ANALYSIS OF RESISTANCE OF CASSAVA TAPE BY EXPOSURE TO 1000 µT INTENSITY ELF MAGNETS

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Abstract :
Extremely Low Frequency (ELF) electromagnetic waves are electromagnetic waves with a frequency range of 0 to 300 Hz. ELF electromagnetic wave radiation produces non-thermal effects on the biological objects used, meaning that it does not cause temperature changes when interacting with or inducing the system. Electromagnetic waves are waves that arise due to changes in electric fields and strong magnetic fields. This research aims to prove the effect of Extremely low frequency (ELF) magnetic field on the food resilience process. The research method used is experimental research method. This research was carried out in the basic physics laboratory at the University of Jember. Data collection techniques using observation. Based on the research, it can be concluded that ELF magnetic field radiation has the potential as an alternative method in increasing the nutritional value and durability of fermented food ingredients. Exposure to Extremely Low Frequency magnets with an intensity of 1000 µT for 45 minutes resulted in changes in pH value and physical quality that affect food durability in cassava tape.

Keywords: Cassava Tape, Extremely Low Frequency, Electromagnetic Wave

INTRODUCTION

Electromagnetic fields are closely related to electromagnetic resonances that affect the flow of electricity (Utama et al., 2021). Electromagnetic fields are phenomena that play an important role in the world of electronics and physical science. According to Utama et al. (2021), electromagnetic field is a combination of magnetic field and electric field. This is a very basic concept in electromagnetic science. Electric fields are created by electric charges, while magnetic fields are related to the movement of electric charges. Electric fields and magnetic fields can form electromagnetic fields due to the presence of charged particles (Rusydi et al., 2018). The resulting electromagnetic field can have a variety of frequencies, ranging from very low to very high. One important category of electromagnetic fields is Extremely Low-Frequency Electromagnetic fields. Extremely low-frequency electromagnetic fields or ELFs are fields with frequencies of 0-300 Hz generated mainly by power lines (Cios et al., 2021). The main sources of ELF are power lines and equipment that uses electricity in this frequency. It is important to note that the magnetic induction produced when exposed to ELF electromagnetic fields is very low. Magnetic induction, when exposed to very low frequency electromagnetic fields, is typically below 0.1 µT (Cios et al., 2021). Despite their low intensity, long-term exposure to ELF electromagnetic fields can be a public health concern. ELF is a subradio frequency, some journal reviews mention that ELF is a very low frequency with frequencies of 50 Hz and 50-80 Hz (Saleh et al., 2021). This shows that there are variations in the definition of ELF in the scientific literature.

Extremely Low Frequency (ELF) electromagnetic waves are electromagnetic waves with frequencies ranging from 0 to 300 Hz. ELF electromagnetic wave radiation produces non-thermal effects on the biological objects used, meaning that it does not cause temperature changes when interacting with or inducing the system. Extremely Low Frequency (ELF) magnetic fields are part of electromagnetic waves. ELF magnetic fields can be utilized in everyday life, one of which is in the field of food fermentation. ELF magnetic field exposure has biological effects that can be detrimental depending on the current intensity, field strength, and duration of exposure (Sulistiyowati et al., 2023). Electromagnetic wave radiation generated by electric fields and magnetic fields ranges from extreme low to very high frequencies. Exposure to ELF magnetic field intensities of 300 μT and 500 μT has an effect on changes in the number of microbes in the cassava tape fermentation process, the highest decrease in the number of microbes occurs in the treatment of exposure intensity of 500 μT at exposure time 72 hours after fermentation. The highest increase in PH value occurred in the 500 μT treatment at the exposure time of 24 hours after division. According to Apriani et al. (2021) exposure to ELF magnetic fields with an intensity of 300 μT affects the growth of ranti tomatoes. The greater the intensity of the ELF magnetic field and the longer the exposure exposed to plants will have a major effect on the growth process. ELF megnet field exposure can be used to increase bacterial growth. Exposure to ELF magnetic fields on bacteria causes changes in movement and an increase in the rate of ion movement (Apriani et al., 2021).

