CHAPTER 1

INTRODUCTION

1.1 Background of study

Meat is widely used as food in our daily life. However, meat can be characterized into two which is slaughtered and non-slaughtered. The purpose of this project is to determine the values of capacitance for respective applied frequencies. This project also comes out with the capacitor's prototype to differentiate between slaughtered and non-slaughtered chicken meat. Slaughtered and non-slaughtered chicken meat will be used as dielectric medium of the capacitor placed in series connection of RC circuit. Different values of the dielectric constant were obtained due to variation of the frequencies and time of slaughtering.

1.2 Problem Statement

Nowadays, people tend to buy the meat without proper checking of the meat. Properly slaughtered meat and non-slaughtered (improperly slaughtered) meat are difficult to differentiate in real life situation. This project basically aims to analyze the difference between slaughtered and non-slaughtered meat.

1.2.1 Problem Identification

For the project, the capacitance values of the meat are to be measured and to do that, several tests is to be conducted. Experiment is conducted using a device with resistor.

1.2.2 Signification of the Project

This project is really important in order to maintain our health, since the meat is consumed by us. It will help people to know the difference between slaughtered and non-slaughtered meat as well as the quality of the meat.

1.3 Objectives

- To analyze the difference between slaughtered and non-slaughtered meat in term of measuring the capacitance and voltage in a chicken meat.

1.4 Scope of Study

The scope of study involved the collection of data and searching the required information as in the following:

- Measure the dielectric of the chicken meat with varied frequency.
- Slaughtered chicken = Cutting the blood vessels, trachea, and esophagus.
- Non-slaughtered chicken = stunned animal before animal be slaughtered.

1.5 Relevancy of the Project

This project is more related to the power electronic and physics. This project needs to use a capacitor to measure the energy stored when there is a voltage passing through the capacitor with the existing charges of the meat. This research is useful in order to fulfill the human need which wants a healthy meat for food consumption. This is to build a healthy community and reduce the number of human disease by not taking the unhealthy meat.

1.6 Feasibility of the Project within the Scope and Time frame

This project is feasible within the scope and time frame of 2 semesters.

CHAPTER 2
LITERATURE REVIEW

2.1 Capacitor

Analysis on slaughtered and non – slaughtered meat has grown rapidly with a lot of techniques and measurements. Measuring capacitance is one of the techniques that we used. Electrical capacitance exists between two conductors separated with a high resistivity material by some distance (*d*) [5]. When a voltage source is supplied to the conductors, charge of equal and opposite polarity is transferred to the conductor's surface as shown in Figure 1[5].

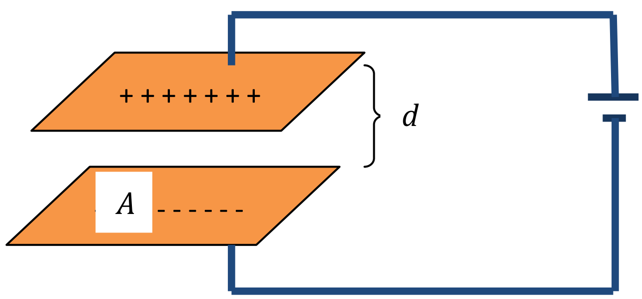

Figure 1: Capacitor

$$C = \frac{Q}{V} \quad (1)$$

[Q = charges, V = voltage, C = capacitance]

Note that capacitance, C depends on potential difference, V and charges, Q. The capacitance, C increases linearly with Q for a given potential difference, V [7]. Therefore, plates with larger amount of charges will affect the capacitance's value. Slaughtered (properly slaughtering) and non-slaughtered (improperly slaughtering) meat is different from each other in terms of capacity of blood inside the meat [8]. Stunning (improperly slaughtering) make the hearts of animals stopped beating early resulting in the retention of more blood in the meat. This makes the meat unhygienic for the consumer [8].

Capacitance also can be measured based on Equation (2) below. Value of the capacitance is very much related to the dielectric (permittivity) of the free space, E and meat, k. Permittivity of the meat muscles decreased gradually with applied frequency [9]. One of the methods to differentiate between slaughtered meats and non-slaughtered meats is based on that permittivity [9]. Dielectric (permittivity) method of measurements is an effective way to differentiate between slaughtered and non-slaughtered meat because of its non-destructive, easy to carry out the experiment and practical [10].

$$C = \frac{k.E.A}{d} \tag{2}$$

Where:

E= (8.85 x 10^{-12} C^2/Nm) dielectric constant of free space,

A = area of plate,

k= dielectric constant of a material,

d= distance between plate [2]

