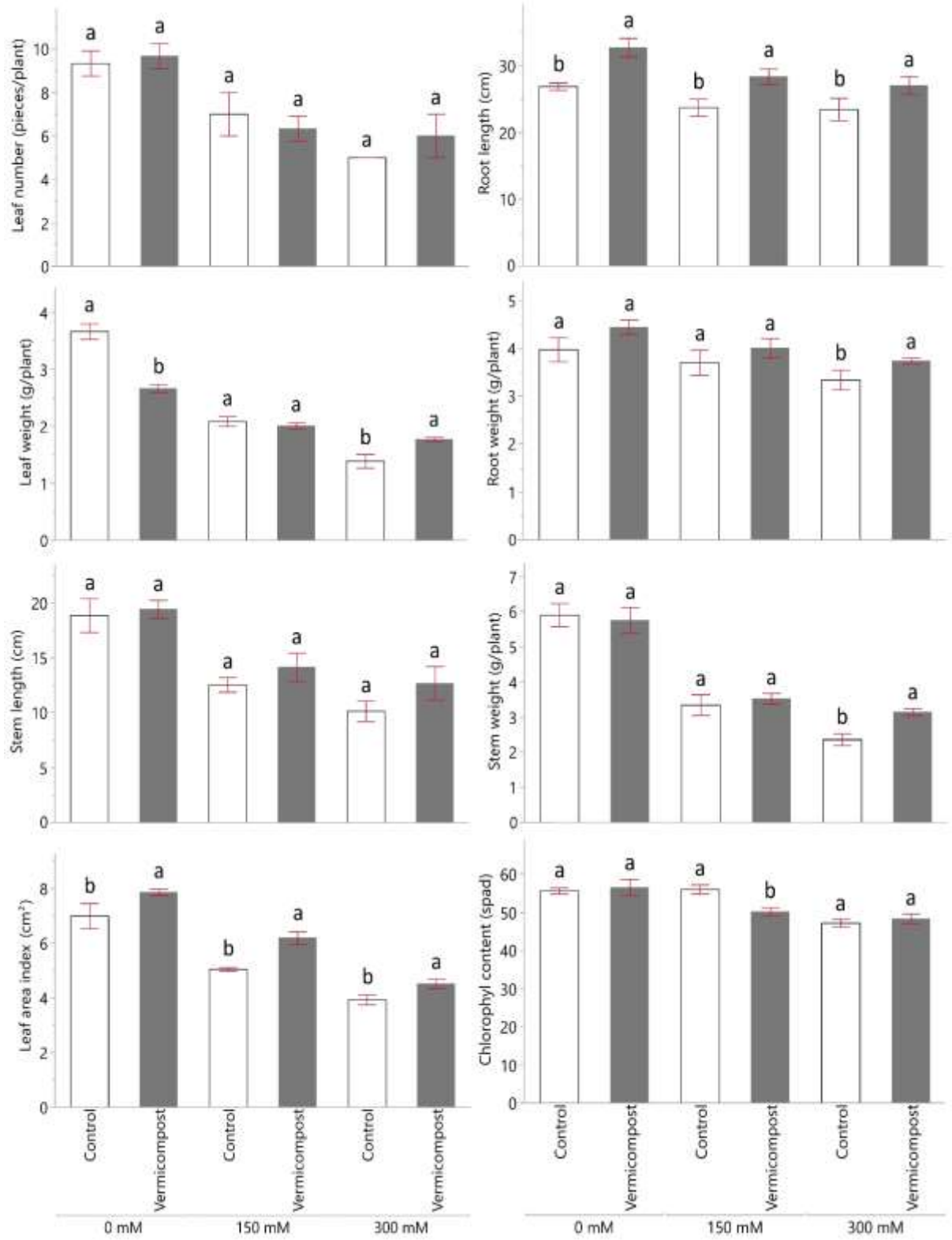

Figure 1. Statistical differences between the treatment groups of the saline doses.

It has been proven that vermicompost has a positive effect on the physiological parameters of some field crops under saline stress (Liu et al., 2019; Ding et al., 2021; Beyk-Khormizi et al., 2022). In this study, results were obtained in parallel with the literature as physiological parameters. This research observed that vermicompost application against saline stress resulted in substantial variations in physical development parameters. Especially in a recurrence of the control group exposed to high dose (300 Mm) saline stress, the yellowing and inward curling of the leaves indicates that worse results will occur in terms of peanut yield values in the later vegetation periods (Figure 2). For this reason, it is thought that vermicompost treatment can be a good alternative for yield values against saline stress that prevents the development of peanuts.

Figure 2. Peanuts grown in the study (K0: Control/0 mM NaCl K1: Control/150 mM NaCl K2: Control/300 mM NaCl V0: Vermicompost/0 mM NaCl V1: Vermicompost/150 mM NaCl V2: Vermicompost/300 mM NaCl).

3.2. Chlorophyll Content

The highest average value in chlorophyll amount was obtained from vermicompost/0 mM NaCl application with 56.4 spads, and the lowest average value was obtained from control/300 mM NaCl application with 47.2 spads. There was no statistically significant difference in stem lengths obtained from the 300 mM doses of the gruel and the control group. However, it is seen that vermicompost treatment at this dose has numerical superiority compared to the control. High chlorophyll content indicates that the plant will have more photosynthesis capacity and, therefore, higher efficiency (Kızılgeçi et al., 2017). There are many studies in which the amount of chlorophyll is in parallel with the yield values (Ghimire et al., 2015; Kandel et al., 2020; Yılmaz and Çiftçi, 2021). The values of this study are in parallel with the literature, especially for high doses.

3.3. Correlations of Parameters

Correlation analysis revealed significant associations in both control and vermicompost treatment. The highest correlation in both treatments was between leaf weight and stem weight, being r=0.99 and r=0.97 in control and vermicompost, respectively. However, the second highest correlation in vermicompost treatment was between chlorophyll content and stem weight (r=0.96), while the relationship of these traits was only r=0.66 in control as one of the weakest correlations calculated.

In general, there were higher correlations among traits in vermicompost treatment compared to the control. Interestingly, although all properties had significant positive correlations in vermicompost treatment, chlorophyll content only had a significant positive correlation with leaf features. All correlations among the studied traits are presented in Figure 3.

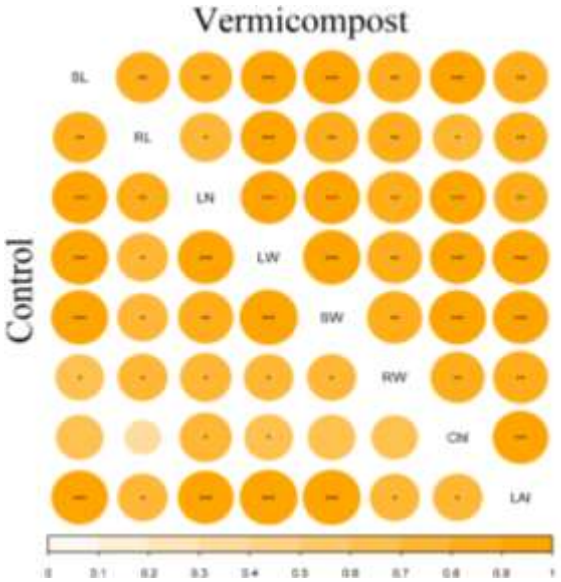

Figure 3. Correlation coefficients among parameters for both control and vermicompost treatment.

3.4. Interrelations of Parameters and Applications

Principal component analysis (PCA) revealed the relationships between parameters and applications. The first 3 PCs were important in describing the data. While eight components explained the variation in the data, the first two components explained 90.6% of total variance. PC1 and PC2 accounted for 77.9% and 12.8%, respectively (Table 3). The highest saline dose, 300 mM, was separated by diminish in all traits, as clearly seen in biplot. Vermicompost treatment was clustered into the same group with leaf area index, root length, and root weight. On the other hand, control was characterized by chlorophyll content and leaf weight. Relationships between all traits and applications are shown in Figure 4.

Table 3. Eigenvectors and variances of principal components

Traits	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8
Stem length	0.38	0.01	-0.28	0.39	0.08	0.61	-0.31	-0.38
Root length	0.29	0.66	-0.07	0.32	0.30	-0.11	0.49	0.18
Leaf number	0.38	-0.15	0.20	-0.22	0.70	-0.37	-0.28	-0.20
Leaf weight	0.34	-0.38	-0.48	-0.39	-0.04	0.03	0.58	-0.14
Stem weight	0.39	-0.13	-0.26	-0.01	-0.07	-0.01	-0.34	0.80
Root weight	0.33	0.43	0.37	-0.62	-0.26	0.33	-0.07	-0.03
Chlorophyll content	0.31	-0.44	0.66	0.34	-0.10	0.16	0.32	0.12
Leaf area index	0.38	0.09	-0.04	0.21	-0.58	-0.59	-0.16	-0.31
Variance	77.92	12.76	4.72	1.70	1.32	0.88	0.41	0.30
Cumulative variance	77.92	90.67	95.39	97.09	98.41	99.29	99.70	100.00
P-value	<.0001	<.0001	0.03	0.55	0.52	0.58	0.84	

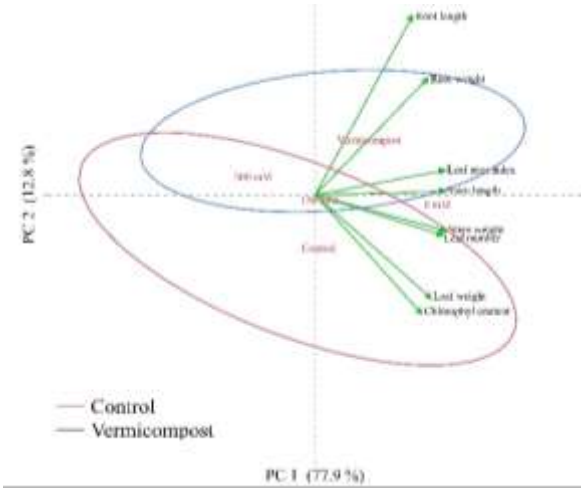

Figure 4. Distribution of parameters on the biplot according to applications.

4. Conclusion

It has been determined that applying the vermicompost gives positive results for the peanut plant grown under saline stress. In future studies, it is possible to obtain more precise results in physical analysis by increasing the application and observation time and by trying different application methods. It is thought that the study's results will be an excellent example of evaluating the resistance of peanuts to saline stress.

Conflict of Interest

The authors declared that there is no conflict of interest.

Ethical Consideration

The author confirms that the ethical policies of the journal, as noted on the journal's author guidelines page, have been adhered to. Ethics committee approval was not required for this study because of there was no study on animals or humans.

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Author Contributions

All tasks made by the single author of the manuscript and the percentage of the author contributions is present below. The author reviewed and approved final version of the manuscript.

	A.Y.
C	100
D	100
S	100
DCP	100
DAI	100
L	100
W	100
CR	100
SR	100
PM	100
FA	100

C=Concept, D= design, S= supervision, DCP= data collection and/or processing, DAI= data analysis and/or interpretation, L= literature search, W= writing, CR= critical review, SR= submission and revision, PM= project management, FA= funding acquisition.

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INVESTIGATION OF VEGETABLE PRODUCTION AMOUNT AND THE SIZE OF CULTIVATION AREAS IN KAHRAMANMARAŞ WITH THE ECONOMETRIC MODEL

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Abstract: This study aims to determine the relationship between the size of the agricultural land planted between 2016 and 2020 and its average yield in Afşin, Andırın, Dulkadiroğlu, Ekinözü, Elbistan, Göksun, Nurhak, Onikişubat, Pazarcık, Türkoğlu and Çağlayancerit districts of Kahramanmaraş province. For this, according to the data obtained from TUIK, 5 products selected in grain, which are thought to be produced more widely in the region, are respectively; Wheat, corn, barley, chickpea and sugar beet, while the others are probably 5 products selected in fruit, respectively; Apple, cherries, strawberries, mulberries and walnuts and the other 5 selected vegetables, which are thought to be produced more than others, are respectively; pepper, cucumber, acrid, tomato and garlic. According to the estimation results obtained in the research, it has been determined that there is a harmony relationship between the size of agricultural land and the amount of yield in selected crops in Kahramanmaraş districts between 2016 and 2020, and as a result of the vector autoregressive model (VAR) analysis, the most appropriate delay size is the 10th delay.

Keywords: Land, Cereals, Fruit and vegetables

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1. Introduction

Soil, which is one of the sine qua non of life like air and water, is a natural entity that cannot be reproduced, produced and has definite lines. The soil, forests and pastures are the growing area, an important nutrient store in plants, as well as the main material of certain industries and an area for residential and industrial settlements. For this reason, soil is an indispensable production element for agricultural sectors, as well as an equally important element in non-agricultural areas (Topçu, 2012).

Land is known in legal language as a part of the earth whose boundaries are determined by legal and geometric methods; it cannot be destroyed, transferred, and cannot be reduced or reproduced. It is a source of wealth due to the raw materials and ores it contains, as the establishments determine the places of establishment, obtain economic values and create the main space of human living spaces and activities (Yomralıoğlu and Çete, 2005; Tanrıvermiş, 2016). Agricultural lands, on the other hand, are known as the most effective economic resource in rural areas as crop and animal production is carried out on them, and land capital is among the most important elements of farm capital, which is seen as the basic element of income (Bayramoğlu, 2014). For people residing in rural areas, agricultural lands can be seen as collateral value, social reputation and security in extraordinary situations (Awasti, 2014).The structure of the land, the amount of soil fertility, the climatic conditions of the region and the frequency of natural disasters such as erosion and flooding can have an impact on income and yield (Karakayacı, 2005). Agricultural lands; Various studies have been conducted on its size, yield, and average productivity per 1 hectare area (Zeren et al., 1995; Akıncı et al., 1997; Özden et al., 2005; Yılmaz et al., 2006; Keleş, 2015; Özkan et al., 2019). According to these studies, the aim of this study is to determine the relationship between the size of the agricultural land planted between 2016 and 2020 and its average yields in Afşin, Andırın, Dulkadiroğlu, Ekinözü, Elbistan, Göksun, Nurhak, Onikişubat, Pazarcık, Türkoğlu and Çağlayancerit districts of Kahramanmaraş province and the specified years.

The aim of this study is to determine the two most cultivated areas in cereals, fruits and vegetables, which are thought to have more cultivation areas than the others in the districts, respectively.

2. Materials and Methods

2.1. Materials

The data of this research are based on the databases of the agricultural land size and average yields planted between 2016 and 2020 in the Afşin, Andırın, Dulkadiroğlu, Ekinözü, Elbistan, Göksun, Nurhak, Onikisubat, Pazarcık, Türkoğlu and Çağlayancerit districts of Kahramanmaraş province) was obtained from. According to the data obtained, 5 products selected in grain, which are thought to be produced more widely in the region, are respectively; Wheat, corn, barley, chickpea and sugar beet, while the others are probably 5 products selected in fruit, respectively; Apple, cherries, strawberries, mulberries and walnuts and the other 5 selected vegetables, which are thought to be produced more than others, are respectively; pepper, cucumber, tomato and garlic, and the econometric program was used to determine the relationship between the size of the cultivated land and the amount of yield in the districts by years.

2.2. Methods

2.2.1. Vector autoregressive model (VAR)

Tested values must be stationary series so that the relationships between values can be of good quality. For this, the stationarity test of the values can be determined with Dickey Fuller (DF) analysis (Tarı, 2012). The Dickey Fuller (DF) test is given in the following Equation 1:

$$\Delta\gamma_t = \mu + \beta_t + \delta\gamma_{t-1} + \varepsilon_t \quad (1)$$

Here Δ_{Y_t} time series tested for stationarity μ and β_t the coefficients determining t and ε t in testing a structural trend in the analyzed time series represents the random error term. With the Dickey Fuller (DF) test $H_0: \delta = 0$ (there is a unit root) hypothesis is analyzed, H_0 If the hypothesis is not accepted, it means that there is no unit root in the test of stationarity in the series and that the series is stationary. The most important detail in the Dickey Fuller (DF) analysis phase is to determine the number of delays suitable for the series. Akaike information criterion (AIC) or Schwarz information criterion (SIC) can be used to determine the appropriate number of delays. The model that gives the smallest AIC or SIC value can be determined as the most appropriate model (Fuller, 1996).

In econometric studies, it is inevitable to use the simultaneous equation system in case the links between the link sizes are multilateral and complex. One of the methods developed as a solution method of simultaneous equations is Vector Autoregressive Models (VAR). Vector autoregressive model (VAR) (Equation 2):

$$y_t = A_1 y_{t-1} + \cdots + A_p y_{t-1} + B_{x_t} + \varepsilon_t \quad (2)$$

is shown as (Johansen, 1995).

Vector autoregressive models (VAR) are used for time series as they do not impede the systematic model and do not need to distinguish between extrinsic and intrinsic values. In addition, vector autoregressive models (VAR) models have lagged values of dependent values, making it possible to make better and stronger predictions for the future. Since the coefficients calculated with the vector autoregressive models (VAR) model are quite complex and difficult to interpret, variance decomposition and impulse-response analysis methods are mostly used (Gacener, 2005). While variance decomposition tries to explain how many % of the change in the variance of each of the analyzed values has its own delay and what percentage of the other values are excluded, impulse-response analysis tries to explain what happens when the other value or values cause a one-unit effect on any of the values. Tries to explain how much he is affected (Tari, 2012).

In this study, it was determined that the 10th lag length was the most appropriate in the analysis applied in the vector autoregressive model (VAR) to the data that became stationary after taking the first differences.

3. Results and Discussion

According to the results of the research, it has been determined that there is a 0.99 correlation between the size of agricultural land and the amount of yield in selected crops in Kahramanmaraş districts between 2016 and 2020, and as a result of the vector autoregressive model (VAR) analysis, the most appropriate delay size is the 10th delay. In addition, according to the data obtained, the 5 products selected in the cereals that are thought to be produced more widely in the region are respectively; Wheat, corn, barley, chickpea and sugar beet, while the others are probably 5 products selected in fruit, respectively; Apple, cherries, strawberries, mulberries and walnuts and the other 5 selected vegetables, which are thought to be produced more than others, are respectively; pepper, cucumber, acrid, tomato and garlic. 61.50% wheat and 21.94% barley in fruit; 50.47% walnut and 45.23% apple and vegetable; It was determined that 51.39% tomatoes and 34.86% garlic. The first two crops planted in Andırın, respectively, by years: in grain; 80.56% wheat and 13.56% corn in fruit; 50.3% cherry and 46.09% walnut, also in vegetables; it was determined that 44% tomato and 35.89% cucumber. The first two crops planted in Dulkadiroğlu, respectively, are: in grain; 68.01% wheat and 22.01% corn, in fruit; 61.34% walnut and 22.24% cherry, also in vegetables; it was determined that 35.17% tomato and 24.07% cucumber. The first two crops planted in Ekinözü, respectively, by years: in grain; 54.69% wheat and 38.52% barley in fruit; 64.86% apple and 29.59% walnut, also in vegetables; it was determined that 74.06% tomatoes and 13.88% peppers. The two most planted crops in Elbistan, respectively, by year: in grain; 57.93% wheat and 20.90% barley in fruit; 76.54% apple and 18% walnut, also in vegetables; 38.40% pepper and 26.34% tomato were determined. The two most planted crops in Göksun by year, respectively: in grain; 71.90% wheat and 19.39% barley in fruit; 87.81% apple and 6.76% walnut, also in vegetables; it was determined that 72.05% tomato

and 11.29% garlic. The two most planted crops in Nurhak, respectively, by year: in grain; 77.95% wheat and 16.48% barley in fruit; 51.51% apple and 43.15% walnut, also in vegetables; It was determined that there were 34.01% tomato and 30.07% pepper. The first two crops planted the most in order by year in February, are in grain; 76.33% wheat and 12.55% corn in fruit; 69.06% walnut and 20.01% apple, also in vegetables; 49.05% tomato and 20.37% cucumber were determined. The two most planted crops in Pazarcık, respectively, by year: in grain; 56% wheat and 22.27% corn in fruit; 67.84% walnut and 20.63% apple, also in vegetables; It is stated that there are 34.10% garlic and 32.06% pepper. The first two crops planted in Türkoğlu, respectively, by years: in grain; 63.66% wheat and 31.84% corn in fruit; 58.38% walnut and 16.89% strawberry, also in vegetables; it was determined that 43.94% cucumber and 28.56% tomato. The first two crops planted the most in Çağlayancerit, respectively, by year: in grain; 56.34% wheat and 30.42% barley in fruit; 76.52% walnut and 20.68% apple, also in vegetables; Average productivity of 69.05% tomatoes and 22.08% peppers on a total cultivated land of 1 decare for selected years is 0.6909 in Afşin, 0.4397 in Andırın, 0.6732 in Dulkadiroğlu, 0.4057 in Ekinözü, 0.6371 in Elbistan, 0.5208 in Göksun, and Nurhak. It was determined that it was 0.3068 tons in Türkiye, 0.5542 tons in Onikisubat, 0.5891 tons in Pazarcık, 0.6827 tons in Türkoğlu and 0.6046 tons in Çağlayancerit.

As a result of the data obtained from the Turkish Statistical Institute (TUIK), keeping the time interval determined to obtain better results and choosing the products that are thought to have more cultivation areas in the region, compared to the products that are likely to have cultivation areas everywhere in the country, especially in grain. More local products should be preferred and more diversified. In order to avoid these and similar disruptions in future articles or thesis research, the specified period should be kept wider and regions or regions dealing with agriculture should be preferred. In order to apply the vector autoregressive model (VAR) method in this research, firstly, the series were tested for stationarity. Table 1 and Table 2 showed the stationarity result after taking the first difference of the series. Since the probability value in Table 1 is less than 0.05, the series is stationary.

Table 1. The result of the stability analysis after taking the first differences of the size of the cultivated land in the districts according to the years.

Augmented Dickey-Fuller fullness test statistics	
%1 Level	-3.588509
%5 Level	-2.929734
%10 Level	-2.603064
t	-10.94162
Probability	0.0000

Table 2. The result of the stability analysis after taking the first differences of the productivity of the cultivated land in the districts by years.

Augmented Dickey-Fuller fullness test statistics	
%1 Level	-3.587504
%5 Level	-2.928731
%10 Level	-2.601067
t	-19.39069
Probability	0.0001

Since the probability value in Table 2 is less than 0.05, the series is stationary. In Figure 1, it was determined that the data set is stationary since all the points are inside the circle.

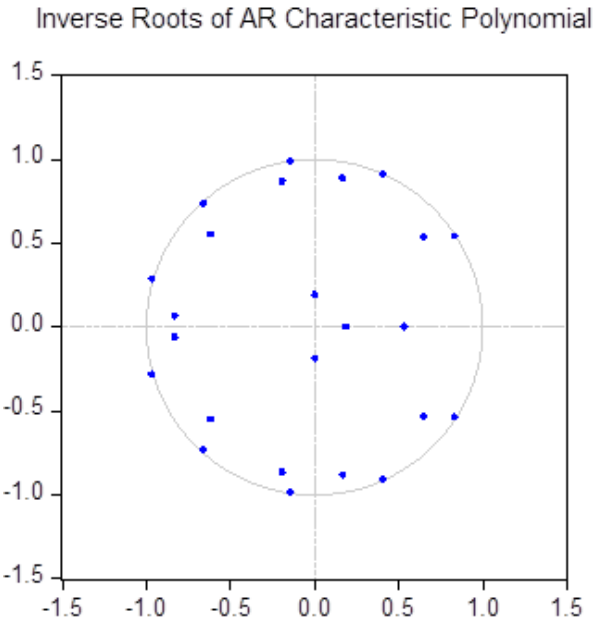

Figure 1. Vector autoregressive model (VAR) stationarity analysis result.

In order to determine the most appropriate lag length from the vector autoregressive model (VAR) analysis during the back of the stationarity test, the most appropriate lag length result is given in Table 3.

In Table 3, the 10th lag length, where '*' is the most and Akaike information criterion (AIK) is the smallest, has been determined as the most appropriate lag length in the data set. Table 4 and the vector autoregressive model (VAR) analysis result is given in Table 5.

In Table 6, it has been determined that a 1% change in the total area planted in the districts by years in R2 affects the yield amount by 0.993146 and a 1% change in the amount of yield over the years in R^2 affects the total area planted in the districts by 0.991494. The corrected R^2 in Table 6, on the other hand, restores R^2 back with a probability of 0.987187 due to the increase in R^2 if an independent variable that is not relevant is added to the equation in the total area planted by years, while it does not relate to the subject in the amount of yield according to years.

Table 3. The result of the Vector Autoregressive Model (VAR) analysis to determine the most appropriate lag length

Latency length	Logarithmic value	LR test statistic	Final prediction error	Akaike knowledge criteria	Schwarz information criterion	Hannan-Quinn knowledge criterion
0	-1139.819	NA	1.19e+20	51.90084	51.98194	51.93092
1	-1123.025	31.29635	6.65e+19	51.31934	51.56263	51.40956
2	-1111.463	20.49610	4.72e+19	50.97561	51.38111	51.12599
3	-1098.554	21.71106	3.16e+19	50.57065	51.13834	50.78117
4	-1093.477	8.077437	3.03e+19	50.52168	51.25158	50.79236
5	-1089.426	6.076502	3.05e+19	50.51936	51.41146	50.85019
6	-1073.483	22.46492	1.80e+19	49.97650	51.03080	50.36749
7	-1067.493	7.896351	1.68e+19	49.88603	51.10253	50.33717
8	-1064.980	3.083952	1.85e+19	49.95363	51.33232	50.46492
9	-1062.854	2.415306	2.09e+19	50.03884	51.57973	50.61028
10	-993.4590	72.54976*	1.12e+18*	47.06632*	48.76941*	47.69791*

* indicates the delay order selected by the criterion.

Table 4. Vector autoregressive model (VAR) analysis result

	Area cultivated in districts by years	Yield amount in districts by years
Total Sown Area (1)	-0.915492	-0.025792
	(0.14629)	(0.10838)
	[-6.25818]	[-0.23799]
Total Sown Area (2)	-0.802975	-0.019253
	(0.19468)	(0.14423)
	[-4.12464]	[-0.13349]
Total Sown Area (3)	-0.799230	-0.076459
	(0.23771)	(0.17611)
	[-3.36216]	[-0.43416]
Total Sown Area (4)	-0.279988	-0.023169
	(0.26183)	(0.19398)
	[-1.06934]	[-0.11944]
Total Sown Area (5)	-0.403859	-0.058272
	(0.26777)	(0.19837)
	[-1.50824]	[-0.29375]
Total Sown Area (6)	-0.531717	-0.112912
	(0.27162)	(0.20123)
	[-1.95759]	[-0.56112]
Total Sown Area (7)	-0.515238	-0.030996
	(0.25937)	(0.19215)
	[-1.98647]	[-0.16131]
Total Sown Area (8)	-0.650249	-0.145196
	(0.22628)	(0.16764)
	[-2.87364]	[-0.86613]
Total Sown Area (9)	-0.387310	-0.025223
	(0.16967)	(0.12570)
	[-2.28268]	[-0.20066]
Total Sown Area (10)	-0.286068	-0.072832
	(0.07597)	(0.05628)
	[-3.76549]	[-1.29404]

Table 5. Vector autoregressive model (VAR) analysis result

	Area cultivated in districts by years	Yield amount in districts by years
Yield Amount (1)	-0.134470	-1.033691
	(0.24536)	(0.18177)
	[-0.54805]	[-5.68668]
Yield Amount (2)	-0.264639	-1.031715
	(0.34338)	(0.25439)
	[-0.77068]	[-4.05558]
Yield Amount (3)	-0.294383	-1.022776
	(0.41631)	(0.30842)
	[-0.70713]	[-3.31620]
Yield Amount (4)	-1.146508	-1.072790
	(0.47110)	(0.34901)
	[-2.43369]	[-3.07382]
Yield Amount (5)	-0.978519	-0.957798
	(0.47041)	(0.34850)
	[-2.08013]	[-2.74834]
Yield Amount (6)	-0.831246	-0.887965
	(0.45938)	(0.34033)
	[-1.80951]	[-2.60917]
Yield Amount (7)	-0.836485	-0.921764
	(0.43109)	(0.31937)
	[-1.94040]	[-2.88621]
Yield Amount (8)	-0.571741	-0.750121
	(0.36760)	(0.27233)
	[-1.55534]	[-2.75444]
Yield Amount (9)	-0.978320	-0.894654
	(0.28430)	(0.21062)
	[-3.44118]	[-4.24773]
Yield Amount (10)	-1.131674	-0.819523
	(0.13112)	(0.09714)
	[-8.63108]	[-8.43684]

It has been determined that if an independent variable is added to the equation, it will restore R^2 with a probability of 0.984097 due to the increase in R^2. In Table 6, it was determined that the data set was significant since the F statistic was 166.6437 in the area sown in the districts by years, the F statistic was 134.0484 in the amount of yield in the districts according to the years, and the F statistic at the 0.05 confidence level was much higher than the F table value. In order to help analyze the goodness of fit and model complexity of the model by making a relative estimation in Table 6, the Akaike Information Criterion and the total area planted in the districts by years were determined as 23.88000 and the yield amount in the districts by years was determined as 23.28006.

In addition, the average yield per decare planted in the districts by years is given in Table 7.

Table 6. R^2, $\overline{R}^2$, F and Akaike information criterion (AIK) results in vector autoregressive model (VAR) analysis

	By years planted in districts area	Yield amount in districts by years
R^2	0.993146	0.991494
$\overline{R}^2$	0.987187	0.984097
F	166.6437	134.0484
AIK	23.88000	23.28006

AIK= akaike information criteria.

The average percentage size of the total cultivated area in cereals in the districts according to the years determined in Table 8 (the grain area determined during the year / the total cereal area in the year), the average percentage size of the total planted area in fruits in the districts according to the years determined in the Table 9 fruit area determined during the year / total fruit area in the year) and the average percentage size of the total planted area for vegetables in the districts (vegetable area determined during the year / total vegetable area in the year) according to the years determined in Table 10.

Table 7. Average yield amount in 1 decare area in districts by years (ton/decare)

Districts	Average yield amount in 1 decare area in districts by years (ton/decare)				
	2016	2017	2018	2019	2020
Afşin	0.7560	0.7569	0.7813	0.4788	0.6819
Andırın	0.4355	0.4536	0.4329	0.4551	0.4216
Dulkadiroğlu	0.6128	0.7280	0.6247	0.6650	0.7359
Ekinözü	0.4618	0.5090	0.3353	0.4051	0.3177
Elbistan	0.6909	0.6574	0.6717	0.5705	0.5954
Göksun	0.5216	0.5057	0.5369	0.4984	0.5415
Nurhak	0.2832	0.3422	0.3331	0.3208	0.2548
Onikişubat	0.4952	0.5335	0.5577	0.6218	0.5630
Pazarcık	0.6720	0.5442	0.5979	0.4910	0.6406
Türkoğlu	0.4788	0.5859	0.6397	0.7430	0.9665
Çağlayancerit	0.3305	0.7630	0.7137	0.6709	0.5449

Table 8. Average percentage size of total cultivated area in cereals in districts by determined years (determined cereal area in the year / total cereal area in the year)

Districts	Average percentage size of sown areas					Average size of sown areas
	Wheat	Maize	Barley	Chickpeas	Sugar Beet	
Afşin	%61.50	%5.74	%21.94	%5.38	%5.44	426790 decare
Andırın	%80.56	%13.56	%5.65	%0.23	%0.00	110519 decare
Dulkadiroğlu	%68.01	%22.01	%4.64	%4.05	%1.29	128869 decare
Ekinözü	%54.69	%0.43	%38.52	%3.99	%2.37	32287 decare
Elbistan	%57.93	%11.59	%20.90	%4.07	%5.51	590336 decare
Göksun	%71.90	%0.43	%19.39	%6.65	%1.63	256308 decare
Nurhak	%77.95	%0.35	%16.48	%5.22	%0.00	17504 decare
Onikişubat	%76.33	%12.55	%5.74	%5.38	%0.00	137997 decare
Pazarcık	%56.00	%22.27	%16.83	%4.49	%0.41	207831 decare
Türkoğlu	%63.66	%31.84	%3.29	%0.66	%0.55	136202 decare
Çağlayancerit	%56.34	%0.48	%30.42	%12.74	%0.00	16313 decare

Table 9. Average percentage size of total cultivated area in fruits in districts according to determined years (determined fruit area in the year / total fruit area in the year)

Districts	Average percentage size of sown areas					Average size of sown areas
	Apple	Cherry	Strawberry	Berry	Walnut	
Afşin	%45.23	%2.89	%1.16	%0.25	%50.47	9098 decare
Andırın	%3.39	%50.3	%0.22	%0	%46.09	14284 decare
Dulkadiroğlu	%15.69	%22.24	%0.73	%0	%61.34	8812 decare
Ekinözü	%64.86	%5.55	%0	%0	%29.59	7617 decare
Elbistan	%76.54	%5.46	%0	%0	%18	6743 decare
Göksun	%87.81	%3.46	%1.97	%0	%6.76	35455 decare
Nurhak	%51.51	%3.77	%1.57	%0	%43.15	1575 decare
Onikişubat	%20.01	%4.78	%6.15	%0	%69.06	15953 decare
Pazarcık	%20.63	%11.53	%0	%0	%67.84	4509 decare
Türkoğlu	%14.46	%10.27	%16.89	%0	%58.38	3766 decare
Çağlayancerit	%20.68	%2.8	%0	%0	%76.52	20345 decare

Table 10. Average percentage size of total cultivated area for vegetables in districts according to determined years (determined vegetable area in the year / total vegetable area in the year)

Districts	Average percentage size of sown areas					Average size of sown areas
	Pepper	Cucumber	Acrid	Tomato	Garlic	
Afşin	%7.77	%5.23	%0.75	%51.39	%34.86	14220 decare
Andırın	%20.11	%35.89	%0	%44	%0	980 decare
Dulkadiroğlu	%20.07	%24.07	%9.05	%35.17	%11.64	8454 decare
Ekinözü	%13.88	%12.06	%0	%74.06	%0	345 decare
Elbistan	%38.40	%23.90	%0	%26.34	% 11.36	9200 decare
Göksun	%9.01	%7.65	%0	% 72.05	%11.29	3882 decare
Nurhak	%30.07	%12.34	%3.18	%34.01	%20.40	314 decare
Onikişubat	%17.26	%20.37	%2.85	%49.05	%10.47	10404 decare
Pazarcık	%32.06	%1.68	%1.45	% 30.71	%34.10	10810 decare
Türkoğlu	%6.09	%43.94	%18.03	%28.56	%3.38	5890 decare
Çağlayancerit	%22.08	%0	%0	%69.05	%8.87	282 decare

Various studies have been conducted on the size, yield, and average yield per 1 hectare area, and in these studies, it has been determined that there is 43% effective work and efficiency in the study on plant production enterprises and productivity in Aydın district of İzmir (Özden et al., 2005). As a result of a study conducted in Isparta province, it was determined that while grain cultivation areas decreased between 1991 and 2003, productivity increased, vegetable and fruit areas and production increased (Yılmaz et al., 2006). As a result of a study conducted in Çumra district of Konya province, the average farm size is 105.33 decares and grain production is 50.21%. It has been determined that the first rank in production is wheat with 34.46%, the second rank is corn with 23.05% and the third rank is barley with 15.75% (Keleş, 2015). As a result of a study conducted in Isparta province, it was determined that the total area allocated for field agriculture in Türkiye is 15.8 million hectares and it is used as 70% in cereals, 14% in industrial plants, 11% in forage plants and 5% in pulses. In addition, it has been determined that the most cereal production is wheat, barley and corn, chickpeas and lentils in legumes, sunflower and olive in oil plant, sugar beet in sugar plant (Baydar H, 2017). As a result of a study conducted in Çarşamba district of Samsun province, the total land of the plain is 777,560 decares and 76% of these lands are used for agriculture, and Çarşamba district covers 15.67% of this area. In addition, it has been determined that 50.4% of it is used as orchard area, 21.4% is used as vegetable area and 22.2% is used as field crops in Çarşamba district (Samsun Investment Support Office, 2018). As a result of a study conducted in the province of Ankara, it was observed that the producers' plant production activities included fruit growing, field crops and vegetable growing, respectively, and they acted carefully and meticulously in the relevant field (Vijdan, 2020).

4. Conclusion

In this study, in order to determine the relationship between the size of agricultural lands planted between 2016 and 2020 in all districts of Kahramanmaraş province and the average yield, with the data obtained from TUIK, 5 selected products in cereals, which are thought to be more widely produced in the region, respectively; wheat, corn, barley, chickpea and sugar beet, respectively, 5 selected fruit products; apple, cherry, strawberry, mulberry and walnut and 5 selected vegetables respectively; pepper, cucumber, acrid, tomato and garlic, and firstly, the stationarity test of the series was performed in order to apply the vector autoregressive model (VAR) method. The stationarity result is given after taking the first differences of the series.

Author Contributions

The percentage of the author(s) contributions is present below. All authors reviewed and approved final version of the manuscript.

	İ.G.	M.Ş
C	50	50
D	50	50
S	50	50
DCP	50	50
DAI	50	50
L	50	50
W	50	50
CR	50	50
SR	50	50
PM	50	50
FA	50	50

C=Concept, D= design, S= supervision, DCP= data collection and/or processing, DAI= data analysis and/or interpretation, L= literature search, W= writing, CR= critical review, SR= submission and revision, PM= project management, FA= funding acquisition.

Conflict of Interest

The authors declared that there is no conflict of interest.

Ethical Consideration

Ethics committee approval was not required for this study because of there was no study on animals or humans.

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EFFECT OF NATIVE BEAUVERIA BASSIANA VUILLEMIN ISOLATES ON EGG HATCHING OF TETRANYCHUS URTICAE KOCH (ACARI: TETRANYCHIDAE)

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Abstract: In this study, the effect of culture filtrates prepared at different doses of native *Beauveria bassiana* isolates (BIM-001, BY2, and IGÇ) on egg hatching of *Tetranychus urticae* Koch was determined. The adult females of *T. urticae* were transferred to bean leaves (4 cm) prepared according to the leaf disc method, as 10 individuals. After 24 hours, 20 eggs/leaf disc were prepared in each petri dish. Pure culture filtrates (1X) and other diluted doses (5X, 10X) were applied to leaf discs containing eggs for 10 seconds by spraying method. Observations were started 24 hours after the application and continued until the 7th day. Experiments were carried out with 5 replications for each dose of entomopathogen fungus isolates. The egg hatching of *T. urticae* was 19% at the pure culture filtrate dose of *B. bassiana* BIM-001 isolate (1X) 7 days after the application, and it was different and significant than the other isolates ($P < 0.05$). Egg hatching rates of *T. urticae* for BIM-001, BY2, and IGÇ isolates were determined between 19-38%, 32-48%, and 36-53%, respectively. These rates were found to be 31-38%, 43-48%, and 46-53% at 5X and 10X doses of BIM-001, BY2, and IGÇ isolates. There was no significant difference in egg hatching rates of pure culture filtrates of *B. bassiana* BY2 and IGÇ isolates ($P>0.05$).

Keywords: Culture filtrate, Entomopathogenic fungus, Two-spotted spider mite

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1. Introduction

The two-spotted spider mite, *Tetranychus urticae* Koch (Acari: Tetranychidae) is an important agricultural pest with a wide host range, including more than 1,400 plant species in different geographic regions (Afrotropic, Australasian, Nearctic, Neotropical, Eastern, and Palearctic) (Migeon et al., 2010; Vacante, 2016; Ghongade and Sood, 2021). *Tetranychus urticae* feeds on the sensitive, green parts of plants and causes a decrease in nutrients, stunting of plants, and insufficient chlorophyll in the leaves due to physiological changes (Budai, 2002). This pest reduces the chlorophyll content (55.26%) and the carotenoid content (79.3%) of the leaves (Hildebrand et al., 1986; Bosnyákné et al., 2017). In case of intense contamination, it is known that it reduces the area of photosynthesis activity and causes leaf fall (Gorman et al., 2002). There are many approaches including host plant resistance, cultural measures, biological and chemical control for the management of *T. urticae* in agricultural production areas (Sabelis and Van de Baan, 1983; Costello and Daane, 1998; James and Price, 2004; Van Leeuwen et al., 2015; Azadi Dana et al., 2018). The control of this pest is widely based on the use of acaricides and insecticides. It becomes more difficult to control due to its high reproductive potential, very short life cycle and archenotocous parthenogenesis, and development of resistance to insecticides and acaricides (Luczynski et al., 1990, Nauen et al., 2000; Van Pottelberge et al., 2009, Van Leeuwen et al., 2010). *Tetranychus urticae* is one of the pests with the highest incidence of pesticide resistance among all arthropods (van Leeuwen et al., 2010). It is known that very intensive use of pesticides leads to outbreaks of *T. urticae* (Fraulo et al., 2008). In this context, biological control is becoming one of the most economical and environmentally friendly control methods for farmers (Cock et al., 2010). In biological control, the application of entomopathogenic fungi is increasing radically due to greater environmental awareness, food safety concerns, and the failure of conventional chemicals with an increasing number of insecticide-resistant species (Rai et al., 2014). Entomopathogenic fungi are known to regulate insect and mite populations in nature with epizootics and cause lethal infections (Burges, 1981; McCoy et al., 1988; Shahid et al., 2012). Although there are an estimated 750 entomopathogenic fungal species in about 90 genera, most commercially produced fungi are species belonging to *Beauveria*, *Lecanicillium*, *Isaria* (Cordycipitaceae), and *Metarhizium* (Clavicipitaceae) that are taking place Hypocreales, which are relatively easy to mass produce (Roberts and Humber, 1981; Rai et al., 2014). In previous studies, the effects of different spore suspensions of

different isolates of *B. bassiana* on different developmental stages of *T. urticae* were generally investigated (Chandler et al., 2005; Örtücü and Albayrak İskender, 2017; Yanar et al., 2018; Yücel, 2021). Spore suspensions as well as culture filtrates of entomopathogenic fungi are known to have various effects on pests as insecticides or feeding deterrents (Kim et al., 2013). The culture filtrates may contain enzymes such as protease, chitinase, and lipase, which are important in the infection process with conidia (Yoon et al., 2013). From this point of view, the use of culture filtrates of entomopathogenic fungi in the control of harmful species has been also a matter of interest. The high reproductive potential and laying a large number of eggs of *T. urticae*, one of the harmful species that cause significant economic losses, make control more difficult. It was aimed to determine the effect of culture filtrates of three different isolates of *B. bassiana*, isolated from different provinces and hosts, on egg hatching of *T. urticae* in the current study.

2. Materials and Methods

Egg stages of *Tetranychus urticae* populations, and three different doses (1X, 5X, 10X) of culture filtrate of BY2 (Burdur, Yeşilova) and BIM-001 (Isparta, Center), IGÇ (Isparta, Center) isolates of *B. bassiana* were used. *Beauveria bassiana* BY2 was isolated from an individual belonging to Phlaeothripidae species collected from the wheat production area in Yeşilova, Burdur. BIM-001 isolate was isolated from potato beetle collected from potato production areas and also IGÇ isolate, on the other hand, was isolated from soil samples obtained outside the agricultural area in Isparta Center using *Tenebrio molitor* (Linnaeus, 1758) (Coleoptera: Tenebrionidae).

2.1. Plant Production

Phaseolus vulgaris L. (Fabaceae) plants were grown under climatic chamber conditions (25±2 °C temperature, 65±5% humidity, 16: 8 photoperiod). Bean seeds were sown in plastic pots with a diameter of 15 cm using a previously sterilized soil mixture (soil + organic matter).

