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Assessment of Raw Milk Quality by Neural Networking (N-N) Model in Macedonia Dairy Farms

Vesna Karapetkovska Hristova*
*Faculty of Biotechnical Sciences, University of St. Kliment Ohridski, Partizanska, bb. 7000 Bitola, Macedonia
v.primavera79@gmail.com

M. Ayaz Ahmad
Physics Department, College of Science, P.O. Box 741, University of Tabuk - 71491, Saudi Arabia
mayaz.alig@gmail.com

Julijana Tomovska
Faculty of Biotechnical Sciences, University of St. Kliment Ohridski, Partizanska, bb. 7000 Bitola, Macedonia
dzulitomovska@yahoo.com

Biljana Trajkovska
Faculty of Biotechnical Sciences, University of St. Kliment Ohridski, Partizanska, bb. 7000 Bitola, Macedonia
bile.petkovska@yahoo.com

Georgi Bonev
Faculty of Agriculture, Students Campus, Trakia University, Stara Zagora
gbonev@af.uni-sz.bg

***Abstract*— In the present research work an attempt has been made to obtain some important facts for the milk properties of Holstein-Friesian cow's milk. The milk samples have been taken from the local Pelagonia's farms in the Republic of Macedonia, and the primary safety and quality of raw milk has been predicted. The experimental results obtained directly from the raw milk have been compared with a theoretical / mathematical model so called neural network (N-N) model and we found a better agreement between the results obtained from raw milk analyses and the predicted results of neural network (N-N) model.**

Index Terms—**Holstein- Friesian breed, Raw Milk, Milk quality and Neural Network (N-N) model.**

INTRODUCTION

In the world of technology where theory and experiment agreed completely and where there were no experimental acceptance cuts, the technique named neural network (N-N) model would be a perfect tool to determine some experimental observables and/or facts. In dairy science, the neural network (N-N) model / technique is frequently applied for identification and in checking of milk and dairy products quality. The cows' milk is nowadays produced on a large scale all over the world. Today, the biggest world producers of cow's milk are the USA, India, China, Brazil, Russia and also all of the European Union countries.

The milk is the nutritional fluid secreted by the mammary gland of mammals. The composition of milk varies by species, but it always contains significant amounts of proteins (approx. 3.3%), carbohydrate (approx. 4.6%) and fat (approx. 4.3%), as well as a great source of calcium and other components, organic acids, peptides, and vitamins (Heck et al., 2009) [1].

In this paper our first goal is to test the suitability of headspace analysis for quality control of raw milk in general and the second goal is to further develop the headspace analysis for the identification of somatic cell counts (SCC) and the number of bacteria counted in terms of colony forming units per ml (CFU/ml) in raw milk. The somatic cells consist almost totally (98%) of white blood cells. If the bacteria succeed in entering from the outside, then the second line of defense comes into play and inflammation occurs, i.e. white blood cells or somatic cells. These somatic cells try to destroy the bacteria and prevent it from infecting and damaging the udder tissue. Thus, these somatic cell counts (SCC) are the first reliable indication of mastitis infection. A certain level of somatic cells has been always present in milk, as a protection for the cow against mastitis infection (Bunevski et al. 1999; O'Brien et al. 2007; Trajkovska et al. 2013 b) [2-4] and their influence on the yield of the dairy product (Trajkovska et al., 2011) [5].

NEURAL NETWORKING (N-N) MODEL

Neural network (N-N) model [6] is nothing but an approximate functional fitting to any experimental data. For this purpose, one wants to construct a mapping "M" between a set of observable quantities S_i (where i = 1, . . . , n) and category variable "N" by fitting "M" to a set of "Q" known "training" samples $\left(S_i^{(p)}, N_k^{(p)}, i = \cdots . n; k = 1 \ldots r\right)(p = 1 \ldots . Q, N_k \in N)$. Once the parameters in "M" are fixed, and then it uses for parameterization to interpolate and find the category of "test" samples not included in the "training" set. A schematic diagram of the N-N Model has been depicted in "Fig. 1".