This spread of elementary particles and radiation energy can have a significant effect on the exposed material. Radiation means radiation emission or irradiation, which is the spread of elementary particles and radiation energy from a radiation source to the surrounding medium or destination (Alfarizi et al., 2021). Electromagnetic radiation is the process of emission and passage of electromagnetic energy, in electromagnetic waves, and the resulting effects on the material it affects (Khoiriyah & Sudarti, 2022). An in-depth understanding of electromagnetic fields and electromagnetic radiation is essential in the context of human safety and health, especially when humans are continuously exposed to various sources of this radiation in their daily lives. Research and monitoring efforts are ongoing to understand the impact of exposure to electromagnetic fields, particularly in the ELF frequency range, and develop appropriate safety guidelines.

Electromagnetic waves are waves that arise due to changes in strong electric and magnetic fields. The combination of oscillating electric and magnetic fields is called electromagnetic radiation, this radiation is divided into two groups, namely electromagnetic radiation of very low frequency (Extremely Low Frequency) and very high frequency (Extremely High Frequency). Extremely Low Frequency magnetic field is part of the electromagnetic wave spectrum with a frequency of >300 Hz. ELF magnetic fields have been widely utilized in various fields, one of which is in the food sector. Magnetic fields with intensities below 500μT can support the process of cell proliferation while intensities above 500μT can play a role in the process of cell death or apoptosis so as to inhibit the growth of bacteria in food ingredients. The utilization of ELF magnetic fields has a good impact in maintaining the quality of food, which can be proven by looking at the results of previous research (Nuriyah et al., 2022). According to Sari et al. (2019) that tape has great benefits for the body, including containing vitamin B1 with levels three times that of other food ingredients which functions to facilitate the work of the nervous system, muscle cells, and the digestive system, and contains vitamin B12. Seeing the many benefits of cassava tape, one alternative is to utilize ELF electromagnetic wave radiation in the processing and preservation of fermented tape. The length of tape fermentation can affect the glucose content, alcohol content, texture and flavor of the tape (Sari et al., 2019).

According to Putri & Hersoelistyorini (2012) the chemical and nutritional components in 100 g of cassava are as follows: 8.11 g protein; 15.20 g crude fiber; 0.22 g pectin; 1.29 g fat; 0.63 g calcium while the chemical and nutritional components of cassava meat in 100 g are 1 g protein; 154 g calories; 36.8 g carbohydrates; 0.1 g fat. HCN content in cassava skin can be reduced by several treatments including soaking, boiling, and fermentation. The fermentation process can reduce HCN content and increase the content of energy, protein, crude fiber, and increase the digestibility of low-quality food ingredients (Turyoni, 2005). Fermentation is influenced by several factors, one of which is the length of fermentation. The length of fermentation required in the fermentation process is 2-3 days, the appropriate time will produce tape with a distinctive flavor, sweet taste with a slight sourness and the aroma of alcohol. The sweet taste is due to the change of carbohydrates into glucose as a simpler carbohydrate, while the sour taste is due to the fermentation process of acid formation, so that the longer the aging, there will be an increase in alcohol content and total acid (Fahmi & Nurrahman, 2011). tape durability has a close relationship with the number of microbes, especially acid-forming bacteria, which is also closely related to the pH value (degree of acidity). tape fermentation produces acetic acid compounds (CH3COOH) which can be caused by the activity of acid-forming bacteria. With magnetic field technology, the decrease in pH can be inhibited by transferring energy from the magnetic field to ions in acid-forming bacterial cells and eventually causing cell death (Sadidah & Ghani 2015). Based on the results of research by Magfirah & Trapsilo Prihandono (2022) which states that Extremely Low Frequency (ELF) magnets can affect the average pH value in the cassava tape fermentation process. This is caused by exposure to Extremely Low Frequency (ELF) magnetic fields affecting the development of microorganisms in the cassava tape fermentation process.

Electromagnetic waves known as Extremely Low Frequency (ELF) magnetic fields have a very low frequency, below 0-300 Hz. ELF magnetic fields are not only generated when electricity flows through wires, but also arise from waves coming from electronic devices. The frequency generated by electronic equipment is 50-60 Hz. ELF radiation cannot isolate any material/object in its path, therefore this radiation is included in the category of non-ionizing radiation (a type of radiation that is not able to isolate the material it passes through). (Setiani et al., 2023). Changes in magnetic fields can produce electric fields, conversely changes in electric fields can produce magnetic fields. Very low frequency is a term used to describe eletromagnetic wave radiation with a frequency of 3 to 300 Hz, with wavelengths from 100,000 to 1000 kilometers with frequencies from 3 Hz to 3kHz (Saleh et al., 2021: 2-3). The electromagnetic spectrum is the distribution of various frequencies, wavelengths, and photon energy of electromagnetic radiation. Types of frequencies are distinguished based on frequency bands called by various names, such as radio waves, microwaves, infrared, visible light, ultraviolet, X-rays, and gamma rays (Muladi et al., 2021).

