# MANAGEMENT
# &
# MARKETING

Volume XXII, issue 1/2024

**UNIVERSITARIA**
**CRAIOVA 2024**

The Journal is indexed in international databases:

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- Central and Eastern European Online Library - CEEOL
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Editura Universitaria
Str. A.I. Cuza, nr 13, 200585, Craiova
Website: www.mnmk.ro
Contact person: Cosmin Ionut Băloi
Email: revista_management_marketing@yahoo.ro



**ISSN 1841-2416**
**ISSN-L 2068-9667**

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# STATISTICAL STUDY OF SOME INDICATORS IN THE LIVESTOCK SECTOR

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DOI: 10.52846/MNMK.22.1.01

*Abstract*:
*In this paper, some indicators covering milk production, weight gain and feeding efficiency are studied, such as the duration of lactation, total amount of milk, daily amount of milk, percentage of fat, protein, lactose in milk, for a representative sample taken from S.C.D.A Simnic. In the first part, a descriptive statistical analysis is made of the indicators in the zootechnical field presented, followed by econometric methods regarding confidence intervals for the average of the entire population, at a threshold of 5%. Also, the correlation matrix between the indicators is analyzed and three validated linear regression models are presented with the interpretation of the results. These results help to optimize management in the zootechnical field by making decisions based on quantitative analyses*.

*Keywords: livestock management, statistical methods, correlation and regression.*

## 1. Introduction

The use of statistical methods in agriculture and animal husbandry is of significant importance for effective resource management, informed decision making and improved yield and productivity. Agricultural statistics allow field personnel to monitor and evaluate production, identify trends, and make comparisons between different periods or batches. It helps to identify factors that can negatively or positively influence production. Statistics provide data on the demand for resources such as water, energy, animal feed, and agricultural inputs. This helps in proper resource planning to ensure efficient and sustainable management. Weather and climate statistics help farmers plan their activities according to weather conditions and take measures to reduce weather-related risks such as drought, floods or extreme temperatures. Statistics can also be used to evaluate the performance of different plant varieties or animal breeds according to characteristics such as yield, disease resistance or the quality of meat and dairy products. This helps in selecting the best genetic lines to get better yields. Moreover, it helps to efficiently manage stocks of agricultural products and plan their distribution to markets or consumers. In animal husbandry, statistics can be used to track animal health and quickly detect disease outbreaks. This allows rapid interventions to prevent the spread of disease and maintain animal health.

Animal husbandry is one of the important branches of agriculture, having as its object the growth, reproduction, breeding and exploitation of animals. Thus, raising and improving animal breeds is necessary to provide the population with animal products, the food and light industry with raw materials, and agriculture with organic fertilizers.

Statistics also play a significant role in livestock management (Cucu and Maciuc 2004, Maciuc 2006), contributing to effective decision-making to improve performance and productivity in animal husbandry. Thus, it enables the collection and analysis of animal performance data such as milk production, weight gain and feed efficiency. This data helps identify individuals or groups of animals performing above or below average and can provide clues to the genetic quality of the herd. Statistically analyzed data can contribute to the optimization of nutrition and can be used to monitor feed consumption, animal nutritional needs and feeding efficiency. This helps optimize the diet to ensure maximum growth and production at minimum cost. Statistics can also be used to track animal reproductive cycles, reproductive rate, and reproductive success. This helps in planning breeding programs and optimizing breeding yield. Last but not least, by evaluating costs and profitability, statistics allow the calculation of production costs, including costs for food, care and health. These data are essential to assess the profitability and efficiency of livestock operations.

In conclusion, statistical methods play an important role in livestock management, helping managers make effective decisions and optimize operations to achieve better yields, improved animal health, and increased profitability in animal husbandry.

In the present paper we will deal with the statistical study of some quantitative and qualitative indicators regarding a sample of 31 cattle (females), out of a total of 98, and the production of dairy products at S.C.D.A Simnic.

