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# Analysis of Physical Resistance of Apple Tomatoes After Exposed to A Magnetic Field Extremely Low Frequency (ELF) Intensity 600 µT and 1000 µT

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**Abstract:** Apple tomatoes with the scientific name Lycopersicum Pyriporme can last 7 days at room temperature and 14 days if stored in the refrigerator. The purpose of this study was to examine the effect of the ELF magnetic field intensity 600 uT and 1000 uT for 30, 60 and 90 minutes on the degree of acidity (pH), density (ρ) and physical quality of apple tomatoes. The research design used was RAL (completely randomized design). Data collection on the pH variable begins with crushing the tomatoes and then measuring the pH value of each fruit using a digital pH meter. The density variable was obtained by weighing the mass of each fruit and dipping the fruit in 150 ml of distilled water as the initial volume, then the difference between the final volume and the initial volume was obtained to obtain the final density of each fruit using the density equation. Physical condition variables can be obtained by counting the number of good fruits and recording each measurement. Observations were made for 20 days with data collection on the 0, 4th, 8th, 16th, and 20th days. The results showed that there were differences in the value of pH, density and physical quality of tomatoes between the control group and the experimental group. Exposure to the ELF magnetic field can affect the activity and reproduction of pathogenic microorganisms in apple tomatoes so as to maintain the pH value, density and physical quality of apple tomatoes.

**Keywords:** ELF Magnetic Field; Apple Tomato; Physical Resistance

## Introduction

Research on the benefits of the ELF magnetic field in the food sector continues to grow, this is due to the characteristics of the ELF electromagnetic magnetic field which is able to penetrate almost all materials, including biological materials without breaking up the ions in it (Sudarti et al., 2017). Some of these studies include the results of exposure to an ELF magnetic field with an intensity of 500µT for 60 minutes can increase production, wet mass and dry mass of tobacco leaves (Sudarti et al., 2018). The results of this study can be used as a reference in further research using a different object, namely using tomatoes as a sample of this study. Apple tomato which has the Latin name Lycopersicum Pyriporme is a global fruit and vegetable commodity that is used as both fresh and processed vegetables (Ma et al., 2020). The data shows that tomato production in 2017 was 962,849 tons, which is 17.31 tons/ha. In 2018 tomato production increased by 976,809 tons and the yield was 18.04 tons/ha (BPS Indonesia, 2018). This shows the stability of tomato production as a fruit and vegetable commodity in Indonesia. However, the current problem is that tomatoes can only last 7 days at room temperature and 14 days if stored in the refrigerator (Obekpa, 2019).

The use of magnetic fields is increasingly being applied in food processing to maintain food quality (Miñano et al., 2020). Preservation by exposure to magnetic field radiation can inhibit the growth of acid-

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forming microorganisms (Balogu & Attansey, 2017). The ELF magnetic field affects the direction of migration and changes in the reproduction of pathogenic microorganisms so that the ELF magnetic field is able to suppress the growth of microorganisms and is able to slow down enzyme activity so that it can affect the pH of tomatoes which is one indicator of tomato quality. High-intensity magnetic fields can weaken pathogenic bacteria that cause an increase in acidity in fruit (Niati, 2021).

Density or density is defined as mass per unit volume. The volume in food is closely related to the water content contained in the food. The greater the volume of food, the higher the water content in it (Qumairoh, 2021). The ELF magnetic field can suppress the metabolism and activity of bacteria, causing a decrease in the number of bacteria, therefore respiration in food will run normally and make the water content and volume of food stable. Physical deterioration can be slowed by exposure to the ELF magnetic field. Sari (2018) stated that the magnetic field can maintain the pH value and density of chicken meat because the magnetic field can suppress the growth and activity of pathogenic bacteria that cause rot, so that with exposure to the ELF magnetic field the deterioration of physical quality will run more slowly.

