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THE IMPACT OF LOW-FREQUENCY MAGNETIC FIELD ON KETAN TAPE MATURATION: pH, DENSITY, AND TASTE

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Abstract :
This study explores the novel effect of Extremely Low Frequency (ELF) electromagnetic waves on the fermentation process of sticky rice tape, a traditional Indonesian food made from glutinous rice. ELF electromagnetic waves are waves consisting of magnetic fields and electric fields that do not require intermediaries in their propagation and have frequencies ranging from 0-300 Hz. The study uses a unique experimental method that exposes 2 kg of sticky rice tape, divided into 10 control and 10 experimental samples, each weighing 100 grams and wrapped in ziplock plastic, to ELF electromagnetic waves for two days. The study uses a device that generates ELF electromagnetic waves with a certain intensity and frequency. The study measures the changes in the pH, density, and taste of the sticky rice tape samples after the exposure. The results show that the experimental group's sticky rice tape had a higher pH, higher density, and sweeter taste than the control group's sticky rice tape. The study proves the effect of ELF electromagnetic waves on the fermentation process of sticky rice tape and provides insights for the development of new food processing techniques. The study demonstrates the applicability and innovation of using ELF electromagnetic waves for food fermentation.

Keywords: ELF magnetic field, Food maturation, Radiation

INTRODUCTION

Magnetic field refers to the region around a magnet that remains affected by the magnetic force. The visual representation of a magnetic field is usually done through magnetic lines of force. The strength of a magnetic field is reflected through the density of the magnetic lines of force (Hashish et al., 2008; Aini & Riswandi, 2020). The concept rule of magnetic lines of force is explained by the existence of forces between electric charges (Griefahn et al., 2002; Rismaningsih et al., 2022). The relationship between magnetic and electric fields is explained by several scientists. The Theory according to a scientist from Denmark, Hans Cristian Oersted, suggests that the magnetic field is around the electric current wire. The theory according to Faraday is that the induced voltage of the electric field is caused by changes in the magnetic field from the movement of magnets in the coil. Maxwell I, also found changes from the magnetic field and the electric field occur together in a perpendicular manner and influence each other (Hozayn, EL-Mahdy, & Abdel-Rahman, 2015; Nawawi, 2018).

Radiation is energy in the form of particles or waves that have a high speed, of which two types of particles arise from radioactive particles and electromagnetic waves, namely alpha and beta particles. Electromagnetic wave radiation can be divided into ionizing and non-ionizing radiation according to the amount of energy that can be produced. Ionizing radiation has a high frequency to have the energy to

break the bonded electrons, while non-ionizing radiation has a low frequency and insufficient energy to break the bonded electrons (Iqlima, 2020; Sudarti et al., 2023). Power tools are a source of radiation. Increased exposure to electromagnetic radiation such as exposure to ELF magnetic fields can be caused by the use of a lot or excessive electrical energy (Agustina et al., 2018; Sulistiyowati, Zuyyina, & Sudarti, 2023).

Electromagnetic waves arise due to strong changes between magnetic and electric fields. Electromagnetic radiation is an isolated combination of magnetic and electric fields. This radiation can be divided into two categories, namely electromagnetic radiation with very low frequency and very high frequency. The very low frequency of the magnetic field is referred to as Extremely Low Frequency, while the very high frequency of the magnetic field is referred to as Extremely High Frequency (Nuriyah et al., 2022). The spectrum of electromagnetic waves generated from the earth and sun includes microwaves, radio waves, visible (light) rays, infrared rays, ultraviolet rays, gamma rays, x-rays, and electrical equipment such as cable systems (Suri et al., 2020; Astutik & Sudarti, 2021).