RESEARCH METHOD

The type of research used in this study is experimental research or practicum in the basic physics laboratory. In research that aims to prove the effect of extremely low frequency magnetic fields on the food security process, the first thing to do is to prepare research tools and materials in accordance with the basic physics practicum module on ELF magnetic field radiation. The tools and materials needed are as follows, ELF magnetic field generator, EMF-meter 1 thermometer, pH meter, measuring cup, balance sheet, plastic tray, cup, gloves, and ruler, as well as 2 kg of ripe cassava tape material with a requirement of 2 days after ripening, 20 large size ziplock plastic, and permanent markers. The research began by preparing practicum materials, namely 20 packs of cassava tape, each weighing 100 grams per pack. Then divide the ripe cassava tape into groups, 10 packs constitute the control group and 10 packs constitute the experimental group. After that, mark each pack with a permanent marker. Putting the control group and the experimental group on two different trays. Giving exposure to extremely low frequency magnetic field to the experimental group with an intensity of 1000µT. After the experimental group finished being exposed to the ELF magnetic field, storing both groups at room temperature, then observing the material after two days of exposure.

The independent variable in this study is ELF magnetic field exposure. In addition, the storage time of the material is also an independent variable. The control variables in this ELF magnetic field radiation practicum include the type of tempeh, sticky tape, and cassava tape used and the mass of each material in each sample, which is a total of 100 grams. The dependent variable of this study is the pH of the material used, as well as the aroma, texture and taste of cassava tape. In this study, cassava tape was divided into two groups, namely the control group and the experimental group. The control group was not treated with exposure to extremely low frequency electromagnetic wave magnetic field, while the experimental group was treated with exposure to extremely low frequency electromagnetic wave magnetic field with exposure duration of 45 minutes with intensity of 1000µT.

RESULTS AND DISCUSSION

Cassava Tape pH Measurement

Research data based on the measurement of the pH of cassava tape in the control group and the experimental group obtained results according to Table 1.

Table 1. pH value of cassava tape

Control Group		Experiment Group	
K1	4.0	E1	3.4
K2	4.7	E2	4.1
K3	3.9	E3	4.1
K4	3.8	E4	3.8
K5	4.0	E5	4.2
K6	4.2	E6	4.1
K7	4.7	E7	4.1
K8	4.1	E8	3.6
K9	3.9	E9	4.6
K10	4.2	E10	3.2
Average pH	4.15	Average pH	3.92

Measurement of Density of Cassava Tape

Research data based on measurements of cassava tape density in the control group and experimental group obtained results according to Table 2.

Table 2. Density Value of Cassava Tape

Control Group				Experiment Group			
Sample Name	m (gr)	ΔV (ml)	ρ (gr/ml)	Sample Name	m (gr)	ΔV (ml)	ρ (gr/ml)
K1	100	90	1.11	E1	100	90	1.11
K2	100	75	1.33	E2	100	90	1.11
K3	100	90	1.11	E3	100	75	1.33
K4	100	75	1.33	E4	100	75	1.33
K5	100	75	1.33	E5	100	75	1.33
K6	100	75	1.33	E6	100	75	1.33
K7	100	75	1.33	E7	100	75	1.33
K8	100	75	1.33	E8	100	75	1.33
K9	100	75	1.33	E9	100	90	1.11
K10	100	75	1.33	E10	100	90	1.11
Average density			1.28	Average density			1.242

Physical Condition of Cassava Tape

Aroma of Cassava Tape

Research data based on the identification of the aroma of cassava tape in the control group and experimental group obtained the results according to Table 3 and Table 4.

