ACQUIRING DATA FOR CHEESE AGING USING GAS SENSORS

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Abstract

The paper presents the monitoring of cheese aging using gas sensors. The data are acquired via specially developed device and can be used after that for classification purposes. Comparing different cheeses, it is possible to evaluate how various kinds of milk reflect on the process of aging.

Keywords: gas sensors, data acquisition.

INTRODUCTION

The use of gas sensors for monitoring air and environmental quality is becoming more common. This is due to the continuous progress in the production of new types and generations of gas sensors, as well as in the development of new techniques for data processing and classification. Apart from monitoring of air parameters, another major application of gas sensors is food quality monitoring.

Various gas monitoring methods are used for air pollution control [1]. In addition to expensive analytical instruments, measuring modules based on gas sensors are also used. They have a low cost and enable rapid measurements [2]. Since often harmful chemical constituents in the air cannot be identified using a single gas sensor, it is necessary to use multiple sensors combined in the corresponding sensor module.

Regarding the quality of food products, consumers need an objective and accurate assessment of what they are buying. They must receive information and a guarantee that the food they buy is produced from the specified products and stored correctly by the traders (according to the prescriptions and requirements of the manufacturer and control authorities). Last but not least, the ability to accurately detect contamination both in different foods and in the raw materials used for their preparation is important. This increasingly necessitates the development of fast and accurate methods and devices, through which it will be possible to determine the quality of various food products, as well as to determine the condition during their storage. One of the possibilities in this direction is the use of a set of gas sensors united in the so-called "Electronic nose". The "electronic nose" makes it possible to quickly and accurately determine the quality of products [3]. The use of gas sensors is suitable for testing various food products in solid or liquid state. They are suitable for detecting, for example, the added amount of water in milk [4], and can also be used to detect dairy products infected with Escherichia coli [5], as well as for monitoring the quality of yogurt [6]. With the help of gas sensors, research was also done on contaminated sheep's milk with toxins [7], which are carcinogenic and extremely dangerous for human health.

The results obtained in these studies are particularly indicative of the possibilities of gas sensors in their use to classify different food products. The aim of this paper is to present a module with gas sensors that is used in application for data acquisition about aging of cow cheese. The acquired data are further processed and classified.

SENSOR MODULE FOR DATA ACQUISITION

It is developed a sensor module for monitoring of three main types of gases. It can be used for measurements of gas footprints of various foods (Fig.1).

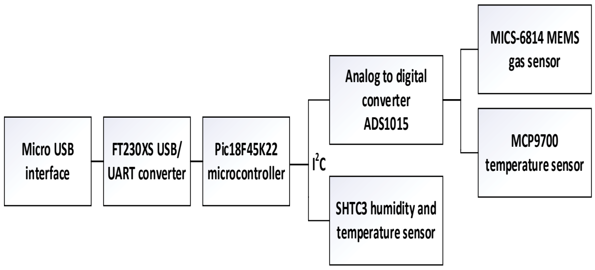

Fig. 1. *Block diagram of sensor module*

The developed module uses MICS-6814 gas sensor [8]. The sensor is able to detect the following gases- Carbon Monoxide (CO), Nitrogen Dioxide (NO_2), Ammonia (NH_3).

The sensor type is metal oxide sensor which means that the sensing elements are resistive and their resistances change with the changes of measured gases. The oxidizing gases (such as ozone or nitrogen dioxide) make the resistance of sensing elements to increase while the reducing gases such as carbon monoxide or VOC's cause the resistance to decrease. The module is placed in specially developed housing (Fig.2).

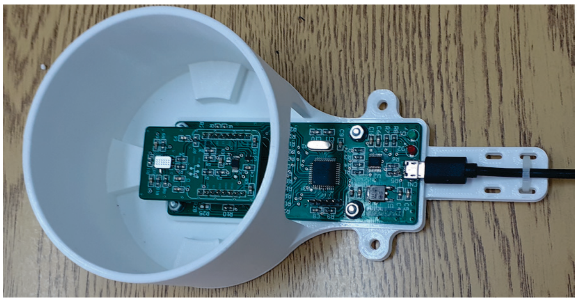

Fig. 2. *Sensor module*

SOFTWARE FOR DATA ACQUISITION

A program for data acquisition is developed and it is used for reading and storing the acquired by the sensor data on personal computer. The program is developed with LabVIEW and after successful initial tests it is compiled as stand-alone application (Fig.3).

