Jurnal Pembelajaran Fisika
FKIP Universitas Jember
p-ISSN : 2301-9794
e-ISSN : 2721-1959
Available at: https://jurnal.unej.ac.id/index.php/jpf

Utilization of Tempeh as a Basic Material in the Study of ELF (Extremely Low Frequency) Electromagnetic Wave Properties

Arinda Pravitasari, Adelia agustin, Muhammad Habibi, Adelia Andini Puji Lestari, Via Amanda, Eka Rinda Wati, Saidah Intan Kurnia, Sudarti

Universitas Jember, Jl. Kalimantan Tegalboto No. 37, Krajan Timur, Subersari, Jember
e-mail: arindapravitasari1404@gmail.com, adel.agustin18@gmail.com, ahmadharis120807@gmail.com, adelialestari2305@gmail.com, via93912@gmail.com, ekarindaa2@gmail.com, saidahintan90940@gmail.com, sudarti.fkip@unej.ac.id
* Corresponding Author.

Received: 3 Desember 2024; Revised:7 Desember 2024; Accepted:13 Desember 2024

Abstract: Electromagnetic waves are transverse waves consisting of electric and magnetic fields that are perpendicular to each other and can propagate without a medium. The sub-spectrum of electromagnetic waves with a frequency range between 0 and 300 Hz is characterized by non-ionizing and non-thermal properties. This study investigates the effect of ELF magnetic field exposure on the fermentation process of food products, particularly tempe. The experiment involved two groups: a control group and an experimental group, each containing 10 samples of tempe weighing 100 grams. The experimental group was exposed to an ELF magnetic field of 700 μT for one hour during fermentation, while the control group underwent natural fermentation. The results showed significant differences in physical properties such as pH, density, texture, aroma, and color between the two groups. ELF exposure accelerated fermentation, resulting in a denser and more uniform texture, a lower pH, and increased microbial metabolic activity. This study demonstrates the potential application of ELF magnetic fields in optimizing the fermentation process.

Keywords: ELF magnetic field; fermentation; physical conditions

How to Cite: Pravitasari, A., Adelia, A., Muhammad, H., Adelia, A, P, L., Via A., Eka, R, W., Saidah, I,K., Sudarti (2024). Utilization of Tempeh as a Basic Material in the Study of ELF (Extremely Low Frequency) Electromagnetic Wave Properties. *JURNAL PEMBELAJARAN FISIKA*, *13* (4), 168-179. doi:10.19184/jpf.v13i3.48554

Introduction

doi:10.19184/jpf.v13i3.48554

Electromagnetic waves are a physical phenomenon consisting of interactions between electric and magnetic fields that are perpendicular to each other and can propagate without requiring a medium. This ability distinguishes electromagnetic waves from mechanical waves. Examples of electromagnetic waves, such as radio waves, X-rays, and gamma rays, are widely used in communication technology, medicine, and industry (Jumingin et al., 2022). Electromagnetic radiation is also produced by everyday devices such as mobile phones, computers, and televisions, contributing to radiation exposure in human life. One type of electromagnetic radiation is the Extremely Low Frequency (ELF) magnetic field, which has a frequency of less than 300 Hz and is non-ionizing (Qumairoh et al., 2021). In food science, ELF magnetic fields have been used to extend the shelf life of products by destroying microorganisms in food. For example, ELF radiation at certain intensities can improve the quality and safety of food without affecting the taste or color of the product (Uswatun & Sudarti, 2022). However, the effects of ELF magnetic fields on the fermentation process, particularly in traditional products like tempeh, still require further investigation.

Tempe is a fermented food product made primarily from soybeans. It is a fermented product produced from soybeans with the help of the fungus *Rhizopus oligosporus*. This fermentation process enhances the nutritional value of soybeans through enzymatic activity, such as phytase, which reduces antinutritional compounds and increases mineral bioavailability (Moehady & Hidayatulloh, 2020). This food is known for being nutrient-rich and easily digestible. Tempeh is a traditional Indonesian food made by fermenting soybeans using *Rhizopus oligosporus* fungus.

