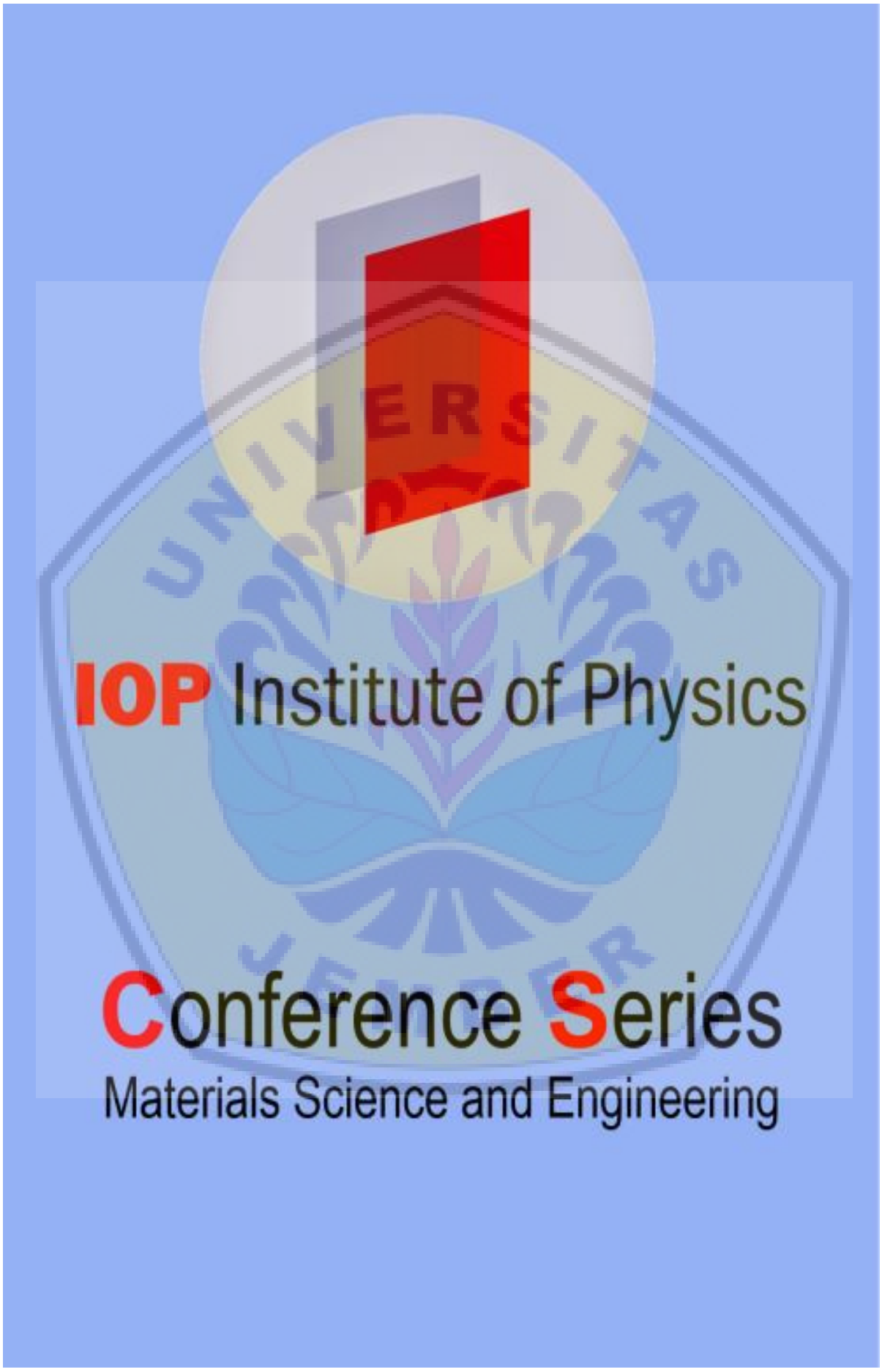

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The 1st Materials Research Society Indonesia Conference and Congress

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The Materials Research Society Indonesia Conference & Congress 2017

MRS-INA C&C 2017

SAHID JAYA HOTEL AND CONVENTION
YOGYAKARTA, INDO OCTOBER
8-12, 2017 — INDONESIA

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Accepted, peer reviewed papers from the MRS-INA C&C 2017

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2018

PREFACE

The **Materials Research Society-Indonesia Conference and Congress 2017** (MRS-INA C&C 2017) was held in Yogyakarta on October 8 – 12, 2017. The main theme of MRS-Ina C&C 2017 is "***Innovation of Advanced Materials for A Better World".*** The conference is organized by Materials Research Society-Indonesia (MRS-INA) with the aim to provide international forum for presenting scientific results in the field of materials science by scientists, academicians, industries and government from national, as well as regional and international.

The pupose of the MRS-INA C&C 2017 is to gather Indonesian Materials Researchers, and to promote international collaboration and cooperation among scientists and academia from regional and developed countries. This should be accomplished by presence of invited world-class speakers for the scientific program. In this event, the fundamentals, innovations and industrial applications of Materials Sciences and Technology will be discussed.