2.2 RC (Resistor-Capacitor) Circuit

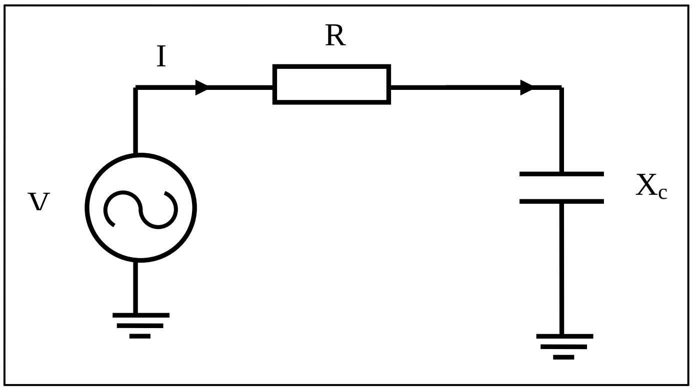

Figure 2: Circuit for the meat permittivity measurement

Theoretically, current I that flow through the circuit can be measured with the known voltage V applied as shown in the Figure 2. The capacitance, C of the meat can be calculated using the equation provided below. Voltage drop across the resistor, V_R and meat, V_c will be used to determine the capacitance, C [6].

$$V = IR \tag{3}$$

V = voltage drop

I = Current flow

R = total resistance

In a series circuit, there is only one direction of current. All circuit components are connected as in Figure 2 so that the same amount of current flows through each [14]. Total resistance, R includes the resistance in the meat itself.

$$\frac{V}{I} = \sqrt{R^2 + (\frac{1}{2\pi f C})^2} \tag{4}$$

Where:

R = total resistance of the resistor

C = capacitance

f = frequency

Capacitive Reactance, X_c is the resistance of the capacitor. This reactance was measured according to the formula shown below and measured in ohms. Frequency as a denominator of this equation and is inversely proportional to capacitive reactance. The value of the capacitive reactance will decrease when the frequency is increased [4].

$$X_C = \frac{1}{2\pi f C} \tag{5}$$

From Equation (3) to get the equation for total resistance in that RC circuit [6]. Total resistance is the square root the resistance existed in the circuit. External resistance, R and internal reactance from the capacitor, X_C is squared.

With,

$$I = \frac{V_R}{R} = \frac{V_C}{X_C} = V_C 2\pi f C \tag{6}$$

Dividing the resistance with the available voltage, V_R and V_C will get the same current flow [6]. Substitute Equation (5) to form new equation (6). The equation is to determine the capacitance is shown in (7).

$$C = \frac{V_R}{2\pi f R V_c} \tag{7}$$

Figure 2 shows the relationship of voltage V, current I and total resistance, R. Based on this information, it can be rewritten including the internal resistance of the meat, X_C [6]. Where f is the applied frequency of the power supply and R is an external resistance contributed in the RC (Resistor-Capacitor) circuit [6].

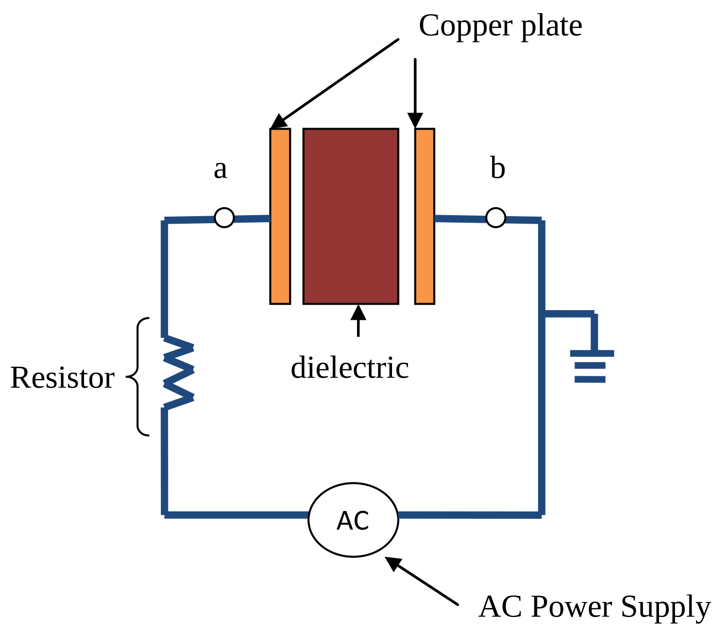

Figure 3: RC Circuit

Figure 3 shows the RC (Resistor-Capacitor) circuit placed in series connection. This is the circuit that will be used to conduct the experiments. We inject the power through power supply and voltage/current will flowing through the copper plate. Capacitance is measured at point a and point b.