The spectrum of electromagnetic wave radiation produced by magnetic fields and electric fields is very wide, so it is distinguished by its wavelength and frequency range. From low to very high frequencies. The magnetic field is seen to have a positive impact and a negative impact. The level of exposure to magnetic fields of various frequencies is non-linear, meaning that the bad or good effect of the level of exposure to magnetic fields depends on the object exposed to the magnetic field. According to WHO, the limit of exposure to magnetic fields that can be received by the body is 50/60 Hz with an intensity of <100 μT and according to the International Radiation Protection Association (IRPA) stipulates that the amount of exposure to magnetic fields is still very far below the threshold of 500 μT. According to Lacy-hulbert et al. (1998) if exposure exceeds these limits it will result in an increase in uncontrolled cell proliferation in humans. However, the effect is different in bacteria.

Some related previous research results, including Kristinawati and Sudarti (2017) with the title The Influence of Extremely Low Frequency (ELF) Magnetic Field Exposure on The Process of Making Cream Cheese concluded that exposure to a 100 μT ELF magnetic field for 5 minutes can reduce the pH of cheese kind of cream cheese. In a study by Sadidah et al (2015) entitled Effects of 300 μT and 500 μT ELF (Extremely Low Frequency) Magnetic Field Exposure to Changes in Microbial Amount and pH in the Glutinous Tape Fermentation Process reported that the highest decrease in microbial count occurred at 500 μT exposure intensity with long exposure 30 minutes and Sudarti's research (2016) entitled Utilization of Extremely Low Frequency (ELF) Magnetic Field is as Alternative Sterilization of Salmonella typhimurium In Gado-Gado concluded that an intensity of 646.7 μT with an exposure time of 30 minutes was able to inhibit the growth of Salmonella typhimurium. With these studies, it encourages researchers to study the effect of the ELF magnetic field on improving processing and preservation technology in food, especially processing food through a fermentation process.

Extremely Low Frequency (ELF) magnetic field radiation is a type of radiation that is non-ionozing, non-thermal and unobstructed with frequencies up to 300 Hz (Garip et al., 2011). Some research results show that ELF magnetic field radiation at high intensity can inhibit cell growth, but at low intensity it can increase cell proliferation (Aslanimehr et al., 2013). Sudarti (2016) reported that exposure to ELF magnetic fields can kill Salmonella bacteria, but does not change the texture or taste of food. With the existence of magnetic field technology, decay can be inhibited by growing energy from the magnetic field to the ions in the bacterial cell. The resulting magnetic field effect will damage the function of cell parts, causing cell death.

## Method

The research was conducted in the advanced physics laboratory of the physics education study program, FKIP Jember University. Tomato samples totaled 180 fruits with homogeneous size and fresh conditions from the farmers were divided into two groups, namely the control group with 30 fruits and the experimental group with 150 fruits. The control group is the group without ELF magnetic field exposure, while the experimental group is the group with 600 μT and 1000 μT ELF magnetic field exposure. The variation of exposure time is 30, 60 and 90 minutes. The study was conducted for 20 days with five times of data collection, namely on the 4th day, the 8th day, the 12th day, the 16th day and the 20th day.

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**Figure 1.** Sample preparation process

**Figure 2.** ELF. magnetic field exposure

## Result and Discussion

The presentation was carried out the day after harvest, this was due to the distance factor in obtaining samples which were quite far from the research location, namely from tomato farmers in Sabrang, Ambulu, Jember. In addition to the distance factor that affects the implementation of sample exposure, the preparation stages such as grouping and sterilizing samples also take a long time.

Data collection on the pH variable begins with crushing the tomatoes and then measuring the pH value of each fruit using a digital pH meter that has been calibrated with a buffer of 4.00. The density variable was obtained by weighing the mass of each fruit and dipping the fruit in 150 ml of distilled water as the initial volume, then the difference between the final volume and the initial volume was obtained to obtain the final density of each fruit using the density equation. Physical condition variables can be obtained by counting the number of good fruits and recording each measurement.