The Committee received over **200 scientific articles** showing a diverse and stimulating program, from more than 40 national and international institutions, covering 15 countries (UK, Taiwan, Sweden, Austria, Germany, USA, Malaysia, Singapore, Thailand, Japan, Bangladesh, China, Australia, Korea and Indonesia). The publication committees were responsible for arranging approximately **150 full peer review** of the manuscripts that will appear in several media of internationla publications, such as Progress in Natural Science: Materials International, IONICS, Journal of Atom Indonesia, Indonesian Journal of Materials Sciences as well as the IOP Conference Proceedings. After selection process, there are 65 articles are to be published in IOP Materials and Engineering.

There are several International Symposia covering subjects in material research, namely (1) Nuclear Science and Technology Application (NST], (2) Metallurgy, Ceramics, Composites and High Temperature Materials (MCT), (3) Nanomaterials, Nanotechnology, Thin Film, Carbon Based Materials and Functional Materials (NTC), (4) Energy Materials and Devices (EMD), (5) Polymers, Biomaterials and other Soft Matters (PBS), (6) Theoretical Modeling and Simulation of Materials (TMS). I truly acknowledged all the publication team and reviewers who have been working very hard on reviewing all those submitted articles.

The conference was remarked by the Minister of Research, Technology and Higher Education of the Republik of Indonesia, and a Plenary Speech from the President of International Union of Materials Research Society (IUMRS), Professor Soo Wohn Lee. The inauguration of MRS-INA as official member of IUMRS was declared by the IUMRS President, and a certificate of membership was given to Prof.Dr. Evvy Kartini, President of MRS-INA.

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All papers published in this volume of *IOP Conference Series*: *Materials Science and Engineering* have been peer reviewed through processes administered by proceedings editors. Reviews were conducted by expert referees to the professional and scientific standards expected of a proceedings journal published by IOP Publishing.

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PAPER • **OPEN ACCESS**

Effective dose analysis of extremely low frequency (ELF) magnetic field exposure to growth of *S. termophilus, L. lactis, L. acidophilus* bacteria

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Effective dose analysis of extremely low frequency (ELF) magnetic field exposure to growth of *S. termophilus, L. lactis, L. acidophilus* bacteria

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Abstract. The Extremely Low Frequency (ELF) magnetic field, which is a component of a non-ionizing radiation, at low intensity has been shown to increase cell proliferation. This fact is expected to lead to a technological breakthrough in *S. thermophilus*, *L. lactis*, and *L. acidhopilus* bacteria activation which is needed in the production process of cream cheese. The main issue considered here in the production process of cream cheese is the growth of bacteria which often cannot be optimal, causing it to taste bad. This study is an initial step to determine the effective dose of exposure to ELF magnetic fields on the *S. thermophilus*, *L. lactis*, and *L. acidhopilus* bacteria growth. This research used the exposure of ELF magnetic field with intensity of 100 μT and 300 μT to those three types of bacteria with exposure durations of 5, 15, 25, 35, and 45 minutes. Measurements of the amount of bacteria were performed 1 hour, 2 hours, and 16 hours after exposure to ELF magnetic field. The results of this study indicated that the growth of three types of bacteria exposed to ELF magnetic field with an intensity of 100 μT was significantly faster than the control one, but the other one which were exposed to 300 μT ELF magnetic field was not different from the control one. The analysis results provided evidence that the rate of optimal growth occurred in three types of bacteria after being exposed to 100 μT ELF magnetic fields for 5 minutes. Therefore, it could be concluded that exposure to ELF magnetic field with an intensity of 100 μT for 5 minutes is an effective dose for the activation of *S. thermophilus*, *L. lactis*, and *L. acidhopilus* bacteria growth.

1. Introduction

Extremely Low Frequency (ELF) magnetic field is a component of ELF electromagnetic waves, proven to have the ability to penetrate almost all types of matter. It is a form of non-ionizing radiation, low-energy, and non-thermal energy. This characteristic provides a very high advantage that ELF magnetic field radiation is not destructive because it does not cause ionizing effects or thermal effects on the atoms that interact with it. In addition, the ELF magnetic field is easy and cheap to obtain, we are always around of ELF magnetic field, considering that in every current flow in electricity cable and equipment around us will arise the ELF magnetic field. Therefore, the utilization of ELF magnetic field becomes the focus of the researcher's attention, especially in the food industry. The result of Sudarti's research, 2016, showed that ELF magnetic field radiation is potentially used for *Salmonella thypimurium* sterilization in the gado-gado dish, showing that exposure to 646.7 μT for 30 minutes was able to decrease *Salmonella typhimuriun* amount 56% growth [1], while Sudarti and Kristiani A, 2016, proved that exposure to 100 μT magnetic field for 5 minutes was able to lower the water content

in the process of making cream cheese [2]. Tessaro LW, *et al*., 2015, also proved that exposure to ELF magnetic field of 250 μT can increase the growth of *Staphylococcus* bacteria cultures [3].

This study provides inspiration to utilize ELF magnetic field as a breakthrough in technology of bacterial culture activation of lactic acid bacteria that is very useful for the process of cheese production. Given the difficulty in the process of making cream cheese is generally produced cheese is still less tasty, bitter or sour, one of the factors is the proliferation of lactic acid bacteria in the process of less optimal pengmentation. As an alternative solution, this research will utilize Extremely Low Frequency (ELF) magnetic field for activation of lactic acid bacteria proliferation. Lactic acid bacteria used in this study is a mixture of bacteria *Streptococcus thermophilus* (*S. thermophilus*), *Lactococcus. lactis* (*L. lactis*), and *Lactobacillus acidophilus* (*L. acidophilus*).

