The Influence of Extremely Low Frequency (ELF) Magnetic Field Exposure on The Process of Making Cream Cheese

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Abstract— Extremely Low Frequency (ELF) Magnetic field exposure in bacteria can impact the proliferation process. Cheese is one of the milk products produced by the process of fermentation using mesophilic and thermophilic bacteria. However, the taste of the cheese is commonly not good, bitter or too salty. It happens because the growth of mesophilic and thermophilic bacteria often fail. Thus, it needs an effective method to optimilize the growth of mesophilic and thermophilic bacteria. As the alternative solution, this research applies ELF magnetic field to activate the mesophilic and thermophilic bacteria. The intencity of the ELF magnetic field used 100 µT by the exposure of about 5 minutes, 20 minutes, 35 minutes, 50 minutes, and 65 minutes. The indicators used in this research are pH and moisture. The process of exposing ELF magnetic field was conducted in physics laboratory of Faculty of Teaching and Education University of Jember, while measuring pH was conducted in microbiology laboratory of Faculty of Teaching and Education University of Jember and measuring moisture was conducted in microbiology laboratory of Faculty of Mathematics and Sciences University of Jember. The result of this research confirmed that the pH and moisture at the controlled group are 5,50 and 85,6%. The pH and moisture at the exposed ELF magnetic field group 100 µT for 5 minutes and 20 minutes were lower than the controlled group. Based on the descriptive analysis, it can be seen that the decreasing happened at the 5 minutes exposed group at the time of 25 and 30 after the exposed ELF magnetic field. Therefore, it can be concluded that the effective dose to reduce the pH and moisture is the exposure to the ELF magnetic fields of 100 µT for 5 minutes.

Keywords— extremely low frequency magnetic fields, acid bacteria, pH, moisture.

INTRODUCTION

The use of magnetic field is mostly used in various fields, one of them is in food sectors. The magnetic field usage in food sectors is mostly used in the process of preserving. ELF magnetic field exposure is 6,7 T for 20 minutes in the process of preserving apple extract (*Mallus sylvestris Mill*) can impact the decreasing of 99,45% microbe, while the exposure on the same intencity for 25 minutes can impact the decreasing 99,96% microbe [1]. As todays' usage of ELF magnetic field in the food sectors aims to kill the disadvantages bacteria found in the food. Bacteria can be divided into two, advantages and disadvantages bacteria. The advantages bacteria in the food sectors, i.e., the bacteria used in the use of the process of making milk into cheese and yoghurt. The growth of the advantages bacteria is crucial in the process of making food.

ELF magnetic field exposure can be used to increase the growth of the bacteria itself. Some characteristics of ELF magnetic field are the frequency of less than 300 Hz, non ionizing radiation, and non termal radiation. The magnetic field in the bacteria can impact the process of cell proliferation [2]. Another research showed that ELF magnetic field exposure of 20 – 32 µT in an intermittent way for 8 hours/day for 15 hours and 30 days can increase cytocol Ca^{2+} ionic in mencit Bablb/C [3]. The previous study conducted also showed that there is an increasing of the growth mesophilic bacteria and thermophilic bacteria in the process of making cream cheese.

Food becomes a primary need for human in daily life. Milk is one of the food materials which has high calsium and nutrition. Some places that produce milk in Jember are Rembangan, Garahan, and Mangli. However, based on the observation conducted on March 2014, it was found that production of fresh milk in Jember only limit on the pasteuritation milk product, yoghurt and ice cream. Meanwhile, fresh milk with its high nutrition contents can be processed into other derivative products with long-term storage and it also has high economical value, one of them is cheese which is, until now, not produced yet in Jember.

