MEASUREMENT OF THE PROCESS OF MAKING WINE WITH THE HELP OF IOT

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Abstract
The article deals with the fermentation process of rice wine and obtaining data during fermentation with the help of IoT. The process of converting D-glucose into ethanol together with the oxidation of reduced coenzymes is called fermentation. Ethanol fermentation takes place anaerobically, i.e. without access to air with the help of yeast. The fermentation process is gradually being improved with the help of acquired sensor data and the gradual possibility of automation. The main objective of this paper is to develop an experimental environment for measuring rice wine fermentation processes with the help of IoT. During the fermentation of rice wine, there are measurable attributes that can be measured with the help of sensors. These attributes affecting the final product quality, positively but also negatively (pH, temperature, humidity, etc.). It is therefore necessary to select a given sensor that can monitor the attributes and then devices that can then manage and evaluate it. the correct selection and use of sensors and computing equipment, the acquisition and processing of data and the application of the resulting values to fermentation procedures, the resulting product quality increases.

Key words: *automation, IoT, fermentation, rice wine, senzors, ethanol*

INTRODUCTION

The development of industrial technologies nowadays is moving forward relatively quickly, and that is why sensorics can be applied to a wider extent in the food-agricultural complex. The Internet of Things includes technologies that present themselves as a network of physical objects that are connected using the Internet and acquire data, then send them via the Internet to compute units that process them. It is a relatively demanding architecture, which must be properly designed, connected, and equipped with suitable sensors and devices for communicating with each other *(Gilchrist, 2016).*

Today, thanks to industrial technologies, the fermentation process can be monitored and tracked via programmed internet interfaces with the help of IoT. These measured data can then be processed and used in the food-agricultural complex for the subsequent improvement of processes and output products. In this case, to improve the resulting properties of fermented rice wine and thus minimize the resulting negative properties of the product *(Lokman et al., 2020).*

One of the main units in systems designed for IoT are the sensors themselves, external devices designed to measure and collect the required data. Subsequently, these measured data are stored on computing units that are connected to the internet, and then these data are sent to storage, such as the Linux server. The measured data are in the fermentation processes about temperature, humidity, acidity etc. Complete information about the fermentation process is obtained and processed continuously in the fermentation process. Subsequently, they can be processed for various applications that can run locally or be presented to the world of the internet with the help of web interfaces *(Tomtsis et al., 2016).*

Fermentation is the process in which D-glucose C6H12O6 is converted into C2H5OH ethanol along with the oxidation of reduced coenzymes (NADH, FADH) - called fermentation *(Keot et al., 2020).*

Overall, fermentation processes are very demanding regarding the technological process, especially to ensure the inaccessibility of air, as there is a risk of mold attack. To improve the fermentation process, the process of automation, i.e. the IoT industry, is also suitable. The design of an autonomous stainless-steel mixer can also be applied here. To better mix the released substances into the solution during the fermentation process, it is also advisable to use a stirrer, which mixes the so-called dead spots during the fermentation process. The aim of this arcite was measure and compare data during fermentation process using a stirrer and without stirrer *(Uehara et al., 2018; Cai et al., 2019).*

MATERIALS AND METHODS

To realize the fermentation process of rice wine, an experimental environment was designed and assembled in which the specified fermentation process took place under constant conditions for all fermented products in Fig. 1. The fermentation process was fitted in two vessels with a designed and constructed stirrer and two vessels were not fitted with an experimental stirrer and here the fermentation process took place naturally.

Fig. 1 Experimental fermentation environment

The applied autonomous stirrer in the fermentation process was made of stainless food grade steel ČSN 17240. AISI 304 in the Czech Republic in Fig. 2. Subsequently constructed, it was installed in two fermentation vessels.

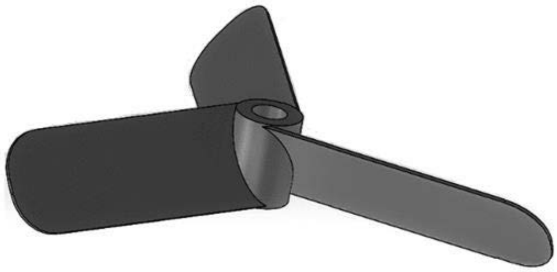

Fig. 2 Part of autonomic food stainless-steel stirrer

Before the actual implementation of the fermentation process and production of the autonomous mixer, information was obtained about the individual types of sensors that can be used in the fermentation process. Subsequently, they were acquired and applied to the fermentation process. A Raspberry Pi 4 model B 4GB RAM microcomputer was chosen as the main computing unit for the task of data collection and subsequent processing. This sensors had to be properly programmed in Python or C++.
The first measurable attribute in rice wine fermentation was moisture, and this attribute was measured by the BMP-280. The program for this sensor was programmed using the Python language. Another well-measurable attribute is the temperature inside the container and the external temperature outside the container. For this purpose, the experimental environment was fitted with a DS18S20 sensor. The temperature sensor placed inside the container was made in a waterproof version and was placed directly in the solution. Another sensor that was also immersed in the solution was the E-201C-Bue solution pH probe, which was properly calibrated and programmed in C++.