Fermentation is a complex biochemical process that involves the interaction between specific microorganisms and their substrate. The fermentation activity is influenced by environmental factors such as pH and temperature, which determine the growth rate of microorganisms (Cahyaningtiyas & Sindhuwati, 2023). A decrease in pH during fermentation, for example, can inhibit fungal growth when it reaches a certain threshold (Fadlilah et al., 2024). This study aims to investigate how exposure to an ELF magnetic field at an intensity of 700 µT for 60 minutes affects the tempeh fermentation process, particularly in terms of changes in pH and enzyme activity. This study seeks to place the use of ELF magnetic fields within the context of food science, while also contributing to the literature on the application of electromagnetic technology in biological systems.

ELF magnetic fields have attracted attention due to their non-thermal effects, meaning they do not cause a temperature rise. These fields often occur around electrical devices and can have biological effects depending on the intensity and duration of exposure (Rahman & Sudarti, 2021). Several studies have shown that ELF magnetic fields can be used in various applications, including enhancing food quality by modifying microorganism activity (Uswatun & Sudarti, 2022). However, despite the benefits, exposure to high doses of these magnetic fields can have negative effects on the human body, such as sleep disturbances or an increased risk of certain diseases (Utoyo et al., 2023).

Previous research by Azizah et al. (2022) showed that Extremely Low Frequency (ELF) magnetic fields have an effect on pH during the tempeh fermentation process. However, this result was limited to observing pH changes as a single indicator. As explained in the introduction, ELF magnetic fields have a broader potential, especially in influencing biological systems such as enzyme activity and microorganisms, which play an essential role in fermentation. Further research is needed to explore the effects of ELF magnetic fields in more depth, not only on pH but also on other parameters such as enzyme activity produced by *Rhizopus oligosporus*, the nutritional quality of tempeh, and other biological mechanisms that support fermentation. This is important, as the introduction has outlined how ELF magnetic fields can influence ion movement, such as calcium, which may accelerate biological processes.

This study aims to investigate how exposure to an ELF magnetic field at an intensity of 700 μT for 60 minutes affects the tempeh fermentation process, particularly in terms of changes in pH and enzyme activity. This article is written to complement and improve existing articles by providing a broader and deeper context regarding the effects of Extremely Low Frequency (ELF) magnetic fields on biological systems, particularly in the fermentation process. This article not only discusses the basic properties of ELF magnetic fields but also highlights potential mechanisms that can affect microorganisms like *Rhizopus oligosporus* in producing enzymes and optimizing fermentation. Additionally, this article places the research within a more relevant framework based on recent literature, including the benefits and challenges of using ELF magnetic fields in food technology.

Method

This study uses an experimental approach to evaluate the impact of Extremely Low Frequency (ELF) magnetic field exposure on the tempeh fermentation process, conducted in a laboratory with a controlled environment to ensure the validity of the results. An ELF magnetic field intensity of 700 μT was chosen based on previous literature studies (Agustina et al., 2023; Azizah et al., 2022), which showed that this intensity effectively enhances microbial metabolic activity without causing adverse side effects, and is within safe limits for application in fermented foods. No preliminary experiments were conducted separately, as the intensity parameter had already been validated in related studies. The sample size used in this study was 10 for each group, i.e., the control and experimental groups. This sample size was chosen based on sample uniformity, ease of management, and available resources. Although formal statistical power analysis was not conducted, this sample size was deemed adequate to detect significant differences based on similar studies (Qumairoh et al., 2021; Utoyo et al., 2023).