The ELF magnetic field is the ELF electromagnetic wave component generated around the electric current.The Gauss law of electric field can be expressed as:

$$\nabla \cdot \mathbf{D} = \rho$$

If the assumption of propagation in a vacuum is used, with ρ = 0 and J = 0, then Maxwell's equation has the following modification with result of formulation written as:

$$\nabla \times \mathbf{H} = \frac{\partial \mathbf{D}}{\partial t}$$

For the propagation of electromagnetic waves in free space, Maxwell's equations are rearranged to be expressed explicitly on time and coordinates.

$$\nabla^2 \mathbf{E} = \mu\epsilon \frac{\partial^2 \mathbf{E}}{\partial t^2}$$

$$\nabla^2 \mathbf{B} = \mu\epsilon \frac{\partial^2 \mathbf{B}}{\partial t^2}$$

In a material, the speed of light is less than *c*. It can be grouped into materials depicted by refraction index, the ratio of the speed of light in vacuum to velocity in a medium

$$n = \frac{c}{v} = \sqrt{\frac{\epsilon\mu}{\epsilon_0\mu_0}}$$

The wave propagation around the strings that move the energy with the wave is proportional to the square of the wave amplitude. Electromagnetic theory explains that energy density (J/m^3) is associated with electromagnetic waves as

$$U = \frac{(\mathbf{D} \cdot \mathbf{E} + \mathbf{B} \cdot \mathbf{H})}{2}$$

Using relation of $\mathbf{D} = \epsilon\mathbf{E}$ and $\mathbf{B} = \mu\mathbf{H}$ if applied in medium of propagation:

$$U = \frac{1}{2}\left(\epsilon E^2 + \frac{B^2}{\mu}\right) = \frac{1}{2}\left(\epsilon + \frac{1}{\mu c^2}\right)E^2$$

In vacuum place:

$$U = \epsilon_0 E^2 = \frac{B^2}{\mu_0}$$

In addition to propagating, the waves also carry energy. The change in energy density (energy per unit of sectional area, each time unit) transferred is represented by the Poynting vector [19]. John Henry Poynting demonstrates that the presence of both electric fields and magnetic fields at the same time in place produces a flow in the energy field, called the Poynting theorem and the Poynting vector described

$$\mathbf{S} = \mathbf{E} \times \mathbf{H}$$

The unit of the Poynting vector is J/(m^2.sec) using the wave field to describe some portion of the vector. **S** involves a quadratic relationship on **E**, it is important to use the actual form of **E**

$$I = |\langle \mathbf{S} \rangle| = \frac{1}{T}\int_{t_0}^{t_0+T} \mathbf{A}\, cos^2\,(\omega t - \mathbf{k}\cdot\mathbf{r} + \phi)dt \text{[20]}$$

The magnetic field on a transmittable carrier is written:
Gauss's law

$$\mu_0 I = \int_0^{2\pi a} B.dl$$

$$\mu_0 I = B.dl|_0^{2\pi a}$$

$$= B(2\pi a) - B(0)$$

$$B = \frac{\mu_0 I}{2\pi a}$$

Based on the formula explains that the intensity of the ELF magnetic field that arises is directly proportional to the electric current flowing in the conductor. If a living being is in an ELF magnetic field, the ELF medal directly interacts with the cell membrane, capable of changing the cell membrane potential, causing the calcium cannal to open, and there is a Ca^{2+} influx that results in an increase in intracellular calcium. Increased intracellular calcium may activate cell propiferation [4]. The impact of exposure to the ELF magnetic field is not linear, but depends on the characteristics of the sample. Exposure of more than 500 μT has a damaging effect. The results of the Sudarti's study (2015) shown that exposure to ELF magnetic fields of less than 300 μT does not cause cellular damage effects, while exposure to ELF magnets of 500 μT suppresses bacterial growth [5].

The intensity of exposure to the ELF magnetic field used in this study was 100 μT and 300 μT with time exposure are 5 minutes, 15 minuntes, 25 minuntes, 35 minuntes, and 45 minutes.

2. Experimental method

This study was an experimental study, with exposure of magnetic field treatment on cultures of *S. thermophilus*, *L. lactis*, and *L. acidophilus* in agar-agar medium. The design of this study used a complete randomized design. This research was conducted at Advanced Physics Laboratory and FMIPA Microbiology Laboratory Building, University of Jember which started from July to December 2016. The ELF magnetic field was produced by current transformer (CT). The voltage regulation (V) was kept minimal (close to zero) and the magnitude of the current adjusted to set the resulting exposure of the ELF field 100 μT and 300 μT. The intensity of exposure ELF magnetic field in a homogeneous CT exposure space, the CT image as the source of the ELF magnetic field is presented in Figure 1.

Figure 1. Current Transformer (ELF Magnetics Source).