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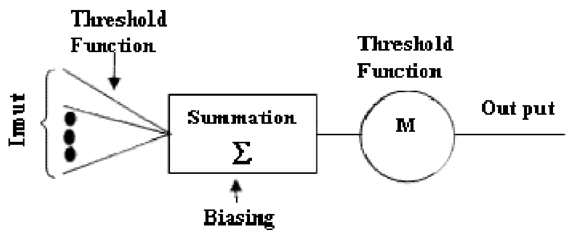

Fig. 1. A Schematic diagram of Neural Network (N-N) Model.

A typical multilayer neural network (N-N) programming model is also represented in "Fig. 2". It consists of an input layer and an output layer with various numbers of nodes, so called neurons in each layer. In the present work, we use the multilayer perceptron program developed in the MATLAb. Here, we have applied three input parameters, measured directly from the raw milk of Holstein-Friesian cow's in our dairy farms: milk fat, protein and pH values of milk. After the completion of computer programming, we get one output parameter that is simulated values of the various factors corresponding to the experimental data.

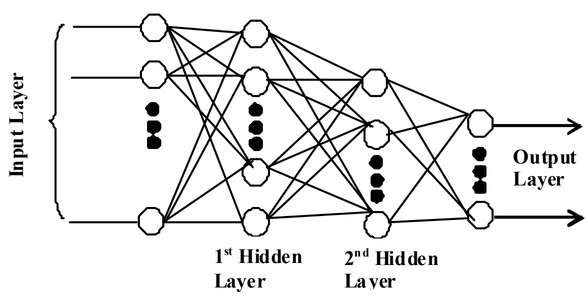

Fig. 2. A sketch of multilayer Neural Network (N-N) Model.

OBJECTIVE OF THE STUDY

It is hypothesized that the microbial population brings biochemical changes in raw milk such as % of Fat, % SNF (solids-non-fat), specific gravity, etc. The number of microbes present in milk samples is directly influenced by the type of milking systems. The research work, presented in this paper evaluates good results for developing a model that could predict microbial classification of raw milk by routine analysis data.

EXPERIMENTAL APPLICATION

A robust and speedy model would provide the basis for an automated scheme of raw milk quality evaluation and price appreciation at farm level. It is estimated that quality can be evaluated in less than one hour without for waiting the results of the routine analysis data.

MATERIAL AND METHODS

For the present experimental tasks, we chose Holstein-Friesian cow's milk from two dairy farms Pelagonia's in R. of Macedonia, and to distinguish between them, we assigned their name such as: cows from farm "X" and farm "Y". The cows from farm "X" were kept in tied-up barn milking system. The milking takes place at the place where the cows are standing, and is carried out using a portable milking unit which provides pulsation and delivers vacuum to the teat end. The cows from farm "Y" were kept in the free-boxing system with milking type rotolactor (rotary milking parlour) pattern De Laval. The cows were milked twice a day between 06.00/07.00 hours and 17.00/18.00 hours daily regime (the cows up to 150 days after calving were milked three times).

DATA SAMPLING PROCEDURE

The present study was carried out during the period from January 2011- December 2013. Data were collected from 520 (N = 520) dairy cows which were milked in the separate milking in tied up and 470 (N = 470) dairy cow which were milked in milking parlour – rotolactor. The milk samples were collected after morning milking in sterile plastic cups (50 ml), and kept at the temperature < 6 °C, and by using of movable refrigerator immediately transported to the laboratory. The milk analyses were done in the "Bitola indipendant laboratory" in R. Macedonia. Some much more detail in about of data sampling, is given in our earlier publications along with the Ph.D. thesis submitted by Vesna Karapetkovska Hristova, Ph.D. submitted at Faculty of Agriculture, Trakia University, Stara Zagora Bulgaria, (2014) [7-9].

MILK ANALYSIS

Experimental samples of milk were taken of the morning milking. They were shipped in an insulated package to the laboratory and were analyzed within 3 hours by following reception; fat, dry matter and protein contents and were assessed using a Milkoscan instrument (Foss Electric - Hillerod, Denmark). The pH values were measured by potentiometer using a pH meter by SCHOTT Lab 860 from Germany. The somatic cell count (SCC) was performed by Somaskop named Alfa Laval from Germany. The total number of bacteria CFU/ml (colony forming units) was examined by Bacto Scan^{TM} FC.