The tempeh samples were divided into two groups: the control group, which underwent natural fermentation without ELF magnetic field exposure, and the experimental group, which was exposed to the ELF magnetic field at 700 μT intensity for one hour. Each group consisted of 10 samples weighing 100 grams each, with fermentation occurring over a period of 24 to 48 hours in a uniform environmental condition, including temperature and humidity. A calibrated ELF magnetic field generator was used to ensure consistent exposure for the experimental group. Parameters observed in the sensory evaluation included texture, aroma, and color of the tempeh, which were assessed using a standard scale based on food evaluation protocols. Texture was evaluated based on density (dense, soft, watery), aroma was categorized as normal, odorless, or foul, and color was divided into normal (bright white), brownish, and blackish. Evaluations were performed by a trained panel of five individuals, with each parameter scored based on standard guidelines to ensure consistency in assessment.

pH measurements were taken using a calibrated pH meter, while density was measured with a density meter. The growth of *Rhizopus oligosporus* was observed using a microscope to evaluate the extent and thickness of the growth. Statistical analysis was performed to compare the control and experimental groups using an independent t-test, with SPSS version 26 software used to process the data and evaluate the significance of results at a 95% confidence level ($p < 0.05$). The data results were visualized in tables and graphs for easier interpretation.

Results and Discussion

This study discusses the effects of ELF (Extremely Low Frequency) radiation exposure on tempe and compares it with tempe that was not irradiated. ELF radiation is electromagnetic radiation with low frequency, typically below 300 Hz. In this experiment, 10 experimental groups and 10 control groups were used. The aspects evaluated in this experiment include differences in pH, density, texture, aroma, color, and rhizopus presence in the tempe of the control and experimental groups. The degree of acidity (pH) is an important indicator in assessing the physical properties of tempe, particularly related to its acidity and alkalinity. *Rhizopus oligosporus*, the fungus used in tempe fermentation, produces lactic acid that causes a decrease in pH during the fermentation process. Below is the table of pH measurement results for the tempe of the control and experimental groups.

Tabel 1. Pengukuran pH tempe menggunakan pH meter

Kelompok kontrol		Kelompok eksperimen	
K-1	7,6	E-1	7,6
K-2	7,5	E-2	7,3
K-3	7,7	E-3	7,6
K-4	7,4	E-4	7,5
K-5	7,5	E-5	7,2
K-6	7,8	E-6	7,5
K-7	7,7	E-7	7,7
K-8	7,8	E-8	7,3
K-9	7,6	E-9	7,5
K-10	7,6	E-10	7,6
Rata-rata pH	76,2	Rata-rata pH	74,8

Based on the pH data obtained, it is observed that there is a small difference between the control group and the experimental group. In general, the pH of the control group is slightly higher than that of the experimental group, with the average pH of the control group being 7.62, while the experimental group is 7.48. These findings are consistent with the study by Qumairoh et al. (2021), which showed that the pH of tempe exposed to ELF radiation is lower compared to that which is not exposed. ELF radiation exposure can stimulate the growth of microorganisms such as bacteria and the fungus *Rhizopus oligosporus*, which accelerates the fermentation process of tempe. The increased metabolic activity of these microorganisms produces more organic acids, which lowers the pH and improves the quality of tempe, including reducing the growth of pathogenic microorganisms and enhancing the texture of the tempe. This decrease in pH not only indicates an increase in fermentation but may also influence the improvement of tempe quality, as lower acidic conditions help control the growth of pathogenic microorganisms.

Tabel 2. Pengukuran massa jenis tempe sudah matang

Kontrol Group				Experimental Group			
Sample Name	massa m	volume Δv	Density p	Sample Name	M	Δv	p
K-1	50	50	1	E-1	50	75	0,6
K-2	50	50	1	E-2	50	75	0,6
K-3	50	50	1	E-3	50	75	0,6
K-4	50	50	1	E-4	50	50	1
K-5	50	50	1	E-5	50	50	1
K-6	50	50	1	E-6	50	50	1
K-7	50	50	1	E-7	50	50	1
K-8	50	50	1	E-8	50	50	1
K-9	50	50	1	E-9	50	50	1

K-10	50	50	1	E-10	50	50	1
Rata-rata massa jenis			1	Rata-rata massa jenis			0,88

Based on the table above, it is evident that the average density of the experimental group is smaller compared to the control group. The average density of the control group is 1, while the average density of the experimental group is 0.88. This is because tempe exposed to ELF radiation tends to trap less gas, as the faster fermentation process reduces the time required for gas formation. The quicker fermentation leads to a more efficient breakdown of the substrate, resulting in less gas being produced and trapped within the tempe, which in turn lowers its overall density gas in the tempe structure causes the tempe exposed to ELF radiation to have a lower free water content, as the faster fermentation results in less water being produced from the breakdown of soybean components.

