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STUDY OF FAT CONTENT DYNAMICS IN DAIRY PRODUCTS WITH THE SIMULATIONS OF ARTIFICIAL NEURAL NETWORK (ANN) MODEL

VESNA KARAPETKOVSKA-HRISTOVA[1], BORCHE MAKARIJOSKI[1], M. AYAZ AHMAD[2], GODSWILL NTSOMBOH-NTSEFONG[3], ESRAA MOUSA[4], BILJANA TRAJKOVSKA[1], GORDANA DIMITROVSKA[1]
[1]faculty of biotechnical sciences , university of "st. Kliment ohridski"- bitola, macedonia
[2]physics department, faculty of science, p.o. Box 741, university of tabuk, saudi arabia
[3]institute of agricultural research for development (irad-cerepah), b. P. 243 douala, cameroon
[4]food technology research institute, agricultural research center, giza, egypt
Corresponding auther: vesna karapetkovska-hristova

Abstract : *In this article an attempt has been made to find some important features of starter cultures on the fat content dynamics in the dairy product "white brined cheese" at a dairy industry laboratory in republic of macedonia. The data samples were collected from a private dairy during the year 2015-2017from the above mentioned and the three samples were three different starter cultures of three white brined cheese variants (a, b, c). Here we tried to find some direct effects on the fat content dynamics for such samples. The whole experimental works have been done for all above three different starter cultures and also were analyzed over the fat content during the process of ripening of the white brined cheese. These results were compared with the simulated data of artificial neural networking (ann) model. The obtained results were found in good agreement with simulated data.*

Keywords - *fat content dynamics, artificial neural networking (ann) model, white brined cheese*

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I. Introduction

Milk and its products, e.g. Cheese play an important role in human nutrition in different ages and supervising on health standards of its production, transportation, storage and supply will be vital. Within the worldwide level, as the dairy industry starts to grow and cheese manufacturing begins to be done in larger production facilities, it became apparent that a more scientific and standardized method for improving the dairy products [1-4]. White brined cheese is a specific dairy product for balkan peninsula countries, mediterranean, north africa, eastern europe and some parts of asia. This cheese has a great tradition and also in general, it produced from the cow milk. Based on the statistics of the dairy industry laboratory in the republic of macedonia during the year 2015-2017, the production of milk in macedonia with an annual growth of 7.5 percent reach to 10.5 million tones. The increased consumption of white brined cheese contributes to the necessity to be produced in almost all dairy facilities in industrial way: milk pasteurization, adding ingredients (calcium chloride, color, rennet…etc.), and also the addition of starter cultures for continuous milk acid fermentation. Some other workers [5-8] in the field of dairy science and technology, did some research earlier for the use of commercial starter cultures in an industrial way of cheese production is necessary for obtaining a final product with a standard identifiable feature. The most important function of the starter cultures is the production of lactic acid and the release of enzymes during the fermentation process of white brined cheese (leroy and de vuyst, 2004) [9].

Due to recent advancements in dairy science and technology, various mathematical predictions and/or models have been used to reduce the laboratory / industry costs and accelerate high quality of the dairy products. By using predictive models, determining the quality of milk will be possible faster and more accurate based on somatic cell count in a short period of time after receiving raw milk. The artificial neural networks (anns) are computer software or hardware models inspired by the structure and behavior of neurons in the dynamics of fat content [10-14 and references therein]. As a powerful learning tool, increasingly neural networks have been adopted by many large-scale information processing applications. We have experimentally collected some samples from the dairy farm in bitola, r. Macedonia and later on setup a computer programming by neural networking (n-n) model and also with anns model and unearth some valuable results from present study. A typical format of (anns) model to produce theoretical nodes with experimental data has been shown in fig. 1. In the present experimental work some important features of three different starter cultures of three white brined cheese variants (a, b, c) have been studied regarding the fat content dynamics. The starter culture in variant a (smch - 5) contained following bacteria strains: *lb. Bulgaricus, str. Thermophilus* and *lb. Acidophilus*. In the variant b (choozit feta a) the follow bacteria strains were included: *lac. Lactis* ssp. *Lactis*, *lac. Lactis* ssp. *Cremoris, str. Thermophilus, lb. Bulgaricus* and *lb. Helveticus.* The variant c (motc 092 ee) was a combination of the strains: *lac. Lactis* ssp. *Lactis*, *str. Thermophilus*, *lb. Bulgaricus*, *lb. Helveticus* and *lb. Casei*. The impact of the above mentioned three different starter cultures was determined over the fat content during the process of ripening of the white brined cheese. Finally, significant impact on the obtained values of the fat content during the 60 days of ripening process has not been found.