Table 3. Control group aroma

Sampel	Normal/typical			No scent			Rotten		
	P(1)	P(2)	P(3)	P(1)	P(2)	P(3)	P(1)	P(2)	P(3)
K1	✓	✓	✓	-	-	-	-	-	-
K2	✓	✓	✓	-	-	-	-	-	-
K3	✓	✓	✓	-	-	-	-	-	-
K4	✓	✓	✓	-	-	-	-	-	-
K5	✓	✓	✓	-	-	-	-	-	-
K6	✓	✓	✓	-	-	-	-	-	-
K7	✓	✓	✓	-	-	-	-	-	-
K8	✓	✓	✓	-	-	-	-	-	-
K9	✓	✓	✓	-	-	-	-	-	-
K10	✓	✓	✓	-	-	-	-	-	-

Table 4. Aroma of Experimental Group

Sampel	Normal/typical			No scent			Rotten		
	P(1)	P(2)	P(3)	P(1)	P(2)	P(3)	P(1)	P(2)	P(3)
E1	✓	✓	✓	-	-	-	-	-	-
E2	-	✓	✓	-	-	-	✓	-	-
E3	✓	✓	✓	-	-	-	-	-	-
E4	-	-	-	-	-	-	✓	✓	✓
E5	-	✓	-	-	-	-	✓	-	✓
E6	✓	✓	✓	-	-	-	-	-	-
E7	✓	✓	✓	-	-	-	-	-	-
E8	✓	✓	✓	-	-	-	-	-	-
E9	-	-	✓	-	✓	-	✓	-	-
E10	-	-	-	-	-	-	✓	✓	✓

Texture of Cassava Tape

Research data based on the identification of the texture of cassava tape in the control group and experimental group obtained the results according to Table 5 and Table 6.

Table 5. Texture of Control Group

Sampel	Solid			Flabby			Watery		
	P(1)	P(2)	P(3)	P(1)	P(2)	P(3)	P(1)	P(2)	P(3)
K1	-	-	-	✓	✓	✓	-	-	-
K2	-	-	-	-	-	-	✓	✓	✓
K3	-	-	-	-	-	-	✓	✓	✓
K4	-	-	-	-	-	-	✓	✓	✓
K5	-	-	-	-	-	-	✓	✓	✓
K6	-	-	-	✓	✓	✓	-	-	-
K7	-	-	-	-	-	-	✓	✓	✓
K8	-	-	-	✓	✓	✓	-	-	-
K9	-	-	-	-	-	-	✓	✓	✓
K10	-	-	-	✓	✓	✓	-	-	-

Table 6. Texture of Experimental Group

Sampel	Solid			Flabby			Watery		
	P(1)	P(2)	P(3)	P(1)	P(2)	P(3)	P(1)	P(2)	P(3)
E1	-	-	-	✓	✓	✓	-	-	-
E2	-	-	-	✓	✓	✓	-	-	-
E3	-	-	-	✓	✓	✓	-	-	-
E4	-	-	-	✓	✓	✓	-	-	-
E5	-	-	-	✓	✓	✓	-	-	-
E6	-	-	-	✓	✓	✓	-	-	-
E7	-	-	-	-	-	✓	✓	✓	-
E8	-	-	-	✓	✓	✓	-	-	-
E9	✓	✓	✓	-	-	-	-	-	-
E10	-	-	-	✓	✓	✓	-	-	-

Cassava Tape Flavor

Research data based on the identification of cassava tape flavors in the control group and experimental group obtained results according to Table 7 and Table 8.

Table 7. Control Group Flavors

Sampel	Good/Typical			Bitter			Acid		
	P(1)	P(2)	P(3)	P(1)	P(2)	P(3)	P(1)	P(2)	P(3)
K1	-	-	-	3	3	3	2	2	2
K2	-	-	-	3	2	3	1	1	1
K3	-	-	-	2	3	3	1	1	1
K4	-	-	-	2	3	3	1	2	1
K5	-	-	-	3	3	2	2	1	3
K6	-	-	-	3	3	3	2	2	2
K7	2	2	2	1	1	3	3	3	3
K8	2	2	2	2	2	3	3	3	2
K9	2	2	2	3	3	3	3	3	3
K10	1	2	3	2	3	3	3	3	2