The substance of this research is a culture of lactic acid bacteria consisting of three species of bacteria, namely *S. thermophilus*, *L. lactis*, and *L. acidhopilus* bacteria, which were cultured in MRSA (deMannRogosa Sharpe Agar) media. The process of exposure of the ELF magnetic field to the bacteria culture was carried out at the beginning of the breeding process. The group exposed to the ELF magnetic field consisted of a group exposed to ELF 100 μT and 300 μT magnetic fields, each exposed for 5 minutes, 15 minutes, 25 minutes 35 minutes, and 45 minutes. The control group was placed in a place not exposed to an ELF magnetic field from an artificial source. The exposure by current transformer was done at the Physical Education Laboratory of FKIP University of Jember.

Examination of number of *S. thermophilus*, *L. lactis*, and *L. acidophilus* bacteria in control group was done shortly after bacterial isolate was adapted in culture medium (K-0), one hour later when bacteria undergoing adaptation process and called Lag phase (K- 1), the next 2 hours when bacterial proliferation enters Log phase (K-2), and the next 16 hours when bacteria enter the stationary phase (K-16). The examination of the bacterial count of the treatment group was done one hour (E-1), two hours (E-2), and 16 hours (E-16) after exposure to ELF 100 μT and 300 μT magnetic fields for 5 minutes, 15 minutes, 25 minutes, 35 minutes, and 45 minutes in units of CFU (colony forming unit).

3. Results and discussion

Breeding of lactic acid bacteria *S. thermophilus, L. lactis*, and *L. acidophilus* bacteria in the control group described the bacterial proliferation condition as naturally depicted in Figure 2.

Figure 2 shown that the proliferation of *S. thermophilus*, *L. lactis*, and *L. Acidhopilus* bacteria in natural conditions without intervention. In general, the breeding of these three bacteria began to increase at the hour to hour 1 and hour 2, but at the 16th hour decreased. Breeding of bacteria at 1 o'clock shows the bacterial response or adaptation phase; this condition is called lag phase. Breeding of bacteria at 2 o'clock shows logarithmic proliferation rate, this phase is called log phase. The proliferation of bacteria at the 16th hour begins to decrease, so this phase is referred to as the stationary phase. Analysis of the number of *S. thermophilus*, *L. lactis*, *L. Acidhopilus* at the 1st hour (lag phase) after exposure to ELF 100 μT magnetic field for 5 minutes, 15 minutes, and 25 minutes are presented at Figure 3.

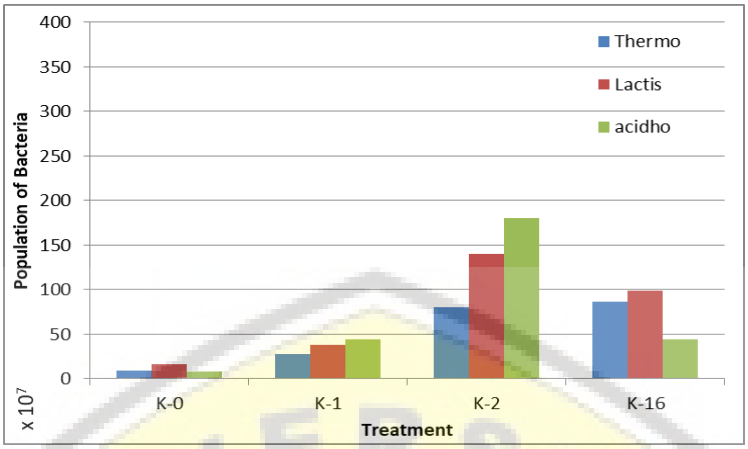

Figure 2. Graphic of Natural Bacteria Growth (control group).

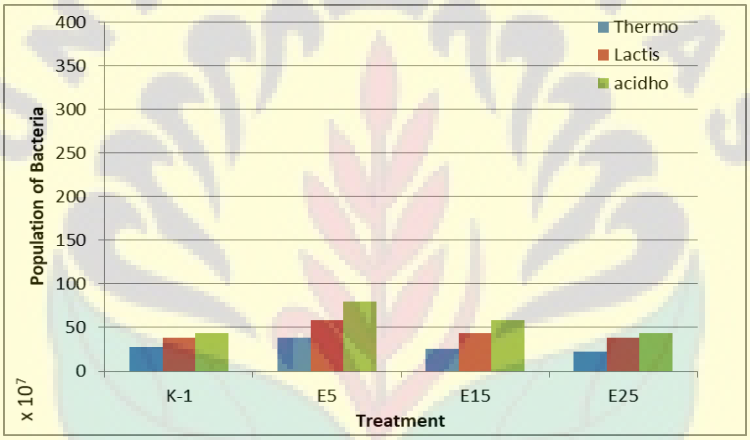

Figure 3. Growth of lag phase bacteria after exposure by ELF magnetic field 100 μT.

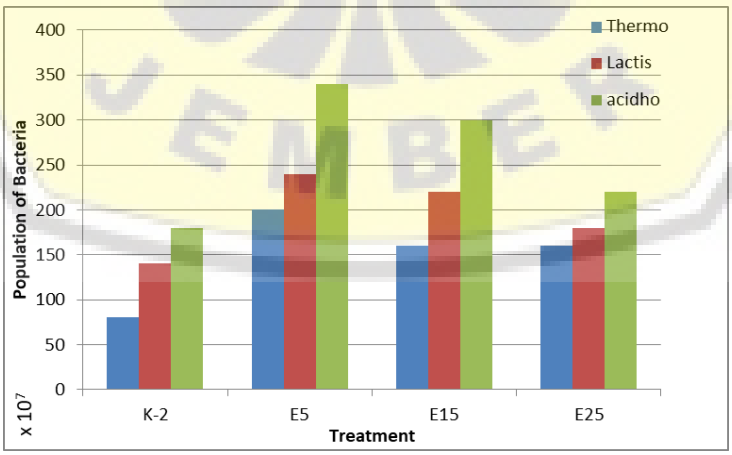

Figure 4. Growth of log phase bacteria after exposure by ELF magnetic field 100 μT.

