Volume 8 Number 3, December 2023, pp. 363-368
P-ISSN:2477-7935
E-ISSN:2548-6225
DOI: 10.59052/edufisika.v8i3.30210

EXTREME LOW FREQUENCY MAGNETIC FIELD RADIATION: EFFECT ON THE PHYSICAL CONDITION OF KETAN TAPE INTENSITY 500 µT

Inggrit Aulya Hartono[1,*], Fitroh Aysyatun Hasanah[1], Amalia Azizah Zain[1], Firdha Kusuma Ayu Anggraeni[2], Yushardi[2], Audri Mely Prabandari[2]

[1] Biology Education, Universitas Jember, Jawa Timur, Indonesia
[1] Physics Education, Universitas Jember, Jawa Timur, Indonesia
Corresponding author email: 230210103130@mail.unej.ac.id

Article Info
Received: 015 Nov 2023
Revised: 01 Dec 2023
Accepted: 08 Dec 2023
OnlineVersion: 13 Dec 2023

Abstract :
The electromagnetic wave spectrum includes extremely low frequency (ELF) magnetic fields, which have a frequency below 300 Hz and are considered non-radiation radiation. This research examines the effect of ELF magnetic fields on the physical condition of white sticky rice tape food, a traditional fermented food in Indonesia. The research is an experimental study that evaluates the physical condition of food ingredients. The research divides the materials into two groups: the control group, which is not exposed to magnetic fields, and the experimental group, which is exposed to magnetic fields with an intensity of 500 µT. The research uses 20 packs of each ingredient, with 10 packs in each group and 100 gr in each pack. The research tests four modules: login page, teacher's profile update, image upload, and question creation. The research finds that exposure to an ELF magnetic field affects the aroma and texture of food ingredients. Exposure to ELF magnetic fields can speed up the growth of microorganisms. The research observes that the white sticky rice tape in the experimental group has a softer texture than the control group.

Keywords: Extreme Low Frequency, Ketan Tape, Magnetic Radiation.

INTRODUCTION

Electromagnetic waves are classified as a current that does not require a medium in its propagation process and can only propagate in a vacuum (Hozayn, El-Mahdy & Abdel-Rahman 2015; Soe et al., 2020; Poomanee et al., 2021). Radio waves, X-rays, gamma rays, and television rays are examples of electromagnetic waves. Electromagnetic waves can be formed due to the interference of a magnet with an electric field. When energy is released at different levels, the longer the energy level, the higher the frequency, the lower the energy level, the lower the resulting wave. (Karimi et al., 2019; Lin et al., 2021; Jumingin et al., 2022).

The characteristic of electromagnetic waves is that there is an exchange of electric and magnetic fields simultaneously at the same time. The electric field and magnetic field have mutually vertical directions and are both vertical to the direction of the incoming wave. Electromagnetic waves can

experience reflection, refraction and scattering. The speed of propagation of electromagnetic waves depends on the medium through which they pass (Wang et al., 2019; Alfahrezi et al., 2022). The distribution between magnetic fields and electric fields is vertical. Every electrical device is capable of producing a magnetic field when an electric current flows. This shows that the presence of an electric current results in the formation of a magnetic field. To increase the intensity of the decomposition of the surrounding magnetic and electric fields, electrical equipment needs to be used (Keiji et al., 2016; Teixeira da Silva et al., 2016; Qumairoh et al., 2021).

The decomposition of the magnetic field can take place in current-carrying cables and around devices that are influenced by electric current. When the magnetic field gets further away from the source, the intensity will weaken and decrease. The magnetic field radiation that occurs in some electronic devices is inversely proportional to its position (Lin et al., 2022; Solaesa et al., 2022; Cahyono et al., 2023). The characteristic of a magnetic field is that it can penetrate solid materials, plates, cross-sections, and has a very low frequency. The frequencies produced by electrical devices and power systems are 1Hz to 300 Hz, these frequencies can have a significant impact on the environment and human health. This is different from an electric field which requires a medium to propagate the current. Sometimes ELF-EMF exposure levels around electrical devices such as power grid transformers and household appliances can exceed the limits recommended by many health institutions (Karimi et al., 2020; Kessaratikoon et al., 2021; Ding et al., 2022).