Research and utilization of ELF electromagnetic waves in foodstuffs have entered the process of processing and preserving fermented foods, one of which is tape. Exposure to ELF magnetic fields on tape can maximize microbial growth rates and play a role in changing the pH of the tape. ELF magnetic fields can be used to accelerate the fermentation process and improve the quality of food ingredients (Tenforde, 1991; Magfirah et al., 2022). Magnetic field radiation on food ingredients can affect food ingredients in terms such as pH, density, and physical condition. Research conducted by Rahman and Sudarti (2021) on the impact of ELF magnetic field radiation exposure on water guava shows the results if the density of guava after exposure to ELF magnetic radiation increases and the pH of water guava decreases over time, as well as physical conditions that experience changes in terms of soft fruit texture and increasingly sour aroma. Another study on ELF magnetic field radiation conducted on peanut cream cheese showed that the pH of the control group (not exposed to ELF) was lower than the experimental group (exposed to ELF) (Yan et al., 2010; Teixeira da Silva & Dobránszki, 2016; Apriani et al, 2021). Magnetic field radiation experiments were also conducted on ranti tomatoes which showed that the control group had a larger density while the experimental group had a smaller density (Rahman et al., 2022).

The research does not mention the previous studies that have investigated the effect of ELF magnetic field radiation on the fermentation process of food ingredients, especially on sticky rice tape. The research also does not explain the mechanism of how the ELF magnetic field influences the microbial activity and the chemical changes in the sticky rice tape. The problem formulation that can be studied in this practicum is related to the impact of Extremely Low Frequency (ELF) magnetic fields on the maturation process of foodstuffs. Therefore, the purpose of this practicum is to test and verify the effect of an ELF magnetic field on tape maturation, focusing on the aspects of pH, density, and flavor characteristics.

RESEARCH METHOD

This research was conducted in November 2023 at the Basic Physics Laboratory, Faculty of FETT, Building Three, University of Jember. The research method used is a practicum method that uses Complete Randomized Design (CRD) research. In this study 2 treatments were applied with each treatment given 10 repetitions. The first treatment is the control group, which is a group that is not given exposure to the ELF magnetic field and left at room temperature. The second treatment is the experimental group, which is the group given exposure to the ELF magnetic field with an intensity of 500 µT for 45 minutes.

This study has independent variables in the form of glutinous rice tape at the beginning of fermentation. This study also has dependent variables in the form of pH, density, and flavor measurement results. Finally, the control variables, the control variables in this study consist of air humidity, temperature, time required during fermentation, and the size of the glutinous tape mass which is made the same in each ziplock, amounting to 100gr.

The tools used in this study include an ELF magnetic field generator, 1 EMF-Meter, thermometer, pH meter, measuring cup, digital scale, plastic tray, cup, gloves, and ruler. For the materials needed there is glutinous rice tape at the beginning of fermentation (2 days before ripening) as much as 2 kg, medium size ziplock plastic as many as 20 pieces, and label paper or permanent markers.

The following is the design of the research design.

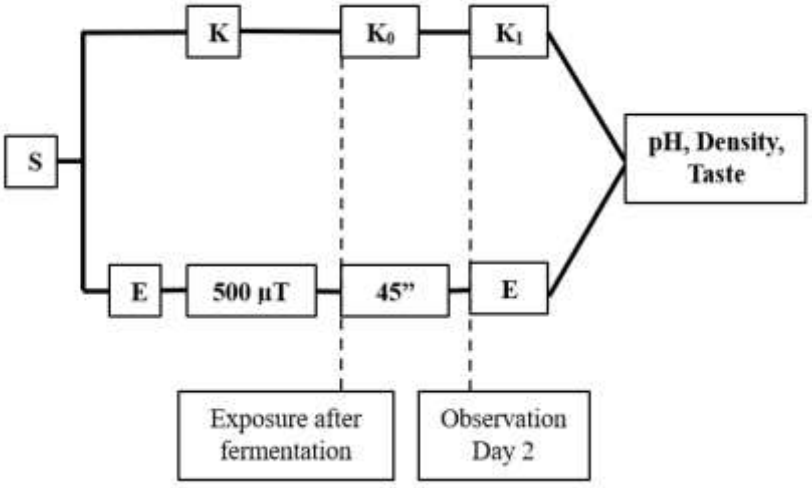

Figure 1. Research Design

In the research design above, S is a sample in the study, where the sample used is glutinous rice tape of early fermentation quality (2 days before ripening) as much as 2 kg. then glutinous tape is grouped into two treatments. The first treatment is the control group denoted by K. The second treatment is the experimental group denoted by E. Where each treatment is repeated 10 times. In each repetition, glutinous rice tape is put into ziplock plastic packaging, and each package contains 100 grams of glutinous rice tape.