2.2. Obtaining of *Tetranychus urticae* Eggs

In studies carried out to obtain eggs, individuals of *T. urticae* populations, which have been reared since 2018 at Isparta University of Applied Sciences, Faculty of Agriculture, Department of Plant Protection were used. Adults were reared on common bean plants in climate rooms at 25±1 °C and 65±10% humidity. Then, these adults were taken to leaf discs (4 cm) to lay eggs for 24 hours.

2.3. Preparation of Culture Filtrates of Entomopathogenic Fungus Isolates

Three different isolates of *B. bassiana* included in the study were cultured on potato dextrose agar (PDA) plates for 14 days at 25 °C. One agar disc (1 cm) from each isolate, which was incubated for two weeks, was inoculated into 50 mL potato dextrose water (PDB) in 150 mL Erlenmeyer flasks and shaken at 25±1 °C and 200 rpm for 10 days. Then, the culture liquid of each isolate was passed through Whatman filter paper to remove the spores from the medium, and culture filtrates were obtained (Kim et al., 2013).

2.4. Method

The prepared bean leaf discs (4 cm) were placed on sterile water-saturated cotton and kept in plastic Petri dishes (9 cm). Then, 10 adult females were gently transferred to the leaf discs with a soft-tipped brush and allowed to lay eggs. Eggs were counted under a stereomicroscope 24 hours after the adult females were released and the number of eggs was adjusted to 20 eggs/leaf disc. Pure culture filtrate concentration (1X) and diluted concentrations (5X, 10X) of 3 different isolates of *B. bassiana* (BY2, BIM-001, and GÇ8) were prepared (Liu et al., 2008). The culture filtrate dose of each entomopathogenic fungus isolate was applied on the leaf discs with eggs for 10 seconds with the help of a modified apparatus that provides spraying at 4 atm pressure. After spraying, the petri dishes were transferred to the incubator under 25±2 °C, 65%±5% humidity, and 16:8 photoperiod conditions. Observations were started 24 hours after the application and continued until the 7th day. Experiments were carried out in plastic Petri dishes with 5 replications for each dose of entomopathogenic fungus isolate.

All percentage egg hatching values obtained from the study were calculated using the Abbott's formula [Corrected % = (1-n in T after treatment / n in Co after treatment) *100], (n= mitet population, T= treated, Co= control) (Abbott, 1925). Then, one-way analysis of variance (One-Way ANOVA) Tukey multiple comparison test was performed on these data using the SPSS® 20.0 package program ($P<0.05$). In addition, the Paired Samples Test t-test was applied for paired comparisons in determining the time effect (Genç and Soysal, 2018).

3. Results

In experiments where pure culture filtrate dose (1X) was applied to BIM-001 isolate of *B. bassiana*, it was determined that only 19% of *T. urticae* eggs hatched 7 days after the application and 81% of the eggs in the experiment were not hatched. It was determined that the pure culture filtrate dose of BIM-001 isolate (1X) inhibited egg hatching significantly and was higher than other BIM-001 doses and culture filtrate doses of other *B. bassiana* isolates ($P < 0.05$). Egg hatching rates were 31% and 32% at the 5X dose of BIM-001 and 1X doses of BY2, respectively, and it was found that it inhibited egg hatching by 68-69%, higher than the other remaining doses ($P > 0.05$). In the study, the highest percentage of egg hatching occurred at the 10X dose of IGÇ with 53% (Table 1).

The effect of time after application on the hatching of *T. urticae* eggs to which all culture filtrate doses of different isolates of *B. bassiana* were applied was evaluated.

Table 1. The egg hatching rates of *Tetranychus urticae* Koch in which different culture filtrate doses of different isolates of *Beauveria bassiana* Vuillemin

Treatments	Doses	Egg hatching rates ± S. E. (%)
Beauveria bassiana BIM-001	1X	19 ± 2.00 [a]
	5X	31 ± 1.87 [ab]
	10X	38 ± 2.54 [bc]
Beauveria bassiana BY2	1X	32 ± 3.31 [ab]
	5X	43 ± 3.74 [bcd]
	10X	48 ± 3.67 [cd]
Beauveria bassiana IGÇ	1X	36 ± 2.54 [bc]
	5X	46 ± 2.00 [cd]
	10X	53 ± 3.67 [d]

[a,b]The difference between the values shown with separate letters in the same column was found to be statistically significant (P<0.05).

It was determined that there was no significant difference between egg hatching on the 3rd and 5th observation days (t= 0.972, P= 0.125), but there was a significant difference between the 3rd and 7th observation days in terms of egg hatching (t= 10.717, P= 0.125). 0.013). Again, a significant difference was found between the egg hatching rates detected on the 5th and 7th observation days of the study (t= 13.537, P= 0.001).

4. Discussion

It is estimated that there are about 1000 species of entomopathogenic fungi known worldwide (Shang et al., 2015). More than 100 mycoinsecticides are commercially available worldwide and are used as biocontrol agents (Jaronski, 2010). They represent the majority of the current biopesticide market worldwide (Muñiz-Paredes et al., 2017; Bugti et al., 2018). Previous studies have noted the efficiency of some entomopathogenic fungi against *T. urticae*, such as *B. bassiana*, *Lecanicillium* (*Verticillium*) *lecanii*, and *M. anisoplia* (Chandler et al., 2005; Saranya et al., 2013; Bugeme et al., 2014; Zhang et al., 2014; Örtücü and Albayrak İskender, 2017; Elhakim et al., 2020). Sáenz-de-Cabezón Irigaray et al. (2003) reported that *B. bassiana* can be used as a mycoinsecticide on the adult and egg stages of *T. urticae*, which has a wide host range. In addition, studies were carried out to determine the lethal effect or egg hatching of spore suspensions of *B. bassiana* on *T. urticae* eggs. Negash et al. (2014) found that 82% and 65% mortality occurred in *T. urticae* eggs, respectively, seven days after applying $1x10^8$ conidia/ml suspension of *B. bassiana* 9614 and 9609 isolates. In this study, it was determined that pure culture filtrates (1X) of *B. bassiana* BIM-001, BY2, and IGÇ isolates did not hatch in 81%, 68%, and 64% of *T. urticae* eggs, respectively. Bugeme et al. (2014) found the egg hatching rates of *T. urticae* to be 60.2%, 50.8%, 34.7%, 27.4%, 7 days after the application of $3x10^5$, $1x10^6$, $3x10^6$, and $1x10^7$ conidia/ml concentrations of *B. bassiana* (ICIPE279) under laboratory conditions. Hassan et al. (2017) investigated the effects of 10^6, 10^7, and 10^8 spore/ml doses of 4 different isolates (B1, B2, B3, B4) of *B. bassiana* on *T. urticae* eggs. 7 days after applying suspensions of *B. bassiana* isolates, the egg hatching rates of B1, B2, B3, and B4 isolates were 93.29, 81.67, 85.93, 80.2% for 10^6 spore/ml, 87.26, 58.75, 71.94, 36.38% for 10^7 spore/ml, 68.07, 33.9, 56.66, 25.2% for 10^8 spore/ml. In this study, egg hatching of *T. urticae* 7 days after the application varied between 19-38% in BIM-001 isolate, 32-48% in BY2 isolate, and 36-53% in IGÇ isolate. Doğan (2016) determined the mortality rates that occurred 7 days after applying the $1x10^7$ conidia/ml suspension of *B. bassiana* to *T. urticae* eggs by the spraying method, as 11.8% in Petri trials and 14.8% in pot trials. Wu et al. (2020) reported that $1x10^7$ conidia/ml suspension of *B. bassiana* GZGY-1-3 isolate caused 2.7-3.8% mortality in *T. urticae* eggs. In the mentioned studies, it was determined that different *B. bassiana* isolates caused low mortality rates in *T. urticae* eggs 7 days after the application of spore suspensions. In this study, it was found that the highest egg hatching rate was reached at the 10X dose of *B. bassiana* IGÇ isolate. In addition to these, an increase in death rates or a decrease in egg hatching occurred with the increase of spore concentrations in spore suspensions, in the other studies as well as an increase in egg hatching with the decrease of doses in this study.

5. Conclusion

Culture filtrates of entomopathogenic fungi may contain secondary metabolites or compounds with different insecticidal activities (Kim et al., 2013). The use of secondary entomopathogenic fungal metabolites as the active component of mycoinsecticides is more effective and can be more easily integrated with other pest control methods (Gustianingtyas et al., 2020). Egg hatching rate of *T. urticae*, which is one of the important pests in agricultural production areas, is 19% in the culture filtrate application of *B. bassiana* BIM-001 isolate, and it can be considered promising for determining the effects of this pest on other developmental periods. In addition, it is thought that the different effects of different entomopathogenic fungal isolates on the same species can be determined by revealing the content of the culture filtrates in detail.

Author Contributions

All tasks made by the single author of the manuscript and the percentage of the author contributions is present below. The author reviewed and approved final version of the manuscript.

	A.U.Y.
C	100
D	100
S	100
DCP	100
DAI	100
L	100
W	100
CR	100
SR	100
PM	100
FA	100

C= Concept, D= design, S= supervision, DCP= data collection and/or processing, DAI= data analysis and/or interpretation, L= literature search, W= writing, CR= critical review, SR= submission and revision, PM= project management, FA= funding acquisition.

Conflict of Interest

The author declared that there is no conflict of interest.

Ethical Consideration

Ethics committee approval was not required for this study due to the use of research materials that did not fall under the definition of experimental animals (The Scientific and Technological Research Council of Türkiye, Animal Experiments Local Ethics Committee Directive, 2018, Article 3-c).

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MODELING EGG CURVES IN PARTRIDGES

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Abstract: In this study, a modeling study was carried out on the weekly average values of henna partridge egg production. For this purpose, weekly average of henna partridge egg yields of 148 days from the herd consisting of 320 breeders were taken and cubic spline, Gompertz, Logistic, Richard, Schunute, Quadratic Spline, McNally and Gamma equations were used in the modeling. In the comparison of the goodness of fit of the equations, Determination Coefficient(R^2), Mean Square Error (MSE), Durbin-Watson (DW) and Akaike Information Criteria (AIC) values were taken into account. As a result of the study, Logistic (MSE= 12.4, R^2= 0.994, AIC= 43.56, DW= 2.09), Cubic Spline (MSE= 10.56, R^2= 0.996, AIC= 46.55, DW= 1.95) and McNally (MSE= 11.02, R^2= 0.996, AIC= 48.67, DW= 2.11) models were found to have the best results with similar results. It was concluded that the Schnute (MSE= 11.24, R^2= 0.990, AIC= 136.51, DW= 0.49), Gamma (MSE= 24.67, R^2= 0.991, AIC= 69.89, DW= 2.95) and Quadratic Spline (MSE= 10.43, R^2= 0.946, AIC= 149.34, DW= 2.97) models had the worst results.

Keywords: Partridge, Egg production, Curve modeling

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1. Introduction

Henna partridges are extremely important both in terms of economy and in terms of controlling harmful species due to the fact that they are materials for hunting tourism and the pests (mainly ticks) they consume in nature. Partridges produced in the partridge production centers of the Ministry of Agriculture and Forestry are released both to nature and to private hunting grounds. For this reason, it is extremely important to obtain quality eggs in terms of maximum and incubation yield in one season. This will be possible by establishing breeding flocks that are superior in terms of egg production.

As in laying hens, turkeys and Japanese quails, egg production in partridges is a complex cycle influenced by genotype and environmental factors. The effects of race, season, and age, hatching conditions, moult, feeding style and other environmental factors on egg production in poultry are too high to be ignored. Although these factors are different from population to population, the curve they will form will show a similar distribution. The main purpose of modeling egg yield curves is to estimate the egg yield of the flock in the early stages, and to use it for selection and creation of breeding flocks. The aim is to create a flock with maximum productivity in terms of egg production. Of course, in the selection to be made on the basis of these models, the decision-making and process will be shortened. As a result, the degree of accuracy in selection will also increase. In particular, the approach of modeling individual egg production will increase the probability of selecting individuals with high genetic capacity on a flock basis. However, it is not considered possible in this application, especially in henna partridge. Because in practice the ratio of male to female is usually 1:4 (1 male: 4 females) and it is difficult to determine the individual eggs of females kept in the same compartment. As the number of females per male increases, the fertility rate decreases (Alkan et al., 2008). On the other hand, the ratio of 1:1 is not preferred as it will cause the necessity of feeding more male individuals. For this reason, egg curves are mostly obtained and modeled over cage or flock averages.

2. Materials and Methods

2.1. Materials

In this study, 148 days (December 17-13 May) henna partridge egg yields were obtained from the Kapiçam Henna Partridge Production Center, which is affiliated to the Republic of Türkiye Ministry of Agriculture and Forestry, Kahramanmaraş Nature Conservation and National Parks Branch Office. Daily egg numbers of 320 breeders in 2021 were obtained and a modeling study was carried out on the weekly average values of egg yields corresponding to 20 weeks.

2.2. Methods

In this study, segmented Cubic Spline (two-knotted), Gompertz, Logistic, Richard, Schunute, Quadratic Spline,

McNally and Gamma models were used to model the egg production of henna partridges. The curve and model parameter estimations of egg yields were made in the SAS package program (SAS, 2011).

Equations of these models and their expansions are as follows (Equations 1-8);

Cubic Spline:

$$w_t = \beta_0 + \beta_1 t + \beta_2 t^2 + \beta_3 t^3 + \beta_4 (t-\alpha)^3 + \beta_5 (t-b)^3 \quad (1)$$

Logistic:

$$w_t = \beta_0 / (1 + \beta_1 e(-\beta_2 \quad (2)$$

Gompertz:

$$w_t = \beta_0 e(-\beta_2 e(-\beta_3 t) \quad (3)$$

Richard:

$$w_t = 1/(\beta_0 + \beta_1 e(\beta_2 t)^{(-\beta_3)} \quad (4)$$

Schunute:

$$Z_1 = \beta_4{}^{(\beta_2)} - \beta_3{}^{(\beta_2)}, Z_2 = \beta_3{}^{(\beta_2 + Z_1)},$$
$$Z_3 = (1 - e(-\beta_1 (X - X_1)/(1 - e(-\beta_1 (X_2 - X_1))^{(\frac{1}{\beta_2})} \quad (5)$$
$$w_t = Z_1 Z_3$$

Quadratic spline:

$$w_t = \beta_0 + \beta_1 t + \beta_2 t^2 \quad (6)$$

McNally:

$$w_t = \beta_0 t^{(\beta_1)} e(-\beta_2 t + \beta_3 t^{0.5} \quad (7)$$

Gamma:

$$w_t = \beta_0 t^{(\beta_1)} e(-\beta_2 t) \quad (8)$$

here w_t: t. number of eggs per week β_0, β_1, β_2, β_3, β_4 *ve* β_5 constants defined for models, a and b; in the piecewise regression, the nodal points, e: 2.7182, t: represent the week (Yavuz et al., 2019; Mazi, 2021).

Determination Coefficient, Mean Error Squares, Durbin-Watson and AIC (Akaike Information Criteria) were taken into account in the comparison of the goodness of fit of the equations used in the modeling (Narinç et al., 2014; Şengül et al., 2016; Kazancı, 2019). The average of the obtained values of egg production on a weekly basis was taken and modeling was done on the average values of 20 weeks.

3. Results

In this study, in which the egg production curves of henna partridges were modeled, it was concluded that the Logistic, Cubic Spline and McNally models were similar and gave the best values in terms of comparison criteria. It was determined that Schnute, Gamma and Quadratic Spline models had the worst results in terms of goodness of fit. In the literature, it is seen that different models are applied in the modeling of egg yield curves in layer hens, quails and henna partridges. Considering that many environmental factors affect egg production such as breed, age, temperature, humidity, feeding style, etc., although there are small changes in the standard egg yield curve in each egg production period, it is necessary to give priority to the models obtained from this and similar studies and to have more than one model in the modeling. The use of a model is extremely important in terms of breeding. On the other hand, it must be taken into account that the determined model can be interpreted as biologically meaningful.

The arithmetic mean, standard deviation, maximum and minimum values for 20-week-old egg yields are given in Table 1. As a result of the study, the Coefficient of Determination, Mean Error Squares, Durbin-Watson and AIC (Akaike Information Criteria) used in the comparison of the model fit of the equations used in the modeling of the egg production curve are given in Table 2. In Figure 1, the point distribution of egg yields of 320 breeder henna partridges at 148 days, and in Figure 2, the curves created for 20-week egg yields are given.

Table 1. Descriptive statistics of egg yield values

Week	Number of eggs			
	$\bar{X}$	S	Mak	Min
1	15.762	6.934	8	26
2	27.042	1.676	29	21
3	26.619	1.471	20	31
4	26.952	2.344	19	33
5	29.905	2.884	26	35
6	44.233	3.244	39	52
7	50.952	1.595	43	57
8	54.857	1.986	49	29
9	56.095	0.474	51	19
10	61.762	3.372	59	71
11	54.143	2.181	51	69
12	51.667	1.113	47	61
13	52.048	1.844	49	65

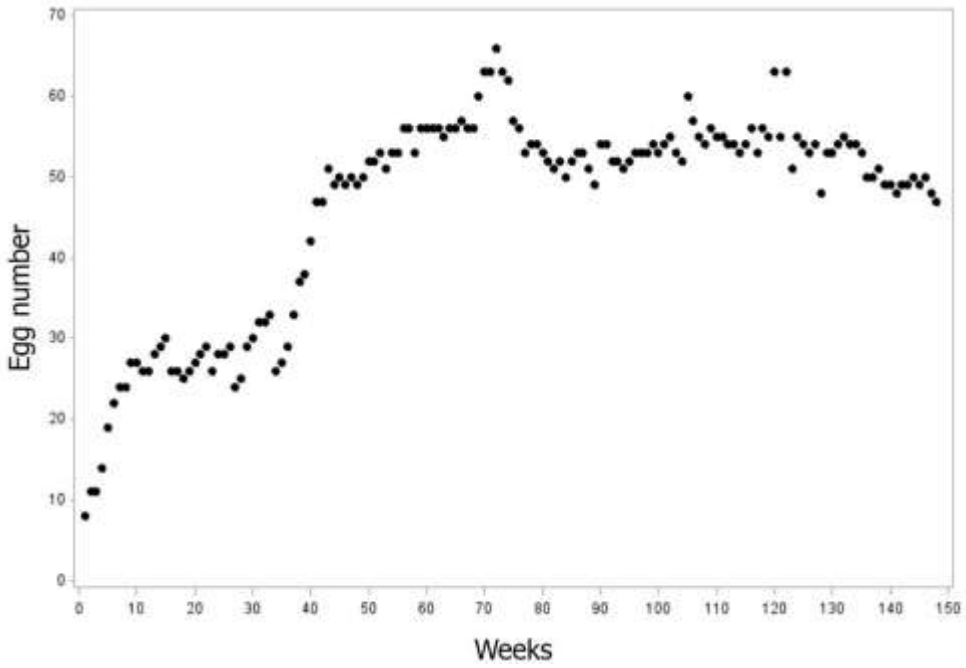

Figure 1. Point distribution of egg yields for 320 breeding henna partridges for 148 days.

Table 2. Mean Error Squares, Coefficient of Determination, Akaike Information Criteria and Durbin-Watson autocorrelation values of egg yield curves

Model	HKO	R^2	AIC	DW
Richard	16.1	0.994	89.71	2.99
Logistic	12.4	0.995	43.56	2.09
Gompertz	13.9	0.994	71.52	2.13
Schnute	11.24	0.990	136.51	0.49
Cubic Spline	10.56	0.996	46.55	1.95
Quadratic Spline	10.43	0.946	149.34	2.97
McNally	11.02	0.996	48.67	2.11
Gamma	24.67	0.991	169.89	2.95

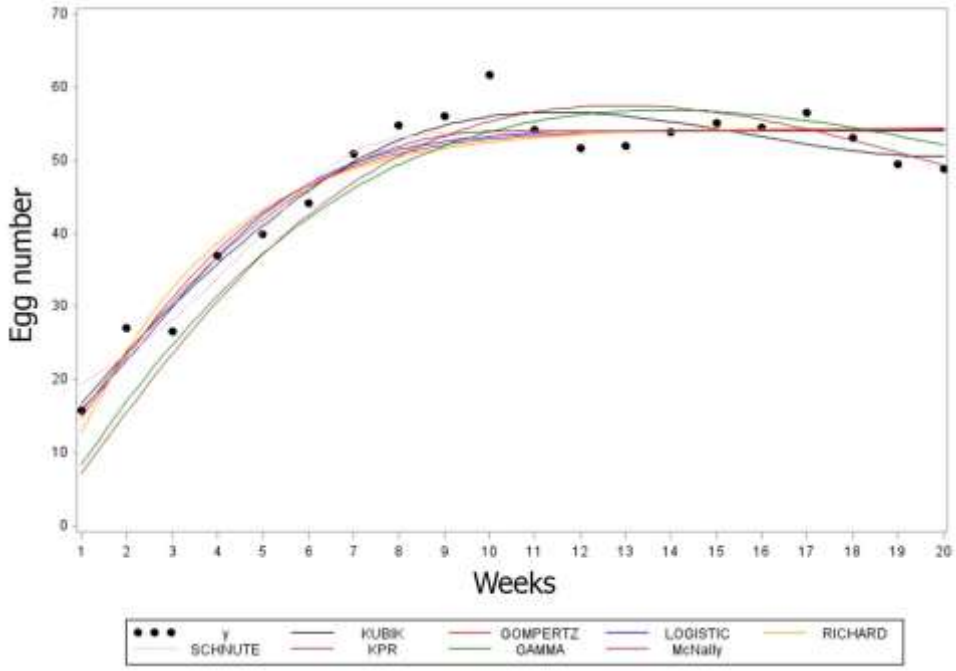

Figure 2. Curves created for 20-week egg yields.

4. Discussion and Conclusion

When the Mean Error Squares, Coefficient of Determination, Akaike Information Criteria and Durbin-Watson Autocorrelation values of the egg yield curves in Table 2 are examined, it is seen that the Logistic, Cubic Spline and McNally models give similar results. All three models have the best results compared to other models. It is seen that Schnute, Gamma and Quadratic Spline models have the worst results. It is seen that especially the AIC values of these three models are quite high compared to the other models, and the DW values are quite close to the negative or positive autocorrelation limit values. When the curves created for all models in Figure 2 are examined, it supports the findings obtained.

Şengül et al. (2016), non-linear Gamma, McNally, Modified Compartmental and Adams-Bell models were used to model egg production in henna partridges and it was concluded that McNally model is the best model to describe egg production in partridges, while AdamsBell model obtained the least descriptive model. Yalçınöz and Şahin (2020), two different Cubic Piecewise Regression (two and three node), Logistics, MMF, Gamma, McNally, Modified Compartmental and Quadratic Piecewise Regression models used in modeling egg production curves in layer hens, and the best results are from the Modified Compartmental model. They reported that Cubic Piecewise Regression (two and three nodes), Logistics, MMF and McNally models gave very close values to the Modified Compartmental model in terms of model comparison criteria.

Thuja (2021) used Cubic, Gompertz, Logistics, Gamma, Richard, Schunute, Quadratic Spline and McNeally equations to model the average egg yield curves in Japanese quails and reported that the best results in average egg yield were obtained from the Bifid Cubic Piecewise Regression model. The results obtained from this study Sengul et al. (2016), Yalçınöz and Şahin (2020), Üçkardeş and Narinç (2014) and Mazı (2021).

Author Contributions

The percentage of the author(s) contributions is present below. All authors reviewed and approved final version of the manuscript.

	T.T.	E.Y.	M.Ş.	İ.G.
C	25	25	25	25
D	25	25	25	25
S	25	25	25	25
DCP	25	25	25	25
DAI	25	25	25	25
L	25	25	25	25
W	25	25	25	25
CR	25	25	25	25
SR	25	25	25	25
PM	25	25	25	25
FA	-	-	-	-

C=Concept, D= design, S= supervision, DCP= data collection and/or processing, DAI= data analysis and/or interpretation, L= literature search, W= writing, CR= critical review, SR= submission and revision, PM= project management, FA= funding acquisition.

Conflict of Interest

The authors declared that there is no conflict of interest.

Ethical Consideration

Ethics committee approval was not required for this study because of there was no study on animals or humans. The data taken from Kapiçam Henna Partridge Production Center, which is affiliated to the Republic of Türkiye Ministry of Agriculture and Forestry, Kahramanmaraş Nature Conservation and National Parks Branch Office. There was no applied study on animals.

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Research Article
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GEOMETRIC MORPHOMETRIC INVESTIGATION OF INCUS IN HORSE (EQUUS FERUS CABALLUS) AND DONKEY (EQUUS ASINUS)

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Abstract: In this study, it was aimed to determine the shape of the incus in horse and donkey by geometric morphometric method and to evaluate the shape differences between horse's and donkey's incus. The left incus bone of 5 adult horses and 5 donkeys were used in the study. Incus were photographed at same lateral direction. Thirteen homologous landmarks were marked from the photographs using TpsUtil (Version 1.79) and TpsDig2 (Version 2.31) software. As a result of the study, the first principal component explained 38,642% of the total shape variation. In the PC1 plot, samples were clearly clustered by group. Acording to canonical varians analysis, in the wire frame warp graphic, the corpus incudis edges (right, left, and bottom) were flatter in donkeys. Angle at the LM13 level was more pronounced on the crus breve. The apex of the crus longum (Landmark 4, 5, and 6) was wider in donkey. In the study, the morphological features of horse's and donkey's incus were determined by geometric morphometric method. This study is important in that it is the first geometric morphometric study on the incus that is one of the ossicula auditus in horse and donkey. We think that the study will contribute to the anatomy of the ossicula auditus in the equide family.

Keywords: Donkey, Geometric morphometry, Horse, Incus

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1. Introduction

The ossicula auditus are located in the pars petrosa of the os temporale, dorsal to the cavum tympani. These are located between the membrana tympanica and the fenestra vestibuli as the malleus, incus, and stapes, respectively (Pazvant and Gündemir, 2021). There is also os lenticulare between the incus and stapes in young animals. This ossicle fuses with the incus in later ages to form the processus (proc.) lenticulare. The ossicula auditus magnify the vibrations from the eardrum by 20 times and transmit them to the inner ear and cause the fluctuation in the endolymph (König and Liebich 2007). At the same time, the ossicula auditus can also reduce sound pressure by separating each other through certain muscles (musculus tensor tympani and musculus stapedius) (Reece, 2012).

In the studies carried out to date, there is information about the anatomy (Özgüden, 1962; Hebel and Stromberg, 1986; Masuda et al., 1986; Huang et al, 1996; Kristensen et al., 1996; Botti et al., 2006; Solntseva, 2013) and morphometry (Kürtül et al., 2003; Mohammadpour, 2011; Demiraslan et al., 2015; Gürbüz et al., 2016; Gürbüz et al., 2019; Dalga and Aslan, 2019; Gürbüz et al., 2020) of the ossicula auditus in different animal species However, no study was found in which the shape of the ossicula auditus was determined by the geometric morphometric method. For this reason, in this study, it was aimed to reveal the morphological anatomical values of the horse's and donkey's incus belonging to the Equidae family and to evaluate the shape differences between the horse's and donkey's incus.

2. Materials and Methods

2.1. Samples

In the study, the incus that one of the left ossicula auditus of 5 adult horses and 5 donkeys, were used.

2.2. Imaging and Digitization

Incus were photographed laterally with a stereo microscope (Leica S6D) focusing on the median line. The distance between the lens and the material was determined as 10 cm. The photos were saved on the computer with the Jpg extension. From the photographs, 13 homologous landmarks were marked using TpsUtil (Version 1.79) (Rohlf, 2019) and TpsDig2 (Version 2.31) (Rohlf, 2018) software (Figure 1 and 2). Thus, the x and y Cartesian coordinates of homologous anatomical points representing the general shape of the incus from the lateral direction were determined. Before statistical analysis, confirmation test was performed for landmarks in TpsSmall (Version 1.34) (Rohlf, 2017) program. In TPS small analysis, slope and corelation values of landmarks were found as 0.998850 and 1.000000, respectively.

These values show that the landmarks are placed correctly.

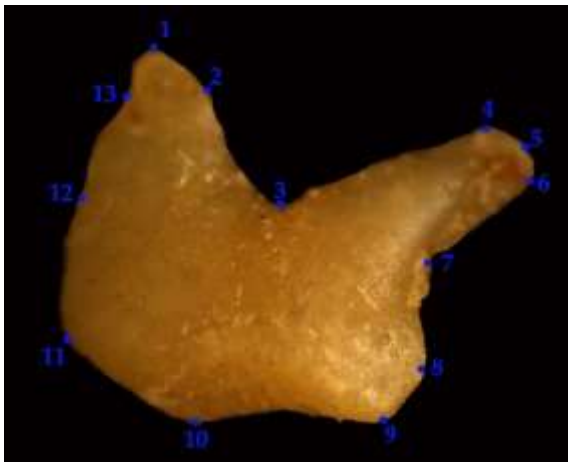

Figure 1. The Landmarks on Horse's incus.

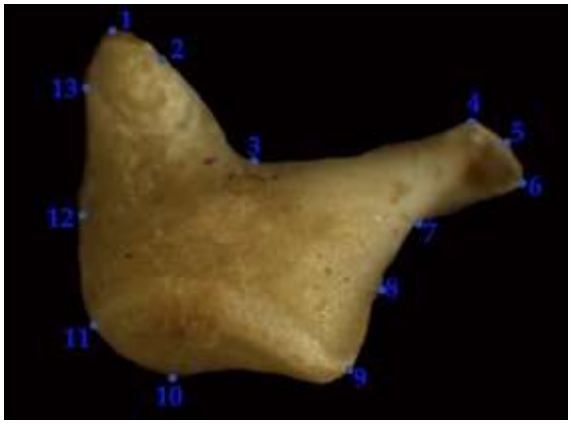

Figure 2. The landmarks on Donkey's incus.

For Figure 1 and 2; 1. The highest point of the crus breve, 2. The rightmost peak of the crus breve, 3. The angle of the crus breve with the crus longum, 4. The leftmost peak of the crus longum, 5. The midline of the crus longum of the peak point, 6. The righmost peak of the crus longum, 7. The angle of crus longum and corpus incudis, 8. The most protruding point of corpus incudis on the right edge, 9. Right corner point of corpus incudis, 10. The most protruding point of corpus incudis on ventral edge, 11. Left corner point of corpus incudis, 12. The most protruding point of corpus incudis on the left edge, 13. The rightmost peak of the crus breve.

2.3. Statistical Analysis

The differences in size, position and orientation of Incus' lateral photographs were superimposed by General Procrustes Analysis (superimposition) (Slice, 2007). PAST (Version 4.02) (Hammer et al., 2001) program was used for this analysis. With the same program, principal components analysis was performed on the new coordinates obtained as a result of the Procrustes analysis, and the components between the groups were calculated. In addition, 2-t test was applied to compare the landmark coordinate values (procrustes) according to the groups. The degree of closeness (Classical cluster) of individuals was analyzed in the PAST (version 4.02) program. Using the MorphoJ (Klingenberg, 2011) program, at which landmarks the shape differences were concentrated (PCA) and grouping characteristics (Canonical variance analysis-CVA) were analyzed.

3. Results

The results of principal component analysis performed with the landmark coordinates are shown in Table 1. Accordingly, the first principal component (PC.1) explained 38.642% of the total shape difference, and the first four principal components (PC1+PC2+PC3+PC4) explained 85.903%. Evident breakpoint among principal components was observed between PC1 and PC2. The distribution of samples according to PC1 was shown in the graph in Figure 3. Accordingly, the samples were clearly clustered according to the groups. It was observed that the donkey samples were collected on the right of the y axis, and 4 of the horse samples were collected on the left of the y axis.

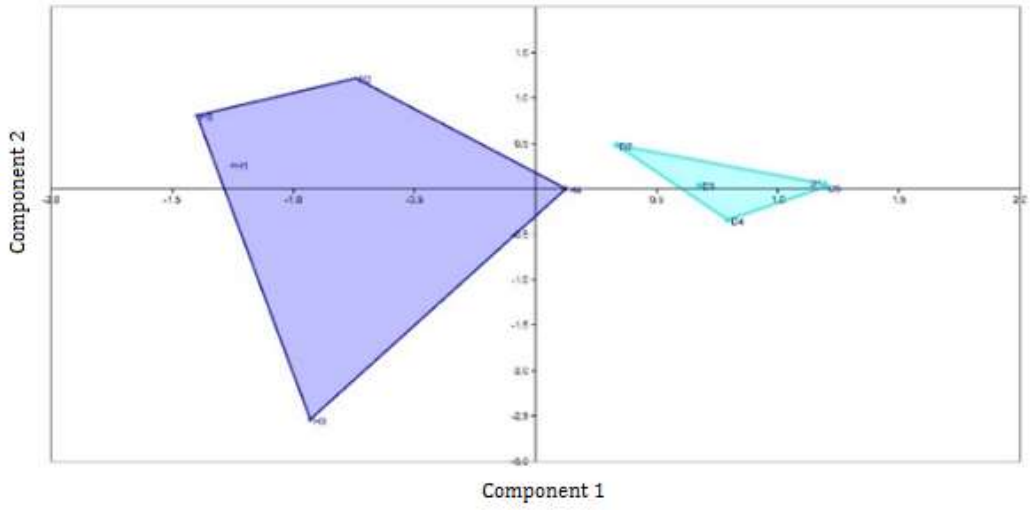

Figure 3. Distribution of samples on the graph over the first principal component (PC1), Light blue: Donkey's incus (D), Blue: Horse's incus (H).

In the study, the graph obtained as a result of the test performed to determine the proximity of the samples is given in Figure 4. Accordingly, the samples were largely grouped according to the race factor.

Table 1. Results of the principal component analysis, PC: principal component

PC	Eigenvalue	% variance
1	0.00407434	38.642
2	0.00244738	23.211
3	0.00151831	14.4
4	0.00101748	9.65
5	0.000636602	6.0377
6	0.000360864	3.4225
7	0.000296456	2.8116
8	0.00015774	1.496
9	3.46808E-05	0.32892

The graphs showing the shape differences at which landmarks (LM) according to PC1 were shown in Figure 5. Accordingly, shape differences for PC1 became evident in the landmarks except for LM1, LM2 and LM9.

Canonical variance analysis defined the between-group difference within a canonical variable (CV1). Shape variations with respect to CV1 were similar to anatomical points according to PC1. Mahalanobis and Procrustes distances values were determined as 3.2349 and 0.1098 (p: 0.0052), respectively. Shape differences and frequencies according to groups in incus' wire-frame warp graph were shown in Figure 6 and Figure 7. Accordingly, it was observed that the frequencies were homogeneously distributed between the groups.

According to canonical variance analysis, in the wire frame warp graphic, corpus incudis edges (right, left and bottom) were flatter in donkeys. Angle at the LM13 level was more pronounced on the crus breve. The apex of the crus longum (Landmark 4, 5, and 6) was wider in donkey.

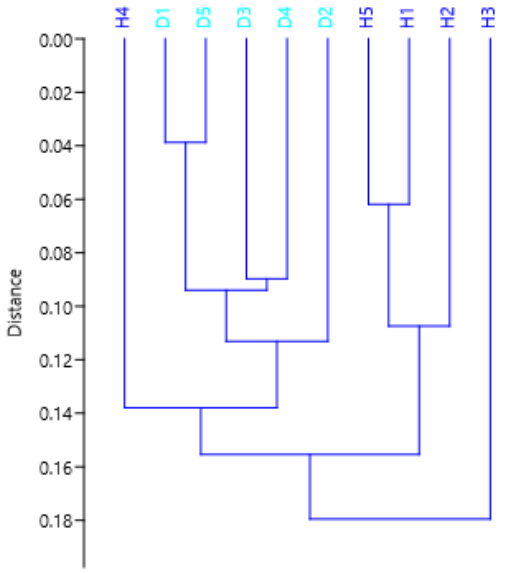

Figure 4. Graph of hierarchical proximity of individuals. Light blue: Donkey's incus (D), Blue: Horse's incus (H).

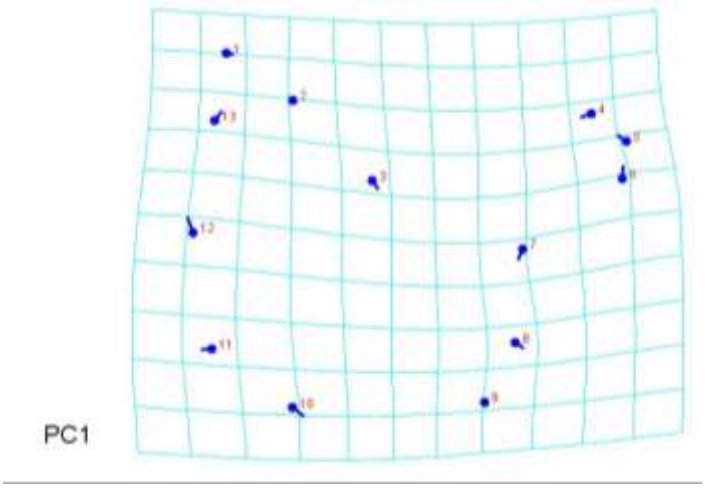

Figure 5. Landmark representation of shape differences of incus between donkey and horse for the first principal component (PC1). (Set scale factor: 0.05).

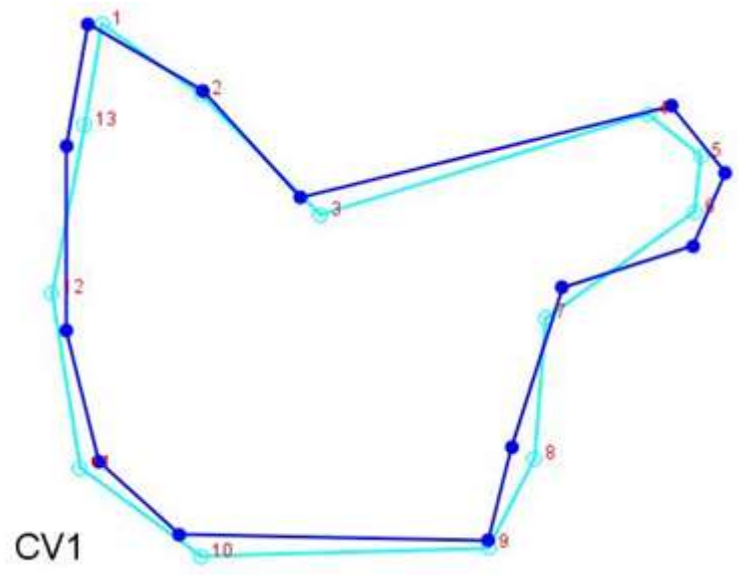

Figure 6. Canonical variance analaysis. Wire-frame warp plot (Set scale factor: 3.0). Dark blue: donkey, Light blue: Horse.

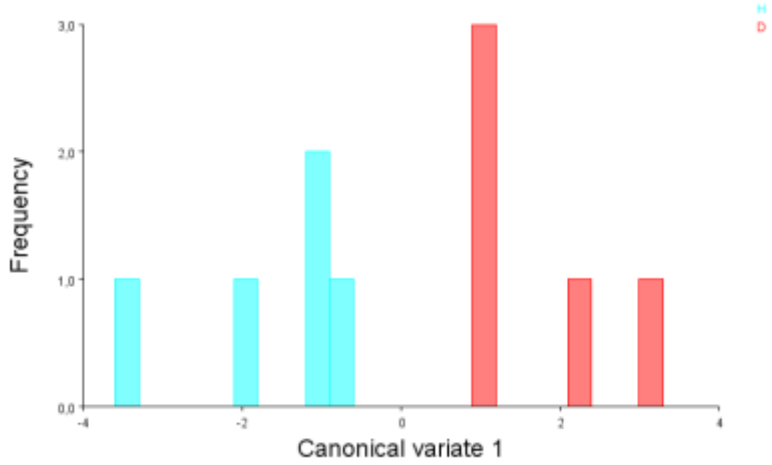

Figure 7. Grouping by Canonical Analysis of Variance. Light blue: Horse, Red: Donkey.

4. Discussion

The most important factor in the difference in bone shapes is genetic structure (Seeman, 2003). Anatomically, the bones of different members of a family subgroup are similar. However, the bone shape and size are different. Therefore, many studies have been carried out on the geometric morphometry of various bones (Gündemir et al., 2020; Gürbüz et al., 2020; Demircioğlu et al., 2021; Duro et al., 2021; Gündemir et al., 2021; Demiraslan et al., 2022; Gürbüz et al., 2022; Szara et al., 2022). In this study, it was aimed to reveal the anatomical features and differences of the incus between the donkey and horse belonging to the same family subgroup. In the study, the left incus of horse and donkey was examined by geometric morphometric method. The study contains restrictions in terms of the number of materials. However, it was determined that the incus shape of the horse and donkey were different from each other with the geometric morphometric method.

The incus hangs medial to the malleus and lateral to the stapes and connects these ossicles with synovial joints. Anatomically, the horse's and donkey's incus have a large body called the corpus incudis and two projections, the crus longum and the crus breve, which are separated from the body. The crus longum has a projection called the proccessus lenticulare, which articulates with the stapes (Demiraslan et al., 2015; Gürbüz et al., 2016). Incus length on the left side is 2.53 mm, corpus incudis width is 1.25 mm in donkeys (Demiraslan et al., 2015), and these lengths are 3.92 mm and 3.68 mm in horses (Gürbüz et al., 2016), respectively. According to the results of the previously reported morphometric study (Demiraslan et al., 2015; Gürbüz et al., 2016), the horse's incus was larger than the donkey's incus, that is, their sizes differ from each other. In the study, although the incus of the horse and donkey were similar anatomically, it was determined that there were some differences in shape by detailed geometric morphometric analysis.

Accordingly, the corpus incudis margins (right, left, and bottom) were flatter in donkeys. Angle at the LM13 level on the crus breve was more pronounced in horse. The apex of the crus longum (Landmark levels 4, 5 and 6) was wider in donkeys.

5. Conclusion

As a result, the shape differences of horse's and donkey's incus were determined by geometric morphometric method. Accordingly, in the PC1 graph, the principal component analysis, the samples were significantly clustered according to the race factor. The points of shape differences were determined by canonical variance analysis. It is important in that it is the first geometric morphometric study performed on the incus that is one of the ossicula auditus in horse and donkey. We think that this study will contribute to the morphology of the ossicula auditus.

Author Contributions

The percentage of the author(s) contributions is present below. All authors reviewed and approved final version of the manuscript.

	İ.G.	Y.D.
C	50	50
D	50	50
S	50	50
DCP	50	50
DAI	50	50
L	50	50
W	50	50
CR	50	50
SR	50	50
PM	50	50
FA	50	50

C=Concept, D= design, S= supervision, DCP= data collection and/or processing, DAI= data analysis and/or interpretation, L= literature search, W= writing, CR= critical review, SR= submission and revision, PM= project management, FA= funding acquisition.

Conflict of Interest

The authors declared that there is no conflict of interest.

Ethical Consideration

Ethics committee approval was not required for this study because of there is no live animal research. In this research, no ethical statement was needed since the experimental materials were obtained from previously dead animals (Animal experiment ethics committee regulation on working procedures and principles; Will data belonging to any living thing be used in the research? - No; Ethics committee permeation is not required).

