

Analysis of Vitamin C Resistance in Red Grapes (*Vitis vinifera*) After Exposure to Extremely Low Frequency (ELF) Magnetic Fields Intensity 700 μ T and 900 μ T

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Abstract: The resistance of grapes at room temperature only reaches 7 days, then it will experience a decrease in quality and spoilage by the activity of pathogenic bacteria. This study aims to analyze the resistance of Vitamin C in red grapes (*Vitis vinifera*) by exposure to an Extremely Low Frequency (ELF) magnetic field with an intensity of 700 μ T and 900 μ T. This research is a laboratory experimental research using a completely randomized design. The sample of this study was red grapes (*Vitis vinifera*) in fresh condition as much as 7 kg, grouped into 7 groups @ 1 kg. One group as a control (K), three groups were exposed to an ELF magnetic field with an intensity of 700 μ T, with a duration of exposure of 2x15 minutes (E-700.15), 2x30 minutes (E-700.30), and 2x45 minutes (E-700, 45). Three other groups were exposed to an ELF magnetic field with an intensity of 900 T, with a duration of exposure of 2x15 minutes (E-900.15), 2x30 minutes (E-900.30), and 2x45 minutes (E-900.45). is a component of ELF electromagnetic waves generated by current transformers by minimizing the intensity of the electric field up to 30 Volt/m. Measurement of Vitamin C and pH at the beginning and then 6 days, 12 days, and 18 days after being exposed to the ELF magnetic field. The results showed that the levels of Vitamin C in the group exposed to the ELF 900 T magnetic field for 2x30 minutes did not differ significantly ($p>0.05$) compared to the initial condition when it was still fresh, and physically the number of fresh fruit until the 12th day is the most. Conclusion: exposure to the ELF magnetic field intensity of 900 T for 2x30 minutes significantly ($p<0.05$), was able to maintain Vitamin C in red grapes until the 12th day.

Keywords: Grapes (*Vitis vinifera*); Extremely Low Frequency; Magnetic Field; Vitamin C.

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Introduction

Grapes have many health benefits since they contain low fat, high calories 1, and polyphenol compounds that work more strongly than vitamin C and vitamin E. The benefits of polyphenols for the human body are that they can reduce systolic and diolic blood pressure 2. Besides, it has relatively high-vitamin C content. However, grapes are one type of fruit that is easily damaged due to pathogenic bacterial

contamination and oxidation reactions during storage at room temperature. They can only last for 5 - 7 hours, then the fruit will rot. There are several factors that determine the quality of grapes, i.e., the appearance of the fruit, such as color, aroma, fruit uniformity, sweetness, and the absence of seeds.

Grapes have a relatively high-water content. However, during the storage period the grapes will experience a lot of water loss and an increase in respiration-transpiration, so the vitamin C dissolved in

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water also evaporates with the discharge of water. The decrease in vitamin C level occurs during fruit development and ripening 3. According to Astria (2018), the decreased vitamin C content causes the pH in the fruit to change 4. This will affect the quality of the grapes getting sour which leads to the process of spoilage and can even shorten the shelf life of the grapes. The low quality of grapes can be observed from the appearance of dark brown indentations around the fruit as a result of the proliferation of pathogenic bacteria and the oxidation reaction of chlorogenic acid by the enzyme polyphenol oxidase to melanoidin to form a blackish brown color.

Based on the above description, it is necessary to perform a proper handling to maintain the quality of the grapes. One of the innovations that is rarely done is to use non-thermal preservation technologies, such as ELF magnetic fields. Extremely Low Frequency (ELF) magnetic field is a spectrum of electromagnetic waves with a frequency of 0 - 300 Hz. The energy provided by the ELF magnetic field is very small so that the energy efficiency is much better than that of the thermal processes. However, the bigger the exposure of magnetic fields, the greater the decrease in the number of microorganisms. The resistance of microbes to non-thermal preservation technologies depends on several factors, such as the type of microorganism, physiological conditions, treatment, and recovery conditions. A diffusion magnetic resonance imaging in grapes causes the loss of cell vitality to the absence of pericarp cells as a result of osmotic imbibition of water 5.

metabolism of bacteria 7. Treatment using non-thermal preservation technology has an effect on microbial resistance during its growth phase 8. Non-thermal technology allows it to extend shelf life, deactivate pathogenic bacteria, and preserve the nutritional content of foodstuffs 9. The intensity of 646.7 μ T for 30 minutes can inhibit the prevalence of Salmonella Typhimurium bacteria, but does not change the taste, texture and color of gado-gado 10. The intensity of 170 mT for 120 hours can inhibit cell proliferation 11. There was an inhibition of CFU colony formation by 95.2% in *S. aureus* and 85% in *E. Coli*12.