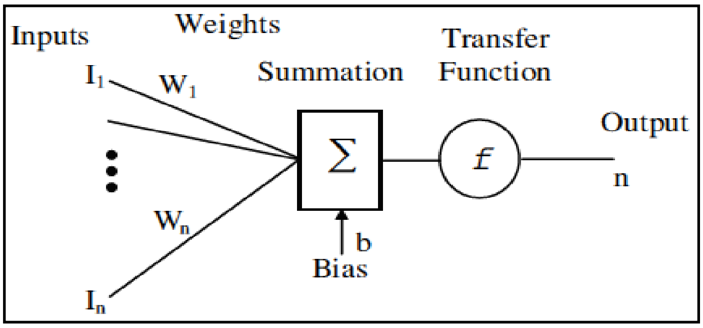

Fig. 1:- a typical working format of (anns) for present data samples.

The nodes of (anns) model are distributed on many different layers: (a) one input layer, (b) one or many hidden layers and (c) one output layer. The processing element calculates the neuron transfer function (f) of the summation of weighted inputs. The neuron transfer function, f, is typically step or sigmoid function that produces a scalar output as it has been expressed in mathematical relation (1) such as follows:

$$N = f\left(\int_i w_i i_i + b\right) \qquad (1)$$

Where i_i, w_i, b are the i th input, the i th weight and b the bias respectively.

A particular transfer function (f) is chosen to satisfy some specification of the problem that the neuron is attempting to solve. The most commonly used functions are the tansigmoid and logsigmoid transfer function.

For training the neural network, a vector in the data matrix is a pattern. Each pattern is given to the network and the output is compared with the response. The data set is randomly divided into training and test sets. The error function is calculated after all the patterns are presented. Hence, it is a supervised learning. The best architecture (fig. 2) is chosen by changing the number of hidden layers, hidden neurons in each layer, transfer function and learning algorithm. The widely employed optimization procedure (learning algorithm) in 1980, [10-14 and references therein] was back propagation (bp), which is a variation of the steepest descent algorithm. Recently marquardt, conjugate gradient, simulated annealing algorithm, genetic algorithm, etc. Have been incorporated in ann software.

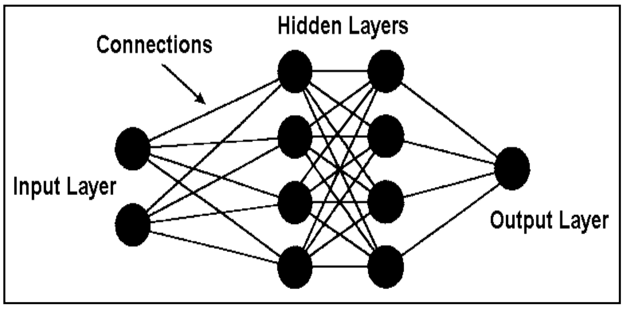

Fig. 2:- the multilayer perception neural network architecture.

We have experimentally collected some samples from the dairy farm in bitola, r. Macedonia and later on setup a computer programming by neural networking (n-n) model and also with anns model and unearth some valuable results from present study. The results obtained from neural networking (n-n) models suggested that all the studied parameters are in a good agreement from the other worker in the field of dairy science.