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ANALYSES OF OPERATIONAL AND ECONOMIC CONDITIONS IN SELECTED DAIRY FARMS

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Abstract: Dairy farms are an essential component of livestock production in Türkiye. This article aims to show the current situation on these dairy farms and incredibly show the technical and operational conditions in milking technology. We researched 32 dairy farms with 6 to 681 lactating dairy cows. The milking technology on these farms corresponds to the usual structure of milking equipment on Turkish dairy farms. It includes bucket milking, pipe-line milking systems, tandem milking parlour, herringbone milking parlours and side-by-side milking parlours. To analyse the current situation, we used a calculation on the model, with evaluation criteria: the total time required for milking and the final direct specific costs. Evaluation of existing milking systems showed the possibilities of reducing human labour costs by optimizing the work activities. Larger farms characterize by more progressive milking technology, higher milk yields, and lower specific costs.

Keywords: Cost, Cow, Milking equipment, Milking process, Model, Milking parlour

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1. Introduction

Dairy farming is one of the oldest areas of animal production and is widespread throughout the world. The efficiency of milk production is greatly influenced by the capacity of the farm (Chiumenti et al., 2020; Dorottya Ivanyos et al., 2020) and specific differences in housing technologies (Dorottya Ivanyos et al., 2020; Leso et al., 2019), feeding (Silva et al., 2021) and especially milking (Chiumenti et al., 2020; Silva at al., 2021; Mangalis et al., 2019). All of this depends largely on the technological and technical development of agriculture in the country and region (Celozzi et al., 2020). The selection of an appropriate milking system depends on many factors, but gentle and quick milking and herd size are very important aspects in this farm management decision (Ózsvári and Ivanyos, 2021).

The analysis of the farmers' efficiency in the dairy production using cross-sectional data collected from 92 sample dairy farmers in the West Mediterranean Region of Türkiye is presented in (Yılmaz et al., 2020). The study used the Stochastic Frontier Analysis (SFA) to measure the efficiency farmer's technical in milk production. The technical efficiency of the sample of dairy farms ranged from 0.30 to 1.00. The most significant factors affecting the efficiency of dairy products were household size, the total number of cattle, and the ratio of the total number of dairy cows to the total number of livestock, technological level, barn type, and production of maize silage.

The comparison of dairy farms on different scales regarding milk production cost and profitability in Hatay Province, Türkiye, is the subject of research in publication (Tapki, 2019). The results show that dairy enterprises with fewer milking cows yield the lowest milk production costs, low milk yield, high feed prices and shortages of feed, insufficient regular veterinary control, and low technology adoption, especially in rural areas where the costs are even lower. Despite the low cost of milk production on small-scale farms, mainly because of their low input costs, both milk yields and the efficiency with which farm inputs are used are very limited. The production cost per litre of milk (0.305 USD) and the selling price (0.370 USD) was the highest in the fourth group.

In a study recorded by Unakıtan and Kumbar (2019), energy use efficiency and feed conversion ratios of feed costs of different size dairy cattle farms were calculated in the Thrace region. In addition, the results of the economic analysis of dairy farms were given. When the energy efficiency coefficients are examined, it is seen that

the average of the region is 0.23. Although energy efficiency is desired to be higher than 1, this coefficient is generally low in analyses of perennial plants and animal production. On the other hand, the positive reflections of the specialization and the scale of the farms on the producer's income have been revealed as a result of the economic analysis. In Türkiye, the monthly minimum wage is 285 USD. Considering this situation, a dairy farm must breed at least 22 cattle units to obtain enough income.

In other study (Aydemir et al., 2020), cost analysis and technical efficiency were performed for dairy cattle farms in Artvin province of Türkiye, milk production costs were calculated, and the factors influencing milk production were identified. Research data were gathered through the questionnaires with 118 dairy cattle farms selected through the random sampling method. Total production costs per farm were calculated as 17557.64 USD, and 57.76% of such a sum was constituted by variable costs and 42.24% by fixed costs. The average cost of 1-litre milk was calculated as 0.32 USD.

Growing consumers' awareness, high production costs and low milk price, hi-tech offer, mortgages, production diseases, high replacement rates, and issues like antibiotic resistance and environmental impact makes the modern dairy farmer constantly under target (Brombin et al., 2019).

The results of milk production on dairy farms are influenced by the health status of dairy cows and by milking technology, as well. It has a great influence on the quality of milk. Systematic collection of all necessary data and good management are of great importance for controlling the situation on farms (Cabrera et al., 2020; Leso et al., 2021). It can be used to support herd management decisions. The optimization calculation makes it possible to determine the necessary parameters of milking equipment, which is important for large farms. This is important for those farms that use rotary milking parlours with movable milking stalls (Mangalis et al., 2019), but most milking parlours are simpler at a lower cost and have immovable milking stalls.

Several Italian farms were studied (Chiumenti et al., 2020). The time for milking and the final specific direct costs are the main parameters that enable the evaluation and choice of suitable milking parlour from the dairy; neglect or promotion of only one of the mentioned criteria may lead to an uneconomic investment or impaired operation of a farm.

The issue of milking time and its effect on efficiency is studied in the article (Poulopoulou et al., 2018). Shares of the activities of milking and feeding stands for more than half of the total working time. The highest potential to increase productivity can be the adoption of certain milking systems or feeders, despite their costs, of course. However, the possible investment in machinery should be made under careful examination of the proposed capacity used. Especially in small- and medium-sized herds, investments will increase labour productivity, but not necessarily farm income if machinery is not used at its capacity.

The impact of housing, including an outdoor stay of cattle even in the cold season, has a positive impact on health (Sjostrom et al., 2019). To obtain reliable and objective results, the management of accurate data collection on farms is important (Van Os et al., 2018), which needs to be emphasized in terms of animal welfare evaluation.

Appropriate farm solutions and milking techniques are also affected by the local situation, and the human factor also plays an important role. E.g. research results according to (Pugliese et al., 2021) demonstrated that in Sicily, the semi-intensive farm is better than the intensive one to satisfy the conditions of animal welfare.

The article (Dorottya Ivanyos et al., 2020) surveys the milking technology and the relationship between the milking technology, the herd size, and the milk production parameters on the Hungarian commercial dairy farm. The large capacity brings advantages for efficiency and milk yields.

According to Silva et al. (2021), the use of precision technology is increasingly seen as an option to improve productivity, animal welfare, resource use efficiency, and workplace features on dairy farms. Analyses results presented in (Yang et al., 2021; Edwards et al., 2020) are focused on labour-saving technologies and innovations on New Zealand dairy farms. The use of automation plays an important role in reducing the working time of partial work operations during milking processes.

Despite the growing number of farms equipped with AMS (Pezzuolo et al., 2017), the most common and available milking system is the use of milking systems without robotization, especially in countries with a lower cost of human labour. However, it must be emphasized that robotization is not for everyone. Differences between AMS and conventional systems are quite challenging and complex (Filho et al., 2020). The introduction of AMS implies important changes (Bugueiro et al., 2019) in farm routine and management. It also changes culling dynamics (both modifying causes for culling and increasing the percentage of animals culled), at least during the first years after installation. The modification of culling dynamics will have a great impact on dairies.

AMS have the potential to increase dairy farm productivity and profitability; however, adoption rates, particularly in pasture-based systems, have been lower than expected (Gargiulo et al., 2020). The AMS farms had higher overhead costs such as depreciation and repairs and maintenance; however, no differences in total labour costs were observed between systems.

Risk factors for mastitis were evaluated at the cow level and the herd level in the article (Silva et al., 2021). The risk factors evaluated at the herd level were related to milking management, environment and management practices. The authors identified some risk factors; increased parity, later stage of lactation, not milking clinical and subclinical cases last, lack of routine cleaning of the milking parlour, using the dry-off treatment and

optimized feed before calving.

According to Sánchez-Duarte et al. (2020), increasing milking frequency from twice to three times per day positively affects milk production and yields of milk fat and milk protein without increasing dry matter intake. Application of three times per day milking frequency must consider dairy cow management, labour availability, and milking parlour infrastructure particular to each dairy farm.

Influence of milking technology on operating conditions from the point of view of health protection of farmworkers is also significant (Edwards and Kuhn-Sherlock, 2021) appropriate technology and automation help to reduce injuries.

The goal of the article (Lopes et al., 2021) was to assess the economic impact of some environmentally friendly technologies on the production costs and cost-effectiveness of a dairy cattle confinement system, estimating environmental costs and their representativeness in both effective and total operating costs, as well as in the total cost. The results of this research showed, among other things, that in terms of costs are also high costs of machines and tools, maintenance, improvements and energy consumption.

According to the results of cost analysis (Koç and Uzmay, 2019), it was determined that climate change will lead to a 10-50% cost increase on dairy farms by the year 2044. The heat stress is responsible for 48-71% of the increase in the cost of production, whereas 24-52% is due to an increase in feed prices. Based on the outcome of this research, it was suggested that agricultural extension activities should be carried out for farms to get adapted to climate change.

For the analysis of dairy farms in terms of milking technology, it is appropriate to use a mathematical model (Kic, 2015) developed so that it is possible to evaluate the existing situation on the dairy farm in terms of milking and use specific criteria to objectively assess the conditions in terms of labour costs, costs of technical equipment and operating costs for consumed material, energy, etc. The model can be used to model conditions under which it would be possible to improve the current situation and achieve savings, such as better use of milking equipment, modernization of technical equipment, changing operating conditions, or model changed conditions in an extended farm with a larger herd of dairy cows, with larger milk production.

This article aims to analyse the current conditions in milking equipment on farms in Türkiye. The analysis of operating and economic conditions in selected dairy farms allows us to show the strengths and weaknesses and recommend options for possible improvements.

2. Materials and Methods

The research was focused on farms in the Cukurova Region, which has very intensive agriculture, and conducted in March - July 2018. Cattle breeding is one of the developed areas of animal production. The examined farms are mainly focused on milk production (Figure 1). From the figure and the course of the intersected line, it is obvious that the percentage of dairy cows in the whole cattle herd is approximately the same for all farm sizes. It increases only slightly with the size of the herd.

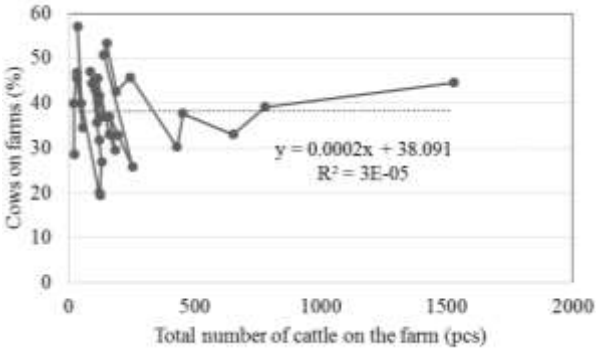

Figure 1. Percentage of dairy cows (%) depending on the number of cattle bred in the all farms.

In addition to dairy cows, other categories of cattle (calves, heifers and cattle fattening) are kept on farms, as shown in Figure 2. It can be seen from Figure 2 that larger farms can keep a larger number of other categories of cattle, but following results valid for cows presented in Figure 1, the percentage is approximately the same on all farms.

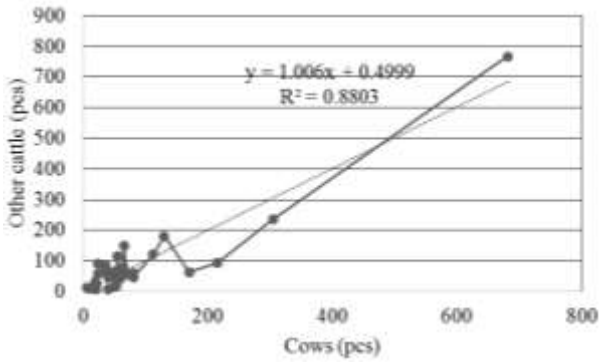

Figure 2. Number of cattle of other categories (calves, heifers, fattening cattle, breeding bulls, pcs) depending on the number of dairy cows.

Table 1 shows an overview of farms in terms of the number and size of farms (number of milked cows from 6 to 681cows) and basic data on milking equipment (type of milking equipment and number of milking units on the farm). The structure of the farms examined roughly corresponds to the usual structure of milking equipment on Turkish dairy farms.

The most common are milking parlours (MP), mainly Herringbone Milking Parlours (HBMP). There are also quite common milking parlours Side by Side (SBSMP) with parallel arrangements of milking stalls. Tandem Milking Parlours (TMP) are less common than others nowadays. Since many dairy farms still have a small herd capacity, many smaller farms still use a milking system in a cowshed, either Bucket Milking (BM) or Pipe-line

Milking Systems (PLMS). The results of measurements and calculations are divided into groups of farms according to the type of milking equipment. Farms in group A are equipped with BM, group B has PLMS, group C has TMP, farms in group D have HBMP, and farms E are equipped with SBSMP.

Table1. Analysed dairy farms and their milking equipment.

Farm Groups	Milking equipment			NF	Number of Lactating Cows		
	Type	Age (Years)	NC		Mean	Minimum	Maximum
A	BM	6 ± 2	4 ± 2	5	13	6	20
B	PLMS	7 ± 3	9 ± 1	2	30	19	40
C	TMP	13	10	1	60	60	60
D	HMP	6 ± 2	18 ± 6	17	81	20	305
E	SBSMP	8 ± 5	19 ± 9	7	161	24	681
Summary	-	-	-	32	84	6	681

NC= number of clusters, NF= number of farms

The first parameter taken into consideration is the milking time. Having a short duration of milking time enables cows to take feed and rest, to go grazing, and so on. As regards human working process and working operations, the total duration time of single milking T_{cd} includes the time of preparatory work before milking and subsequent work (cleaning after the milking, etc.) according to Equation (1).

$$T_{cd} = T_p + T_{vd} + T_c \quad (1)$$

Where;
T_{cd} – total duration time of single milking, T_p – the time of preparatory work before milking, h; T_{vd} – the duration of one milking, h; T_c – the time of subsequent work after milking, h;
When the period of T_{cd} is short enough, then there is enough time for workers (milkers) to carry out the other activities (feed preparation, cleaning, control of animals, etc.). Therefore, the time should be a criterion for optimization and selection of suitable milking parlour for the farm. The total duration time of single milking T_{cd} can be recalculated according to Equation (2) as a specific time of single milking per cow t_{cds}.

$$t_{cds} = \frac{T_{cd}}{N} \quad (2)$$

Where;
N – number of lactating cows on the farm, cow.
In modelling and analysis of the current state (Kic 2015), the overall real capacity of milking equipment Q_h is calculated according to Equation (3) based on several lactating cows in the dairy herd and time data.

$$Q_h = \frac{N}{T_{cd}} \quad (3)$$

Where;
Q_h – the overall real capacity of milking equipment, cow h^{-1}; N – number of lactating cows on the farm, cow; T_{cd} – the total duration time of single milking, h.
In terms of the operational function of the milking equipment and the milker's work, the real capacity of the milking equipment was calculated according to Equation (4).

$$Q_{LS} = \frac{N}{T_{vd} - T_{pr}} \quad (4)$$

Where;
Q_{LS} –real capacity of milking equipment, cow h^{-1}; N – number of lactating cows on the farm, cow; T_{vd} – duration of one milking, h; T_{pr} – duration time of working breaks, h.
This real capacity of milking equipment is affected by the working capacity of one milker, which can be calculated according to Equation (5).

$$W_{dh} = \frac{Q_{LS}}{n_{ds}} \quad (5)$$

Where;
W_{dh} – the working capacity of one milker, cow h^{-1}; n_{ds} – the number of milkers, pers.
From the working capacity of one milker, it is possible to determine, according to Equation (6), the need for human labour for one milking of one dairy cow.

$$t_{rc} = \frac{1}{3600 \cdot W_{dh}} \quad (6)$$

Where;
t_{rc} – the time of human labour spent for milking operations of one dairy cow, s cow^{-1}.

The second decisive criteria for optimizing and selecting a suitable milking system for the farm should be the economic criteria. It is necessary to compare the specific data, which are in this case the final specific direct costs of a milking system per cow and year ${}^{u}C_{MP}$, calculated according to Equation (7) as a sum of specific labour costs of milking per cow and year ${}^{u}C_{W}$, specific costs of the milking equipment per cow and year ${}^{u}C_{P}$ including the construction of milking parlour (if it is used), and specific costs ${}^{u}C_{S}$ of supplies including the water, electricity, disinfectants, etc. per one cow and year.

$$ {}^{u}C_{MP} = {}^{u}C_{W} + {}^{u}C_{P} + {}^{u}C_{S} \quad (7) $$

Where;
${}^{u}C_{MP}$ – the final specific direct costs of the milking parlour, EUR cow^{-1} year^{-1}; ${}^{u}C_{W}$ – the specific labour costs per cow and year, EUR cow^{-1} year^{-1}; ${}^{u}C_{P}$ – the specific costs of the milking equipment, EUR cow^{-1} year^{-1}; ${}^{u}C_{S}$ – the specific costs of consumed supplies, EUR cow^{-1} year^{-1}.
Specific labour costs ${}^{u}C_{W}$ are determined based on labour requirements per cow per year T_r (h cow^{-1} year^{-1}) obtained by using Equation (8) and an average hourly wage of the milker. The labour requirement T_d can be used by equation (9).

$$ T_r = \frac{365 \cdot T_d}{60} \quad (8) $$

Where;
T_r –labour requirement for milking per cow per year, h cow^{-1} year^{-1}; T_d –labour requirement during milking per cow per day, min cow^{-1} day^{-1}.

$$ T_d = i \cdot \left[\frac{N \cdot (t_{rc} + t_p + t_c) + T_{pr} \cdot n_{ds}}{N} \right] \quad (9) $$

Where;
i –number of milking per day, day^{-1}; t_{rc} –average net labour requirement for milking per cow, min cow^{-1}; t_p – time of preparatory work before milking calculated per one cow, min cow^{-1}; t_c –time of finishing and cleaning work after milking calculated per one cow, min cow^{-1}.
Specific costs of the milking equipment ${}^{u}C_{P}$ are evaluated as specific data of total operating costs of the milking machine per single cow. Hence, it takes into consideration of amortization of machinery, amortization of construction which includes construction costs and percentage of building amortization and the cost of servicing, maintenance and repairs.
Specific costs of supplies ${}^{u}C_{S}$ are determined as a sum of costs of all necessary operating materials and energy. The consumption of electricity is proportional to the power inputs of motors and all electrical appliances during their operation, water, disinfection etc. All are re-computed per cow and year (EUR cow^{-1} year^{-1}).
The real number of milkers for the whole farm n_{ds} is the rounded integer n_d. The theoretical required number of milkers n_d is based on the calculation of Equation (10).

$$ n_d = \frac{Q_{PL}}{W_d} \quad (10) $$

Where;
n_d – the theoretical required number of milkers per one parlour, pers.; Q_{PL} – the required capacity of the milking parlour, cow min^{-1}; W_d – the working capacity of one milker, cow min^{-1}.
The maximum reasonable number of milkers per parlour n_{dm} is a criterion to avoid the idle time or complicated work of milkers. It is calculated by the number of milking stalls m_Z divided by the number of clusters n_s that can operate one milker.

$$ n_{dm} = \frac{m_Z}{n_s} \quad (11) $$

Where;
n_{dm} – the maximum number of milkers per one parlour, pers.; m_Z – the number of milking stalls in the milking parlour, pcs; n_s – the maximal number of clusters per milker, pcs.
An important technical parameter is a theoretical number of milking stalls in a parlour m_T, obtained by using Equation (12).

$$ m_T = Q_{PL} \cdot (t_d + t_v) \quad (12) $$

Where;
m_T – the theoretical number of milking stalls in the parlour, pcs; t_d – the average duration of milking by machine per one cow, min; t_v – the average idle time of a cluster, min.

$$ t_v = t_n + t_s + t_m \quad (13) $$

Where;
t_n – the average time for cluster attachment, min; t_s – the average time to remove the cluster, min; t_m – the average time for manipulation with cluster, min.
Some important measured data were evaluated using the program *STATISTICA - ANOVA F-test* method, i.e. a hypothesis H_0 presents a statistically insignificant difference among measured data ($p > 0.05$) and a hypothesis H_1 presents a rejection of the hypothesis H_0, i.e. there is the statistically significant difference among measured data ($P < 0.05$).

3. Results and Discussion

Evaluation of the current milking conditions enables us to compare all farms and milking parlours and propose some ideas for improvement. A summarized results of measurements at the farms with different milking systems and model calculations of the current situation and suggested improvements are in Tables 2 and 3, and Figures 3 to 8.
The results obtained from all farms allow assessing the effect of farm size (number of dairy cows) on milk production, which is shown in the graph in Figure 3. It can be seen from Figure 3 that with the growing size of the farm (with the number of dairy cows) the average milk production efficiency on the farm also increases.

The more detailed analysis allows evaluation of milk production on farms listed in Table 2. The highest productivity is on farms equipped with HBMP (7696 ± 553 kg cow^{-1}year^{-1}) and SBSMP (7316 ± 1048 kg cow^{-1}year^{-1}). Significantly the lowest productivity is on farms with BM (5521 ± 464 kg cow^{-1}year^{-1}), which are also farms with the lowest number of cows.

The number of non-dairy cows (e.g. dry cows, cows with health problems, etc.) as a function of the total number of dairy cows on the farm in Figure 4, expressed as a percentage depending on the total number of dairy cows on the farm, decreases, indicating a positive trend.

Table 2. Average milk yield per cow, per year, according to the type of milking equipment.

Farm Groups	Type of Milking equipment	Annual Milk Yield per Cow (kg cow^{-1}year^{-1})		
		Mean	Minimum	Maximum
A	BM	5521 ± 464 [a]	4575	6100
B	PLMS	6176 ± 686[a,b]	5490	6863
C	TMP	7168 ± 0.0[a,b]	7168	7168
D	HBMP	7696 ± 553 [b]	6100	9150
E	SBSMP	7316 ± 1,048 [b]	6100	10675
Summary	-	7146 ± 956	4575	10675

[a, b] Different superscript letters is a sign of high significant difference (ANOVA; Tukey HSD Test; P ≤ 0.05) between the mean values of milk yields of different milking equipment.

Table 3. Data determined by analysis from farms): overall resulting real hourly capacity of the milking equipment Q_h, the real capacity of a milking equipment Q_{LS}, the working capacity of one milker $W_{dh,}$ and the need for human labour for one milking of one dairy cow t_{rc}.

Farm Groups	Type of Milking equipment	Q_h	Q_{LS}	W_{dh}	t_{rc}
		(cow h^{-1})	(cow h^{-1})	(cow h^{-1})	(s cow^{-1})
A	BM	8.83 ± 1.78 [a]	15.0 ± 3.0 [a]	9.5 ± 4.2[a]	462 ± 118[a]
B	PLMS	19.67 ± 7.00[a,b]	29.5 ± 10.5[a,b]	14.8 ± 5.3[a,b]	279 ± 99[a,b]
C	TMP	12.00 ± 0.00[a,b]	40 ± 0.0[a,b]	20 ± 0[a,b]	180 ± 0[a,b]
D	HBMP	35.63 ± 13.04[b]	53.3 ± 17.6[b]	27.8 ± 9.5[b]	154 ± 46[b]
E	SBSMP	49.46 ± 37.57[a,b]	71.7 ± 44.9[a,b]	26.2 ± 8.5[a,b]	163 ± 61[b]

[a, b] Different superscript letters are signs of high significant difference (ANOVA; Tukey HSD Test; P ≤ 0.05) between the mean values of milk yields of different milking equipment.

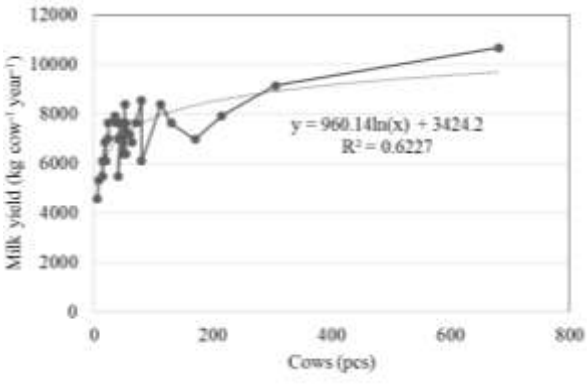

Figure 3. Average milk yield per cow, per year according to the number of milked cows on the farm.

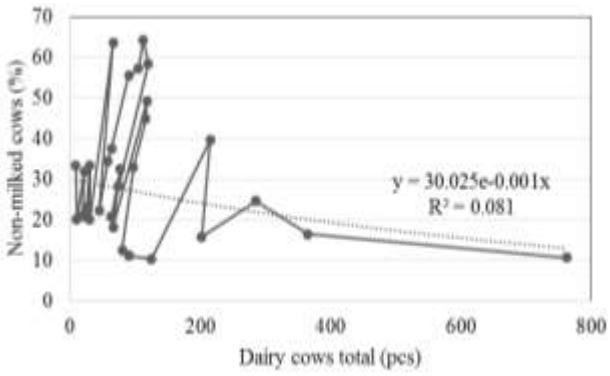

Figure 4. Percentage of non-milked cows (e.g. dry cows, cows with health problems, etc.) as a function of the total number of dairy cows on the farm.

The overall time of the whole single milking covers all milking- related activities, it also includes time for pre-milking and post-milking activities, incidental activities and loss times that degrade the performance and capacity of milking equipment. The specific time of single milking per cow t_{cds}, shown in Figure 5 shows a significant decrease in the use of MP compared to BM or PLMS milking.

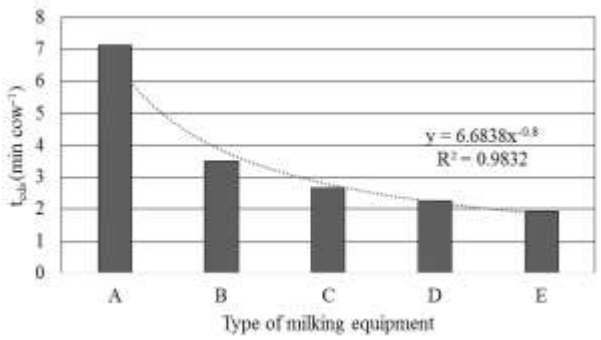

Figure 5. The specific time of single milking includes preparation, washing, milking, cleaning, etc. per lactating cow (min cow^{-1}).

Determining final average values of the overall resulting capacity Q_h of milking equipment, the real capacity Q_{LS} of milking equipment, the working capacity W_{dh} of one milker and the need of human labour t_{rc} for one milking of one dairy cow, summarized from all examined milking facilities and divided into groups according to of the type of milking equipment are given in Table 3. From these calculated results of parameters characterizing milking processes, a significant difference is evident, especially between milking inside the cowsheds (BM and PLMS) and milking in milking parlours.

The average values of the overall resulting capacity Q_h of milking equipment reached a relatively small value of 12 cows h^{-1} in the case of TMP, which is mainly due to longer preparation before milking (15 min preparation of milker and 15 min preparation of milking parlour) and longer the time required for the final activities after milking (40 min cleaning, washing and disinfection of the milking equipment). This may explain the reason why this parameter is lower for this milking parlour than for milking by the PLMS system, where it reached 19.67 ± 7 cow h^{-1}. The largest overall resulting capacity Q_h of milking equipment is 49.46 ± 37.57 cow h^{-1} reached in SBSMP, but from the statistical evaluation, it is clear that there are large differences between the examined milking parlours (large variance of values) which in some cases significantly reduces this parameter.

Real capacity Q_{LS} of milking equipment provides a better idea of the actual performance of milking equipment. A mutual comparison shows that milking parlours (TMP, HBMP and SBSMP) perform better than milking inside cowsheds (BM and PLMS). Also, according to this parameter, 71.7 ± 44.9 cow h^{-1} SBSMP achieves the best results, but again there is a large variance around the average value. Furthermore, there is the influence of a larger number of milkers working in these milking parlours, which can increase this performance.

For a more objective assessment of technical possibilities and operational results, the working capacity W_{dh} of one milker and the need for human labour t_{rc} for one milking of one dairy cow are interesting. The highest average value of the working capacity W_{dh} of one milker is 27.8 ± 9.5 cow h^{-1} in the HBMP, a little lower this value is 26.2 ± 8.5 cow h^{-1} in the SBSMP and significantly the lowest is 9.5 ± 4.2 cow h^{-1} in BM.

The calculated values of the need for human labour t_{rc} for one milking of one dairy cow also correspond to these results. This information indicates the real need for human labour for all tasks and work operations that the milker must perform during milking. This shows the importance of the milking parlour which reduces the need for human labour, facilitates the handling of the milking equipment, and in addition, provides better hygienic conditions for milking. Due to certain differences between farms in milking system equipment and milking facilities as well as different work intensities of individual milkers, there is considerable variance around the average values in individual groups of milking parlours. The lowest need for human labour 154 ± 46 s cow^{-1} is in HMP, slightly higher is 163 ± 61 s cow^{-1} in SBSMP and the largest is 462 ± 118 s cow^{-1} in BM.

Specific direct costs of milking system per cow and year $^{u}C_{MP}$ divided according to Equation 7 into three components ($^{u}C_W$, $^{u}C_P$ and $^{u}C_S$) are presented in Figure 6. The comparison of specific labour costs shows that the most expensive (269 EUR cow^{-1} year^{-1}) is the labour in cowsheds with BM. The lowest specific direct costs per cow and year (115 EUR cow^{-1} year^{-1}) are in the cowsheds with SBSMP.

The need for human labour is reflected in specific labour costs $^{u}C_W$. Overall, these specific labour costs can be assessed as quite high, especially in comparison with the results achieved e.g. (Chiumenti et al., 2020). A more detailed analysis of the technical solution and operating conditions has shown that there is a discrepancy between the technical equipment and the results achieved on many farms. E.g. on small farms (only 6, 8, or 15 lactating dairy cows) equipped with BM, 2 milkers work and the milking time is quite long. Only 1 milker would be enough.

Similar shortcomings can be found in some other farms, equipped with HBMP. What is the current number of milkers on the farm n_{df} and what should be n_d concerning technical equipment and achieved milking time shows a comparison of the number of milkers in Figure 7. It can be seen from the figure that in most farms the number of milkers is higher than optimal. Improved organization of farm work and better use of technical facilities especially in milking parlours would reduce the number of milkers and thus lower labour costs. Workers could work on other necessary work activities on farms in the saved time.

The specific costs of technical equipment for milking technology $^{u}C_P$ correspond to the given situation and because MPs are used for larger farms, the specific costs are slightly lower than for milking in the cowsheds (BM and PLMS). The specific costs of $^{u}C_S$ of supplies are influenced mainly by the extent and frequency of washing, cleaning and disinfection of milking facilities as well as the thoroughness of preparation, including cleaning of dairy cows before milking and disinfection

after milking. These specific costs are the highest at MPs, mainly HBMP and especially SBSMP. These PMs are used on larger farms and farmers pay more attention to washing and disinfection than on small farms.

Figure 8 shows the specific direct costs of a milking system per cow and year uC_{MP} divided according to Equation 7 into three components ($^{u}C_W$, $^{u}C_P$ and $^{u}C_S$) after changing the number of milkers (in most milking systems to a lower number of milkers) to better match the technical and capacity capabilities of the milking system on each farm. It can be seen from the figure that the biggest savings could be achieved with BM, PLMS and HBMP.

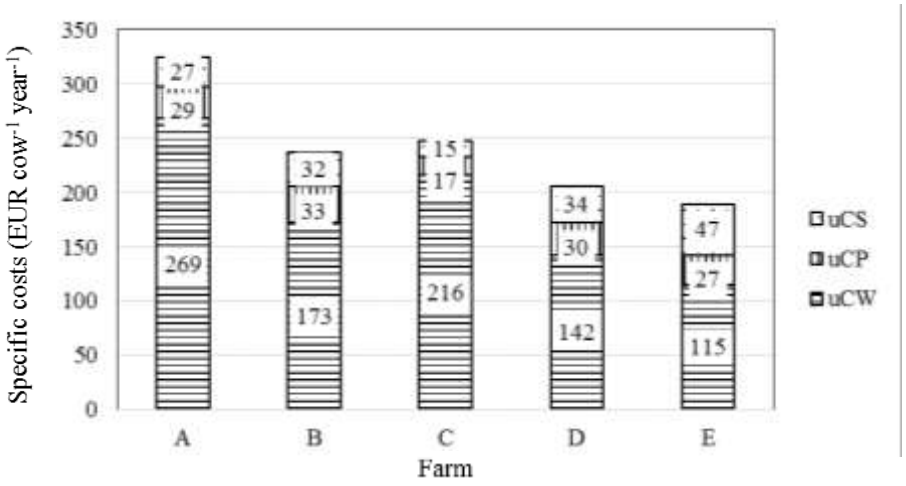

Figure 6. Specific direct costs of a milking system per cow and year $^{u}C_{MP}$ (EUR cow^{-1} year^{-1}) in the current situation in farms.

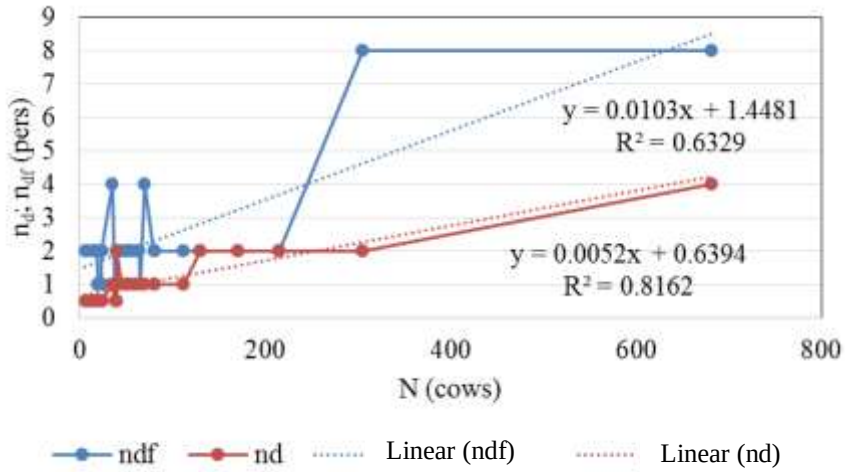

Figure 7. Current number of milkers on the farm n_{df} and optimal number of milkers n_d (pers).

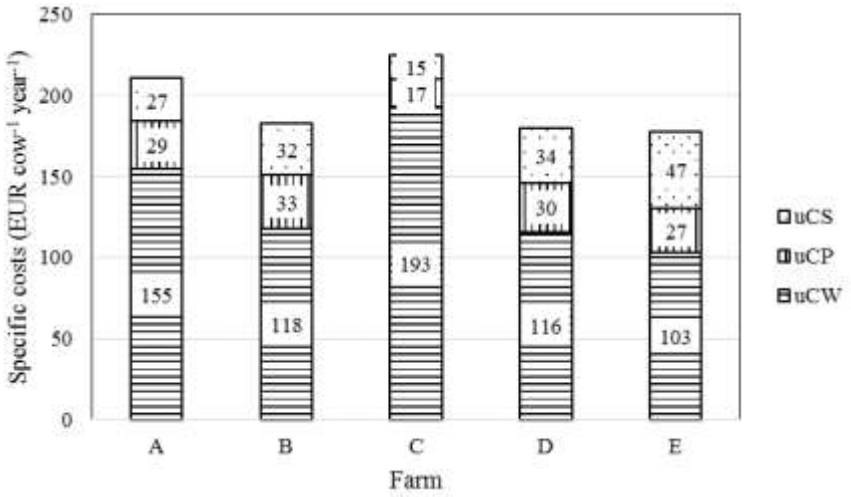

Figure 8. Specific direct costs of a milking system per cow and year $^{u}C_{MP}$ (EUR cow^{-1} year^{-1}) in farms with a reduced number of milkers according to the model calculation.

4. Conclusions

Based on the performed research and the results of the model calculation the following conclusions can be drawn:

- Greater capacity of dairy farms gives preconditions for increasing milk yield;
- Greater capacity of the dairy farms enables the application of progressive milking techniques in separate milking parlours;
- Greater capacity of the dairy farm allows to keep more young cattle and possibly cattle for fattening;
- The selection of a suitable milking technique should be evaluated in the light of the prospective development of the farm, including increased capacity;
- In particular, two criteria should be considered for the selecting a suitable milking technique, i.e. the total time required for milking and the final direct specific costs;
- When choosing a milking technique, it is appropriate to use a model for optimization calculations enabling the analysis of expected technical and economic results;
- Evaluation of existing milking systems would improve the milking process and operations from the point of view of either technical improvement or improved activity of milkers.

Author Contributions

The percentage of the author(s) contributions is present below. All authors reviewed and approved final version of the manuscript.

	M.D.	P.K.	B.D.	G.A.K.G.
C	25	25	25	25
D	25	25	25	25
S	25	25	25	25
DCP	25	25	25	25
DAI	25	25	25	25
L	25	25	25	25
W	25	25	25	25
CR	25	25	25	25
SR	25	25	25	25
PM	25	25	25	25
FA	25	25	25	25

C=Concept, D= design, S= supervision, DCP= data collection and/or processing, DAI= data analysis and/or interpretation, L= literature search, W= writing, CR= critical review, SR= submission and revision, PM= project management, FA= funding acquisition

Conflict of Interest

The authors declared that there is no conflict of interest.

Ethical Consideration

Ethics committee approval was not required for this study because of this article produced using data before 2019.

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Research Article
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AN ECONOMIC EVALUATION OF MOHAIR PRODUCTION IN ANKARA PROVINCE

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Abstract: Angora goat is the most important goat breed that spread from Central Asia to Anatolia and became a part of Turkish culture. Angora goat, which is thought to have been brought to Anatolia in the 13th century, is intensively raised in the Central Anatolian region, especially in Ankara and its surroundings. In this study, it is aimed to give information about the distribution of the goat population according to Ankara province and its districts, the amount and price of mohair purchase by years, and the fiber quality of Angora goats raised in the region. According to the findings, it has been observed that there is an increase in the number of Angora goats in Ankara parallel with the total number of small ruminants in Türkiye. When the farms that are members of the Ankara Sheep and Goat Breeders' Association are examined, Ankara goat breeding is carried out in almost all districts of Ankara. The number of Ankara Goats, which was approximately 158 thousand in 2012, reached approximately 289 thousand in 2021. Between 2016 and 2021, a total of 48814.00 kg of mohair was obtained from Ankara Goats in Ankara. Furthermore, when mohair prices are analyzed in dollars, it is determined that the highest price was in 2019, and the amount of subsidy given by the State decreased over the years. In terms of literature, we can say that there are not enough new studies on Angora goats and that up-to-date studies are needed. The fact that Ankara is suitable for goat breeding due to its geography and that the importance of goat breeding for those living in rural areas in cultural terms has ensured the continuity of Ankara Goat production. Although the goat population seems to be increasing in the last 10 years, there has been a serious decrease compared to the beginning of the 1900s. Necessary studies should be done properly in order to increase the Angora goat population.

Keywords: Ankara, Mohair, Angora goat, Price, Quality

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1. Introduction

Angora goat is the most important goat breed that spread from Central Asia to Anatolia and became a part of Turkish culture. Angora goat, which is thought to have been brought to Anatolia in the 13th century, is intensively raised in the Central Anatolian region, especially in Ankara and its surroundings (Yanar and Akpınarlı, 2016).

Ankara, which is an important commercial transit point due to its geography, had an important place in the export income obtained from Angora goats, especially in the Ottoman period (Sen et al., 2015). However, in the last 50 years, the increase in migration from rural areas to the city, low quality mohair production and decrease in mohair income have caused a decrease in the interest in Angora goat breeding. Especially in recent years, crossing with Hair Goat, which has been done intensively and unconsciously, has adversely affected the production and quality of Mohair (Behrem, 2011; Daskıran and Koluman, 2015).

Since both the number of goats and the number of other domestic breeds are not competitive compared to the world-wide breeds in terms of production, their numbers are decreasing day by day. Although studies have been carried out to identify the genetic potential of domestic animal genetic resources in terms of economically important traits, these studies are not yet sufficient in Türkiye (Gül et al., 2020; Behrem, 2021; Kizilaslan et al., 2022; Arzik et al., 2022; Yilmaz et al., 2022). There are similar situations in Angora goats, and unfortunately their number has experienced a serious decline for a period. The number of goats in our country has a share of approximately 20% in the sheep and goat population and has reached approximately 12 million with an increase of 47.67% in the last 10 years. The number of Angora goats has doubled in the last 10 years and is approximately 289000 (TUIK, 2020).

The National Small Ruminant Breeding Programme, carried out by the Ministry of Agriculture and Forestry and the Ankara Sheep and Goat Breeders' Association, had started breeding studies and financial support for fleece production played an important role in this increase since 2005. In this study, it is aimed to give information about the number of Angora goats in Ankara and its surrounding, the amount and price of mohair, and the fiber quality of Angora goats raised in Ankara.

2. Materials and Methods

Angora Goat is raised in 18 districts of Ankara namely Mamak, Sincan, Yenimahalle, Akyurt, Beypazarı, Çamlıdere, Çubuk, Etimesgut, Evren, Kazan, Gölbaşı, Ayaş, Güdül, Haymana, Kızılcahamam, Nallıhan, Polatlı and Şereflikoçhisar. It is the second largest city of Türkiye due to being the capital city and the immigration recieved from nearby cities. The coordinates of Ankara are 39.57 N latitude and 32.53 E longitude. It has an area of 26,897 km² and its altitude is approximately 890 meters (m).

Ankara has a demonstrates characteristics of semi-arid climate and has a large territory, so different climate characteristics can be seen. The steppe flora can be seen in the northern part of the city due to the climate effect of the Black Sea. But usually, it has cold winters and dry summers. The annual temperature ranges from -25˚C to 40˚ C. Precipitation is between 300 mm and 540 mm and humidity is between 40-79% (Anonymous, 2020).

In the study, based on the data of the 812 herds registered to Ankara Sheep and Goat Breeders' Association, the number of Angora goats, the status of local breeding practices, amount of received mohair, price of mohair and its quality were evaluated. The dollar-based annual subsidy amount in the tables has been calculated according to the Central Bank's annual dollar exchange rate in June.

3. Results and Discussion

3.1. The number of Small Ruminants in Türkiye

When the numbers of sheep and goats in Türkiye are examined in Table 1, it is observed that the number of domestic sheep, Merino crossese, Hair goat, Angora goat and the total number of small ruminants increased by 78%, 59%, 160%, 46% and 83%, respectively.

3.2. Ankara Sheep and Goat Breeders' Association and the Number of Members

The districts with the highest number of breeders registered in Angora goats breeding in Ankara are Beypazarı (203), Güdül (124) and Ayaş (120), respectively. There are no registered breeders in Etimesgut, Evren and Yenimahalle districts. The total number of herds registered to the Ankara Sheep and Goat Breeders' Association is 812 (Figure 1).

When we examine the districts in terms of the number of Ankara goats, Güdül, Beypazarı and Ayaş districts are appear to be top three places with 40615, 28359 and 26745 heads of animals, respectively. As seen in Figure 2, Ankara Angora goat is raised in almost all districts.