In the first years (1958-1962), the research-development activity had as its general objective the establishment of the productive effect and the way of using hybrid maize, green and "pickled" in the nutrition of different species of animals. Along the way (1962-1977) the area of concern was expanded to include food works, feed technology, animal maintenance and exploitation technology, breeding and animal reproduction. Studies were undertaken on sheep, pigs and bulls. It was necessary to solve some new problems (the development of intensive animal breeding systems), but also to reconsider the old conceptions of animal breeding. The results of research and collaborations with other units served the preparatory stage for the concentration and specialization of animal production in industrial breeding systems. Next, emphasis was placed on the study of the possibilities of forming new breeds of animals and the genetic consolidation of some types, families and zootechnical lines with high productive potential, but also with valuable technological attributes in sheep, pigs and bulls.

Starting with 1977, the research-development activity had as its general objective the continuous improvement of the productivity and efficiency of the growth of the Holstein Frize breed. The specific objectives were aimed at solving the complex physiological, ecological, ethological, ameliorative, reproductive, technological and sanitary-veterinary problems of the breeding of this breed imported from Denmark in 1977 and 1978. The broadening of the genetic base and the change of the genetic structure of the imported herd was done continuously through methods and specific means (selection, migration, mating management), the beneficial effects accumulating over time and manifesting in the conditions of the milk production system at S.C.D.A. Simnic.

At the beginning, the ˝Şimnic˝ dairy cow type was formed and consolidated with good morpho-productive characteristics (body weight 650-660 Kg, productive potential 8000-9000 l udders with a fat content of 3.95-4.06%, age at first calving 25-27 months and docile temperament).

Due to the numerical increase of very valuable phenotypes, the farm is integrated into the National Bull Breeding Program as an ″elite farm″ with the objective of activity being the directed production of generations of bulls intended for selection, with a view to their use in the insemination of Romanian cow herds. Among the bulls "built" at Şimnic, we mention here LINCOLN ET 1, PENSTAR 3, ARLINDA JET 8.

Starting with the year 1990, the intensive use of intensively improving milk production bulls (imported) was imposed for the insemination of females. The genetic material used determined the variation of the productive and functional characteristics of the herd from S.C.D.A. Simnic. The Holstein Friesian progeny in which genes of North American origin predominated were phenotypically different from the progeny in which genes of European origin predominated. Taking into account the future diversification of cow's milk production systems, it was considered that matching the type of cow with the production system in which it is raised is of great importance for optimizing profitability. For this purpose, starting from 2004, the cattle herd from S.C.D.A. Simnic served as the basis for the formation of two genetic lines with different body development at maturity.

The first genetic line was called the Holstein Friza Şimnic line with high live weight at maturity (Holstein Friza Şimnic G.V.M.) and the second, the Holstein Friza Şimnic line with low live weight (Holstein Friza Şimnic g.v.m.). Holstein Friza line Şimnic G.V.M. it is intended for 'high input' systems where the focus is on technical efficiency and managerial decisions are based on their direct impact on profitability. Holstein Friza line Şimnic g.v.m. it is suitable for 'low input' systems where the focus is on maximizing the use of fodder from pastures and hayfields. The formation of the two genetic lines was based on the existence of interactions between genotype and environment.

Holstein Friza line Şimnic G.V.M. has a productive potential of over 9,000 kg of milk, the percentage of milk protein of 3.3 - 3.4%, and of fat of 3.6 - 3.8%. Holstein Friza line Şimnic g.v.m. it has a productive potential of 7,500-8,000 kg of milk, the milk protein percentage is 3.2-3.3% and the fat percentage is over 4.5%. The HF Śimnic G.V.M line has a higher stature, a higher live weight, a calving interval greater than 360 days, mobilizes a lot of energy from body reserves in the first part of lactation, a longer postpartum period, with a negative energy balance and uses less energy to restore body reserves during lactation, compared to the Holstein Friza Line Șimnic g.v.m.

Starting from 2015, research began on improving the robustness of the animals and the quality of the milk produced, research carried out within a project called "Improving a line of cows from the Holstein Friza breed towards the simultaneous improvement of robustness and milk quality"

In this paper, some indicators covering milk production, weight gain and feeding efficiency are studied, such as the duration of lactation, total amount of milk, daily amount of milk, percentage of fat, protein, lactose in milk, but also the weight of cattle. We also have four nutrition indicators given by the vital functions nutritional units, vital functions digestible protein (proportional to weight), but also lactation nutritional units and lactation digestible protein (proportional to the daily amount of milk).