Cheese is one of comestibles which has good storage mode and rich of proteins, fat, calcium, fosfor, riboflavin, and other vitamins in concentration form. The concentration nutrition contents can be very benefit compared with the milk with much water. The protein contents of 100 grams of soft cheese is equivalent to 185 grams of egg, 111 grams of chicken, 144 grams of meat, or 1086 grams of potatoes. The fat content in 100 grams of soft cheese is equivalent to 247 grams of eggs, 593 grams of chicken, 104 grams of meat, or 25500 grams of potatoes [4]. The cheese consumption period is longer than milk because solid cheese can last for months, even years and the soft cheese can last until two weeks if it is saved in a plastic bag or package. Another superiority of cheese is that it has a selling value and the higher target market compared with milk or yoghurt.

Cream cheese is a kind of cheese whose process of making is relatively quick by using simple method. However, in order to get the cream cheese with great ripeness level and in a short time is not that easy. Based on interview with enterpreneur of cheese and yoghurt in Batu, Malang, he states that it happens because the making process formulated by Mesophilic and Thermophilic bacteria often fail. Based on the explanation noted above, it highly requires certain experiment to make a test of the influence of dose intencity and various time of ELF magnetic field exposure towards the ripeness of the cream cheese, so the data can be a guidance for determining the time estimation of the exposure that is whether suitable and benefit.

This research aims to explore the influence of the time estimation of ELF magnetic field exposure 100 µT for 5 minutes, 20 minutes, 35 minutes, 50 minutes, and 65 minutes to the pH and moisture of cream cheese.

METHOD

The type of this research is experimental research. The research design used in this research is randomized subject post test only control group design. This research is conducted in physics laboratory and microbiology laboratory of Faculty of Teaching and Education at 3rd building, and microbiology laboratory of Faculty of Mathematics and Sciences University of Jember started from March to May 2015.

The tools used in this research are current transformer, measuring cylinder, volume pipette, stirrer, glass cup, thin cotton fibric, pH meterrs, cup, oven, and balance. The materials are dairy milk which had been pasteurized, that is skimmed milk (skimmed milk of pasteurized Diamond), Meshophilic and Thermophilic bacteria, and rennet.

The procedure applied in this research are sampling, processing, measuring the pH and moisture. The samples are cream cheese made of dairy milk which is given the Meshophilic and Thermophilic bacteria and the rannet of about 72 samples and each sample had 100 ml volume, each group had 12 samples. The instruction of determining the samples uses 'federer' formulation as follows:

$$(t-1)(r-1) \geq 15 \quad (1)$$

Description : r = the number of repetition
t = the number of process

The process of ELF magnetic field exposure 100 µT is conducted for 5 minutes, 20 minutes, 35 minutes, 50 minutes, and 65 minutes in experimental group. The control group lets to expose by the natural magnetic field,

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that is by putting it on outdoor without sunlight. The process of measuring to determine the time estimation of cheese ripeness is done three times, at the 20th hour, 25th hour, and 30th hour by measuring the pH and moisture with oven application. The data analysis used in this research is descriptive analysis.

RESULT AND DISCUSSION

This research aims to explore the influence of the time estimation of ELF magnetic field exposure 100 μT of cream cheese. The result of pH measurement in cream cheese can be seen in Table 1.

Table 1. Result of pH measurement in cream cheese

pH value	Measurement (at hour)			
	0	20	25	30
Control	6,7	5,75	5,60	5,50
5 minutes exposure	6,7	5,63	5,38	5,35
20 minutes exposure	6,7	5,60	5,53	5,40
35 minutes exposure	6,7	5,60	5,58	5,50
50 minutes exposure	6,7	5,55	5,55	5,53
65 minutes exposure	6,7	5,58	5,65	5,55

The cream cheese is categorized 'ripeness' if the pH value of the samples is 5,50. Based on the result of pH measurement in cream cheese as shown in Table 1, the samples of ripeness cream cheese that can be sorted first os the samples on experimental group I, experimental group II, experimental group III, and control group. The result as shown in Table 1 can also be presented in the form of graph as follows.