The resistance of grapes can also be seen from changes in vitamin C level. Vitamin C is a white crystal that is easily soluble in water. In a dry state, vitamin C is quite stable, but it is easily damaged by contact with air (oxidation) but in a soluble state, especially when it is exposed to heat. The intensity magnetic field of 500 μ T can inactivate pathogenic microorganisms because there will be an increase in Ca^{2+} across the cell membrane when the magnetic field interacts with fruit cells, which then results in damage to cell structures and proteins in cells. As a result, the metabolism of pathogenic microorganisms will be inhibited, and the fruit will become intact. The content of vitamin C in fruit will change and this is correlated with the presence of enzyme activity that affects the redox state of the fruit 13.

Based on the above background, the problem in this study is formulated as follows: Does exposure to ELF magnetic fields with intensities of 700uT and 900uT affect the resistance of vitamin C and pH in grapes? Therefore, the objective of this study is to examine the effect of exposure to ELF magnetic fields with intensities of 700 and 900 on the resistance of vitamin C and pH in grapes. This study is expected to have a real and significant impact on the field of food technology.

Method

This study belongs to a laboratory experimental study using a randomized post-test only control group design in which the two groups of research subjects were randomly selected. Observations were made on day 0, 6, 12, 18. The sample used in this study was 210 fresh grapes. The data collection method was laboratory experiment.

Materials and Tools:

The materials and tools used in this study included: (1) Tools, i.e., electromagnetics field source, EMF tester, pH meter, mortal, watch glass, Erlenmeyer, burette 50 ml, funnel, test tube, dropper pipette, statif, clamp, titar mat, and burette reading mat; and (2) Ingredients, i.e., grapes, buffer solution pH 7, distilled water, I2 0.01 N,

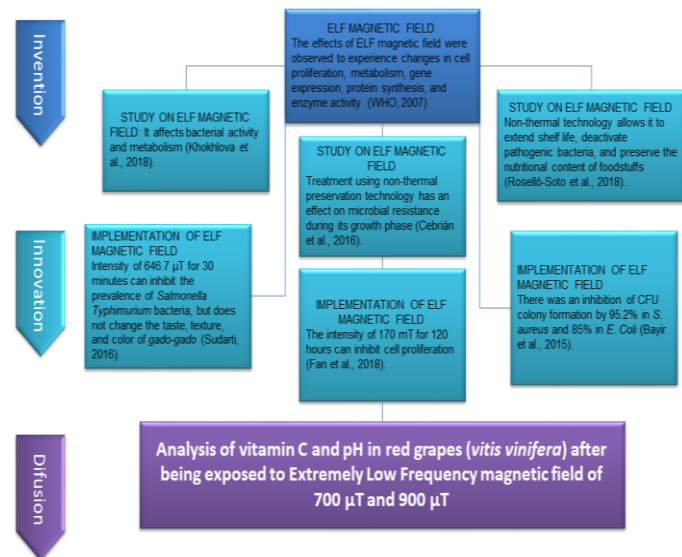


Figure 1. State of the art of ELF magnetic field

The effects of ELF magnetic field were observed to experience changes in cell proliferation, metabolism, gene expression, protein synthesis, and enzyme activity 6. ELF magnetic fields can affect the activity and

starch indicator, wiping filter paper, and funnel wedge paper.

Exposure to ELF Magnetic Fields

This study used ELF magnetic field treatment with a voltage source input of PLN 220 V, frequency 50 Hz. The Current Transformer tool or ELF magnetic field source was conditioned so that the electric field component reached its minimum number by turning the voltage control knob to a value of 0, and the electric field exposure in the exposure room reached a value of about 5 mV/m (equivalent to natural electric field intensity). Samples of the experimental group were exposed to ELF magnetic fields with intensities of 700 μ T and 900 μ T, for 2 x 15 minutes, 2 x 30 minutes, and 2 x 45 minutes. Meanwhile, the control group was left in an open space. The research design pattern was presented below.