In tempe that is not exposed to ELF radiation, the fermentation process occurs more slowly, allowing more water to be trapped within the tempe. The soybean structure does not undergo significant changes in a short time, leading to more water being retained. This higher water content makes the tempe looser and lighter, thus lowering its density. Additionally, the looser structure of tempe that is not irradiated tends to produce larger pores, which further contributes to the decrease in density. The next table presents the data on the differences in color between tempe exposed to ELF electromagnetic waves and the one that was not exposed.

Tabel 3. Warna tempe kelompok eksperimen untuk tempe yang sudah matang

Sampel	Normal			Kecoklatan			Hitam		
	P(1)	P(2)	P(3)	P(1)	P(2)	P(3)	P(1)	P(2)	P(3)
E-1	1	1	1	2	2	2	1	1	1
E-2	1	1	1	2	2	2	1	1	1
E-3	2	2	2	1	1	1	1	1	1
E-4	1	1	1	2	2	2	1	1	1
E-5	2	2	2	1	1	1	1	1	1
E-6	2	2	2	1	1	1	1	1	1
E-7	2	2	2	1	1	1	1	1	1
E-8	2	2	2	1	1	1	1	1	1
E-9	2	2	2	1	1	1	1	1	1
E-10	2	2	2	1	1	1	1	1	1

Tabel 4. Warna tempe kelompok kontrol untuk tempe yang sudah matang

Sampel	Normal			Kecoklatan			Hitam		
	P(1)	P(2)	P(3)	P(1)	P(2)	P(3)	P(1)	P(2)	P(3)
K-1	2	2	2	1	1	1	1	1	1
K-2	2	2	2	1	1	1	1	1	1
K-3	2	2	2	1	1	1	1	1	1
K-4	1	2	2	2	1	1	1	1	1
K-5	2	2	2	1	1	1	1	1	1

K-6	2	2	2	1	1	1	1	1	1
K-7	1	1	1	2	2	2	1	1	1
K-8	2	2	2	1	1	1	1	1	1
K-9	1	1	1	2	2	2	1	1	1
K-10	1	1	1	2	2	2	1	1	1

Based on the data, it is known that ELF exposure can alter the color of tempe. ELF waves can stimulate or inhibit enzymatic activity, which affects the production of certain pigments, such as melanin or other related compounds. These changes in enzymatic activity can influence the color development of tempe during fermentation. The exposure may accelerate or slow down the formation of these pigments, leading to variations in the final color of the tempe Other secondary metabolites. This can cause the color of the tempe to become darker, brighter, or uneven depending on the duration and intensity of exposure. Meanwhile, tempe that is not exposed to ELF waves has the typical off-white or cream color. This color is produced by the optimal growth of the mold (*Rhizopus oligosporus*) and the even distribution of spores. The exposure to ELF waves may alter the growth patterns and pigmentation of the mold, leading to variations in color compared to tempe that undergoes regular fermentation without such exposure.

ELF radiation exposure, which accelerates fermentation, can make the color of tempe lighter or whiter at the early stages of fermentation. ELF radiation increases the metabolic rate of microorganisms such as *Rhizopus oligosporus*, which converts soybean components like carbohydrates and proteins into fatty acids, amino acids, and other compounds more quickly. This breakdown of components reduces the formation of dark-colored compounds that typically appear in tempe fermented for longer periods. As a result, tempe exposed to ELF radiation tends to appear brighter and does not develop the deep brown color typical of tempe fermented more slowly.