Table 8. Experimental Group Flavors

Sampel	Good/Typical			Bitter			Acid		
	P(1)	P(2)	P(3)	P(1)	P(2)	P(3)	P(1)	P(2)	P(3)
E1	-	-	-	-	-	3	3	3	-
E2	-	-	-	2	3	2	3	2	2
E3	-	-	-	1	1	2	3	3	3
E4	-	-	-	3	3	1	3	2	3
E5	-	-	-	2	1	3	3	3	2
E6	-	-	-	2	1	1	2	3	3
E7	-	-	-	2	1	2	3	2	3
E8	-	-	-	-	-	2	3	3	2
E9	-	-	-	-	1	1	3	2	3
E10	-	-	-	-	2	1	3	3	3

Electromagnetic fields are a combination of magnetic and electric fields. The electric and magnetic fields in electromagnetic waves are interrelated and move parallel to each other. Wave radiation is radiation in the form of electromagnetic waves, which are waves that do not require a medium to propagate. Wave radiation has various types depending on the wavelength and frequency it has. Wave radiation has many benefits, but it can also cause harm if overexposed. Electromagnetic wave radiation can carry energy from one place to another without the need for a propagation medium. Electromagnetic radiation is the emission of electromagnetic waves that have an effect on the material they affect. Electromagnetic waves have properties such as amplitude, frequency, speed, and a variety of wavelengths, ranging from radio waves with long wavelengths to gamma rays with very short wavelengths. The electromagnetic wave spectrum consists of nine kinds of waves, namely radio waves, microwaves, infrared rays, visible light, ultraviolet light, X-rays, gamma rays, LF or Low Frequency waves, and ELF or Extremely Low Frequency waves.

Analysis of pH Value of Cassava Tape

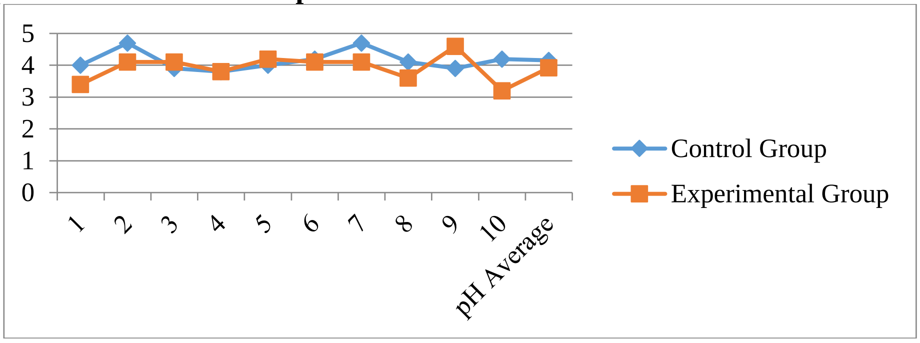

Figure 1. pH value of cassava tape

Exposure to Extremely Low Frequency (ELF) magnetic field of 1000 µT intensity for 45 minutes in this study caused differences in the pH value of cassava tape that received ELF magnetic field exposure and cassava tape that did not receive ELF magnetic field exposure. The control group has a pH range of 3.8-4.7 with an average pH of 4.15 and it is known that the group that received exposure to the magnetic field experienced a slight decrease in pH, but the pH was still controlled in the range of 3.2-4.6 with an average pH of 3.92 so that the experimental group cassava tape exposed to the ELF magnetic field has a taste that tends to be more acidic than the control group. The pH condition <4.3 in cassava tape is not the optimal condition for mold microbes to produce glucose, so the sweet taste is not so strong and a fairly strong sour taste appears, because the pH is the optimal condition for Acetobacter sp. bacteria to produce lactic acid.