RESULTS AND DISCUSSIONS

The maximum travel time was 3.00 hours for the milk samples of both farms ("X" and "Y"). Temperature (T °C) of milk was recorded immediately after it is taken from the tank which ranged from 5 to 8 °C. In general, it was obvious that longer travel time and higher temperatures directly affect the microbial population in milk. We have measured the % milk fat, % protein, pH values, solids-non-fat (% SNF) and temperature (T °C) with respect to time directly from raw milk samples by the statistical measurement. All these values are depicted in TABLE I along with the values of mean, standard deviations (S.D.), the coefficient of variation (% CV) and the median values.

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AVERAGE VALUES OF CHEMICAL COMPOSITION OF RAW MILK PER YEARS (FARM "X" AND "Y")

Farm Identification	Statistical measurements	% Milk fat	% Protein	pH	% SNF	(T^0C)
Farm "X" N = 520		**Year 2011**				
		3.70	3.36	6.04	8.52	5.04
		Year 2012				
		3.73	3.37	6.02	8.53	5.47
		Year 2013				
		3.81	3.40	6.01	8.57	5.69
	$\bar{x}$	3.74	3.37	6.02	8.54	5.40
	SD	0.09	0.06	0.03	0.06	0.55
	CV %	2.55	1.60	0.45	0.73	10.2
	median	3.75	3.37	6.01	8.54	5.36
Farm "Y" N = 470		**Year 2011**				
		3.60	3.19	6.06	8.32	5.25
		Year 2012				
		3.60	3.28	6.03	8.44	5.43
		Year 2013				
		3.68	3.33	6.02	8.48	5.08
	$\bar{x}$	3.63	3.27	6.04	8.41	5.25
	SD	0.13	0.09	0.04	0.11	0.47
	CV%	3.44	2.95	0.69	1.33	9.06
	median	3.62	3.28	6.02	8.44	5.19

The milk fat, although it is the most variable component in milk in our studies was quite equal to the average 3.74 in farm "X" and 3.63 in farm "Y" and with low coefficient of variation. The annual average value of proteins 3.37 (farm "X") and 3.27 (farm "Y") shows that we should address more attention to this parameter by balancing the cows diet to increase the percentage of protein that will achieve a higher profit. As a constant parameter for determining the quality of milk in all official regulations concerning dairy solids-non-fat has been used. It averages ranged from 8.54% (farm "X") to 8.41 % (farm "Y"), which should be noted that the legal minimum is 8.50%. Active acidity values and also the temperature ($T\ ^{\circ}C$) of the milk samples were in accordance with the Statute for special requirements for safety and hygiene method and procedure of conducting official controls of milk and Dairy products, Official Gazette of the RM no. 26 of 02. 21. 2012.[10]

Further, we evaluated the average values of the hygienic parameters in raw milk per years for both the farms ("X" and "Y") and also compared with the algorithm of neural networking (N-N) model and have been reported in TABLE II and TABLE III. There is a good agreement between the values of somatic cell count (SCC) and colony forming unit (CFU/ml) for both the data the experimentally measured and the data obtained by the algorithm of neural networking (N-N) model. The values of Milk yield / kg (MY / kg) with standard error also depicted per year for both the milk samples / cow's identifications in the same tables.