The work is structured as follows. In the second section, a presentation of the specialized literature in the field is made, highlighting the research undertaken previously. The third section contains the research methodology, mentioning the main statistical indicators used in the analysis, as well as the statistical tests used to validate the econometric models. The fourth section contains the novelty of the work. In the first part, a descriptive statistical analysis of the previously presented zootechnical indicators is performed, followed by econometric methods regarding confidence intervals for the average of the entire population, at a threshold of 5%, as well as correlation and regression. The work ends with conclusions. Analyzed data were obtained from S.C.D.A. Siminic (Annex 1).

## 2. Literature review

Anghel, Anghelache and Panait (2017) studied the results that were recorded by the member countries of the European Union in the field of agriculture from the period before 2017, highlighting those of Romania and analyzed, among others, certain aspects regarding the evolution agricultural production and animal production. Anghelache and Dumitrescu (2015) carried out research, which largely focused on the analysis of agricultural production by types of crops, animals, reproduction, but also the size of agricultural holdings. Anghelache et al. (2014) presented the evolution of agricultural production in Romania, analyzing the two main components of agriculture, namely, plant production and animal husbandry.

In their work, Herrero et al. (2013) studied the main systems of raising and exploiting animals: intensive closed, mixed (plant culture and animal breeding) and open (pasture), which totals a herd of over 17 billion animals. of animals contribute by providing meat, milk, eggs to ensure the nutritional value of food providing approximately 13% of the energy and 28% of the protein consumed worldwide. Moreover, in developed countries, these percentages increase to 20% for energy and 48 % for protein (FAO, 2009). Farkas et al. (2023) conducted research using statistical data from the period 1990-2022, a literature review and 66 interviews conducted in the southern region of Hungary. The results showed a decrease in the number of livestock and small farms in rural settlements, correlated with an intense concentration of farms, which negatively affects income generation opportunities.

Herath, Weersink and Carpentier (2005), study, among others, the factors that affect the state's annual share of the national inventory for each of the cattle and milk sectors, using data from the 48 states from 1976 to 2000. The results indicate that differences in the severity of environmental regulations faced by livestock producers had a significant influence on production decisions in the dairy sector.

Robinson and others (2014) show that animal husbandry contributes directly to the livelihoods and food security of almost a billion people. This paper describes the current approach in detail and presents new global distribution maps at 1 km resolution for cattle, pigs and chickens. These digital layers are made available to the public via the Livestock Geo-Wiki (http://www.livestock.geo-wiki.org), as are maps of other livestock types as they are produced.

Sandu (2015) evaluates the Romanian livestock sector, studying the evolution of the main indicators of animal production, through the lens of the availability of agri-food products of animal origin. The analysis of the main indicators of livestock production is based on statistical data from the National Institute of Statistics. It was found that animal husbandry presents serious structural problems due to excessive property fragmentation, low productivity and high self-consumption in farms. The level of livestock production is low, caused by the sharp and constant reduction of livestock numbers, poor performance and lack of competitiveness. Grosu and others (2003), Korkmaz and others (2012) use regression in the statistical study of indicators in the livestock sector.

## 3. Research methodology

The statistical analysis of some quantitative and qualitative indicators in the zootechnical field was carried out by calculating the following numerical indicators: selection mean, selection dispersion, standard deviation and coefficient of variation. To check whether or not the data series follow a normal distribution, the Kolmogorov-Smirnov, Shapiro-Wilk and Jarque-Bera tests are used (for more details see Georgescu, 2005, Maddala, 2001, Wooldridge, 1999). The Kolmogorov-Smirnov and Jarque-Bera tests are mainly used to test large data sets while the Shapiro-Wilk test is more meaningful for a smaller sample, such as 50 observations or less. If the probability attached to the test, for any of the tests, is above 0.05, the data are normally distributed, at a significance threshold of 5%.