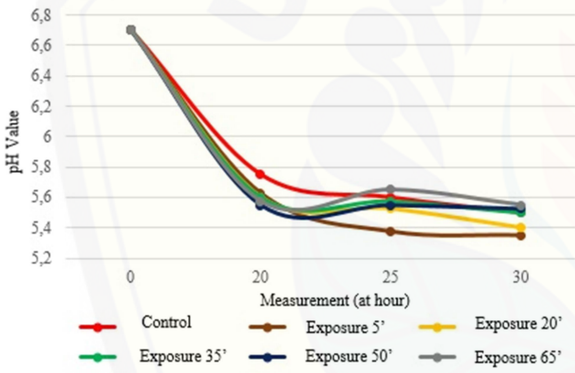

Figure 1. Graph of the result of pH measurement in cream cheese

Figure 1 shows that the pH value in cream cheese is generally decreasing on each measurement. The lowest decreasing pH value occurs on the samples of experimental group I. Experimental group I and II decrease faster than control group. It is so because the rate of the growth of Mesophilic and Thermophilic bacteria in the samples of experimental group I and II is higher than the samples of control group.

The magnetic field has biological effect of ELF that can impact the level of the growth of cell that changes [5], the number of RNA and proteins transcript that changes [6], and the nature of the surface of the cell that changes [7]. According to [8] , the value of magnetic permeability relatively from the glands is 1. Therefore, the density of magnetic flux in the cell is almost similar with the density of magnetic flux outside the cell. ELF magnetic field can normally pierce the cell membrane of in vitro [9]. The magnetic field plays on the plasma membrane through the interaction medium that affects the activity of an enzyme and the signals transduction [10].

Ionic flew through the proteins channels is affected by the chemical and electrical potency on cell membrane. If the cell is put in the environment with electrical area, the elctrical potency of cellular membrane will be affected. The presence of strong magnetic field will affect the environment. This potency will storm in all potencies of the cell and make it uncontrolled for the ionic motion while passing the membrane [11]. According to [7], every single change of the activity of membrane tranportation is detected by ionic and molecular motion that pass the plasma membrane. The motion can impact the change of metabolic activity.

Maxwell III equation stated that the change of magnetic field can produce induction current. The magnetic exposure creates the change of Ca^{2+} ioinic motion in extracellular that pass the cell membrane, while the induction current produced by the change of magnetic field can improve the rate of Ca^{2+} ioinic motion through the area of magnetic flux density. The exposured are of the magentic field will produce the strenght to the Ca^{2+} ioinic motion to move and actively to be tied in proteins channels and it can affect the condition of the channels gate opening. The vibration produced by the flux density lines of magentic field will occasionally be beyond the critical value, so there is an inonic motion and rotation that can give the fake signal to the gate of cell membrane, and it will also cause the error of electrochemistry balance of cell membrane and its sustainability to the overall cells function [2].

Ca^{2+} ioinic is an ion lied in cell that can affect the magnetic field. It is so because the Ca^{2+} ioinic belongs to paramagnetic materials and has positive susceptibility value. The nature of paramagnetic materials can be affected by magnetic field (maagnetized). The growth of the increasing Mesophilic and Thermophilic bacteria will affect the decreasing of pH in the cream cheese. The decreasing is affected by the bacteria which is used in this research, that is a bacteria producing lactic acid, so the more bacteria produced, the higher lactic acid production and the lower pH will be.

In addition, the samples on experimental group III had the same time estimation of 'ripeness' with the control group. It happens because the rate of the growth of both bacteria on the experimental group III decrease and they had the same rate of growth with the samples on the control group. Whereas the samples in experimental group IV and V did not reach the time estimation of 'ripeness' on the measurement at hour of 30. It happens because the growth of both bacteria decrease and the rate of the growth is under the rate of both bacteria on the control group. The over provision of magnetic field can decrease the rate of the growth of both bacteria. According [1] stated that the movement of over energy produces the increasing of the rate, and the rate of ion Ca^{2+} motion while passing the cell membrane. The area of magnetic field interaction is the cellular glands that is mostly affected by magnetic field. The ionics also resulted in the magnetic field from the area of interaction to the glands and other organs. Over effects of magnetic field would finally destroy the cellular proteins. The broken proteins in a cell resulted in the obstruction of cellular metabolism processes, so the activity of the bacteria producing acid would be disturbed.