Breeding of bacteria at 1 o'clock (lag phase), after exposure of ELF 100 μT magnetic field for 5 minutes, 15 minutes, and 25 minutes showed that, the total number of three types of bacteria reached the optimum value occurring in the experiment group of ELF 100 μT for 5 minutes, but the total number of three types of bacteria decreased after exposure to magnetic field 100 μ for 15 minutes and 25 minutes. Further analysis of bacterial count data *S. thermophilus, L. lactis,* and *L. Acidhopilus* in the second clock (log phase) after exposure to ELF 100 μT magnetic field for 5 minutes, 15 minutes, and 25 minutes are presented in Figure 4.

The proliferation of three types of bacteria at log phase (2 o'clock) after exposure to ELF 100 μT magnetic field showed that the number of the three types of bacteria reached the optimum value in the group exposed to ELF 100 μT field for 5 min, and decreased after exposure to 100 μT magnetic field for 15 minutes and 25 minutes but still higher than the control. Furthermore, comparative analysis of bacterial proliferation *S. Thermophilus*, *L. lactis*, and *L. Acidhopilus* after exposure to a 100 μT and 300 μT ELF magnetic field with a 5-minute, 15 minute, and 25-minute exposure in lag phase versus control (K), is presented in Chart 4.4 and the log phase is presented in Figure 5.

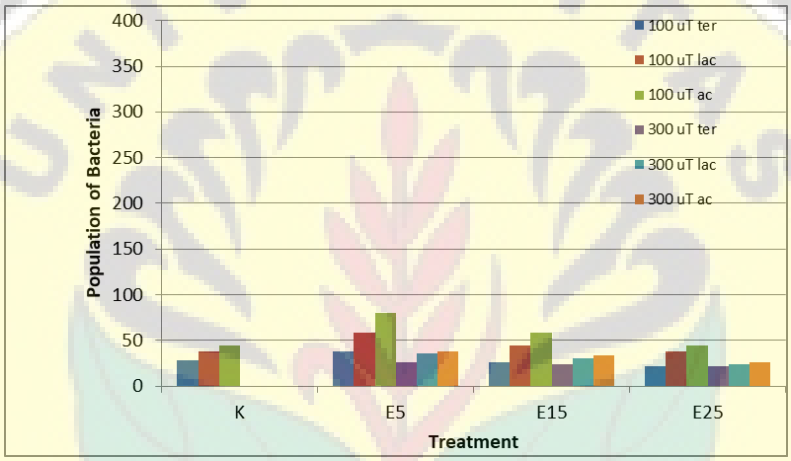

Figure 5. Growth of bcateria lag phase after exposure by ELF magnetic field 100 μT and 300 μT.

The *S. thermophilus* appears to increase only in the group exposed to 100 μT ELF magnetic field for 5 minutes, but the number of *S. thermophilus* bacteria appears to decrease in the group exposed to the ELF magnetic field 100 μT for 15 minutes, 25 minutes, and groups exposed to ELF 300 μT magnetic field. Proven proliferation of three types of *S. thermophilus*, *L. lactis*, and *L. acidhopilus* on lag phase bacteria achieve the optimum value occurs in the bacterial group after exposure to ELF magnetic field with intensity of 100 μT for 5 minutes. Overall, however, the proliferation of three types of bacteria exposed to an ELF magnetic field with an intensity of 300 μT for 5 minutes, 15 minutes, 25 minutes proved to suppress the proliferation of *S. Thermophilus*, *L. lactis*, and *L. acidhopilus* bacteria. Furthermore, comparative analysis of breeding of three types of log phase bacteria after exposure to ELF magnetic field between 100 μT and 300 μT with exposure time of 5 minutes, 15 minutes, and 25 minutes compared to control (K), presented in Figure 6.

Exposure to ELF 100 μT magnetic field for 5 minutes, 15 minutes, and 25 minutes significantly increased bacterial proliferation of *S. thermophilus, L. lactis* and *L. acidhopilus* log phase, but exposure to ELF 300 μT magnetic field for 5 minutes, 15 minutes, and 25 minute significantly suppress the breeding of the three bacteria. The number of bacteria after the 300 μT magnetic field was exposed for 5 minutes, 15 minutes, and 25 minutes lower than the control. Breeding patterns of the three bacteria after exposure to the ELF magnetic field were consistent, with the rate of bacterial proliferation of *L. acidhopilus* being the fastest, and the lowest rate of reproduction occurred in the *S. thermophilus* bacteria.

