

Using Artificial Intelligence for Dynamically Selecting of White Cheese Production Parameters

Yasin Ozdemir^{1*}, Salih Akyuz², Omer Nuri Cam³ and Basri Kul³

¹Ataturk Horticultural Central Research Institute, Food Technologies Department, Yalova, Turkey

²Akyuz Dairy Products Food Industry, Kutahya, Turkey

³Uludag University, Technical Sciences Vocational School, Bursa, Turkey

*Corresponding Author: Yasin Ozdemir, Ataturk Horticultural Central Research Institute, Food Technologies Department, Yalova, Turkey.

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Abstract

Artificial intelligence applications are increasing rapidly in many industries. But it is still in its infancy for food industry. Although there are industrial applications and scientific studies of machine learning on quality control of foods, there are no dynamic approaches that will enable quality control with artificial intelligence or more importantly, the selection and use of process parameters during food production. In this research, it is aimed to reveal the potential of dynamically determining the optimum parameters such as pasteurization norms, enzyme application time, enzyme amount and packaging pH in white cheese production by using artificial intelligence. In this way, it will be possible with future studies to make higher quality and more efficient productions by using artificial intelligence for white cheese production industry.

Keywords: Artificial Neural Networks; Cheese Quality; Cheese Production; Supervised Learning

Introduction

Food producing companies are being forced to develop factories to be more productive and flexible in order to cope with the expanding market scale and quality as well as product diversity in the future. In order to increase efficiency and flexibility, they have started to implement automation technologies in the production system with the spread of Industrial 4.0 and smart factory [1]. It reveals that next generation smart manufacturing uses the concepts of internet of things, cloud computing, service-oriented computing, cyber-physical systems managed by artificial intelligence and data science [2].

The main purpose of artificial intelligence studies is to create computer programs that can think, interpret and make decisions like humans. With artificial intelligence applications, it is possible to make healthy decisions in many areas, to make correct interpretations and to analyze many more variables in a shorter time and reach a conclusion [3]. Although there are industrial applications and scientific studies on quality control of foods using

machine learning, there are no dynamic approaches that will enable quality control with artificial intelligence or more importantly, the selection and use of process parameters during production. The image about machine learning and artificial intelligence is given in figure 1.

Figure 1: Image of machine learning and artificial intelligence.

The parameters used in the pasteurization for milk and suppression for crude processes in the production of white cheese, as well as the development and life span of *E. coli* and *Y. enterocolitica* in cheese were modeled with artificial intelligence [4]. It has been reported that the elevation of the milk produced by using genetic algorithms and artificial neural networks can be determined according to the compounds it has according to Ossolano Italian cheeses [5]. In a study artificial neural network modeling was performed for pH estimation of cream cheese fermentation at laboratory and industrial scales. It was reported that reliable pH estimations were provided at both laboratory and industrial scales [6]. In another study, it was reported that application of artificial neural networks was an effective tool in evaluating the effect of the film on the diffusion process of Na⁺ and K⁺ ions in salting mozzarella cheese [7].

In an artificial intelligence study on cheese production, soluble nitrogen, pH, standard plate count, yeast and mold count, and spore count were taken as input parameters and sensory score as output parameters, the results showed a high correlation between training and validation data. Therefore, it has been reported that the developed models are efficient in predicting the shelf life of processed cheese [8]. Artificial intelligence was reported as accurate prediction tool for pH change in cheese fermentation and fermentation ending time. Artificial intelligence application can help improve process efficiency, improve quality control and process efficiency [9].

It has been reported that artificial intelligence is used to provide information about the characteristics and consumption habits of artisan cheeses in Brazil. In addition, in the same study, it was stated that artificial intelligence could be used as a dynamic, managerial and strategic tool for developing new products, marketing strategies and sales for the cheese industry [10]. In another study, it was stated that the use of artificial intelligence could be an effective tool in determining the geographical indications of cheeses [11,12]. In Turkey and in different parts of the world, there are many cheeses with artisanal characteristics and/or geographical indications such as Serro cheese [13], Minas cheese [14], Erzincan tulum cheese, Van herbed cheese [15] and Bayramic cheese [16]. Studies with artificial intelligence on these will also be beneficial in terms of revealing the difference among cheeses [13,17,18].