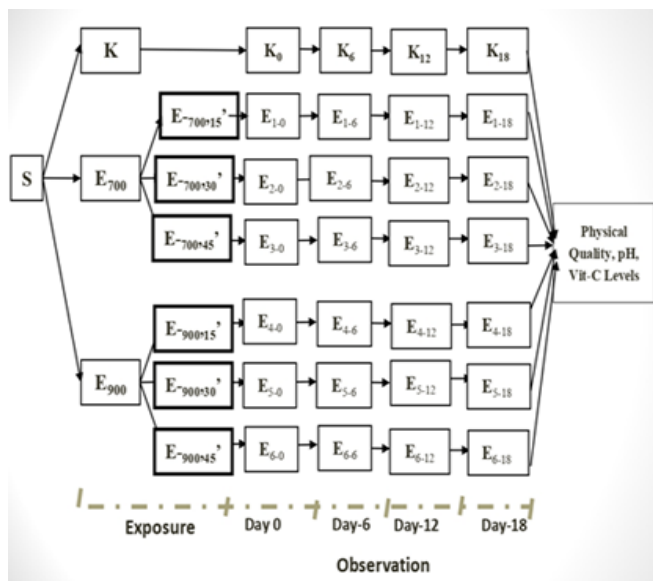


Figure 2. Research design

Annotation:

K : Control, the group without exposure to ELF magnetic fields

E7-15' : the experimental group with an intensity of 700 μ T and time 2 x 15 minutes

E7-30' : the experimental group with an intensity of 700 μ T and time 2 x 30 minutes

E7-45' : the experimental group with an intensity of 700 μ T and time 2 x 45 minutes

E9-15' : the experimental group with an intensity of 900 μ T and time 2 x 15 minutes

E9-30' : the experimental group with an intensity of 900 μ T and time 2 x 30 minutes

E9-45' : the experimental group with an intensity of 900 μ T and time 2 x 45 minutes

Measurement of the pH in Grapes: The degree of acidity of the grapes was measured using a digital pH

meter by immersing the pH meter sensor in the grape juice. The first calibration was previously carried out using a buffer solution of pH 7. The grape juice was made by crushing grapes, then mixing them with distilled water to make them homogeneous.

Measurement of the Vitamin C Level: The iodimetric titration method test was used to test the vitamin C level of grapes by preparing a sample of grapes and the necessary equipment, then mashing the grapes until smooth, putting the grapes into a test tube, and adding 5% distilled water then shaking them until well blended. The mixture of grapes and distilled water were then filtered using whatman paper (filter paper). A total of 5-25 ml of filtrate was transferred to Erlenmeyer using a pipette, added 2 ml of 1% starch and 20 ml of distilled water, and then irritated with a solution of I2 0.01 N. Observation of the Physical Quality Resistance of Grapes: The physical quality endurance test of grapes was performed by counting the number of fruits that had spots on their surface. Statistical Analysis: The data were analyzed using the One-way ANOVA test with SPSS 23 software.

Result and Discussion

Observation of the pH in Grapes

The results of measuring the pH in grapes every 6 days indicated that the pH in all samples decreased. This was caused by the ongoing process of decomposition of the grapes which made their taste to become increasingly sour. Fruit maturity has a significant effect on pH 14.

The pH measurement on the 18th day showed that the sample with an intensity of 900 μ T for 2 x 30 minutes had the highest pH value, i.e., 3.80. Meanwhile, the lowest pH value was found in the control sample, i.e., 3.20, indicating that the degree of acidity of the control group was higher than that of the experimental group. The control group experienced a significant decrease in pH compared to the experimental group, i.e., 1.26. The change in pH value is one of the factors that affects bacterial growth and enzyme activity 15. However, there was a relatively small decrease in the pH value in the experimental group with an intensity of 900 μ T for 2 x 30 minutes and 2 x 45 minutes. Based on the research results, exposing ELF magnetic fields to the grapes significantly ($p > 0.05$) could maintain the pH value compared to the control group. In accordance with the results of research conducted by Lins et. al., (2016) exposure to magnetic fields for 2 hours gives the effect of no significant changes during the storage period 16. This confirms that the magnetic field affects the pH value of the grapes.