Another indicator to determine the cheese ripeness is moisture. In some food sectors, the moisture in a relatively big amount, i.e., in a fresh milk is around 87%, and fresh meat is around 70%. The result of moisture measurement in cream cheese can be seen in Table 2. Cream cheese is categorized 'ripeness' if the moisture of the samples is 85,6%.

Table 2. Result of moisture measurement in cream cheese

Moisture Rate	Measurement (at hour)			
	0	20	25	30
Control	91%	88,3%	86,6%	85,6%
5 minutes exposure	91%	84,3%	81,6%	79,7%
20 minutes exposure	91%	86,1%	85,7%	84,5%
35 minutes exposure	91%	87,5%	86,0%	85,5%
50 minutes exposure	91%	88,0%	86,5%	86,2%
65 minutes exposure	91%	88,2%	86,9%	86,5%

Based on the result of the measurement as shown in Table 2, it can be seen that the samples of cream cheese which had been 'ripeness' first is the samples of cream cheese on the experimental group I, experimental group II, experimental group III, and control group. The data can also be presented in the following graph.

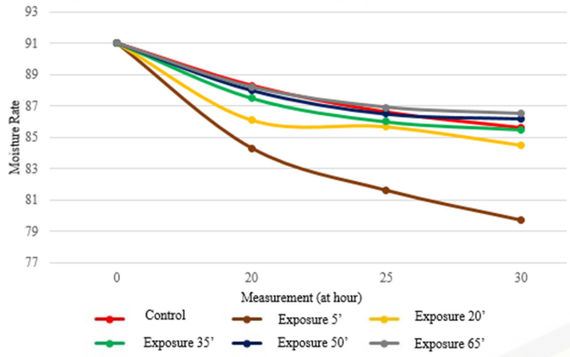

Figure 2. Graph of the result of moisture measurement in cream cheese

Based on the result as presented in Figure 2, it can be seen that the moisture in cream chese on all groups both the experimental group and the control group had decreased in each measurement. It also shows that the samples on the group of experiement I is the samples decreasung the lowest moisture.

Regarding of the explanation about the influence of ELF magnetic to pH and moisture in cream cheese, the growth of the increasing of Mesophilic and Thermophilic bacteria would affect the decreasing of moisture in the cheese. The decreasing itself is affected by the acid produced by both bacteria. The change of pH which is getting sour would affect the change of amino acid polarization. If the proteins polarization increased, the amount of moisture would also increase. Besides, the process of denaturating proteins by the acid would result in the decreasing of denaturating proteins solubility. The molecular cell which is hydrophobic would come out, while the part of hydrophilic would be folded inside. The folding or the flap would occur if the proteins reaches isoelectric pH which the proteins then would clump and settle [12]. The clumping and deposition resulted in the increasing of viscosity.

The samples on the group of experiment III had the time estimation which is almost the same with the samples on the group of control. It is affected by the rate of the growth of both bacteria on the former group which decreased and had the rate of growth which is almost the same with the latter group. The samples of the experimental group IV and the samples of the experimental group V on the measurement at hour of 30th did not reach the time estimation of 'ripeness' yet. It is affected by the rate of the growth of both bacteria that decreased and the rate of the growth

The decreasing of the rate of the growth if both bacteria resulted in the decreasing of the moisture in the cheese that became slower. The slow of the decreasing of moisture in the cheese is affected by the lack of acid produced by both bacteria. The lack of the acid resulted in denaturating proteins in the milk became slower, so the moisture would be more.