ELF waves are classified as electromagnetic waves which have a frequency value between 0 Hz to 30 Hz. Electromagnetic waves will experience radiation which can result in no changes being found in the object used, which means it does not result in a temperature change when induced (Sulistiyowati et al., 2023). ELF waves include static fields, radio waves, microwaves, infrared radiation and visible light. This electromagnetic field is in the non-radiation part of the electromagnetic spectrum. (Tenforde, 1991; Vijayalaxmi & Prihoda, 2009; Wyszkowska et al., 2018; Prajoko, 2020).

Previous studies on the effects of extremely low frequency (ELF) magnetic fields on food have mainly focused on the chemical and biological aspects, such as nutrient content, antioxidant activity, and microbial growth, but have not explored the physical aspects, such as aroma and texture, which are important for the sensory quality and consumer acceptance of food. Moreover, most of the existing studies have used low-intensity magnetic fields, ranging from 0.1 to 10 μT, which may not reflect the actual exposure levels in some environments.

Indonesia is a country famous for its typical food. One of the typical traditional foods is tape which is made through the fermentation process of carbohydrate foods. Tape has a distinctive taste, namely sweet, slightly sour, this difference in taste arises due to changes in the initial ingredients that make it into tape. Tape has an amylose content in glutinous rice starch of 9 - 33%, and the amylose content in glutinous rice tends to be low, namely 2-9%, while the amylose in pectin tends to be high, ranging from 88.9% to 90% (Ilhami & Kusumasari, 2022). Tape is made from organic substances whose basic ingredients are tape yeast (*Saccharomyces cerevisiae*), tape yeast contains chemicals that can be converted by the human body into nutrients, the organic compound content of this tape yeast is polysaccharides and starch. In general, the body needs carbohydrates, if you overdo it you can harm yourself. Just like sugar, tape also contains alcohol, if there is too much alcohol it will be dangerous for the body. On the other hand, if the tape contains sufficient amounts of alcohol, it can help dissolve fat in the body. Tape is made by a reaction of organic compounds in the basic ingredient, namely tape yeast (Saccharomyces cerevisiae) (Griefahn et al., 2002; Hashish et al., 2008; Wahyuni & Arif, 2021).

RESEARCH METHOD

Research on the influence of Elf magnetic field radiation on the physical condition of white sticky rice tape with an intensity of 500 μt is classified as experimental research by looking at the physical condition of food ingredients. Research can be carried out with the aim of understanding the influence of the ELF magnetic field on the ripening process of food ingredients. This research was carried out at the Basic Physics Laboratory, Jember University on November 7 2023. The data generated from the research was then analyzed using tabulation techniques. The tabulation technique can be said to be a technique for creating tables containing research data. The tools used in this experiment were, ELF magnetic field generator, 1 EMF-meter, thermometer, pH meter, measuring cup, balance/balance,

plastic tray, cup, gloves and ruler. The materials needed in this research are ketan tape fermented 2 days before ripening, 25 plastic ziplocks, and label paper.

This experiment was carried out using several steps, namely; 1) Prepare practical materials, 20 packs of white sticky rice tape (100 grams per pack); 2) Divide the food ingredients into two parts, 10 packs are the Control group (K) and the other 10 packs are the experimental group (E), the Control group is material that is free from exposure to magnetic fields while the experimental group is material that is exposed to an intensity of 500 μT exposure magnetic field with, then mark each package with label paper; 3) Put the control group and experimental group on two different trays; 4) Expose the experimental group to the ELF magnetic field; 5) Store both groups at room temperature; and 6) Observe the material after two days of observations.

RESULTS AND DISCUSSION

In this experiment, the purpose of ELF magnetic field exposure is to determine the texture of glutinous tape exposed to magnetic field exposure. Judging from the experiments carried out, due to exposure to ELF magnetic fields on the texture of fresh glutinous rice tape, the control group and the experimental group are presented in the table below.

Table 1. Glutinous Tape Control Group Texture

Sample	Congested			Mushy			Juicy		
	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	-	-	-	✓	✓	✓	-	-	-

In the table above, it can be seen that glutinous tape that has been observed by observers 1, 2, and 3 tends to have a mushy texture. This is due to the length of the fermentation process on glutinous tape. So, the greater the amount of yeast used on the tape will affect the texture of the glutinous tape.

Table 2. Glutinous Tape Experiment Group Texture

Sample	Congested			Mushy			Juicy		
	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	-	-	-	-	-	-	✓	✓	✓

In the table above, it can be seen that glutinous tape that has been observed by observers 1, 2, and 3 tends to have a watery texture. White sticky rice tape can be watery due to the large number of microorganisms that grow due to exposure to ELF fields. These microorganisms will degrade starch into dextrin and sugar, the more so that the texture of glutinous tape will be watery.

