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The Use Of Fuzzy Logıc Approach In Evaluatıon Of Sublınıc Mastıtıs

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ABSRACT

This study was carried out with the aim of investigating the possibility of detection of subclinical mastitis in the number of somatic cell count and electrical conductivity by using fuzzy logic method in Holstein cows raised in a private farm in the Karapinar district of Konya.
As a result of the analysis, mean of somatic cell count was 348153 ± 52340 and average of electrical conductivity was 4.23 ± 0.18. Linear regression of electrical conductivity and milk fat to somatic cell count were found statistically significant (P<0.01), while the parity was insignificant to the somatic cells count. For the electrical conductivity, the effect of the parity, animal group and the protein group was very important (P <0.001) and the effect of the milk fat group was significant (P<0.05). In the analysis according to the fuzzy logic method, the accuracy ratio between the number of somatic cells count and the electrical conductivity was determined as 92.45%.
As a result, 92% of subclinical mastitis can be correctly detected using the number of somatic cells and electrical conductivity values.

1. Introduction

Turkey take third place within EU countries and twenty-seventh within world in terms of cattle population, where the share of cattle in milk production is increasing every year (Günaydın, 2007). The number of cattle in Turkey increased by 13.2% compared to the previous year in 2017 rose to 16 million 105 thousand head. In this increase, the share of cattle increased by 13.2% to 15 million 944 thousand heads. (Anonymous, 2017; Memmedova, 2012). According to the data of 2017, the number of milking animals was 5.969.047 heads, the average milk production per animal was 3.143 kg and milk production was 18.762.319 tons in Turkey (Anonymous, 2017; Memmedova, 2012).

One of the problems faced by most of the dairy farmers in Turkey is mastitis. Mastitis can be defined as the reaction of the udder gland to irritant effects. According to shape of the route, there are two types of mastitis. The first is clinical mastitis and the second is subclinical mastitis. Clinical mastitis is evident in the course of the disease and is very easy to recognize. Subclinical mastitis is a udder inflammation that has been caused falling in milk yield and quality in a long process because it does not cause visible defects in the udder and milk composition. For dairy cattle breeders, subclinical mastitis is associated with major problems. Since subclinical mastitis cannot be diagnosed clinically, it causes significant economic loss (Baştan et al., 1997; Atasever & Erdem, 2008).

In order to diagnose subclinical mastitis, the somatic cell count is directly determined by some tests and indirectly by the CMT (California Mastitis Test). CMT is an easy method to be done under all conditions. Another method used for diagnosis of subclinical mastitis is also electrical conductivity. Today, it is used to devices called Milk Checker. The electric conductivity in the milk varies depending on the structure of the electrolytes such as Ca, Na, and lactose. Besides, the electrical conductivity of the milk varies depending on the animal, genotype and environmental factors (Timurkan, 2014).

In recent years, a model that is often used in evaluating raw milk quality is fuzzy logic. The fuzzy logic theory began to be used in Turkey has been the subject of many successful projects in the livestock sector. For example, it can be used to detect of estrus, animal breeding, and estimation of various yield characteristics and classification of animal products into quality classes (Akıllı et al., 2014).

This study was carried out to evaluate the subclinical mastitis using the fuzzy logic approach by determining somatic cell count and electrical conductivity values in milk samples taken from Holstein cattle.

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2. Materials and Methods

The animal material of the study was formed of 164 head Holstein cattle raised in a private farm in the Karapinar district of Konya. It is used the Cetasoft program, a computerized herd management system that provides the highest level of profitability, producing solutions for herd management, health, nutrition, official books and commercial businesses at the farm. With this system, individual information of animals, live weights, movement activities are automatically recorded.

In the farm, milking is done three times a day, from 05:00-08:00, 11:00-14:00, 17:00-20:00. Immediately at the end of the milking, gel solutions are applied to the udder to prevent contamination of the bacteria. Samples of 50 cc ependorf tubes were taken at the farm on test day evening milking. Milk samples were taken through the milking with the help of the milk sampling devices available in automatic milking machines. The purpose of intake of milk samples was to calculate the number of somatic cells count and electrical conductivity, therefore the samples were kept in the cold chain.

As soon as the milk samples are taken, they are kept in transport bags with ice molds. On the same day, the samples were brought to Selçuk University Biotechnology Laboratory of Agricultural Faculty and placed in a preheated oven. The electrical conductivities of the receiving milk samples were made twice for each sample to increase the reliability with the Lastoscan MMC-30 milk analyzer, and the somatic cell counts were performed once with the NucleoCounter SCC-100 somatic cell counting device. Content tests in the milk were made on the same device. Obtained data were recorded to the computer. The samples were evaluated for mastitis by the CMT test and classified into three groups as 0 = negative, 1 = suspicious and 2 = mastitis.