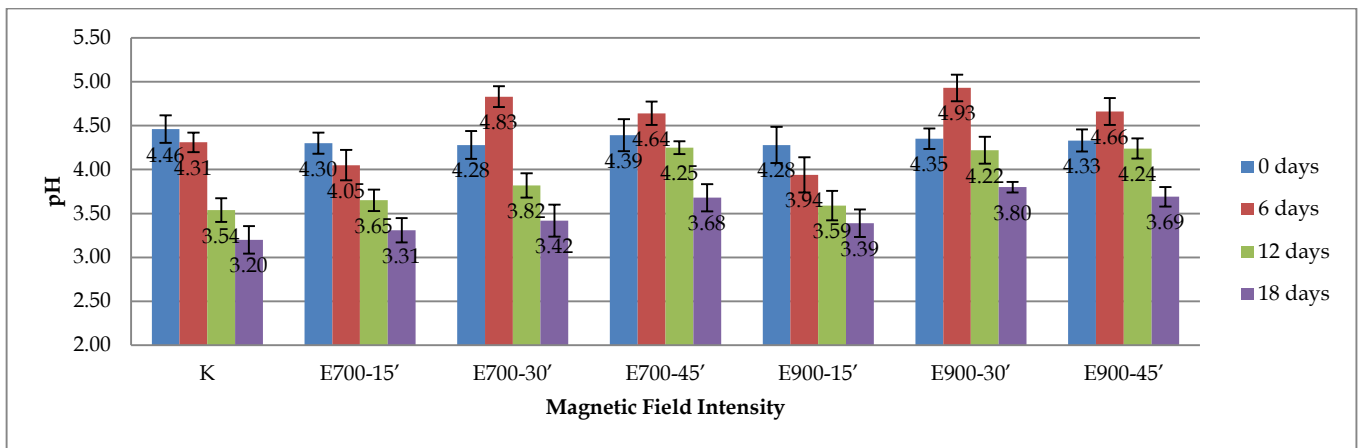


Figure 3. Graph of the measurement results of the pH in grapes after being exposed to the ELF magnetic field

Figure 3 shows that the control group had a lower pH value than the group exposed to the ELF magnetic field on day 18. The intensity of the ELF magnetic field showing the smallest decrease in pH value was experienced by grapes exposed to an intensity of 900 μT for 2 x 30 minutes and 2 x 45 minutes. Overall, the pH value in the experimental group maintained the pH value due to inhibition of the metabolic activity of acid-forming bacteria by magnetic fields. Based on the results of research that has previously been conducted, giving a magnetic field of 1000 μT intensity for 2 hours has an effect on changes in physicochemical properties and there is a slight decrease in bacterial proliferation 17. The energy of the magnetic field will be transferred to the ions in the acid-forming bacterial cell. As a result, the effect of the magnetic field will ultimately inhibit the metabolic process of cells which also affects the activity of acid-forming bacteria.

Vitamin C Level in the Grapes

The vitamin C level in the grapes experienced a decrease in each measurement, i.e., 1) The group without

magnetic field exposure experienced the decrease by about 1.88 mg/100 g; 2) The experimental group exposed to an ELF magnetic field with an intensity of 700 μT for 2 x 15 minutes experienced the decrease by 1.30 mg/100 g in; 3) The experimental group exposed to an ELF magnetic field with an intensity of 700 μT for 2 x 30 minutes experienced the decrease in vitamin C level by 1.17 mg/100 g; 4) The experimental group exposed to an ELF magnetic field with an intensity of 700 μT for 2 x 45 minutes experienced the decrease in vitamin C level by 0.94 mg/100 g; 5) The experimental group exposed to an ELF magnetic field with an intensity of 900 μT for 2 x 15 minutes experienced the decrease in vitamin C level by 1.29 mg/100 g; 6) The experimental group exposed to an ELF magnetic field with an intensity of 900 μT for 2 x 30 minutes experienced the decrease in vitamin C level by 0.87 mg/100 g; and 7) The experimental group exposed to an ELF magnetic field with an intensity of 900 μT for 2 x 45 minutes experienced the decrease in vitamin C level by 0.88 mg/100 g.

