METHOD FOR DETECTING SLAUGHTERED OR NON-SLAUGHTERED CHICKEN MEAT USING CAPACITANCE MEASUREMENT

By

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A dissertation submitted to the
Electrical & Electronics Engineering Programme
in Partial Fulfillment of the Requirements
for the Degree
Bachelor of Engineering (Hons)
(Electrical & Electronics Engineering)

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CERTIFICATION OF APPROVAL

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TRONOH, PERAK

June 2009

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

Nadia Hayati Md Nasukha

ABSTRACT

Now days, chickens are used for daily meals of most consumers. Demand of the slaughtered chicken meat is very good and yet, there is no intelligent device to help them to differentiate between the slaughtered and non-slaughtered chicken meat in the market. Therefore, the purposes of this project are to determine the values of blood's capacitance for respective applied frequency, to do simulations on RC circuit and to come out with the prototype to differentiate between slaughtered and non-slaughtered chicken meat using the capacitance measurement technique. In order to achieve the desired outcome, capacitor construction is designed and tested in RC circuit (series connection). The slaughtered and non-slaughtered chicken meat was used as the dielectric medium of the capacitor in the RC circuit. The different values of dielectric constant value were obtained due to variation of the dielectric medium of the meat as capacitor.

ACKNOWLEDGEMENT

First and foremost, I would like to praise God the Almighty for His guidance. Though difficulties occurred, His guidance gave me the chance to still complete this challenging project successfully. Here, I would like to use this special opportunity to express my heartfelt gratitude to everyone that has contributed to the completing of my Final Year Project (FYP).

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Apart from them, I really appreciate the help given by the workshop practice technician of UTP from Electrical and Electronics especially for supporting me, especially during the progress of building the mechanism of my project. Also, not to forget is En. Jani from the Mechanical Department. My high gratitude's' to all the lecturers of UTP, my beloved family members, and also all my friends that gave feedback's and helped a lot through their useful ideas and advices. Last but not least, for all the people that had give their cooperation directly or indirectly, thanks for being with me, for helping me and most of all for supporting me in completing our project.

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CHAPTER 1

INTRODUCTION

1.1 Background of Study

The concept of measurement using capacitance is widely used in industries. Relatively not much application of this technique has been made in the food industries from processing, storing and cooking of the food [2]. Physically, a capacitor is two electrical conductors separated by a non-conducting (or very high resistance) medium between conductors. The key in using capacitor measurement is the variation of the medium between the conductors (dielectric component) that can be used in order to get different capacitance values. This special characteristic of capacitor makes the capacitor concept to be easily applied in various measurements as long as a dielectric component exists. It is possible to assess the quality of food using dielectric properties [3]. In this project, the dielectric of the capacitor is chicken meat. Variation in the dielectric property comes from slaughtered or non-slaughtered chicken meat. These two types of chicken meat have different properties as the chicken is killed using different methods [5]. Values of the dielectric directly influence the values of capacitance. The difference values of capacitor for each meat will distinguish the slaughtered and non-slaughtered chicken meat.

Studies done some years back in the UK show chicken are overtaking the beef market around 1988 and the demand keeps increasing in 1994 to reach 458,000 tonnes in the total meat market [6]. The perceptions of risk towards chicken meat vary with time and depend on the consumers groups [9]. It can be said these perceptions differ due to the sociodemographic characteristic [7]

Consumers are mostly satisfied with the chicken's quality based on the meat tenderness, taste and price but on top of that they are more particular about the health risk towards the chicken meat which leads to the chicken meat quality by using rapid, non-destructive instrument-based techniques in the poultry industry [3]. One exploratory investigation has performed to understand consumers' perceptions towards chicken meat risk issue. It is shows that 23 out of 28 respondents called out for "more product information". They want to know "where the food comes from" and "how it is produced and processed" [8].

For a Muslim, Islam clearly states what is permissible to eat and what is forbidden. They are only allowed to have animal meat if the animals are slaughtered by cutting the front neck of the animal using a sharp cut [5].

1.2 Problem Statement

1.2.1 Problem Identification

Referring to emails, discussions, and forum in the Persatuan Pengguna Islam Malaysia (PPIM) which is the Muslims consumer organization in Malaysia, there are lots of questions among the consumers on how to check the status of the chicken at the market. This because there is no intelligent device available to check either the chicken is slaughtered or not. It is hard for people to differentiate between slaughtered and non-slaughtered meat with the naked eye without help from any device.

1.2.2 Significance of Project

Upon completion of the research and testing, the final results shall be implemented in checking the status of the meat either slaughtered or non-slaughtered chicken meat. The testing and variation of the capacitance values will determine the status of the chicken meat either the chicken was slaughtered or not. Therefore, the concern of consumers of the chicken meat can be entertained.

1.3 Objectives

The main objectives of the study/project are:

1. To determine the values of capacitance for different value of capacitor dielectric medium for respective applied frequency.
2. To construct an RC circuit in simulation using Multisim Software and implement it on hardware.
3. To come out with the prototype to differentiate between slaughtered and non-slaughtered chicken meat.

1.4 Scope of Study

The method for detecting a slaughtered or non-slaughtered meat (chicken) using capacitor project activity consists of:

1. Construction of RC circuit using software and hardware.
2. Variation of the capacitor's dielectric medium
3. Measurement of capacitance values.
4. Differentiation between slaughtered or non-slaughtered meat.

Activities conducted in this project are carried out in UTP and outside UTP if there is a need.

CHAPTER 2

LITERATURE REVIEW

2.1 Capacitor

The application of the capacitance measuring techniques is growing continuously and limited only by imagination of the industry. Electrical capacitance exists between two conductors separated by some distance (D) as shown in Figure 1 where we can relate the effective area A and D by the equation below:

$$C = \frac{\varepsilon_o \varepsilon_r A}{D} \quad \text{..........(1)}$$

ε_o is the dielectric permittivity in vacuum [9]

ε_r is the relative dielectric permittivity of the dielectric material [10].

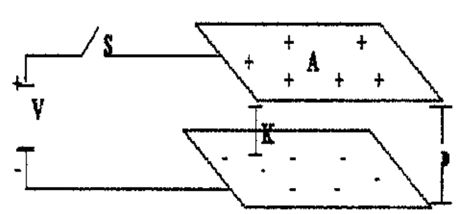


Figure 1: Capacitor's construction [11]

If the medium between the two conductors is filled with some dielectric material and the switch, S being closed, there will be current flowing:

$$I = \frac{V}{R} \quad \text{..........(2)}$$

Capacitance can be related to frequency by using the equation below:

$$F = \frac{1}{2\pi RC} \quad \text{..........(3)}$$

Where R is the value of resistance in Ohms and C is capacitance in Farad. This relation is established in the Resistor-Capacitor (RC) first order circuit. First order circuit can be characterized by using application of the first-order differential equation [1].

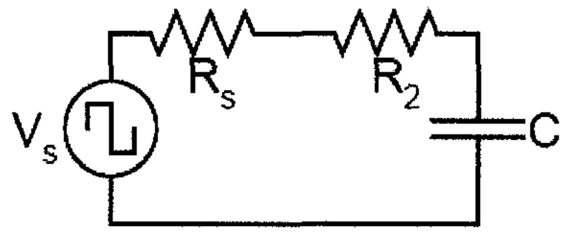


Figure 2 : RC circuit series connection [11]

Both equation (1) and (2) can be rearranged to get the relationship between the dielectric properties and the frequency.

$$\frac{1}{2\pi RF} = \frac{\varepsilon_o \varepsilon_r A}{D} \;..........(4)$$

The frequency and the dielectric is inversely proportional to each other.

Research shows that the dielectric properties of chicken meat depend on the frequencies of the electric field used and also on the temperature of the meat [2],[3]. Dielectric properties of the animal meat are different from the time it is killed, processed, cooked or stored. The changes resulted from the rapid change of the animal tissue after death. Also from the research [2], it is stated that those fresh samples were less dependent on the frequencies. It is found that permittivity decreased at higher frequencies and this follows the relation between frequencies and dielectric properties before. Below are the dielectrics of the blood for some frequencies:

Table 1 : The blood's dielectric to respective frequency [19]

Frequency (Hz)	Dielectric of blood
30	7500
30M	160

2.2 Slaughter

There are lots of methods for slaughtering animals. The methods can generally be divided into two big groups; stunned and un-stunned slaughter. The un-stunned slaughter is the ritual or religious slaughter practiced by the Jews and the Muslims. Stunned slaughter can be further divided into stunned by mixture of gasses, CO_2, Electrical, Pneumatic or Captive Bolt Pistol.

The stunned slaughter methods involve movement and mechanized operations in order to process the animal for example the evisceration of the carcass. This process can become the medium for the micro-organism to contaminate the carcasses. Some common food-poison bacteria associated with poultry meat are genera *Salmonella, Campylobacter* and *Listeria* [6]. *Salmonella* can cause diarrhoea, vomiting and fever for days [14]. More serious case patients are hospitalized, need medical care or incur even death [15]. There was a case where 15 children became infected with *Salmonella* after picking up chicks which had just hatched. They were treated for bad diarrhoea and fever [16]. While the *Campylobacter* can lead to mild or severe diarrhoea, fever, nausea, vomiting, and abdominal pain. The worst disease this micro-organism can lead to are urinary tract infections, meningitis or acute paralysis [17].

Other than diseases stated above, there are other issues being questioned by the consumers about health risk of the meat. In a recent research carried out at Texas A&M University and by Canada's Food Inspection Agency, a method called pneumatic stunning (which is the firing of metal bolt into the cow's brain followed by a pulverizing burst of 150 pounds of air pressure) can deliver a force so explosive that it scattered brain tissue throughout the animal. This news is disturbing since brain tissue and spinal cord are the most infectious parts of an animal infacted with mad cow disease [5]. Additionally, the captive bolt pistol stunning introduces a risk of brain emboli embedded in the edible carcasses [13]. This results in retention of more blood in the meat and becomes unhygienic for the consumer [5].