In determination of electrical conductivity, groups are formed as follows.; Animal group (1, 2, 3), Milk fat groups (1=low (<3.00), 2=normal (3.01-4.00), 3=high (>4.01)), Somatic cell count groups (Normal=0-200.000, Weak Suspect=200.001-300.000, Suspect =300.001-500.000, Mastitis=>500.001), Protin groups (1=Low (<3.20), 2=Normal (3.21-3.50), 3=High (>3.51)) and Parity (1, 2, 3, 4, 5).

The statistical analyzes were made using the Harvey package program developed by Harvey (1987). Fuzzy Logic Toolbox of MATLAB 7 (Anonymous, 2009) PROGRAM was used for fuzzy logic modeling. In the fuzzy logic model, Sugeno inference method was used. For the Sugeno fuzzy model, the two fuzzy "IF-IF" rules are as follows.

Rule 1: $IF_x = A_1$ and $y = B_1$ IF $f_1 = p_{1x} + q_{1y} + r_1$

Rule 2: $IF_x = A_2$ and $y = B_2$ IF $f_2 = p_{2x} + q_{2y} + r_2$

The features analyzed in the fuzzy logic method are divided into definite and fuzzy clusters and analyzed. The Duncan multiple comparison test was used to determine which difference between the two group averages was significant (Düzgüneş et al., 1987).

3. Results and Discussion

3.1. Somatic cell count

The obtained Least Square Means (LSM) and Standard Error (SE) for the number of somatic cells were determined as 348153.37 ± 52340.09. The Constant Estimation (CE) and Least Square Means (LSM) of the factors affecting the number of somatic cells count are given in Table 1.

Table 1.
CE, LSM and SE of Somatic Cell Counts of different parities

Parity	N	CE	$S_{\bar{X}}$	$\bar{X}$	$S_{\bar{X}}$
1	61	16563.42	7421.98	382929.25	6955.18
2	24	-84529.50	9661.08	281836.31	10776.28
3	24	7682.10	9919.83	374047.93	11052.65
4	43	-87430.77	7945.91	278935.04	8095.59
5	11	147714.75	13220.25	514080.58	15819.75
General				348153.37	52340.09

CE: Constant estimation

The effect of the parity on the somatic cells count was statistically insignificant. However, the highest somatic cells count was detected in the fifth parity followed by the animals in the first lactation.

A study was conducted to determine the effects of various factors on Somatic Cell Count (SCC) and SCC in milk samples of Brown Swiss and Holstein Friesian at Atatürk University farm. In the study, milk samples were taken from 501 udder lobes of 150 cows. SCC is determined by 'direct counting method'. The effect of SCC value on parity was statistically significant (P <0.01). Seasonal effect was found to be statistically significant and it was determined that SCC was higher in winter than in summer (P<0.05). The effect of the lactation period to the mean SCC was statistically significant (P<0.05), but the effect of breed and farm factors was non-significant. As a result, it was reported that the SCC value was higher than the EU and Turkey standards (Çoban et al., 2007).

In the study conducted by Şekerden (2002), the relations between lactation period, milk yield and milk component ratios were investigated in 371 Holstein Friesian Cattle. The researcher reported that there was a statistically significant negative correlation between 305-day milk yield and total dry matter (TDM), solids non fat (SNF) in the first lactation period. The researcher also reported that the relationship between 305-day milk yield and milk fat, protein, TDM and SNF ratios was not statistically significant.

Şekerden (2002) reported that the relationship between parity and milk fat content was statistically significant (P <0.05) in a study of Holstein cattle.

Pure and hybrid Holstein cow milk samples were examined in order to determine the factors affecting somatic cell count and their relationship to mastitis in three intensive dairy cattle farm. The effects of enterprise, parity and lactation period were found as statistically significant (P<0.05). It is stated that SCC increases with increasing of parity. According to the first and second parity groups, the average SCC was found to be 856.830 ± 96.140 and 2.295.150 ± 25.846 SHS / ml, respectively. It was reported that different months of the year were effective on SCC (P <0.01) and the highest SCC values were in July and October (Göncü and Özkütük, 2002). The somatic cell numbers obtained in this study were found to be significantly higher than in the present study.

In a study conducted by Göncü (2000) in order to determine the factors affecting the somatic cell count and the relationship with mastitis in pure and hybrid Holstein cow reared in intensive dairy cattle farms in Adana, milk samples taken from 86 cows in lactation were used. The differences between the results of SCC of udder lobe were statistically insignificant (P>0.05), but the effects of farms, parity and lactation period were statistically significant (P <0.001). It has been stated that SCC increases with the increase of parity.