Artificial intelligence has been used as a problem solving tool in the food industry [19], beside the problem solving capacity prediction artificial intelligence can also help predict of parameters. So that, food industries have high demand for artificial intelligence in recent years [20]. Different studies can be found on artificial intelligence for food safety, quality control and increase production efficiency [21,22]. Some artificial intelligence studies also focused on food drying technology and control of drying process [23-25]. In an artificial intelligence study for the cheese industry, artificial neural network achieved the highest predictive ability for cheese-making properties and outperformed other key learners (gradient boosting machine, extreme gradient boosting and elastic net). Although it is stated that these tools need to be tested further, the results are reported to be promising, especially in relation to their applications in sensitive livestock [26].

There are studies showing that artificial intelligence can be used for the optimization of cheese production process parameters. However, in these studies, it is seen that only a certain process step is studied, not the whole process. In this research, it is aimed to reveal the possibilities of dynamically using optimum parameters in the production of white cheese by using artificial intelligence.

Training in the use of artificial intelligence in white cheese production

There are two types of machine learning processes. These are; supervised learning and unsupervised learning or a supervised machine learning is presented with both input and output, and artificial intelligence is expected to relate them. Whereas in the unsupervised system, it is presented with input only and is expected to detect similarities or relationships in the input when none is specified beforehand [27,28]. It is thought that the use of supervised learning system in white cheese production will be beneficial.

Mastery and technological knowledge are required for the production of quality white cheese. Many factors such as seasonal changes and animal care conditions change the quality and microbiota of raw milk [29]. Selecting the white cheese production parameters that will be suitable for these changes is important for a quality and efficient production. Corporate companies control many factors during production and select the most appropriate

parameters to produce quality white cheese [30]. Raw milk quality (delivery temperature, total live count, mold and yeast count, protein, fat and dry matter content etc.), air temperature and ambient temperature of raw milk and production-related parameters of corporate companies are recorded. In addition, it is recorded day by day from which raw milk, in which parameters and in which quality white cheese is produced. This actually provides a big data opportunity for the use of artificial intelligence. Thanks to the establishment of correlations/links by artificial intelligence between the raw material and the final product data, which have been practically recorded in the past, artificial intelligence is likely to make the most accurate decision without the need for an outside person (production supervisor or masters) to decide on the parameters to be used in new white cheese productions.

The most important and most variable raw material in the production of white cheese is raw milk [29]. Enzyme and, if used, starter culture inputs do not vary as they can be supplied as standard. For this reason, raw milk properties, enzyme and starter culture properties and quantities are important in the selection of parameters to be used in cheese production steps. For this reason, it is necessary to teach the input characteristics and quantities of artificial intelligence.

Although the number of microorganisms is a very important factor for determining the temperature and duration of pasteurization to be used in raw milk quality evaluation and cheese process, the number of microorganisms cannot be used in decision-making processes due to the inability to count bacteria instantly or within a few hours. For this reason, pH and/or acidity values are measured to obtain information about the number of microorganisms and/or storage time and conditions of raw milk [31-33].

In order for the parameters to be used in the white cheese production process to be determined by artificial intelligence, artificial intelligence needs three main training set groups. These are inputs, parameters, and result values. The graph related to the training set to be used in teaching the optimum parameters in white cheese production is given in figure 2.

Ordinal logistic regression will be used. With the regression parameters obtained for high quality cheese, artificial intelligence will be able to advise us which values to use to obtain high quality