The Islamic and Jewish practice of slaughtering animals involve rapidly cut in single stroke at the carotid artery, two jugular veins, trachea and the oesophagus without cutting the spinal cord [4],[5]. The cut should not burrow, tear or ripp the animal. It is recommended that the knife used for slaughtering is razor sharp with a straight blade that is at least twice the width of the animal's neck. This method results in a rapid gush of blood which will dry out most of the blood from the animal's body. The result is, the slaughtered meat will stay fresh longer and also more hygienic compared to other slaughtering method [4]. Furthermore, the slaughtered meat without stunning has less drip before cooking and meat is juicier [18].

Below are the findings from experiment conducted by Professor Wilhelm Schulze and his colleague Dr. Hazim at the school of Veterinar Medicine, Hanover University in Germany on studies of animal the pain during the slaughtering and stunning process [4]. The experiment compared the Islamic way of slaughtering and the western C.B.P stunning. The electroencephalograph (EEG) and electrocardiogram (ECG) were recorded.

Islamic Method

1. The first three seconds from the time of Islamic slaughter as recorded on the EEG, did not show any change from the graph before slaughter, thus indicating that the animal did not feel any pain during or immediately after the incision.

2. For the next 3 seconds, the EEG recorded a condition of deep sleep - unconsciousness. This is due to the large quantity of blood gushing out from the animal body.

3. After the above-mentioned 6 seconds, the EEG recorded zero level, showing no feeling of pain at all.

4. As the brain message (EEG) dropped to zero level, the heart was still pounding and the body was convulsing vigorously (a reflex action of the spinal cord) driving a maximum amount of blood from the body, thus resulting in hygienic meat for the consumer.

Western C.B.P Stunning Method

1. The animals were apparently unconscious soon after stunning.

2. EEG showed severe pain immediately after stunning.

3. The hearts of animals stunned by C.B.P. stopped beating earlier as compared to those animals slaughtered according to the Islamic method. This results in the retention of more blood in the meat, leading to unhygienic meat for the consumers.

The different properties of the animal meat lead to differences of dielectric properties of each meat at a constant frequency and temperature. Therefore, the meat will vary the capacitor values due to different slaughter method.

CHAPTER 3
METHODOLOGY

3.1 Procedure Identification

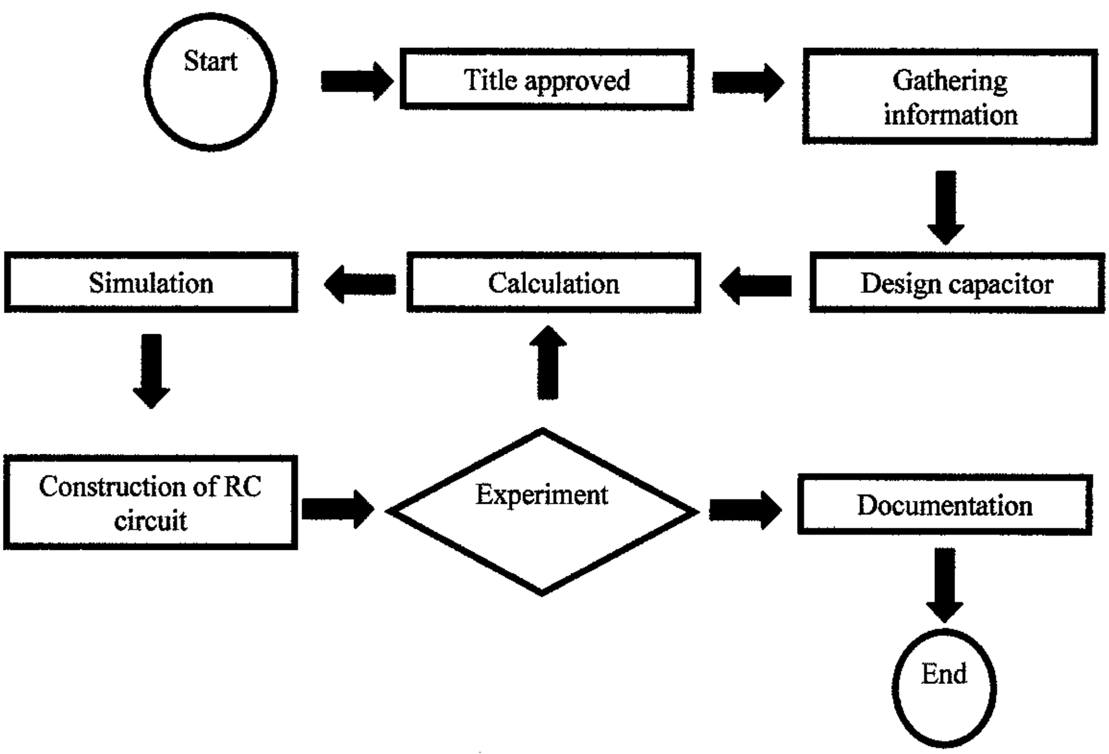


Figure 3: Project flow chart

3.2 Tools

3.2.1 Software

i) Software used is Multisim version 7

ii) Construct the RC circuit by using variable value for resistor and capacitor from calculation. Vary the value of capacitor.

iii) Record the changes of capacitor voltage

iv) Microsoft Excel 2003- Gathering, calculating and analysis collection data

3.2.2 Hardware

i) Construct the RC circuit using the final parameter values from the calculation.

ii) Experiment using the slaughtered and non-slaughtered meat at various frequency applications.

iii) The apparatus involved are:

1) Oscilloscope
2) Power Supply
3) Function Generator
4) Resistor
5) Wire
6) Wire connector
7) Bread board
8) Conductor plate (Platinum)
9) Digital multimeter (DMM)
10) Perspex

3.2.3Chicken Samples

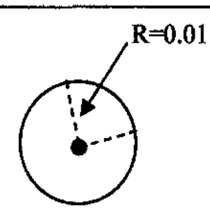
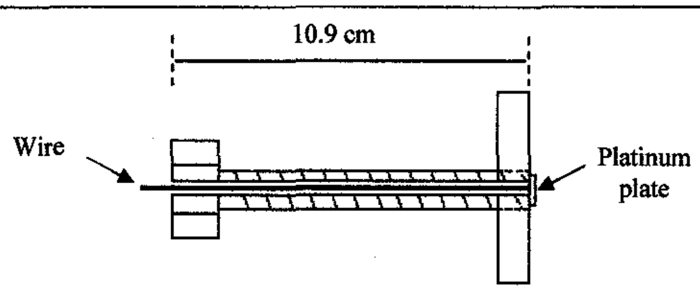
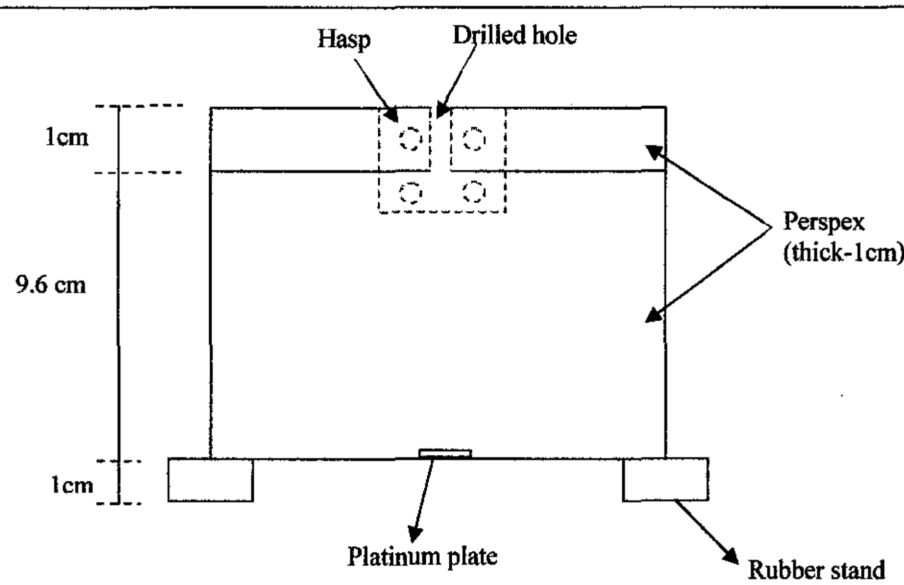
Chickens were obtained from the market at Tronoh, Perak. The chicken was immediately killed and time of death was recorded. The samples were taken from the breast and cut into small pieces with thickness of 1cm. The deboned samples later were kept in the same refrigerator.

CHAPTER 4
RESULT AND DISCUSSION

4.1 Results

4.1.1 Capacitor's design

Table 2: Design of capacitor prototype for each part.