Furthermore, the initial glutinous rice tape of the experimental group will be exposed to an ELF magnetic field with an intensity of 500 µT within 45 minutes, while the initial glutinous rice tape of the control group will be left at room temperature. After the glutinous rice tape of the experimental group has been exposed to the ELF magnetic field, the tape of the experimental group will be stored in the same place as the control group, namely in a room at room temperature. In the final step on the second day after exposure, observations will be made regarding the difference in pH, density, and flavor between the control group's glutinous rice tape and the experimental group's glutinous rice tape.

RESULTS AND DISCUSSION

Based on Table 1. above, it is found that the average pH of glutinous rice tape of the control group is 2.22 while the average pH of the experimental group is 2.45. These results show that the control group glutinous rice tape has a lower average pH, while the experimental group glutinous rice tape has a higher average pH. Glutinous rice tape that goes through the fermentation process indicates that lactic acid bacteria are developing that help in the fermentation process. The occurrence of a decrease in pH is one sign that lactic acid bacteria are working well. However, an excessive decrease in the pH of glutinous rice tape is also not good because it will indicate excessive alcohol production and produce glutinous rice tape with a taste that tends to be sour. As is known, the ELF magnetic field has non-ionizing characteristics, namely being able to penetrate all biological materials without causing the split of biological ions contained therein.

ELF magnetic field exposure to an ion will disrupt biochemical and biophysical processes due to the process of coupling on the ion. Giving exposure to ELF magnetic fields using an intensity of 500 µT is able to prevent the process of poliferation of bacterial microorganisms that want to damage proteins in cells in the fermentation process (Nuriyah et al., 2022). This gives the result that the provision of ELF magnetic field exposure on glutinous rice can inhibit the activity of lactic acid bacteria in the fermentation process, which results in an increase in pH in the experimental group. In contrast, glutinous rice tape in the control group, which did not get exposure to ELF magnetic field radiation, showed a lower pH level because the microorganism activity of lactic acid bacteria tended to be faster than the experimental group.

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Table 1. Density Measurement Results

Control Group				Experimental Group			
S_1	m	ΔV	ρ	S_2	m	ΔV	ρ
C_1	100	80	1.25	E_1	100	70	1.42
C_2	100	77	1.29	E_2	100	72	1.38
C_3	100	78	1.28	E_3	100	73	1.36
C_4	100	80	1.25	E_4	100	80	1.25
C_5	100	85	1.17	E_5	100	70	1.42
C_6	100	80	1.25	E_6	100	80	1.25
C_7	100	75	1.33	E_7	100	70	1.42
C_8	100	75	1.33	E_8	100	85	1.17
C_9	100	78	1.28	E_9	100	80	1.25
C_{10}	100	80	1.25	E_{10}	100	75	1.33
Density Average			1.268	Density Average			1.325

Information :
S_1 = Control group sample
S_2 = Experimental group sample
m = Glutinous tape mass (gram)

Reviewing the results of the measurement of the density of raw glutinous rice tape in Table 2, the average density of the control group was 1.268 g/cm3. While the average density of the experimental group was 1.325 g/cm3. This shows an increase in density after exposure to ELF electromagnetic radiation. ELF exposure to raw glutinous rice tape can stimulate changes in the molecular structure of the tape. This process triggers water absorption or changes in the water content of the tape, which in turn can lead to an increase in its density.

Glutinous rice tape exposed to ELF magnetic field radiation will stimulate fermentation in the tape. During the fermentation stage, microorganisms, especially yeast, begin to consume the sugars present in the raw glutinous rice tape. This process produces ethanol (alcohol) and carbon dioxide gas as well as the amount of water content. The increase in the amount of water content will also affect the density of the tape, resulting in a difference in the density conditions of the control group tape and the experimental group tape.