RESULTS AND DISCUSSION

The best measurable quantity in the rice wine fermentation process is clearly the temperature of the solution in which the fermentation takes place. Heat is generated by the process of converting D-Glucose into the desired ethanol. The measured temperature before starting the fermentation process was, as in the previous project, 21 °C to obtain the most accurate results. During vigorous fermentation, i.e. when the highest amount of conversion of D-glucose by the yeast into ethanol occurs, lower temperature values were measured in vessels with a stirrer compared to fermentation vessels without a stirrer in the order of 2 °C. Later, after vigorous fermentation, the fermented solution began to gradually cool down due to the gradually decreasing activity of the yeast. Here, the temperatures of 11.6 and 13.6 differed by 1.85 °C, and on the other remaining days the temperature difference was in the order of tenths of a degree Celsius (up to 0.20 °C). Following the completion of the yeast fermentation process, consumption of D-glucose, the fermented solution was subsequently cooled to a constant temperature of 12 °C, corresponding to the previous project. The temperature was subsequently maintained by cooling boxes (with thermoregulation) at the mentioned temperature. The highest temperature reached during the fermentation process was reached on 10.6 at a temperature of 29.9 °C in the vessel without a stirrer and 29.7 °C in the vessel with an experimental stirrer on the sixth day in Fig. 3. The rise in temperature in containers without a stirrer is higher in vigorous fermentation than in containers with a stirrer, but after vigorous fermentation, the solution cools down faster in containers without a stirrer than in containers with a stirrer.

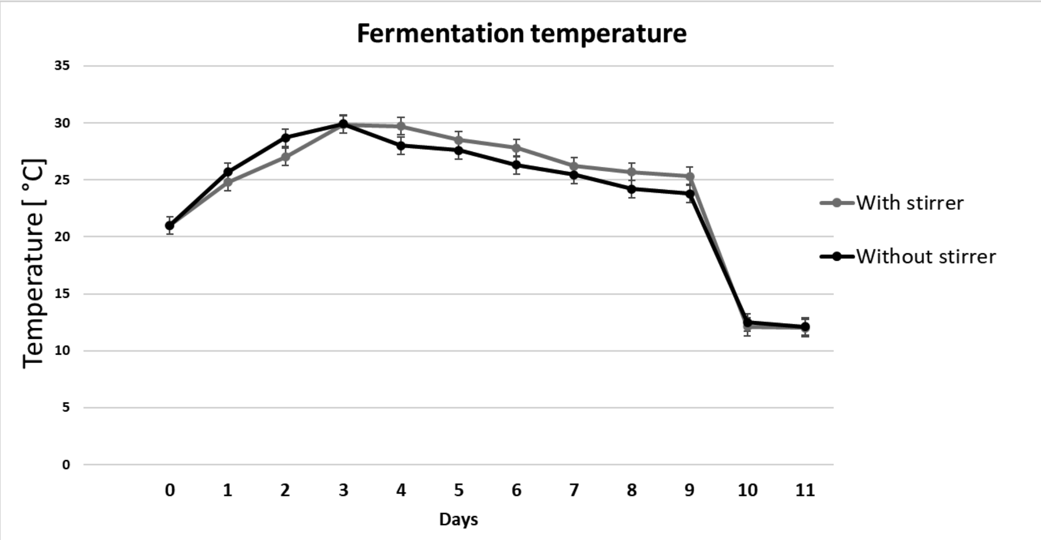

Fig. 3 The course of fermentation temperature

The next well-measurable quantity during the fermentation process is the humidity in the fermentation vessels. The measured values in the same conditions as in the previous project were an average of 85% with a 5% deviation in all vessels measured by sensors. The percentage moisture during vigorous fermentation was 4.7 °C higher in the container with the fermented solution without a stirrer on the first day than in the container with the experimental 3D printed stirrer in Fig. 4.