For a series $Y_t$, t = 1,...,n, the Shapiro-Wilk test (Shapiro & Wilk, 1965) regarding the normality of the distribution is defined as follows:

$$W = \frac{\sum_{t=1}^{n}(p_t\, y_t)^2}{\sum_{t=1}^{n}(y_t - \bar{y})^2},$$

where $y_t$ represent the values of the initial series $Y_t$, which are ordered in ascending order ($y_1 \leq y_2 \leq \ldots \leq y_n$), $\bar{y}$ is the mean of the respective series and $p_t$ are weights. The null hypothesis $H_0$ of normality of the distribution is rejected if $W \leq W_\alpha$, where the critical thresholds $W_\alpha$ are tabulated by Shapiro & Wilk (1965), at the chosen significance threshold. The test also generates an attached probability (SPSS software) and the hypothesis of normality is accepted if the probability is greater than 0.05 at the chosen significance threshold $\alpha = 5\%$.

The Jarque-Bera test is a statistical test for verifying the assumption of normality of a distribution. It is based on measuring the skewness S and the kurtosis K of a distribution. The tested variable is

$$JB = \frac{n}{6}\left(S^2 + \frac{(K-3)^2}{4}\right)$$

which follows a $\chi$-square distribution law, where $n$ is the number of observations or degrees of freedom. The null hypothesis of the Jarque-Bera test is $H_0$: the data are normally distributed and is evaluated against the alternative hypothesis $H_1$: the data are not normally distributed and follows another distribution from the family of Pearson distributions. Using the t-Student test and the standard error, confidence intervals were calculated for the mean at a chosen significance level of 5%, for normal distributions, given by

$$[\bar{x}_s - t \cdot \frac{\sigma_s}{\sqrt{n}},\ \bar{x}_s + t \cdot \frac{\sigma_s}{\sqrt{n}}].$$

In order to evaluate the parameters in regression models, we used the method of least squares, where the coefficient of determination $R^2$ shows us the percentage by which the influence of the independent variables on the dependent variable is explained. Student's t-test was used to test the null hypothesis $H_0$ (coefficients are not significantly different from 0) and the alternative hypothesis $H_1$ (coefficients are significantly different from 0). The F-test verifies the null hypothesis $H_0$ (all coefficients are not significantly different from 0) and the alternative hypothesis $H_1$ (there is at least one coefficient different from 0).

Furthermore, we used the Durbin-Watson test to check first-order autocorrelation or independence of model errors, the Breusch-Godfrey test to check higher-order autocorrelation of errors, the Kolmogorov-Smirnov, Shapiro-Wilk and Jarque-Bera tests to see if the model errors follow a normal distribution and White's test to check the homoscedasticity or heteroscedasticity of the regression model (see Georgescu, 2005, Maddala, 2001, Wooldridge, 1999).

## 4. The main results

### 4.1. Statistical analysis

In this section we will statistically analyze the qualitative and quantitative indicators that characterize the group of cattle (females) chosen for the study and the quality of the milk collected from them. The numerical indicators of the tendency of the distribution series were calculated, such as the selection mean, median, minimum and maximum value, but also variation indicators such as the selection dispersion, the standard deviation and the coefficient of variation (Table 1). The Kolmogorov-Smirnov, Shapiro-Wilk (Table 3) and Jarque-Bera (Table 2) tests were also used to verify whether or not the data series follow a normal distribution. Finally, using the t-Student test and the standard error, the confidence interval for the mean was calculated in the case of series with normal distributions at a significance threshold of 5% (Table 4).

**Table 1. Descriptive statistics of zootechnical indicators**

| | Mean of selection | Standard error | Median | Standard deviation | Coef. of variation | Dispersion of selection | Minimum value | Maximum value |
|---|---|---|---|---|---|---|---|---|
| Duration of lactation (days) | 298,493 | 2,117 | 305 | 11,787 | 3,94% | 138,951 | 254 | 305 |
| Total amount of milk (litres) | 9652,771 | 210.680 | 9898 | 1173,022 | 12,15% | 1375980,66 | 6437,33 | 11248,66 |
| Daily quantity of milk (litres) | 32,355 | 0,700 | 32,872 | 3,898 | 12,04% | 15,196 | 21,846 | 37,655 |
| Weight (kg) | 604,838 | 5.,72 | 600 | 33,253 | 5,49% | 1105,806 | 560 | 680 |
| Nutritional units vital functions (kg) | 3,024 | 0,0298 | 3 | 0,166 | 5,49% | 0,027 | 2,8 | 3,4 |
| Lactation nutritional units (kg) | 16,177 | 0,350 | 16,436 | 1,949 | 12,04% | 3,799 | 10,923 | 18,827 |
| Digestible protein vital functions (gr) | 423,387 | 4,180 | 420 | 23,277 | 5,49% | 541,845 | 392 | 476 |
| Digestible milk protein (gr) | 2103,078 | 45,509 | 2136,6 | 253,386 | 12,04 % | 64204,572 | 1420 | 2447,61 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Fat percentage | 5,066 | 0,057 | 5,036 | 0,320 | 6,31% | 0,103 | 4,24 | 5,68 |
| Protein percentage | 3,319 | 0,016 | 3,320 | 0,094 | 2,83% | 0,008 | 3,104 | 3,525 |
| Lactose percentage | 4,714 | 0,015 | 4,710 | 0,085 | 1,80% | 0,007 | 4,520 | 4,862 |