Both Equations (2) and (5) can be rearranged to get the relationship between frequency and capacitance.

$$\frac{k.E.A}{d} = \frac{1}{2\pi f Xc} \quad (8)$$

The dielectric or permitivity of the meat tissues are typically decreased with increasing frequency [11].

2.3 Slaughtered & Non-slaughtered Meat

Blood counted as 7.5% of the body weight of the animal varies with the size [13]. Bleeding process normally takes about 1.5 to 3 minutes to complete. About 35%-50% of blood comes out from stunned chicken, with the rest is remaining mainly in the organ [12]. It restricts spilling of the blood from the animal once the blade is apllied to it [8]. On the other hand, blood in properly slaughtered animal is one-third of the total blood in the live animal [6]. Properly slaughtered aminal didn’t touch the nervous system. It still allow brain to function and thereby keeps the heart working expelling as much blood as possible [8].

CHAPTER 3

METHODOLOGY

3.1 Procedure Identification

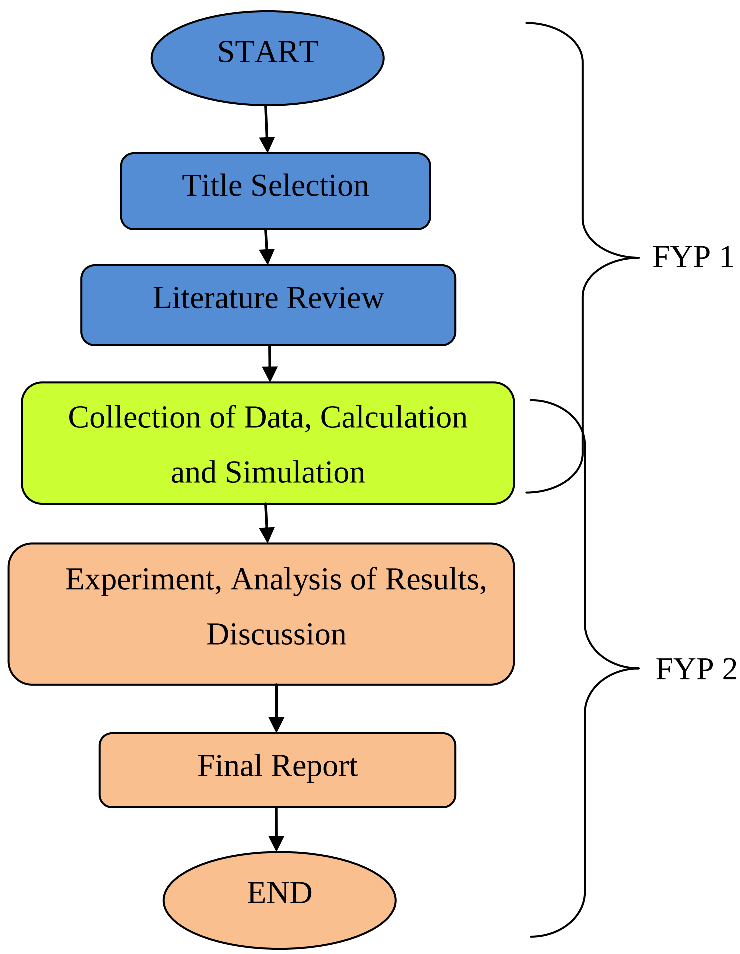

Figure 4: Project Flow Chart

Project starts with the simulation on RC circuit using multisim software. This simulation is needed to see the relationship between voltages produced with a variation of the capacitance values. After simulation on RC circuit was done, capacitor prototype was created. Value of resistor that needs to be used with respect to the frequency and distance between two conductors was calculated.

3.2 Tools & Equipments Used

This project required several tools which consist of software and hardware. Multisim is the software used in order to measure the voltage with a variation of capacitance value. Gathered data will be proceed in Microsoft excel. Using Microsoft excel is easy in terms of plotting the graph.

3.2.1 Software

i. Software used is Multisim version 10
   - To construct the RC circuit and simulate.

ii. Microsoft excel 2007
   - To gather and analyze the data.