The accelerated microbial activity due to ELF radiation also reduces the likelihood of the Maillard reaction. The Maillard reaction is a reaction between amino acids and sugars that results in the browning of the tempe surface. This reaction requires more time to develop, so in tempe exposed to ELF radiation, the process is shorter, resulting in a lighter color. The increased metabolism of microorganisms also reduces the formation of other dark compounds, such as melanoidins, which are commonly formed during tempe fermentation at higher temperatures or with longer fermentation times. The following section of the study focuses on the aroma of tempe. Below is the data on the differences in aroma between tempe exposed to ELF radiation and those that were not.

Tabel 5. Aroma tempe kelompok eksperimen untuk tempe yang sudah matang

Sampel	Normal/khas	Tidak ada aroma	Busuk

	P(1)	P(2)	P(3)	P(1)	P(2)	P(3)	P(1)	P(2)	P(3)
E-1	2	2	2	1	1	1	1	1	1
E-2	2	2	2	1	1	1	1	1	1
E-3	2	2	2	1	1	1	1	1	1
E-4	3	2	2	1	1	1	1	1	1
E-5	1	2	1	1	1	1	2	1	2
E-6	1	2	1	1	1	1	2	1	2
E-7	3	3	2	1	1	1	2	2	2
E-8	1	3	1	1	1	1	1	2	1
E-9	1	3	1	1	1	1	1	2	1

Tabel 6. Aroma tempe kelompok kontrol untuk tempe yang sudah matang

Sampel	Normal/khas			Tidak ada aroma			Busuk		
	P(1)	P(2)	P(3)	P(1)	P(2)	P(3)	P(1)	P(2)	P(3)
K-1	1	1	1	1	1	1	2	2	2
K-2	2	1	2	1	1	1	1	2	1
K-3	2	1	1	1	1	1	1	2	1
K-4	1	1	2	1	1	1	1	2	2
K-5	1	1	1	1	1	1	2	2	2
K-6	1	1	2	1	1	1	2	2	1
K-7	2	2	2	1	1	1	1	1	1
K-8	2	2	2	1	1	1	1	1	1
K-9	1	2	1	1	1	1	2	1	2
K-10	2	2	2	1	1	1	1	1	1

Based on the data obtained, ELF exposure can influence enzymatic activity in microorganisms more sharply, leading to changes in the composition of volatile compounds formed during the fermentation process. These changes directly impact the aroma characteristics of the resulting tempe, with the emergence of sharper, milder, or even slightly different aromas than what is typically found. These changes are heavily influenced by the duration and intensity of ELF exposure, which can trigger different chemical reactions in the microbial metabolic process. On the other hand, tempe that is not exposed to ELF radiation will have a stable, characteristic aroma, derived from compounds such as methyl ketones, esters, and small amounts of alcohol. These compounds are normal fermentation by-products produced by the mold *Rhizopus oligosporus*.

Tabel 7. Tekstur tempe kelompok eksperimen untuk tempe yang sudah matang

Sample	Solid			Mushy			Watery		
	P(1)	P(2)	P(3)	P(1)	P(2)	P(3)	P(1)	P(2)	P(3)
E-1	2	1	2	1	2	1	1	1	1
E-2	1	2	1	3	1	3	1	1	1
E-3	2	2	2	1	1	1	1	1	1

E-4	2	2	2	1	1	1	1	1	1
E-5	2	2	2	1	1	1	1	1	1
E-6	2	2	2	1	1	1	1	1	1
E-7	1	1	1	2	2	2	1	1	1
E-8	2	2	2	1	1	1	1	1	1
E-9	2	2	2	1	1	1	1	1	1
E-10	2	2	2	1	1	1	1	1	1

Tabel 8. Tekstur tempe kelompok kontrol untuk tempe yang sudah matang

Sample	Solid			Mushy			Watery		
	P(1)	P(2)	P(3)	P(1)	P(2)	P(3)	P(1)	P(2)	P(3)
K-1	2	2	2	1	1	1	1	1	1
K-2	2	3	2	1	3	1	1	1	1
K-3	2	2	2	1	1	1	1	1	1
K-4	3	3	3	3	3	3	1	1	1
K-5	3	3	3	3	3	3	1	1	1
K-6	2	2	2	1	1	1	1	1	1
K-7	3	2	2	1	1	1	1	1	1
K-8	2	2	2	1	1	1	1	1	1
K-9	2	2	2	1	1	1	1	1	1
K-10	2	2	2	1	1	1	1	1	1