*Source: Developed by author*

**Table 2. Jarque-Bera Test test for normality for zootechnical indicators**

| | Value Jarque-Bera test | Probability | Asymmetry | Kurtosis |
|---|---|---|---|---|
| Duration of lactation | 59.10458 | 0.000000 | -2.259477 | 8.033630 |
| Total amount of milk | 3.598778 | 0.165400 | -0.829908 | 3.176517 |
| Daily amount of milk | 1.905396 | 0.385699 | -0.604684 | 2.887860 |
| Weight | 4.281751 | 0.117552 | 0.910343 | 2.997998 |
| Nutrient units vital functions | 4.281751 | 0.117552 | 0.910343 | 2.997998 |
| Lactation nutritional units | 1.905396 | 0.385699 | -0.604684 | 2.887860 |
| Digestible protein vital functions | 4.281751 | 0.117552 | 0.910343 | 2.997998 |
| Digestible milk protein | 1.905396 | 0.385699 | -0.604684 | 2.887860 |
| Fat percentage | 0.128277 | 0.937875 | -0.154128 | 2.934504 |
| Protein percentage | 0.015024 | 0.992516 | 0.003634 | 2.892397 |
| Lactose percentage | 0.829881 | 0.660379 | -0.221434 | 2.331901 |

*Source: Developed by author with Eviews software*

**Table 3. Kolmogorov-Smirnov and Shapiro-Wilk tests for zootechnical indicators**

| | Kolmogorov-Smirnov | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|
| | Statistic | df | Sig. | Statistic | df | Sig. |
| Duration of lactation | ,292 | 31 | ,000 | ,631 | 31 | ,000 |
| Total amount of milk | ,128 | 31 | ,200 | ,937 | 31 | ,066 |
| Daily amount of milk | ,120 | 31 | ,200 | ,949 | 31 | ,145 |
| Weight | ,203 | 31 | ,002 | ,900 | 31 | ,007 |
| Nutrient units vital functions | ,203 | 31 | ,002 | ,900 | 31 | ,007 |
| Lactation nutritional units | ,120 | 31 | ,200 | ,949 | 31 | ,144 |
| Digestible protein vital functions | ,203 | 31 | ,002 | ,900 | 31 | ,007 |
| Digestible milk protein | ,120 | 31 | ,200 | ,949 | 31 | ,144 |
| Fat percentage | ,083 | 31 | ,200 | ,979 | 31 | ,796 |
| Protein percentage | ,068 | 31 | ,200 | ,993 | 31 | ,999 |
| Lactose percentage | ,096 | 31 | ,200 | ,968 | 31 | ,458 |

*Source: Developed by author with SPPS software*

**Table 4. The confidence interval for the mean of zootechnical indicators**

| | Mean | $t \cdot \frac{\sigma_s}{\sqrt{n}}$ | confidence interval |
|---|---|---|---|
| Total amount of milk | 9652,771 | 430,267 | [9222.503; 10083.038] |
| Daily amount of milk | 32,355 | 1,429 | [30,926; 33,784] |
| Lactation nutritional units | 16,177 | 0,714 | [15,463; 16,891] |
| Digestible milk protein | 2103.078 | 92.942 | [2010,136; 2196,02] |
| Fat percentage | 5.066 | 0.117 | [4,949; 5,183] |
| Protein percentage | 3.319 | 0,034 | [3.285; 3.353] |
| Lactose percentage | 4.714 | 0.031 | [4,683; 4,745] |