Table 1. Sheep and goat numbers (heads) by year in Türkiye (TUIK, 2020)

Year	Domestic Sheep	Merino Crossbreed Sheep	Hair Goats	Angora Goats	Total
2012	25 892 582	1 532 651	8 199 184	158 102	35 782 519
2013	27 485 166	1 799 081	9 059 259	166 289	38 509 795
2014	29 033 981	2 106 263	10 167 125	177 811	41 485 180
2015	29 302 358	2 205 576	10 210 338	205 828	41 924 100
2016	28 832 669	2 151 264	10 137 534	207 765	41 329 232
2017	31 257 408	2 420 228	10 419 027	215 645	44 312 308
2018	32 513 293	2 681 679	10 698 553	223 874	46 117 399
2019	34 199 467	3 076 583	10 964 374	241 055	48 481 479
2020	38 579 748	3 547 033	11 698 825	287 020	54 112 626
2021	41 182 899	3 994 791	12 051 957	289 557	57 519 204

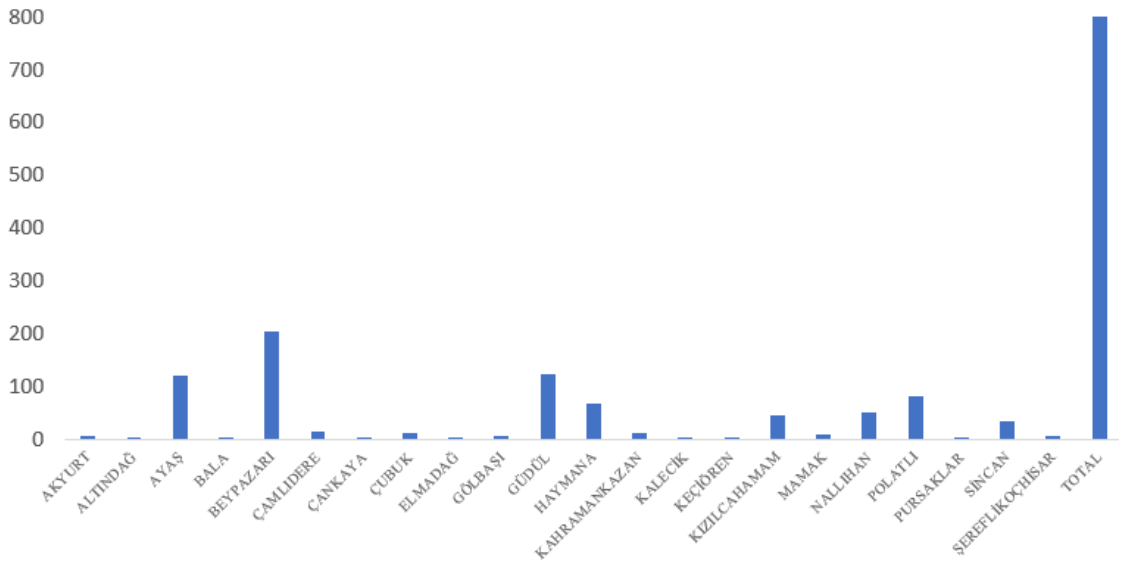

Figure 1. The number of members registered in Ankara Sheep and Goat Breeders' Association by regarding districts of Ankara in 2021.

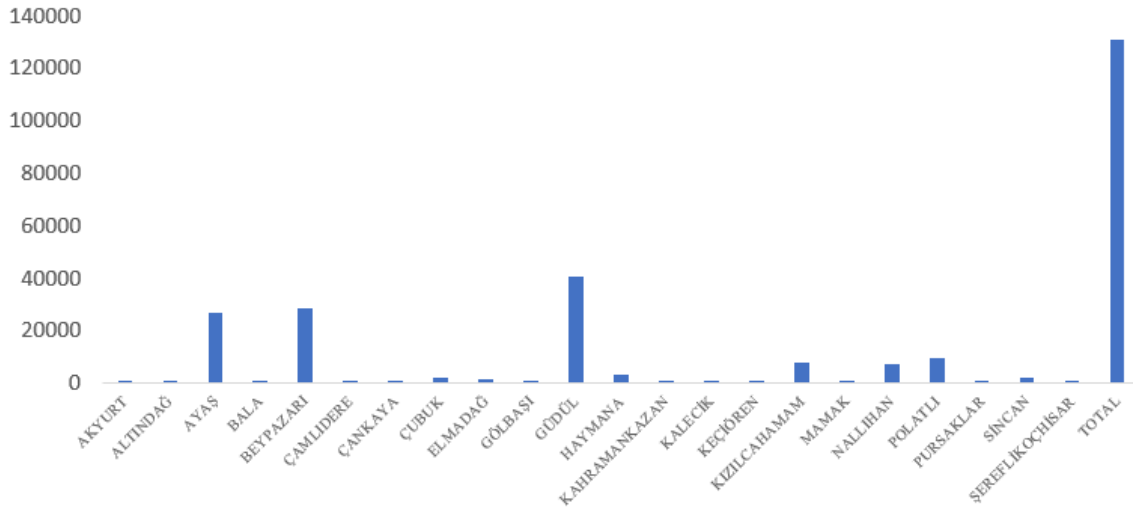

Figure 2. The number of district-based Angora goats belonging to herds registered to Ankara Sheep and Goat Breeders Association in 2021.

Until 2015, Mohair and Wool Agricultural Sales Cooperatives Union (MWASCU) was the only organization in our country for purchasing mohair. However, after 2015, Ankara Sheep and Goat Breeders Association (ASGBA) started to purchase mohair as of 2016, with authorization given by the Ministry of Agriculture and Forestry. In our country, mohair subsidy is given if mohair is sold to the institutions authorized by the Ministry of Agriculture and Forestry. In addition, according to Article 4 of the Presidential Decree dated 5.11.2020, wool processing factories registered with the Ministry are allowed to collect mohair with a receipt. Starting in 2020, farmers selling mohair to these factories are also included in additional subsidy.

It is seen that there has been an increase in mohair prices since 2016, with ASGBA starting to purchase mohair and also depending on the world markets. Table 2 shows that prices were the lowest in 2018 and the highest in 2019. Moreover, Table 2 shows that yearling kids' mohair is a more preferred product due to its smaller micron diameter and accordingly, its price is higher than that of 2 years old goat mohair. Unclassified mohair, on the other hand, is defined as dirty mohair with faces remaining on the underbelly and rear parts and finds buyers at a very low price.

The amount of mohair collected by the Ankara Sheep and Goat Breeders Association (ASGBA) is presented in Table 3. According to this table, it is seen that the highest amount of mohair was collected in 2020. For the sake of mohair classification, OFDA 2000 optical measurement instrument is used to sort those samples by determining the fibre diameter (micron) and get those ready for sale.

Table 2. Kids, adults and un-classified dirty mohair prices of Ankara Sheep and Goat Breeders Association (ASGBA) and Mohair and Wool Agricultural Sales Cooperatives Union (MWASCU) by years (Anonymous, 2021)

	Kids kg/$		Adults kg/$		Unclassified Mohair kg/$	
Years	ASGBA	MWASCU	ASGBA	MWASCU	ASGBA	MWASCU
2015	None	3.73	None	2.98	None	0.74
2016	5.08	4.07	4.41	3.39	1.02	1.02
2017	5.10	4.25	4.25	3.68	0.85	0.85
2018	4.36	3.70	3.70	3.27	0.65	0.65
2019	8.91	6.00	7.54	5.14	0.86	0.86
2020	6.61	6.61	5.88	5.58	0.73	0.88
2021	5.88	5.88	5.29	5.29	0.59	0.71

Table 3. The amount of mohair collected by Ankara Sheep and Goat Breeders Association (ASGBA) by years (Anonymous, 2021)

Year	Kids (kg)	Adults (kg)	Unclassified Mohair (kg)	Total (kg)
2016	4.483.86	12.333.70	430.20	17.247.76
2017	7.734.10	17.451.30	364.40	25.549.80
2018	14.328.80	29.478.00	946.4	44.753.20
2019	17.354.90	29.475.40	529.8	47.360.10
2020	13.440.50	56.006.00	1.845.50	71.292.00
2021	11.709.00	36.542.00	563.00	48.814.00

The amount of subsidy given by the Republic of Türkiye Ministry of Agriculture and Forestry has decreased in dollar terms over the years. The subsidy model is as follows: Ankara Sheep and Goat Breeders Association (ASGBA) or Mohair and Wool Agricultural Sales Cooperatives Union (MWASCU) collects and invoices mohair from breeders. Farmers receive subsidies over the amount they produce according to these invoices.

According to previous studies, the average weight of dirty mohair for kids and adults are 1.42 kg and 3.62 kg, respectively. As can be seen in Table 4 and 5, according to previous studies, the average weight of dirty mohair is 1.42 kg and 3.62 kg, respectively, according to different age groups in kids and matriarch goats. Again, for the kids and adult groups, the mean fibre diameter was 25.36 µ and 39.81 µ, the mean elasticity was 27.35% and the mean strength was 45.26%, 10.16 g and 23.74 g, the mean medulla fibre ratio was 0.29%, 6.89%, the mean length was 62.9 mm and 176.3 mm, respectively (Öztürk and Goncagül, 1994; Öztürk and Örkiz, 1994; Vatansever and Akçapınar, 2006; Bilgen et al., 2008; Şen, 2015; Erol et al., 2017). It is seen that the dirty mohair weight is the lowest in kids and the dirty mohair yield increases as the age increases. When we examine the studies, thinness increases as age increases.

Table 4. The amount of subsidy provided by the Republic of Türkiye Ministry of Agriculture and Forestry for kids, adults and unclassified mohair (Anonymous, 2021)

Year	Kids kg/$	Adults kg/$	Unclassified mohair kg/$
2016	7.46	7.46	7.46
2017	7.65	7.65	7.65
2018	6.53	6.53	6.53
2019	5.14	4.80	3.43
2020	4.41	4.11	2.94
2021	4.11	3.52	2.58

Table 5. Previous studies on Mohair characteristics

Year	Sex	Dirty Mohair (kg)	Diameter (µ)	Elasticity (%)	Strength (g)	Medulla fibre ratio (%)	Length (mm)	Reference
Kid	M F	-	25.36 26.55	43.25 45.26	12.27 14.31	6.89 5.82		Şen (2015)
1-3 year	M	1.62, 2.98, 3.13	30.03, 32.34, 34.72	29.25, 27.50, 27.35	14.12, 23.45, 23.74	0.39, 0.65, 2.58		Öztürk and Goncagül (1994)
1-3 year	F	1.42, 2.55, 2.69	30.10, 31.34, 34.21	30.56, 31.34, 34.21	14.38, 23.63,22.68	0.29, 0.48, 0.28		
>2 year	F	3.67, 3.41	38.41, 39.81	29.68, 29.98	20.82,21.78	0.50, 0.53	176.3, 175.5	Öztürk and Örkiz (1994)
1-6 year	F	2,67	34.64	38.92	10.16	-	62.9	Bilgen et al. (2008)
2-6 year	F	3.11	37.98	37.78	10.89	1.50	64.9	Vatansever and Akçapınar (2006)
1-5 year	F	2.26, 2.18, 1.81	37.15	40.15	20.24	-	73.5, 111.2	Erol et al. (2017)

4. Conclusion

The fact that Ankara is suitable for goat breeding due to its geographical structure and the cultural importance of goat breeding for those living in rural areas has been underlying the uninterrupted Angora goat production. Although the goat population seems to be increasing in the last 10 years, there has been a serious decrease compared to the beginning of the 1900s. It is essential that the necessary studies be done consciously in order to increase the current number. It is thought that the price of mohair and subsidy, which has decreased in dollar over the years, will weaken the production. For this reason, the Ministry of Agriculture and Forestry, the Associations and the Cooperatives should determine the improvement and subsidy policy of the next 10 years and carry out studies that will make Angora goats more attractive for breeding.

Author Contributions

The percentage of the author(s) contributions is present below. All authors reviewed and approved final version of the manuscript.

	Y.A.	S.B.	M.K.
C	30	40	30
D	30	40	30
S	30	40	30
DCP	30	40	30
DAI	30	40	30
L	30	40	30
W	40	30	30
CR	30	40	30
SR	30	40	30
PM	30	40	30
FA	30	40	30

C=Concept, D= design, S= supervision, DCP= data collection and/or processing, DAI= data analysis and/or interpretation, L= literature search, W= writing, CR= critical review, SR= submission and revision, PM= project management, FA= funding acquisition.

Conflict of Interest

The authors declared that there is no conflict of interest.

Ethical Consideration

Ethics committee approval was not required for this study because of there was no study on animals or humans. The data taken from Ankara Sheep and Goat Breeders' Association.

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Research Article
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FINAL FATTENING LIVE WEIGHT PREDICTION IN ANATOLIAN MERINOS LAMBS FROM SOME BODY CHARACTERISTICS AT THE INITIAL OF FATTENING BY USING SOME DATA MINING ALGORITHMS

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Abstract: This study's objective was to compare the performances of Random Forest (RF), eXtreme Gradient Boosting (XGBoost), and Bayesian Regularization Neural Network (BRNN) algorithms, which are some data mining algorithms used in final fattening live weight prediction. As the independent variable in the design of the algorithms, some body characteristics taken before fattening of 54 heads of Anatolian Merino lambs, with single birth and male, were withers height (WH), rump height (RH), body length (BL), chest girth (CG), leg girth (LG), and chest depth (CD) was used. The mean±standart errors for the body characteristics of Anatolian Merino lambs were determined to be 63.481±0.538, 63.315±0.501, 78.930±1.140, 60.037±0.549, 47.704±0.543, and 29.926±0.377, respectively. The mean initial live weight (ILW) and the mean final live weight (FLW) were found as 35.89±0.84 and 49.49±0.88 kg, respectively. There was difference of 13.60 kg between ILW and FLW means. The ILW and FLW were shown to positively correlate with body characteristics, and this correlation was statistically significant (P<0.01). While the highest Pearson's correlation (r=0.95) of FLW was between WH and RH, the lowest Pearson's correlation (r=0.51) was found between LG and CD. While the largest share of body characteristics in the total variance in the FLW estimation was BL (42.969%) in the XGBoost algorithm, the lowest share was found to be CD (0.00) in the XGBoost algorithm and LG (0.00) in the BRNN algorithm. The model evaluation criterias which were Root mean square error (RMSE), Standard deviation ratio (SDR), Mean absolute percentage error (MAPE), and Adjusted coefficient of determination (R^2_{Adj}) performed as 1.492, 0.233, 2.241 and 0.944, in the XGBoost algorithm, as 2.220, 0.347, 3.139 and 0.880 in the BRNN algorithm, as 2.859, 0.446, 4.340 and 0.792 in the RF model, respectively. As a result, it can be said that the data mining algorithms used in prediction FLW taking advantage of body measurements of Anatolian Merino lambs at the beginning of fattening will benefit from their use in fattening due to their high prediction performance.

Keywords: Anatolian Merino, Body characteristics, Data mining algorithms, Fattening, Prediction

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1. Introduction

The revenue from slaughter lambs is a significant portion of the income from sheep breeding. Butchery lambs are generally supplied from extensive sheep breeding in Türkiye. Lambs grazed on pastures, which are the cheapest source of roughage, with their dams in spring and summer, are evaluated as butchery lambs when they reach 25-30 kg live weight. The lambs are fattened with concentrate and roughage sources after being weaned, and when they weigh 35 to 40 kg live weight, they are sent to slaughter. However, some breeders may have to resort to early lamb slaughter due to socio-economic reasons (Boztepe et al., 1997). The goal of lamb meat production is to get the best yield and quality for the least amount of cost in the shortest fattening time (Aytekin et al., 2015). The success of an intensive fattening performance is demonstrated by selling the product at the highest price by the best satisfying consumer demand (Şahin and Akmaz, 2002). In order to avoid financial losses, it is crucial to follow growth and development during the fattening phase. Body measurements taken to monitor growth and development are also required to select the best animals based on the direction of the yield, identify issues with maintenance and feeding in the business, and estimate the number of tools and equipment, such as feeders, grazers, and drinkers (Ertuğrul, 1996).

The ideal lamb fattening program is started immediately after the lambs are weaned, by applying an adaptation period in herd management. However, in some breeding seasons, feed and meat price instability and poor enterprise management hinder both the beginning and

end of fattening periods. However, some conventional sheep producers may delay the start of lamb fattening in order to complete other agricultural activities such as sowing and planting, and so on. In such cases, the breeders are working on production systems with the least cost, and the proper provision of it makes for more profitable and satisfactory sheep husbandry for breeders. For such reasons, sometimes a slightly later start of fattening may be preferred.

It is possible to compare animals by measuring their bodies at regular intervals in order to track their growth and development, express their body structures, and get an idea of how to set up care and food plans for herd management (Zülkadir et al., 2008). Body measurements vary depending on significant traits such as breed, age, sex, and type of yield during growth and development periods (Pesmen and Yardimci, 2008). There have been many studies of literature in which the relationships between body weight and body measurements are defined and the body weight estimation is made with some data mining algorithms by using body measurements (Yakubu, 2012; Ali et al., 2015; Eyduran et al., 2017; Aytekin et al., 2018; Çelik and Yılmaz, 2018; Huma ve Iqbal, 2019; Abbas et al., 2021; Louis-Tyasi et al., 2021; Mathapo and Tyasi, 2021; Altay, 2022; Coşkun et al., 2022; Mathapo et al., 2022). However, the fact that there is no study that predicts final live weight (FLW) by using both Anatolian Merino breed and initial fattening body characteristics distinguishes this study from others.

In this study, eXtreme Gradient Boosting (XGBoost), Random Forest (RF), and Bayesian Regularization Neural Network (BRNN) data mining algorithms were used to predict the live weight at the end of fattening by using some body characteristics at the initial of fattening in Anatolian Merino lambs, and they was aimed to compare the prediction evaluation performances.

2. Materials and Methods

2.1. Animal Material

This study's animal material included 54 head lambs with single birth type and male Anatolian Merino, which were fattened on a private farm in the district of Kadınhanı in Konya. Lambs were fed intensively for 45 days between October and November 2021. Lambs were fed concentrated feed *ad libitum* along with 180 g of dried alfalfa per day for 8 weeks beginning after a 14-day acclimation period. The mixed feed used during fattening is presented in Table 1.

2.2. Measurement of Body Characteristics and Live Weight of Anatolian Merino Lambs

Lambs were measured individually for live weight, withers height (WH), body length (BL), rump height (RH), chest girth (CG), leg girth (LG), and chest depth (CD) at the beginning of fattening in the morning on an empty stomach. The determination of live weights was made with a 100 g precision scale. Body measurements were determined with a measuring stick (WH, RH, BL, and CD) and measuring tape (CG and LG) as reported by Ertuğrul (1996). The fattening lasted for 45 days, and at the end of the fattening, the live weights of the animals were determined and the study was terminated. This study did not require ethical approval because different body measurements were taken from lambs in accordance with their operational procedures for each measurement.

Table 1. Ingredient composition and nutritional composition of the feed used in the study

Ingredients	(%)
Barley	60.00
Corn	22.76
Sunflower seed meal	15.35
Limestone	1.39
Salt	0.25
Vitamin- mineral premix	0.25
Total	100
Calculated nutrient composition	
Crude protein, %	15.64
Metabolic energy, kcal/kg ME	2720
Ca, %	0.62
P, %	0.46

2.3. Statistical Analysis

2.3.1. Bayesian regularized neural network algorithm (BRNN)

One of the most popular artificial intelligence algorithms, Artificial Neural Networks (ANNs), is architecturally similar to the human brain and may be used for sequential, nominal, and scale-dependent variables (Ali et al., 2015). Three layers make up an ANNs: the input layer, the hidden layer, and the output layer, respectively. The hidden layer depends on the input layer, which is the first layer, which is made up of independent variables, to begin the process. The activation functions and weights of the independent variables are handled by the hidden layer, which is used to examine how independent variables affect the dependent variable (Kayri, 2016). In comparison to linear models, two types of ANN algorithms, such as radial basis functions neural networks (RBFNN) and BRNN, allow analysts to build better predictive models (Pérez-Rodríguez et al., 2013).

2.3.2. Random forest (RF)

Breiman, (2001) proposed the RF algorithm, which increases the bagging algorithm and adds a layer of arbitrariness. The RF algorithm combines sets of regression trees to create a learning algorithm. A regression tree is characterized as a collection of restrictions that are utilized hierarchically to the tree's leaves from the root (Rodriguez-Galiano et al., 2014; Wang et al., 2016). The best feature of this algorithm is how easily it can be applied to non-linear situations.

The RF algorithm requires a three-stage procedure (Liaw and Wiener, 2002). A number of the trees (n_{tree}) bootstrap samples from the initial data constitute the first step. The creation of an un-pruned classification or

regression tree for each sample is the second step. Predicting the most recent data from the tree is the final step. Model parameters like n_{tree} and the number of variables tried at each split (m_{try}) are selected to be 100 and 3, respectively, for this data set.

2.3.3. eXtreme gradient boosting algorithm (XGBoost)

Chen and Guestrin (2016) proposed the XGBoost algorithm as a more efficient machine learning algorithm constructed by gradient boosting (Ma et al., 2018; Carmona et al., 2019). Additionally, the XGBoost algorithm is based on the gradient tree boosting method and the regression tree algorithm, both of which use parallel decision laws as the decision tree (Hastie et al., 2009; Zhong et al., 2018). The independent variables that can increase the effectiveness of the model created for the decision tree identifying the groups are used by XGBoost during the training process. Also, unnecessary variables are frequently created at the cost of computation time (Gertz et al., 2020). The primary goal of this process is to create decision trees with high-variance and low bias (Chen and Guestrin, 2016).

2.3.4. Performance evaluation criteria of data mining algorithms

In the study, the prediction performances of data mining algorithms were evaluated with the help of criteria commonly used in the literature, and it was given in the equations between 1 and 9 below (Zhang and Goh, 2016; Zaborski et al., 2019). In the comparison phase of algorithms, root-mean-square error (RMSE), relative root mean square error (RRMSE), coefficient of variation (CV), performance index (PI), mean error (ME), relative approximation error (RAE), mean relative approximation error (MRAE), mean absolute percentage error (MAPE), and mean absolute deviation (MAD), Akaike's information criterion (AIC), and adjusted Akaike's information criterion (AIC Adj) prediction evaluation criteria should be close to 0, while Pearson's correlation coefficients (PC), coefficient of determination (R^2), and adjusted coefficient of determination (R^2_{Adj}) criteria should be close to 1 in order to be good estimators. Also, the standard deviation ratio (SD_{ratio}) criterion must take values less than 0.10 (Eyduran et al., 2019). Equations 1 to 9 below were mathematical formulas for presenting some critical prediction performances criteria.

$$RMSE = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(y_i - y_{ip})^2} \quad (1)$$

$$SD_{ratio} = \frac{\sqrt{\frac{1}{n}\sum_{i=1}^{n}(y_i - \overline{y_i})^2}}{\sqrt{\frac{1}{n}\sum_{i=1}^{n}(y_{ip} - \overline{y_{ip}})^2}} \quad (2)$$

$$RAE = \sqrt{\frac{\sum_{i=1}^{n}(y_i - y_{ip})^2}{\sum_{i=1}^{n} y_i^2}} \quad (3)$$

$$MAPE = \frac{1}{n}\sum_{i=1}^{n}\left|\frac{y_i - y_{ip}}{y_i}\right| x100 \quad (4)$$

$$MAD = \frac{1}{n}\sum_{i=1}^{n}|y_i - y_{ip}| \quad (5)$$

$$R^2 = 1 - \frac{\sum_{i=1}^{n}(y_i - y_{ip})^2}{\sum_{i=1}^{n}(y_{ip} - \overline{y_{ip}})^2} \quad (6)$$

$$R^2\text{Adj} = 1 - \frac{\sum_{i=1}^{n}(y_i - y_{ip})^2/(n-1)}{\sum_{i=1}^{n}(y_{ip} - \overline{y_{ip}})^2/(n-p-1)} \quad (7)$$

$$AIC = n.In\left[\frac{1}{n}\sum_{i=1}^{n}(y_i - y_{ip})^2\right] + 2k \quad (8)$$

if n/k>40, or $AIC_{Adj} = AIC + \frac{2k(k+1)}{n-k-1}$ (9)

where: n is the number of lambs, k is the number of model parameters, p is the number of body characteristics, y_i is the actual value of live weight of Anatolian Merino lambs at ending fattening, and y_{ip} is the predicted FLW.

R software was used for all analyses, taking cross-validation as 5 (R Core Team, 2020). Results were obtained by using RF algorithm "randomForest", XGBoost and BRNN algorithms "e1071" packages. Data mining algorithms' model evaluation performance criteria were evaluated using the "ehaGoF" package (Eyduran, 2020). Using the R software "corrplot" package, Pearson correlation coefficients between FLW and body characteristics were calculated. Also, the multicollinearity problem between the independent variables was examined at the outset of the analysis, and it was discovered that there was none.

3. Results and Discussion

Table 2 showed that some descriptive statistics on the live weight at the beginning of fattening, the live weight at the end of fattening, and some body characteristics of Anatolian Merino male lambs. While the average live weight of lambs at the beginning of the fattening was 35.891 kg, the average live weight at the end of the fattening was 49.487 kg. The average daily live weight gain of the lambs during the 45-day fattening period was calculated to be 0.302 g. The variation coefficient of the live weight at the beginning of fattening, and the variation coefficient of the live weight at the conclusion of fattening were 17.20 % and 13.05 %, respectively, this situation indicates that there were more homogeneous lambs at the end of fattening (Table 2).

The Pearson correlation coefficients of the live weights of the lambs at the beginning and end of fattening and some body characteristics of the lambs at the beginning fattening were shown in Figure 1 (P<0.01). The characteristics of WH and RH had the highest correlation coefficient (r=0.95), while LG and CD had the lowest (r=0.51). Sensitivity analysis was performed for each data mining algorithm to predict the variable importance values of the independent variables on live weight at the fattening (Table 3).

Table 2. Some descriptive statistics on body characteristics and live weights at the initial and final of fattening

Variable	N	$\bar{X} \pm S_{\bar{x}}$	CV
ILW	54	35.891±0.840	17.20
WH	54	63.481±0.538	6.22
RH	54	63.315±0.501	5.82
CG	54	78.930±1.140	10.57
BL	54	60.037±0.549	6.72
LG	54	47.704±0.543	8.36
CD	54	29.926±0.377	9.27
FLW	54	49.487±0.879	13.05

Table 3. Variable importance of data mining algorithms

Variable importance	XGBoost	BRNN	RF
WH	7.779	26.656	22.472
RH	6.951	25.700	13.157
CD	0.000	19.203	14.437
BL	42.969	18.123	15.408
CG	23.571	10.317	17.792
LG	18.729	0.000	16.733

While the body characteristic with the highest relative importance value in the XGBoost (42.969) algorithm was BL, it was determined that it was the WH characteristic in the BRNN (26.656) and RF (22.472) algorithms. Also, the CD characteristic in the XGBoost algorithm and the LG characteristic in the BRNN algorithm did not contribute to estimating the live weight at the end of fattening.

Table 4 showed that the prediction performance results for the XGBoost, BRNN, and RF algorithms. When all prediction performance criteria were considered, it became clear that the XGBoost algorithm outperforms the BRNN and RF algorithms in terms of estimating the live weight at the end of fattening.

Table 4. Predictive performance of data mining algorithms in a 5-fold cross-validation

Good of Fit Model Criteria	XGBoost	BRNN	RF
RMSE	1.492	2.220	2.859
RRMSE	3.014	4.486	5.777
SDR	0.233	0.347	0.446
CV	3.040	4.530	5.820
PC	0.973	0.938	0.895
PI	1.528	2.315	3.049
ME	0.039	0.000	0.168
RAE	0.001	0.002	0.003
MRAE	0.004	0.006	0.008
MAPE	2.241	3.139	4.340
MAD	1.068	1.488	2.058
R^2	0.946	0.880	0.800
R^2_{Adj}	0.944	0.880	0.792
AIC	47.190	86.121	117.441
AIC_{Adj}	47.426	86.121	117.676

Distribution of the actual final live weight values at the end of the fattening and the values predicted by the data mining algorithm is given in Figure 2.

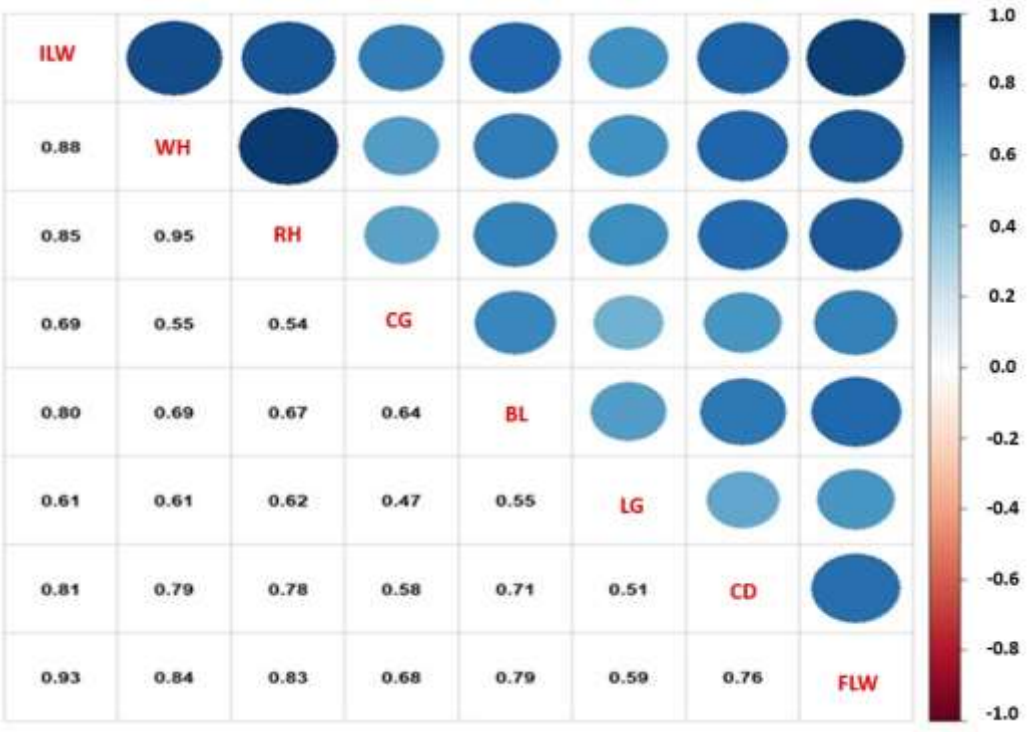

Figure 1. Pearson correlation coefficients between the ILW with some body characteristics and the FLW at the fattening.

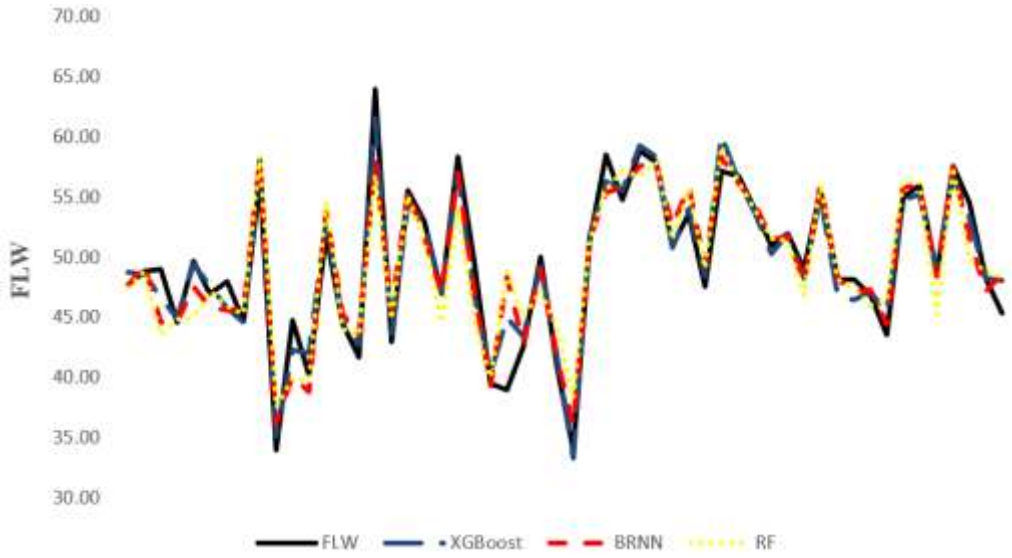

Figure 2. Actual final live weight values at the end of fattening and predicted values with data mining algorithms.

In herd management, many approaches based on body measurements are commonly used to monitor or evaluate the growth and development of animals. The reliability of the statistical methods used in estimating the live weight of animals is also of great importance. It was also stated that model comparison criteria should be used in the selection of the best model in multivariate statistics in literature (Salawu et al., 2014; Tırınk, 2022). The lowest RMSE, rRMSE, PI, SDR, MAPE, RAE and the highest r, R^2 and R^2_{Adj} values in the choice between the models in the study are taken into account. Despite the fact that there are many algorithms in the literature, some of them have still not received enough interest from researchers.

It is critical for herd management to contribute to selection by determining the algorithm or algorithms that best predict growth and development Since algorithms such as Multivariate Adaptive Regression Splines (MARS), Classification and Regression Tree (CART), Chi-Square Automatic Interaction Detection (CHAID), Random Forest (RF) and Artificial Neural Network (ANN) are widely used in the literature, some findings in this study have been partially compared with these algorithms.

To predict body weight from body measurements in Thalli sheep by using four algorithms in study made of Tırınk (2022), R^2 values of BRNN and RF algorithms were found to be 75.8% and 72.9%, respectively. As a result, the researcher stated that the MARS algorithm, which has a slightly higher R^2 (76.6%) compared to BRNN, can be used to obtain an elite Thalli sheep breed population. Akkol et al. (2017) stated that Bayesian regularization (BR) algorithm has the best prediction values (R^2: 91.00%, RMSE: 3.838, MAD: 2.9446 and MAPE: 4.7957) according to R^2, RMSE, MAD and MAPE values within BRNN, Levenberg-Marquart (LMNN) and Scaled Conjugate Gradient (SCGNN) and Multiple Linear Regression (MLR) results. As a result, they reported that this algorithm can be used as an alternative method. Akıllı and Atıl (2020) reported that the best successful performance value was obtained with Decimal Scaling normalization technique with the BR algorithm (R^2_{Adj} = 0.8181, RMSE= 0.0068, MAPE= 160.42 for test set; R^2_{Adj} =0.8141, RMSE= 0.0067, MAPE= 114.12 for validation set) for the prediction of 305-day milk yield in Holstein Friesen cows. Balta and Topal (2020) stated that Boosting, Bagging, RF and CART algorithms have obtained similar results in order to determine the best decision tree algorithm in order to determine the effects of the birth type, herd type, main age, pasture type, sex and lamb color variables in the Hemşin lambs. But, researchers stated that the Bagging algorithm with the lowest MSE (970.09), MAE (1362.65) and SMAPE (3.03) was formed. This algorithm was followed by the RF algorithm with the lowest MSE (1050.857), MAE (1404.448) and SMAPE (3.06) via best predictive performance.

Usman et al. (2020) stated that the highest coefficient of determination observed for Bayesian Regularization (BR), Levenberg Marquardt (LM) and Scaled Conjugate Gradient (SCG) respective algorithms were 82.67, 74.22 and 76.69 % respectively, in the comparative study of artificial neural network algorithms performance for prediction of first lactation 305-day milk yield in crossbred cattle. In a study made of Abbas et al. (2021), R^2 values of ANN algorithms were found to be 61.45 % to predict body weight from body measurements by using four algorithms in 152 head Thalli sheep. Although the researchers stated that all algorithms could be used in prediction, they stated that CHAID was the best prediction algorithm. When the current study and the R^2 values of both studies are compared, it is thought that the reason for the difference is due to breed and independent variables in the models. On the contrary to Akkol et al. (2017) study, Coşkun et al. (2022) stated that the MLR algorithm can be used safely for prediction by using data

mining algorithms (MLR, RF, Decision Tree (DT) and K-Nearest Neighbours (kNN) used in predictive of live weight from body measurements in Holstein cattle at different growth and development periods. In addition, researchers also stated that the RF algorithm (R^2: 91.2%, MSE: 404.08, RMSE: 20.102 and MAE: 14.718 values) has the best predictive performance after MLR algorithm (R^2: 93.9%, MSE: 277.544, RMSE: 16.66 and MAE: 13.197 values).

When the current study's results are compared to those of previous studies, the choice of algorithms with the best predictive performance in the literature may be altered due to characteristics such as the differences of species, breeds, animal numbers, animal age, and herd management method.

4. Conclusion

The results obtained from the current study show that there was a significant relationship between live weight and some body measurements. Since the predictive performance of the XGBoost model is as high as 94.6% among the data mining algorithms used in the estimation of the live weight at the end of fattening, it can be used safely in the estimation of the live weight. In addition, in the 63-day fattening period of Anatolian Merino Male lambs made by Şahin and Boztepe, (2010) study, in the group with a live weight of 35 kg at the beginnig of fattening, the total average live weight gain and daily live weight gain from fattening performans values were found to be 20.43 kg and 0.324 g, respectively. In this values in the current study, it was determined as 13.59 kg and 0.302 g, respectively. As a result, it can be said that male Anatolian merino lambs can be fattened in intensive conditions with an average initial live weight of 35 kg at fattening, and it is a good slaughter lambs material since the end of fattening can be achieved at 50 kg. In addition, the use some body measurements and algorithms used in estimating live weight at the end of fattening will be useful in other scientific studies with practical, reliable and accurate results, and their use in fattening studies will benefit breeders in selection and marketing strategy.

Author Contributions

The percentage of the author(s) contributions is present below. All authors reviewed and approved final version of the manuscript.

	G.C.	Ö.Ş	Y.A.	i.A.
C	25	25	25	25
D	25	25	25	25
S	25	25	25	25
DCP	25	25	25	25
DAI	25	25	25	25
L	25	25	25	25
W	25	25	25	25
CR	25	25	25	25
SR	25	25	25	25
PM	25	25	25	25
FA	25	25	25	25

C=Concept, D= design, S= supervision, DCP= data collection and/or processing, DAI= data analysis and/or interpretation, L= literature search, W= writing, CR= critical review, SR= submission and revision, PM= project management, FA= funding acquisition.

Conflict of Interest

The authors declared that there is no conflict of interest.

Ethical Consideration

Data collection and animal husbandry procedures were carried out in compliance with Law No. 5996's Article 9's rules for animal welfare. There is no violation of animal rights within the scope of this study.

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Research Article
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PERCEIVED EFFECTS OF CLIMATE CHANGE ON POULTRY EGG PRODUCTION IN RIVERS STATE NIGERIA

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Abstract: The study assessed the effects of climate change on poultry egg production in Rivers State, Nigeria. A total of 120 poultry egg farmers were randomly selected through questionnaire and interview schedule. Descriptive statistics and inferential statistical tools were used for data analysis. Result of the socio-economic characteristics revealed that majorities (60.8%) of the poultry farmers were males, 80.8% were married, and 61.6% had tertiary education. Also from findings, the majority (67.5%) of the poultry farmers were aware that high temperature, increase in rainfall (86.7%), erratic rainfall pattern (71.7%), decrease in relative humidity (55.8%) and flooding of poultry farms (71.7%) has harmful effects on poultry egg production. More so, the perceived effects of climate on egg production include high rate of diseases and parasites incidence, soft egg shell formation, low quantity and quality of egg production, high costs of poultry production activities, reduction in feed and water intake, and increase in poultry bird mortality. Results also revealed that television, radio, social media and fellow poultry farmers were their main sources of information on climate change. The result of Chi-square also revealed that education attainment and marital status of poultry farmers were significant at 5% used in controlling the effects of climate change, because married farmers have family labour capacity to build adaptive strategies. It is therefore commended that poultry farmers should be adequately informed on the best operating systems to minimize the harmful effect of climate change on poultry egg production as well as ensure optimum level of poultry egg production.

Keywords: Climate change, Information, Poultry production, Perceived effects, Rivers State

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1. Introduction

Climatic change is a continual alteration in the average mean of climatic parameters such as temperature, wind speeds, rainfall, relative humidity and soil moisture content owing to the changes in the constituent and structure of atmospheric gases (Otitoju, 2013). In accordance with Intergovernmental panel on climate Change [IPCC] (2001) report, the United Nations Framework Convention on Climate Change (UNFCCC) defines climate change as a variation of meteorological conditions which is associated directly and indirectly to human being enterprise that affects the distribution and formation of the global and regional environment in addition to natural climate fluctuation observed over a proportionate duration of seasons. It is apparent and understandable from this definition that change is inbred and indispensable characteristic of climate, which is induced by both man's action and natural means. According to Krishna (2011) the change in the atmospheric constituent and structure is ascribed to the emissions of greenhouse gases (GHG) such as Carbon dioxide (CO_2), Methane (NH_4), Nitrogen oxide (N_2O) and other gases. Climate change is an alteration in the mean weather that an area experienced over a given period of time. Farmers are confronting with a lot of difficulties because of change in climate and it may not be obvious in empirical stipulations what loss farmers encounter but it is acknowledged to cause more damage to the farmers' production than good (FAO, 2015). There are many human activities that are accountable for climate alteration worldwide such as poor environmental sanitation, deforestation, bush burning, drilling of boreholes, fuel combustion, and cement manufacture (European Commission Climate Action, 2022; Intergovernmental Panel on Climate Change IPCC, 2022).

The greatest impact of climate change has however been foreseen to be in the livestock production in Sub-Saharan Africa (Adesoji and Famuyiwa, 2010). Therefore, adaptation to, and mitigation of the damaging effects of acute climates has played a huge task in fighting the climatic impact on livestock (Sejien et al., 2015). There is no doubt that climate change will have effect on poultry egg productivity in many regions of the world. The adversity facing livestock is weather extremes which include severe heat waves, droughts and floods. In conjunction to production deficit, acute occurrences like disease or infection attack also lead to death of livestock (Gaughan and Cawsell-Smith, 2015).

Poultry production is a core source of protein which has encouraged poultry farmers to obtain a way of survival and livelihood. Climate change alters poultry productivity

by decreasing poultry produce and nutritional quality of feeds, fostering disease and disease-scattering pests, decreasing water accessibility and making it tough and strenuous for poultry birds to survive (Spore, 2008). Climate change shows as increase in temperature leading a fall in relative humidity and provides a favourable means for fungal and bacterial development. Epidemic of disease becomes inescapable; diseases such as coccidiosis, fowl typhoid, haemorrhagic syndrome, chronic respiratory disease, fowl pox, and bronchitis will thus be multiply (Sejian et al., 2016). Rowlinson (2008) stated that slit change in temperature will lead to reduction in the rate of poultry bird feed consumption triggering poor performance. Animal have optimum temperature confines for growth, development and coziness known as the Thermos-Neutral Zone (TNZ) that based on the species, livestock age and physiological stature, relative humidity and other determinants. Within the TNZ, livestock has maximum production level and best feed conversion efficiency. Low temperatures will lead to more feed consumption to match increased maintenance vigor and energy needs of poultry birds. Beyond the TNZ, high temperatures that bring heat stress on livestock may result in low feed consumption, decreased in production of eggs, high mortality and low reproduction. According to Indian Council for Agricultural Research [ICAR] (2010), as the environmental or atmosphere temperature rise to ≥34 °C the rate of mortality owing to heat was considerably high in meat (broiler) poultry bird by 8.4%, the feed intake of the poultry bird reduces from108.3g/bird/day at 31.6 °C to 68.9g/bird/day at 37.9 °C, the poultry bird egg production equally reduced by 6.4% as related to their normal egg production.

Given that the effects of climate change can only be mitigated and adapted to, it is appropriate and relevant to determine a forehand the effect of the trend by the farmers most involved in poultry farming. Therefore, this study aims to determine the effects of climate change on poultry egg production. The study was conducted in Rivers State Nigeria. The specific objectives of the study are to:

1. Determine the socioeconomic characteristics of the poultry farmers in the study area;
2. Ascertain the climatic factors affecting poultry egg production in the study area;
3. Identify the source of information on change in climate by the poultry farmers in the study area; and
4. Describe the perceived effects of climate change on poultry egg production in the study area.