Based on the data obtained regarding the texture assessment of tempe, it was found that tempe exposed to ELF radiation has a smoother and denser texture. The faster fermentation process enhances the conversion of soybean components into amino acids and fatty acids, reducing the amount of trapped gas. The trapped gas typically forms pores, but due to the faster fermentation, the gas is reduced, resulting in a denser and more uniform tempe. The more active microorganisms form a tighter and more organized fungal network, binding the soybeans more effectively, which leads to a firmer and well-structured texture.

Tempe that is not exposed to ELF radiation undergoes slower fermentation, allowing more time for gas to be trapped. As a result, the tempe is looser with larger pores, feeling lighter and more porous. The slower-working microorganisms form a looser fungal network, causing the soybeans to be less tightly bound, which makes the tempe more fragile and coarse. The looser structure of the soybeans results in tempe that is less compact and more prone to breaking or separating.

Tabel 9. Luasan dan ketebalan rhizopus kelompok eksperimen tempe sudah matang

Sample	Area			Thickness
	P (mm)	L (mm)	Luas (mm)	
E-1	20	5	100	1
E-2	10	3	30	0,5

E-3	20	4	80	1
E-4	4	6	24	0,5
E-5	10	3	30	0,5
E-6	20	2	40	0,5
E-7	23	5	115	1
E-8	17	1	17	1
E-9	4	3	12	0,5
E-10	10	6	60	1

Tabel 10. Luasan dan ketebalan rhizopus kelompok kontrol tempe yang sudah matang

Sample	Area			Thickness
	P (mm)	L (mm)	Luas (mm)	
K-1	15	5	75	0,5
K-2	6	3	18	1
K-3	15	5	75	1
K-4	10	3	30	1
K-5	10	5	50	1
K-6	15	3	45	1,5
K-7	16	1	16	1
K-8	3	1	3	1,5
K-9	7	5	35	1,5
K-10	20	10	60	1

The data shows that in tempe exposed to ELF radiation, *Rhizopus oligosporus* grows more evenly compared to the control tempe. The faster fermentation process accelerates the growth of *Rhizopus* in a short period of time. Its growth is more uniform and dense throughout the soybeans. Microorganisms work more efficiently in converting soybean components, such as carbohydrates and proteins, into amino acids and fatty acids. This occurs without causing excessive growth that could reduce the quality of the tempe.

In tempe that is not exposed to ELF radiation, the fermentation process is slower, resulting in the growth of *Rhizopus oligosporus* being slower and its initial quantity being lower. The longer fermentation provides more time for the fungus to develop, but in smaller amounts compared to the irradiated tempe. Its growth is more scattered and less organized. Microorganisms work more slowly, leading to a looser fungal network. This results in less compact *Rhizopus* growth in tempe that is not exposed to ELF radiation.

Conclusion

Based on the results obtained, tempe exposed to ELF radiation has a lower pH compared to tempe that was not exposed to ELF radiation. ELF exposure stimulates the growth of microorganisms involved in the tempe fermentation process, such as bacteria and the fungus *Rhizopus oligosporus*, by increasing their metabolic activity. The density of tempe exposed to ELF radiation is lower compared to that of tempe not exposed to ELF radiation. The color of tempe also changes after being exposed to ELF radiation, resulting in a darker, brighter, or uneven color, depending on the duration and intensity of the exposure. The aroma of the tempe can become sharper, softer, or slightly altered, depending on the duration and intensity of ELF exposure. The texture of tempe exposed to ELF radiation becomes smoother and denser, as ELF radiation accelerates microbial activity and promotes more even growth of *Rhizopus*. These experimental results show that ELF radiation can be applied not only to tempe but also to the tofu industry, kimchi production, fermented beverage industry, or other industries involved in fermentation processes.