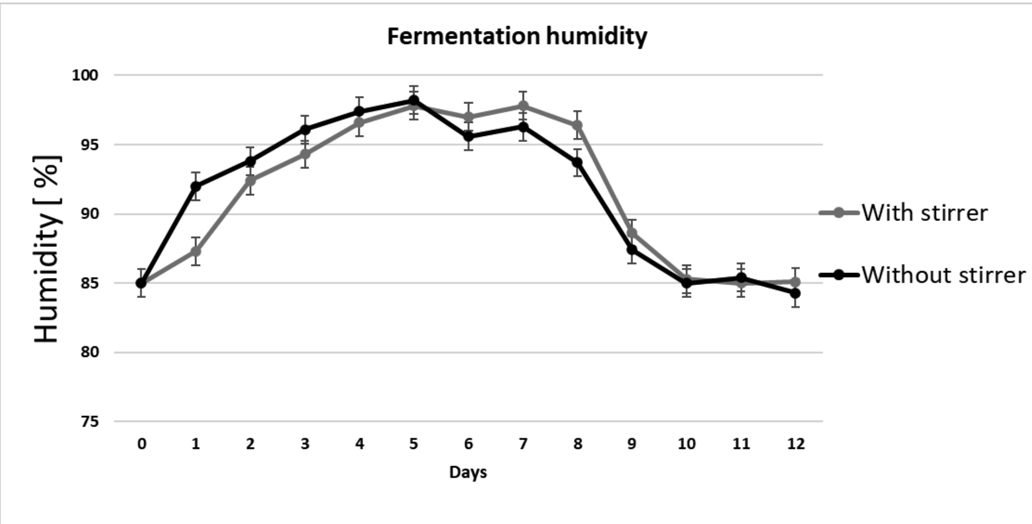

Fig. 4 The course of fermentation humidity

A well-measurable aspect is the pH value, or the acidity of the fermented solution, which is indicated by the hydrogen exponent. The initial pH was measured to be 7.28 before fermentation started. As a result of the gradual conversion of D-Glucose into the desired ethanol by yeast, the pH value in the fermented solution decreases. the acidity of the solution increases in Fig. 5. Throughout the fermentation of the solution, as in the previous measurement, the solution with the experimental self-sustaining stirrer showed lower pH values compared to the containers with solution, in which the experimental spontaneous stirrer was not applied. However, there was now a lower dispersion of values between these fitted and unfitted vessels with an experimental stirrer compared to the previous measurement, in the order of hundreds to tenths of units of the hydrogen exponent pH.

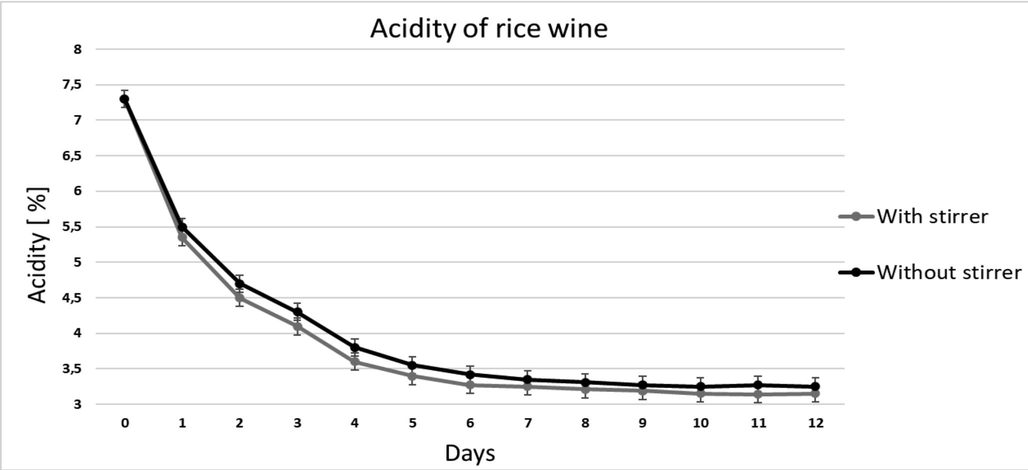

Fig. 5 The course of fermentation acidity

The value of the percentage content of sugar content with the applied additives was fine-tuned to a value of 23.5% sugar content with a minimal deviation (up to 0.66%). When the fermentation process starts, the sugar content in the solution is gradually consumed by the yeast up to 0 %. This means that all the sugar has been converted to alcohol.

The alcohol value reached a value of 13.9% and in a container with an applied experimental stirrer, the value was 13.6%. The fermented rice wine reached low values for the typical alcohol range of rice wines.

CONCLUSIONS

The application of experimental stirrers affects, albeit in some cases minimally, the ongoing and final properties of fermented rice wine.

The moisture percentages are higher in the vessels without the applied experimental stirrer in the vessels during the rampant fermentation process. After the vigorous fermentation process, the opposite effect occurs, with the vessels with the experimental stirrer reaching higher continuous values.

In both cases, however, the percentage of alcohol met the criteria for the percentage of alcohol content in rice wine (lower limits). With a higher amount of initial sugar content in the solution, the resulting alcohol value would be higher.

In vessels without an experimental stirrer, the value of both the continuous and the final pH was higher than in the vessels with an experimental stirrer printed on a 3D printer. The resulting pH value is desirable at lower values, as it indicates a better mixing of the individual ingredients into the solution.

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