3.2.1.1 Simulation

Simulation on series RC circuit shown in Figure 5 is done to get the voltage across the capacitor. Capacitance was increased by 10% every measurement. Referring to Equation (1), it shows that the capacitance is inversely proportional to the voltage. The first assumption is the voltage across the capacitor will reduce as the capacitance increases. Simulation result proved that the RC circuit is correct and can be used in experiment. Current and voltage are injected to the circuit using AC power supply which also we can set the frequency on that power supply. Frequency used is

50 kHz. Resistor (R1) will control the current flow through the circuit. Multimeter is used to measure the voltage across the capacitor. This measurement occurred when there is a potential difference between two conductors of the capacitor. All the values will be displayed on the screen of the multimeter. Frequency counter is used to make sure the frequency applied to the circuit is 50 kHz. It will display the value on the screen of the frequency counter. All the readings were taken and placed in tables.

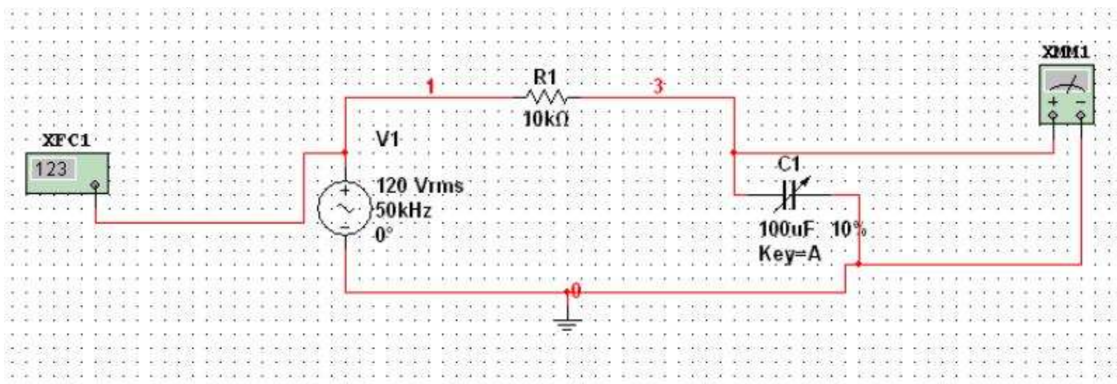

Figure 5: Simulation Circuit

1) Multimeter (XMM1) is to measure the capacitor's voltage.
2) Frequency Counter (XFC1) is to measure the frequency
3) Resistor is used to prevent the high current flow in the circuit.

All the hardwares as mentioned below are used to construct a RC circuit. The AC power supply is used to change the voltage and current to the RC circuit.

3.2.2 Hardware

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i. AC Power Supply
ii. Resistor
iii. Copper plates
iv. screws
v. Wire
vi. Perspex
vii. Digital Multimeter

3.2.2.1 Construction of Capacitor

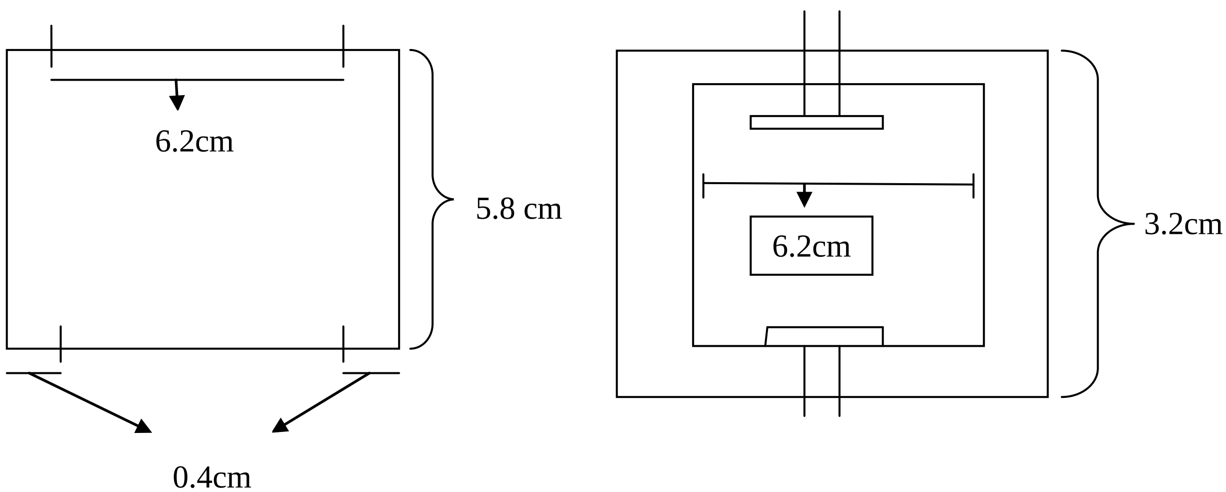

Figure 6: Prototype Dimension

Figure 6 shows the construction of the capacitor using Perspex as a box to hold the copper plate. To build the box is used Perspex to show what inside the box. Experiment need to be performed continuously and with specific time duration. Perspex is the right material because it is light to carry anywhere.