II. Data sample collection and methodology

For the present experimental work as well as simulations the data samples of the white brined cheese were manufactured from pasteurized cow milk in a local dairy plant “milkom" - v. Nogaevci, gradsko, from republic of macedonia [15]. The chemical composition of the milk used for the manufacturing of white cheese was 12.13% total solids, 3.70% fat, 3.21% protein, 0.67% ash, and 4.55% lactose. The ph of the milk was 6.49 and it was pasteurized at maximum temperature of 75°c for 30 seconds and cooled up to 35°c temperatures. The curding was done at a temperature of 35 $^{\circ}$c. First the following starter cultures were added: for white brined cheese-variant a- smch – 5, for white brined cheese-variant b- choozit^{tm} feta a lyo 100 dcu and for white brined cheese variant c - motc 092 ee. Then the $cacl_2$ 0.02% and blego color 10 ml/100 liters milk was added. The cow milk was coagulated with chymosin rennet (chymax extra powder 1.5 g/100 l milk) completed in 60 minutes. Further on, the curd was cut in cubes of 1.00 cm^3, and within the resting of 5 minutes and also afterwards pressed in cheese mold for 3 hours. Cheese blocks were placed in tinned cans filled with brine solution of 8.0 g nacl/100g. During the ripening period of 30 days the cheese was held at 15-17 $^{\circ}$c, and then kept at 2 - 4 $^{\circ}$c. One can understand easily the applied methodology for the present experimental work as given in the flow chart fig. 3.