Part	Design
Platinum plates	
A	
B	

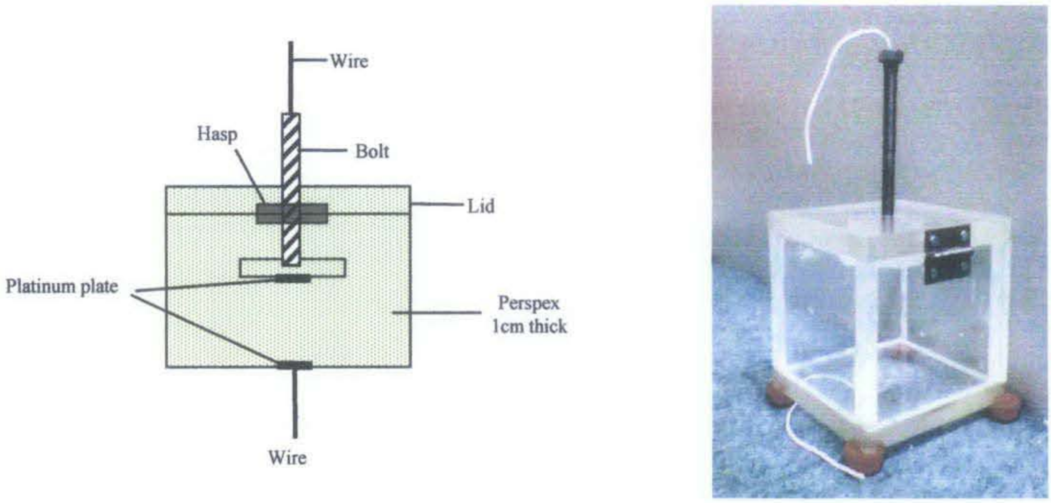


Figure 4: Complete design of capacitor prototype

4.1.2 Calculation of capacitor and resistor values

Table 3: Calculated values of capacitor and resistor for different applied frequency and different distance between the capacitor parallel plates (D)

	F=30Hz		F=3KHz		F=3MHz	
D	C1 (nF)	R1 (MΩ)	C2(nF)	R2 (kΩ)	C3 (F)	R3 (Ω)
0.01	1.042616062	5.088320584	1.021763741	51.9216386	0.0022242475n	238.515
0.02	0.521308031	10.176641	0.51088187	103.843	0.011121237n	477.03
0.03	0.347538687	15.264962	0.34058791	155.765	7.41458663p	715.55
0.04	0.260654015	20.353282	0.25544094	207.687	5.560618997p	954.06
0.05	0.208523213	25.441603	0.20435275	259.608	4.448495198p	1192.55

4.1.3 Simulation

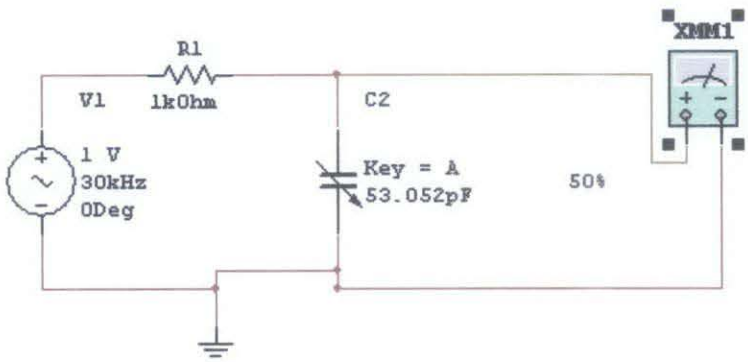


Figure 5: Series RC circuit in the simulation

Table 4: Values of capacitor's voltage when capacitance is changing

F=30Hz		F=30MHz	
Increase capacitor value in percentage (%)	Voltage (mV)	Increase capacitor value in percentage (%)	Voltage (mV)
50	3.49	0	1.882
55	3.173	5	1.765
60	2.908	10	1.759
65	2.685	15	1.748
70	2.493	20	1.732
75	2.327	25	1.714
80	2.181	30	1.691
85	2.053	35	1.666
90	1.939	40	1.638
95	1.837	45	1.608
100	1.745	50	1.577

4.1.4 Experiment

4.1.4.1 Sensitivity test of capacitor prototype

Table 5: Change of capacitor's voltage for various applied frequency

Freq (Hz)	Capacitor Voltage (mV)	Freq (Hz)	Capacitor Voltage (mV)
1.6	2.47	1.82	2.464
16	2.423	18	2.42
161	2.415	183	2.412
1000	2.415	1800	2.412
160800	2.415	180000	2.412

4.1.4.2 Specimen: Slaughtered Chicken

Table 6: Dielectric values for applied frequency of 30Hz

sample	<3 Hours	12 Hours	24 Hours	48 Hours	60 Hours
1	59621.93	59621.93	119255.3	39741.59	17010.28
2	68141.4	47694.11	119255.3	79500.36	13216.62
3	0	0	238516.4	39741.59	13216.62
4	119255.3	0	238516.4	119255.3	14876.83
5	0	0	238516.4	59621.93	17010.28
6	59621.93	39741.59	238516.4	59621.93	14876.83

Table 7: Dielectric values for applied frequency of 250 KHz

sample	<3 Hours	12 Hours	24 Hours	48 Hours	60 Hours	> 72 Hours
1	325.210546	650.4835455	325.210546	650.4835455	650.4835455	650.4835455
2	325.210546	325.210546	162.5428046	433.6383493	650.4835455	650.4835455
3	325.210546	650.4835455	162.5428046	650.4835455	433.6383493	650.4835455
4	433.6383493	325.210546	325.210546	650.4835455	325.210546	433.6383493
5	650.4835455	650.4835455	260.1496992	325.210546	433.6383493	650.4835455
6	520.3774688	433.6383493	260.1496992	1300.998316	325.210546	325.210546

Table 8: Dielectric values for applied frequency of 3 MHz

sample	<3 Hours	12 Hours	24 Hours	48 Hours	60 Hours	> 72 Hours
1	472.4416264	329.6683936	514.5490355	436.1476865	514.5490355	436.1476865
2	436.1476865	376.6273158	329.6683936	514.5490355	514.5490355	436.1476865
3	376.6273158	436.1476865	514.5490355	376.6273158	376.6273158	514.5490355
4	514.5490355	436.1476865	514.5490355	436.1476865	436.1476865	436.1476865
5	514.5490355	472.4416264	436.1476865	404.5011987	514.5490355	564.059486
6	436.1476865	472.4416264	329.6683936	436.1476865	436.1476865	436.1476865

4.1.4.3 Specimen: Non-Slaughtered Chicken

Table 9: Dielectric values for applied frequency of 250 KHz

Sample	>3Hours	12 Hours	24 Hours	36 Hours	60 Hours	>72 Hours
1	650.4732	325.2054	433.6314	650.4732	1445.533	1300.978
2	650.4732	650.4732	650.4732	650.4732	1486.834	1182.705
3	1300.978	650.4732	650.4732	650.4732	1530.565	1084.144
4	650.4732	325.2054	650.4732	650.4732	1369.451	1300.978
5	1300.978	650.4732	650.4732	650.4732	1445.533	1445.533
6	650.4732	433.6314	650.4732	325.2054	1300.978	1084.144
7	650.4732	650.4732	650.4732	650.4732	1530.565	1300.978
8	650.4732	650.4732	650.4732	1300.978	1445.533	1300.978
9	650.4732	650.4732	650.4732	650.4732	1576.947	1300.978
10	650.4732	650.4732	650.4732	433.6314	1445.533	1300.978
11	325.2054	650.4732	650.4732	650.4732	1445.533	1445.533
12	650.4732	650.4732	650.4732	650.4732	1626.227	1300.978
13	650.4732	650.4732	650.4732	650.4732	1369.451	1300.978

14	650.4732	650.4732	1300.978	650.4732	1369.451	1300.978
15	650.4732	650.4732	650.4732	650.4732	1406.464	1084.144
16	1300.978	650.4732	650.4732	650.4732	1369.451	1300.978
17	650.4732	650.4732	650.4732	650.4732	1530.565	1300.978
18	650.4732	650.4732	433.6314	650.4732	1300.978	1300.978
19	433.6314	1300.978	650.4732	433.6314	1445.533	1084.144
20	650.4732	650.4732	650.4732	650.4732	1300.978	1300.978
21	433.6314	325.2054	650.4732	433.6314	1576.947	1300.978
22	650.4732	650.4732	650.4732	650.4732	1406.464	1300.978
23	433.6314	650.4732	650.4732	650.4732	1626.227	1300.978
24	650.4732	650.4732	650.4732	650.4732	1486.834	1300.978
25	325.2054	650.4732	650.4732	650.4732	1182.705	1239.025
26	650.4732	650.4732	650.4732	650.4732	1530.565	1182.705
27	433.6314	650.4732	650.4732	650.4732	1445.533	1040.777
28	1300.978	650.4732	1300.978	1300.978	1369.451	1084.144
29	1300.978	650.4732	1300.978	1300.978	1406.464	1084.144
30	650.4732	650.4732	129.9947	1300.978	1300.978	1084.144

Table 10: Dielectric values for applied frequency of 3 MHz

Sample	>3Hours	12 Hours	24 Hours	36 Hours	60 Hours	>72 Hours
1	472.4341	514.5408	514.5408	404.4948	472.4341	514.5408
2	472.4341	564.0505	472.4341	514.5408	514.5408	623.188
3	436.1407	564.0505	436.1407	564.0505	514.5408	564.0505
4	436.1407	514.5408	472.4341	436.1407	514.5408	623.188
5	472.4341	564.0505	404.4948	514.5408	472.4341	623.188
6	436.1407	472.4341	376.6213	472.4341	436.1407	623.188
7	472.4341	623.188	376.6213	404.4948	514.5408	623.188
8	514.5408	623.188	472.4341	564.0505	472.4341	623.188
9	436.1407	564.0505	436.1407	514.5408	514.5408	623.188
10	436.1407	514.5408	436.1407	514.5408	514.5408	623.188
11	436.1407	514.5408	436.1407	514.5408	514.5408	623.188
12	514.5408	564.0505	472.4341	514.5408	514.5408	623.188
13	329.6631	436.1407	436.1407	436.1407	472.4341	623.188
14	404.4948	514.5408	436.1407	472.4341	472.4341	623.188
15	376.6213	514.5408	436.1407	514.5408	514.5408	623.188
16	436.1407	514.5408	436.1407	514.5408	436.1407	623.188
17	514.5408	514.5408	436.1407	514.5408	514.5408	564.0505
18	436.1407	514.5408	436.1407	472.4341	472.4341	623.188
19	436.1407	564.0505	514.5408	514.5408	472.4341	623.188
20	376.6213	436.1407	404.4948	472.4341	472.4341	514.5408
21	404.4948	472.4341	436.1407	514.5408	472.4341	623.188
22	472.4341	514.5408	436.1407	514.5408	514.5408	623.188
23	329.6631	436.1407	376.6213	472.4341	436.1407	564.0505
24	291.4695	404.4948	376.6213	436.1407	404.4948	564.0505
25	329.6631	376.6213	376.6213	436.1407	436.1407	564.0505
26	329.6631	376.6213	376.6213	472.4341	472.4341	514.5408
27	404.4948	514.5408	436.1407	472.4341	472.4341	436.1407
28	436.1407	514.5408	472.4341	514.5408	514.5408	514.5408
29	376.6213	514.5408	472.4341	514.5408	514.5408	564.0505
30	376.6213	514.5408	436.1407	514.5408	472.4341	514.5408