The novelty of this research study investigates the effect of ELF magnetic fields on the physical condition of white sticky rice tape food, a traditional fermented food in Indonesia. The study uses a high-intensity magnetic field of 500 μT, comparable to some industrial and household sources of ELF magnetic fields. The study also compares the physical condition of the food between the control group and the experimental group, which are exposed to different levels of magnetic fields. The study has some limitations that need to be addressed in future research. First, the study only uses one type of food, white sticky rice tape, which may not represent the diversity of food products exposed to ELF magnetic fields. Second, the study only measures the physical condition of the food after one exposure session, which may not capture the cumulative effects of repeated or prolonged exposure to magnetic fields. Third, the study does not consider the possible interactions between the magnetic fields and other environmental factors, such as temperature, humidity, and light, which may also affect the physical condition of the food.

The results of experiments on glutinous rice tape stated that exposure to ELF magnetic fields is short or low which can affect the texture of glutinous tape. Exposure to the ELF magnetic field changes the elasticity of the glutinous tape, which indicates the interaction between the magnetic field and the structure of the material (Repacholi et al., 2019; Sudarti et al 2023). In response to exposure to magnetic fields, the softness of glutinous tape increases, which can be quantitatively measured. The experimental results showed that the cohesion of glutinous tape changed; This indicates the potential influence of the magnetic field on the intramolecular properties of the material. These results provide empirical evidence that ELF magnetic fields can be used as a modifying factor to change the texture of glutinous tape and other traditional food products (Yan et al., 2010; Kasyanov et al., 2013; Sarraf et al., 2020; Suri et al., 2023). These results can be used to develop food technologies that use magnetic fields to change the properties of foodstuffs. However, more research is needed to understand the detailed mechanism behind the changes in glutinous tape texture caused by exposure to ELF magnetic fields. Research is also needed to determine whether this can be used in the food industry more broadly.

CONCLUSION

Based on the results of the ELF magnetic field research, it can be concluded that the white sticky rice tape in the experimental group tends to have a watery texture. White sticky rice tape can become watery due to the large number of microorganisms that grow due to exposure to the ELF field. These microorganisms will degrade starch into more dextrin and sugar so that the texture of the white sticky rice tape will be watery. Meanwhile, the control group tended to have a soft texture. This is caused by the long fermentation process in white sticky rice tape. So, the more yeast used in the tape will affect the texture of the white sticky rice tape.

ACKNOWLEDGMENTS

The researcher would like to thank the physics laboratory of the University of Jember for providing adequate facilities to support the smooth running of the research.

REFERENCES

Alfahrezi, M. F., N. A., Nabila, A. D., Andhini, V. A. P., Aritonang, & Arjuna, M. (2022). *Physics*. Nasmedia.

Cahyono, A. D., Sudarti, S., & Pribandono, T. (2023). Analisis radiasi medan magnet peralatan elektronik rumah tangga terhadap kesehatan. *Jurnal Hasil Kajian, Inovasi, dan Aplikasi Pendidikan Fisika, 9*(1), 73-78. https://doi.org/10.31764/orbita.v9i1.14654

Ding, C., Zhang, H., Zhao, S., Luo, Y., Hu, Q., Liu, Q., ... & Xue, X. (2022). Efficiency, functionality, and multi-scale structure of citric acid esterified glutinous rice starch synthesized via infrared radiation. *Food Hydrocolloids*, *125*, 107377. https://doi.org/10.1016/j.foodhyd.2021.107377

Griefahn, B., Künemund, C., Blaszkewicz, M., Lerchl, A., & Degen, G. H. (2002). Effects of electromagnetic radiation (bright light, extremely low-frequency magnetic fields, infrared radiation) on the circadian rhythm of melatonin synthesis, rectal temperature, and heart rate. *Industrial health*, *40*(4), 320-327. https://doi.org/10.2486/indhealth.40.320

Hashish, A. H., El-Missiry, M. A., Abdelkader, H. I., & Abou-Saleh, R. H. (2008). Assessment of biological changes of continuous whole body exposure to static magnetic field and extremely

low frequency electromagnetic fields in mice. *Ecotoxicology and environmental safety*, *71*(3), 895-902. https://doi.org/10.1016/j.ecoenv.2007.10.002

Hozayn, M., EL-Mahdy, A. A., & Abdel-Rahman, H. M. H. (2015). Effect of magnetic field on germination, seedling growth and cytogenetic of onion (Allium cepa L.). *African Journal of Agricultural Research*, *10*(8), 849-857. https://doi.org/10.5897/AJAR2014.9383

Ilhami, S. D., & Kusumasari, F. C. (2022). Pemberdayaan wanita tani melalui produksi tape ketan putih. *Jurnal Pengabdian kepada Masyarakat Nusantara*, *3*(2), 1026-1033.