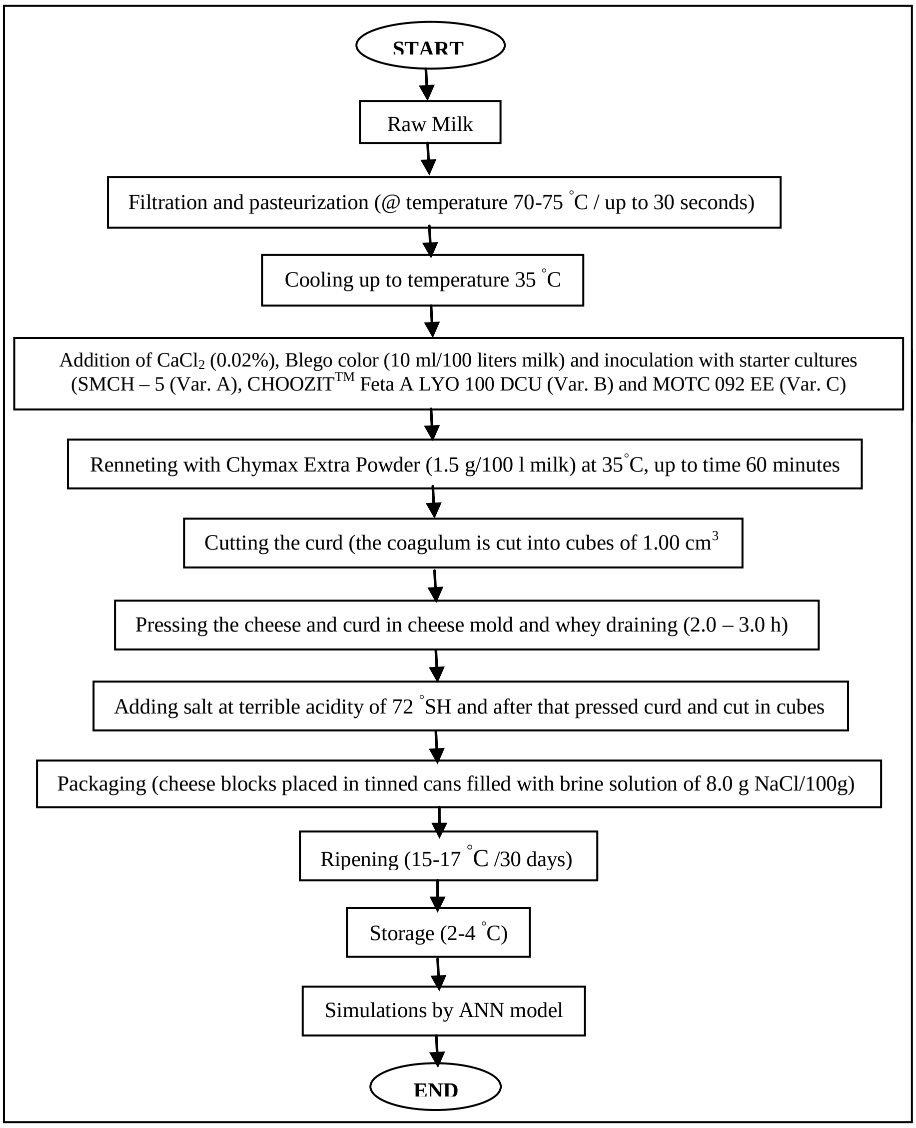

Fig. 3:- flow chart for the methodology of white-brined cheese technology.

In order to determine their influence on fat content in white brined cheese three different types of starter cultures were used. There were three variants of cheese produced which differ by starter cultures used in production process (var. A - smch – 5,product by lb lactis – bulgaria, var. B- choozit^{tm} feta a lyo 100 dcu- product by danisco - denmark and var.c motc 092 ee (produced by sacco clerici) [16].

The determination of the content of milk fat in cheese is determined by the gerber method (caric at al. 2000 and other (a.o.a.c.)) [17-19]. The determination of milk fat content of white brined cheese was examined on the 1st day, 10th day, 30th day and the 60th day. Further on, the standard statistical method [5-7, 13-15] was used for statistical presentation of the analyzed data as well as the f-test for analysis of the variance in tested cheese variants.

III. Results and discussions

The milk fat remains incorporated between the protein matrix and the curd, although a very small part is eliminated through the whey after cutting and pressing the curd. And also the milk fats influence rheological and sensory characteristics of white brined cheese. The greater amount of milk fat helps generate white brined cheese with softer consistency and better sensory properties, unlike the low fat milk percentage which helps generate white brined cheese with hard consistency and its sensory properties are less expressed.

Further, the fat content regarding the examined three varieties of white brined cheese is depicted in table 1, 2 and 3, and also in fig. 4. According to the results presented in tables 1, 2 and 3, it can be concluded that fat content in the white brined cheese in all three cases of variant (var. A, var. B and var. C) at the first day of production were the following: 20.96% (var. A) 21.36%, (var. B) and 21.32% (var. C).

The significant changes regarding the further period of ripening have not been registered which is shown in the figure 1. The continuous increase of fat content was noticed to all examined variants of white brined cheese in all three cases of variant (var. A, var. B and var. C) without significant peaks. After 60 days of ripening period, variant a had shown 22.40% of fat content, variant b had shown 22.42% of fat content and variant c had shown 22.34% of fat content.

Table1:- the fat content dynamics for the white brined cheese (in case of variant a)

Variant a (smch - 5)					
Day	1 day	10 day	30 day	60 day	Types
б	20.96 ± 0.50 21.23 ± 0.63	21.48 ± 0.43 22.00 ± 0.51	22.02 ± 0.48 23.50 ± 0.63	22.40 ± 0.51 23.00 ± 0.76	Present experiment Simulation (anns)
Min	20.60 ± 0.44 21.00 ± 0.38	21.00 ± 0.46 22.05 ± 0.47	21.70 ± 0.49 22.36 ± 0.51	22.10 ± 0.48 23.00 ± 0.61	Present experiment Simulation (anns)
Max	21.20 ± 0.46 22.00 ± 0.71	21.70 ± 0.57 22.00 ± 0.50	22.30 ± 0.72 22.57 ± 0.64	22.60 ± 0.75 23.00 ± 0.80	Present experiment Simulation (anns)
S.d.	0.230 0.250	0.295 0.250	0.239 0.250	0.187 0.250	Present experiment Simulation (anns)
Cv	1.098 ± 0.03 2.075 ± 0.05	1.373 ± 0.05 2.105 ± 0.05	1.084 ± 0.03 2.005 ± 0.05	0.835 ± 0.01 2.013 ± 0.05	Present experiment Simulation (anns)