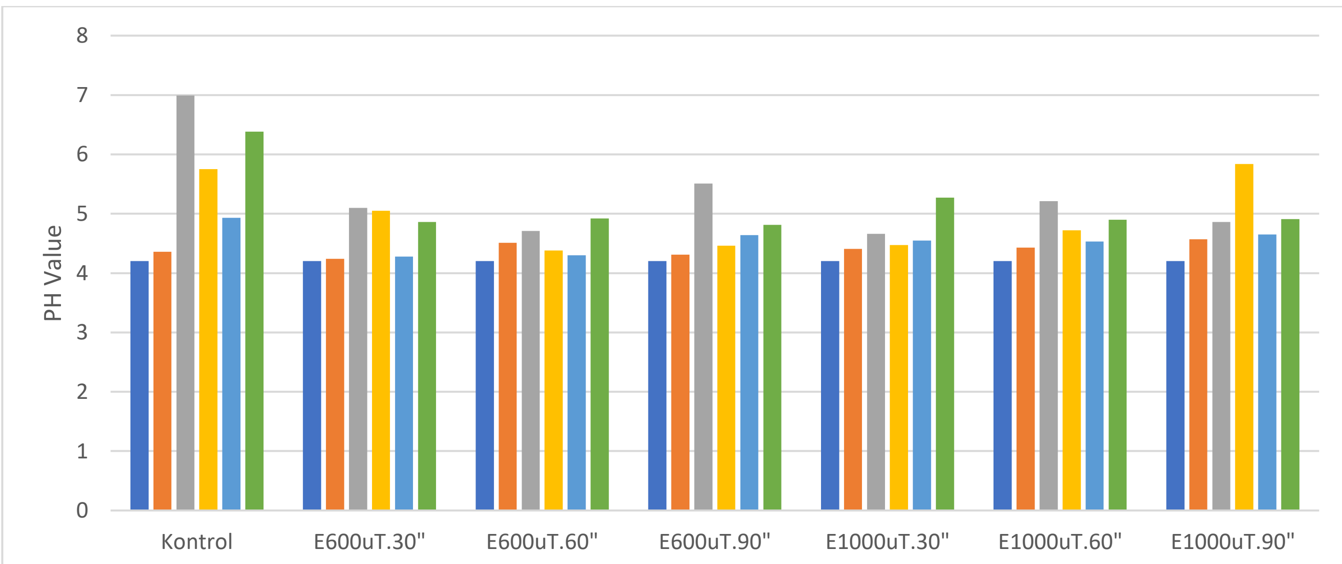


**Figure 3.** The pH Value of Apple Tomatoes After Exposure to an ELF Magnetic Field Intensity of 600 µT and 1000 µT

The pH value of tomatoes will increase along with their shelf life, because the natural acid compounds in tomatoes will decrease. The drastic increase in the pH of apple tomatoes experienced by the control group was a change on day 0 from the initial pH value of 4.20 to 6.38 on the 20th day of measurement due to the disconnection of nutrients from organic acids in tomatoes such as citric, tartaric and malic acids. so that the metabolism in the climacteric process is disrupted. Citric acid in apple tomatoes functions as a natural fungicide, so that when the amount of citric acid decreases, bacterial injection can occur as an external factor that can increase the pH value of tomatoes quickly (Safari et al., 2021). The decay process is characterized by an increase in the pH value and an increase in the growth of spoilage bacteria (Qumairoh, 2021). According to Obekpa (2019), tomatoes will rot on the 7th day at room temperature storage. The reason is due to an increase in respiration patterns and due to infection with pathogenic microorganisms by Rhizopus sp which can accelerate the process of fruit decay (Marzouk et al., 2021).

