

THE EFFECTS OF ELECTRIC FIELD ON MICROORGANISMS IN SEMI-LIQUID AND LIQUID EDIBLE FOOD SUBSTANCES

In partial fulfillment of the requirements

for the degree of

Bachelor of Science

in Electrical and Electronic Engineering



Inspiring Excellence

Submitted By

ADEL BASHER RAHMAN

Student ID: 10321045

MOHD. WASIM CHOUDHURY

Student ID: 10121063

AUGUST 2015

DECLARATION

We hereby declare that the thesis titled "**The Effects Of Electric Field On Microorganisms In Semi-Liquid And Liquid Edible Food Substances**", submitted to the Department of Electrical and Electronic Engineering, BRAC University for the fulfillment of degree in Bachelors of Science in Electronics and Electronic Engineering, is our original work. Any information used from other sources has been acknowledged in the reference section.

Submitted by:

Adel Basher Rahman

Student ID: 10321045

Mohd. Wasim Choudhury

Student ID: 10121063

Signature of the Supervisor

Ms. Marzia Alam,

Department of Electrical and Electronic Engineering,

Brac University

ACKNOWLEDGEMENT

Over the course of this thesis, for the past year, we have devoted ourselves to this work, the progression of which have made would never have been culminated on our own and for that; we have found ourselves indebted to many members of the faculty.

First and foremost, we are sincerely greatly to our supervisor, Ms. Marzia Alam, the senior lecturer of EEE department, BRAC University for whose without continuous positive support, guidance and counsel for the completion of this work would not have been otherwise possible.

We would also like to show our gratitude to Professor Mahbubur Rahman, of MNS department, BRAC University, whose expertise in the area of microbiology has helped us manifold and has given invaluable assistance, whenever required. We are also indebted to Ms. Asma the laboratory technical officer of microbiology lab, MNS department, whose dedication, practical support and patience for the thesis made it possible for us to complete our thesis. Lastly, we would like to thank all the other lecturers, faculty members and other technical offers of the BRAC University, for their involvement in the completion of our thesis.

ABSTRACT

Pulsed electric field (PEF) is a new, emerging and a non thermal method of processing of food preservation technique, which uses pulsating electric field for the inactivation of microorganisms. The process causes a minimal effect on food quality characteristics such as smell, taste, color and texture. PEF can be especially used for processing liquid and semi-liquid edible food substances. Studies conducted on the energy requirements have concluded that PEF is an energy efficient process compared to the traditional thermal methods such as pasteurization.

In this study the PEF was applied to various edible food items: raw milk, fruit juice, sugarcane extract and tap water. High energy electric field, ranging from 400 V/cm up to 1600 V/cm of frequency 50 Hz was applied and the corresponding microbial colony growth was counted. Here effectiveness of the AC field against the DC field was also compared; the impact of number of pulses applied and effect of thickness of the metal plates on the growth of the microorganisms were studied. The experimental results are encouraging and are supportive of the applied technique.

TABLE OF CONTENTS

CHAPTER 1: INTRODUCTION	1
1.1 Historical Background	4
1.2 Motivation	5
CHAPTER 2: RESEARCH METHODOLOGY	6
2.1 The Effect on the Microbial Growth for Various Samples Exposed under Variable AC Fields ranging from 700v/cm up to 1600 v/cm.	8
2.2 The Effect of Number of Pulses on the Microbial Growth	8
2.3 A Comparison between the AC and DC Field	8
2.4 The Effect of Thickness of the Plates	9
2.5 Electroporation of Cell Membrane due to PEF	9
2.6 Derivation of $E=v\backslash d$	12
CHAPTER 3: EXPERIMENTAL SETUP	14
3.1.0 The Electrical System Setup and the Equipment Used	15
3.1.1 Testing the Rating of a Transformer	17
3.2.0 The Biological Systems	18
3.2.1 The Agar Gel Preparation	18
3.2.2 Preparation of EMB Agar	18
3.2.3 Preparation of Macconkey Agar	19
3.2.4 The Difference between EMB and Macconkey Agar	20
3.2.5 Safety Protocol	20
3.2.6 Preparation of Saline Solution	20

3.2.7 Preparation of Sample Using Serial Dilution Method	21
3.2.8 Procedure of Colony Count in Petri Dishes	22
CHAPTER 4: EXPERIMENTS AT DIFFERENT TESTING CONDITIONS	23
4.1.1 Experiment 1: Samples at Different AC Field Length	24
4.1.2 Equipments Used	24
4.1.3 Experimental Procedure	24
4.2.1 Experiment 2: Effect of Number of Pulses	26
4.2.2 Equipments Used	26
4.2.3 Experimental Procedure	26
4.3.1 Experiment 3: Comparing AC with DC Field	28
4.3.2 Equipments Used	28
4.3.3 Experimental Procedure	28
4.4.1 Experiment 4: Effect of thickness of the plates	30
4.4.2 Equipments Used	30
4.4.3 Experimental Procedure	30
4.5.1 Safety Protocols	33
4.5.2 While Performing the Experiments with the Electrical Equipments in the Power Laboratory	33
4.5.3 While performing the Experiments in the Biology Laboratory	33
CHAPTER 5: DATA AND RESULTS	34