Analysis of Density Value of Cassava Tape

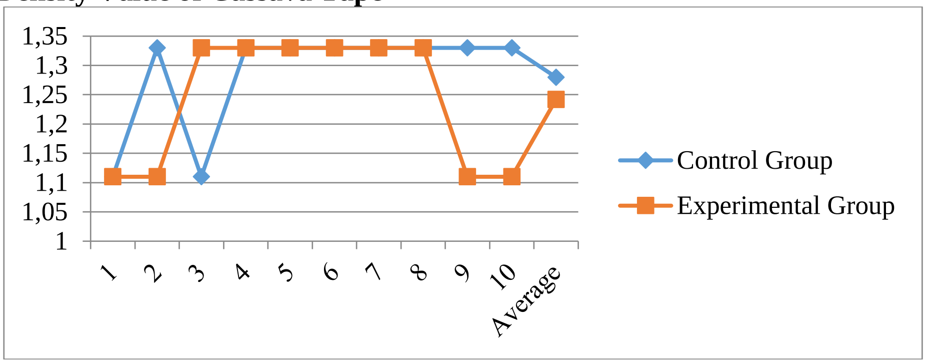

Figure 2. Density Value of Cassava Tape

There is a slight difference in the calculated volume in both the control and experimental groups. In samples K1 and K3 as well as E1, E2, E9, and E10 the measured cassava tape has a mass of 100 grams with a volume of 90 ml so that the density is 1.11 grams/ml. Whereas in the others, namely K2, K4, K5, K6, K7, K8, K9, and K10 as well as E3, E4, E5, E6, E7, and E8 the measured cassava tape has a mass of 100 grams with a volume of 75 ml so that it has a density of 1.33 grams/ml. The difference in volume can be caused by the lack of accuracy of the observer when measuring the volume of the cassava tape, resulting in measurement results that are less precise.

Analysis of Physical Condition of Cassava Tape

Aroma Analysis of Cassava Tape

In the study of the aroma, texture and taste of cassava tape, there were several differences seen in the cassava tape of the control group and the experimental group. All three observers thought that the cassava tape of the control group had a normal or distinctive aroma and was not rotten. Whereas in the experimental group cassava tape, all observers thought that most of the experimental group samples had a distinctive aroma but some others had a foul aroma. The three observers were of the opinion that the experimental group cassava tape samples E1, E3, E6, E7, and E8 had a normal or typical aroma and in samples E4 and E10 had a rotten aroma. Whereas in samples E2, E5, and E9 some observers thought that the cassava tape samples had a distinctive aroma, and others thought that the cassava tape samples had a rotten aroma. This shows that the quality of cassava tape aroma in the control group is better than the experimental group.

Texture Analysis of Cassava Tape

The texture of cassava tape in the control group and experimental group has little similarity but in different amounts. A small portion of the control group cassava tape had a mushy texture and a large portion had a watery texture. In the cassava tape control group, the three observers thought that cassava tape samples K1, K6, K8, and K10 had a mushy texture, while samples K2, K3, K4, K5, K7, and K9 had a watery texture. Almost all cassava tapes in the experimental group had a moist texture except for sample E7 where the third observer thought that the sample had a mushy texture and the first observer and second observer thought that the cassava tape sample had a watery texture. Therefore, it can be said that the experimental group on cassava tape has better quality than the control group because only one sample has a watery texture.

Flavor Analysis of Cassava Tape

The taste of cassava tape in the control group and experimental group all have a sour taste, but some are also mixed with bitterness. All samples in the control group have a bitter and sour taste, but in samples K7, K8, K9, and K10 there is still a little taste that is typical of cassava tape. In the experimental group, all samples had a taste that was a combination of bitter and sour without the distinctive taste of cassava tape. The dominant sour taste in cassava tape can be caused by the fairly low pH of cassava tape, which is <5. The experimental group cassava tape has a lower pH than the control group cassava tape so that the strong sour taste in cassava tape is more dominant in the experimental group. Based on research conducted by (Sari et al., 2019) that exposure to Extremely Low Frequency (ELF) magnetic fields with an intensity of 300 µT and a duration of exposure of 30 minutes has an effect on the pH value of cassava tape, where cassava tape exposed to ELF magnetic fields experiences a pH decrease that is not so significant so that it is not easily stale and more durable, the pH value of the exposure results affects the quality of the taste, texture, and aroma of cassava tape, because the more stable the pH value of the tape, the dominant type of microbes is from the mold group as a producer of glucose which causes a sweet taste, whereas if the pH decreases significantly, the dominant microbes are the mold group.

CONCLUSION

Based on the results of the research and discussion above, it can be concluded that extremely low frequency electromagnetic waves or ELF have a role in the process of food security in cassava tape. Exposure to extremely low frequency magnetic fields affects the pH value of cassava tape where cassava tape exposed to ELF magnetic fields experiences a decrease in pH that is not so significant so that it is not easily stale and durable. There is a difference between the control group that is not exposed to the ELF magnetic field and the experimental group exposed to the ELF magnetic field. ELF magnetic field exposure affects the pH value of physical quality which includes aroma, texture, and taste of cassava tape. According to the results of the study, exposure to the ELF magnetic field given has an effect in accelerating the decline in the quality of aroma, texture, and taste of cassava tape.

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