Copper plate is used as a parallel conductor for a capacitor prototype. Conductors (copper plate) used in this project is square plate dimension. Copper plates required dimension about 2.5cm for each side and thickness is $\leq$1mm. Small piece of meats as a dielectric are placed between the parallel conductor plates.

It is proven that copper plates have an electrical conductivity much greater than other conductors such as aluminium. Electrical conductivity is a measure of material's ability to conduct an electrical current.

Figure 7: Capacitor Prototype

Perspex was used to hold the conductor plates and be able to conduct the meats. Selecting Perspex is to make work easier to be monitored. Furthermore, characteristics of Perspex which is light and easy to carry were the main reason for selecting this hardware.

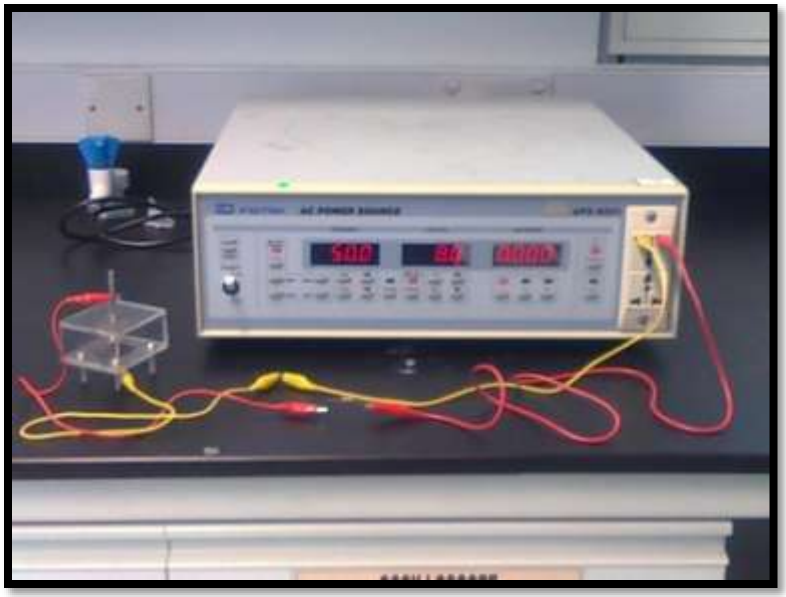

Figure 8: Actual RC Circuit

Figure 8 shows the complete actual RC (resistor-capacitor) circuit. This circuit consists of AC power supply to inject the voltage and also the multimeter to take the measurement. Voltage applied to the RC circuit is about 8-10 Volt.

Figure 9 shows the main procedure for a measurement of the meat samples.

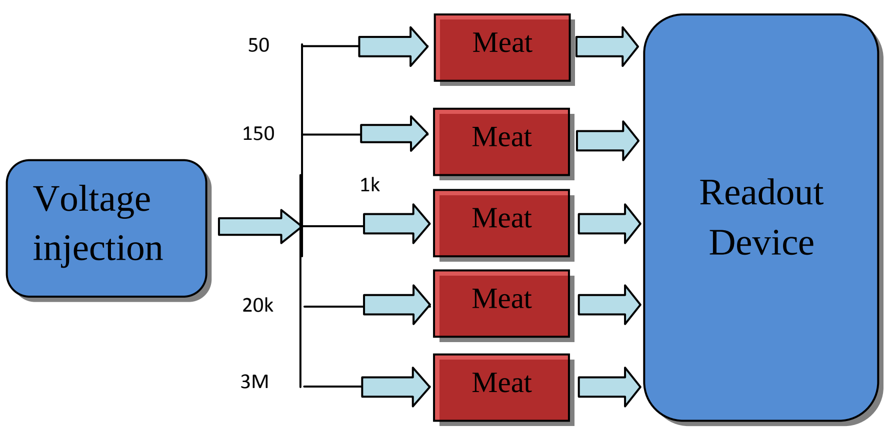

Figure 9: Flow of Measurement

Complete circuit used for this experiment is shown in Figure 10 below. It clearly shows the parts to be measured in order to find a capacitance value of the meat. Voltage drop across the resistor, V_R and meat V_C are taken using multimeter. Using Equation (3) based on voltage drop measurements of V_R and V_C to calculate the capacitance. The dielectric value of meat was then calculated for samples of slaughtered and non-slaughtered meat.