Table 2:- the fat content dynamics for the white brined cheese (in case of variant b)

Variant b (choozit^{tm} feta a lyo 100 dcu)					
Day	1 day	10 day	30 day	60 day	Types
б	21.36 ± 0.41 21.89 ± 0.44	21.84 ± 0.63 22.00 ± 0.52	22.00 ± 0.40 22.67 ± 0.71	22.42 ± 0.61 23.00 ± 0.80	Present experiment Simulation (anns)
Min	21.20 ± 0.52 21.93 ± 0.67	21.60 ± 0.73 22.00 ± 0.77	21.80 ± 0.65 22.45 ± 0.79	22.20 ± 0.54 23.00 ± 0.81	Present experiment Simulation (anns)
Max	21.60 ±	22.10 ±	22.20 ±	22.60 ± 0.71	Present experiment Simulation (anns)

	0.45 22.00 ± 0.71	0.61 22.89 ± 0.83	0.73 23.00 ± 0.91	23.08 ± 0.65	
S.d.	0.167 0.108	0.207 0.196	0.187 0.131	0.148 0.112	Present experiment Simulation (anns)
Cv	0.783 ± 0.04 0.639 ± 0.03	0.949 ± 0.06 0.886 ± 0.04	0.850 ± 0.05 0.745 ± 0.03	0.662 ± 0.03 0.639 ± 0.02	Present experiment Simulation (anns)

Further, we also calculate the fat content dynamics for the white brined cheese in all the three cases of variant named such as; (var. A, var. B and var. C) by artificial neural networks (anns) model. The simulated values for various parameters; average (б), the minimum value (min.), maximum value (max.), standard deviation (s.d.) And cv were evaluated for all samples (var. A, var. B and var. C) along with the prediction of days 1, 10, 30 and 60. All these results / parameter were found approximate constant and only the standard deviation was slightly were found in increasing order. The outcomes of the present study were also found within good agreement as per our earlier work [5-7, 13-15].

Table 3:- the fat content dynamics for the white brined cheese (in case of variant c)

Variant c (motc 092 ee)					
Day	1 day	10 day	30 day	60 day	Types
б	21.32 ± 0.39 21.76 ± 0.42	21.80 ± 0.49 22.30 ± 0.52	21.94 ± 0.38 23.07 ± 0.65	22.34 ± 0.58 23.30 ± 0.73	Present experiment Simulation (anns)
Min	21.00 ± 0.51 21.76 ± 0.63	21.50 ± 0.69 22.10 ± 0.71	21.60 ± 0.70 22.17 ± 0.70	22.20 ± 0.80 23.00 ± 0.85	Present experiment Simulation (anns)
Max	21.50 ± 0.41 22.00 ± 0.66	22.00 ± 0.58 22.73 ± 0.65	22.20 ± 0.69 23.00 ± 0.82	22.50 ± 0.68 23.10 ± 0.72	Present experiment Simulation (anns)
S.d.	0.217 0.121	0.212 0.198	0.230 0.201	0.152 0.172	Present experiment Simulation (anns)
Cv	1.017 ± 0.04 0.639 ± 0.03	0.973 ± 0.04 0.759 ± 0.03	1.049 ± 0.05 0.745 ± 0.03	0.679 ± 0.03 0.635 ± 0.02	Present experiment Simulation (anns)

The presented data are in correlation with the conclusions of some other worker of dairy science and technology [1-19] and it is emphasizing that in the production process of white brined cheese, lipolytic reactions are not significantly expressed which however differs for blue cheeses, where more lipolytic processes and more changes in fat content percentage are noticed.