The findings of this study will provide useful information on the effect of climate change on poultry egg production and proffer appropriate ways to mitigate its effect. It will also provide vital information for policy makers in taking appropriate actions toward improving livestock and nutrition needs of Rivers State and Nigeria at large.

2. Materials and Methods

The study was carried out in Rivers State, Nigeria. The state lies between longitude 6° 50'E and Latitude 4° 45'N, bounded on the South by the Atlantic Ocean, to the North by Imo and Abia States, to the East by Akwa-Ibom State and to the West by Bayelsa and Delta States (Niger Delta Regional Development Master Plan [NDRDMP], 2006). The state is made up of 23 Local Government Areas (LGAs). Total annual rainfall decreases from about 4,700mm on the coast to about 1,700mm in extreme north of the State and the mean monthly temperature is in the range of 25 °C to 28 °C (Niger Delta Regional Development Master Plan [NDRDMP], 2006). The State is proficient with vastness of land right and proper for cultivation of yam, cassava, maize, vegetables and rearing of livestock such as poultry, cattle, pig, sheep, fish and goat.

Multistage sampling was used to select respondents for the study. In the first stage, simple random sampling was used to select six Local Government Areas (LGAs); namely Oyigbo, Obio/Akpor, Emohua, Ikwere, Etche and Eleme LGAs. Secondly, four communities in each of the six LGAs were randomly selected to give twenty-four. Thirdly, five poultry egg production farmers were selected from each of the communities to give a total of one hundred and twenty (120) poultry egg production farmers that form the sample size for the study. Data were collected using questionnaire and interview schedule; frequencies, percentages and chi-square were used to describe and analyze the data. In order to achieve the objectives of the study, Chi-square was used to examined the relationship between socioeconomic characteristics of respondents and their awareness on climate change, as used Adesiji et al. (2013) and expressed as given Equation 1;

$$\chi^2 = \frac{(f_o - f_e)^2}{f_e} \quad (1)$$

Where;

χ^2 = Chi-square

f_o = Observed frequency

f_e = Expected frequency if NO relationship existed between the variables.

Statistical Package for the Social Sciences (SPSS) version 23 statistics software was used to analyze the data.

3. Results and Discussion

The socioeconomic characteristics of the poultry farmers are presented in Table 1 which shows that majority (60.8%) of the respondents were males. This agrees with Amos (2006) that reported that there is uneven gender distribution in poultry production in Ondo State Nigeria. It also shows that about 80.8% of the respondents were married this implies the significance of the poultry egg production in meeting the family needs and welfare.

Table 1. Socioeconomic distribution of the poultry farmers

Variables	n	%
Gender		
Male	73	60.8
Female	47	39.2
Age		
<30	13	10.8
31 – 40	33	27.5
41 – 50	31	25.9
51 – 60	38	31.6
61 and Above	5	4.2
Mean	44.69	
Marital Status		
Single	17	14.2
Married	97	80.8
Widow/Widowers	6	5.0
Level of Education		
No Formal Education	14	11.7
Primary	5	4.2
Secondary	27	22.5
Tertiary	74	61.6
Primary Occupation		
Poultry Farming	46	38.3
Civil Servant	21	17.5
Public Servant	10	8.3
Student	5	4.2
Others (Traders, Artisan and Clergy)	38	31.6
Annual Income (in ₦'000,000)		
<1	31	25.8
1.1 – 5	81	67.5
5.1 – 10	4	3.3
10.1 – 15	2	1.7
>15.1	2	1.7
Mean	2,681,930	

The mean age was 44.69 years. This agrees with Adesiji, Baba and Tyabo (2013) who reported the active age of 31 – 40 years among poultry farmers in Ondo State Nigeria. This implies that poultry farming in the study area is dominated by young people within the productive age and work force that are strong and energetic to engage in poultry farming enterprise. The majority (74.0%) of the poultry farmers had tertiary education, this agrees with Adesiji et al. (2013) that reported 42.2% among poultry farmers in Ondo State, this shows that most of the respondents were educated enough and could have access to information on climate change and its adaptive strategies. However, about 38.3% of the farmers had poultry egg production as their primary occupation and as a source of livelihood this means that the business is viable in the study area. Result of analysis also showed that majority (67.5%) make between 1.1 million and 5 million naira per annum with mean of ₦2,681,930.00 annually from poultry egg production.

Table 2 shows that change in climate is obvious. Poultry farmers were well aware of higher temperature (67.5%), increase in rainfall (86.7%), flooding of poultry farms (71.7%), and decrease in relative humidity (55.8%). This finding agrees with Elijah and Adedapo (2006) that reported that change in climatic factors are simple and evident; and the changes revolve around temperature and volumes of rainfall and their deviations.

Table 3 shows that the majority (55.8%) of the poultry farmers got most of their information from television, about 29.2% from radio, and about 30.8% from fellow poultry farmers. This supports the findings of Yahaya (2002) that television and radio are the potent source of information to farmers and their families. And with the findings of Henri-Ukoha et al. (2012) who reported that among Livestock farmers in Ukwa West L.G.A of Abia State recorded high level of usage for conventional information communication technology (ICTs) such as radio and television to obtained information on livestock production. However, radio air agricultural programmes on crops farming related than livestock production distinctively. In addition, fellow poultry farmers are not to be relied on with such professional information because it could be more of trial and error sourced.

Table 4 shows that the majority (94.0%) of the poultry farmer agreed that climate change has effect the rate of distribution of poultry diseases and parasites incidence. About 91.4% confirmed that change in climate leads to increase in poultry bird mortality while about 52.6% had been displaced due to floods incidence. Majority (87.1%) and (85.3%) attested that climate change actually leads to low feeding intake and water consumption respectively. This finding is in support of Spore (2008) which reported that change in climate could lead to an increase in diseases and parasites incidence in the pens. Research interview schedule reports the production of thin egg shells, shell-less eggs, small egg sizes, increase in broken eggs and bird life weight, agreeing with (Demeke, 2004). This endangers protein production, accessibility and utilization and also the achievement of food security and nutritional requirement in the area.

Table 5 shows that poultry farmers change poultry breeds (72.5%), plant crops (60.8%), trees and plantain around the pens (95.0%). This finding agrees with Chahet al. (2013) who reported that poultry farmers in Enugu North agricultural zone of Enugu State Nigeria adapted to climate change by planting of crops. About 5.0% construction of polyvinyl chloride (PVC) with holes over the roof of the pens. This finding agrees with Chah et al. (2013) who reported about 10.3% among poultry farmers in Enugu North agricultural zone of Enugu State that installed cooling system. This will reduce heat during high temperature and provide a well-ventilated housing stabilized the birds.

Table 2. Distribution on awareness of climate change by the poultry egg farmers (Field Survey 2018)

Variables	Yes		No	
	n	%	n	%
Higher temperature	81	67.5	39	32.5
Lower temperature	88	73.3	32	26.7
Increased in rainfall	104	86.7	16	13.3
Decreased in rainfall	47	39.2	73	60.8
Delay/Erratic rainfall pattern	86	71.7	34	28.3
Heavy winds	50	41.7	70	58.3
Change in wind direction	58	48.3	62	51.7
Flooding of poultry farms	86	71.7	34	28.3
Drought	64	53.3	56	46.7
Decrease in relative humidity	67	55.8	53	44.2

Table 3. Distribution of poultry farmers according to source of information on climate change (Field Survey 2018)

Variables	Yes		No	
	n	%	n	%
Radio	35	29.2	85	70.8
Television	67	55.8	53	44.2
Social group/association	3	2.5	117	97.5
Fellow poultry farmers	37	30.8	83	69.2
Social media	33	27.5	87	72.5
Phone	17	14.2	103	85.8
Printing materials	6	5.0	114	95.0

Table 4. Effects of climate change on poultry egg production (Field Survey 2018)

Variables	Yes		No	
	n	%	n	%
High rate of diseases and parasites incidence	109	94.0	7	6.0
Decrease weight gain	68	58.6	48	41.4
Soft egg shell formation	73	62.9	43	37.1
Low quantity and quality of eggs production	83	71.6	33	28.4
High costs on poultry production activities	84	72.4	32	27.6
Reduction in poultry bird rate of feed consumption	101	87.1	15	12.9
Reduction in poultry bird rate of water intake	99	85.3	17	14.7
Increases poultry bird mortality	106	91.4	10	8.6
Instability and inconsistency in poultry farming	71	61.2	45	38.8
Displacement of poultry farmers	61	52.6	55	47.4

Table 5. Distribution of respondents according to measures for controlling effects of climate change on poultry egg production (Field Survey 2018)

Variables	Yes		No	
	n	%	n	%
Change poultry bird breeds	87	72.5	33	27.5
Construction of polyvinyl chloride (PVC) over the roof of the pens	6	5.0	114	95.0
Poultry and crop farming	73	60.8	47	39.2
Planting of trees and plantain around the pens	114	95.0	6	5.0
Change poultry bird feeds	101	84.2	19	15.8
Reduce stock size of birds	38	31.7	82	68.3
Use of vaccines and other medications	116	96.7	4	3.3

Table 6. Relationship between socioeconomic characteristics of respondents and their awareness on climate change (Field Survey 2018)

Variables	Chi-square value	df	Significance	Decision
Age	42.000	35	0.193	NS
Gender	5.633	1	0.18	NS
Level of education	189.600	5	0.001**	S
Income level	62.400	63	0.498	NS
Marital status	123.350	2	0.001**	S

df= degree of freedom; S= Significant; NS= Not Significant; **= Significant at 5%.

Table 6 shows the relationship between measures used in controlling effects of climate variation and some socioeconomic characteristics of the poultry farmers. Level of education and marital status were significantly related to procedures and measures in adjusting and controlling the effects of climate change. This finding agrees with Adesiji, et al. (2013) who reported that the more educated an individual farmer is, the more he or she will be exposed to several techniques and means of controlling the effects of climate change and in addition, he or she will be able to search for information from the social media, printed materials and extension officers. Also, marital status of the poultry farmer will determine how much family labour he or she will be able to utilize, marital status is an essential component in determining access to adaptation strategies. This finding agrees with Aelst and Holvoet (2016) who reported that marital status of married is very central and important in accessing and building adaptive strategies in comparison to single, widows/ widowers and/ or divorcees in agricultural water management in rural area in Tanzania.

Poultry farmers with high household size could be more disposed to production information because they needed to sustain their household. However, climate change awareness did not differ across age groups, gender and level of income.

4. Conclusion

The study concluded that majority of poultry egg farmers in the study area were male, married and educated. Most of them were aware of high temperature, increase in rainfall, erratic rainfall pattern and flooding. Some of the effects of climate change on poultry egg production are high rate of diseases and parasites incidence, low quantity and quality of eggs, increase in bird mortality, reduction in the rate of feed and water consumption. These adverse effects of climate change were being adapted to/or mitigated in poultry production through planting of trees and plantain around the pens, change poultry bird feeds and use of vaccines and other medications.

From the findings, it is therefore recommended that:

1. Poultry egg farmers particularly should be adequately informed on the best operating systems to minimize the harmful effect of climate change on poultry egg production such construction of cooling system during high temperature.
2. Efforts should be made to minimize human actions that contribute immensely to the occurrence of change in climate, such activities like deforestation, bush burning, and piling of poultry waste without disposing them on time.
3. Private organizations, NGOs and Government agencies should also be encouraged to sponsor radio and television programs that will create awareness and mitigation and/or adaptation strategies on climate change as it affects livestock especially poultry production.

Author Contributions

The percentage of the author contributions is present below. The author reviewed and approved final version of the manuscript.

	A.R.A.
C	100
D	100
S	100
DCP	100
DAI	100
L	100
W	100
CR	100
SR	100
PM	100
FA	100

C=Concept, D= design, S= supervision, DCP= data collection and/or processing, DAI= data analysis and/or interpretation, L= literature search, W= writing, CR= critical review, SR= submission and revision, PM= project management, FA= funding acquisition.

Conflict of Interest

The author declared that there is no conflict of interest.

Ethical Consideration

This study was conducted before the year of 2019. In that case ethical approval doesn't required.

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Research Article
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THE EFFECTS OF NITROGEN (UREA) AND ZINC APPLIED IN DIFFERENT DOSES FROM THE SOIL AND LEAVES ON THE DEVELOPMENT, DRY MATTER AMOUNT AND MINERAL CONTENT OF WHEAT AND CORN PLANTS

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Abstract: This study was carried out to determine the effects of nitrogen and zinc applied in different doses (0.0, 0.5, 1 and 1.5 kg N/ha and 0.0 and 2.5 ppm Zn) to the soil sample taken from Erzurum Atatürk University Faculty of Agriculture Farm land on the dry matter content and mineral content of wheat and maize. It was carried out under greenhouse conditions in 96 pots (2 plants, 2 application methods, 4 nitrogen doses, 2 zinc doses and 3 replications). As a base fertilizer, it was applied to all pots before planting at doses of 1 kg P_2O_5/ha (TSP: 44.0% P_2O_5) and 1 kg K_2O/ha (K_2SO_4: 50.0% K_2O). Considering the applications, Urea and Zinc fertilizers were applied to the soil before planting in soil application, and from foliar application 5 times in every 2 weeks, starting one week after germination in foliar application. 90 days after sowing, the plants were harvested, dried, their dry weights were determined, the necessary analyzes were made and the plant mineral content was determined. According to the results obtained, nitrogen application from the soil was more effective, and the highest dry matter amount and plant height in both plants were obtained from the soil application of 1.5 kg N/ha urea and 2.5 ppm Zn. Depending on the applications, the dry matter increase is 77.5% in wheat and 80.4% in corn in application from soil. In foliar application, the dry matter increase is 11.4% in wheat and 30.6% in corn. A similar change has also emerged in plant height, the plants applied fertilizer from the soil are taller, with an average of 62.5 cm in wheat and 75.5 cm in maize. These values are on average 55.0 cm and 64.0 cm in plants applied foliar fertilizer. The mineral content of the plants applied foliar fertilizer is higher.

Keywords: Dry matter, Urea, Zinc, Dose

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1. Introduction

The rapid increase in world population and needs necessitate increasing agricultural production. It is very difficult, even almost impossible, to increase the existing agricultural lands on earth. Therefore, studies are carried out to buy more products from the unit area. These studies should be carried out using the most appropriate techniques and inputs that will not harm the environment and living things. The reasons for the use of chemical fertilizers can be counted as detecting the missing nutrients in plants, increasing the quality of the products grown, keeping the fertility of the soil at a certain level, and increasing the resistance of the plants under adverse conditions (Guzel et al., 2002, Gucdemir et al., 2008).

Plant production is one of the sources used in human nutrition. E.g; 55.0% of the energy source taken during the feeding period is met from cereals, 18.0% from animal products, 13.0% from legumes and similar products (Ayyıldız, 1982). Wheat cultivation area in the world is 220,417,745 ha and wheat production is 729,012,175 tons and the average yield is 3,310 kg/ha. In Türkiye, the cultivation area is 7.866.887 ha, the production is 22.600.000 tons and the average yield is 2.873 kg/ha. The cultivation area of corn in the world is 184,800,969 ha and its production is 1,037,791,518 tons, with an average yield of 5,620 kg/ha. In Türkiye, the cultivation area is 688.170 ha, the production is 6.400.000 tons and the average yield is 9.300 kg/ha. While wheat ranks first in the world and in Türkiye in terms of cultivation area and production among cereals, it ranks third in corn cultivation area and second in production (TUIK, 2015).

The fact that wheat plays an important role in human nutrition, especially bread, that maize is rich in carbohydrates, fats and digestible proteins in human and animal nutrition, and that maize is used in industry and handicrafts increases the importance of these plants. Corn has found a wide cultivation area in the world due to its short development period among cereal varieties, its high productivity, its suitability for mechanized agriculture, and its cultivation in different ecology and climatic conditions.

Akman and Topal (2010) investigated the effects of urea

application in different forms on yield, yield components and quality in durum wheat. In addition to the 17 kg Diamonyum Fosfat (0.8 kg P_2O_5/ha and 0.3 kgN/ha) fertilizer applied with planting, the researchers applied urea fertilizer equivalent to 10 kg N/da in the spring in seven different ways (control, all on the soil surface during tillering, and all on soil during tillering period). under tillering - 1/2 on the soil surface during tillering, 1/2 on tillering period - 1/2 under soil during tillering period, 1/2 on soil surface during tillering period - 1/ 2 by sprinkling during the earing period and 1/2 by sprinkling during the tillering period - 1/2 by sprinkling during the earing period) to plant height, ear length, ear number, number of grains per ear, grain per ear in "Cort 125" durum wheat variety. They determined the effects on the weight, the number of ears per m^2, the weight of hectoliters, the weight of a thousand grains, the harvest index, the grain yield, the protein ratio, the vitreousness. According to the findings of the researchers, the effect of urea application methods is significant on plant height, spike number, number of grains per spike, thousand grain weight, grain yield, protein content and vitreousness, spike length, grain weight per spike, number of spikes per m^2, hectoliter weight and harvest index was found to be insignificant.

In a study, the effect of ammonium sulphate fertilizer on three different rapeseed cultivars at different doses (0.0, 0.8, 1.2 and 1.6 kgN/ha) on yield and yield components of rapeseed was investigated by applying half of it at planting and the other half during flowering. According to the results of the research, nitrogen doses on plant height, number of side branches attached to the main stem, number of capsules on the main stem, capsule size, number of seeds in the capsule, thousand-grain weight, seed yield, % protein and % oil ratio, plant height, number of capsules on the main stem, The effect of cultivars on the number of seeds in the capsule, seed yield, % protein and % oil was found to be very significant (P<0.01) (Baslama, 1999).

Soğut (2005) determined the plant height, fruit number, 100 seed weight, harvest index, parcel yield and seed yield per hectare of some soybean varieties by bacterial inoculation and nitrogen fertilizer application. According to the findings of the researcher, grafting and nitrogen fertilizer application had a significant (P<0.01) effect on the investigated plant parameters.

In addition, although the investigated parameters differ according to soybean varieties, it has been revealed that bacterial inoculation is more effective on plant height, fruit number, 100 seed weight, harvest index and yield per hectare.

Karaca and Cimrin (2002) applied different doses of nitrogen (0 and 6 kg N/ha) and phosphorus (0, 0.4, 0.8 and 1.2 kg P_2O_5/ha) to a mixture of barley (25%) and vetch (75%). investigated the effects of plant height, grass yield, hay yield, % protein, plant N, P, K, Ca and Mg content. According to the researchers, the effects of nitrogen fertilizer doses on plant height, green grass yield, hay yield, % protein, nitrogen, phosphorus and potassium content of plants are significant (P<0.01), insignificant on calcium and magnesium content, phosphorus doses on plant height, green grass yield The effect on hay yield, % protein, nitrogen, potassium, calcium and magnesium content of plants was insignificant, but the effect on phosphorus content was significant (P<0.01).

Polat et al. (2007) conducted a study to determine the effect of different application methods and times on potato yield and tuber size with different nitrogen fertilizers, ammonium sulfate (21% N), ammonium nitrate (32% N) and urea (30 kg N equivalent per decare). 45% N) fertilizers (all of the fertilizer at planting; 1/3 of the fertilizer before planting - 1/3 of the first hoe - 1/3 of the neck filling; 2/3 of the fertilizer to the first hoe - 1/3 of the fertilizer) neck filling; 2/3 of the fertilizer before planting - 1/3 of the first hoe; 1/3 of the fertilizer before planting - 2/3 neck filling; 1/2 of the fertilizer before planting - 1/2' 1st hoe; 1/2 of the fertilizer to the first hoe - 1/2 of the neck filling; 1/2 of the fertilizer to the first hoe - 1/2 of the neck filling; 1/2 of the fertilizer before planting -1/4 1st hoe - 1/4 throat filling; 1/4 of the fertilizer before planting -1/2 of the first hoe - 1/4 neck filling; 1/4 of the fertilizer before planting -1/4 ' first anchor - 1/2 throat filling) were applied.

According to the results obtained by the researchers, the highest tuber yield per decare (41.64 kg/ha) is given with all the fertilizer at planting, the highest medium tuber yield (66.11 kg/ha) per decare is the highest tuber yield (22.2 kg/ha) with urea application. kg/ha) all of the fertilizer was given with planting, the least small tuber yield (15.01 kg/ha) was obtained from the fertilizer application, where 1/4 of the fertilizer was applied by planting, 1/2 in the first hoe and 1/4 in the throat filling.Small tuber yield is 183.4 kg/da in ammonium sulfate applied, 17.38 kg/ha in ammonium nitrate applied and 17.29 kg/ha in urea applied. According to the application time, the total tuber yield per decare was between 90.66 and 128.04 kg/ha, and the effect of nitrogen fertilizer application time on tuber yield was found to be significant at the p<0.01 level. When nitrogen forms are taken into account, an average of 97.19 kg/ha tuber was obtained from the ammonium nitrate applied plots, 1049.1 kg/ha from the urea applied plots and 1061.8 kg/ha from the ammonium sulfate applied plots. According to their findings, the researchers determined that it would be more appropriate to apply ammonium sulfate fertilizer together with planting at a time.

In a study conducted by Nazar (2012), foliar fertilizers with different nutrient content were applied to four different wheat varieties during tillering and stalking periods. The researcher determined that the grain yield increased depending on the fertilizers applied, and the wheat variety and foliar fertilizers were effective on the grain yield. The effects of zinc applied at increasing dose (control), 0.2, 1.5 mg kg-1 and in different forms (ZnO,

$ZnSO_4.7H_2O$, Zn-EDTA, $ZnCl_2$) on growth, dry matter and zinc content of maize plants were determined in greenhouse conditions. The highest increase in these parameters compared to the control was obtained at 1 and 5 mg kg-1 zinc doses. In general, it was determined that the most effective zinc dose was 1 mg kg-1 and the active form was Zn-EDTA, followed by $ZnCl_2$, $ZnSO_4.7H_2O$ and ZnO forms, respectively (Duymuş et al. 2020).

2. Materials and Methods

Soil samples taken from the farm land of Erzurum Atatürk University, Faculty of Agriculture, from a depth of 0-30 cm were used in the research. The soil sample taken was dried under suitable conditions, crushed and sieved through a 4 mm sieve. The research was carried out under greenhouse conditions in 96 pots and 2.5 kg of soil in each pot. After the necessary fertilizer applications were made in the pots, 10 wheat seeds were planted in the pots where wheat will be planted and 4 corn seeds were planted in the pots in which corn will be planted. After germination, 5 wheat and 2 corn plants were left in the pots. Plants were harvested, dried and dry matter amounts were determined by measuring plant heights after 90 days (Kacar, 1972). After the total nitrogen in the plant is subjected to microkjeldahl method, the plant samples that are wet burned with a phosphorus nitric-perchloric acid mixture, vanadomolybdate is subjected to yellow color method, other elements (K, Ca, Mg, Fe, Mn, Zn and Cu) are wet burned with a nitric-perchloric acid mixture. It was determined by reading in the AAS (Bayraklı, 1987). The pH of the soil sample used in the experiment was 1:2.5 in soil water suspension (McLean 1982), electrical conductivity (Rhoades 1996), lime content (Nelson 1982), organic matter content (Nelson and Sommers 1982), texture (Gree and Hortage 1986), KDK and exchangeable cations (Rhoades 1982b), available phosphorus content (Olsen and Sommers 1982), statistical evaluations were determined using the SPSS 17.0 package program.

3. Results and Discussion

3.1. Some Physical and Chemical Properties of the Research Soil

The pH of the soil sample taken from Erzurum Atatürk University Faculty of Agriculture Farm land and used in the experiment is 7.70, and it is in the class of slightly alkaline, lime content of 5.4%, medium calcareous, organic matter content of 2.1%, and phosphorus content of 5.9 kgP2O5/da. . Its CDK is 24.4 me/100g, exchangeable Ca+Ma 17.2 me/100g, exchangeable K 2.2 me/100g is sufficient, exchangeable Na is 0.6 me/100g (Aydın and Sezen, 1995). Microelements Fe 4.22 ppm, Zn 1.35 ppm, mn 4.74 ppm and Cu 1.19 ppm are at sufficient levels (Lindsay and Norvell, 1978). With an electrical conductivity of 0.75 mmhos/cm, it is salt-free, and the texture class of the trial soil is loam, containing 41.4% sand, 28.3% silt and 30.3% clay (Demiralay, 1993).

3.2. The Effect of Fertilizer Dose and Fertilizer Application Method on Plant Height and Dry Matter Amount

The changes in plant height depending on the fertilizer application method and fertilizer doses are seen in Table 1 and Figure 1, and the differences in the amount of dry matter are seen in Table 2 and Figure 2. When the plant heights are examined from Table 1 and Figure 1, the plant height in wheat varies between 45 cm and 75 cm in soil application, it is 48.5 cm in the average control and 73 cm in the highest nitrogen dose. Plant height varies between 46 and 66 cm in foliar application, with an average of 48.5 cm in control and 61.5 cm in the highest nitrogen dose. In maize, it varies between 50 and 100 cm in soil application, the average plant height is 54 cm in the control, 94 cm in the highest nitrogen dose, the plant height is between 50-76 cm in the foliar application, the average plant height is 54 cm in the control samples and 73 cm in the highest nitrogen dose was measured. Plant height is 58.5 cm in wheat and 68.7 cm in maize as an average of doses and applications. According to the fertilizer application method in wheat and corn, the average plant height is 67.8 cm in soil application and 59.5 cm in foliar application.

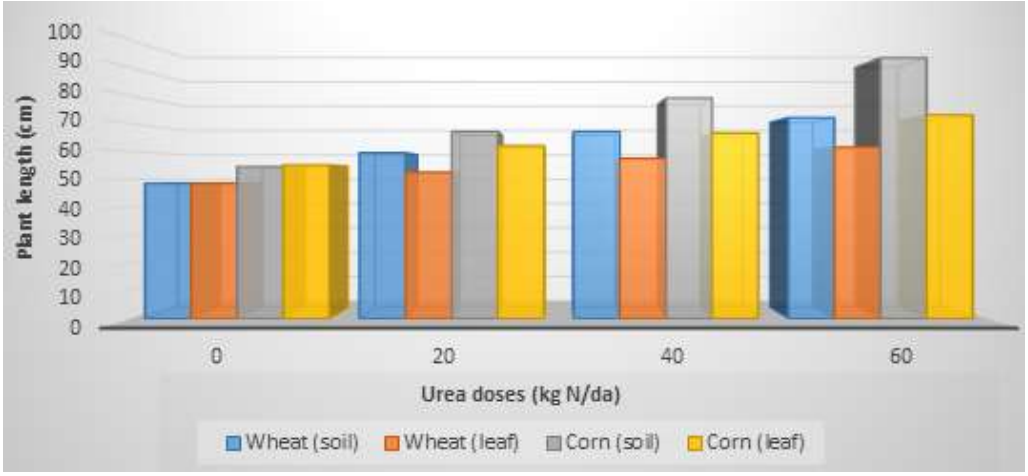

Figure 1. The effect of nitrogen doses and application method on plant height.

Table 1. Effect of nitrogen (Urea) and zinc applied in different doses from soil and leaf on plant length in wheat and corn (cm)

Plant type	Application	Fertilizer Dose		Iteration			
		Urea-N (ppm)	Zinc (ppm)	1	2	3	Mean
		0	0.0	45	49	50	48
			2.5	47	53	47	49
		20	0.0	63	57	58	59
			2.5	60	58	62	60
	Soil	40	0.0	63	69	66	66
			2.5	72	64	68	68
W		60	0.0	70	75	74	71
h			2.5	74	73	72	73
e			Mean	61.8	62.3	61.2	61.75
a		0	0.0	49	52	46	49
t			2.5	47	46	51	48
		20	0.0	52	50	54	52
			2.5	55	52	52	53
	Leaf	40	0.0	58	59	54	57
			2.5	60	55	59	58
		60	0.0	57	66	60	61
			2.5	61	60	65	62
			Mean	54.9	55.0	55.4	55.10
		0	0.0	52	55	55	54
			2.5	60	50	55	55
		20	0.0	62	73	66	67
			2.5	72	65	65	67
	Soil	40	0.0	80	75	79	78
			2.5	73	85	82	80
		60	0.0	90	90	98	93
C			2.5	92	100	90	94
o			Mean	72.6	75.4	73.8	73.90
r		0	0.0	55	50	57	54
n			2.5	53	58	58	56
		20	0.0	59	60	66	62
			2.5	64	55	67	62
	Leaf	40	0.0	68	70	60	66
			2.5	67	65	70	67
		60	0.0	72	75	70	73
			2.5	74	69	76	73
			Mean	64.0	62.8	65.5	64,10

Therefore, this plant height difference, which occurs depending on the fertilizer doses and the way of fertilizer application, is naturally reflected in the amount of dry matter. While the effect of fertilizer application method and nitrogen doses on plant height was found to be significant ($P<0.01$), the effect of zinc dose was not significant (Table 3 and 4).

When the amount of plant dry matter was examined from Table 2 and Figure 2, it was revealed that there were significant differences depending on the fertilizer application method. In wheat, the amount of dry matter in soil application varies between 7.25 and 17.80 g/pot depending on nitrogen doses, and between 7.19 and 8.87 g/pot in foliar application. In maize, on the other hand, the amount of plant dry matter in soil application varies between 8.14 and 21.70 g/pot, depending on the nitrogen doses, and between 8.21 and 13.13 g/pot in foliar application. This change in the direction of increase in the amount of wheat dry matter provides an increase of 39.5% at a dose of 0.5 kgN/ha, 125.0% at a dose of 1 kgN/ha and 145.4% (on average 77.5%) at a dose of 1.5 kgN/ha, compared to the control samples in soil application. Compared to the control, dry matter increased by 7.2% at 0.5 kgN/ha, 14.9% at 1 kgN/ha and 23.4% (mean 11.4%) at 1.5 kgN/ha. In the study conducted by Erdem (2011) Zn was applied to different corn varieties and it was stated that there was a significant increase in the dry matter amount of the corn plant as a result of the application. It has been stated that the nitrogenous fertilizer types applied to the soil increase the dry matter content of both wheat and corn plants (Kızılgöz and Sakin 2011).

Table 2. Effect of nitrogen (Urea) and Zinc applied in different doses from soil and leaf on dry matter amount of wheat and corn plants (g/pot)

Plant type	Application	Fertilizer Dose		Replications			
		Urea-N (ppm)	Zinc (ppm)	1	2	3	Mean
		0	0,0	7,25	7,10	7,33	7,23
			2,5	7,06	7,38	7,40	7,28
		20	0,0	9,91	10,34	9,69	9,98
			2,5	11,01	9,65	10,10	10,25
	Soil	40	0,0	15,68	16,48	16,23	16,13
			2,5	15,72	17,11	16,70	16,51
W		60	0,0	17,84	17,07	18,16	17,69
h			2,5	18,62	16,88	18,21	17,90
e			Mean	12,88	12,77	12,98	12,87
a		0	0,0	7,22	7,44	6,86	7,17
t			2,5	7,00	7,28	7,31	7,20
		20	0,0	7,32	7,43	7,88	7,53
			2,5	7,55	7,98	8,05	7,86
	Leaf	40	0,0	8,41	7,69	8,17	8,09
			2,5	8,72	8,50	8,05	8,42
		60	0,0	8,95	8,67	8,69	8,77
			2,5	9,55	8,51	8,83	8,96
			Mean	8,09	7,94	7,98	8,00
		0	0,0	8,33	7,69	8,22	8,08
			2,5	8,11	8,50	8,98	8,19
		20	0,0	10,66	13,74	12,62	12,34
			2,5	14,10	12,11	11,89	12,70
	Soil	40	0,0	16,06	17,85	17,13	17,10
			2,5	18,21	18,01	16,96	17,76
		60	0,0	20,19	22,54	21,18	21,30
C			2,5	23,07	20,96	22,30	22,11
o			Mean	14,85	15,18	14,79	14,94
r		0	0,0	7,78	8,35	8,38	8,17
n			2,5	8,10	7,98	8,70	8,26
		20	0,0	10,30	11,03	9,87	10,40
			2,5	11,21	10,84	10,77	10,94
	Leaf	40	0,0	11,25	11,34	12,12	11,57
			2,5	10,93	13,38	12,32	12,21
		60	0,0	13,46	12,22	12,78	12,82
			2,5	15,06	12,12	13,17	13,45
			Mean	10,88	10,53	10,76	10,72

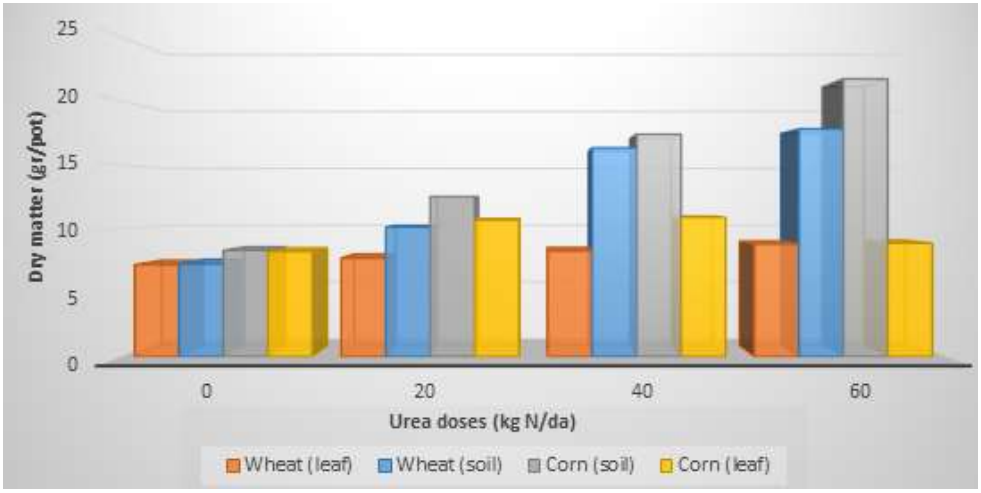

Figure 2. The effect of nitrogen doses and application method on the amount of plant dry matter.

Table 3. The effect of fertilizer doses on plant height and dry matter amount depending on the fertilizer application method and plant type

Plant Height (cm)				Dry matter (g/pot)			
Dose	n	Mean±St. Error	P	Dose	n	Mean±St. Error	P
0 ppm	24	51,67±0,876[a]	0,000	0 ppm	24	7,74±0,123[a]	0,000
20 ppm	24	60,29±1,285[b]		20 ppm	24	10,26±0,386[b]	
40 ppm	24	67,54±1,731[c]		40 ppm	24	13,46±0,770[c]	
60 ppm	24	75,00±2,476[d]		60 ppm	24	15,38±1,020[d]	
Total	96	63,63±1,219		Total	96	11,71±0,447	
0 ppm	48	63,18±1,71[a]	0,703	0 ppm	48	11,52±0,62[a]	0,676
2,5 ppm	48	64,12±1,75[a]		2,5 ppm	48	11,89±0,65[a]	

Table 4. The effect of fertilizer application method and plant type on plant height and dry matter amount

	Plant Type		Application	
	Wheat	Corn	Soil	Leaf
Plant Height (cm)	58,52±1,238[a]	68,73±1,834[b]	67,77±1,999[a]	59,48±1,129[b]
Dry matter (g/pot)	10,44±0,578[a]	12,98±0,635[b]	13,93±0,710[a]	9,49±0,304[b]
n	48	48	48	48

Dry matter increase in corn was 50.8%, 109.4% and 161.4% (average 80.4%) in soil application, 29.9%, 32.6% and 59.9% (average 30.6%) dry matter increase in foliar application, respectively. The average amount of plant dry matter in terms of doses and applications is 10.44 g/pot in wheat and 12.98 g/pot in corn. According to the fertilizer application method in wheat and corn, the average plant dry matter amount is 13.93 g/pot in soil application and 9.49 g/pot in foliar application. Considering the fertilizer doses and applications, the dry matter increase was 44.0% in wheat compared to the control, while it was 57.0% in maize, and the dry matter increase in maize was higher. The average dry matter increase is 79.0% in soil fertilizer applied plants and 23.2% in foliar applied plants. As the nitrogen dose increased, the dry matter content increased. Soil application was more effective in increasing dry matter. While the effect of nitrogen doses and application methods on the amount of plant dry matter was found to be significant, the effect of the zinc dose was not found to be significant (Tables 3 and 4).

3.3. The Effect of Fertilizer Doses and Fertilizer Applications on Plant Mineral Content

The changes in the mineral content of the plants caused by the different doses of urea and zinc fertilizers applied to wheat and corn plants from the soil and leaves are seen in Table 5. When the mineral content of the plants is examined from Table 5, the plant mineral content varies depending on the fertilizer dose and application method. Generally, depending on the application of increasing doses of nitrogen, the nitrogen content of the plants in the wheat plant contained an average of 1.72% N, while the plants applied 0.5 kgN/ha nitrogen were 1.97% N, the plants applied 1 kgN/ha 2.13% N and the plants applied 1.5 kgN/ha nitrogen. The control samples contained 2.42% N, while the control samples contained 1.52% N on average, 1.67% N on 0.5 kgN/ha nitrogen, 1.80% N on 1 kgN/ha nitrogen and 2.00% N on 1.5 kgN/ha nitrogen applied. While the nitrogen content of the experimental plants increased as the nitrogen dose increased, the concentration of other elements (P, K, Ca, Mg, Fe, Mn, Zn, Cu) in the plant tissue showed a decrease. The increase in the nitrogen content of the plant tissue can be attributed to the application of nitrogen fertilizer, and the change in the direction of decrease in other elements can be attributed to the relative decrease of these elements in the plant tissue as a result of the plant growth and dry matter increase resulting from the application of nitrogenous fertilizer.

The N, P, K, Ca, Mg, Fe, Mn, Zn and Cu contents of the plants applied fertilizer from the soil as an average of doses in the wheat plant are 2.05%, 0.22%, 3.13%, 0.59%, 0.23%, 87.1 ppm, 67.8 ppm, 60.5, respectively. ppm and 14.4 ppm, N, P, K, Ca, Mg, Fe, Mn, Zn and Cu contents of plants applied foliar fertilizers were 2.07%, 0.23%, 3.17%, 0.62%, 0.24%, 93.3 ppm, 72.0 ppm, 62.5 ppm and 15.0 ppm, respectively. N, P, K, Ca, Mg, Fe, Mn, Zn and Cu contents of the plants applied fertilizer from the soil as the average doses in the corn plant were 1.73%, 0.21%, 3.00, 0.47%, 0.16%, 69.8 ppm, 61.1 ppm, 50.2, respectively. ppm and 13.5 ppm, N, P, K, Ca, Mg, Fe, Mn, Zn and Cu contents of plants applied foliar fertilizer are 1.77%, 0.23%, 3.06%, 0.49%, 0.18%, 74.6 ppm, 63.1 ppm, 52.8 ppm and 14.1 ppm, respectively.

The N, P, K, Ca, Mg, Fe, Zn, Mn and Cu contents of the plants applied foliar fertilizer are slightly higher. This increase in dry matter mineral content is probably related to the amount of dry matter obtained. In a soil where corn plants are grown 0; 2.5; 5,0 and 10.0 µg g-1 doses of Zn were applied and it was stated that the concentrations of Fe, Mn and Cu in plant green parts decreased statistically significantly (Taban ve Alpaslan, 1996). It was stated that there was a decrease in green part phosphorus (P) concentrations, and increases and decreases in potassium (K) concentrations of wheat and corn plants applied Zn (Torun et al., 2019).

Table 5. Effect of nitrogen (Urea) and zinc applied in different doses from soil and leaf on mineral content of wheat and corn

PT	Ap	Fertilizer Dose		%					ppm			
		N, ppm	Zn, ppm	N	P	K	Ca	Mg	Fe	Mn	Zn	Cu
		0	0.0	1.71	0.25	3.23	0.64	0.26	96,4	73.6	66.9	15,9
	S		2.5	1.72	0.24	3.18	0.63	0.27	95.1	75.3	65.4	16.2
	o	20	0.0	1.99	0.22	3.13	0.61	0.24	89.3	71.8	62.6	15.3
	i		2.5	1.97	0.22	3.15	0.60	0.24	91.2	69.0	61.3	15.1
	l	40	0.0	2.15	0.21	3.09	0.58	0.22	83.6	64.8	60.5	13.7
			2.5	2.07	0.22	3.12	0.57	0.22	85.2	66.6	59.2	13.7
W		60	0.0	2.40	0.20	3.08	0.55	0.20	78.9	60.2	54.7	12.6
h			2.5	2.38	0.20	3.07	0.54	0.18	77.2	61.1	53.2	12.7
e			Mean	2.05	0.22	3.13	0.59	0.23	87.1	67.8	60.5	14.4
a		0	0.0	1.73	0.25	3.23	0.64	0.27	98,7	75.1	67.7	16.4
t	L		2.5	1.70	0.26	3.20	0.63	0.27	96.4	73.4	65.5	15.8
	e	20	0.0	1.97	0.24	3.18	0.64	0.25	94.3	74.5	64.2	15.5
	a		2.5	1.95	0.23	3.16	0.63	0.24	92.9	72.9	63.8	15.6
	f	40	0.0	2.15	0.23	3.19	0.62	0.24	93.5	71.3	60.4	14.3
			2.5	2.14	0.22	3.15	0.61	0.23	94.2	70.9	61.3	14.6
		60	0.0	2.45	0.22	3.13	0.60	0.22	89.3	69.7	59.2	13.9
			2.5	2.46	0.21	3.12	0.59	0.22	87.0	68.2	58.1	13.7
			Mean	2.07	0,23	3.17	0.62	0.24	93.3	72.0	62.5	15.0
		0	0.0	1.51	0.24	3.13	0.52	0.20	75.6	66.6	56.1	14.8
	S		2.5	1.52	0.23	3.08	0.51	0.19	78.2	65.4	53.4	14.5
	o	20	0.0	1.69	0.22	3.03	0.50	0.17	74.8	63.8	52.5	14.3
	i		2.5	1.68	0.22	3.05	0.48	0.16	70.9	64.0	51.8	13.5
	l	40	0.0	1.75	0.20	2.99	0.45	0.15	65.5	59.7	50.2	12.7
			2.5	1.77	0.21	2.94	0.45	0.14	68.6	59.3	48.2	13.1
		60	0.0	1.96	0.18	2.88	0.43	0.14	63.2	55.8	44.9	12.5
C			2.5	1.94	0.18	2.91	0.42	0.13	61.6	54.2	44.5	12.6
o			Mean	1.73	0,21	3.00	0,47	0.16	69.8	61.1	50.2	13,5
r		0	0.0	1.53	0.25	3.11	0.53	0.20	79.3	66.9	55.7	14.4
n			2.5	1.50	0.24	3.13	0.51	0.20	77.4	65.8	54.9	15.0
	L	20	0.0	1.67	0.24	3.08	0.51	0.18	76.7	64.8	54.6	14.5
	e		2.5	1.65	0.24	3.07	0.51	0.17	73.9	63.3	53.5	14.4
	a	40	0.0	1.85	0.23	3.09	0.48	0.16	75.5	62.5	51.8	14.0
	f		2.5	1.84	0.23	3.02	0.47	0.17	70.7	61.6	52.2	13.6
		60	0.0	2.05	0.20	2.98	0.46	0.16	73.0	59.7	50.3	13.7
			2.5	2.07	0.21	3.00	0.45	0.16	70.2	60.2	49.4	13.2
			Mean	1.77	0.23	3.06	0.49	0.18	74.6	63.1	52.8	14.1

4. Conclusion

According to the results of the research, nitrogen application from the soil was more effective on the plant height and dry matter amount as the average doses. The height of the plants applied fertilizer from the soil is taller, with an average of 62.5 cm in wheat and 75.5 cm in maize. These values are on average 55.0 cm and 64.0 cm in plants applied foliar fertilizer. The difference in plant height was naturally reflected in the amount of dry matter. The highest amount of dry matter and plant height in both wheat and maize were obtained from the soil application of 15.0 kgN/da urea and 2.5 ppm Zn. Depending on the applications, the dry matter increase is 77.5% in wheat and 80.4% in maize in soil application, while the dry matter increase in foliar application is 11.4% in wheat and 30.6% in corn, the average dry matter increase is 44.5% in wheat and 58.5% in corn. The effect of nitrogen doses and application methods on plant height and dry matter amount was found to be significant. The effect of zinc application on both plant height and dry matter amount was found to be insignificant. On the other hand, foliar fertilizer application was more effective on plant mineral content. - The mineral content of the plants applied foliar fertilizer is higher than the ones applied from the soil, although it is not very obvious.

