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Electrical Impedance Analysis of the Mixture of Lard in Beef Fat by Electrical Spectroscopy Method Using Four Probes

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Abstract— *This research discusses the electrical impedance measurements using the four-probe method on the lard and beef fat. This research is a continuation of previous studies that do fat impedance measurements at high frequencies by using the two-probe method. Analysis of four probe models can indicate changes in the electrical properties of the material when the material contains different liquid media based on its impedance and minimizes the effect of the double layer. The saturated and unsaturated fatty acids contained in each fat will determine the electrical properties of the material In this study, will explain four-probe electrical impedance measurements of lard fat mixture in beef fat by giving 100 µA current at a frequency of 1 Hz to 1MHz. The results showed that the electrical impedance of both fats decreased with increasing frequency. The electrical impedance of the fat cows smaller than lard. The impedance meter works well at frequencies up to 1 Hz-1MHz. The addition of the mixture concentration of lard will cause an increase in the value of the electric impedance of beef fat.*

Keywords— *Electrical impedance, mixture, lard, beef fat.*

I. INTRODUCTION

Impedance spectroscopy is an established and stable method. Biolelectrical property measurements with impedance spectroscopy more efficiently because of the analysis process faster and simple instrument. In food, bioelectric properties are generally used to assess the quality and purity of ingredients quickly, non-destructively. This method has been used to detect additives in food [1], analyze and monitor the quality of food such as of fruits and vegetables [2], [3], and separate olive oil from other vegetable oils [4]. The effect of NaCl concentration on the ionic NaCl solutions electrical impedance [5]. The dielectric properties of a material are determined by frequency, temperature, air composition, density, composition, and material structure [6].

The nature of impedance is very complex because it is influenced by the internal conditions of the material so that the shape and arrangement of the electrodes (probes) become very influential on the measurement results. The connection between the electrode and the current source is very important for the impedance value [7]. Therefore it is necessary techniques and analysis that is fast, accurate, and relatively inexpensive to analyze the quality and purity of a material based on impedance, one with a four probe method.

This paper studies the bioelectric properties of lard and beef fat by measuring its impedance at different frequencies. In previous studies, electrical impedance measurements of various types of fat samples using LCR meter GW-instek series 816 and method 2 probes at high frequencies have not shown satisfactory results. The same study was also carried out by using PICO-SCOPE S-5000 with samples of various types of fat at a frequency of 100 Hz-10 kHz unable to show the impedance value of the mixture of lard on fat properly [8].

In this study, Randles Model is used as an equivalent electric circuit approach. The Resistance of biological material is a significant factor in the impedance of a bioelectric system. So in this study, the measurement of electrical impedance in the mixture of lard into beef fat was carried out by the four probe method with a frequency of 1 Hz to 1 MHz.

II. RESEARCH METHODS

A. Impedance Measurement System

Test equipment used is the PicoScope 5000 series that serves as a measure of electrical impedance and capacitance. PicoScope uses 2 channels for Vin and Vout. The circuit is equipped with an AC signal generator that can be operated up to a frequency of 20 MHz. In an AC signal generator, the amplitude and frequency can be set with the default software installed on the PC. The voltage generator on the PicoScope is set to the input voltage of 1 Volt with a frequency of 1 Hz to 1 MHz. As for the output of the voltage signal obtained from the voltage that has been amplified by the amplifier circuit in the V to I converter.

V to I converter is a voltage converter into an electric current that will be injected on the measured sample. The injected current depends on the type of sample and as needed. Channel 1 on the PicoScope is used to issue input voltages for parallel plates. While channel 2 is used to record the output voltage of parallel plates.

In this study, the voltage generator is set to produce a voltage of 1 V with a frequency of 1 - 1 MHz. The data acquisition system of an electrical impedance measuring device uses four electrode probes, where two electrodes are sensors, the other two are for visiting the current and voltage, as shown in Figure 1. The electrode probe is made of gold which has a dimension of 2.3 cm; outer diameter of 2.7 cm; inner diameter (side) 0.7 cm; inner diameter (top) 0.4 cm and distance between needles 0.3 cm. While in the tube inner diameter of 2.3 cm and an outer diameter of 2.7 cm. The needle on the lid has a diameter of 0.7 cm. The hardware measures data acquisition systems and computers with programmable software that supports the system.

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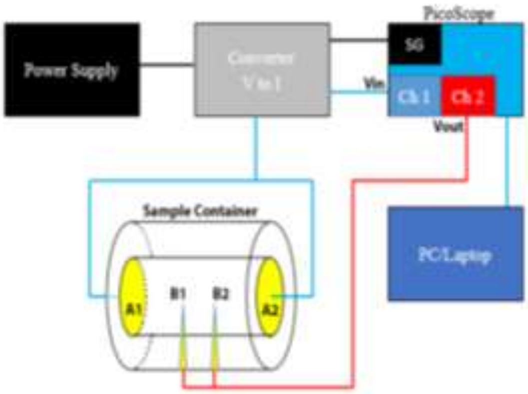

Fig. 1. Measurement system design.