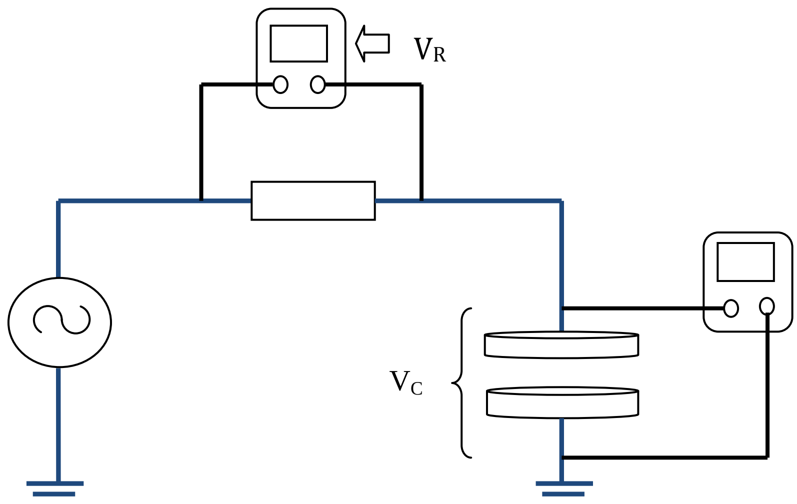

Figure 10: Measurement Section

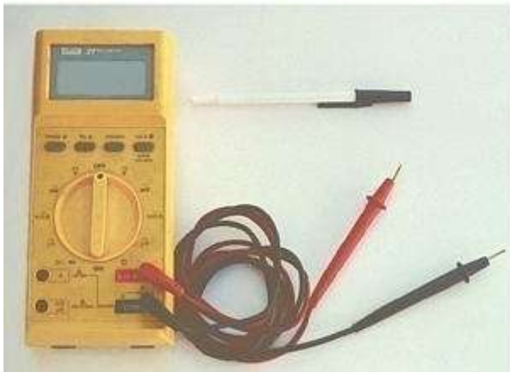

Figure 11: Multimeter

Figure 11 shows the multimeter that is used in this experiment. Red and black wire/connector is placed at one side of the conductor. When circuit is powered with current/voltage conducted, numerical digits appear in that screen. Red connector is placed at the positive side of the conductor. Black connector is placed at the negative side of the conductor. Conductor side which is connected to the positive side of the power supply is called positive side of the conductor. Conductor side which is connect to the negative side of the power supply is called negative side of the conductor. Multimeter also can measure the resistance, current and many more.

3.3 Preparation of Meat Sample

Meat samples are taken from fresh dead chicken's body. Chicken is brought from the market and slaughtered immediately in the closed room for properly and improperly slaughtering of chicken. After certain time (≤5 hours), meat samples are taken from its body and brought to laboratory. Equipments for the experiment are prepared earlier to make work run smoothly. Next, these samples are placed in the clean box and stored in the refrigerator at $\pm$ 40^0C for further testing. Same sample is used and being applied at different frequencies. Meat capacitance are being measured with a specific frequencies range (50 Hz – 3 MHz).

Figure 12: Properly Slaughtered Meat

CHAPTER 4
RESULT AND DISCUSSION

4.1 Relationship between Capacitor's Voltage and Capacitance

Below shows the results on simulation process:

Table 1: Value of Capacitor's Voltage when capacitance is varied (50 Hz)

Increase capacitance in %	V_c
10%	6.908 mV
20%	3.454 mV
30%	2.303 mV
40%	1.728 mV
50%	1.328 mV
60%	1.152 mV
70%	987.422 uV
80%	863.805 uV
90%	767.01 uV
100%	691.214 uV

As the value of the capacitor increases, it will lead in decreasing the value of capacitor's voltage. Capacitor's voltage is inversely proportional with the value of capacitance. Results are placed in Table 1 and displayed in terms of graph form, see figure 13. Results followed the ohm's law which shows resistance is directly proportional to voltage.