5.1.0 Experimental Conditions	35
5.1.1 Sample Data at Different AC field Length Showing the Colony Count	35
5.1.2 Sample Data at Different ac Field Length Showing the Microbial Count	35
5.2.0 Experimental Conditions	36
5.2.1 Sample Data showing the Effect of Number of Pulses on the Colony and the Microbial count	36
5.3.0 Experimental Conditions	37
5.3.1 Sample Data Showing the Effects of AC Field and DC Field on the Colony and the Microbial Count	37
5.4.0 Experimental Conditions	38
5.4.1 Sample Data Showing the Effect of the Thickness of the Plates to Plate Separation Distance to the Colony and the Microbial Count	38
CHAPTER 6: ANALYSIS AND DISCUSSION	39
6.1.0 The Effect on the Microbial Growth for Samples Exposed under Variable AC Fields	40
6.1.1 Relationship between the Microorganisms Survival Ratio as a Function of the Effective Applied Electric Field	44
6.1.2 Extrapolations of the Trend Lines and Interpretations	47
6.2.0 Effect of Number of Pulses	48
6.2.1 Graphical Analysis	50

6.3 AC Field Compared with the DC Field	53
6.4.0 Data Showing the relationship between of the Thickness of the Plates and Plate Separation Distance to the Colony and the Microbial Count	54
CHAPTER 7: DESIGNING AND MODELLING OF THE TEST CHAMBERS	56
7.1 Design of the Test Chamber	57
7.2. Practical Static Chamber, as Constructed for the Experiment	59
CHAPTER 8: CONCLUSION AND FUTURE WORKS	61
REFERENCES	63
APPENDIX	65
LIST OF FIGURES	
Figure [2.5.a]: Electroporation Affecting a Living Cell	10
Figure [2.5.b]: Electroporation Affecting a Living Cell, Step by Step	11
Figure [3.1.a]: High Voltage Variable AC Supply Unit 0-900v, 50Hz	15
Figure [3.1.b]: Testing of the Fixed AC Voltage Supply Unit (400v highest)	16
Figure [3.1.c]: Testing of the Variable AC Voltage Supply Unit (0~800v)	16

Figure [4.1.a]: Testing and Placing of the Glass Slide Position between Two Plates	25
Figure [4.1.b]: Removing the Glass Slide, Placing the Sample and Notice the Separation Distance	25
Figure [4.1.c]: Glass Slide with Sample, Placed into position and the Power is Switched on	25
Figure [4.2.a]: Equipments: Plate Holder, Durham Tubes, Vials, Pipette Tips, Stopwatch	27
Figure [4.2.b]: The Setup is Connected to the Supply, Durham Tubes Filled with Samples are Placed in the Parallel Plate Holder	27
Figure [4.3.a]: The Setup is Very Similar to Experiment 4.1.1, However Once it is Connected to the Variable DC Supply and the Other Time to a Variable AC Supply	29
Figure [4.4.a]: The Equipments and the General Setup	31
Figure [4.4.b]: The Experiment with one Single Plate (1mm Thickness)	31
Figure [4.4.c]: Increasing Thickness of the Plates to 16mm	32
Figure [4.4.d]: Placing the Sample on the Glass Slide and Connecting the 16mm Plates to Power Supply	32
Figure [4.4.e]: The Top View of the Figure 4.4.C	32
Figure [7.1.a]: Prototype of the Two Chamber “Plates”	59
Figure [7.1.b]: Prototype of Static Chamber Used While Conducting Experiments	59
Figure [7.1.c]: The Horizontal View of the Prototype	60

Figure [7.1.d]: The Top View of the Prototype	60
---	----

LIST OF TABLES

Table [5.1.1]: Samples at Different AC Field Strength	35
Table [5.1.2]: Samples at Different AC Field Strength	35
Table [5.2.1]: Effect of Number of Pulses	36
Table [5.3.1]: AC Field versus DC Field	37
Table [5.4.1]: Thickness of the Plates	38
Table [6.1.1]: Samples at Different AC Field Strength	42
Table [6.2.1]: Effect of Number of Pulses	48
Table [6.3.1]: AC Field versus DC Field	53
Table [6.3.2]: Thickness of the Plates	54