4.2 Discussion

4.2.1 Calculation of capacitor and resistor value

Both capacitor and resistor values were calculated using equation stated below;

$$C = \frac{\varepsilon_0 \varepsilon_r A}{D} \quad ; F = \frac{1}{2\pi RC}$$

Value of area (A) and distance between two parallel plates (D) are obtained from the capacitor's design. Additionally, from study that is being done earlier, values of vacuum and blood permittivity for respective applied frequency are already known.

4.2.2 Simulation

Simulation is useful to check the feasibility of this project. Using software called Multisim, the capacitor value is varies in order to see any changes of capacitor's voltage as below equation;

$$Vrms = \frac{Vin}{\sqrt{1 + (2\prod fRC)^2}}$$

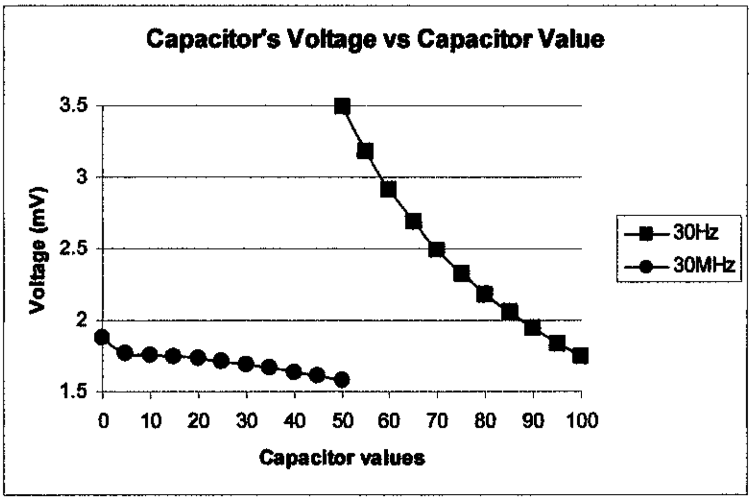


Figure 6: Capacitor voltage vs Changes of capacitor value

Clearly Figure shows that the changes of capacitor value will affect the capacitor's voltage. Capacitor value and capacitor voltage is inversely proportional to each other as shown in the equation above. Therefore, this project is feasible.

4.2.3 Experiment

4.2.3.1 *Sensitivity test of capacitor prototype*

Sensitivity test is carried out in order to make sure the designed capacitor (prototype) is properly working. Capacitor prototype should follow the equation used in simulation process. Below is the graph for the sensitivity test;

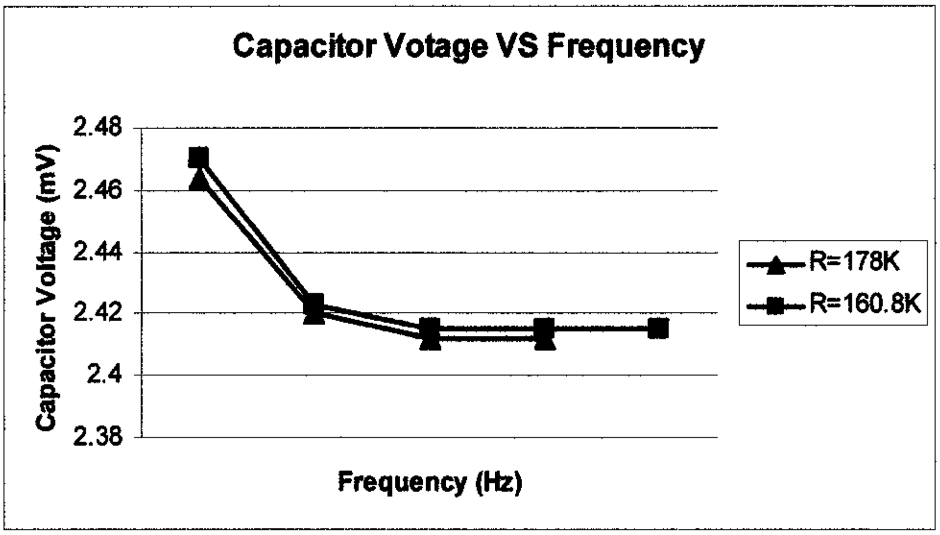


Figure 7 : Changing of capacitor voltage with variation of applied frequencies.

During sensitivity test, the frequency applied is varied instead of capacitor value. Graph shows that, the change of frequency applied also affect the capacitor voltage in the same manner of changes in capacitor value, which is, inversely proportional to each other. From the result of this test, it is verified that the capacitor prototype is functioning.

4.2.3.2 Dielectric constant of chicken meat at different frequencies applied.

The dielectric properties of chicken meat for slaughtered and non-slaughtered were measured over the frequency of 30 Hz, 250 KHz, and 3 MHz. Data were gathered for time of chicken's death less than three hours (fresh sample), 12 hours, 36 or 48 hours, 60 hours and more than 72 hours. The result for 30 Hz is agreed with the previous study of "The Dielectric Properties of Meat", conducted by B.Bodakian and F.XHart.

Study shows that if the frequency applied during experiment is below then 1 KHz, 'electrode effects' begin to dominate [1]. 'Electrode effect' is same as noise in a system. It is disturbance to the output of experiment. This is shown in the figure below, where dielectric constant of meat is not stable and has a very large variation which gives standard deviation value about 74200.

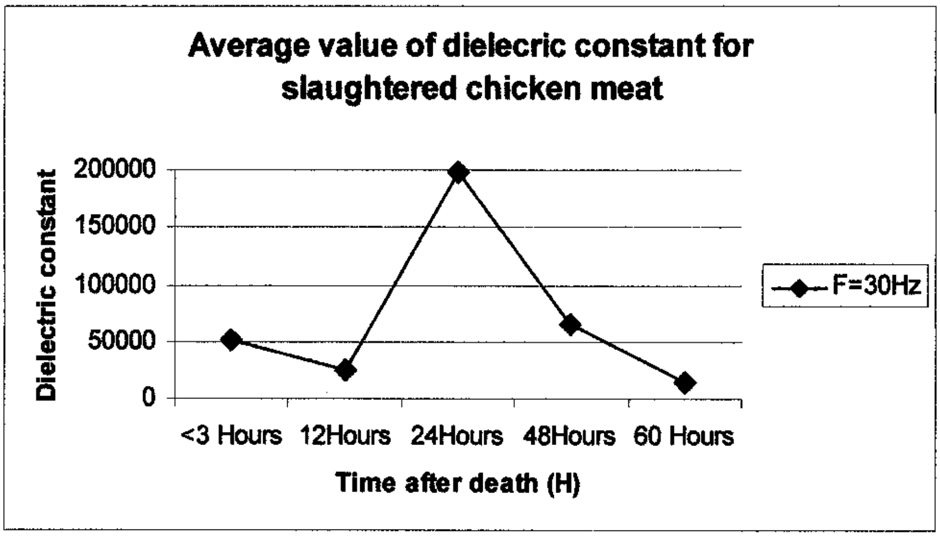


Figure 8: Average value of dielectric constant for slaughtered chicken meat (F=30 Hz)

Therefore, the result for frequency of 30 Hz is held from being implemented in the other experiment. This is because the collected readings were not representing the bulk meat alone but significant 'electrode effect'.

Consequently, the dielectric constant for frequencies more than 1 KHz will present the meat alone, without 'electrode effect' [1]. As for this, the next graphs are showing the average of dielectric constant for both slaughtered and non-slaughtered chicken meat with applied frequency, 250 KHz and 3 MHz.