B. *Sample Preparation*

Preparation of samples of lard and beef fat as done in previous studies. The fat obtained is obtained from the market. Addition of lard to other fat samples with concentrated fat of 15%, 10%, 5%, 4.5%, 4%, 3.5%, 3%, 2.5%, 2%, 1.5%, 1% , 0.5%, 0.4%, 0.3%, 0.2% and 0.1%. Fat samples were placed in a four probe reactor. Impedance readings are taken in the voltage signal frequency range from 1Hz to 1 MHz.

The output voltage of the double probe is further amplified by instrumentation amplifiers, to be subsequently recorded by Picospoce Ch-2. At the same time, the voltage signal from Picoscope is recorded on Ch-1 as a current reference. The electrical impedance value is obtained from the calculation of the measured voltage divided by the value of the injected AC current of 100μA.

III. Results and Discussion

In previous studies, the value of fat impedance has not been well differentiated. That is, at a low frequency there is no impedance value. Impedance measurement using two electrodes allows a very large double layer event because ions from the solution will combine with electrons originating from the electrode when injecting the current in the sample. This causes the impedance value measured by changes in the voltage on the electrode impedance is not purely of a solution because it is influenced by the resistance and capacitance electrodes. So that this causes the measurement of impedance at a low frequency not measured because the wave is Cut Off. In addition, at high frequencies, the signal decreases with increasing frequency.

The addition of two (probe) electrodes on the two probe method is the impedance measurement by using four electrodes. Two electrodes are used to inject the current in the sample while the other two electrodes are used to measure the difference in voltage present in the sample so that no double layer events occur. The outcomes measured were representing the impedance value of the measured material.

From the graph above it can be seen that in general, the impedance value of each fat decreases when there is an increase in frequency. The maximum impedance value when the frequency range is 1 Hz - 1 kHz. The impedance value decreases in the frequency range of 1 kHz - 100 kHz. The minimum impedance value occurs in the frequency range 100 kHz - 1 MHz. In the frequency range of 1Hz to 2 kHz, the measurement system is still able to detect and distinguish between two different types of pure fat. However, at frequencies above 5 kHz impedance value difference is getting smaller.

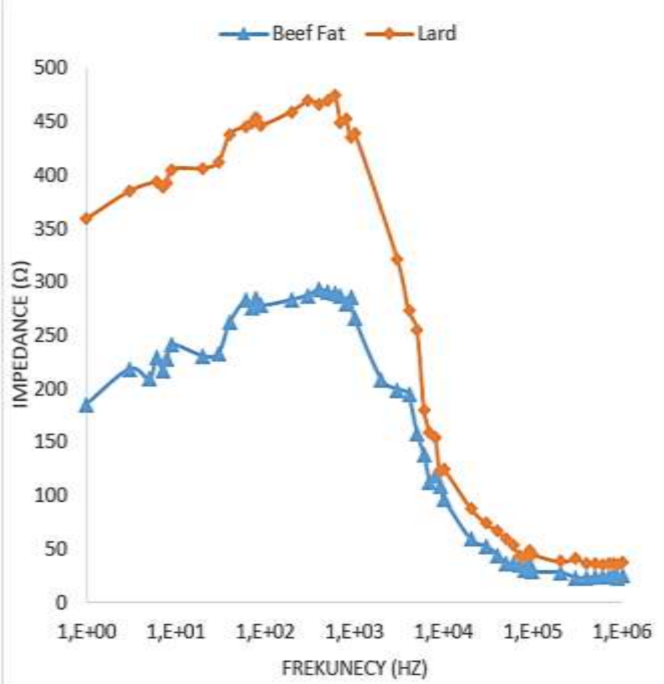

Fig. 2. The impedance versus frequency relationship of fat.

The average impedance value of beef fat is smaller than lard for all frequency ranges. Differences in the composition of each fat becom the main cause, especially for unsaturated fats greatly affect the impedance value. Fat impedance is influenced by the composition of unsaturated fatty acids from each fat. The composition of saturated fat in beef fat is greater than that of lard. So as the saturated fat composition that the greater it will cause the impedance of the smaller pure beef fat lard.

Types of fatty acids, namely fatty acids that have carbon-carbon double bonds are called unsaturated fatty acids, especially for oleic acid (C18: 1) and linoleic acid (C18: 2), and fatty acids that have no double bonds are called saturated fatty acids. At the time of a certain frequency is given to fatty predominantly unsaturated fatty acids are great, the activation energy is used for movement of electrons from one position to another and has a higher polarity[9].