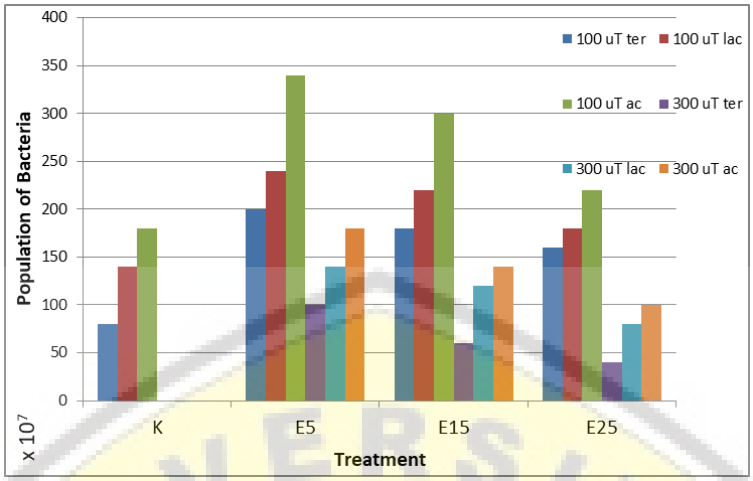

Figure 6. Growth of log phase bacteria after exposure by ELF magnetic field 100 µT and 300 µT.

Based on the descriptive analysis, the proliferation of *S. thermophilus, L lactis* and *L. acidhopilus* bacteria in log phase reached the optimum value in the group exposed to ELF 100 µT magnetic field for 5 min. Subsequent analyses were performed on the proliferation of all three bacteria at the 16th hour (stationary phase) after exposure to a 100 µT ELF magnetic field for 5 minutes, 15 minutes, 25 minutes, 35 minutes, and 45 minutes as presented in Figure 7.

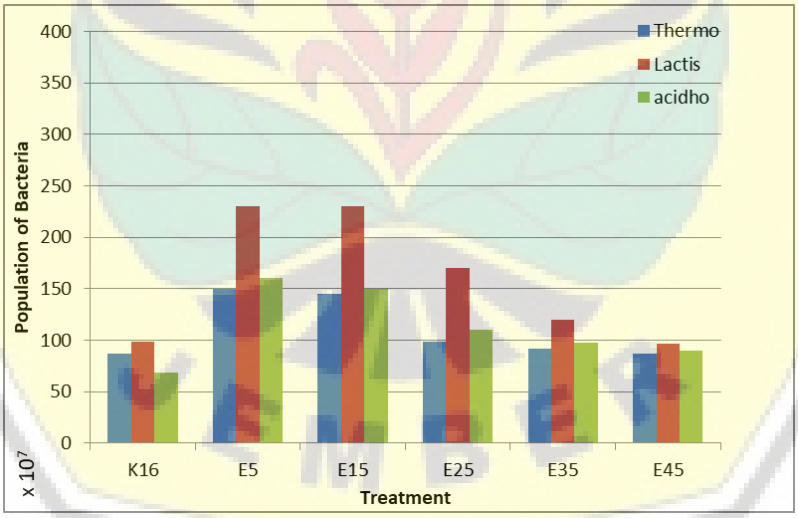

Figure 7. Growth of Stationer phase bacteria after exposure by ELF magnetic field 100 µT.

Proven proliferation of three types of lactic acid bacteria at the stationary phase reached the optimum value in the group exposed to 100 µT intensity ELF magnetic field for 5 minutes and 15 minutes. Furthermore, the total number of three types of bacteria decreased after exposure to ELF 100 µT magnetic field for 25 min, decreased after exposure for 35 min, and decreased again until the position was no different with control after exposure of ELF magnetic field for 45 min. Based on the results of bacterial analysis of *S. thermophilus, L. lactis*, and *L. acidhopilus* after exposure to the ELF magnetic field, the proliferation of the three types of bacteria in the Lag phase and Log phase achieved optimal values in the group exposed to the 100 µT ELF for 5 minutes. However, the proliferation of

these three bacterial strains at the 16th hour achieved optimal values in the group exposed to 100 μT ELF magnetic field for 5 minutes and 15 minutes. It can therefore be concluded that the effective dose of the ELF magnetic field which can trigger the proliferation of *S. thermophilus, L. lactis,* and *L. acidophilus* bacteria optimally is the exposure to the ELF magnetic field at an intensity of 100 μT with an exposure duration of 5 min.

The bacteria *Streptococcus thermophilus*, *Lactococcus lactis*, and *Lactobacillus acidophilus* comprise a group of lactic acid bacteria can be used as a starter in the process of cream cheese. The important role of the bacterial mixture in the cheese-making process can be to produce lactic acid, have the ability to break down proteins, the ability to produce CO_2 gas, and provide the aroma of cheese. The addition of *Lactobacillus acidophilus* bacteria alone proved to produce higher carbohydrates in the soft cheese making process than the addition of mixed *Lactobacillus acidophilus*. The bacteria *Lactobacillus acidophilus* and *Lactococcus lactis* are able to inhibit the growth of pathogenic bacteria, especially *E. coli*, while actor *S. thermophilus* has an important role especially in the formation of textures and flavors in producing cheese.