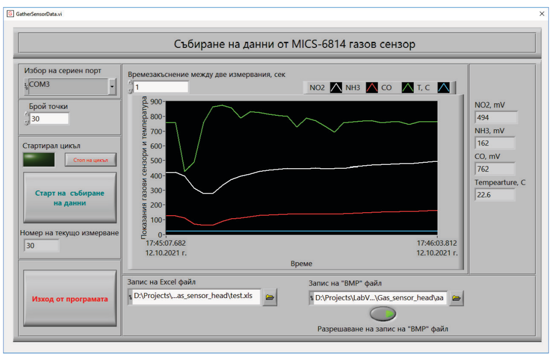

Fig. 3. *Data acquisition program*

The main properties of the program are intuitive user interface, graphical representation of acquired data and possibilities for storing the data in Excel file. The program also enables the data to be plotted into BMP image and stored locally.

EXPERIMENTAL SETUP

The data from gas sensor module is acquired using glass vessel where cheese samples with approximate weight of 20g are placed. The sensor module is placed over the glass vessel (Fig.4) and the measurements are started.

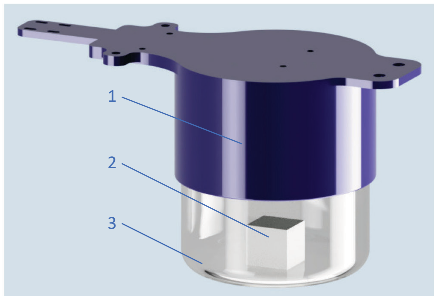

Fig. 4. *Experimental setup 1) sensor module, 2) cheese sample, 3) glass vessel*

During measurements it is possible the glass vessel to be placed on heating plate, that is controlled to have temperature between 40ºC and 50ºC.

ACQUIRED DATA SETS

During data acquisition samples of local brand of cheese "Bojenci" were tested. It was acquired data from samples with maturing time 17, 31 and 46 days. Fig.5 presents how the data acquired with sensor module looks like a graphic for certain period of time. Initially the sensors are not warmed and therefore they need time to stabilize and go in work mode.

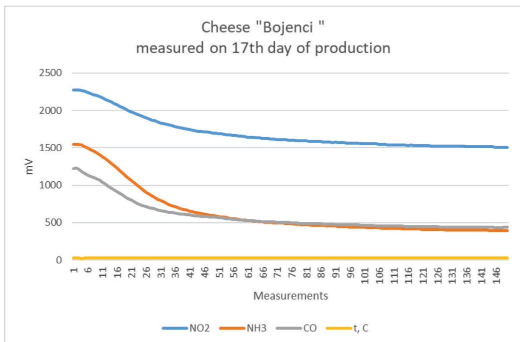

Fig. 5*. Measured data for test sample with 17 days of maturing*

The entire process of measure takes 5 minutes. From these 5 minutes, only data for the last 20 seconds is used for receiving the average values of sensors outputs in mV. Table 1 presents averaged values for sensors outputs.

Table 1. *Average values for sensors outputs*

Day	NO_2	NH_3	CO
17	1514.075	396.925	438.15
31	1518.85	292.55	425.025
46	1317.9	222.25	329.35

Visual inspection of the chart of above data shows that there is change in sensors outputs during mention period of cheese aging (Fig.6).