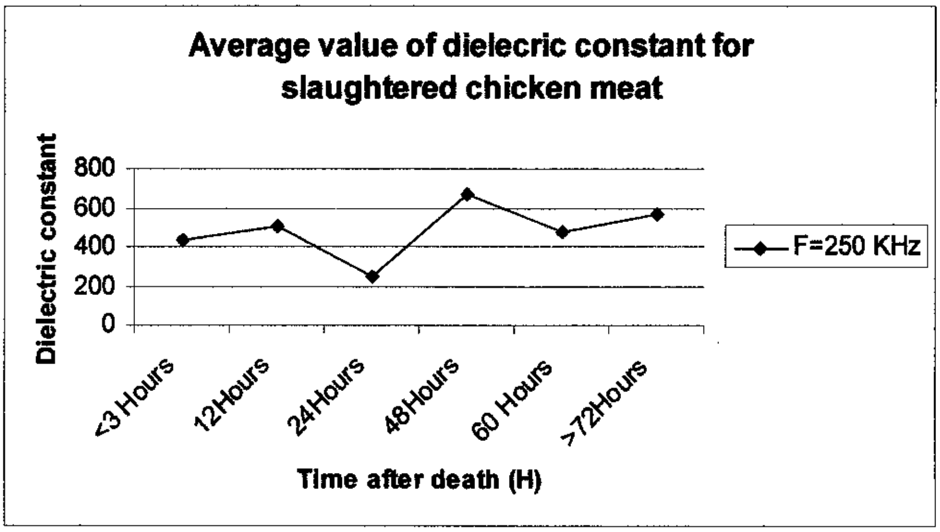


Figure 9: The average value of dielectric constant for slaughtered chicken meat (F=250 KHz)

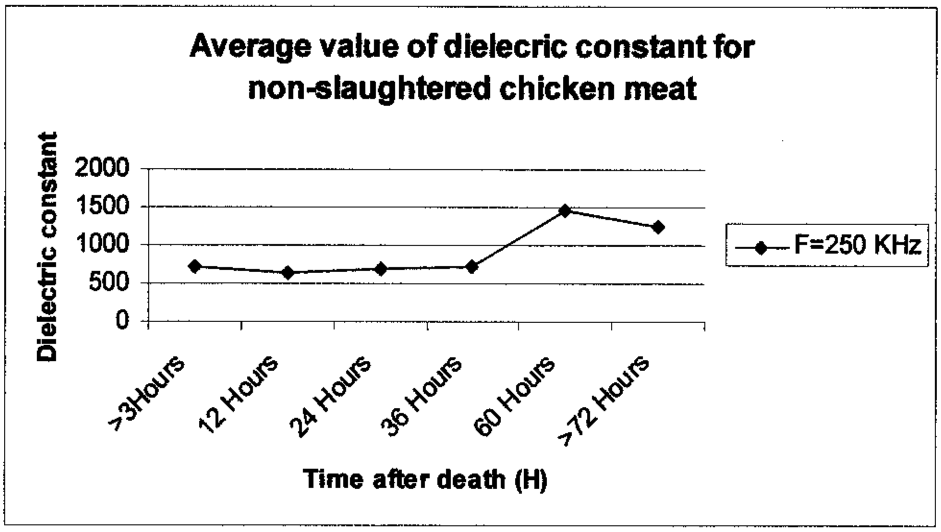


Figure 10: The average value of dielectric constant for non-slaughtered chicken meat (F=250 KHz)

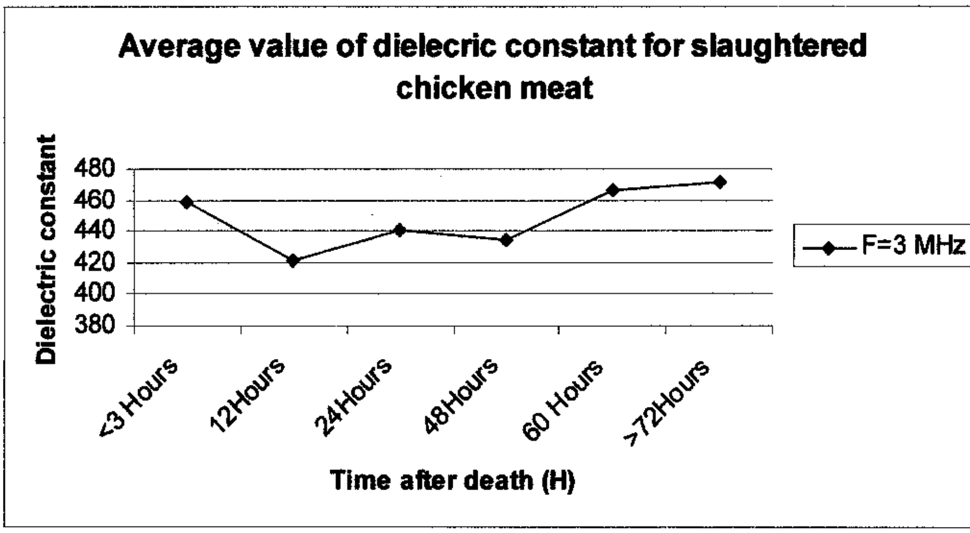


Figure 11: The average value of dielectric constant for slaughtered chicken meat (F=3 MHz)

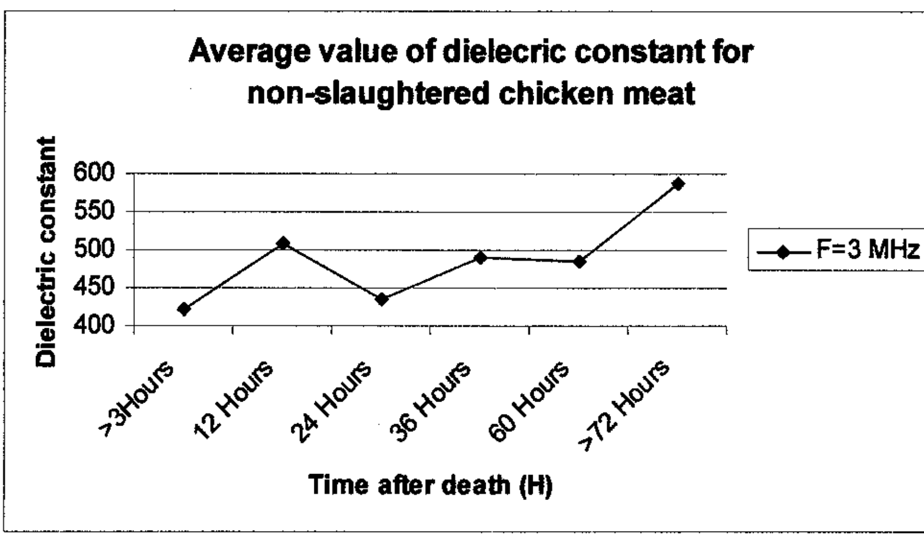


Figure 12: The average value of dielectric constant for non-slaughtered chicken meat (F=3 MHz)

From figures above, the standard deviation of dielectric constant for slaughtered and non-slaughtered with frequency 250 KHz is 140.3322 and 345. While for frequency 3 MHz, the standard deviation for slaughtered meat is 19.66 and 59.53 for the non-slaughtered.

More or less, the dielectric values for applied frequency of 3 MHz and 250 KHz are giving the same pattern as expected Comparing to frequency 30 Hz, variation on the dielectric values at frequency 250 KHz and 3 MHz are very much smaller. Therefore, the recorded data are more stable. Subsequently, dielectric value is confident to be represented of the chicken meat. It is just the range of dielectric values are different which is depend on the resistance value used during the experiment.

Although by applying frequency of 250 KHz and 3 MHz gives stable readings, these studies have indicated that between these two frequencies, it is clearer to used 250 KHz to differentiate between slaughtered and non-slaughtered chicken meat. Dielectric constant gives larger variation between slaughtered and non slaughtered with applied frequency of 250 KHz compared to 3 MHz as shown in the graphs below; Details comparison can be see in Appendix C, graph 1-8.

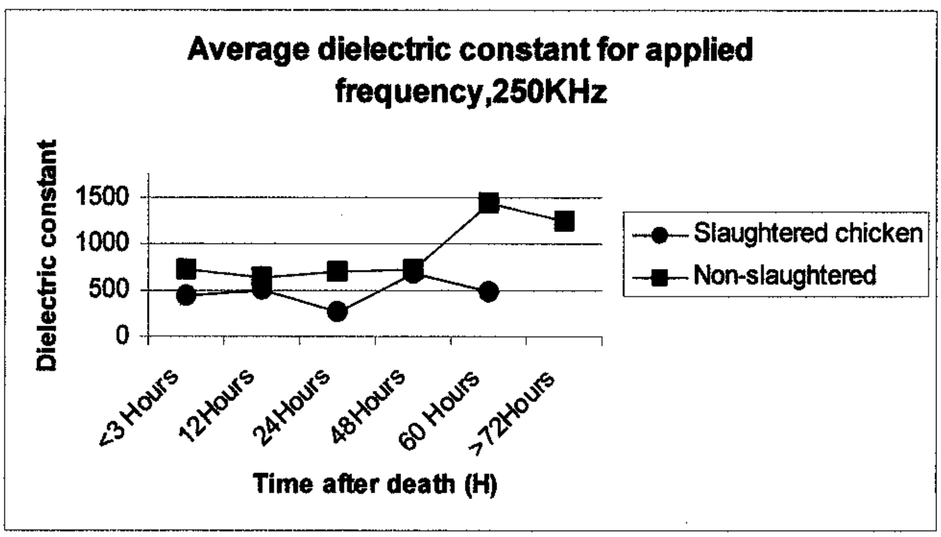


Figure 13: Comparison between average dielectric of slaughtered and non-slaughtered chicken meat (F=250 KHz)

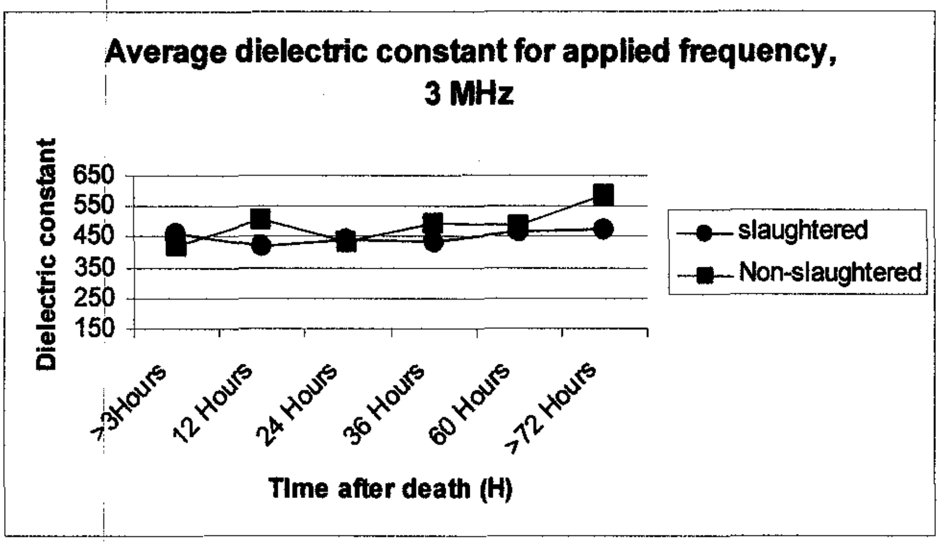


Figure 14: Comparison between average dielectric of slaughtered and non-slaughtered chicken meat (F=3 MHz)

As shown in the graphs, dielectric values for non-slaughtered chicken meat are higher compared to the slaughtered chicken meat. This condition is interrelated with permittivity, conductivity and the haemoglobin of the chicken meat. Permittivity is a material ability to transmit or permit an electrical field and conductivity is ability of materials to conduct an electrical current. In order to put in a simpler explanation, permittivity is a path for current to move from high to low potential energy and conductivity is the speed of the material can provide for the current to move through it. As for haemoglobin, it is one of the blood components that contains of ions that make it possible to be an electrolyte (electrical conductive medium).