When we look at the data obtained from the experiment, it is more important to apply macro (N, P, K, Ca, Mg, etc.) nutrients to the plants from the soil rather than the leaves turned out to be appropriate. Therefore, macronutrients must be applied from the soil. The insignificant effect of zinc application on dry matter and

plant height can be attributed to the sufficient zinc (1.35 ppm) content of the trial soil and the suitability of soil pH (7.70) and lime content (5.4%).

It has been concluded that it is economical and beneficial to apply fertilizer from soil, but micro (Fe, Zn, Mn, Cu, B, Mo etc.) nutrients can be applied from leaves in problematic soils (highly calcareous, high pH, coarse textured, organic soils).

Author Contributions

The percentage of the author(s) contributions is present below. All authors reviewed and approved final version of the manuscript.

	E.Y.	A.A.
C	50	50
D	50	50
S	50	50
DCP	50	50
DAI	50	50
L	50	50
W	50	50
CR	50	50
SR	50	50
PM	50	50
FA	50	50

C=Concept, D= design, S= supervision, DCP= data collection and/or processing, DAI= data analysis and/or interpretation, L= literature search, W= writing, CR= critical review, SR= submission and revision, PM= project management, FA= funding acquisition.

Conflict of Interest

The authors declared that there is no conflict of interest.

Ethical Consideration

Ethics committee approval was not required for this study because of there was no study on animals or humans.

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Review
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BLOOD SAMPLING TECHNIQUES AND PREPARING FOR ANALYSIS IN RAINBOW TROUT (ONCORHYNCHUS MYKISS)

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Abstract: In aquaculture, biochemical and hematological analyzes are frequently performed for scientific research, health screening and diagnosis of diseases. Biochemical and hematological parameters in fish as in other vertebrates varies nutrition, water quality, pathogens and various environmental factors that can create stress. Caudal vascular blood collection is a non-invasive method that is widely used to investigate fish health, biochemistry, and physiology. As a result of this method being performed under the influence of a properly selected anesthetic agent, animal welfare is affected the least, thus preventing a serious change in biochemical parameters with minimum stress. In this review, sampling collection suitable for the analysis to be performed and choosing the right anesthetic agent are presented.

Keywords: Rainbow trout, Blood sampling, Biochemistry, Hematology

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1. Introduction

Hematological and biochemical analyzes in fish are widely used methods to evaluate the physiological state and health of fish. Some of the hematological parameters are very sensitive to the change of environmental factors. All preanalytical and analytical factors can affect the results. Therefore, experience and care is required to obtain reliable hematological data (Witeska et al., 2022). Caudal puncture is a commonly used technique for blood collection in live fish. With adequate practice and improvement of procedures, it is possible to take a blood sample from the caudal vascular system of a fish, especially in large fish, without the use of even anesthetics (Lawrence et al., 2020). Various methods are used to induce sedation in fish to prepare them for sampling and to facilitate caudal puncture. For this purpose, pharmaceuticals (MS-222, Clove oil, 2-phenoxyethanol Etc.) (Martins et al., 2018) and physical influencers (electric current) (Reid et al. 2019), lowering water temperature and CO_2 (Erikson, 2008) can be applied.

The aim of this review is to compile the factors that may affect the results and to present information for researchers who will work in this field, taking into account the studies in which the blood collection process in fish is performed.

2. Various Factors That Can Affect Blood Biochemistry

Reference ranges for hematological and serum biochemical parameters have been extensively studied in humans and other mammals because of their critical importance in the diagnosis of various pathophysiological conditions (Nabi et al., 2022). Studies on fish biochemistry in veterinary medicine are few compared to human medicine. For this reason, studies in the human field have been expanded in the veterinary field (Reshma et al., 2020). Many authors have revealed the difficulty of determining normal reference values related to hematology and serum biochemistry in rainbow trout (*Oncorhynchus mykiss*) (Wedemeyer and Chatterton, 1970; McCarthy et al., 1973; Hille, 1982; Fazio, 2019). Biochemical blood parameters in fish change due to biological and environmental factors. Biological factors include fish species, population, reproduction and sex. Environmental factors, on the other hand, are the changes in the physicochemical properties of water depending on climate or eutrophication and stress. The situation does not change in rainbow trout. In order to correctly interpret the blood values observed in fish, the factors affecting them should be known and taken into consideration.

Except for recirculated systems, the changes in the water should be carefully monitored before taking samples

from the fish. Environmental pollution, biological and chemical wastes, and the pesticides (Sertçelik et al., 2018) used in the fight against agricultural pests may directly affect non-target organisms. The negative effects that may occur in any organism of the ecosystem may also affect the rest of the ecosystem through food chain or interchangeable interaction (Tunçsoy et al., 2021). The pesticide contamination following the use of organophosphorus pesticides even in sublethal doses may occur as a result of reaching the aquatic ecosystem and change biochemical parameters in the bodies of fish species that constitute non-target teleost populations (Kaya et al., 2021). In a study conducted by Deveci et al. (2016), it was revealed that the frequently used pesticide Chlorprifos-Ethyl caused oxidative stress in fish due to an increase in reactive oxygen species. Successful blood collection and obtaining reliable hematological analysis results are highly dependent on the fish itself, environmental conditions and especially the stress level at blood sampling. Some of the stress factors that can lead to biochemical changes are the preparation of fish during blood collection, transportation of the cage from one place to another, exposure to air during transportation, hypoxia, and an inexperienced person dealing with blood collection (Pollock et al., 2007; Fagundes and Urbinati, 2008; Aguirre-Guzman et al., 2016; Witeska et al., 2022).

Stress-induced haematological changes depend on the type, size, and time of action of the stressor (Ruis and Bayne 1997). Stress can cause changes on erythrocytes and biochemical parameters (eg glucose, catecholamine, enzyme activity, and cortisol etc.) (Sugeçti, 2021a; Sugeçti, 2021b; Witeska et al., 2022). There is an increase in MCV and Ht values due to stress. An increase in the number of RBCs has also been reported depending on the duration of the stressor (Dobšíková et al., 2009; Aguirre-Guzman et al., 2016; Fazio, 2019). There is also a change in the number of leukocytes depending on the duration of the stressor. While there is an increase in the number of WBCs due to short-term stress, chronic stress causes leukopenia (Tort, 2011). Stress also causes changes in the values of biochemical parameters. There is an increase in glucose, lactate and cortisol levels, especially with the effect of adrenaline (Martínez-Porchas et al., 2009; Pankhurst, 2011; Refaey and Li, 2018).

In a study conducted by Braun et al. in 2006, it was revealed that there were changes in serum catalase activity in fish exposed to hypoxia (Braun et al., 2006). In addition, in a study conducted by Keleştemur et al.in 2010, reported that lipid peroxidation in blood and tissues started with the increase in serum MDA level due to stress in rainbow trout fry during transplantation (Tuna Keleştemur et al., 2010).

3. Correct Anesthetic Selection and Importance of Dose

Fish can be physically restrained without anesthesia. However, this can cause stress and biochemical changes. It is also not suitable for animal welfare (Barton, 2002; Acerete et al., 2004;Ramsay et al., 2009). General anesthesia is defined as a temporary loss of sensation through depression of the central nervous system. Anesthetics primarily serve to immobilize a fish. Therefore, these agents can provide conditions for rapid blood collection from the animal without physical restraint and to minimize stress-related effects (Lawrence et al., 2020).

Since non-lethal blood or sampling procedures are minor surgical procedures, mild anesthesia or sedation of the fish would be the right choice. Also, using a light dose of anesthetic will speed up the recovery of the fish (Javaher et al., 2012; Trushenski and Bowker, 2012; Smith et al., 2017). In addition to choosing an appropriate anesthesia protocol, the correct dose and correct anesthetic agent selection is very important. Otherwise, fish welfare may deteriorate or data may change. In addition, death may occur in fish exposed to too much anesthetic. Anesthetics commonly used for this purpose, MS-222 and 2-phenoxyethanol, Metomidate and Ketamine can be used singly or in combination (Martins et al., 2018).

There are also some disadvantages of using anesthesia during blood collection from live fish. The most important of these is the slow induction and long awakening time, which causes the fish to be under anesthesia more than necessary due to the short nonlethal blood collection time (Hikasa et al., 1986; Mylonas et al., 2005; Neiffer and Stamper, 2009).

Finally, after the use of anesthetic substances, legal washout periods should be waited for the consumption of fish. Especially in aquaculture, consumption of fish must be prevented after sampling. The wash-out time varies for the anesthetic to be used. For example, for fish using MS-222, the US Food and Drug Administration (FDA) recommends a 21-day washout period for the chemical to leave the tissues. In addition, the FDA recommended dose for sedation with MS-222 is 15 - 50 mg/L, for anesthesia 50 - 200 mg/L (FDA, 2020).

4. Suitable Blood Collection Regions for Rainbow Trout

4.1. Cardiac Puncture

The cardiovascular system in fish is relatively simple compared to other vertebrates. It consists of two main components, the heart and the peripheral vascular system. Due to the absence of the diaphragm found in mammals in fish, the body cavity is in one piece. The heart is located cranially in the main body cavity, inside the pericardium. The heart is a four-chambered structure consisting of *sinus venosus*, *atrium*, *ventricle*, and *bulbus arteriosis*. It also has a one-way flow of deoxygenated blood. Deoxygenated blood is collected posterior to the hepatic veins to enter the *sinus venosus* via a two-channel duct system from the anterior of the fish. *Sinus venosus* opens into the atrium with a valve. The *atrium* has thick

muscular walls and pumps deoxygenated blood into the *ventricle* (Eissa, 2016). The *ventricle* is relatively large enough to receive blood. In adult rainbow trout, the heart can reach 1.5 – 2 cm in size. Considering the contraction of the heart, it is possible for the cannula to come out of the heart. Therefore, blood collection by cardiac puncture is not a practical method (Duman et al., 2019).

4.2. Dorsal Aortic Puncture

By means of a hypodermic needle tip, repeated blood collection from the dorsal aorta at the roof of the oral region is possible. For this procedure, the fish must be anesthetized with a suitable anesthetic. The needle tip is inserted into the dorsal aorta at an angle of approximately 45 °C, just behind the 3rd and 4th gill arches. Eight vessels from the gills join the dorsal aorta just before this point. This technique is suitable for blood pressure studies as well as facilitating sampling for hematological analysis (Schiffman, 1959). For rainbow trout between 60 and 1200 grams, a 22 Gauge needle tip can be used to draw blood with this technique. However, since the mouth of the fish must be open for blood collection from the dorsal aorta, it will not provide a suitable working area for small fish. This process can be used to obtain the appropriate amount of blood in adult fish.

4.3. Caudal Vein Puncture

Depending on the size of the fish, 21 and 23 Gauge needle tips can be used for Caudal Vein Puncture. Generally, the caudal vein is located in the haemal arch dorsal to the vertebral arm. As a result, reaching the tip of the syringe into the vertebral column is the primary cue for finding the caudal vein (Lawrence et al., 2020). For this process, it is recommended to enter the fish at an angle of 45 °C just behind the anal fin and proceed up to the vertebral column. If the blood does not start coming from this point, the syringe is pulled back a little and the vein is reached. However, due to the asymmetrical cut of the needle tip, it is also possible that the blood does not come out despite being in the vein. In order to prevent this, turning the needle tip a little can help the blood to enter the needle tip. Generally caudal puncture is suitable for haemal posterior reach for most fish species (Jeffries et al., 2011; Lawrence et al., 2018). Another advantage of caudal puncture is that it is done behind the anal fin. So, it does not involve the risk of damaging vital organs. For this reason, caudal vein puncture is the most suitable procedure for repeated blood draws (Reid et al., 2019) (Figure 1).

5. Blood Draw Amount

In trout and other teleost fish, the blood volume is about 3% of their body weight. For nonlethal blood collection techniques, large volumes of blood collection in a short time can cause adverse physiological consequences in fish such as hemodilution, cardiovascular changes, lethargy and temporary loss of balance due to hemorrhagic shock, including neuroendocrine responses (Schiffman, 1959; Duff and Olson, 1989). There is no widely accepted rule for how much blood can be drawn from live fish. However, the Canadian Department of Fisheries and Oceans considers it appropriate to take up to 0.1% blood (Canada Department of Fisheries and Oceans, 2004).

6. Equipment Selection

Various sizes and lengths of needles, injectors (vacutainer or manual) and tubes are needed for blood collection. Needle size and length vary depending on the size of the fish, but vary between 20 – 30 Gauge. The tube should be selected in accordance with the analysis to be made. For example, in tubes to be used for the analysis of serum biochemical parameters, silica gel tubes should be preferred because it facilitates the separation of serum in centrifuge (Duman et al., 2019). Vacutainer tubes are classified according to cap colors and analyzes to be used. Accordingly, for serum collection, bacteriological and parasitological analysis, the use of a chemical-free red capped tube, for clinical biochemistry parameters and plasma collection a green cap (with lithium or sodium heparin), for hematological examination a purple cap (with EDTA), and for coagulation studies light blue cap (sodium citrate) it is appropriate to use tubes. Pediatric tubes or manual syringes should be used when collecting blood from small fish, as the use of a very large tube or syringe will cause severe hemorrhagic shock in small fish (Canada Department of Fisheries and Oceans, 2004; Duman et al., 2019; Duran, 2019) (Table 1).

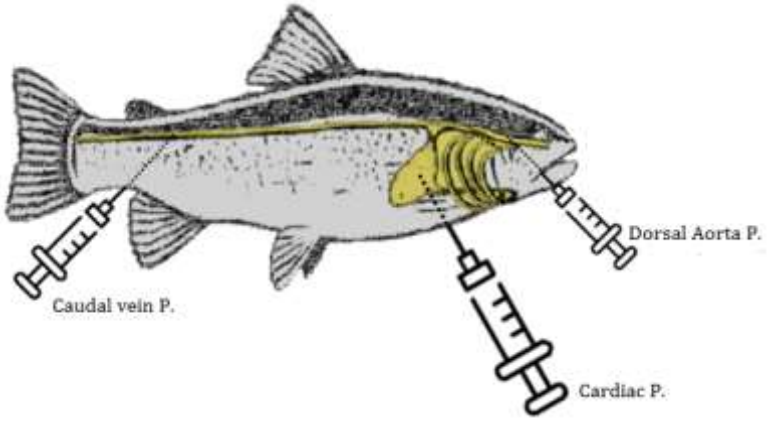

Figure 1. Schematic representation of different body parts for blood collection from fish.

Table 1. Blood collection equipment to be selected according to the size of the fish.

Size (g – cm)		Needle (Gauge)	Syringe (Capacity)	Methods
Larva		Hematocrit glass capillary tube	50 – 75 uL	Tail cuting
Fry (< 5 cm, < 7 g)		30 G	1 cc	Caudal vein P., Cardiac P.
Juvenil (< 250 g)		29 G, 25 G,	1 cc	Caudal vein P., Cardiac P.
Adult (300 g – 3000 g)		23 G, 22 G, 19G	2.5 cc, 5 cc	Caudal vein P., Dorsal aorta P.

7. Equipment Selection

Blood taken into sterile tubes should be brought to the laboratory by paying attention to the cold chain before starting the study. For serum isolation, blood should be kept at +4 °C for at least 1-2 hours in order to allow blood to clot. Coagulation is not possible since 10% EDTA is sampled for plasma isolation (Worldfish/CGIAR, 2019).

It is recommended that the blood taken into dry and clean tubes with yellow or red caps for serum isolation and EDTA tubes for plasma separation should be centrifuged at +4 °C for 7000 G x 15 minutes. For serum and plasma isolation, it is recommended to take at least 200 µL of blood from each fish (Ideally > 500 µL) (Worldfish/CGIAR, 2019). Blood volume scale with body size, that typically 3-4% of body mass in teleost fishes (Olson, 1992). This ratio shouldn't be passed for nonlethal blood drawing in rainbow trout.

Plasma/Serum preparation steps:

1. Draw the appropriate amount of blood for the size of the fish within 3 minutes of being caught.
2. Remove needle and dispense blood into to centrifuge tube.
3. Transport to lab on ice or cool packs
4. Allow blood to coagulate for a minimum of 2 – 4 hours at room temperature for serum isolation.
5. Centrifuge tubes at 7000 x G for 15 minutes.
6. Collect serum (upper clear supernatant layer).
7. Transfer serum to new sterile tube (store at –20 °C or –80 °C for future analysis)

8. Conclusion

The circulatory system provides important data for monitoring the health and physiology of fish. Taking blood samples from live fish with appropriate equipment is a common practice for researchers. The correct selection of the techniques and equipment used is very important for the reliability of biochemical and hematological analyzes. In addition, it should not be forgotten that even the easiest of these processes creates stress on the fish. In terms of animal welfare and reliability of analysis, studies have shown that the most appropriate method for nonlethal blood sampling, including small fish, is caudal vein puncture, and in large fish, both dorsal aorta and caudal vein puncture. In this review, blood collection techniques and correct equipment selection for rainbow trout, which is the most cultured in the world, are presented.

Author Contributions

The percentage of the author(s) contributions is present below. All authors reviewed and approved final version of the manuscript.

	U.D.	S.Ç.	B.Ş.
C	40	30	30
D	25	50	25
S	40	30	30
L	40	30	30
W	25	25	50
CR	50	25	25
SR	50	25	25

C=Concept, D= design, S= supervision, L= literature search, W= writing, CR= critical review, SR= submission and revision.

Conflict of Interest

The authors declare that there is no conflict of interest.

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Review
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TÜRKİYE'S WHEY CHEESES

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Abstract: In parallel with the increase in the population in the world, the amount of milk production also increases and a significant part of it is processed into cheese. Whey, which is mostly a by-product of the cheese industry, has a very high nutritional value and is used in the production of different cheeses in various countries. Different whey cheeses can be produced by processes such as thickening of whey by boiling, kneading curd cheese by mixing with different brine solutions, using yoghurt, butter, Çökelek, local herbs etc. in production, maturing in different ways. Ricotta, Mysost, Primost, Mascarpone, Requesón, Serac, Brousse, Zieger, Manouri, Myzithra, Ziger, Urda, Klila etc. are famous whey cheeses in the world. In Türkiye, cheeses such as Lor Peyniri (widely), Tire Çamur Peyniri, Horç, Tort/Dolaz, Kopanisti, Armola, Sepet Loru, Kirlihanım Peyniri, Taze Keş, Sarı Keş, Antakya Sürkü, Antakya Küflü Sürkü, Sirvatka Loru, Dumas Çökeleği, Otlu Lor and Şor Loru are cheeses made from whey.
Whey cheeses produced in Türkiye have been dealt with separately or in summary in the literature and gathered in a joint report with this study.

Keywords: Whey, Whey cheeses, Lor, Horç, Dolaz

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1. Introduction

Whey is a dairy by-product obtained after coagulation of milk, mostly cheese production, and contains all milk components dissolved in milk in varying proportions (Zall, 1992; Tunick, 2008; Yerlikaya et al., 2010). While this precious product used to be used as animal food and fertilizer or appears as waste around the world, it is now used in various products such as infant formulas, food supplements, sports bars and beverages to meet the various health goals of people of all ages (Hong, 1983; Gangurde et al., 2011; Karimidastjerd and Gulsunoglu-Konuskan, 2021).

Whey is among the drinks that Hippocrates recommended about 2500 years ago to increase the body's immune system, strength and muscle growth rate. In the late 16th century, the importance of whey protein was rediscovered when some Swiss farmers noticed that the pigs fed with whey grew faster than others. So the farmers began to drink the whey themselves. When they noticed improvement in their health, the news quickly spread throughout the country. In the last 20 years, whey protein has transformed from being a waste product of cheese making into a very valuable product in terms of its nutritional and functional properties (Gangurde et al., 2011; Çelik and Yüksel Önür, 2020).

Depending on the type of cheese, 1 kg of cheese is produced from 10 kg of milk, and 9 kg of whey is released. Considering the amount of cheese produced worldwide on a daily or annual basis, this figure reaches much more remarkable dimensions. This whey is left to sewers in significant volumes in our country and some other countries, especially in small businesses. However, the disposal of these by-products causes significant losses in terms of energy and protein resources, as well as causing serious problems in the environment with high biological and chemical oxygen demand (Pintado and Malcata 2000; Almeida et al., 2008). For this reason, a number of countries have introduced strong legislation prohibiting the discharge of whey into streams, rivers and even municipal sewage systems (Smithers, 2015; Blažić et al., 2017).

Over the last seven decades, technological advances, increased processing capacities and new business models have shaped the dairy industry and supported the production of new value-added ingredients derived from whey. The isolation of whey components and the production of powdered whey components have been successful through the development of processing technologies, particularly membrane filtration. In combination with centrifugation and electrodialysis, it allowed the production of pure protein fractions (Yerlikaya et al., 2010; Tsermoula et al., 2021). However, since the production methods of whey proteins require large capital investments, they can only be made by a few large dairy enterprises in our country. In some other businesses, it is turned into powder or given to the milk powder factories for a very low fee or free of charge. On the other hand, in small dairy enterprises, it is used for the production of whey cheese called Lor or it is discarded without being used (Ekin, 2016).

Hatipoğlu and Çelik (2012) in their study on traditional cheeses produced in the Karacadağ basin of Diyarbakır province and the problems encountered, reported that the whey, which is referred to as waste in cheese production, was mostly (90%) not evaluated; and it was used (10%) in making butter or Lor in very few businesses and it was used by adding it to the brine at a low rate to get a brighter appearance.

In our country, dairy products are produced in small family businesses as well as industrially. Here, whey is either processed into Lor Peyniri or is encountered as waste. In this respect, this valuable product can be partially evaluated by processing it as whey cheese in these small businesses, and by increasing people's awareness on this issue and encouraging its consumption. In this study, cheeses produced from whey in our country are discussed.

2. Whey Cheeses

2.1. Lor Peyniri

Although the terms "Lor" and "Çökelek" are sometimes used interchangeably in our country due to their external similarities, the two are different products. Çökelek is a product obtained by precipitating the milk by adding lemon or some local herbs to facilitate precipitation after its acidity increases, and it contains both casein and whey proteins. It is also known as Ekşimik, Süt Koptu, Akkatik, Kesik, Torak, Urda, Süt Kırması or Jaji in its dried form in different regions (Kamber, 2008; Çardak, 2012).

Lor, on the other hand, is a low-fat or fat-free cheese obtained from the precipitation of whey from milk cheese production or buttermilk from yoghurt butter production, and contains less casein since the milk was previously processed into another product. It mostly consists of whey proteins and is sometimes consumed by mixing with products such as yoghurt, butter, Çökelek, local herbs, etc. to increase its flavor (Kamber, 2008; Çardak, 2012). There are some very popular cheeses among whey cheeses in the world. Ricotta in Italy, Argentina and America, Mysost, Primost, Gjestost, Grubransdalsost in Norway, Schottenziegr, Hudelziger, Mascarpone in Switzerland, Requesón in Spain, Serac, Brousse, Broccio, Greuil in France, Zieger, Schottenzieger in Germany, Manouri, Myzithra, Anthotyros in Greece, Ziger, Urda in Romania, Klila in Tunisia, Urda in Israel, Requeijão do Norte, Ricotta Fresca in Brazil, could be examples of cheeses made from whey (Irkin, 2011; Ekin, 2016; Salameh et al., 2016).

When the whey is heated, the remaining proteins (albumin and globulin) that do not coagulate with rennet and can be precipitated by heat are collected on the surface as clots. Acidity facilitates this separation. The well-known example of this in our country is Lor Peyniri (Kurt and Gülümser, 1987).

In our country, Lor Peyniri is generally produced in family businesses according to the traditional method. The whey remaining after cheese production is boiled in boiling cauldrons until coagulation is formed. After boiling, the clot particles (serum proteins) collected on the surface of the boiler are removed and the water is filtered using fine porous cloths. Straining is done for periods ranging from 1 to 4 days. When the desired humidity is obtained, 2-8% salt is added to the product and offered for consumption (Demirci et al., 1994; Tekinşen and Tekinşen 2005). It is used in Turkish cuisine for making pastry, pasta and salads or, as in the Eastern Black Sea region, for breakfast dishes such as Buğulama and Mıhlama. (Durlu-Özkaya and Gün, 2007).

The visual of Lor Peyniri is presented in Figure 1, its chemical and microbiological properties are presented in Table 1 and Table 2.

Lor Peyniri is a nutritious food and is very prone to microbial spoilage. It can turn into a microbiological threat in terms of public health and shorten the shelf life of cheese, if it is not produced and offered for sale under appropriate conditions (Tanıs et al., 2021). Compared to air or vacuum packaging for Lor Peyniri, modified atmosphere packaging prevents the development of microorganisms that cause deterioration of the product and prolongs the shelf life of the product (Irkın, 2011; Temiz et al., 2009).

Figure 1. Lor Peyniri.

Table 1. Chemical properties of Lor Peyniri

	Demirci et al. (1991)	Sönmez et al. (2019)	Çardak (2012)	Ergüllü (1982)
Total solid (%)	25.99	28.70-29.15	27.87-41.87	27.57
Fat (%)	5.34	11.24-11.46	2.80-6.60	7.30
Protein (%)	13.50	-	10.21-21.05	12.88
Ash (%)	1.24	2.40-2.30	2.11-3.45	1.12
Lactose (%)	5.91	-	-	7.50
Salt (%)	-	0.46-0.76	1.12-2.23	-
Acidity (% LA)	1.31	0.46-1.84	0.33-0.82	0.31
pH	-	5.90-5.48	3.75-5.93	-
n	17	50	25	17

Table 2. Microbiological properties of Lor Peyniri (log cfu/g)

	Sert and Kıvanç (1985)	Demirci et al. (1991)	Sönmez et al. (2019)	Çardak (2012)
TAMB	7.75-8.77	6.11-8.46	7.15-8.02	3.46-6.72
Coliform	0-4.60	4.00-6.60	4.44-4.57	<0.47->3.04
E. coli	-∞-3.54	-	3.41-2.52	<0.47->3.04
S. aureus	-∞-1.30	-	1.86-2.52	2.69-4.85
Fecal streptococcus	2.55-4.41	-	-	-
Yeast and mold	3.53-7.92	-	1.86-4.14	2.34-4.90
n	18	17	50	25

TAMB= total aerobic mesophilic bacteria

2.2. Tire Çamur Peyniri

Tire Çamur Peyniri is a spreadable cheese traditionally produced in Tire district of İzmir and is consumed at breakfast (Dağ and Keskin, 2020; Hastaoğlu et al., 2021; Karaalioğlu et al., 2021). While it was previously made with the whey obtained from the production of Beyaz Peynir or İzmir Tulum Peyniri made from sheep and goat milk, today it can also be produced from the whey of these cheeses produced from cow's milk or their mixture (Keskin and Dağ, 2020).

To make Tire Çamur Peyniri, Lor Peyniri is first prepared. If cow's milk is used in production, some milk can be added to the whey at the beginning (Dağ and Keskin, 2020). The whey and milk mixture is heated to 90-95 °C and kept at this temperature for about 30 minutes. Curd collected on the surface is transferred to cloth bags, left to drain, and Lor Peyniri is obtained in this way. The second whey remaining from the Lor Peyniri production is cooled to be used in the kneading process. About 2-3% of salt is added to the Lor Peyniri and left to stand for 4-5 hours. Then, the cooled second whey is added little by little and kneaded well. As a kneading solution, ripened tin Tulum Peyniri brine (prepared with second whey) or normal brine can also be used. Cream can also be added at this stage, if desired. The amount of brine added is measured according to the desired consistency of the cheese. It becomes ready for consumption as a soft cheese suitable for spreading. Çamur Peyniri is stored in a cool place (Çelikel et al., 2020; Karaalioğlu et al., 2021). The visual of Tire Çamur Peyniri is presented in Figure 2, and its chemical and microbiological properties are presented in Table 3 and Table 4.

Figure 2. Tire Çamur Peyniri.

Table 3. Chemical properties of Tire Çamur Peyniri

	Ak and Nergiz (1998)	Erdoğmuş (2020)	Karaalioğlu et al. (2021)
Total solid (%)	37.94	30.35-27.33	31.20
Fat (%)	25.82	-	16.40
Protein (%)	6.75	-	10.95
Salt (%)	3.16	1.02-2.20	-
Ash (%)	0.96	-	-
Acidity (%)	-	0.10-0.08	0.22
pH	-	6.77-5.15	5.50
a_w	-	0.92-0.90	-
n	-	4	8

Table 4. Microbiological properties of Tire Çamur Peyniri (log cfu/g)

	Ak and Nergiz (1998)	Erdoğmuş (2020)
TAMB	9.69	4.99-4.56
Total psychrophilic aerobic bacteria	-	4.99-4.56
Yeast and mold	6.77	3.35-3.87
Lactic acid bacteria	-	3.46-5.35
Total coliform bacteria	6.87	1.75-2.27
Fecal coliform bacteria	-	1.46-1.91
n	-	4

TAMB= total aerobic mesophilic bacteria

2.3. Horç

Horç is a traditional whey product produced by the Yoruks (Yoruk is the Turkish people who have preserved the nomadic lifestyle) living in Anatolia for years (Eliuz, 2020). It was determined that it was known as Horç in Erdemli and Silifke regions, and made by the Yoruks living around Isparta, Afyon, Antalya (in the lakes region), and it was known as Tort/Dolaz there, and it was given different names as Sarı Keş in the Anamur region (Uçgun and Işık, 2018).

Horç is made from sweet whey. Its making steps are summarized by Uçgun and Işık (2018) and Eliuz (2020) as follows: Raw milk is heated to 30-35 °C and fermented for approximately 2 hours by adding ~5ml of rennet for 30 L of milk. Cooking is started after scratches are made on the formed clot with the handle of the spoon. In the meantime, it is stirred frequently and the cooking is stopped when the whey is separated. The mixture is filtered through cloth bags and the obtained whey is collected in a cauldron. At this stage, some milk can be added upon request. Subsequently, heat treatment is applied again. When it starts to boil, the curd formed is taken with ladles and boiling is continued. Boiling time varies depending on the amount of whey. If its amount is high, it takes a long time to reach a certain consistency. After the whey thickens (Figure 3), curd taken can be added back at this stage.

Figure 3. The thickened state of heat-treated whey.

By reducing the cooking temperature, heat treatment is applied for another 15-20 minutes. It is then cooled and filtered through cloth bags. The filtrate is pressed for 1-2 days. After suppressing, it is crumbled, salted, optionally mixed with Çökelek and pressed into a skin bag (tulum) or plastic drums. It can be stored in a pothole or cold storage at 4 ˚C for 3-4 months. Horç, which is pressed into skin bag and rested in a sinkhole, is more delicious than the one that is pressed into a plastic drum. 2.5 kg Horç is obtained from 30 kg of milk. The image of Horç is presented in Figure 4.

Figure 4. Horç.

Horç can be consumed plain, or it can be consumed by adding raw or roasted onions in butter. Again, it is mixed with Çökelek made from the local buttermilk, and then "Sıkma" is done, especially when phyllo bread is made. Sıkma is made as follows; after the flatbread is cooked, it is butterred, wrapped by putting the Horç with onion inside, and squeezed from both sides by hand. Local tradesmen have it made collectively and eat it for breakfast. It is consumed at breakfast and afternoon meals (Uçgun and Işık, 2018).

2.4. Tort and/ or Dolaz

Tort and/or Dolaz are cheeses traditionally made by the Yoruks living in the Mediterranean region around Isparta, Antalya and Afyonkarahisar (Şimşek and Sağdıç, 2006). Tort is obtained by boiling the whey and subjecting it to heat treatment for a long time; Dolaz, on the other hand, is a product obtained by using milk, flour, butter, tort and yoghurt. (Ak and Bulut, 2020). They are produced from sheep, goat and cow milk, mostly sheep and goat milk. However, they are not produced much due to the decrease in sheep and goat husbandry recently (Okur, 2010).

Tort is made by boiling the whey for a long time and then straining it in cloth bags, putting heavy stones on it and pressing, then crumbling the product obtained and pressing it into skin bags or plastic drums. There are some points to be considered while making Tort: First of all, the cauldron in which the whey is boiled is covered with mud from the outside to prevent sticking and burning. Pressing into the skin is more preferred, as the excess water of the cheese will be better drained from its pores. While filling these materials, which are used as tort packaging material, they are pressed tightly and even sticks called "saplık" are used among the people for this. Otherwise, the porosity of the product will increase and air will remain inside. This causes the product to turn green (göğermek) that is, to mold and spoil. Şimşek and Sağdıç (2006) also stated that butter or Çökelek can be optionally added during the pressing into the skin bag.

Tort prepared in this way is taken out a little when it is to be consumed and poured into the butter melted in the pan. After roasting for a while on low heat, a small amount of water and some crumbled phyllo bread pieces are added. It will be ready for consumption after it has been fried for a while. The people call this food Tort or Deli Dolaz (Ak and Bulut, 2020).

Traditionally, in the production of Dolaz, whey, buttermilk, optionally milk, yoghurt and Lor Peyniri are used (Okur and Güzel-Seydım, 2011). If milk is used instead of whey, Dolaz made in this way is also called Süt Dolazı or Akıllı Dolaz (Milk Dolaz or Smart Dolaz). It is made by adding Tort to milk (Ak and Bulut, 2020).

Okur and Güzel-Seydım (2011) obtained cheese samples from the Isparta region in their study to determine the production method, microbial and sensory properties, and aroma components of traditional Dolaz cheese and reported the production of this cheese by observing it on site. Dolaz samples used in this study were prepared using whey (53%), buttermilk (10%), optionally milk (10%), and yoghurt (25%), Lor Peyniri (2%). The mixture prepared in this way was taken into the cauldron and subjected to heat treatment by frequently mixing with a long, cylindrical wooden mixer called “Bişşek” by the local people. Its color was yellow-light brown and heat treatment was applied until it had a consistency. After the heat treatment, it was cooled by resting for 12 hours and then transferred to cloth bags for filtration. After being matured in bags for 3-4 days, it was salted and filled into bags again and kept for 5 days. At the end of this period, it was mixed with some butter depending on preference and stuffed by pressing into the skin bag. The skin bags were kept in cool rooms (15 °C) for 15-20 days. Dolaz production was similarly expressed by Yerli et al. (2018). The visual of this cheese is presented in Figure 5.

Figure 5. Dolaz.

Like other whey cheeses, Dolaz contains all of the essential amino acids in high concentrations and stands out with its functionality. It can be stated that aldehydes and aldehyde derivatives, which are formed mainly by lactic acid fermentation and the maillard reaction during cheese production, add a characteristic aroma to Dolaz cheese (Avcı et al., 2021). According to the descriptive sensory analysis findings, the characteristic sensory properties of Dolaz were determined as a soft, yellowish-light brown color, unique smell and taste, no cooked taste despite long-term heat treatment, and a granular structure similar to Çökelek (Okur and Güzel-Seydım, 2011).

Dolaz is classified as fatty and soft cheese according to its fat values in dry matter and dry matter (Okur, 2010). The researcher also stated that in the protein fraction analyzes of traditional Dolaz samples, especially α and β caseins and β-lactoglobulin bands were observed. Alanine, Leucine- Isoleucine and Histidine were the free amino acids most detected in Dolaz samples. Some volatile components such as acetaldehyde, acetone, ethanol, acetic acid, diacetyl and 1-butanol were detected in Dolaz samples. It was also reported by this researcher that the characteristic natural color of Dolaz is dark yellow-light brown. Chemical and microbiological properties of Dolaz are presented in Table 5 and Table 6.

Table 5. Some chemical analysis results of Dolaz

	Şimşek and Sağdıç (2006)	Okur (2010)
Total solid (%)	52.04	30,31-48,63
Fat (%)	17.70	6,5-19
Acidity	1.62	1,08-3,42
pH	4.58	3,58-5,61
Salt (%)	-	2,11-6,32
Protein (%)	15.21	21,49
n	10	

Table 6. Some microbiological analysis results of Dolaz (log cfu/g)

	Şimşek and Sağdıç (2006)	Okur (2010)
TAMB	5.41	7,68-8,23
Yeast-mold	4.13	6,90-7,37
Coliform	-	2,83-3,84
Lactobacillus	-	7,87-8,08
Lactococcus	-	7,63-8,17
n	10	-

TAMB= total aerobic mesophilic bacteria

2.5. Kopanisti

Kopanisti is a cheese produced in the Greek islands in the Aegean Sea and around İzmir in our country. While it was produced in a larger area consisting of Çeşme, Karaburun, Foça and Urla districts of İzmir and exported to the Greek islands in the Aegean Sea, today it is made by a few families with traditional methods only in Karaburun, Sakız and Midilli. (Akpınar et al., 2014).

Kopanisti is a cheese of Greek origin and the word "Kopanisti" means "kneaded" in Greek (Hastaoğlu et al., 2021). In Greek islands, it is made from sheep, goat or cow's milk or from a mixture of such milks, and in our country, whey. It has a taste reminiscent of Roquefort cheese and it appeals to a certain consumer segment due to its intense aroma and bitter taste (Karabıyıklı and Karapınar, 2006). In addition, mold growth is desired in the production of Kopanisti in Greece. In our country, although surface molding is not observed in the cheese in question, molds have an important place in the microbial flora.

The production technique of Kopanisti shows slight differences according to the districts in our country. This cheese is made from the curd obtained from the whey released in the production of Sepet Peyniri from goat's milk. The main feature of its production is that the curd is transferred to earthen pots and kneaded in these pots until the desired sensory properties are obtained (Dağ and Keskin, 2020).

In the production of Kopanisti, Sepet Peyniri is obtained primarily by using goat's milk, and the remaining whey is heated to 80-85 °C in a separate boiler. In the meantime, 10-20% of fresh goat's milk is added and the heating process is continued. Then the heating is stopped and the mixture in the boiler is left to cool. Cooling of the heated whey is continued until curd is completely formed. This time is approximately 45 minutes. After a while, the clot, which starts to collect on the surface, is taken with ladles and transferred to cheesecloth or knitted baskets. It is left to drain for a few days. The curd obtained is taken into glazed and thoroughly cleaned earthenware pots called "dahar" or "taar" and kneaded thoroughly. The kneading process is repeated several times each day for 15-30 days. However, if the air temperature is low, the time between two kneading operations may be longer, and if the air temperature is high, the time between two kneading operations may be shorter. Meanwhile, if there is any newly made curd, it is added to the bowl and kneaded together. In the last stages of the kneading process, the upper surface of the cheese acquires a shiny, slippery appearance, cracks appear in places and it begins to emit a heavy odor. At this stage, salt is added to the cheese and kneaded again. The salting process is generally carried out in three stages. In the first salting, the cheese is kneaded by adding some salt and kept for three days. The second salting is done on the third day and the third salting is done 7-10 days after that. The amount of added salt is at least 5% in dry matter. In the meantime, various substances such as black cumin can be added to the cheese. Kopanisti cheese, which can be consumed when the salting process is over, is preserved in the pots where the kneading process is done. Since the dahars are without a lid, they are covered with a cloth and some olive oil is added to the cheese to prevent contact with air and stored at temperatures below 10 °C (Dağ and Keskin, 2020; Musullugil et al., 2022). The picture of Kopanisti cheese is presented in Figure 6.

An important feature of the traditionally produced Kopanisti is the addition of one percent ripe Kopanisti cheese to the fresh curd to accelerate ripening. This mature Kopanisti is called "Mana" (Greek word for mother).

Since Kopanisti is soft enough to be spread on bread, has a creamy consistency and a roquefort flavor, it is generally used as an additive and appetizer. Especially as

an appetizer, melon, raki and Kopanisti are a traditional trio. Apart from breakfast, additives are made with melon and white grapes, especially in summer (Uhri, 2017). Kopanisti can also be consumed in table cheese and cheese pie. Locals prepare a dish called "Mykonianrusks" by spreading Kopanisti, moistened with a little water and olive oil, on bread and topping it with tomatoes (Dağ and Keskin, 2020).

Figure 6. Kopanisti.

Since it has a heavy aroma, it is famous for being eaten with the tip of a fork, not a bite. In addition, diluting it with olive oil rather than eating it directly adds an indescribable flavor to the taste of this cheese (Anonymous, 2010). Karabıyıklı and Karapınar (2007) defined lactic acid bacteria that play a role in the fermentation of Kopanisti cheese as *Lactobacillus brevis, Lactobacillus buchneri, Lactobacillus casei, Lactobacillus collinoides, Lactobacillus johnsonii, Lactococcus lactis* subsp. *cremoris, Lactobacillus mali, Lactobacillus minor, Lactobacillus oris, Lactobacillus parabuchneri, Lactobacillus reuteri, Lactobacillus sanfrancisco, Lactobacillus sharpeae, Lactobacillus suebicus, Lactobacillus vaginalis* ve *Lactobacillus viridescens*.

Ergüllü et al. (1998) determined the yeast flora of Koponisti cheese as *Pischia membrane fasciens, Trichon cutaneum, Kluyveromyces lactis, Kluyveromyces marxianus* spp. *lactis, Saccaromyces cerevisiae, Rhodotorula ruba, Rhodotorula mucilaginosa, Candida lusitanrae* and *Debaryomyces hansei. Pischia membrane* formed the dominant yeast flora. They stated that Penicillium species are common as mold flora and *Penicillium commune* constitutes the dominant flora.

Ergüllü et al. (1998) reported short chain fatty acids in Kopanisti as Butyric acid (5,3%), Caproic acid (2,7%), Caprylic acid (3.1%), Capric acid (9.9%), Lauric acid (3.9%), Myristic acid (9.9%), Palmitic acid (23.4%), Stearic acid (13.1%); long chain unsaturated fatty acids as Oleic acid (20.3%), Linoleic acid (1.6%), Linolenic acid (1.9%). The chemical properties of Kopanisti cheese are presented in Table 7.

The total aerobic mesophilic bacteria (TAMB), lipolytic bacteria, proteolytic bacteria, yeast and mold numbers of Kopanisti cheese were determined by Ergüllü et al. (1998) as 5.51, 4.40, 4.43, 3.66 log cfu/g, respectively, and it was reported that there was no coliform bacteria. Karabıyıklı and Karapınar (2007) determined the microbiological properties of Koponisti during the 26-day storage period as follows (Table 8).