*Source: Developed by author*

From the analysis of the results for the normality of the distributions, it is found that the duration of lactation does not follow a normal distribution, according to the Kolmogorov-Smirnov (prob.=0.00), Shapiro-Wilk (prob.=0.00) and Jarque-Bera (prob.=0.00). We also consider that the weight does not follow a normal distribution according to the Kolmogorov-Smirnov (prob.=0.002), Shapiro-Wilk (prob.=0.007) tests, although the Jarque-Bera test has an attached probability of 0.11. Due to the number of 31 observations (n<50), the Shapiro-Wilk test is considered the most representative. It is found that the nutritional units vital functions and the digestible protein vital functions, which are proportional to the weight, do not follow a normal distribution. For the other indicators, the probabilities attached to the three normality tests are greater than 0.05, that is, they tend towards normal distributions. Next, we will do an analysis for each indicator separately

*The duration of lactation* for the chosen sample has a mean of 298.4 days, with a standard deviation of 11.7 days. The coefficient of variation has the value of 3.94%, which shows that the series is homogeneous and the mean representative. The values are in the range of 254-305 days, most of them being at the upper edge and the series does not have a normal distribution (stopping lactation in deliberately, for a new insemination).

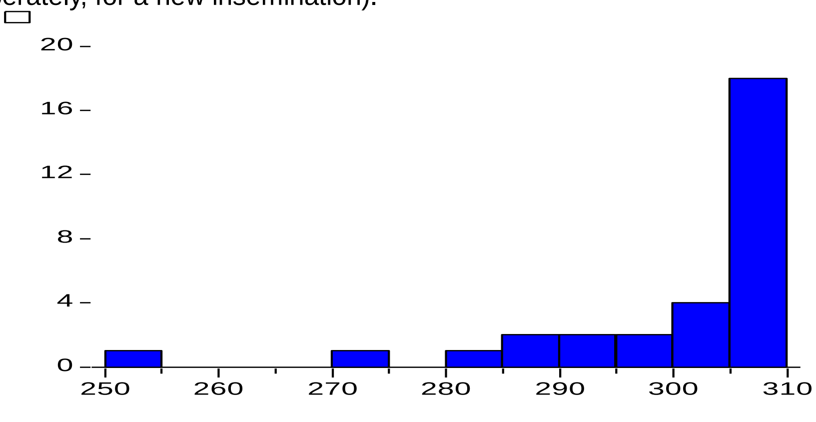


**Figure 1. Lactation duration histogram**

*The total amount of milk* collected during the lactation period is a normally distributed variable, according to the Kolmogorov-Smirnov (prob.=0.2), Shapiro-Wilk (prob.=0.066) and Jarque-Bera tests with the value 3.598 and the attached probability 0.165 (asymmetry =-0.829, kurtosis=3.176). The sample mean is 9652.7 liters with a standard deviation of 1173.02 liters. The coefficient of variation has the value of 12.15% indicating a homogeneous data series, the recorded values are located around the mean, which is significant. The confidence interval for the mean, at a significance threshold of 5%, is [9,222.5; 10,083.03].