CONCLUSION AND SUGGESTION

Based on the previous result and the explanation, it can be drawn a conclusion that regarding the various time estimation of ELF magnetic field exposure used in the process of making milk, the most influencing time estimation of the exposure to the decreasing of pH and moisture in cream cheese is the exposure at minute of 5. Thus, the effective dose to decrease the pH and moisture in the cream cheese is ELF magnetic exposure 100 µT for 5 minutes.

Based on the conclusion above, the suggestion is intended to have further research with: 1) a span of the shorter time estimation of the exposure, between 5-15 minutes to find out the time estimation of the more effective ELF magnetic field exposure in the process of making cream cheese. 2) a span of the shorter time estimation of the measurement to find out the exact time of cream cheese ripeness. 3) using some other indicators to determine the cheese ripeness, such as fat contents, proteins and carbohydrates. 4) using different intensity, less than 100 µT or more than 100 µT. 5) other kinds of processed foods.

I have no any conflict of interest in submitting this manuscript. I am delighted to say that the one and only intention in submitting this manuscript is just for publishing and inspiring the human being.

REFERENCES

[1] Sari, et al. 2012. "Proses Pengawetan Sari Buah Apel (Mallus Sylvestris Mill) Secara Non-Termal Berbasis Teknologi Oscillating Magneting Field (OMF). Journal of Agricultural Technology. Vol. 13 No. 2:78—87.

[2] Grubner, S. J. 2011. "Peningkatan Proliferasi Kultur Sel punca mesenkim Asal darah tepi melalui pemaparan medan magnet disk Permanen 200 mt selama dua dan empat jam per hari". Unpublished research. Thesis. Jakarta: University of Indonesia.

[3] Sudarti, et al. 2006. "The Influence of Extremely Low Frequency (ELF) Magnetic Fields Induction to The Production of IFN- γ On Balb/C Mice. Folia Medica Indonesia". Vol. 42 No. 2:4-10

[4] Daulay, D. 1990. Fermentasi Keju. Bogor: The Center among Universities Food and Nutrition Bogor Institute of Agriculture.

[5] Dong, et al. 2010. "Effects of Extremely Low Frequency Magnetic Field on Growth, Metabolism and Differentiation of Human Mesenchymal Stem Cells". Electromagnetic Biology and Medicine. Vol. 29 No. 2:165-176

[6] Stange, B., & Rowland, R. 2002. "ELF Magnetic Fields Increase Amino Acid Uptake Into Vicia fabaL.Roots and Alter Ion Movement Across the Plasma Membrane". Bioelectromagnetics. Vol. 23 No. 3: 277-282.

[7] Blank, M., & Soo, L. 2001. "Optimal Frequencies in Magnetic Field Acceleration of Cytochrome Oxidase and Na, K-ATPase Reactions". Bioelectrochemistry. Vol. 53 No. 3:171-174.

[8] Panagopoulos, D., & Karabarbounis, A. 2002. "Mechanism for Action of Electromagnetic Fields on Cells". Biochemical And Biophysical Research Communications, Vol. 27 No. 2:95-102.

[9] Yao, C., & Sun, C. 2004. "Experimental Studies on Killing and Inhibiting Effects of Steep Pulsed Electric Field (SPEF) to Target Cancer Cell and Solid Tumor". IEEE Transactions on Plasma Science. Vol. 32 No, 3:1626-1633.

[10] Gobba, F., & Malagoli, D. 2003. "Effects of 50 Hz Magnetic Fields on fMLP-Induced Shape Changes in Invertebrate Immunocytes: The Role of Calcium Ion Channels". Bioelectromagnetics. Vol. 24 No. 1: 347-354.

[11] Gaafar, et al. 2006. Stimulation and Control of E.Colli by Using an Extremely Low Frequency Magnetic Field. Romanian J. Biophysic, Vol. 16 No. 4: 283-296

[12] Anna, P. 1994. Dasar-Dasar Biokimia. Jakarta: UI-Press.