Acknowledgments

Many parties have provided invaluable support, making it possible for this study to be successfully conducted. Sincere gratitude is extended to Mrs. Sudarti, Mr. Yushardi, Mrs. Habiba, and Mrs. Arum for their assistance, guidance, and valuable recommendations throughout the research process. Their expertise in environmental physics made a significant contribution to the development of this research. Their support helped complete the study while providing profound insights that enriched the results. The advice and mentorship they provided ensured that this article was well-structured and met expectations. The effort and attention given throughout this process are deeply appreciated by the author.

Bibliography

Agustina, M. A. D., Tias, E. R. W., A.N, N. N., Yushardi, Y., Anggraeni, F. K. A., & Meilina, I. L. (2023). Extremely Low Frequency (Elf) Magnetic Field Radiation Analysis of Tempe Material Maturity. *EduFisika: Jurnal Pendidikan Fisika*, *8*(3), 395–405. https://doi.org/10.59052/edufisika.v8i3.29872

Azizah, M. N., Sudarti, S., & Bektiarso, S. (2022). Pengaruh Paparan Medan Magnet Extremely Low Frequency (Elf) 200 Mt Dan 300 Mt Terhadap Ph Dalam Proses Fermentasi Tempe. *ORBITA: Jurnal Pendidikan Dan Ilmu Fisika*, *8*(1), 28. https://doi.org/10.31764/orbita.v8i1.8182

Beno, J., Silen, A. ., & Yanti, M. (2022). No 主観的健康感を中心とした在宅高齢者における 健康関連指標に関する共分散構造分析Title. *Braz Dent J.*, *33*(1), 1–12.

Cahyaningtiyas, A., & Sindhuwati, C. (2023). Pengaruh Penambahan Konsentrasi Saccharomyces Cerevisiae Pada Pembuatan Etanol Dari Air Tebu Dengan Proses Fermentasi. *DISTILAT: Jurnal Teknologi Separasi*, *7*(2), 89–94. https://doi.org/10.33795/distilat.v7i2.207

Fadlilah, N., Nuraini, D., Ulya, Z., Hikmal Yaman, D., Qurotul, S., Sardlee, A., Lestari, W., Nurhidayah, S., Danurwenda, A., Kimia, P., & Biologi, P. (2024). Identifikasi Kapang Rhizopus Oligosporus pada Tempe Bungkus yang Dijual di Pasar Krempyeng Kota Semarang. *Jurnal Majemuk*, *3*(2), 340–351. http://jurnalilmiah.org/journal/index.php/majemuk

Jumingin, J., Atina, A., Iswan, J., Haziza, N., & Ashari, B. (2022). Radiasi Gelombang Elektromagnetik Yang Ditimbulkan Peralatan Listrik Di Lingkungan Universitas Pgri Palembang. *Journal Online of Physics*, *7*(2), 48–53. https://doi.org/10.22437/jop.v7i2.17267

Moehady, B. I., & Hidayatulloh, I. (2020). Proses Pembuatan Minyak Kelapa Murni dengan Menggunakan Rhizopus Oligosporus. *Metana*, *16*(1), 11–18. https://doi.org/10.14710/metana.v16i1.25948

Qumairoh, U., Sudarti, S., & Prihandono, T. (2021). Pengaruh Paparan Medan Magnet ELF (Extremely Low Frequency) Terhadap Derajat Keasaman (pH) Udang Vaname. Jurnal Fisika Unand.

Uswatun, U., & Sudarti, S. (2022). Potensi Radiasi Gelombang Elektromagnetik Extremely Low Frequency (ELF) Guna Meningkatkan Ketahanan Usia Simpan Buah-Buahan. *Jurnal Teknologi Pertanian Gorontalo (JTPG)*, *7*(2), 70–74. https://doi.org/10.30869/jtpg.v7i2.957

Utoyo, E. B., Syahdilla, M. I., Prihandono, T., Studi, P., Fisika, P., Ikan, P., & Ikan, P. (2023). Potensi Extremely Low Frequency Pada Pengawetan Ikan Dalam Industri Pengolahan Ikan. *Cermin: Jurnal Penelitian*, *7*(1), 96–105.