According to previous study, residual haemoglobin for not bled death (non-slaughtered) was approximately 15% greater compared with bled treatment (slaughtered) [20]. Therefore, the non-slaughtered chicken meat is said to have more concentration of electrolyte compare to the slaughtered meat. This condition provides a higher permittivity value for non-slaughter chicken meat. As a result, higher conductivity is established. Conductivity is related to dielectric constant value with capacitance through equation below;

$$C = \frac{\varepsilon_o \varepsilon_r A}{D}$$

Higher conductivity means, capacitance will charging faster compared to the low conductivity materials. For the same period of charging, capacitor with higher conductivity will have higher capacitance. Therefore, based on the relationship shown in the equation above, dielectric value will be increase with the increasing of the capacitor value.

4.2.3.3 Dielectric constant value at aging and different physical

During this study, it is found that dielectric constant of the chicken meat for both slaughtered and non-slaughtered are increasing with time after death. This can be explained by the increasing of permittivity value of the meat substantially by the storing, freezing and defrosting processes [1]. As explained before, the increasing of permittivity of the chicken meat will lead to the increasing of the capacitance value and at the end, the dielectric value of those meats also increased accordingly. The increasing of dielectric value is different between slaughtered and non-slaughtered chicken meat. Dielectric value of non-slaughtered chicken meat is increasing faster compared to the non-slaughtered. This is due to more blood retained in the non-slaughtered blood which gives more concentration of electrolyte and increase the rate of capacitor charging.

From graph number 9, 10, 11 and 12 in Appendix C, it shown that slope of slaughtered chicken meat at frequency 250 KHz is about 27.5 compared to 145.6 for the non-slaughtered. While at frequency 3 MHz, slope for non-slaughtered is still higher (23.35) compared to the slaughtered chicken meat, (5.41). This is showing that the increasing rate dielectric constant for non-slaughtered is higher compared to slaughtered chicken meat.

It is being observed that, in the physical appearance of slaughtered and non-slaughtered chicken meat they do not have a significant different. According to previous study, non-slaughtered chicken meat consist high red component and made the meat look redder compared to the slaughtered chicken meat [20]. This consistence with the amount of haemoglobin retain in the non-slaughtered chicken meat, which is 15% greater than the slaughtered meat.

It is not easy for consumer to detect which is slaughtered and non-slaughtered chicken meat. Furthermore, after other disturbance or process that changes the physical appearance of the chicken meat, sometimes those chicken meats physical appearance looks exactly the same. Below are the pictures of samples taken when time of chicken death not more than 3 hours, 24 hours and 60 hours.

a b

Figure 15: Different physical colour a) slaughtered chicken meat b) non-slaughtered chicken meat for fresh sample

.

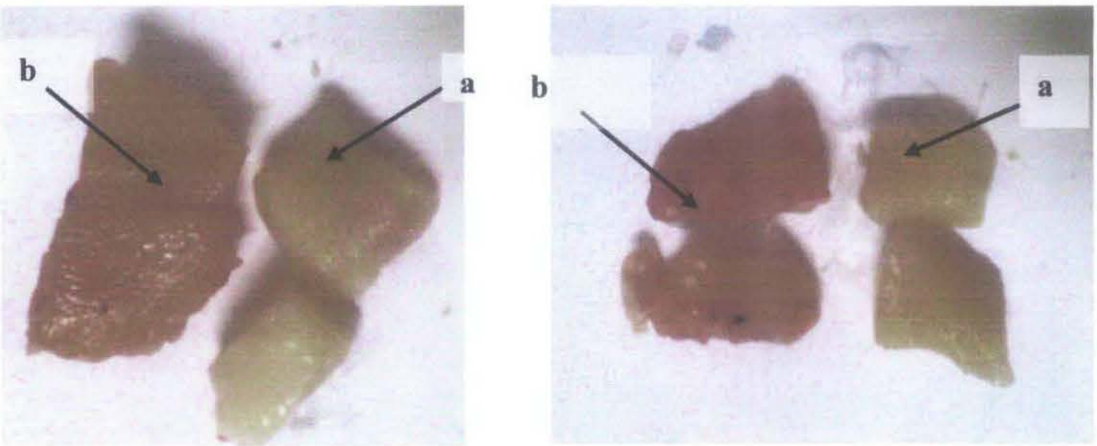


Figure 16: Different of physical colour between slaughtered (a) and non-slaughtered (b) for period of death 24 hours (left side) and more than 60 hours (right side)

From the pictures, there is no significant different between the slaughtered and non-slaughtered chicken meat. Consumer can easily do a mistake to differentiate between those two.

CHAPTER 5
CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

Through intensive study, the values of capacitance for different value of capacitor dielectric medium for respective applied frequency have been determined. The applied frequencies are 30 Hz, 250 KHz and 3 MHz. From those values, parameters of the RC circuit for simulation like resistor and capacitor also being determined. The simulation result shows that this project is feasible to be conducted as the changes of capacitor values are affecting the capacitor voltage. Next, the prototype of the capacitor is being design and manufactured in order to differentiate between the slaughtered and non-slaughtered chicken meat. From the study, the best frequency to be applied is 250 KHz, other than gives stable outputs, it is also show a significant deviation between slaughtered and non-slaughtered chicken meat. The dielectric constant value of slaughtered chicken meat is always below than the dielectric value of non-slaughtered chicken.

5.2 Recommendations

Even though the project is achieved all its objectives, there are lot of rooms for improvement. Here are some recommendations for further development;

1) Run test for more frequencies and samples to find the better results.
2) Improve the experiment method by put more details in sample's temperature.
3) Advance the project in programming, can applied the method automatically
4) DC voltage supply can be used to replace Ac v voltage but need to add rectifier in order to convert the DC to AC voltage.
5) Change the material of parallel plate to cheaper material but yet fulfil all the project requirements (good conductor, rustless,etc).
6) Run more tests on other parts of chicken, eg: liver,legs,wings

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APPENDICES

APPENDIX A

CALCULATIONS

A.1 Calculation for the capacitor design

Note: The calculation is in meter, because the blood permittivity value is Farad/meter

A = 2 x (area of the platinum plate)

= 2 x (pi x radius x radius)

= 2 x (pi x 0.005 x 0.005)

= 0.0001570796327 m^2

A.2 Calculation of the capacitor's value for respective frequencies

$$C = \frac{\varepsilon_o \, \varepsilon_r A}{D}$$

From Table 1, there are the blood's permittivity values for the respective frequency.

$\varepsilon_r = 160$; $\varepsilon_o = 8.85pF/m$; Freq = 30MHz

$$C = \frac{160F/m \times 8.85pF/m \times 0.0009}{0.03}$$

$$C = 42.48pF/m$$

A.3 Calculation of the resistor's value for the respective frequency

Frequency same as above example, freq=30MHz

Capacitor value is from above calculation, C=42.48 pF/m

Using this equation, $F = \dfrac{1}{2\pi RC}$

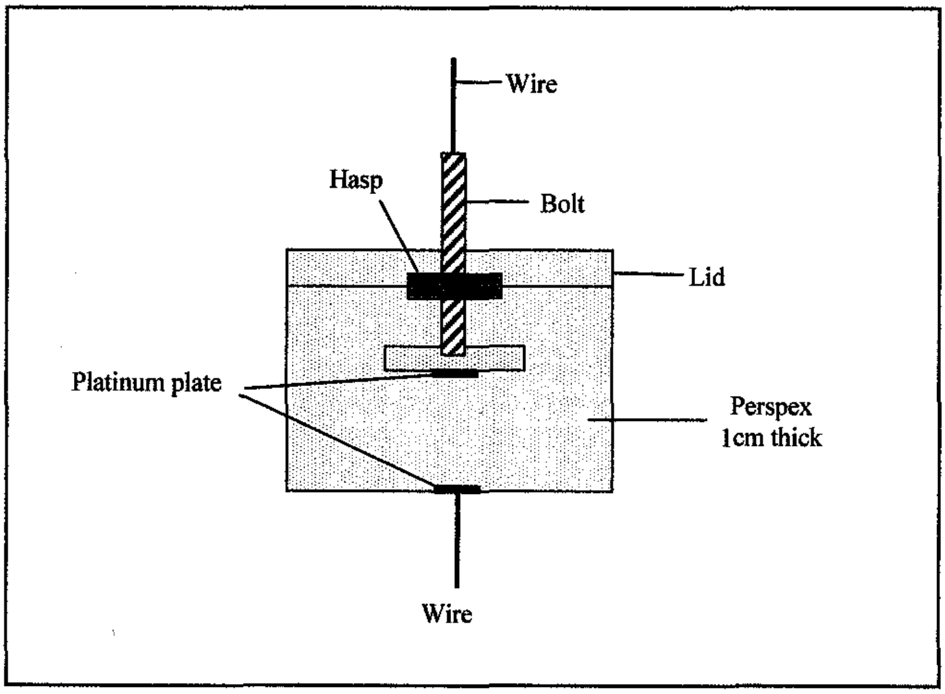
$$R = \frac{1}{2 \times \Pi \times 30M \times 42.48p}$$