3.2. Electrical conductivity

The least squares mean (LSM) and standard error (SE) of the electrical conductivity were determined as 4.2351 ± 0.1761. The constant estimation (CE) and least squares mean (LSM) values for the factors affecting electrical conductivity are given in Table 2.

The effect of the somatic cell count group on electrical conductivity was found to be non-significant. In the high somatic cell count group, although the electrical conductivity was higher than the other groups, the difference with the other groups was found as insignificant. The effect of milk fat group, parity, animal group and milk protein group were found to be significant at P <0.01 level while the effect of milk fat group were found to be significant at P <0.05 level. The electrical conductivity of the low milk fat group was also found low. The milk electrical conductivity of the first and fifth lactation animals was found to be the lowest. The group with the highest protein level had a high electrical conductivity.

Küplülü et al. (1995) reported that the CMT and milk EC results are parallel to each other, but this parallelism varies according to different mastitis factors, so more extensive studies are required. The cows used as material in the study were found to have a positive result in CMT at +1 degree and the milk electrical conductivity of these animals was found to be 5.81 ± 0.06 mS/cm.

Table 2
CE, LSM and SE values of Factors Affecting Electrical Conductivity

Factors / Groups	N	CE	$S_{\bar{X}}$	$\bar{X}$	$S_{\bar{X}}$
Somatic Cell Count	106 (Normal)	-0.0808	0.040	4.511	0.049
	14 (Weak suspect)	-0.0262	0.044	4.485	0.068
	15 (Suspect)	0.0463	0.043	4.557	0.072
	28 (Mastitis)	0.0608	0.067	4.572	0.084
Milk Fat	81 (Low)	-0.0587	0.052	4.452^{B}	0.053
	59 (Normal)	0.0606	0.041	4.572^{A}	0.045
	23 (High)	-0.0018	0.082	4.509^{AB}	0.115
Parity	61 (1)	-0.1385	0.051	4.372^{b}	0.071
	24 (2)	0.0791	0.035	4.590^{a}	0.059
	24 (3)	0.1353	0.034	4.646^{a}	0.057
	43 (4)	0.0660	0.032	4.577^{a}	0.056
	11 (5)	-0.1419	0.048	4.370^{b}	0.072
Animal	54 (1)	-0.0806	0.033	4.430^{b}	0.062
	54 (2)	-0.0680	0.025	4.443^{b}	0.053
	55 (3)	0.1487	0.044	4.660^{a}	0.063
Protein	42 (Low)	-0.3880	0.043	4.123^{c}	0.045
	116 (Normal)	-0.1896	0.037	4.321^{b}	0.036
	5 (High)	0.5776	0.069	5.089^{a}	0.108
General				4.2351	0.1761

^{A,B}: *Means in a column with different superscripts differ (P <0.05);* ^{a,b}: *Means in a column with different superscripts differ (P <0.01*

In addition, it was determined that Cmt results are incompatible with electrical conductivity results of the milk. This can be interpreted as an indication that the use of CMT and milk EC results, especially in the diagnosis of subclinical mastitis, is still suspicious.

Baştan et al. (1997) reported that the electrical conductivity of milk samples increased in parallel with the increase of CMT and SCC. They also reported that electrical conductivity was between 6.2 and 12 in 37 samples.

Similarly, Chamigns et al. (1984) reported that the efficacy of CMT and electrical conductivity in the diagnosis of subclinical mastitis was 91%, Küplülü et al. reported that 94% of CMT-positive samples were in parallel with EC findings.

3.3. Prediction model

According to the fuzzy logic method, subclinical mastitis can be detected with 92.45% accuracy when somatic cell number and electrical conductivity are used together. The accuracy rate of subclinical mastitis prediction according to other milk components is given in Table 3.

Table 3
Accuracy rates (%) of prediction of subclinical mastitis according to different milk components

Features	Accuracy Rates (%)
Electrical Conductivity	73.58
Somatic Cell Count & Electrical Conductivity	92.45
Electrical Conductivity & Protein	79.24
Somatic Cell Count & Electrical Conductivity & Protein	90.56
All	66.03

The highest accuracy rate for determine the subclinical mastitis was obtained by the using of SCC and electrical conductivity together. This was followed by the degree of accuracy obtained by the combined evaluation of SCC-EC-PROT values. As a result, it can be said that the use of SCC-EC values in the determination of subclinical mastitis gives more accurate results.

de Mol & Woldt (2001) stated that the fuzzy logic model gave a major improvement in the detection results, both in mastitis and estrus detection.

As a result, fuzzy logic method can be used successfully and accurately in determining subclinical mastitis by milk properties such as electrical conductivity, somatic cell count and protein ratio. Fuzzy logic method is a method that can be adapted easily to animal husbandry field.

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