The ELF magnetic field has the ability to penetrate a variety of materials including biological materials or living things. The ELF magnetic field directly interacts with the cell membrane, exposure to the ELF magnetic field will force the ion and molecules in the cell and cause cell membrane conductivity changes. According to Gobba and Malagoli (2003), the plasma membrane is a magnetic field interaction medium that affects the enzyme activity and the signal path of the transduction. Changes in the conductivity of the cell membrane will cause the opening of calcium canals. This can lead to an increase in intracellular calcium, and it is this condition that plays an important role in the process of cell cycle as a process of cell proliferation.

Several studies have shown that exposure to the ELF magnetic field affects intracellular calcium alteration. Luo FL *et al*., 2014, these findings indicate that ELF-EMF exposure specifically influences the intracellular calcium dynamics via a calcium channel-independent mechanism [5]. While Golbach LA *et al*., 2016, concluded that low-frequency magnetic fields (LF MF) may influence the calcium homeostasis in cells in vitro, thus any potential clinical implications await further investigation. Furthermore, Martynyuk V *et al*., 2015, clarify that however, the 50-Hz field strengthened the basic intracellular calcium concentration in smooth muscle cells (SMC) in a time-dependent manner, whereas the 8-Hz field alone supports calcium levels. Alabovsky VV *et al*., 2016, that a single exposure to 171 MHz electromagnetic field (180 V / m, 0.04 mW / kg) that enhancement of the Na^+/Ca^{2+} exchange towards removing Ca^{2+} from the cardiomyocytes electromagnetic field exposure is a result of Ca^{2+} extraction from the sarcoplasmic reticulum and the increase of its intracellular level. This proves that the exposure of ELF magnetic fields causes biological effects through intracellular calcium alteration mechanisms, and it is evident that exposure to low-intensity ELF (less than 300 μT) ELF magnetic fields is not mutagenic and does not cause cellular damage, but enhances cell proliferation. This has been proved by Belyaev I**,** 2011, that ELF-MF, under specific conditions of exposure, acted as a non-toxic but cell-growth stimulating agent [20]. Verschaeve L, *et al*., 2016, shown that a 100 μT magnetic field (50 Hz) does not damage DNA and hence is not mutagenic in this assay and that there was also no influence on the DNA damaging capacity of the used mutagens [6].

Verschaeve L, *et al*., 2011, that ELF-MFs (50 Hz, 100 and 500 μT, 1 and 2 h exposure) do not induce SOS-based mutagenicity in *S. typhimurium* bacteria and do not show any synergetic effect when combined with chemical mutagens [7]. Oncul *et al*., 2016, these results show that ELF-EMF, 50 Hz, 1 mT (1000 μT) for 2 h affects the crucial physicochemical processes in both Gram-positive and Gram-negative bacteria which need further research [8]. Bayir E *et al*., 2015, the cultures of bacteria in broth media were exposed to ELF-EMF showed a statistically significant decrease compared to their controls in colony forming capability, especially at long exposure times. An exposure to 4 mT-20 Hz ELF-EMF of 6 h produced maximum inhibition of CFU compared to their controls for both microorganisms (95.2% for *S. aureus* and 85% for *E. coli*) [9].

In addition, Martirosyan V, *et al*., 2013, It has been shown that EMF exposure has pronounced stimulation while at 8 Hz, 0.4 mT (400 μT), 30 min it has inhibited cell proliferation [10].Zhang J *et*

al., 2016, results showed both biomass and mannatide production increased significantly at MF induction 0.4, 0.6, and 0.9 mT and decreased at both 1.2 and 1.5 mT. Magnetic field (MF) inductions, exposure times, and exposure periods varied in a range of 0-1.5 mT, 0-16 h, and six periods of incubation time, respectively [11].

Result shown by Huwiler SG, *et al*., 2012, Moreover, short-term exposure (8 min) to the sinusoidal continuous and power line intermittent signal neither affected bacterial growth nor showed evidence for reliable changes in transcription. This experiments did not indicate that the different tested MFs (50 Hz, 1 mT) affected the transcription of *E. coli* [21].

Research by Lugina C, *et al*., 2008, the results indicate that an exposure to 50 Hz EMF (0.1, 0.5, 1.0 mT), acts as a stressing factor on bacteria which can represent a suitable model to investigate acute and chronic effects related to ELF-EMF exposure [30]. Exposure ELF-EMF (50 Hz, 0.5 mT ELF-EMF for 6 h) induces a decrease in growth rate and morphological changes for both Gram-negative and Gram-positive bacteria [18]. Research by Petecchia L *et al*., 2015, The PEMF effect is primarily associated to early enhancement of intracellular calcium concentration, which is proposed here as a reliable hallmark of the osteogenic developmental stage [28]. In addition, Ma Q, *et al*., 2016, suggest that ELF-EMF (50 Hz, 1 mT) exposure for 1, 2, and 3 days with 4 hours per day promotes the neuronal differentiation and neurite outgrowth [14].

Normally cell proliferation is strongly influenced by cell metabolism that is strongly influenced by intracellular calcium ion activity. Cell cycle processes require intracellular calcium activity higher than ordinary conditions, therefore increased intracellular activity of calcium in conditions according to the needs of the cell cycle process will have an impact on increased cell proliferation. However, if an increase in intracellular calcium exceeds the need for a cell cycle process will result in cell death or weakened cell function and impact on cellular proliferation.