$$R = 124.8862\,\Omega$$

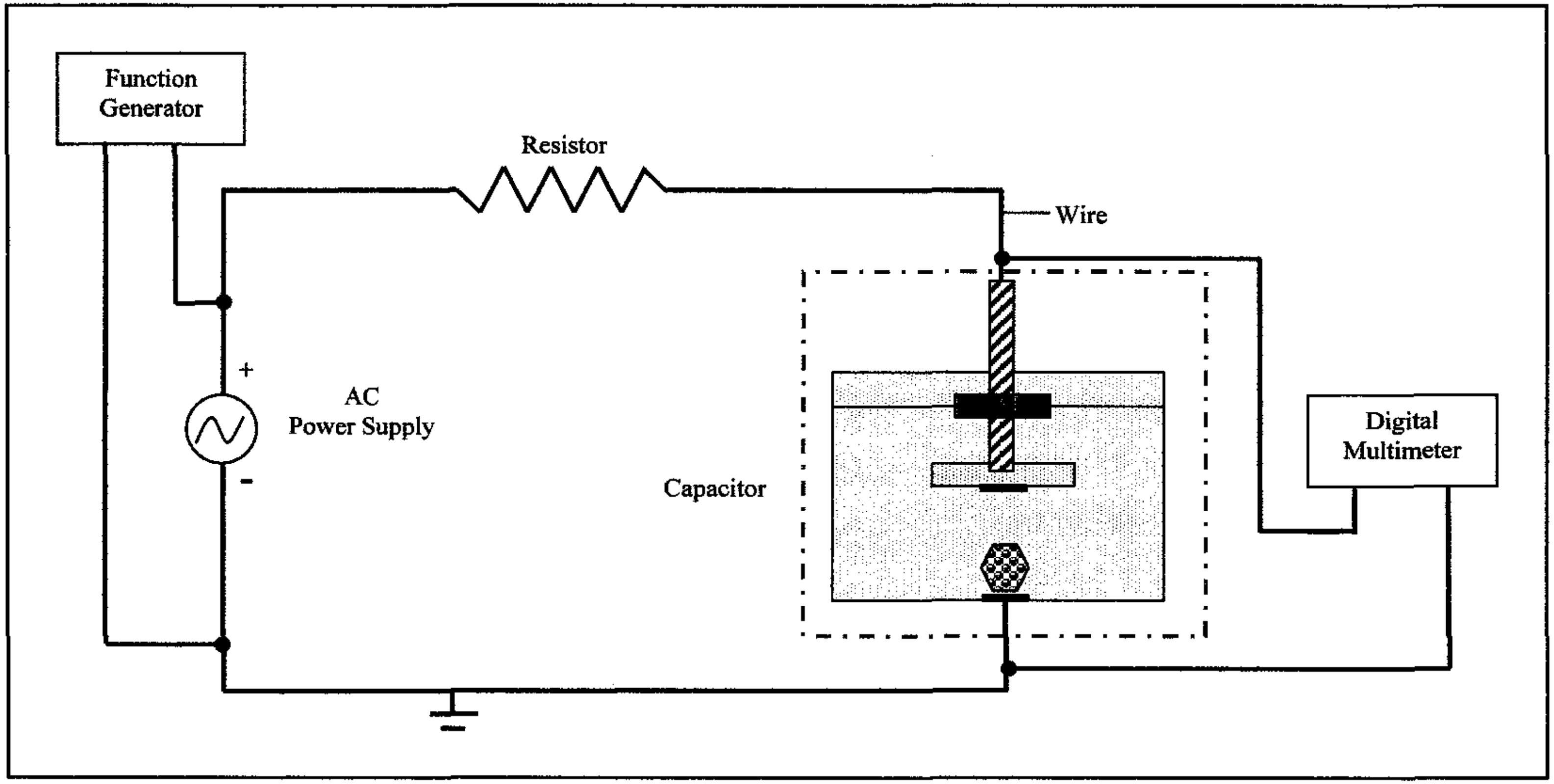
APPENDIX B

DESIGN

B.1 Design of the Capacitor prototype



B.2 Overview of the RC circuit construction for the prototype



APPENDIX C

GRAPHS

C.1 Detail comparison of slaughtered and non-slaughtered chicken meat for each period of data collection.