The injected fat sample measuring tube is basically an insulating material that can weaken and greatly inhibit the electric field. Besides fat to have molecules that are non-polar. In a dielectric molecule with non-polar properties, if there is an influence of an external electric field, the molecular dielectric molecule will induce a moment of the dipole moment in the direction of the field. Dielectric weakens the electric field early because of the dipole moment in the direction of the electric field or the field is polarized by an electric field additional opposite direction to the initial field [10].

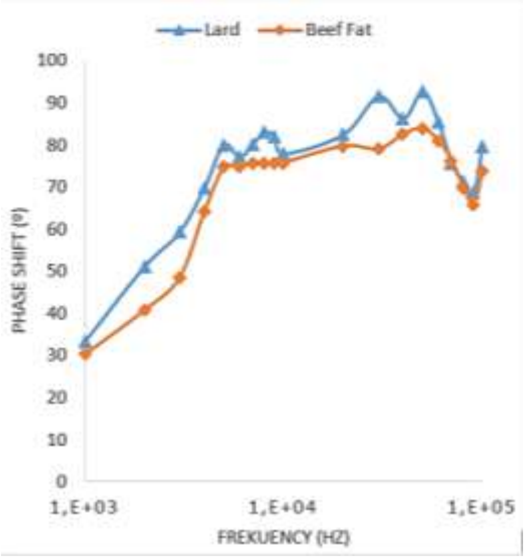

Fig. 3. Fat phase shift at frequency of 1 kHz - 100 kHz.

In non-polar molecules, the atomic atom in it tends to be random while for the polar molecule the atomic atom has formed a permanent electric dipole. Beef tallow and lard have non-polar molecules (aprotic). Non-polar molecules in a solution have a dipole if the molecule is placed in an electric field because the field pushes positive charges in the molecule in the electric field and pushes the negative charge towards the opposite of the electric field.

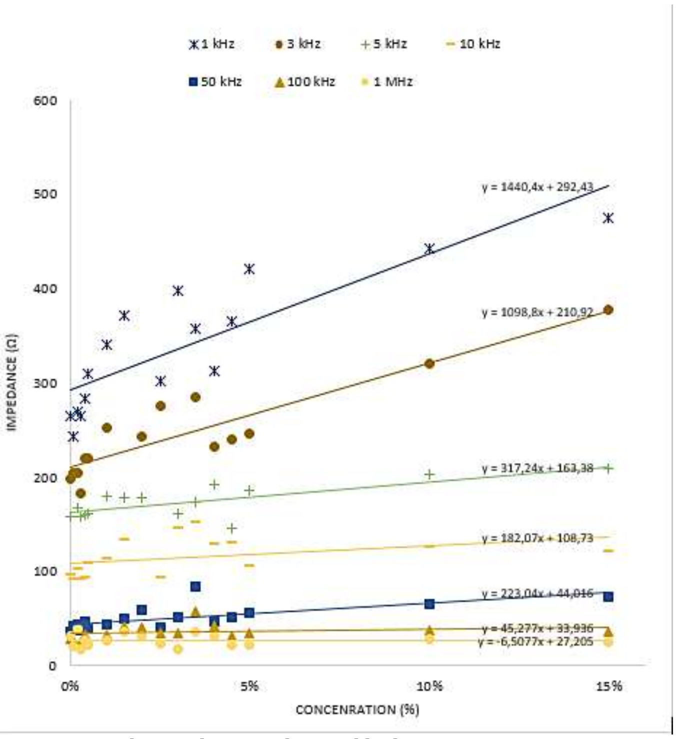

Fig. 4. Impedance value towards Mixed lard at various concentrations at a frequency of 1 kHz to MHz.

The figure 4 shows that the greater the concentration of a mixture of lard given in beef fat then increasing impedance values mixture of the pure fat impedance value

Figure 3 is a plot of the graph of the impedance value for the selected frequency from 1 kHz to 1MHz to the concentration value of the mixed lard given to beef fat. In general the impedance value at the frequency of 1 kHz - 5 kHz increases by 150 Ω. The electrical impedance values for low mix concentrations tend to fluctuate because the addition of the percentage of lard is getting smaller, the composition of beef fat experiences very little embryo which affects the value. In Figure 3, it shows that the phase shift decreases from the frequency of 1 kHz-100 kHz where the lower the frequency the phase shift value decreases to near zero and tends to be stable.

The difference in impedance value is caused by the composition of each material that is different, so the impedance value is also different. The nature of this electricity is used to recognize changes in the composition of materials due to a decrease in quality and/or counterfeiting of materials [11]. Biological networks, especially meat, muscle and fat, have anisotropic impedances, namely impedances that vary based on whether the current run parallel or perpendicular. So that the impedance value decreases with increasing frequency

IV. CONCLUSION

Impedance spectroscopy analysis with four-probe method injection electrode with a current of 100 μA can distinguish lard and beef tallow at a frequency of 1 Hz to 1 MHz. Addition of the concentration of lard will cause the beef fat impedance to increase.

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