The results of this research show that exposure of ELF magnetic field with intensity 100-150 uT intermittently 8 hours/day for 7 weeks and 14 weeks have a significant effect on intracellular calcium increase, thus causing the increase of Germinal apoptosis in Bulb/C mice. Subsequent research of Sudarti, et al, 2014, proves that exposure to ELF magnetic field with intensity of 676 uT can inhibit the proliferation of *Salmonella typhimurium* to 57%. While exposure to Magnetic Field ELF with intensity of 500 μT for 30 min in the process of fermentation of glutinous tape can inhibit microbial proliferation in real 35% at 48 hours [15].

On the contrary, the research results of Sari REYW, Prihandono T, Sudarti, 2015, proved that exposure to ELF magnetic field with intensity 300 μT for 60 minutes can accelerate the growth process of tomato ranti plant. The results of Andika and Sudarti's study, 2016, poved that exposure to ELF magnetic field with intensity of 100 μT for 5 min significantly decreased pH and moisture content in cream cheese making process [16].The results of this study indicate that exposure to ELF magnetic field with intensity of 100 μT for 5 minutes proved to significantly increase the proliferation of *S. thermophilus, L. lactis,* and *L. acidhopilus* bacteries.

It can be stated that exposure to ELF magnetic field with intensity of 100 μT for 5 min is estimated able to interact directly with bacterial membrane, thus causing increase of intracellular calcium as needed in cycle cell process so that mamicu process of cell or bacteria proliferation. However, exposure to the ELF 100 uT magnetic field in more than 25 minutes proved to weaken the bacterial proliferation process, it is estimated that exposure to the ELF 100 uT magnetic field over 25 minutes increases intracellular calcium beyond the requirement in the cycle cell process, resulting in the weakening of the cycle cell process ultimately impact on the inhibition of bacterial proliferation process.

This means that if the cell is placed in an ELF magnetic field, then the cell membrane's electrical potential will be affected.The ELF magnetic field has the properties to penetrate cell membranes, thus affecting uncontrolled cellular intra-cell transport mechanisms. Description of the biological effects caused by exposure to the ELF magnetic field, based on the possibility of a permeability effect on the ion channels contained in the membrane. This can have an impact on cell growth that causes biological changes in organisms [17]. Panagopoulos and Karabarbounis (2002), stated that the relative

magnetic permeability value of the tissue is 1, meaning that the magnetic flux density in the cell is almost similar to the flux density outside the cell.

Some possibilities for the impact of cell growth by exposure to the ELF magnetic field are: 1) the formation of free radicals in cells exposed to the magnetic field, 2) the change in the concentration of ions under exposure to the magnetic field [17]. Blank and L. Soo (2001) suggest that any change in membrane transport activity is detected by the movement of molecules and ions across the plasma membrane. This movement can cause changes in metabolic activity.

Based on the theoretical study that has been done, the Maxwell III equation states that the magnetic field changes can produce induced currents. The presence of exposure to the magnetic field creates changes in the movement of Ca^{2+} ions in the extracellular crossing of the cell membrane while the induced current by the ELF magnetic field will increase the rate of movement of Ca^{2+} ions through the magnetic flux density region. Fields exposed to magnetic fields will produce strength in Ca^{2+} ions to move and are actively bound to the protein channel and affect the channel gate opening conditions. The vibrations due to the ELF flux density line density at a time will exceed some critical values, resulting in rotation or movement of ions which can give false signals to the gate gate of the channel on the cell membrane, and cause errors in the electrochemical balance of the cell membrane and its continuity to the whole cell function [17]. Ca^{2+} ion is an ion in cells that have high sensitivity to exposure to ELF magnetic field, this is because Ca2 + ions are classified as paramagnetic materials and have a positive susceptibility price. The properties of a paramagnetic material can be affected by the magnetic field (termagnetization). The form of magnetic field influence on the material is the spin of electrons found in the material that was originally randomly directed by the magnetic field.The potential change of the cell membrane will at some extent be able to open Ca^{2+} canal, this condition will fall on the transport of Ca^{2+} ions and under certain conditions affect the increase of Ca^{2+} influk. The transport activity of Ca^{2+} influk is needed in the growth process of the cell or Cell Cycle, so that in the appropriate conditions it will trigger cell proliferation, but on the condition of the high enough Ca^{2+} influk transport activity will result in cell death. Exposure to high-intensity ELF magnetic fields (greater than 600 μT) will have an impact on cell death, but at low intensity (less than 300 μT) have an impact on increased cell proliferation.

Increased growth of *S. thermophilus*, *L. lactis*, and *L. acidophilus* bacteria will result in a decrease in pH value in the medium. Increasing the rate of bacterial growth will effect the increased production of lactic acid, thereby effecting the decrease in pH value of the medium.

4. Conclusion

Based on data analysis and discussion of the results of this study, can be formulated some conclusions that the effective dose of exposure to ELF magnetic field affecting the speed of bacterial proliferation of *S. thermophilus*, *L. lactis*, and *L. acidhopilus* is exposure at intensity of 100 μT for 5 min.

Based on the results of the discussion of the results of this study, can be formulated some suggestions as follows.

a. Need to further research the implementation of effective dose of exposure to ELF magnetic field in the process of cream cheese ripening.
b. It is necessary to further study the effective dose of exposure to ELF magnetic field to the death of pathogenic bacteria in cream cheese making process.

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