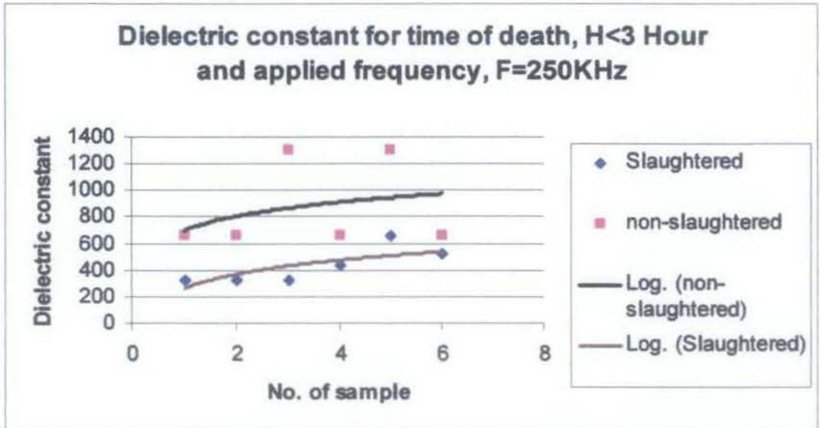


Figure 1

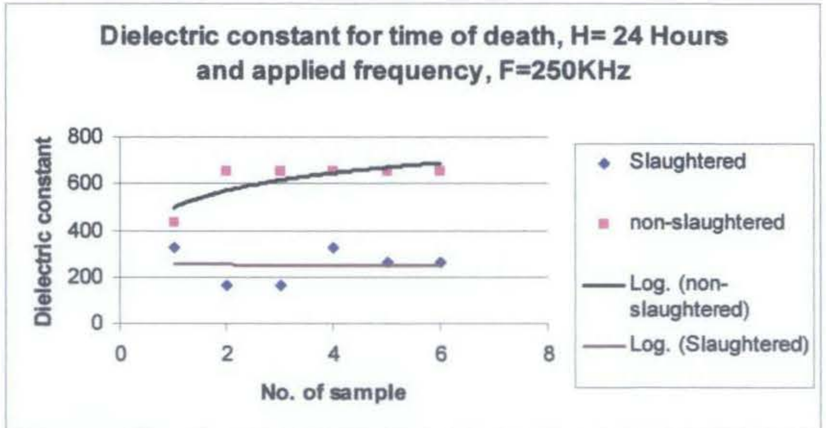


Figure 2

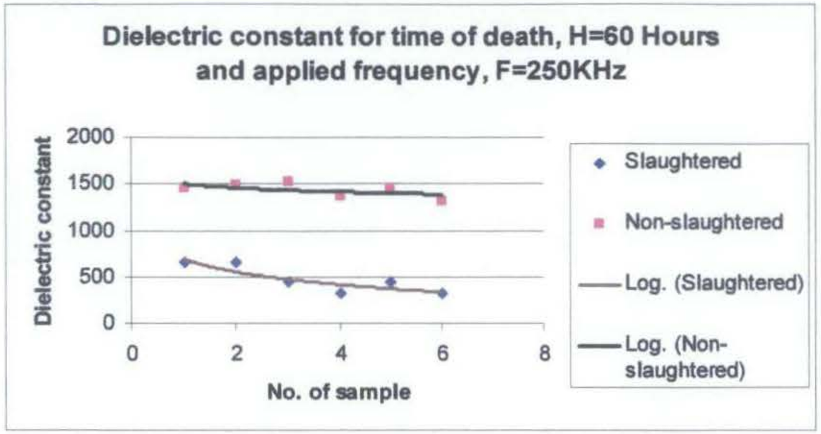


Figure 3

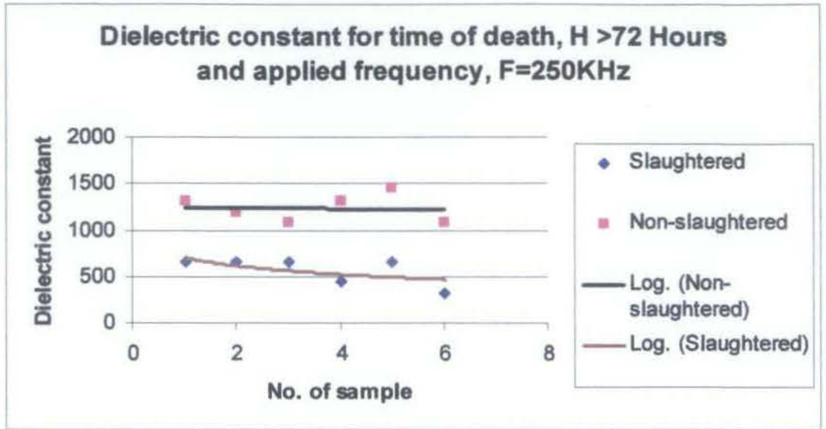


Figure 4

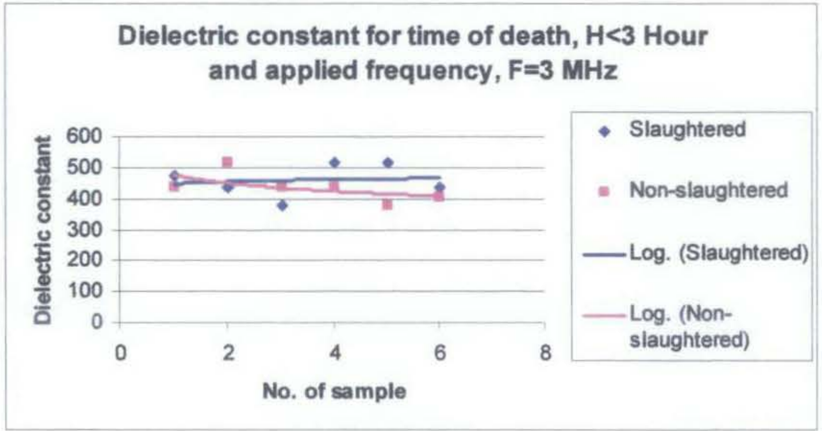


Figure 5

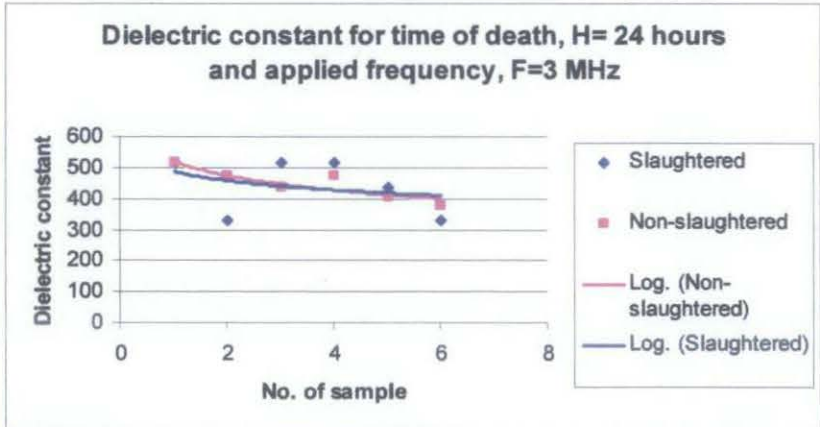


Figure 6

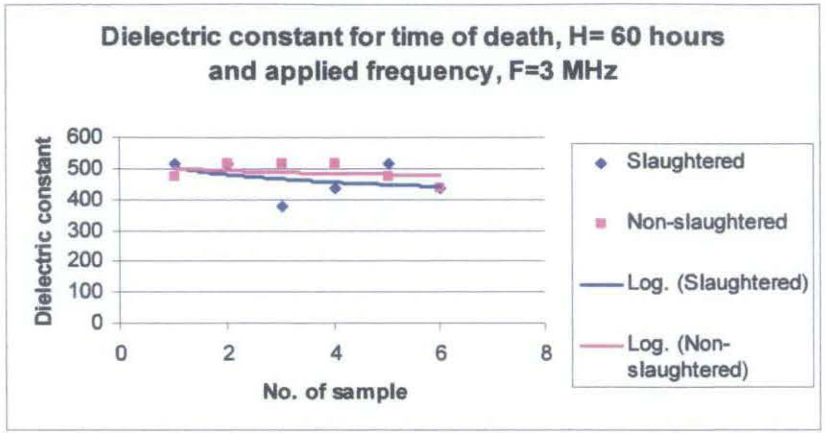


Figure 7

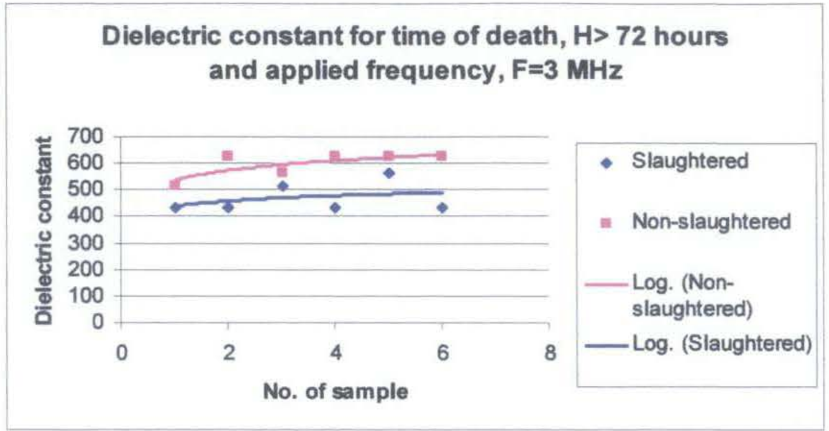


Figure 8

C.2 Details graphs of increasing dielectric constant at aging

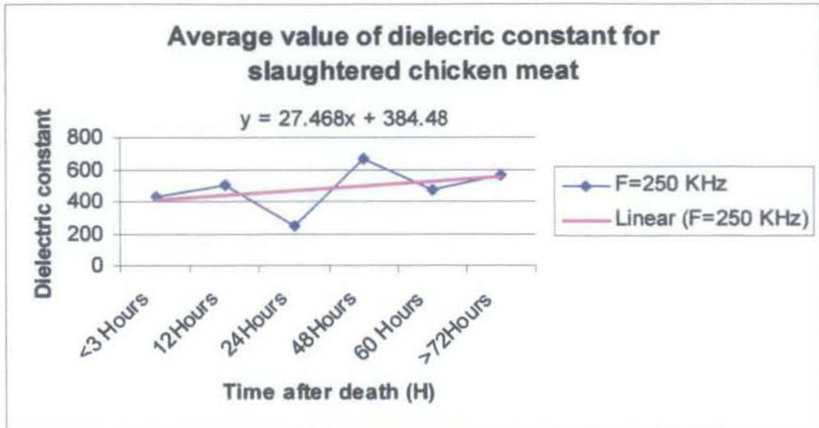


Figure 9

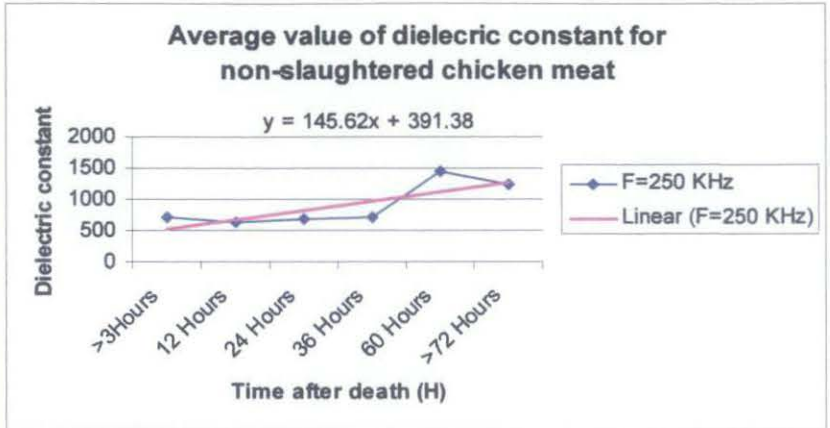


Figure 10

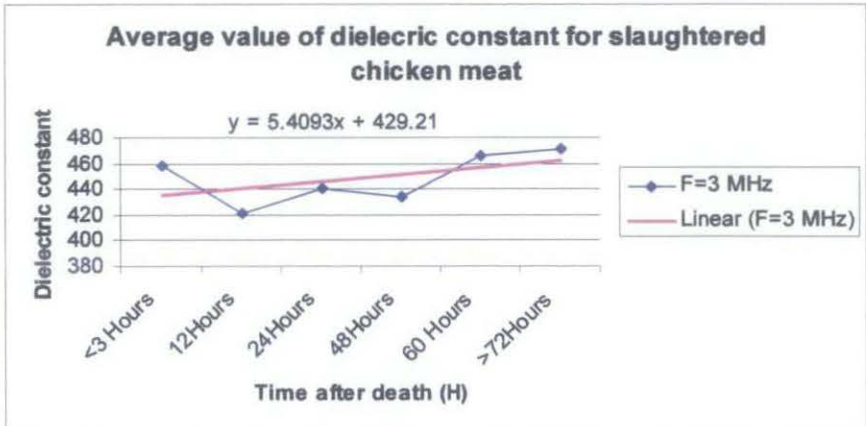


Figure 11

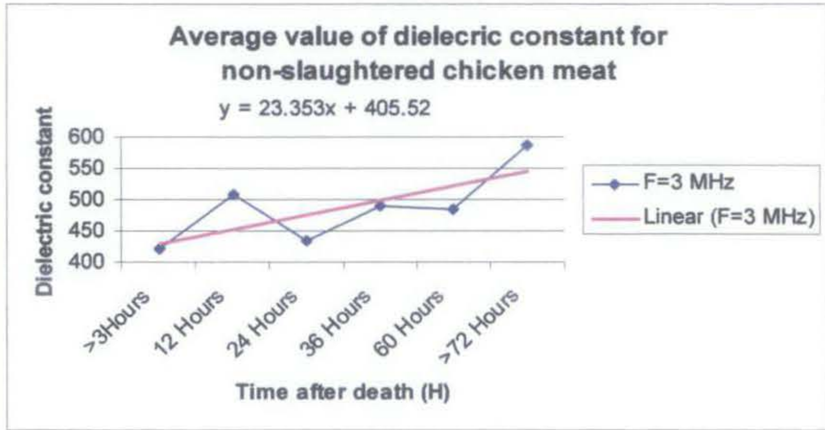


Figure 12