The pH value of the control group and the experimental group increased during the tomato storage period. The difference between the control group and the experimental group lies in how slowly the increase in the pH value takes place. The pH value in the control group on the 20th day of measurement was 6.38, meaning that it was close to a neutral pH value due to the low content of citric acid and the cleavage activity of pathogenic bacteria in apple tomatoes, while in the experimental group the pH value on the 20th day was the lowest compared to the experimental group. Another experiment was owned by the E600µT 60" group, which was 4.81, meaning that the apple tomatoes were still in an acidic state because the rate of decay was hampered by exposure to the ELF magnetic field which suppressed the rate of bacterial division. The results of this study are supported by research on ELF exposure to black grapes, according to Niati (2021) stating that the pH of grapes has increased drastically due to an increase in the number of pathogenic bacteria in the fruit flesh and ELF with high intensity is able to reduce the number of bacteria in the flesh of black grapes so that the increase in the pH of the fruit goes on. slower. So based on this research, it can be concluded that the ELF magnetic field affects the pH of tomato apples. The intensity with the lowest rate of increase in pH was 600µT for 60 minutes on the 20th day of measurement, making it an intensity that had high potential in maintaining the pH value of apple tomatoes.

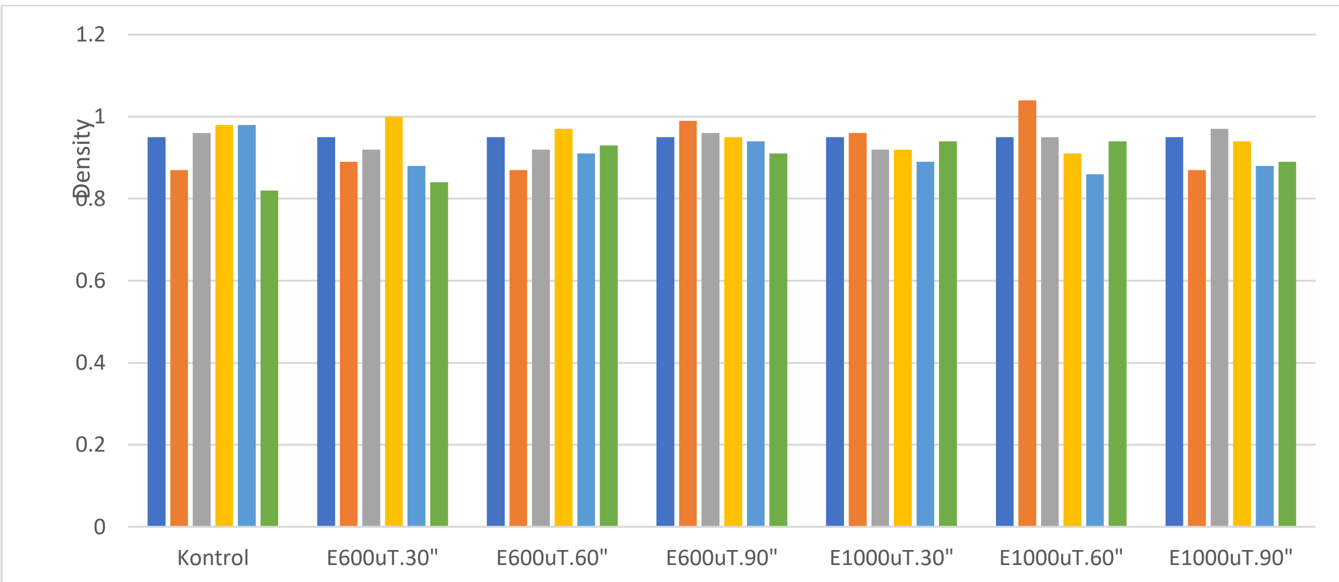


**Figure 4.** Density of Apple Tomatoes After Exposure to ELF Magnetic Field Intensity 600 uT and 1000 uT

This study uses apple tomatoes with a homogeneous mass of 44-57 grams, if the volume increases then the density of apple tomatoes becomes small, this is in accordance with the equations of density (ρ) as equation 1:

$$\rho = \frac{m}{v} \quad (1)$$

Notes:

$\rho$ = density (kg/m$^3$)

m = mass of subtance (kg)

V = volume (m$^3$)

Based on these equations, it is known that the yield of the control group was low as a result of the high volume of apple tomatoes. While the volume of apple tomatoes is influenced by the water content which continues to increase during the storage period due to the activity of pathogenic bacteria. The water content of apple tomatoes is higher in the process of decay, this is due to the respiration process and bacterial activity that produces a by-product in the form of water. On the 20th day of measurement, the respiration process took place along with the proliferation of microorganisms that cause soft fruit, so that the fruit volume increased. This is supported by the research of Niati (2021), that the volume of black grapes will be higher during the storage process due to the ongoing process of fruit decay. This series of processes was also experienced by the experimental group with the intensity of 600µT and 1000µT for 30.60 and 90 minutes, but in the experimental group the rate of increase was smaller and the density value was maintained compared to the control group. This is caused by the ELF magnetic field which is able to inhibit the activity of microorganisms, so that the water content in tomatoes does not increase rapidly. Magnetic fields can affect the direction of migration of microorganisms and inhibit the growth and reproduction of pathogens, thereby maintaining the density value (Qumairoh, 2021). This is supported by the results of Sudarti's research (2018) that exposure to high-intensity ELF magnetic fields can increase production, wet mass and dry mass of tobacco leaves (Sudarti et al., 2018).

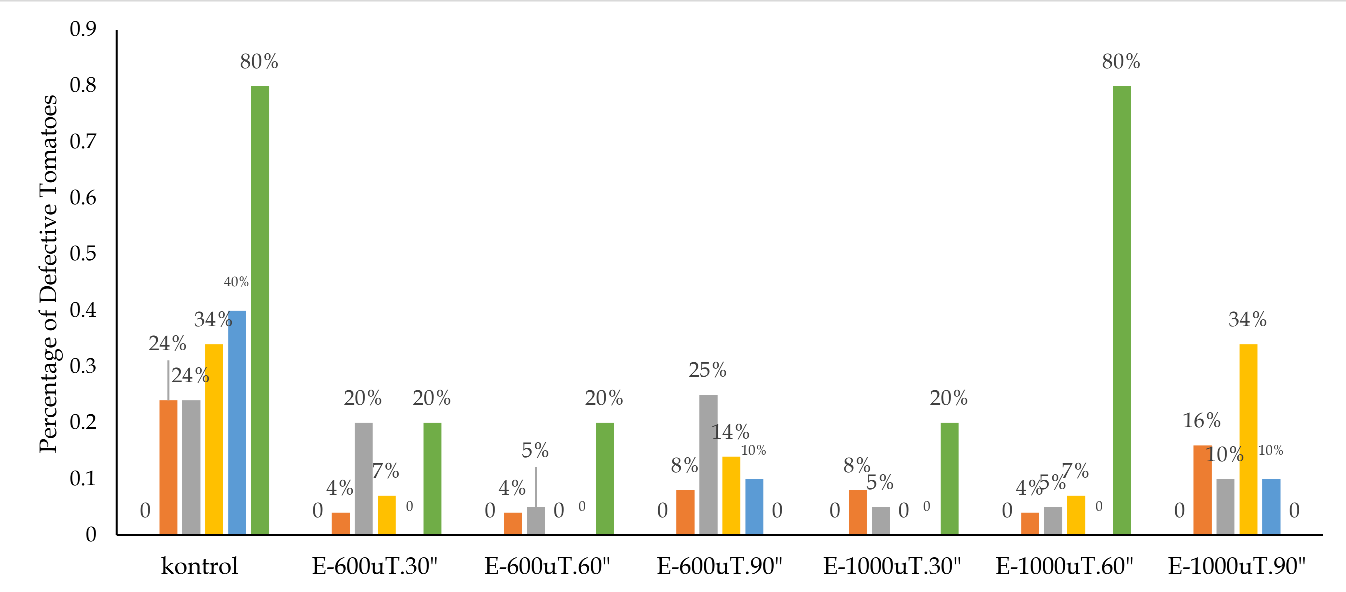


**Figure 5.** Physical Resistance of Apple Tomatoes After Exposure to an ELF Magnetic Field Intensity of 600 uT and 1000 uT