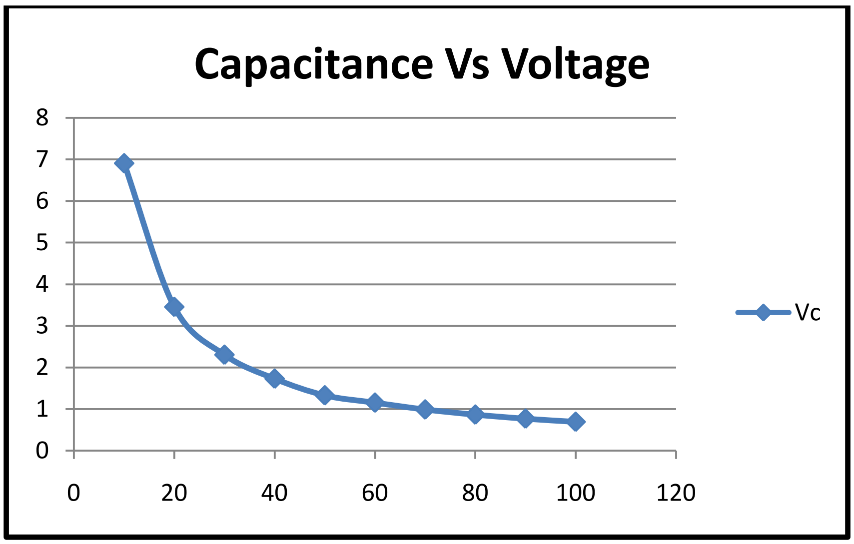

Figure 13: Graph of Capacitance versus voltage

Figure 13 shows the graph of capacitance versus voltage for the applied frequency of 50 kHz. Creating result in terms of graph is easier to understand and easy to compare with other results.

Table 2: Value of Capacitor's voltage when Capacitance is varied (1 MHz)

Increase capacitance in %	V_c
10%	451.623 uV
20%	225.864 uV
30%	150.546 uV
40%	112.909 uV
50%	90.327 uV
60%	75.273 uV
70%	64.532 uV
80%	56.455 uV
90%	50.193 uV
100%	45.173 uV

Table 2 proved that the capacitor's voltage is also inversely proportional with changing of capacitance value for 1 MHz. Voltage values for 50 kHz is much bigger compared to 1 MHz because voltage is inversely proportional with frequency.

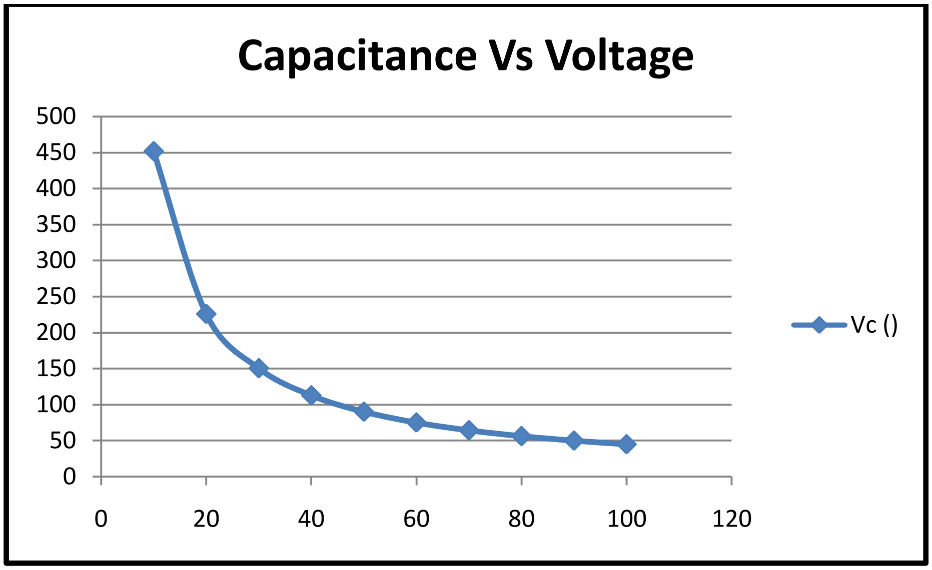

Figure 14: Graph of capacitance versus voltage

Figure 14 shows the graph of capacitance versus voltage for the applied frequency of 1 MHz. This graph also meets the assumption and follows the equation given. But, voltage value for the frequency of 1 MHz is less than frequency of 50 kHz because frequency is inversely proportional to voltage.

4.2 Discussion

a) Calculations for the Surface Area of the Conductor (Copper Plate)

$$\begin{aligned} A &= (width \times height) \\ &= (0.025m \times 0.025m) \\ &= 0.000625m^2 \end{aligned}$$

Surface area is important in calculating the capacitance. The larger the surface area, the more capacitance value will be based on the equation (2).

b) Calculation of permittivity for respective frequency and time.

$$C = \frac{k.E.A}{d}$$

Average capacitance for the sample slaughtered chicken meat,
f = 50 Hz, <5 hours

$$0.584n = \frac{k \times (8.85 \times 10 - 2) \times (0.000625)}{0.005}$$
$$k = 527.91$$

Average capacitance for the sample non-slaughtered chicken meat,
f = 50 Hz, <5 hours

$$0.963n = \frac{k \times (8.85 \times 10 - 2) \times (0.000625)}{0.005}$$
$$k = 870.51$$

Permittivity for the non- slaughtered chicken (improperly slaughtered) meat is found to be greater than slaughtered (properly slaughtered) chicken. This is due to variation of blood contents in the meat.