AVERAGE VALUES OF THE HYGIENIC PARAMETERS IN RAW MILK PER YEARS (FARM "X", N =520)

Parameters	2011		2012		2013	
	SCC × 10^3/ml	CFU × 10^3/ml	SCC × 10^3/ml	CFU × 10^3/ml	SCC × 10^3/ml	CFU × 10^3/ml
$\bar{x}$ *	317.2	170.4	280.1	56.1	162.1	165.2
$\bar{x}$ •	313.0	172.9	275.4	53.2	160.3	163.6
Max* × 10^3/ml	456.8	240.1	450.7	85.7	240.13	245.01
Max• × 10^3/ml	449.9	241.5	451.7	83.6	239.23	239.72
Min* × 10^3/ml	231.7	123.8	123.9	34.6	110.00	120.46
Min• × 10^3/ml	227.9	120.3	124.5	35.1	112.20	125.56
S. D. *	74105.4	112918	46641	45516	13114.8	51681.2
S. D. •	74198.0	112967	46704	456703	13665.1	52015.8
CV (%)*	23.36	26.71	40.20	23.39	28.78	31.28
CV (%)•	19.98	29.03	39.25	21.75	30.05	29.89
Median*	321882.5	150006	291683	53306	138656	129833
Median•	356002.9	190052	301002	65008	140712	130500
M. Y. /kg*	8337		6689		6148	
M. Y. /kg*	----		----		----	

In the above Table, * means, the measured by experimental data and • means compared with neural Networking (N-N) models.

M. Y. / kg means Milk yield /kg

AVERAGE VALUES OF THE HYGIENIC PARAMETERS IN RAW MILK PER YEARS (FARM "Y", N = 470)

Parameters	2011		2012		2013	
	SCC × 10^3/ml	CFU × 10^3/ml	SCC × 10^3/ml	CFU × 10^3/ml	SCC × 10^3/ml	CFU × 10^3/ml
$\bar{x}$ *	288.09	150.72	249.05	103.36	132.02	78.12
$\bar{x}$ •	300.05	165.06	255.23	100.25	150.54	83.50
Max* × 10^3/ml	456.90	245.68	342.11	178.97	234.78	125.54
Max• × 10^3/ml	450.67	255.35	361.70	183.03	239.51	139.25
Min* × 10^3/ml	156.83	93.36	124.59	43.26	77.90	45.68
Min• × 10^3/ml	167.03	100.05	132.09	38.70	102.07	86.03
S. D. *	83464.5	57057	59169.2	45212.5	41649	26583
S. D. •	79908.9	49099	56703.3	45670.9	43665	22016
CV (%)*	28.97	37.86	23.76	43.74	31.55	34.03

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CV (%)•	26.98	39.03	27.25	44.75	30.05	33.89
Median*	309230	124568	236829	109622	129017	72440
Median•	316433	133052	281002	110023	130712	80452
M. Y. /kg*	5037		5276		5117	
M. Y. /kg*	----		----		----	

In the above Table, * means, the measured by experimental data and • means compared with neural Networking (N-N) models.

M. Y. / kg means Milk yield /kg

Whether cows are grazing in paddocks, lying in their stalls or standing in the milking parlour their environment can pose risks of bacterial contamination and mastitis infection (O'Brien et al. 2007 [3]; Dang et al. 2007) [11]. The results of the experimental study are shown in Table 2 and Table 3, and it can be seen that there are significant differences in the somatic cells and the total number of microorganisms due to different milking systems, and the application of good practices. Milking procedures will in general be much more consistent and more efficient in a large rotary parlor than in an equivalently sized herringbone or parallel parlor (Reinemann et al. 2003) [12]. In our study, the obtained results indicate that free way of keeping the cows and milking in conventional parlour has a significant reduction in somatic cells and the total number of microorganisms.The same results are given by the authors (Trajkovska et al. 2013a,b) [4, 13].

CONCLUSIONS AND FINAL REMARK

The Neural Networking (N-N) model has been used in dairy science applications. Results have shown their suitability to be used in this field, in which the quality and accuracy of the models is essential to increase farm returns.

Adequate sanitary control of dairy herds is the best guarantee to prevent the occurrence of pathogens (mastitis) and to ensure the imperative requirement of food safety of dairy products. In order to get a hygienic and sanitary classification of milk it is necessary the animal's health, especially their mammary gland, as well as preparing work protocols which will precisely determine the working manner on the dairy farm by keeping a record for each cow, in order to improve their overall health. By introducing the new neural models and good practices in dairy farming, the milk producers are going to increase the milk production and are going to get milk with better quality, which is understandably going to result with higher profits

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