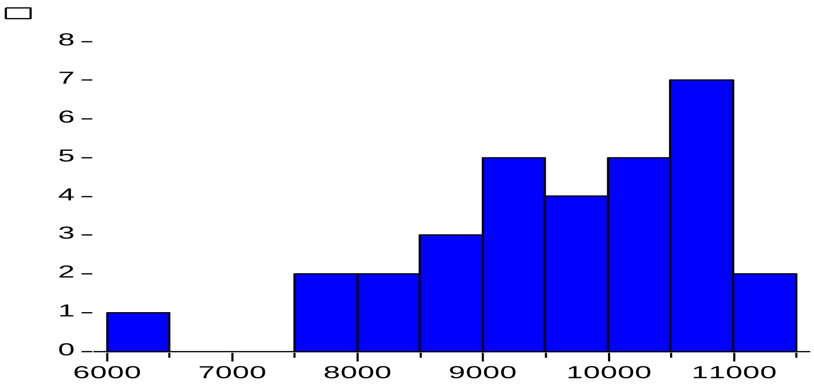


**Figure 2. Total amount of milk histogram**

*The average daily amount of milk* is obtained by dividing the total amount by the duration of lactation and the mean obtained for this sample is 32.355 liters with a standard deviation of 3.898 liters. The data are normally distributed, according to the Kolmogorov-Smirnov (prob.=0.2), Shapiro-Wilk (prob.=0.145) and Jarque-Bera tests with the value 1.905 and the attached probability 0.385 (asymmetry=-0.604, kurtosis=2.887). The coefficient of variation has the value of 12.04%, indicating a homogeneous data series, with a significant mean. The confidence interval for the mean, at a significance threshold of 5%, is [30.926; 33.784].

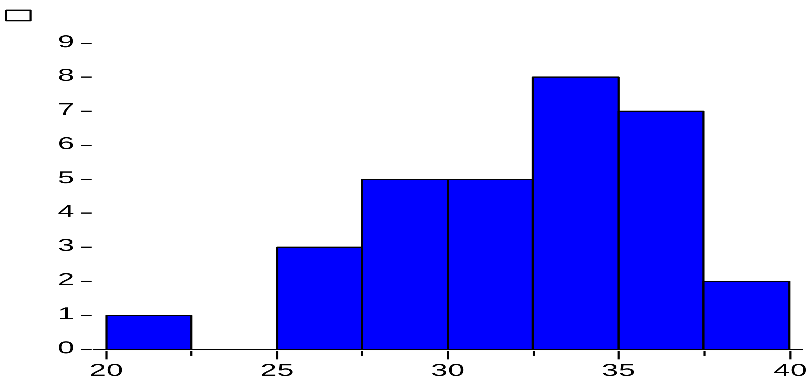


**Figure 3. Daily quantity of milk histogram**

*The weight* of the selected cattle is another indicator taken into account and the mean of the sample is found to be 604.838 kg, with a standard deviation of 33.253 kg. The sample data are not normally distributed according to the Kolmogorov-Smirnov (prob.=0.002), Shapiro-Wilk (prob.=0.007) tests. However, the coefficient of variation is 5.49%, meaning a small variation in the data, which is around the mean, which is representative.

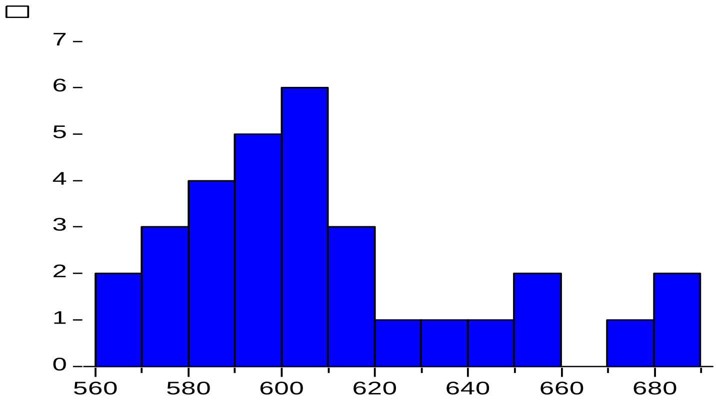


**Figure 4. Weight histogram**

The vital functions nutritional unit indicator is calculated by multiplying the weight by 0.05, having an identical distribution to the weight indicator. The lactation nutritional unit indicator is obtained from the daily amount of milk multiplied by 0.5, so that the two indicators have the same distributions. The vital functions digestible protein indicator (grams) is calculated by multiplying the weight by 0.7 and consequently they have identical distributions. Also, the indicator of digestible milk protein (grams) is obtained by multiplying the daily amount by 65 and they have the same distributions

Analyzing *the milk fat percentage*, it is found that this indicator has a mean of 5.066 and a standard deviation of 0.32 for the chosen sample, the data following a normal distribution, according to the Kolmogorov-Smirnov (prob.=0.2), Shapiro-Wilk tests (prob.=0.796) and Jarque-Bera of value 0.128 with the probability of 0.937 (asymmetry=-0.154; kurtosis =2.934). The coefficient of variation has a value of 6.31%, which indicates a homogeneous series, with values located around the mean, which is representative. The confidence interval for the mean is [4.949; 5.183] for a significance threshold of 5%.