Table 7. Some chemical analysis results of Kopanisti

	Ergüllü et al. (1998)	Akgün (1988)
Total solid (%)	42.2	48.4
Fat (%)	14.3	16.1
Protein (%)	16.8	-
Salt (%)	6.3	12
Ash (%)	4.14	-
Acidity (%)	2.63	2.12

Table 8. Some microbiological properties of Kopanisti (log cfu/g) (Karabıyıklı and Karapınar, 2007)

Days	MRS Agar	M17 Agar	DRBC Agar (yeast)	DRBC Agar (mold)
0	9.72	9.65	7.26	9.65
1	9.59	9.46	6.46	9.46
7	8.94	8.46	6.36	8.46
14	8.15	8.15	6.04	8.15
21	9.04	9.04	6.82	9.04
26	8.92	8.52	< 1	8.52

2.6. Armola

Armola cheese is produced in Seferihisar, a quiet town in Izmir. This cheese, which is made in almost all villages of Seferihisar, has emerged as a traditional evaluation method. It is a product inherited from the Greeks in our country and Armola means "whey" in Greek (Dağ and Keskin, 2020). In the past, they used to stuff Tulum Peyniri into the skin of their animals and when the Tulum

Peyniri was about to run out, they would add yoghurt, Lor Peyniri etc. left in the house and some milk on top of it so that the cheese crumbs left in the skin bag would not go to waste. It is rumored that Armola emerged in this way. Although it is made in different ways because it is a mixed cheese, it is mostly made by mixing strained yoghurt, Beyaz Peynir and low salt Lor Peyniri (Dağ and Keskin, 2020).

In the study of Yoldaş (2017), the mixture was prepared using 10 kg of pasteurized cow's milk, 3 kg of full-fat unsalted Lor Peyniri, and 5kg of full-fat yoghurt to make traditional Armola. A small amount of salt was added to the prepared mixture and pressed into skin bag, and it was matured by closing its mouth in an airtight manner.

Armola cheese is matured for an average of 1 month by hanging the skin bag in a cool and airy place. Meanwhile, some filtrate drains from the skin and the cheese hardens. In order to soften the cheese and maintain its consistency, goat milk is added after a few days, and the skin is rubbed from the outside to ensure homogeneous distribution of the milk. This is why it is called "milk cheese" in some villages. In addition, to prevent deterioration of the skin, the skin is rubbed with salt from the outside and this process is repeated frequently.

It is consumed for breakfast by adding thyme, chili pepper, olive oil and mint to Armola cheese (Figure 7). It is also widely used in salads and sauces.

Figure 7. Armola prepared for presentation by adding mint, thyme and olive oil.

In her study to determine the quality characteristics and shelf life of Armola, Orşahin (2012) determined the chemical and microbiological properties of 40 cheese samples obtained from dairy farms in Seferihisar, as in Table 9 and Table 10, respectively.

Table 9. Some chemical properties of Armola (Orşahin, 2012)

Total solid (%)	Fat (%)	Salt (%)	Protein (%)	pH	Acidity (%)	a_w	n
37.26	19.52	2.51	10.87	4.70	0.95	0.91	40

Table 10. Some microbiological properties of Armola (log cfu/g) (Orşahin, 2012)

TAMB	Coliform	Lactococcus	Lactobacillus	Enterococcus	Yeast	Mold	Staphylococcus spp.	n
7.82	4.56	7.55	7.87	6.17	7.33	-	5.94	40

TAMB= total aerobic mesophilic bacteria

The high microbial load in Armola cheese showed that the hygienic conditions in production were quite low. In the sensory analysis, the dominant basic flavors were salty and sour, while creamy, baked and whey flavors were found to be aromatic flavors. According to the genotypic identification results, the dominant bacteria were reported as *Enterococcus ratti, Enterococcus durans, Enterococcus hirae, Streptococcus lutetiensis, Streptococcus equines, Streptococcus luteciae, Lactobacillus paracasei* subsp. *tolerance, Lactobacillus casei* subsp. *casei, Lactobacillus zeae*, and *Lactobacillus paracasei* subsp. *paracasei* (Orşahin, 2012).

2.7. Sepet Loru and Kirlihanım Peyniri

2.7.1. Sepet Loru

Sepet Loru is produced in the South Marmara Region and the North Aegean Region, particularly in the Ayvalık district (Kamber, 2007). This cheese, which is said to have been transferred to our culture from the Greeks, is mostly placed in perforated plastic containers today, while in the past it was shaped in buckets made of reeds. These reed baskets are made from stems collected from riverside and humid areas (Akpinar et al., 2014).

Sepet Loru is made by boiling the remaining whey after the Sepet Peyniri is made and leaving it aside to drain into these baskets (Keskin and Dağ, 2020). The image of Sepet Loru is presented in Figure 8.

Figure 8. Sepet Loru.

2.7.2. Kirlihanım Peyniri

Kirlihanım Peyniri is made from Sepet Loru produced in Ayvalık (Çelikel et al., 2020). Creamy curd obtained from full-fat sheep or goat whey is filtered in reed baskets for

1 day. It is then removed from the basket, covered with a thin layer of salt and left to mature in a cool place. Within 15-20 days, the outer layer of the cheese begins to mold; but the inner layers remain white. For this reason, it is referred to as "dirty lady" (Keskin and Dağ 2020) (Figure 9). These molds are yellow-brown and purple in color and give the cheese its unique smell, taste and flavor (Çelikel et al., 2020; Hastaoğlu et al., 2021). It is matured by turning it upside down for 6-7 months. Cheese is consumed after the moldy parts on it are cut and discarded. Due to the lack of widespread production of this rare cheese in the Aegean Region, it is among the lesser-known cheeses of Anatolia (Keskin and Dağ 2020). Before eating Kirlihanım Peyniri, it can optionally be consumed by pouring olive oil, honey, molasses or jam on it. The chemical properties of Kirlihanım Peyniri were reported by Akgün (1988) as 64.3% dry matter, 17.9% fat, 10% protein and 4.9% salt.

Figure 9. Kirlihanım Peyniri.

2.8. Keş

Keş is a traditional Turkish product that is widely produced and consumed in many parts of Anatolia, especially in the western and southwestern regions (Tarakçı et al., 2010). In our country, there are different types of Keş produced from yoghurt, buttermilk or whey. However, this report includes products consumed as cheese.

2.8.1. Taze Keş

Taze Keş is produced from yoghurt buttermilk. For yoghurt production, after the milk is filtered through a cheesecloth, heat treatment is applied at 90-100 °C for approximately 15-20 minutes. It is then cooled to 40-45 °C and inoculated with 2-3% yoghurt culture (homemade yoghurt). After the fermentation and cooling processes, the yoghurt produced is churned and processed into butter. After separating the butter, the remaining buttermilk is heated at 90-100 °C for about 10 minutes until a clot forms on the surface and transferred into cheesecloths. After the coarse water is removed, the pressing process is applied until the desired dry matter level is reached, and the obtained curd is salted with 2-3% dry salt and filled into cotton bags. The bags are suspended from a platform in a warm room for 2-3 days, and the bags are sometimes turned inside out for uniform dryness. In recent years, a mosaic-like structure has emerged in the final product by adding 20-30% Beyaz Peynir curd to the curd of Kes cheese to make the product more attractive. Cheeses with a total solids content of 60% to 70% can be stored in a cool place for 4-5 months (Tarakçı et al., 2003; Dervişoğlu et al., 2009; Tarakçı et al., 2010). Taze Keş sample is presented in Figure 10, the chemical composition of Keş is presented in Table 11, and the microbiological properties of Keş are presented in Table 12.

Figure10. Taze Keş.

Table 11. Chemical composition of Keş

	Kalender and Güzeler (2013)	Kalender and Güzeler (2013)	Tarakçı et al. (2003)	Dervişoğlu et al. (2009)
	Taze Keş	Sarı Keş	Keş	Keş
Total solid (%)	34.96	57.37	68.03	56.17
Fat (%)	3.00	8.70	11.35	8.79
Salt (%)	0.93	4.70	7.08	3.22
Protein (%)	27.18	29.80	42.34	-
Ash (%)	-	-	8.33	4.31
Acidity (%)	2.68	1.87	2.64	-
pH	3.54	4.65	3.88	4.75
n	10	6	20	35

Table 12. Microbiological properties of Keş (log cfu/g) (Tarakçı et al., 2003)

TAMB	Yeast -mold	Lactic acid bacteria	Proteolytic bacteria	Lipolytic bacteria	n
5.98	4.69	4.47	4.54	3.93	20

TAMB= total aerobic mesophilic bacteria

2.8.2. Sarı Keş

Sarı Keş is a dark or light brown product obtained by cooling the whey of cheeses made from sheep and goat milk, usually produced by the Yoruks in Anamur and its surroundings, after boiling for a long time and straining it from cloth bags. Sarı Keş is known as “Horç” in Silifke, and “Dolaz” or “Tort” around Isparta, Antalya and Afyon (Dinçel and Alçay 2017). Sarı Keş is an orange-brown dairy product with a distinctive taste and odour. It is consumed by the people of Anamur for breakfast either plain, mixed with onion or black cumin or mixed with Anamur village cheese, with phyllo bread. In addition, it is consumed plain or mixed with onions, together with hot flatbread, or it can be used as a filling in pastries (Kalender and Güzeler, 2013). The sample of Sarı Keş is presented in Figure 11, the chemical composition of Keş is presented in Table 11, and the microbiological properties of Keş are presented in Table 12.

Figure 11. Sarı Keş

Kuru Keş is obtained by crushing the Taze Keş produced in the Anamur region, laying it on a clean cloth and drying it in the sun until it turns yellow. A semi-hard cheese obtained by mashing and salting Taze Keş and Anamur village cheese, mixed with black cumin upon request, pressing into skin bag and then aging in a cool place for three to four months is called Deri Keşi. Gök Keş is a moldy cheese type obtained by leaving Deri Keşi or Sarı Keş to mold in a cool place after ripening (Kalender and Güzeler, 2013).

2.9. Antakya Sürkü and Antakya Küflü Sürkü

These cheeses are produced traditionally in Hatay region (Keleş et al., 2004; Hayaloğlu and Fox 2008). Antakya Sürkü and Antakya Küflü Sürkü are the products that received the Geographical Indication Registry Certificate in 2018 (Anonymous-1, 2018; Anonymous-2, 2018).

For the production of Antakya Sürkü, raw cow's milk is first filtered and then heated to boiling temperature. The heat-treated milk is cooled to 40-45 °C and fermented with yoghurt culture (1-3%) and incubated at 40-45 °C for 3-5 hours (as the local term puts it to sleep).

The yoghurt obtained is left to rest in refrigerator conditions (4-7 °C) for one or a few days, then diluted 1:1 and processed into buttermilk. Butter and buttermilk are obtained by churning buttermilk. The buttermilk is taken to another boiler and heated up to 90-95 °C without mixing. The clot collected on the surface is transferred to cloth bags with strainers, filtered and put under pressure. The clot, which remains under pressure for 5-6 hours and the excess water has been removed, is called Çökelek. After this step, 0.1-0.3% spice mixture is added to the Çökelek. This spice mix contains thyme (8-14%), allspice (11-40%), cloves (3-8%), mahaleb (8-9%), cumin (5-14%), black pepper (5-8%) , cinnamon (0-13%), ginger (0-10%), basil (0-2%), fennel (0-2%), black cumin (0-2%), chili pepper (0-2%), coriander (0-5%) and nutmeg (0-5%). (Especially the "wild thyme", locally known as "Zahter" (Tymbra spicata var spicata) and collected from the mountains, gives Antakya Sürkü its distinctive thyme scent). It is also kneaded by adding 1-3% salt, optionally a clove of garlic for 1 kg of Çökelek and optionally 1% pepper paste. The kneading process is done for the homogeneous distribution of the raw materials and takes 5-10 minutes. Palm-sized pieces are taken from the homogenized mass and shaped into a conical or pear shape by hand. The weight of each Sürk ball is 150-200 grams. Antakya Sürkü is then covered with a thin cheesecloth and left to dry in a shaded place at ambient temperature. The drying process takes one or several days depending on the ambient temperature. Drying may take 2-3 days depending on ambient conditions. The cheese obtained in this way is called fresh Sürk. It can be consumed fresh or after ripening with mold.

For molding, fresh Sürk is wrapped in paper one by one and placed in glass jars or plastic drums and left to mold. These environmental conditions are ideal for mold growth, as molds grow rapidly in moist and stagnant air. As a matter of fact, mold spores contaminated by the environment rapidly develop on Sürk preserved in this way and cover the entire surface. During 3-4 weeks at room temperature, physical, microbiological and sensory changes occur in the product due to storage conditions and mold growth, and Antakya Küflü Sürkü is formed when the product gains a completely different character. Unlike other moldy cheeses, Antakya Küflü Sürkü is consumed after the molds are removed from the surface. There is currently no industrial production of Antakya Küflü Sürkü. Pictures of Antakya Sürkü and Antakya Küflü Sürkü are given in Fig 12 and 13, and their chemical properties are given in Table 13. TAMB, yeast and mold, lactobacillus, staphylococcus numbers of fresh Antakya Sürkü were determined as 7.20, 5.91, 9.92, 3.76 log cfu/g by Keleş et al. (2004), respectively.

Figure 12. Antakya Sürkü

Figure 13. Antakya Küflü Sürkü

3. Others

Sirvatka Lor Peyniri is a type of cheese that is produced in almost all Balkan countries and is made more often in the regions where the immigrants from the Balkans reside. It is widely produced in Bursa and Balıkesir and in Mustafakemalpaşa, Manyas and Savaştepe districts in our country. This cheese is made from the whey obtained during the production of Mihaliç Peyniri. Popularly known as Kelle or Mihaliç Lor Peyniri, this cheese has a milky cream-like odor and is therefore preferred more than other curd cheeses.

For the production of Sirvatka Lor Peyniri, the whey left over from the Mihaliç Peyniri production is heated around 90 °C and waited for 10-15 minutes. Meanwhile, the curd cheese collects on the surface of the whey. Curd accumulated on the surface is transferred to cloth bags with scoops. After the intensive whey output is finished, the cloth bags are hung on the hangers and the filtering process continues for 24 hours. It is packaged without salt and offered for sale. Since it is not salted, its shelf life is short, 5-10 days. Depending on preference, it is served fresh for breakfast or alternatively salted and mixed with green pepper and spices and pressed into jars. After aging for a while, it is consumed either directly or by using it in pies or other types of pastries (Kamber, 2008).

Dumas Çökeleği is a dairy product traditionally produced in small family businesses in Darende and its villages. It is produced from yoghurt buttermilk. The buttermilk obtained during the production of butter from yoghurt is coagulated by heating. The resulting clot is filtered in cloth bags and pressed. In this way, raw precipitate is obtained. It is kneaded by mixing different proportions of milk, yoghurt, cream and a little salt (1-2%) on the raw Çökelek. Thus, Dumas Çökeleği is obtained. Dumas Çökeleği is consumed fresh or after ripening into skin bag. It can be used by the local people for breakfast, making pies and donuts, and it is also used in the production of some dishes unique to the region (Tarakçı et al., 2003).

The dry matter content of Dumas Çökeleği is 34.93%, fat 8.01%, fat in dry matter 22.08%, ash 2.39%, protein 21.66%, salt 1.64%, acidity (in terms of lactic acid) 1.67%. As a result of the microbiological analysis, TAMB was 6.97, the coliform bacteria was 2.29, the yeast and mold was 7.04, and the lactic acid bacteria was 6.17 log cfu/g (Tarakçı et al., 2003). Şor Loru is a curd cheese made in Kars and obtained by boiling the whey produced while making Kashar Cheese together with water in a boiling cauldron. Since the water in the boiling cauldron is salty, the cheese obtained here is called Şor Loru, which means "şor", "salty" in the local dialect (Kamber, 2008). Otlu Lor is produced from the whey leftover from Otlu Peynir production in the Van province region. Herbs known as "sirmo", "mendi" and "helis", obtained from the region and used in the production of Otlu Peynir, are added to the curds. These herbs not only give curd cheese a different taste, smell and aroma, but also enrich it in terms of mineral content (Kılıçel et al. 2004).

Table 13: Chemical composition of Antakya Sürkü

	Keleş et al. (2004)	Güler and Konar (2002)	Durmaz et al. (2004)
	Taze Sürk	Küflü Sürk	Sürk
Dry matter (%)	48.80	44.32	49.82
Fat (%)	4.05	8.99	14.66
Protein (%)	-	19.02	26.43
Salt (%)	5.59	8.32	5.36
Acidity (%)	0.78	1.14	1.44
Ash (%)	5.80	7.96	-
pH	4.55	4.94	5.81
n	50	36	25

4. Conclusion

Many famous cheeses in various countries can be made from whey. However, in our country, cheese produced from whey remained at the local level, its industrial production was not widespread, and some of it was even forgotten. In this respect, it is necessary to raise awareness of people about whey cheeses and to process whey as whey cheese in small businesses and encourage its consumption in this way. In addition, there is a need for more academic research on whey cheeses produced in our country and studies on industrial production possibilities.

Author Contributions

The percentage of the author contributions is present below. The author reviewed and approved final version of the manuscript.

	E.M.
C	40
D	25
S	40
L	40
W	25
CR	50
SR	50

C=Concept, D= design, S= supervision, L= literature search, W= writing, CR= critical review, SR= submission and revision.

Conflict of Interest

The author declare that there is no conflict of interest.

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EFFECTS OF CLIMATE CHANGE ON ANIMAL HUSBANDRY

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Abstract: Climate has a significant impact on agricultural production. According to scientific data, climate change is having a growing impact on the planet's life, and different regions of the world are experiencing this impact in different ways. The greatest challenge to achieving sustainable development is climate change, which also poses a serious risk to the survival of humanity. It will have far-reaching consequences within the context of animal production, and particularly in regions of vital importance to the world's nutrition and livelihoods. All species have ideal climatic parameters for survival in animal husbandry, and changes to these variables have a negative impact on the quality and quantity of farm animals and animal products. There are four key areas where the effects of climate change on animal productivity can be studied. These include effects on pasture quality, effects on animal diseases and pests, effects on animal health, growth, and reproduction. They also include implications on the availability, quality, and price of feed crops. Planning for the sector's future is crucial in order to meet the population's food needs, lessen the impact of climate change on livestock output, and reduce the sector's contribution to global warming. Adapting animal husbandry to climate change is required to reduce all these harmful effects.

Keywords: Climate change, Global warming, Agriculture, Animal husbandry

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1. Introduction

As a global problem, climate change affects the whole world deeply. Climate change, accepted as one of the major problems of our time, can be defined as changes in the global climate system over long periods of time (Houghton et al., 2001). The situation that the main reason for these changes, which can also be considered as a natural process, is human activities has gained weight. Therefore, it would not be wrong to consider the climate change, the effects of which we are experiencing intensely today, in the context of the destructive effects of human activities on the natural greenhouse effect. The deterioration of the greenhouse gas balance in the atmospheric structure as a result of human activities causes uncertain changes beyond the normal changes in the climate system (Doğan and Tüzer, 2011). These uncertain changes in the climate system, together with the effects from the past, prevent the creation of a sustainable future. Because the imbalance created by the changing climatic conditions negatively shapes not only the present but also the future socio-economic structure (Fankhauser and Tol, 2005). It is stated that the effects and consequences of climate change, defined by the UNFCCC as "change in the climate system as a result of direct or indirect human activities, in addition to natural changes that can be observed in comparable time periods", are now permanent.

One of the areas that will suffer the most from global climate change is agricultural production. Agricultural production, which changes in terms of quality and quantity as a result of fluctuations in the climate, affects food production and therefore human life socially and economically. The effects of climate change on the agricultural economy can be called a decrease in the income of farmers, an increase in food prices, a slowdown in economic development, an increase in the price of land, a decrease in the number of farmers and a decrease in exports. (Dellal and McCarl, 2013; Özçatalbaş 2014).

A significant area of agricultural production, animal husbandry is impacted both directly and indirectly by climate change. Climate change is seen as a severe threat to the survival of many species, ecosystems, and livestock systems in many parts of the world. (Moss et al., 2000). On the other hand, it is held responsible for approximately 14% of the global human-induced (anthropogenic) greenhouse gases resulting from livestock activities and it is stated that it is a source of soil, water and air pollution for human beings. These environmental issues have become an important topic of discussion in sustainability assessments of the livestock market (Herrero et al. 2014). It is predicted that the demand for animal products will increase by 100% starting from the middle of the 21st century. In addition, it is stated that competition that will arise with climate change, use of natural resources, feed quantity and

quality, animal diseases, heat stress and loss of biodiversity will affect animal husbandry. The main challenge at this point is to strike a balance between economic efficiency, food safety and environmental protection (Wright et al. 2012).

Considering this relationship between climate change and animal husbandry, the necessity of dealing with the issue multidimensionally emerges. Literature research carried out as part of the study revealed that although the subject had been investigated in many studies at the crop production level, little work had been done, particularly with regard to animal husbandry and economy. Therefore, the main purpose of this study is to examine the interaction between climate change and animal husbandry within the scope of literature and to bring forward suggestions for the solution of the problem.

2. Evaluation of Global Climate Change

The rise in the earth's surface's average temperature is referred to as global climate change and climate change due to the rapidly increasing accumulations of greenhouse gases released into the atmosphere as a result of human activities such as the burning of fossil fuels, changes in land use, degradation forest management and industrialization processes, intensification of the natural greenhouse effect. Humans are one of the most important causes of global climate change. Increasing world population, increasing consumption and industrialization, use of fossil fuels are examples of human-induced factors. Burning fossil fuels, especially coal, increases the amount of carbon dioxide in the atmosphere. According to the IPCC, 56 percent of human-caused greenhouse gases come from the use of fossil fuels. (WWF, 2019).

According to the climate assessments of the World Meteorological Organization (WMO), when the average of 1981-2010, when global warming became evident, is taken into account, the global average temperatures increased by 0.98 °C in 2018 compared to the pre-industrial revolution (1850-1900), while the global average temperatures increased by 0.38 °C has increased. In this respect, 2018 was the 4th warmest year recorded after 2015, 2016 and 2017 (WMO, 2018).

According to climate estimates from the National Oceanic and Atmospheric Administration (NOAA), global average temperatures in 2018 were 0.79 degrees Celsius higher than the 1901-2000 average (Figure 1). In 2018, while the warming in terrestrial areas was 1.12 °C, this value was 0.66°C in the oceans. Warming in the Northern Hemisphere (1.18 °C) was higher than that in the Southern Hemisphere (0.97 °C) (MGM, 2018). According to the NOAA, 2019 was the second warmest year in the last 140 years with a temperature deviation of 0.95 °C (MGM, 2019).

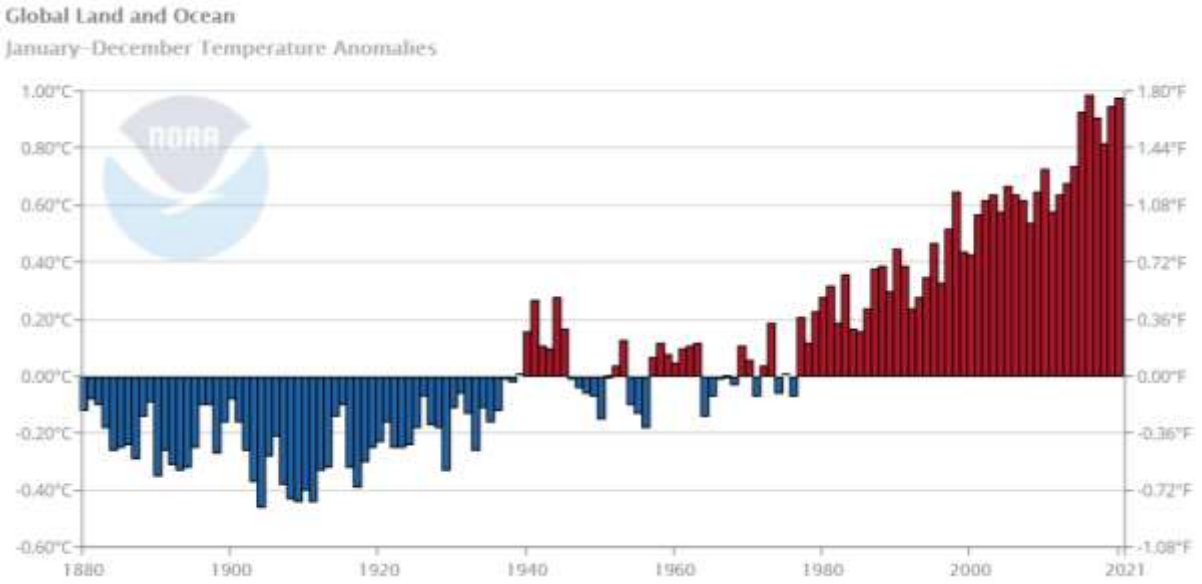

Figure 1. Global mean temperature anomaly (NOAA, 2018)

The WMO published an interim climate report in 2020 and estimated that 2020 could be one of the three warmest years on record. In this report, it was stated that 2020 was 1.2°C warmer than the pre-industrial average (1850-1900). It was also evaluated that the period 2011-2020 will be the 10th warmest year on record, and the period 2015-2020 will be the 6th warmest year on record (Figure 2; WMO 2020).

Major greenhouse gas concentrations rose, particularly in 2019 and 2020. Carbon dioxide (CO_2) mole fractions have surpassed 410 parts per million on a global scale (ppm).Board of experts predict that the CO_2 concentration will surpass 414 ppm in 2021 if the trend from recent years continues. Rising global temperatures are more frequent and severe worldwide, including rising global temperatures, cold and heat waves, floods, droughts, wildfires and storms. causes weather events (WMO, 2021).

In the upcoming years, it is anticipated that the negative consequences of climate change would worsen depending on the rise in greenhouse gas emissions. In addition to its effects on the environment and society, climate change has significant economic ramifications for both industrialized and developing nations. (Doğan and Tüzer, 2011). The cost of compensating for disasters brought on by climate change and taking steps to limit greenhouse gas emissions weighs heavily on national economies. A few of the key businesses affected by climate change include agriculture, cattle, foreign commerce, tourism, forestry, food production, fisheries, health, air conditioning, construction, logistics, and finance (Bayraç and Doğan, 2016).

Agriculture is a naturalistic activity. Changes in production that will result from climate change are essential for both the nation and global trade because agriculture is an economic activity. Agriculture is an industry that both contributes to and is impacted by climate change. Carbon emissions are caused by a variety of processes, including tillage, fertilization, spraying, operations along the product-food supply chain, changes in how agricultural lands are used, energy use, and animal waste (Topçuoğlu and Doğan, 2011).

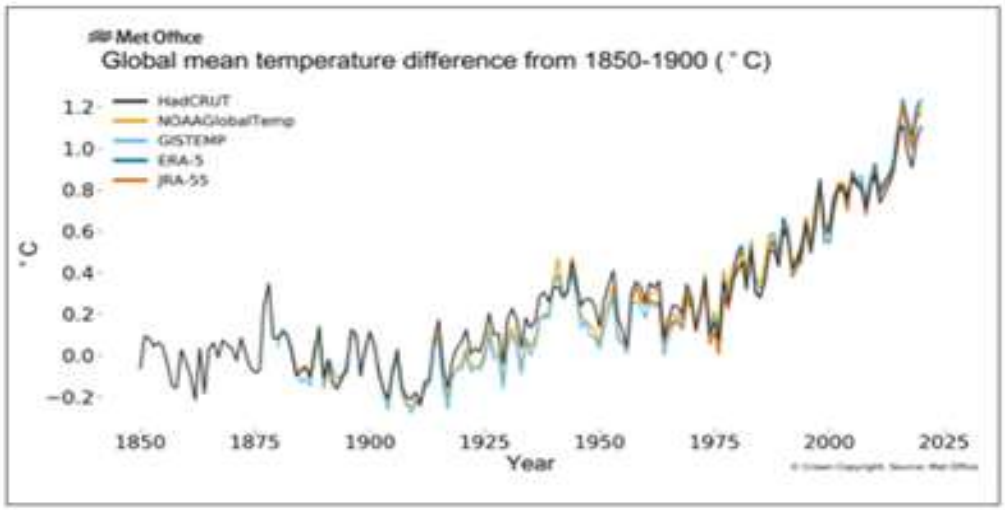

Figure 2. Change of global average temperatures for the period 1850-2020 (WMO, 2020)

3. Interaction between Climate Change and Agriculture

The scientific world has a large consensus that climate change is a real problem today and will continue to be experienced by increasing its effects in the future (Öztürk, 2002; Şen et al., 2013; Şahin et al. 2015). The adverse effects of these continuous climate changes are felt by rural residents, who are already at a disadvantage because of their location and way of life. Particularly the poor who work in agriculture and reside in rural regions are considerably more affected by the disastrous effects of climate change (Vural, 2018).

Climate change will probably make it more difficult for the poor to acquire clean water, jeopardizing their health. The destructive effects of climate change threaten agricultural production and food security in many developing and underdeveloped African, Asian, and Latin American nations. Given that over a billion people worldwide suffer from hunger as a result of a lack of convenient and dependable access to basic food supplies, it should come as no surprise that climate change will have an even greater impact on agriculture in the years to come (FAO, 2009).

Since the economies of developing countries are based on agricultural production, the impacts of climate change are felt more in these countries. Especially extreme weather conditions make agricultural production impossible in developing countries and therefore cause migration (Demirbaş and Aydın, 2020). According to estimates from the UN, more than 500 million people worldwide have been displaced as a result of climate change. Despite significant advancements in the agricultural sector, including product types that are adapted to various environments, spraying, fertilizer, and irrigation systems, climatic factors continue to play the most crucial role in agricultural productivity.

The agriculture sector, one of the industry's most vulnerable to climate change, is affected by it on both the positive and negative sides. Agriculture is impacted by climate change, and agricultural practices also contribute to it. (Polat and Dellal). Agricultural operations in tropical and sub-tropical countries are negatively impacted by extreme floods and droughts as a result of climate change, whereas agricultural productivity is anticipated to increase as a result of the extension of the crop growing season in temperate regions. Arid regions' agricultural production declines and even vanishes owing to desertification brought on by rising global warming. (Atabay et al. 2014). A shortage or surplus of agricultural production as a result of climate change significantly alters the economic balances because agriculture is a productive industry in addition to providing food for people (Miraglia et al., 2009). Due to the decrease in the volume of production, the increase in agricultural prices negatively affects inflation; the supply

of agricultural products through imports negatively affects the current account deficit; the decrease in the number of people employed in the sector negatively affects unemployment; and producers' drought-related losses are fully or partially covered negatively by governments (Baptista et al., 2022).

Agriculture productivity is significantly impacted by particular climatic conditions. Although the increase in temperature and elevated carbon dioxide levels brought on by climate change seem to have a positive short-term influence on the quantity of agricultural products in some regions, these factors may lead to a decline in production and quality of goods in the long run (Akalın, 2014). It takes more than just raising the temperature and carbon dioxide levels to boost agricultural output. To have a favorable impact on agricultural production, rising temperatures and carbon dioxide levels must be combined with good soil structure and quality. Additionally, it is crucial that the soil moisture levels are ideal and that the area to be planted has access to water. These requirements must come together to form an environment that is conducive to agriculture (Lou et al., 2003).

Agriculture production methods are evolving as a result of climate change. This condition puts pressure on the amount of the global food supply and lowers the productivity of agricultural products. According to the FAO, 790 million people in developing nations did not have access to enough food as of the late 1990s. Despite all the cutting-edge culinary innovations, this number has now surpassed one billion. More than half of the population residing in Central, South, and East African countries was reported to be inadequate and malnourished in the FAO report on food security, which also identified countries and populations at risk. Human activities and environmental conditions, which are both considered to be natural elements, are also cited as contributing contributors to the decline in agricultural production. The main factors contributing to the loss in the global food supply are improper land use, drought, barren soils, harsh droughts, cold temperatures, landslides, and extreme precipitation. The individuals who live in undeveloped and emerging countries find it challenging to maintain a healthy development due to these cutbacks in food availability. Particularly, this condition has a negative impact on children's mental and physical development (FAO, 1999).

On the other hand, agricultural production is among the main causes of climate change, since various greenhouse gases are produced as a result of agricultural activities (energy consumption, animal breeding, paddy production, fertilization and spraying, etc.). The amount of environmental pollution produced by animal husbandry has significantly increased in recent years due to the intensification of the meat-and-dairy cow breeding, poultry farming, and dairy industries (Demir and Cevger, 2007). It is stated that ammonia from farm animals causes acid rain and CH4 gas causes global problems by causing greenhouse effect. Ruminant animals release greenhouse gases through gastric fermentation during the digestive process. Paddy grown under water releases CH4 throughout its production. As paddy cultivation areas increase, greenhouse gas emissions also increase. Greenhouse gas emissions in the atmosphere rise when the fertilizer breaks down in the soil or as the CO2 buried during plowing escapes (Iyai and Runtuboi, 2016). Energy use accounts for 26% of greenhouse gas emissions globally, followed by industrial activity at 19%, land use changes at 17%, agricultural at 14%, and transportation at 13% (Lamb et al. 2021).

In addition to the increasing effects of agriculture on climate change, its reducing effects should not be ignored. Agriculture has the power to lower greenhouse gas emissions and carbon sinks. Through photosynthesis, green plants remove carbon dioxide from the atmosphere. Once more, soil is where carbon is kept. Biofuels are agriculture's second means of reducing climate change. Reducing greenhouse gas emissions into the atmosphere by favoring the use of biofuels rather than fossil fuels. It is anticipated that the increased atmospheric CO2 concentration may benefit the cultivation of some agricultural goods. The increased CO2 level will have a good impact on plants classed as C3 class, such as rice and wheat (temperate zone plants that require high CO2 concentration and low temperature, low light intensity capabilities). (Doğan and Tüzer, 2011). On the other hand, the increasing CO2 will have a negative impact on C4 class plants like corn and sugar cane.

4. Effects of Climate Change on Animal Husbandry

One of the most important sub-branches of the agricultural sector is animal husbandry. The livestock sector, which is included in agricultural activities, has great value for all underdeveloped, developing and developed countries. Animal products produced are important in terms of healthy and balanced nutrition of the country's population, creating raw materials for industry and foreign trade income (Yurdakul and Ören, 1995). According to the 2020 data of the FAO, 30.8% of the world's $4.1 trillion agricultural production value is provided by the livestock sector (FAO, 2020). In Türkiye, according to 2020 data, the share of animal product value in the total agricultural production value of 354 billion ₺ is 19.75% and 50% of the animal product value is obtained from milk production (TUIK, 2020).

Livestock is the most important sub-sector of agriculture in terms of social, economic and environmental aspects, in terms of its place in the human diet, its contribution to agricultural income, the livelihood of 1 million people, the amount of land used and fresh water resources (Herrero et al., 2013). It is estimated that animal husbandry will maintain this importance in the future and the demand for animal products will double in 2050

(Alexandratos and Bruinsma, 2012). Climate change and animal production systems interact in a complex way since they are both causes and effects of one another. Animal husbandry is badly impacted by climate change in a variety of ways and negatively influences climate change in a variety of ways (Malik et al., 2015). Livestock are impacted by climate change both directly and indirectly. Among the direct consequences are increased physiological stress, landslides, floods, productivity losses, and drought. Feed quality and quantity, access to drinking water, an increase in diseases, and an increase in input prices are examples of indirect effects (Thornton and Gerber, 2010).

Reilly (1996) identified four ways in which climate has an impact on animal husbandry. These include changes in the supply and cost of grains used to feed livestock, their impact on the yield and quality of forage crops and livestock pastures, shifts in the geographic distribution of animal diseases and pests, and the immediate effects of weather events on animal health, development, and reproduction. In livestock, most species perform well at 10-30 °C. For every 1 °C increase above 30 °C, the feed intake of cattle, sheep, goat, pig species decreases by 3-5% (NRC, 1981). Changes in the amount, distribution and intensity of precipitation directly affect the timing and duration of growth of pastures and crops. Disease vectors are affected by high temperatures, which affect the emergence, spread and distribution of diseases in livestock, and the rate of development of pathogens and parasites. These effects cause loss of live weight and milk yield in animals (Malik et al., 2015).

Global climate change has caused a decrease of around 1-5% per decade in agricultural production in the last 30 years. There is limited information about its effects in animal production, unlike plant production. In general, it is estimated that there will be decreases in feed consumption, reproduction and yield levels depending on the increasing temperature in different animal species. While climate change will increase the susceptibility of animals to diseases, it will cause mutations in disease and parasitic agents, increase in zoonotic diseases and the emergence of some new diseases. For this reason, there is a need for an integration in terms of developing genotypes with good adaptability and high ability to overcome environmental stress, improving soil and water management at the point of reducing the possible effects of climatic changes (Thorne, 2007).

Global climate change has caused a decrease in agricultural production at varying levels, such as 1-5% every ten years, in the last 30 years. In general, depending on the increasing temperature in different animal species, decreases in feed consumption, reproduction and yield performance occur (Figure 3). On the other hand, in countries where animal production is intense, in addition to its direct effects, it may adversely affect animal production with indirect effects such as pathogens, as well as reductions in water and feed (roughage/concentrate) resources. Animals can cope with heat stress by changing feeds, refrigeration or various farm management practices. However, the construction of climate-controlled shelters to adapt the animals to the ambient temperature will result in increased production costs.

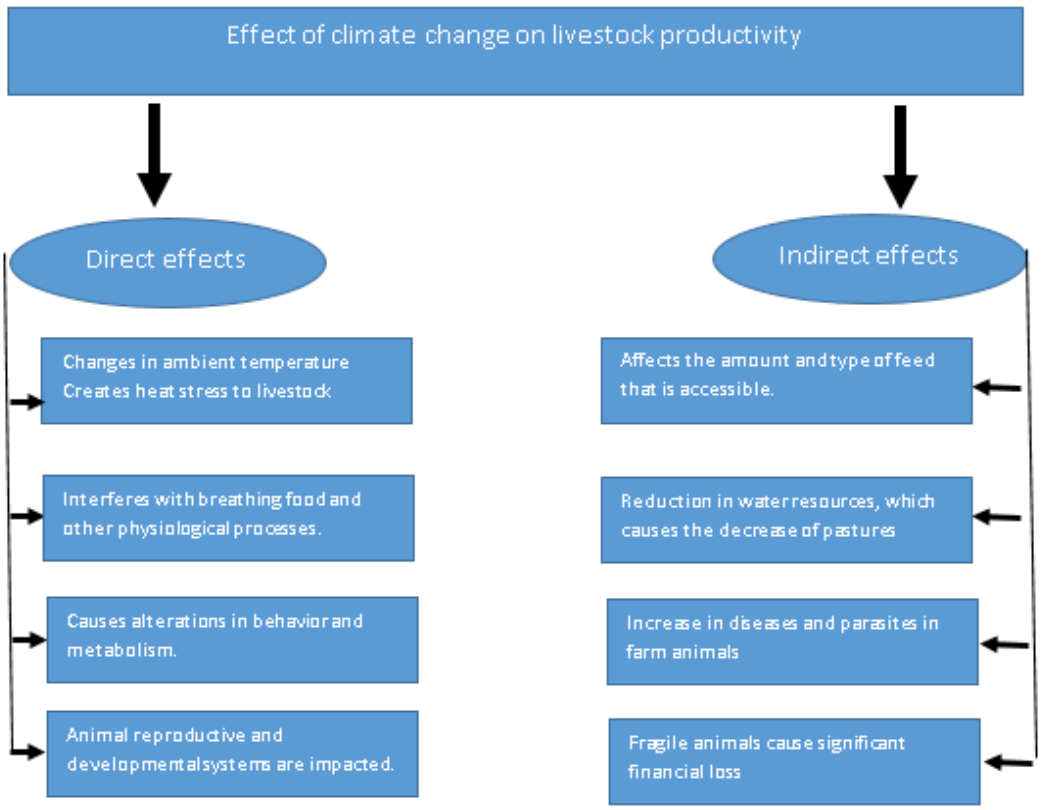

Figure 3. Effects of climate change on livestock productivity (Naqvi and Sejian, 2011).

Extreme occurrences and seasonal changes impair animal wellbeing and reduce productivity and reproductive efficiency. In the world, the sustainability of livestock systems is being threatened by climate change. The fight against the harmful impacts of climate change on animals involves both adaptation and mitigation strategies (Sejian et al., 2015). Global temperatures have been known to rise in response to climate change. According to predictions from different climate models, the average global temperature by 2100 might be 1.1–6.4 °C warmer than it was in 2010. In extreme circumstances, the adverse weather that animals are exposed to (such as intense heat waves, floods, and drought) can cause animal mortality in addition to output losses (Gaughan and CawsellSmith, 2015). Although animals may adapt to hot conditions, the methods they use to help them survive can have a negative impact on how much they produce. Climate change is anticipated to have a significant impact on global animal production systems in the coming years, which will raise demand for already available animal products. Food and water security are among humanity's main concerns in the twenty-first century.

Climate change has direct effects on livestock animals. Extreme temperatures negatively affect production performance (growth, meat, milk, egg production, etc.), reproductive physiology, metabolism and immune system (Koyuncu and Akgün, 2018). Changes in the amount, distribution and intensity of precipitation directly affect the timing and duration of growth of pastures and crops. Disease vectors are affected by high temperatures, which affect the emergence, spread and distribution of diseases in livestock, and the rate of development of pathogens and parasites. These effects cause losses in live weight and milk yield in animals (Koç et al., 2016). Animal production has a significant impact on the world's water, soil, and biodiversity resources, and adversely affects climate change in many ways, including land use change (CO_2), enteric fermentation (CH_4), and manure management (N_2O) (Steinfeld et al., 2006). It is noteworthy that 65% of greenhouse gas emissions come from beef and beef milk (Herrero and Thornton, 2013).

Mauger et al. (2015) think that cows are vulnarable to extreme temperature and humidity, therefore climate change will negatively affect milk yield in cows. Authors examined microclimate data and county-level dairy industry data to predict declines in milk yields from Holstein cows in the USA. In the study, it was determined that the decrease in milk yield throughout the country was around 2%. It is predicted that the decrease in milk yield due to climate change will increase to around 6.5% by the beginning of the 22nd century. This production loss is equivalent to 2.2 billion dollars. Sheikh et al. (2017) reported that the reproductive activities of animals would be adversely affected by heat stress in their research examining the effects of climate change on dairy cows and buffalo production. It has been determined that the extreme heat in summer causes low estradiol levels in buffaloes. For this reason, 80% of the heat is not noticed in the summer months and reproductive activities are interrupted. In addition, when the buffalo's body temperature rises above 40 °C, mature follicles are adversely affected and even become lifeless. In addition, the pregnancy rate of dairy cows falls to the range of 20-27% in summer.

5. Conclusion and Recommendations

This investigation of the current state of climate change and its effects on animal production was undertaken. This paper was conducted using the literature as a review. The study has demonstrated the relationship between agriculture and climate change. In addition, many viewpoints are explored about the direct and indirect effects of climate change on livestock.

Climate change is one of the biggest environmental problems of our time, and the main reason for this is human activities. Human-induced natural climate change, which emerged with the industrial revolution and increased its speed as of the 20th century, has left its place to climate change due to global warming. Climate change affects animal welfare and productivity directly and indirectly.