Jumingin, Atina, J. Iswan, N. Haziza, dan B. Azhari. (2022). Radiasi gelombang elektromagnetik yang ditimbulkan peralatan listrik di lingkungan universitas PGRI di Palembang. *Jurnal Pendidikan Fisika*, *7*(2), 48-53. https://doi.org/10.22437/jop.v7i2.17267

Karimi, A., Ghadiri Moghaddam, F., & Valipour, M. (2020). Insights in the biology of extremely low-frequency magnetic fields exposure on human health. *Molecular Biology Reports*, *47*, 5621-5633. https://doi.org/10.1007/s11033-020-05563-8

Karimi, S. A., Salehi, I., Shykhi, T., Zare, S., & Komaki, A. (2019). Effects of exposure to extremely low-frequency electromagnetic fields on spatial and passive avoidance learning and memory, anxiety-like behavior and oxidative stress in male rats. *Behavioural brain research*, *359*, 630-638.

Kasyanov, G. I., Syazin, I. E., Grachev, A. V., & Davidenko, T. N. (2013). Features of usage of electromagnetic field of extremely low frequency for the storage of agricultural products. *Харчова наука і технологія*, (3), 88-93.

Keiji, T., Yasuaki, M., Yuta, N., Ryota, I., Kayo, F., Kenji, S., & Toshihiko, K. (2016). Magnetic method for measuring moisture content using diamagnetic characteristics of water. *Measurement Science and Technology*, *28*(1), https://doi.org/014010.10.1088/1361-6501/28/1/014010

Kessaratikoon, P., Boonkong, N., Boonkrongcheep, R., & Changkit, N. (2021). Assessment of Background Radioactivity and Related Radioactive Hazard Indices in Glutinous Rice (Oryza sativa var. glu-tinosa). *ASEAN Journal of Scientific and Technological Reports*, *24*(3), 36-46. https://doi.org/10.55164/ajstr.v24i3.243602

Lin, Z., Geng, D. H., Qin, W., Huang, J., Wang, L., Liu, L., & Tong, L. T. (2021). Effects of damaged starch on glutinous rice flour properties and sweet dumpling qualities. *International Journal of Biological Macromolecules*, *181*, 390-397. https://doi.org/10.1016/j.ijbiomac.2021.03.160

Lin, Z., Huang, J., Kawakami, K., Liu, H., Fujishima, T., Qin, W., ... & Tong, L. T. (2022). Effects of particle size of glutinous rice flour on the quality attributes of sweet dumplings. *Journal of Food Processing and Preservation*, *46*(3), e16388. https://doi.org/10.1111/jfpp.16388

Poomanee, W., Wattananapakasem, I., Panjan, W., & Kiattisin, K. (2021). Optimizing anthocyanins extraction and the effect of cold plasma treatment on the anti-aging potential of purple glutinous rice (Oryza sativa L.) extract. *Cereal Chemistry*, *98*(3), 571-582. https://doi.org/10.1002/cche.10399

Prajoko, Y. W. (2022). *Dasar Dasar Imunologi Tumor*. Airlangga University Press.

Qumairoh, U., Sudarti, T., & Pribandono, T. (2021). Pengaruh paparan medan magnet ELF (Extremely Low Frequency) terhadap derajat keasaman (pH) udang vaname. *Jurnal Fisika Unand (JFU)*, *10*(1), 55-61. https://doi.org/10.25077/jfu.10.1.55-61.2021

Repacholi, M. H., & Greenebaum, B. (1999). Interaction of static and extremely low frequency electric and magnetic fields with living systems: health effects and research needs. *Bioelectromagnetics: Journal of the Bioelectromagnetics Society, The Society for Physical Regulation in Biology and Medicine, The European Bioelectromagnetics Association*, *20*(3), 133-160. https://doi.org/10.1002/(SICI)1521-186X(1999)20:3%3C133::AID-BEM1%3E3.0.CO;2-O