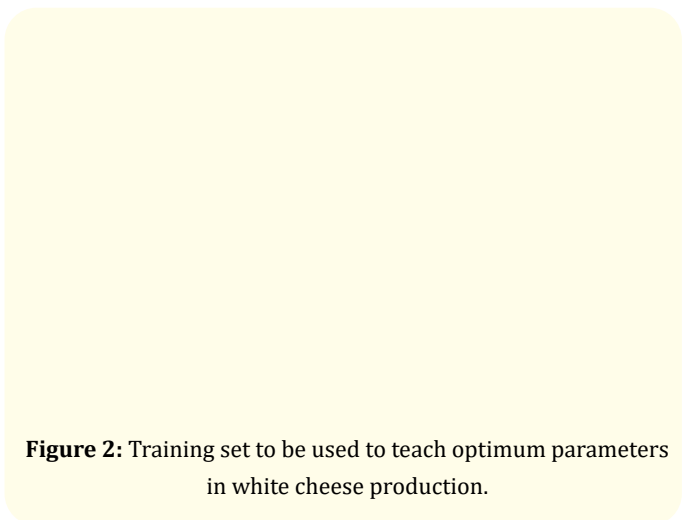


Figure 2: Training set to be used to teach optimum parameters in white cheese production.

cheese according to the condition of the raw milk. Inputs and outputs which should be used in logistic regression were given in table 1. According to moisture value, cheese hardness and cheese sensory analysis scores cheeses can be categorized as high, mid-high and mid. This can make easier to understand and facilitate the application of artificial intelligence.

Inputs		Output
Raw Milk Properties	Cheese Parameters	High
Delivery temperature,	pH value,	Quality
Total live count,	Acidity,	Mid-High
Mold and yeast count,	Fat,	Mid
Protein,	Water,	
Fat,	Protein,	
Dry matter content,	Nonfat dry matter,	
Ambient temperature	Storage time,	
Freezing point,	Storage temperature	
Acceptance temperature		

Table 1: Inputs and output.

The brix, pH value, acidity, fat, water, protein, nonfat dry matter and lactose content, freezing point, acceptance temperature, storage time, storage temperature and air temperature parameters should be determined as parameters and that should be taught to artificial intelligence [34-36]. Cheese factories have been using and recording these parameters for many years. These data can be used to create a training dataset. In these training data sets, artificial intelligence will be able to learn the results to be obtained according to the input and factor information. In rooted cheese

production factories, this information is recorded every day for a period of at least five years. It is possible to teach 1500 data sets to artificial intelligence from 300 production days in five years. After teaching these data sets, it will be possible to report the necessary parameter in order to obtain the input features from the artificial intelligence and the desired final product features. In this way, it will be possible to produce standard quality white cheese by preventing the use of incorrect parameters and human knowledge/ideal errors.

Figure 3: Deciding on the optimum parameters for white cheese production with artificial intelligence.

Pasteurization temperature and time, added calcium chloride amount (if used), enzyme type and amount used, starter culture type/types and amount (if used), enzyme application temperature and time, clot breaking pH value, pressure amount and temperature, settling brine salt concentration, settling temperature and packaging pH value and ripening time (if applicable) are the factor information that should be taught to artificial intelligence as selected parameters. White cheese moisture value, cheese hardness and cheese sensory analysis scores should be taught to artificial intelligence as result values obtained as a result of the data named as input and factor above. After the trainings, it will now be able to recommend the parameters that should be used to obtain the targeted end product according to the artificial intelligence input characteristics to the production personnel. The graph about process of deciding the optimum parameters for white cheese production with artificial intelligence is given in figure 3.

Conclusion

In recent years, it is important for factories to understand the smart factory and smart technology research so that they can

implement the Industry 4.0 concept. In the Industry 4.0 application, the application of artificial intelligence systems developed or adapted specifically for the factory will provide advantages in terms of efficiency and quality. The use of artificial intelligence to assist in the selection of parameters in the production of white cheese, which is the subject of this research, can be considered in this context. Standard process parameters are not applied in the production of white cheese. The selection of the appropriate parameters for the daily incoming raw milk with artificial intelligence will facilitate the work of the decision makers in the factory. Process parameters suggested by artificial intelligence according to input characteristics can be a guide for decision makers of factory. Both the detailed input characteristics and the large number of process parameters that need to be determined make the job of artificial intelligence difficult. However, after long use and with the increase in information its database, the rate of accurate parameter determination will be higher thanks to the continuous improvement of artificial intelligence. As a result, producers using artificial intelligence will be able to produce white cheese with both more standard quality and higher efficiency.

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