Table 2. Taste assessment results of glutinous rice tape control group

Sample	Good			Bitter			Sour		
	$O_{(1)}$	$O_{(2)}$	$O_{(3)}$	$O_{(1)}$	$O_{(2)}$	$O_{(3)}$	$O_{(1)}$	$O_{(2)}$	$O_{(3)}$
C_1	-	-	-	-	-	-	1	1	1
C_2	1	1	-	-	-	-	-	-	1
C_3	1	1	1	-	-	-	-	-	-
C_4	-	-	-	-	-	-	1	1	2
C_5	-	-	-	-	-	-	1	2	2
C_6	-	-	-	-	-	-	2	1	1
C_7	-	-	-	-	-	-	2	2	2
C_8	-	-	-	-	-	-	2	1	2
C_9	-	-	-	-	-	-	2	2	2
C_{10}	2	2	3	-	-	-	-	-	-

Table 3. Table of experimental group glutinous rice tape flavor assessment results

Sample	Good			Bitter			Sour		
	$O_{(1)}$	$O_{(2)}$	$O_{(3)}$	$O_{(1)}$	$O_{(2)}$	$O_{(3)}$	$O_{(1)}$	$O_{(2)}$	$O_{(3)}$
E_1	1	1	1	-	-	-	-	-	-
E_2	1	1	1	-	-	-	-	-	-
E_3	2	2	2	-	-	-	-	-	-
E_4	2	2	-	-	-	-	-	-	2
E_5	2	3	3	-	-	-	-	-	-
E_6	-	1	1	-	-	-	1	-	-
E_7	-	-	-	-	-	-	1	1	1
E_8	2	2	2	-	-	-	-	-	-
E_9	-	-	-	-	-	-	1	1	1
E_{10}	1	2	1	-	-	-	-	-	-

Information :
$O_{(1)}$ = Observator 1
$O_{(2)}$ = Observator 2
$O_{(3)}$ = Observator 3

Yeast is the main microorganism responsible for converting sugars present in raw materials into alcohol (ethanol) through the process of alcoholic fermentation. This happens because yeast consumes the sugar in the raw materials as an energy source for the growth and metabolism of microorganisms. During fermentation, sugar from glutinous rice is converted into ethanol and carbon dioxide gas. The results of the assessment of flavor conditions in glutinous rice tape can be seen in Tables 3 and 4, from the control group it results that most testers rated it sour. While in the experimental group, most of the testers rated good/typical. This shows that the fermentation carried out by the experimental group is more perfect because it is influenced by ELF radiation. Because ELF magnetic field radiation can affect the optimal work of microorganisms that play a role in fermentation. So it has a sweeter taste than without exposure to ELF magnetic field radiation. The control group was considered sour because of the lactic acid bacteria involved in tape fermentation. Some types of bacteria can metabolize sugar into lactic acid. Lactic acid will give a sour taste to the product and may contribute to the sweetness indirectly. When the sourness of lactic acid is balanced with the sweetness of sugar, the sweetness of the tape can be more pronounced (Wyszkowska et al., 2018; Wang et al., 2019; Wahyuni & Arif, 2021).

The research is novel because it uses a device that generates ELF magnetic field with a certain intensity and frequency, which may differ from the natural background level of ELF magnetic field. The research also explores the effect of ELF magnetic field radiation on a specific type of food, which is sticky rice tape, which is a traditional Indonesian food made from glutinous rice. The research has some limitations, such as the small sample size of 20 sticky rice tape samples, the lack of control variables such as temperature, humidity, and light, and the short duration of exposure to the ELF magnetic field, which is only two days. The research also does not measure the changes in the nutritional value, shelf life, and safety of the sticky rice tape after the exposure.

CONCLUSION

It was concluded from the observations made that the ELF magnetic field can indeed influence the maturation process of food ingredients in the fermentation process. This influence can be seen in the average pH, which can affect the development of microorganisms which can also affect the physical condition of food ingredients such as aroma, texture, and taste. The research is novel because it uses a device that generates ELF magnetic field with a certain intensity and frequency, which may differ from the natural background level of ELF magnetic field. The research also explores the effect of ELF magnetic field radiation on a specific type of food, which is sticky rice tape, which is a traditional Indonesian food made from glutinous rice. The research has some limitations, such as the small sample size of 20 sticky rice tape samples, the lack of control variables such as temperature, humidity, and light, and the short duration of exposure to the ELF magnetic field, which is only two days. The

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