Sarraf, M., Kataria, S., Taimourya, H., Santos, L. O., Menegatti, R. D., Jain, M., ... & Liu, S. (2020). Magnetic field (MF) applications in plants: An overview. *Plants*, *9*(9), 1139. https://doi.org/10.3390/plants9091139

Soe, M. T., Chitropas, P., Pongjanyakul, T., Limpongsa, E., & Jaipakdee, N. (2020). Thai glutinous rice starch modified by ball milling and its application as a mucoadhesive polymer. *Carbohydrate polymers*, *232*, 115812. https://doi.org/10.1016/j.carbpol.2019.115812

Solaesa, Á. G., Villanueva, M., Vela, A. J., & Ronda, F. (2022). Impact of microwave radiation on in vitro starch digestibility, structural and thermal properties of rice flour. From dry to wet

treatments. *International Journal of Biological Macromolecules*, *222*, 1768-1777. https://doi.org/10.1016/j.ijbiomac.2022.09.262

Sudarti, S., Permatasari, E., Sumardi, S., Muldayani, W., Utoyo, E. B., & Prihatin, W. N. (2023). Extremely Low Frequency Electromagnetic Field Radiation (50 Hz, 200 µT & 300 µT) to Increase Edamame Productivity and Safety Risks to Health. *Jurnal Penelitian Pendidikan IPA*, *9*(8), 5979-5986. https://doi.org/10.29303/jppipa.v9i8.2494

Sulistiyowati, A., Zuyyina, A., & Sudarti, S. (2023). Potensi radiasi medan magnet extremely low frequency terhadap penyakit leukimia. *Jurnal Ilmiah Wahana Pendidikan*, *9*(13), 125-133.

Suri, S., Dehghan, S. F., Sahlabadi, A. S., Ardakani, S. K., Moradi, N., Rahmati, M., & Tehrani, F. R. (2020). Relationship between exposure to Extremely Low-Frequency (ELF) magnetic field and the level of some reproductive hormones among power plant workers. *journal of Occupational Health*, *62*(1), e12173. https://doi.org/10.1002/1348-9585.12173

Tenforde, T. S. (1991). Biological interactions of extremely-low-frequency electric and magnetic fields. *Journal of Electroanalytical Chemistry and Interfacial Electrochemistry*, *320*(1), 1-17. https://doi.org/10.1016/0022-0728(91)85576-B

Teixeira da Silva, J. A., & Dobránszki, J. (2016). Magnetic fields: how is plant growth and development impacted?. *Protoplasma*, *253*(2), 231-248. https://doi.org/10.1007/s00709-015-0820-7

Vijayalaxmi, & Prihoda, T. J. (2009). Genetic damage in mammalian somatic cells exposed to extremely low frequency electro-magnetic fields: a meta-analysis of data from 87 publications (1990–2007). *International Journal of Radiation Biology*, *85*(3), 196-213. https://doi.org/10.1016/0022-0728(91)85576-B

Yan, J., Dong, L., Zhang, B., & Qi, N. (2010). Effects of extremely low-frequency magnetic field on growth and differentiation of human mesenchymal stem cells. *Electromagnetic biology and medicine*, *29*(4), 165-176. https://doi.org/10.3109/01676830.2010.505490

Wahyuni, N., & Arif, A. (2021). Efektivitas pemberian konsentrasi ragi yang berbeda terhadap hasil tape beras ketan hitam (*Oryza sativa Linn var glutinosa*). *CELEBES BIODIVERSITAS: Jurnal Sains dan Pendidikan Biologi*, *4*(2), 10-18. https://doi.org/10.51336/cb.v4i2.267

Wang, H., Xiao, N., Wang, X., Zhao, X., & Zhang, H. (2019). Effect of pregelatinized starch on the characteristics, microstructures, and quality attributes of glutinous rice flour and dumplings. *Food Chemistry*, *283*, 248-256. https://doi.org/10.1016/j.foodchem.2019.01.047

Wyszkowska, J., Jędrzejewski, T., Piotrowski, J., Wojciechowska, A., Stankiewicz, M., & Kozak, W. (2018). Evaluation of the influence of in vivo exposure to extremely low-frequency magnetic fields on the plasma levels of pro-inflammatory cytokines in rats. *International journal of radiation biology*, *94*(10), 909-917. https://doi.org/10.1080/09553002.2018.1503428