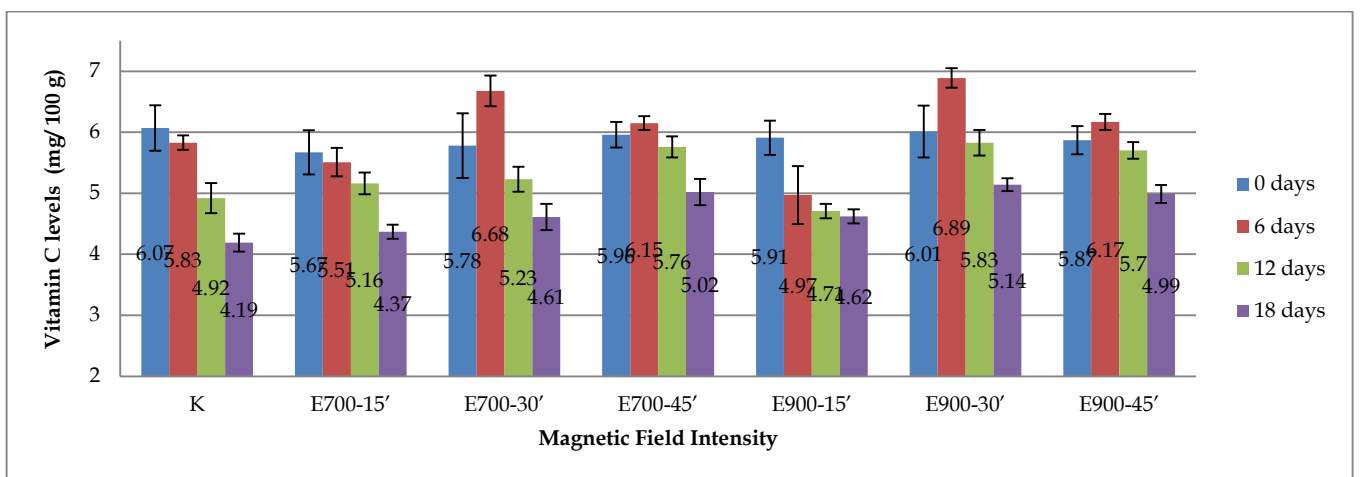


Figure 4. Graph of vitamin C level in grapes after being exposed to ELF magnetic field

Based on the results of these measurements, it highlights that the ELF magnetic field affects the vitamin C level in grapes. It is proven that grapes exposed by an intensity of 700 μT and 900 μT for 2 x 15 minutes, 2 x 30 minutes, and 2 x 45 minutes can maintain the vitamin C level in grapes. The lowest decrease in vitamin C level was found in the 900 μT sample for 2 x 30 minutes and 2 x 45 minutes. Meanwhile, the control group experienced the decrease in vitamin C level more than that of the experimental group. The decrease occurred since vitamin C is easily oxidized and easily dissolves in solvents, such as water. In a dry state, vitamin C is quite stable, but in a soluble state, vitamin C is easily damaged by contact with air (oxidation), especially when it is exposed to heat. The oxidation process can be accelerated by heat, light, alkalis, enzymes, oxidizing agents as well as by copper and iron catalysts. The content of vitamin C in fruits is very sensitive to high temperatures which causes a reduced availability of vitamin levels 18.

Fruit ripeness has a significant effect on vitamin C content 14. The concentration of vitamin C (ascorbic acid) decreases in fruit juices 19. Besides, a storage of vitamin C content for 2 weeks in fruit decreases by up to 20% 20. This is related to the activity of inhibitory enzymes found in grapes. These inhibiting enzymes include ascorbate oxidase, phenolase, cytochrome oxidase, and peroxidase which cause oxidation overhaul so that the oxidative enzymes become active. Also, reduced vitamin C is also caused by water solubility, thermal degradation, and enzymatic oxidation 21.

The presence of oxygen in respiration will cause ascorbic acid (vitamin C) to degrade into dehydroascorbic acid. The decrease in vitamin C level in the product is proportional to the rate of respiration that occurs, if the respiration rate is low due to the CaCl_2 treatment, thus the decrease in vitamin C level is low as well. Respiration naturally cannot be stopped but can be slowed down. Therefore, CaCl_2 treatment can reduce

the rate of respiration and the rate of decline in vitamin C level.

One-way ANOVA analysis was used to test the comparison between the vitamin C level in grapes exposed to a 700 μT and 900 μT ELF magnetic field and grapes exposed to natural magnetic fields.

The level of treatment combination on vitamin C level can be seen from the significance value. If the significance value is <0.05 , then H_0 is rejected. It means that there is a significant effect among treatments on vitamin C level, so there are differences in vitamin C level in each treatment. The One-way ANOVA test results in table 3 shows that the vitamin C level in the grapes of the control group were not significantly different from the experimental group on the 0th day since the sample was a homogeneous sample. Meanwhile, that there was a significant difference between the vitamin C level of grapes exposed to an ELF magnetic field of 700 μT and 900 μT and the grapes exposed to natural magnetic fields on the 6th day, 12th day, and 18th day.