Popović, vranješ at al. (2011) [20] had similar results in their study regarding the fat content in sjenichko cheese**.** They have determined that the average fat content was 22, 97% (minimum 21.97% and maximum 23.97% off at content) which appears as similar to the results presented in this paper.

Starter cultures do not have any impact on the fat content dynamics in white brined cheese, which can be confirmed by the uniform values among the three varieties of cheese. These results were found in good agreements with others [13-15, 21].

There are differences if comparing the results of this paper and the one provided by bojanic, rasovic at al. (2010) [22] intended for fat content in white brined cheese. The latter has presented a particularly high level of fat content (23,86%) in which as a conclusion has been pointed out that this high percentage in montenegro white brined cheese comes as a result of the type and race of the cows, food, physiological condition of the animal etc. The results presented in this survey are quite similar to the results provided by ozcan at al. (2012) [23]. Their values for fat content in white brined cheese are in the range limits of 21-25%.

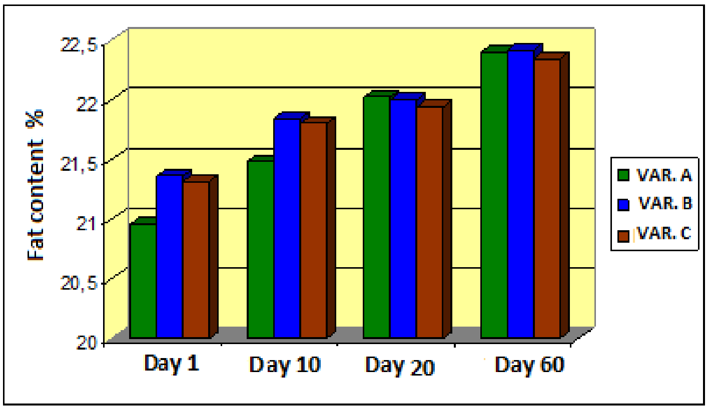

Fig. 4:- histograms for the fat content dynamics in white brined cheese in all three cases of variant (var. A, var. B and var. C)

The increase of fat content in white brined cheese from this survey is also followed by an increase of the dry fat matter content. The energy value of cheese mostly depends on the fat content. It is of a great importance that the milk during the industrial production should not be transported in long lines, causing increased fat loss, which in total will effect on product amount.

With the use of fisher's-test statistically significant differences among the tested varieties were not determined, so it can be concluded that the starter cultures do not affect the fat content in white brined cheese.

IV. Summary and conclusions

As it was stated by various workers of dairy science that the consumption of milk every day per person should be of 0.5 litre. The milk supplies a significant amount of many of the nutrients that are required daily as per nutrition science. The components of milk take part in metabolism in several ways; by providing essential amino acids, vitamins, minerals and fatty acids, or by affecting absorption of nutrients. Therefore, based on the present experimental work along with simulations by artificial neural networks (anns) model, one can conclude the followings:

The significant differences in the content of milk fat during the fermentation process among all three white brined cheese variants (a, b and c) produced by different types of starter cultures have not been found. According to the analyzed data it can be confirmed and concluded that starter cultures do not influence the content of milk fat during the process of fermentation of white brined cheese.

The content of milk fat was presented such as: 22.34 % (variant c), 22.40% (variant a) to 22.42% (variant b).

The simulated values for various parameters were found approximate constant and only the standard deviation was slightly were found in increasing order. The outcomes of the present work were also found within good agreement with other workers in the field of dairy science and technology.

The simulation prediction / model is enough good for the dairy industry for lower costs to accelerate high quality of the dairy products.

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