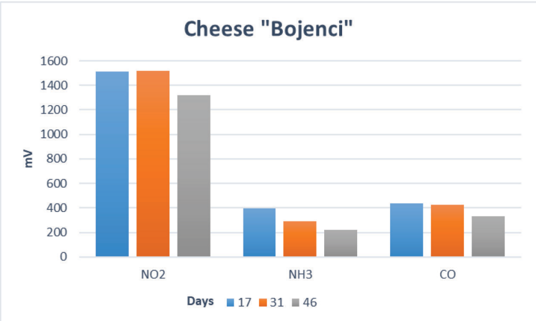

Fig. 6*. Chart of averaged data*

CLASSIFICATION OF PERIOD OF CHEESE AGING

The acquired data can be used for purposes for classification of period of cheese aging. In fact, the measured samples are insufficient for good classification, but it is possible to be added interpolated data. For data interpolation are used cubic splines (Fig.7). After interpolation there are enough number of data sets which can be used for classification purposes.

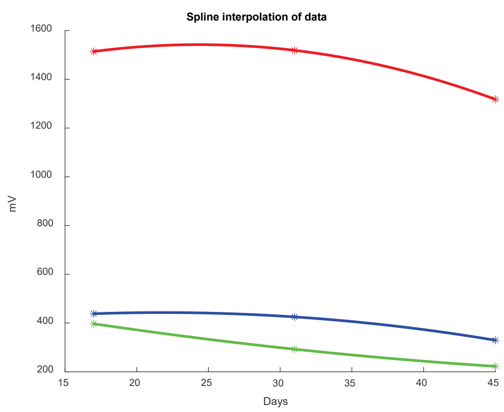

Fig. 7*. Interpolation of data for the three gas sensors*

For fitting of data and classification of period of cheese aging is used artificial neural network (ANN). The ANN has two layers – one hidden and one output layer (Fig.8).

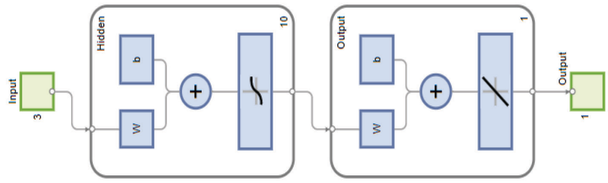

Fig. 8. *ANN structure*

The neural network has 10 neurons in the hidden layer with "tansig" activation function of neurons and 1 neuron in the output layer with linear activation function.

The data set for training after the interpolation consist of more than 280 points. 70% of them are used for training, 15% for validation during training and 15% for testing.

The neural network is successfully trained. After the test of the neural network, the error of classification of period of aging is neglegible small (Fig.9).

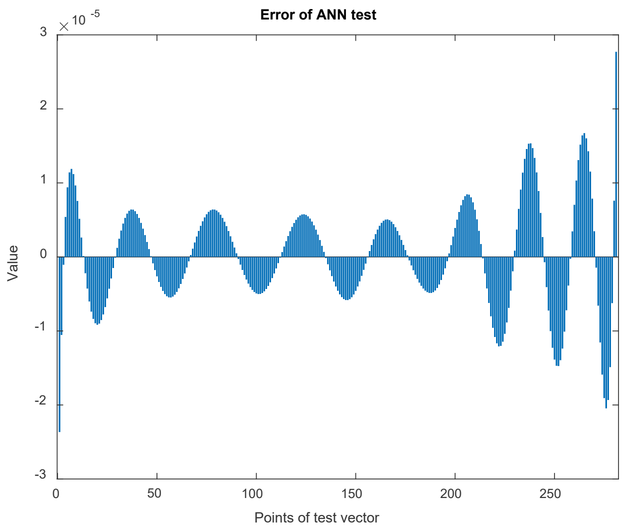

Fig. 9*. The error values after the test of ANN*

The maximum absolute value of the error is 2.7711e-05.

It can be concluded that the trained neural network can very successfully classify the aging period of mentioned brand of cheese.

CONCLUSIONS

The paper demonstrates how the process of cheese aging can be measured with low-cost gas sensor module. The acquired data are used for training of artificial neural network which is able to determine the period of cheese aging. The neural network can be used as ANN model, which can be implemented in the software of a real gas detector for determining the cheese quality based on its period of aging.

ACKNOWLEDGMENT

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