Physical Quality of Grapes

Fruits with good quality could be observed according to the number of spots that appear during the storage period. The observations performed on the 6th day to 18th day showed that all groups experienced an increase in the number of spots. In the control group, the number of fruits with black spots were found on the 6th, 12th, and 18th day, respectively, with the number of grapes were 6.67%, 20%, and 43.3%. This indicates the presence of bacterial activity during the storage period 22. In the experimental group, the number of fruits with black spots increased on the 12th and 18th day of measurement. The appearance of color changes in the fruit is influenced by the oxidation of chlorogenic acid, starting from the polyphenol oxidase enzyme converted into melanoidin to form a blackish brown color 4.

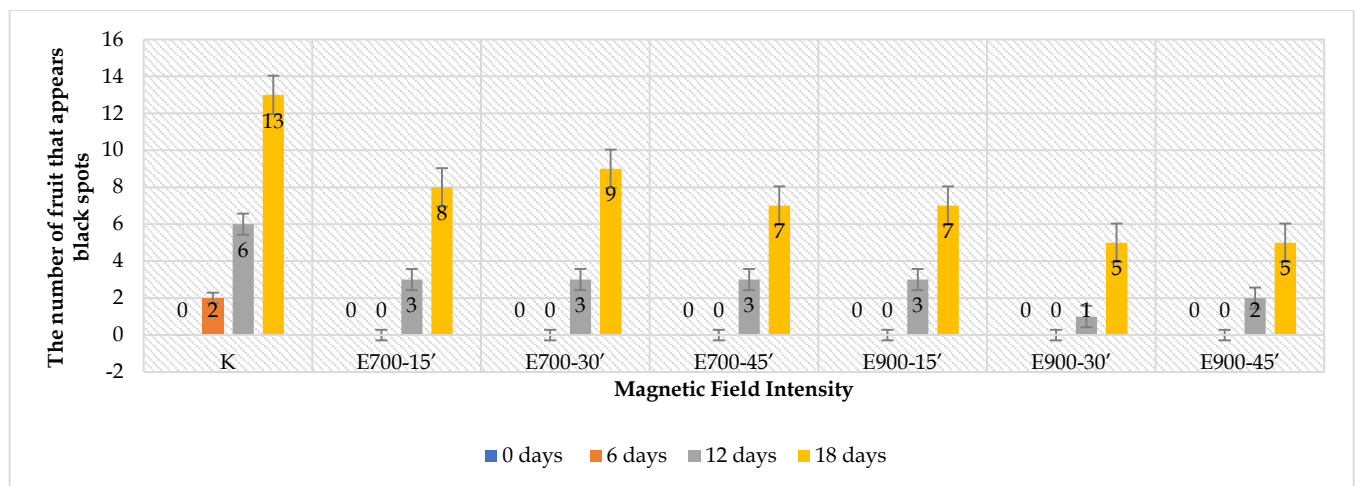


Figure 5. Graph of calculation on the number of black-spotted grapes



(a)



(b)

Figure 6. Physical quality of grapes (a) sample of grapes (b) observation of physical quality of grapes

Based on the results of this study, the exposure to ELF magnetic fields with intensities of 700 μT and 900 μT with for 2 x 15 minutes, 2 x 30 minutes, and 2x45 minutes affected the endurance of the physical quality of grapes. If it was compared to the control group, the experimental group maintained more physical quality of the grapes. The testing until the 18th day indicated that the group with the exposure using an intensity of 900 μT for 2 x 30 minutes and 2 x 45 minutes could reduce the incidence of spotting on grapes, i.e., only 16.6%. This highlights that applying a magnetic field to grapes can improve the quality of the wine without any side effects or the addition of any chemical substances 23.

Conclusion

Based on the results and discussion explained previously, the authors concluded that an exposure to ELF magnetic fields with intensities of 700 μT and 900 μT affects the value of the pH and vitamin C level of grapes. An effective dose to maintain the acidity of the pH and vitamin C level of grapes is the exposure to ELF magnetic field with an intensity of 900 μT for 2 x 30 minutes and 2 x 45 minutes.

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