Diseases that may arise in arid and semi-arid regions of animal production, accessibility to water, etc. It is predicted that it will be adversely affected due to various reasons. At the same time, climate change will affect the nutrient content of animal products, which are the global supplier of calories, protein and essential micronutrients. On the other hand, livestock activities also have an impact on climate change. The expansion of pasture and cultivation areas within the scope of production activities, especially feed raw material production, constitutes half of the contribution to greenhouse gas emissions in the entire animal production process, and this is expected to increase further due to the increase in production.In this context, in order to ensure sustainability in global agriculture and food production and consumption; It is necessary to develop the resources of animal husbandry and increase its environmental performance. In addition, social and economic impacts must be taken into account. It is important to plan the future of the sector in order to reduce its contribution to climate change, to minimize the effects of climate change on livestock productivity and to meet the food needs of the population. In order to minimize all these negative effects, it is necessary to adapt animal husbandry to climate change. To reduce greenhouse gas emissions from agriculture, stopping animal production greenhouse gas growth should be a priority. There are many different ways to do this; using better quality feeds and improving animal nutrition according to changes in temperature, developing new breeds of animals that are resistant to stress, effective manure handling and stocking management, grazing management and pasture improvement studies are some

of them. These studies will both eliminate the low yield in animal husbandry caused by climate change and reduce the effects of animal husbandry on climate change.

Author Contributions

The percentage of the author(s) contributions is present below. The authors reviewed and approved final version of the manuscript.

	M.B.	C.Ö.
C	50	50
D	100	
S		100
L	50	50
W	50	50
CR	50	50
SR	50	50

C=Concept, D= design, S= supervision, L= literature search, W= writing, CR= critical review, SR= submission and revision.

Conflict of Interest

The authors declare that there is no conflict of interest.

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Review
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PHYSIOLOGICAL AND PHYSICAL RESPONSES OF DAIRY CATTLE TO HEAT STRESS

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Abstract: Herd management and nutrition strategies against increasing negative effects of global warming on farm animals have been the subject of significant debates in recent years. The fact that the changes in the environmental conditions are directly related to the habitats of the animals and the conditions inside the barn can affect the farm animals negatively. Although effects of heat stress differ according to species, especially high-yielding dairy cattle exposed to heat stress, respond with various interactive mechanism such as physiological, biochemical, immunological, anatomical and behavioral. Therefore, with the selection practices that have been going on for many years to improve the yield characteristics of the animals significantly increased. In this respect, the increased heat load in the body of dairy cattle due to the high productivity decreases their tolerance to environmental conditions. This situation adversely affects the productivity of cows with high breeding value. Yield losses, varying according to some factors about heat stress, can be partially explained by decreasing feed intake as a result of a series of hormonal responses affecting appetite center. However, the physiological requirements of cattle must be defined in order to develop appropriate strategies to reduce or eliminate the negative effects of heat stress. In this review, the variations in physiological, biochemical and behavioral mechanisms originating from heat stress in dairy cattle and the care, nutrition and herd management strategies that can be applied to eliminate or reduce the negative effects were discussed.

Keywords: Dairy cattle, Care, Heat stress, Herd management, Nutrition

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1. Introduction

The world is experiencing changes that will affect both local and global agriculture due to global warming in this century (Nardone et al., 2010). Climate change, which is a result of global warming, generally increases the temperatures and the severity of drought throughout the world (Berman, 2019; Cheng et al., 2022). Therefore, the effects of heat stress on animals have been more controversial than cold stress (Cheng et al., 2022).

The variations in environmental conditions, which are directly related to the habitats of animals and conditions in the barn, may adversely affect the economic viability and sustainability of animal production systems (Sejian et al., 2018; Collier et al., 2019). In addition, the yield traits of farm animals have significantly increased with the selection practices. This improvement in the productivity of the animals created a large internal heat strain and increased their sensitivity to high temperatures (Van laer et al., 2014; Sammad et al., 2020). In particular, the high-yielding cows such as Holstein, have a significant metabolic rate and cannot maintain thermal balance in hot conditions (Veissier et al., 2018; Collier et al., 2019). This situation adversely affects the growth, reproductive performance, milk yield and quality, immunity, metabolic and health conditions of cattle (Figure 1). Since it is a very difficult and long process to improve the genetic structure of farm animals in order to reduce this sensitivity to high temperatures, there has been a trend towards improving environmental conditions and feeding management (Collier et al., 2019). For this reason, every detail maintains its importance in understanding the negative effects of heat stress on animals and determining the steps to be taken to improve these conditions. This review has been prepared in order to find out the mechanisms of cattle against heat stress, to facilitate the improvement of environmental conditions and nutritional management.

2. Seasonal Factors and Stress

The effects of environmental conditions (care, nutrition and seasonal factors) on farm animals are numerous and the effect of these conditions has a complex structure (Öten et al., 2004; Alkoyak and Çetin, 2016). Season is an important environmental factor influencing welfare and performance in dairy cattle (Alkoyak and Çetin, 2016; Koç and Uğurlu, 2019; Pinto et al., 2019). In particular, temperature and humidity are the most important factors determining the heat exchange between the body

and the environment of animals, and microclimate factors such as air movement and solar radiation are also important climatic stress factors (Herbut et al., 2019). Therefore, among the climatic environmental factors, especially temperature, humidity and wind speed should be at optimum level (temperature 13-18 °C, humidity 60-70%, wind speed 5-8 km/h and moderate solar radiation) (Işık et al., 2016). The dairy cows are more productive among various temperatures, which are considered the 'thermal neutral zone' (TNZ) (Herbut et al., 2019; Collier et al., 2019). When animals are exposed to conditions out of the TNZ, they are able to maintain normal body temperatures against changing temperature within certain limits. However, if ambient temperature moves to more extreme limits, it creates a significant stress factor on the animals (Alkoyak and Çetin, 2016; Işık et al., 2016).

The critical temperatures affecting dairy cows vary according to the age and physiological state of the animals. It has been reported that lower and upper limits of these values are 13 – 26 ˚C, -5 – 26 ˚C, -14 – 25 ˚C and -25 – 25 ˚C for calves drinking milk, growing calves between 50 and 200 kg, dry pregnant cows and the cows in the peak period of lactation, respectively (Collier et al., 2019). As the temperature moves from denoted values to more extreme limits, the metabolism of the animal tries to adapt the changing climate conditions through different adaptive mechanism such as genetic adaptation, physiological adaptation and acclimation to the environment (Ratnakaran et al., 2017). While ruminants can maintain physical balance by increasing feed intake when exposed to cold stress, they cannot maintain this balance at high temperatures this is why the effects of heat stress are mostly emphasized (Durmuş and Koluman, 2019). Cattle adapt to the environment or climate for approximately 2 to 7 weeks when exposed to heat stress (Kamal et al., 2018). However, cattle have difficulties for removing the excess heat accumulation at prolonged high temperatures. This situation creates an important stress factor on animals and affects whole metabolism. The level of arousal in the metabolism of the animals varies according to the duration and intensity of the stress source, as well as the physiological state of the animal and its experience against stress (Ratnakaran et al., 2017; Sejian et al., 2018; Herbut et al., 2019).

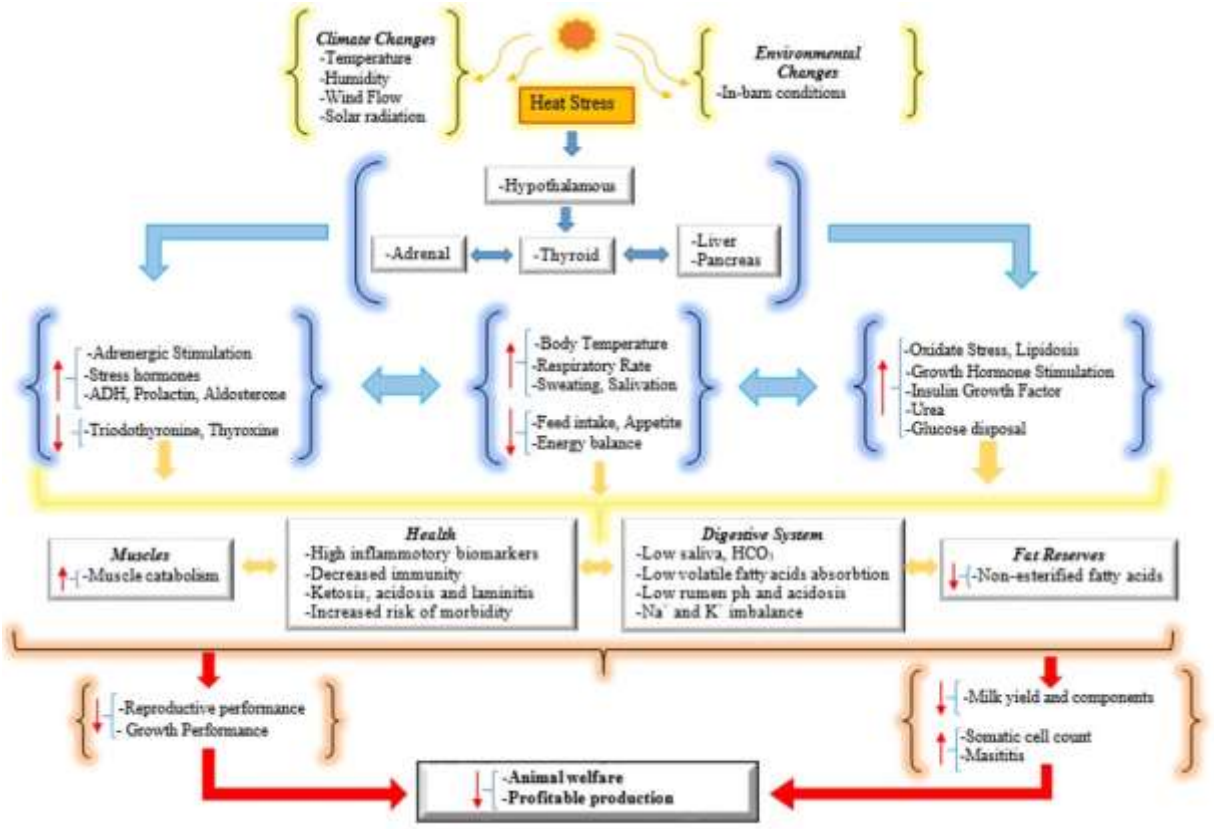

Figure 1. Summary of physiological and biochemical changes due to heat stress in the body of dairy cows. Adapted from Sammad et al. (2020).

3. Physiological Thermal Regulation

The neural process connecting the information from the internal and external thermal environment of the animal until an appropriate response is given that allows the formation of a stable internal environment according to the changing external environment is defined as 'Thermal Regulation' (Collier et al., 2019). In this process, cellular metabolism and endocrine system activity are directly regulated and the connection between the external environment and cellular metabolism is provided. In

cattle exposed to environmental stress, peripheral circulation controlled by the hypothalamus aids in heat dissipation from the skin surface through vasodilation (widening of the vessels, reducing blood flow velocity and lowering blood pressure) and perspiration (Idris et al., 2021). These physiological responses are replied by the central nervous system, peripheral nervous system and endocrine components (Charmandari et al., 2005; Niyas et al., 2015; Collier et al., 2019).

The dairy cows respond to stress in two stages (acute and chronic). Acute and chronic stress are controlled by the 'Sympathetic-Adrenal-Medullary (SAM)' and 'Hypothalamus-Pituitary-Adrenal (HPA) axis', respectively (Pehlivan and Dellal, 2014; Bagath et al., 2019). The acute stress responses are short-term (from a few minutes to a few days), and cattle can adapt with short-term physiological adaptation events such as drinking more water, increasing respiration and sweating to reduce the heat load on the body (Idris et al., 2021). The response to these stressors begins via thermal receptors in the skin and hypothalamus that respond to environmental changes. The collected stimuli for perception of stimulants are transmitted to the thalamus, hypothalamus and central nervous system. These centers then respond in various ways to generate a response to the environment. The acute response to environmental stress is mediated by the autonomic nervous system, which increases the release of catecholamine and glucocorticoids, altering metabolism (Collier et al., 2019).

The release of adrenaline or noradrenaline hormones secreted from the adrenal medulla is stimulated during acute stress. This process activates or initiates a series of physiological response in order to create the necessary reaction against stress by using the reserves of body and to provide physical balance (Altınçekiç and Koyuncu, 2012). This set of physiological responses results in elevation of the pulse, blood pressure, respiratory rate, and blood sugar, as well as suppression of certain anabolic events (digestion, reproduction, growth and immune system) (Farooq et al., 2010; Pehlivan and Dellal, 2014; Niyas et al., 2015).

When short-term adaptation pathways fail as a result of prolonged environmental stress, body temperature significantly increases. Against such stressors, animals often show signs such as increasing pulse and sweating rate and standing. Therefore, feed intake is reduced, resulting in yield losses (Idris et al., 2021). In this case, the restoration of homeostatic and physical balance achieved through HPA. The HPA, having more general effect on the animals, appears more slowly than SAM response. Stress perceived by the central nervous system initiates this sequence of responses with the secretion of corticotropin-releasing hormone (CRH) by the hypothalamus. The CRH stimulates the releasing of adrenocorticotropic hormone (ACTH) from the anterior pituitary lobe, and the release of glucocorticoids increases with stimulation of the adrenal cortex (Altınçekiç and Koyuncu, 2012; Pehlivan and Dellal, 2014). Increasing glucocorticoids as a result of the interactions of these hormones play an important role in initiating physiological responses to balance the effect of heat stress. In particular, the heat has a significant effect on carbohydrate, lipid, mineral and protein metabolism to increase blood glucose levels during stress. This interaction is in the direction of providing the energy needed by the body cells and tissues by obtaining glucose from carbohydrates and non-carbohydrate sources (Durmuş and Koluman, 2019).

The cortisol production during acute stress plays an effective role in stimulating the immune system, while cortisol secretion in chronic stress suppresses the immune system (Bagath et al., 2019). The long duration of heat stress and the continuous release of glucocorticoids secreted from the adrenal cortex of the adrenal glands may result in the emergence of many problems such as metabolic disorders, digestive system diseases, slowing of the immune system, suppression of reproduction and growth (Altınçekiç and Koyuncu, 2012; Durmuş and Koluman, 2019). Activities at the cellular level in response to the acute stress stage include homeostatic endocrine, physiological and metabolic responses, while in the chronic stage it includes reprogramming of metabolism by gene expression (Collier et al., 2019).

4. Heat Stress and Behavior

The first response of cattle to environmental changes in their habitat is behaviorally. When cattle are exposed to high temperatures, they show numerous behavioral responses to reduce the heat load. In response to environmental variations, cattle change their behavior to cope with the current situation. Therefore, behaviors provide an idea about the reaction of the animals to the environment (Tölü and Savaş, 2006; Schütz et al., 2010).

In addition to the ambient temperature, solar radiation, airflow and relative humidity in the unshaded areas of the barn affect the formation of heat stress. In particular, solar radiation contributes directly or indirectly to heat load on cattle (Kamal et al., 2018), prompting cattle to seek shade or other cooling structure (Allen et al., 2013; Herbut and Angrecka, 2018).

Seeking for shade or cooling structures is the fastest behavior in cattle, and they try to improve the negative effects of heat load by using shaded areas they can reach (Sejian et al., 2018). Therefore, the most important way to reduce the effects of heat stress is to be protected from solar radiation with well-designed shades (West, 2003). However, in environments where there is no shade or shelters, cattle can respond to heat stress by spending more time around the drinkers (Schütz et al., 2010). In addition, Schütz et al., (2010) reported that cattle with access to more shade also had less physiological (lower respiratory rate) and behavioral responses (spending less time around drinkers) to heat. Although shade is known to be beneficial for dairy cows Correa-Calderon et

al., (2004) stated that fan and sprinkler (sprinkler system) are more effective than shade in reducing heat load. It was determined by Correa-Calderon et al., (2004) that body temperature and respiratory rate of Holstein and Brown Swiss cows, meeting the need of cooling only with shaded areas in summer, are higher than those that are cooled with a sprinkler or fan. However, in the study conducted by Schütz et al., (2011) emphasized that the fountain is more effective in reducing heat load, but the animals prefer to use shade in summer. For this reason, when planning shelters, it is thought that creating sufficient shaded areas for animals and designing suitable cooling systems will provide advantages in terms of production as well as reducing heat stress.

The dairy cows rest or lie down for approximately 8 to 16 hours a day (Tucker et al., 2003; Endres and Barberg, 2007; Herbut and Angrecka, 2018). Sufficient rest of dairy cows provides many benefits such as increased blood flow, rumination and milk yield and reduced fatigue stress (Uzal, 2008). However, the sleeping time of animals may decrease due to various stress factors (Uzal, 2008, Ratnakaran et al., 2017). In particular, high temperature increases the standing time of cows (Sejian et al., 2018). This behavior is aimed at maximizing evaporative heat loss from the body surface by standing longer to reduce conductive and radiant heat from the hot surface (Ratnakaran et al., 2017).

The water is the essential nutrient that helps transferring heat from the body to the environment during heat stress (Pereyra et al., 2010; Ratnakaran et al., 2017). The water consumption has a high correlation with milk yield and dry matter consumption (0.94 and 0.96, respectively) (Dado and Allen, 1994). Although there are some equations for calculating, water requirements of ruminants are expressed as 3-4 times the amount of dry matter consumed (Schlink et al., 2010). The increase in breathing and sweating activities of cows faster than normal under heat stress conditions causes an increase in water loss and water consumption (Yavuz and Biricik, 2009). The inability of ruminants to consume as much water as they need has an effect on the decrease in dry matter consumption, which is attributed to heat stress and explained as a result of some hormonal responses. The high temperatures affect the water consumption behavior of dairy cows (Pereyra et al., 2010) and increase water intake (Veissier et al., 2018). In a study by Laínez, and Hsia, (2004), it was determined that the water drinking habits of dairy cows vary according to the season and environmental temperature.

In the study, it was stated that cows drink water during the hottest times of the day in winter while they drink water during the coolest times in summer. In addition, significant increases were observed in the water drinking behavior of the cows after milking and feeding times (Laínez and Hsia, 2004). Similarly, Ratnakaran et al., (2017) emphasized that cows consume about 30-50% of their daily water intake within one hour after milking. In this context, it is important to provide fresh water sources that can be easily accessed by all the cows in the barn and that can meet the water requirements of the animals continuously, in terms of reducing the effects of heat stress.

Advances in technology have allowed image analysis systems, electronic animal recognition systems, pedometers, position sensors and other technologies to be combined with herd management systems (Uzmay et al., 2010; Helwatkar, et al., 2014). These developments have made it possible to determine the activities or behaviors of dairy cattle in the barn, to evaluate the nutrition, welfare and comfort status, to determine the sources of environmental stress and to take preventive health measures (Mattachini et al., 2013; Ratnakaran et al., 2017; Knight, 2020). In particular, the effective use of activity meters (feeding, lying, standing, drinking water, number of daily steps and other behaviors) in controlling the stress factors caused by environmental factors in farms with large herds will be beneficial in terms of profitability.

5. Heat Tolerance and Genes

In studies conducted with dairy cows, it was reported that (Dikmen et al., 2012; Howard et al., 2014) many regions on the genome associated with regulation of body temperature (thermotolerance) were detected. The same researchers emphasized that many genes play an active role in body weight and feed intake, apoptosis events, protein events (HSPH1, TRAP1), calcium ion and protein binding, and the initiation of physiological and metabolic events such as insulin stimulation against the temperature stress of animals. Depending on the amount of heat stress, the increase in the expression of heat shock proteins (HSP) has an effective role in protecting the animal against hyperthermia and circulatory shock (Rout et al., 2018). In this context, HSPs are expressed as highly conserved stress proteins playing an important role in environmental stress tolerance and adaptation in response to stress (Kumar et al., 2015). The HPSs, which are found in all large cells and essential for cellular viability, have molecular sizes between 10-150 kDa. The HSP70 protein, an important member of HSP family, is used as a significant indicator and molecular marker of adaptation to harsh environmental stress, since it is the most excitable protein against environmental stress among all HSPs. This protein has a variety of functions, such as resistance to stress and disease, protecting living cells and ensuring their survival (Patir and Upadhyay, 2010; Habib, 2020). In addition, the HSP70 protein is used as a selection parameter in developing of heat stress resistant breeds in cattle. Therefore, this review focused on the 'HSP70' protein. Such markers play an important role in evaluating the stress adaptation mechanism of farm animals. In addition, the constant change of the climatic environment is a major concern, and the identification and use of genotypes resistant to heat stress reveals the impact on livestock productivity (Archana et al., 2017).

6. Stress and Nutrition

As it is known, heat stress negatively affects the basic physiological mechanism in the rumen of cattle and increases the risk of health problems (Nardone et al., 2010; Yue, et al., 2020). In normal conditions, the frequency of the cows going to the manger varies between 12 and 15 times a day, but in the presence of heat stress, the frequency of going to the manger decreases rapidly (3-5 times a day) (Sammad et al., 2020). Feed intake in ruminant animals starts to decrease when the temperature rises above 25-26 °C, and when it rises above 30 °C, it is much sharper (Cheng et al., 2022) and decreases rapidly and the total decrease in feed intake at 40 °C can reach to 40 % (NRC, 1989). Depending on the severity of the negative energy balance, which is the result of this situation, decreases are observed in body weight and body condition score (Yue et al., 2020). Therefore, heat stress causes a series of hormonal responses affecting the appetite region, thus reducing feed consumption and performance (Albright and Alliston, 1972).

Decreases in production and reproductive performance caused by heat stress can be partially explained by decreased feed consumption, but hormonal imbalance, decrease in rumination and nutrient absorption and increased survival rate and nutrient requirement should also be considered (Collier et al., 2005; Baumgard and Rhoads, 2009). Heat stress, which occurs as a result of body temperature leaving the comfort zone, can also occur as a result of being exposed to high temperatures as well as excessive movement. It is thought that a better understanding of this mechanism may support the development of nutrition strategies to eliminate the negative effects of heat stress on ruminant animals (Min et al., 2017). The physiological sequence of events caused by heat stress on ruminant animals is summarized in Figure 2.

The previous studies report that rumination decreases under dehydration and heat stress conditions (Aganga et al., 1990; Soriani et al., 2013). It is also known that the blood flow in the rumen epithelium is reduced. Numerous studies have shown that heat stress suppresses volatile fatty acid production in the rumen (Tajima et al., 2007; Nonaka et al., 2008). While some studies state that the decrease in feed consumption due to heat stress increases nutrient digestibility (Christopherson, 1985; Nonaka et al., 2008) there are many studies stating contradictory results. It is thought to be due to the fact that less digestive content passing through the digestive tract may have an effect on nutrient digestibility.

When ruminant animals are exposed to heat stress, negative energy balance is usually inevitable (Kaufman et al., 2017), the energy taken with feed consumption cannot meet the energy requirement, the low level of insulin in the bloodstream triggers the breakdown of fats, enabling the fatty acids stored in the adipose tissue to be used for energy purposes (Bell, 1995). Afterwards, as a response to adaptation to low feed intake caused by heat stress, blood insulin level rises again with some changes in carbohydrate, fat and protein metabolism (Rhoads et al., 2009). Although the reasons for the increase in the insulin level are not fully known, it is known that the increased insulin level prevents the conversion of muscle and adipose tissue glucose into the blood, which will be used to convert into efficiency under heat stress conditions (Wheelock et al., 2010; Kaufman et al., 2017).

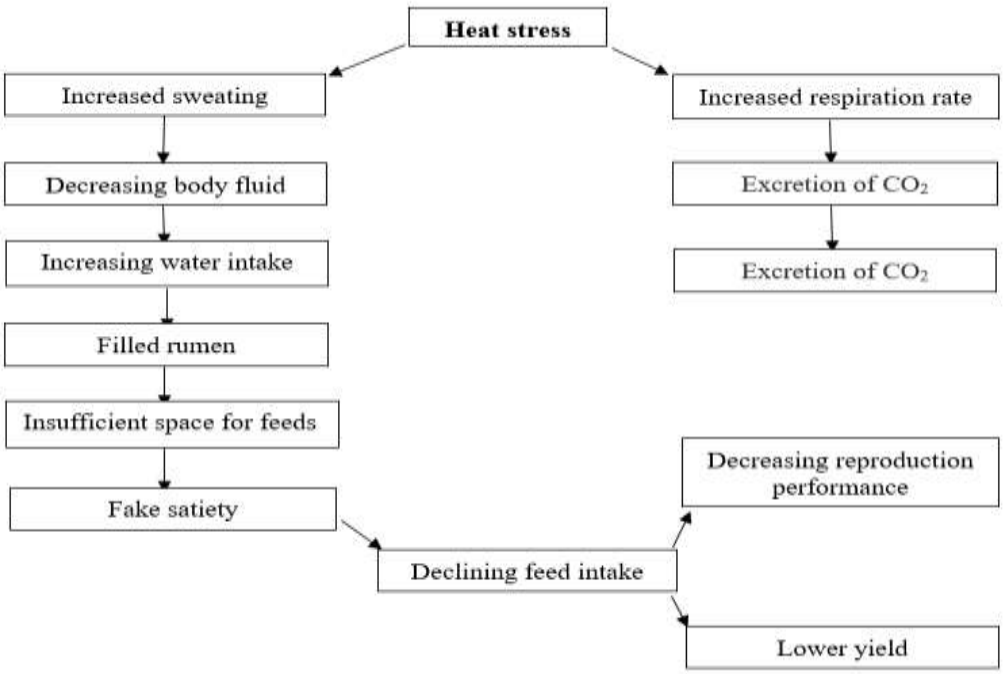

Figure 2. Physiology of ruminants under heat stress conditions (Atrian and Shahryar, 2012).

7. Reproduction

In dairy cows, it is possible to produce milk at an optimum level and to ensure sustainable production conditions by produce one calf per year. In this context, timely and accurate detection of estrus signs of cows is essential for creating profitable breeding (Arı, 2015). When dairy cows are exposed to heat stress, low fertility can be observed because the synthesis of proteins and hormones associated with reproductive organs is suppressed, as well as affecting tissue and organ functions (Liu et al., 2019; Durmuş and Koluman, 2019). The dry matter intake in cows under heat stress decreases rapidly, leading to a negative energy balance. This situation prolongs the negative energy balance period with birth, and therefore insulin, glucose and IGF-I levels in the blood decrease. The decrease in insulin, glucose and IGF-I levels, which are necessary for folliculogenesis, results in disruptions in follicular development, poor oestrus detection and formation of low quality oocytes (De Rensis and Scaramuzzi, 2003).

During acute stress in cows, a decrease is observed in the level of Gonadotropin Releasing Hormone (Gn-RH) secreted from the hypothalamus. The suppression of the synthesis of the Gn-RH hormone indirectly affects the release of Luteinizing Hormone (LH) negatively. This sequence of hormonal interactions can result in delayed release of maturing follicles or absence of ovulation. However, in the case of chronic stress, due to the decrease in the level of estradiol secreted from the follicle, since the ovaries of the animal are directly affected (Sammad et al., 2020), estrus behaviors may be vague or not observed (Arı, 2015). In addition, the physiological events affecting the ability of animal to maintain thermal balance against the heat stress may cause hormonal disruptions and embryonic deaths in the uterine (Cheng et al., 2022). Therefore, service period, calving interval, insemination number per pregnancy, pregnancy rate and reproductive efficiency, which are accepted as important indicators of herd management are also negatively affected (Durmuş and Koluman, 2019). However, Cheng et al., (2022) emphasized that male animals may also experience significant reductions in semen quality and sperm count.

8. Milk Yield Traits

The most important known adverse effect of temperature and humidity on lactating cows is the decrease in milk yield. An index called Temperature-Humidity Index (THI) is used in order to reveal the effects of heat stress in dairy cattle and to control these stress sources in the environment where the animals live. It is considered by many researchers (Yue et al., 2020; Tao et al., 2020) to be an important indicator used to evaluate heat stress in dairy cows. The significant losses in milk yield can be observed when the THI exceeds 68 (Tao et al., 2020). Bouraoui et al., (2002) reported that the milk yield (18.73±0.18 kg) in the spring (mean THI=68) of Holstein cows was higher than the milk yield (14.75±0.18 kg) in the summer (mean THI=78). The same researchers stated that as the THI value increases, the milk protein values decrease and the somatic cell count increases. In addition, Gaafar et al., (2011) determined that heat stress significantly reduces the fat, protein, lactose, dry matter and ash content in milk. In a similar study, Ominski, et al., (2002) reported that the daily dry matter intake of cows exposed to heat decreased by 1.4±0.13 kg, milk yield decreased by 1.7±0.32 kg and non-fat dry matter level decreased by 0.07 ± 0.023 %. However, researchers reported that short-term, moderate heat stress in spring and summer adversely affects the performance of lactating cows. In another study Smith et al., (2013) determined the milk yield in cows exposed to heat stress and not, 34.2 and 35.6 kg, 26.6 and 25.9 kg for Holstein and Jersey, respectively. Moreover, milk fat of both Holstein and Jersey was adversely affected by heat stress. Somatic cell score, which is an important indicator of udder health, was found to be higher in Holstein and Jersey cows exposed to heat stress. In addition, Smith et al., (2013) grouped heat stress as mild, moderate or severe according to THI values and while milk yield of Holstein cows decreased during moderate and severe heat stress, milk yield of Jersey cows was affected during severe stress conditions. Researchers have reported that Jersey cows are more heat tolerant than Holstein cows. On the other hand, Tao and Dahl, (2013) have reported that heat stress negatively affects the regeneration level of mammary cells in cows in the dry period.

9. Conclusion

The heat stress loads significant pressure on protein metabolisms as well as carbohydrate and lipid metabolisms of dairy cows. As a result, it is inevitable that this situation will negatively affect the productivity of cows with high breeding value and result in economic losses. In this respect, the steps to be taken to reduce the effects of heat stress can be defined in two stages. Since strategies for improving environmental conditions will result in a shorter time, the focus should be on improving environmental conditions and feeding management. Therefore, it is important to design and plan the ventilation and cooling systems in the shelters in accordance with the climatic conditions of the region. In addition to ventilation and cooling systems, sufficient areas should be created where cows can reach clean water continuously. In this context, appropriate diet manipulations should be prepared to reduce the stress level in hot and humid seasons. Moreover, digital animal identification systems, pedometers, position sensors and other technologies allowing the determination of the activities or behavior of dairy cattle in the barn should be combined with herd management systems to evaluate of nutrition, welfare and comfort status, as well as the detection of environmental stressors. Improving the genotypic structure of animals, which is the second step to reduce effects of heat stress, is a long-running process.

By determining the regions on the genome related to the regulation of body temperature (thermotolerance), marker-assisted selection practices should be intensified on animals that are resistant to temperature and humidity. Finally, appropriate controlled crossbreeding treatments should be expanded to establish genotypes resistant to heat stress.

Author Contributions

The percentage of the author(s) contributions is present below. The authors reviewed and approved final version of the manuscript.

	I.C.O.	A.A.	H.E.	N.O.
C			50	50
D	50	50		
S			50	50
L	50	50		
W	50	50		
CR	50	50		
SR	50	50		

C=Concept, D= design, S= supervision, L= literature search, W= writing, CR= critical review, SR= submission and revision.

Conflict of Interest

The authors declare that there is no conflict of interest.

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Review
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SENSITIVE LIVESTOCK AND INFORMATION COMMUNICATION TECHNOLOGY APPLICATIONS TO PREVENT THE SPREAD OF COVID-19

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Abstract: The epidemic disease called COVID-19 (SARS-CoV-2) has affected the whole world. With the spread of the epidemic, various measures such as distance education, home-office, and especially movement restrictions, have been tried to be taken. These measures have increased people's demand for healthy food. The formation of food safety awareness among in consumers has revealed the necessity of control of the controlling food chain (production, storage, transportation of products, etc.). In this process, animal products gained importance, especially as people paid more attention to their nutrition compared to previous years. Especially in this process, animal production should be systematically sustainable in order to meet the increasing animal protein needs of people. In this review, it aims to compile sensitive livestock systems in order to ensure the sustainability of animal production, the production of healthier animals and the production of the obtained products within the framework of food safety rules, with the cessation of mobility due to the measures taken under quarantine and social distance in the COVID-19 epidemic. Thus, in addition to reducing the human workforce during the epidemic process, the data collected with modern animal husbandry will prevent diseases, and facilitate the diagnosis and treatment processes in the event of a disease. With the use of information and communication technologies (ICT), which have an important place in this system, the data obtained through the modern livestock system can be easily processed, managed, and shared, thus reducing the possibility of disease transmission during the pandemic process.

Keywords: Covid-19, Animal production, Data, Artificial intelligence, Sensitive livestock, Information communication technologies

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1. Introduction

The quarantine process, which started with the Covid-19 (Sars-cov-2) epidemic and other epidemics in the past, restrictions on people's interactions with the environment and with each other in order not to spread the disease. While this restriction negatively affected many production branches, it also affected the country's economies. However, the extension of the pandemic period has caused problems not only in production, but also in the required workforce and in the management and marketing of agricultural production.

In order for people to lead a healthy and balanced life, as the demand for agricultural products increased, they were faced with an imbalance of supply and demand. In agriculture, which is one of the production branches, this epidemic has given importance to remote management and production in animal and plant production. This process has shown that industrially innovative systems should be used in agricultural production and modern farming methods should be applied. Industrially innovative systems have started to gain importance in order to change and improve the approach used due to the disrupted agricultural production. Thus, the need for labor will be minimized, increasing productivity and ensuring the continuation of production with artificial intelligence-based smart agriculture systems. The common point in precision livestock and precision crop farming is to increase productivity and reduce input costs. In sensitive livestock, unlike sensitive crop production, the thresholds of action-response are low. This can be used to consider animal health, behavior, efficiency and performance, and electronic systems and information technologies based on direct observation should be used (Yıldız and Özgüven, 2018).

Vertical agriculture, digital agriculture, satellite technology, robotic systems and the use of drones, which were referred to as precision agriculture during the epidemic, started to accelerate the management of new generation animal and plant production. Therefore, it has been started to be used to increase the amount and quality of production, to meet the technology need, to

make more efficient, profitable, environmentally friendly and safe production (Yaman et al., 2021). While it is obligatory to keep some animal records such as birth and disease vaccination, some records are not compulsory, causing problems in herd management by the enterprise, especially these problems are more prominent in the control, production and management of large herds. Especially since large herds are more difficult to manage than small herds, recording them also makes animal mechanization widespread and reduces the time spent on the workforce (Yıldız and Özgüven, 2018).

Unlike traditional agriculture, precision livestock farming requires a combination of technology and computer modeling to facilitate its applicability on the farm (Wolfert et al., 2017). It includes the use of precision agriculture in plant and animal production, and the Global Positioning System, geographic information system, remote sensing technologies, yield map systems, electronic measurement systems and control systems. Precision livestock breeding, which is one of the developments in information and communication technologies (ICT), allows eliminating the negativity. Developments in information and communication technologies have affected agricultural production and technologies, revealing smarter agriculture and machinery systems, allowing management and production to continue without interruption (Türker et al., 2015). The basic principle in animal husbandry practices intertwined with sensitive animal husbandry and technology is to increase productivity with a low labor force, to sustain animal husbandry, and to protect animal health and welfare (Walter et al., 2017).

2. Sensitive Livestock Practices (PLF)

The sensitive livestock concept; although it is known as an individual approach to the animal, it is defined as a technological system for real-time monitoring of animals in farm management (Hoque et al., 2022). Precision livestock farming (PLF) reveals an innovative farming system by presenting technology and knowledge in a combined way.

Real-time monitoring and management of sensitive livestock allow immediate intervention with a real-time warning in case of any problem. However, in this system, animals are monitored undisturbed and without contact, and it provides information about the condition of the animal by considering the abnormal differences in behavior and ongoing differences (Türker et al., 2015). In this way, observation-based factors such as estrus, birth and disease can be determined, and necessary precautions will be taken, therefore, it will contribute to healthy and sustainable animal husbandry and increase the amount and quality of the product.

Especially in dairy cattle breeding, monitoring sensitive livestock gives information about the health, reproduction, nutrition and general condition of the animal. Devices called biosensors, which measure different behavior and physiological conditions used in farm management, take into account the physiological state of the animal and provide convenience in feeding and care. As biosensors are a combination of technology and knowledge, they provide continuous and real-time measurement of the physiological parameters and behaviors of the animal, causing the problem to be addressed objectively. Thus, interfering with the problem determined in real-time helps to reduce the risk of disease, to be healthier and to keep the yield and performance in the desired range (Canga et al., 2022).

3. Advantages of Sensitive Livestock Practices

By monitoring animal functions and conditions in precision agriculture, the relationship between animal behavior and health and welfare is revealed, and it is possible to monitor the health status of the animal. In general, animal welfare can be evaluated by force and pressure sensors, image processing and identification systems and animal movement (Tarhan et al., 2015). However, better decision-making and resolution of analytical deficiencies due to objective data are also included (Hoque et al., 2022). There are some advantages in adapting and applying technology and science to animal husbandry. Individual handling, sustainable livestock breeding, increased milk yield, a 30% reduction in methane emissions, and early disease detection, particularly in large farms, improve animal welfare (Bewley, 2008; Uzmay et al., 2010). In addition, limitations and problems arising from labor in sensitive livestock are reduced, and it allows observing animal behavior without restriction (Türker et al., 2015).

Sensitive livestock requires continuous monitoring of animal variables and consistent analysis of data, realistic prediction of animal response to environmental changes, automatic tracking and management of the animal with predictions obtained by digital measurements, and an analytical algorithm for online examination of animal welfare and health. Cameras, sensors, wireless network systems, cloud storage, microphones, and internet connections are all used in sensitive livestock (Hoque et al., 2022).

Technologies to be used in sensitive animal husbandry are; electronic radio frequency recognition systems, image analysis systems, robotic milking and calf feeding systems, automatic classification systems, pedometers (step counters), rumination sensors, ultrasonographic imaging devices, electronic scales, automatic dense feed units, automatic calf feeding systems, water and roughage systems that measure feed consumption, coarse-concentrated feed mixers and dispensers, milk measurement systems, animal temperature measurement systems (thermal cameras), ruminal pH, heart rate blood tests, rumination time, respiratory rate and herd management software (Türker et al., 2015; Tarhan et al., 2015). As their names suggest, these systems are used for different purposes and are effective

in producing the best results and estimates. Thus, in times when the number of animals is high since the animals will be taken on an individual basis, it is possible to collect data individually by using image analysis and other technological factors, and the performance, yield, and health of an animal are kept under control (Yıldız and Özgüven, 2018).

3.1. Animal Health in Precision Farming

Animals exhibit different behaviors (such as lying down, water and feed consumption, rumination) at certain times of the day. Considering whether the animal exhibits normal behavior at these different times, it gives information about animal health. Biosensors, which are generally preferred in the analysis of the farm environment, provide important benefits in monitoring animal health. Biosensors can reduce the negative effects of potentially communicable diseases in animals (accelerating the tendency to treatment due to the recognition of the disease and ensuring that sick animals are easily separated from the herd) and enable animals to be controlled more easily (Canga et al., 2022).

Kinematic (image) analysis, animal movements can be observed by determiningto determine the health and welfare of the animal. The evaluation of abnormal gait, abnormal behaviors that appear suddenly after being inactive for a long time, repetitive behaviors and small deviations with dynamic video images is provided by objective observation (Nääs et al., 2006). In image analysis, deviations are determined by considering animal behaviors and gaits, and these deviations play an important role in scoring foot diseases and lameness (Yıldız and Özgüven, 2018). Since feed consumption will decrease in animals with a high lameness score, the animal's fertility and milk yield will also deteriorate. Not only does it affect performance and yield, but also treatment costs, additional labor, lengthening of calving intervals, additional insemination costs may also cause economic losses (Yaylak, 2008). Image analysis is obtained by using video cameras, electron microscopes, radar, ultrasound and x-ray devices (Nääs et al., 2006).

Another sensitive livestock system that provides information about gait disturbance by evaluating the pressure under the nail during walking is foot pad pressure sensitive mats consisting of force measurement elements, platform scales and pressure plates (Nääs et al., 2006). Thanks to these mats, the lameness score can be determined.

3.2. Feeding in Precision Livestock

Biosensors not only enable the examination of animal health, but also help determine values such as animal feeding behavior and feed consumption. Feed consumption frequency, rumination interval and duration, feed consumption time, amount of feed consumed are important behaviors in animal feeding (Canga et al., 2022). In order to determine the signals related to the chewing movements, the electrodes can be placed on the jaw muscles and information about the nutritional values of the animal can be obtained (Nunes et al., 2021).

The presence of health problems in animals (especially lameness) reduces feed consumption and feeding, thus negatively affecting feeding. Video recordings used on farms allow the analysis of feed consumption and other feeding-related factors. In addition to this situation, the body condition score, which is usually based on individual observation, gives information about the nutritional status of the animal (Canga et al., 2022)

3.3. Reproduction and Performance in Precision Livestock

Animal health and nutrition affect reproduction. Therefore, sensitive livestock systems examining these parameters also give general information about reproduction and performance. With image analysis, animal movements can be examined, and animal performance and reproductive characteristics can be examined. Especially following the heat at the right time has a positive effect on reproduction, and in connection with this, it also positively affects the productivity of dairy cows (Nääs et al., 2006). However, the occurrence of foot diseases can negatively affect the yield as it will reduce feed consumption. Not only does it affect performance and yield reduction, but also treatment costs, additional labor, prolongation of the calving interval, additional insemination costs can also cause economic losses (Yaylak, 2008). In addition, since foot diseases restrict the movements of the animal, they cause negative effects on reproduction and performance. Image analysis is obtained by using video cameras, electron microscopes, radar, ultrasound and X-ray devices (Nääs et al., 2006).

4. Conclusion

Sensitive livestock systems have started to gain importance for sustainable livestock production during the COVID-19 pandemic. Epidemic diseases experienced from the past to the present have caused problems in production, especially in plant and animal production, considering the risk of transmission of the disease and the number of death rates. Therefore, the production shortage has disrupted the supply-demand balance and caused problems in the food supply. People have started to pay attention to nutrition in order to stay healthier. Therefore, as this situation increased the demand for animal products, it also led to an increase in animal husbandry. During the COVID-19 pandemic, precision agriculture and precision livestock systems have come to the fore as they allow remote management and control. Because precision agriculture is based on science and technology, it can reduce the risk of disease transmission by allowing animals to be handled individually and without contact. However, this system is focused on increasing efficiency, protecting the environment and reducing costs.

In short, while agricultural inputs are applied uniformly in traditional agriculture, many technologies are used in line with agricultural needs in precision agriculture, so

that sustainable animal husbandry can be made for healthy animals and humans, preventing economic losses and diseases. It is possible to examine the efficiency, reproduction, health, welfare and behavior of the animal by means of herd monitoring and control systems by making use of the latest developments in technology in sensitive livestock. In the sensitive livestock system, there are problems such as data science, prediction interpretation, high capital, lack of wireless internet connection, lack of power supply, security and privacy problems, and the investment cannot be met due to the low number of animals. However, it is thought that these problems will not be encountered in providing the necessary equipment and equipment in farms where the number of animals is high. The fact that these systems were not preferred much before Covid-19 increased the risk of transmission of epidemic diseases. Not using technological systems in animal husbandry will allow individual animal husbandry, mismanagement and feeding, as well as prevent the handling of animals individually. Therefore, since contactless animal husbandry is not carried out and the data is not recorded (for example, cloud database), the health, nutrition, reproduction and performance of the animal cannot be evaluated correctly.

Author Contributions

The percentage of the author(s) contributions is present below. The authors reviewed and approved final version of the manuscript.

	H.N.K.	M.B.	D.Ç.
C			50
D	50	50	
S			50
L	50	50	
W	50	50	
CR	50	50	
SR	50	50	

C=Concept, D= design, S= supervision, L= literature search, W= writing, CR= critical review, SR= submission and revision.

Conflict of Interest

The authors declare that there is no conflict of interest.

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