4.3 Sample: Slaughtered Chicken

Table 3: Capacitance of Sample 1 (Nanofarad)

f / time	< 5hour	>8hour	12hour
50Hz	0.50	0.50	0.53
150Hz	0.51	0.40	0.53
1kHz	0.49	0.45	0.48
20kHz	0.51	0.55	0.61
3MHz	0.51	0.51	0.61

Table 4: Capacitance of Sample 2 (Nanofarad)

f / time	<5hour	>8hour	12hour
50Hz	0.62	0.65	0.52
150Hz	0.59	0.60	0.62
1kHz	0.65	0.65	0.64
20kHz	0.64	0.66	0.65
3MHz	0.65	0.65	0.65

Table 5: Capacitance of Sample 3 (Nanofarad)

f / time	<5hour	>8hour	12hour
50Hz	0.69	0.70	0.69
150Hz	0.66	0.70	0.67
1kHz	0.65	0.65	0.68
20kHz	0.63	0.60	0.64
3MHz	0.64	0.65	0.67

4.4 Sample: Non-Slaughtered Chicken

Table 6: Capacitance of Sample 1 (Nanofarad)

f / time	< 5hour	>8hour	12hour
50Hz	0.73	0.70	0.53
150Hz	0.70	0.69	0.41
1kHz	0.68	0.65	0.36
20kHz	0.51	0.36	0.57
3MHz	0.52	0.57	0.57

Table 7: Capacitance of Sample 2 (Nanofarad)

f / time	<5hour	>8hour	12hour
50Hz	0.72	0.72	0.72
150Hz	0.67	0.68	0.65
1kHz	0.61	0.61	0.61
20kHz	0.57	0.57	0.61
3MHz	0.53	0.52	0.55

Table 8: Capacitance of Sample 3 (Nanofarad)

f / time	<5hour	>8hour	12hour
50Hz	1.44	0.72	0.70
150Hz	0.80	0.73	0.63
1kHz	0.72	0.70	0.60
20kHz	0.59	0.60	0.61
3MHz	0.48	0.48	0.50

Table 9: Average Capacitance for All Samples for Slaughtered (S) and Non-Slaughtered (NS) Measured in Nanofarad

f (Hz) / time	<5hour		>8hour		12hour	
	S	NS	S	NS	S	NS
50	0.603	0.963	0.617	0.713	0.580	0.650
150	0.587	0.723	0.567	0.700	0.607	0.563
1k	0.597	0.670	0.583	0.653	0.600	0.523
20k	0.593	0.557	0.603	0.510	0.633	0.597
3M	0.600	0.510	0.603	0.523	0.643	0.540

Table 9 shows the comparison of capacitance between slaughtered and non-slaughtered chicken meat. Capacitance for non-slaughtered meat is found greater than slaughtered meat at the lower frequency (50 Hz-1 kHz) in green colour ( ). Capacitance on slaughtered chicken meat found greater than non-slaughtered meat at higher frequency because of conductivity of ions when increased the frequency ( ). There have small change in value of capacitance between times of slaughtering. This is due to loss of water on the meat when the chicken meats are placed in refrigerator for several times. Water has a higher conductivity.

CHAPTER 5
CONCLUSION & RECOMMENDATION

5.1 Conclusion

Analysis on the effect of capacitance for slaughtered and non-slaughtered chicken meat is done through this project. There are several measurements taken in order to calculate the capacitance. Voltage drop were taken using multimeter at the resistor and capacitor prototype. This experiment used different frequency to see the effect on capacitance. Slaughtered chicken (properly slaughtered) have a capacitance lower than non-slaughtered chicken (improperly slaughtered) because of blood contents inside the body. Slaughtered chicken meats have a lower capacitance than non-slaughtered chicken meat at a low frequency (50Hz-1 kHz). Small changes of capacitance when increased the time of slaughtering are due to the loss of water contents of the meat.

5.2 Recommendation

This project can be improved by using another conductor that provides higher electrical conductivity. Temperature of the meat also needs to be considered in doing the experiment.

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APPENDICES