The experimental group with an intensity of 600 µT for 30, 60 and 90 minutes got an average of 9%, 5%, and 10% percentage of defective tomatoes from five measurements for 20 days and a total of 25 fruits in each group. The exposure intensity of 1000 µT at 30, 60 and 90 minutes put the percentage of defective tomatoes on average 6%, 16% and 12% from five measurements for 20 days and a total of 25 fruits per group. This percentage was lower than the percentage of physical quality of apple tomatoes with defects in the control group due to the influence of the ELF magnetic field which was able to suppress bacterial growth. This is supported by Sudarti's research (2020) which explains that exposure to high-intensity ELF magnetic field radiation in fresh milkfish has been shown to reduce bacterial growth by up to 73%. So that in the experimental group the number of active bacteria causing fruit rot was smaller than the control group without exposure.

Based on the results of observations of the physical quality of apple tomatoes that have been carried out, exposure to the ELF magnetic field affects the physical quality of apple tomatoes as evidenced by the percentage of physical quality of the defective apple tomatoes in the experimental group is lower than the control group due to the weakening of bacterial activity by exposure to the ELF magnetic field. So that the freshness of the tomatoes is maintained, which can be seen from the appearance of a bright red color, a hard texture and a fresh smell typical of tomatoes (Yuniastri et al., 2020). This is supported by the research of Niati (2021), that the number of defects in black grapes in the control group was higher than the number of defects in black grapes in the experimental group.

According to several studies the Extremely Low Frequency (ELF) magnetic field is able to affect germination, seed growth, production, character and fruit size. Research by Jedlička et al (2014) showed that exposure to Extremely Low Frequency magnetic fields with an intensity of 20 mT, 40 mT, and 60 mT for 20 minutes a day on tomato seeds significantly affected germination, and plant growth and tomato fruit size. The results of research by Sari & Prihandono (2015) on ranti tomato seeds showed that a dose with an intensity of 300 T with an exposure time of 60 minutes was an effective dose to accelerate the growth rate of ranti tomato plants. Exposure to a low electromagnetic field of 0.5 mT, 1 mT, and 2 mT was able to increase the germination process in date seeds (Fauziah, 2015).

Besides of dates and tomatoes, exposure to a 62 µT magnetic field on chili seeds with exposure times of 4 hours, 8 hours, 12 hours, and 24 hours can stimulate the growth of the first stage of chili seeds, statistically showing a significant increase in germination, early development, and seed growth compared to the control class (Nimmi & Mdhu, 2009). Meanwhile, according to research by Handoko et al, (2016) on large red chili seeds showed that exposure to the 300 µT Extremely Low Frequency (ELF) magnetic field for 60 minutes and 90 minutes had a positive effect on plant height and the number of leaves produced by large red chili plants.

## Conclusion

Based on the description above, it can be concluded that the ELF magnetic field affects the degree of acidity, density, and physical quality of apple tomatoes. The intensity with the lowest rate of increase in pH was 600µT for 60 minutes on the 20th day of measurement, making it an intensity that had high potential in maintaining the pH value of apple tomatoes. The intensity of the ELF magnetic field with the potential to maintain the density value of tomatoes was E1000 µT 30" and 90" on the 20th day of measurement. The intensity of exposure to a magnetic field that has the potential to maintain the physical quality of apple tomatoes is the intensity of 600 µT for 60 minutes as evidenced by the lowest average percentage of defects, which is 5% during the observation time.

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