THE EFFECT OF ELECTRONIC COOKERY UPON THE APPEARANCE AND PALATABILITY OF A YELLOW CAKE

by

Helen Kirk Surratt

A thesis submitted to
the Faculty of
The Consolidated University of North Carolina
in partial fulfillment
of the requirements for the degree
Master of Science in Home Economics

Greensboro
1960

Approved by

Madeleine B. Street

Madeleine B. Street, Adviser

ACKNOWLEDGEMENTS

The researcher wishes to express her most sincere appreciation to the many persons whose cooperative efforts made this study possible:

To Mrs. Madeleine Blakey Street, whose skillful guidance and unstinted gift of time made this study possible. Her kindness, understanding, and continued encouragement were a source of inspiration throughout the study;

To Dr. Naomi Albanese and Dr. Irvin Sperry, who assisted in designing the experiment;

To Dr. Hildegarde Johnson, who so willingly directed the statistical analyses of the data;

To the members of the thesis committee, who gave their assistance and constructive criticisms in the writing of this thesis: Dr. Hildegarde Johnson, Dr. Anna Reardon, Mrs. Mary Andrews Dickey, and Miss Sandra Spahr;

To the members of the taste panel, who served willingly and faithfully as judges throughout the experimental work: Misses Thelma Hinson, Evelyn Howell, Viva Playfoot, Mesdames Mary Andrews Dickey, Mary Taylor Dicks, and Messrs. Herman J. Isreal and Frank Martin;

To the Home Economics major students, who rendered their capable assistance in the laboratory; and

To her husband, C. R. Surratt, who developed and printed the photographs.

TABLE OF CONTENTS

CHAPTER	PAGE
I. INTRODUCTION	1
II. REVIEW OF THE LITERATURE	3
Principles of Electronic Cookery	3
Distribution of heat within the food	4
Browning of food	6
Timing of electronic cooking	8
Heat distribution in the electronic range	9
Cake Cookery in the Electronic Range	11
Proportion of ingredients	13
Preparation of the cake dish	14
Use of a cover	15
Cooking load	15
Cooking position	16
Heat selector switch	17
Cooking time	17
Cooling cake	18
Pilot Study	18
III. EXPERIMENTAL PROCEDURE	20
Design of the Experiment	20
Cake Preparation	21
Cake batter	21
Mixing of batters	23

CHAPTER PAGE

Cooking procedure 23

Treatment after cooking 25

Control Cakes 25

Subjective and Objective Tests on Cakes 26

Subjective scoring of the cakes 26

Weight change during cooking 29

Photographs 29

Methods for Data Analyses 29

Subjective scores 30

Subjective ranks 33

Subjective comments 35

Weight change during cooking 35

Photographs 35

IV. EXPERIMENTAL RESULTS 36

The Effect of Increased Liquid 38

Appearance and palatability 38

Rank preference 47

Weight change during cooking 50

Appearance of crumb faces of cakes 53

Summary 58

The Effect of the Size and Shape of the Container . 59

Appearance and palatability 60

Rank preference 68

Weight change during cooking 70

CHAPTER PAGE

Appearance of crumb faces of cakes 71
Summary 73
The Effect of the Electrical Browning Unit 74
Appearance and palatability. 75
Rank preference 87
Weight change during cooking 89
Appearance of top crusts of cakes 90
Summary. 92
The Effect of the Electrical Browning Unit on Cake
Batter Containing 140 gms. of Liquid 93
Appearance and palatability 94
Rank preference 105
Weight change during cooking 108
Appearance of top crusts of cakes 110
Appearance of crumb faces of cakes 112
Summary. 114
Comparison of Control Cakes 115
Appearance and palatability 115
Rank preference 120
Weight change during cooking 121
Appearance of crumb faces of cakes 121
Appearance of top crusts of cakes 122
Summary. 122
V. SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS. 124
Summary. 124

CHAPTER PAGE

Effect of increased liquid 127

Effect of the size and shape of the container. . . 129

Effect of the electrical browning unit 130

Effect of the electrical browning unit on cake batter containing 140 gms. of liquid 131

Comparison of control cakes. 132

Conclusions. 133

Recommendations. 135

BIBLIOGRAPHY 138

LIST OF TABLES

TABLE		PAGE
I.	Analysis of Variance of the Scores for the Appearance and Palatability of Cakes Prepared with 5 Amounts of Liquid	39
II.	Arithmetic Means of Scores for Appearance and Palatability of Cakes Prepared with 5 Amounts of Liquid	41
III.	Mean Scores of Cakes Judged by the 7 Judges in the First Phase of the Experiment.	42
IV.	Sums of Ranks Assigned to Cakes Prepared with 5 Amounts of Liquid	48
V.	Scored Placement and Ranked Preference of Taste Panel for Cakes Prepared with 5 Amounts of Liquid.	51
VI.	Arithmetic Means and Percentages of Weight Loss During Cooking in Cakes Prepared with 5 Amounts of Liquid	52
VII.	Analysis of Variance of the Scores for the Appearance and Palatability of Cakes Baked in Containers of 3 Sizes and Shapes	61
VIII.	Arithmetic Means of Scores for Appearance and Palatability of Cakes Prepared in Containers of 3 Sizes and Shapes.	62
IX.	Mean Scores of Cakes Judged by the 7 Judges in the Second Phase of the Experiment	64

TABLE PAGE

X. Sums of Ranks Assigned to Cakes Prepared in Containers of 3 Sizes and Shapes 68

XI. Scored Placement and Ranked Preference of the Taste Panel for Cakes Prepared in Containers of 3 Sizes and Shapes 70

XII. Arithmetic Means and Percentages of Weight Loss During Cooking in Cakes Prepared in Containers of 3 Sizes and Shapes 71

XIII. Contingency Table of Judges' Ratings of Crust Tenderness of Cakes Browned for 4 Different Lengths of Time 76

XIV. Contingency Table of Judges' Ratings of Crust Color of Cakes Browned for 4 Different Lengths of Time 78

XV. Analysis of Variance of the Scores for the Appearance and Palatability of Cakes Browned for 4 Different Lengths of Time 80

XVI. Arithmetic Means of Scores for Appearance and Palatability of Cakes Browned for 4 Different Lengths of Time. 81

XVII. Mean Scores of Cakes Judged by the 7 Judges in the Third Phase of the Experiment 83

XVIII. Sums of Ranks Assigned to Cakes Browned for 4 Different Lengths of Time. 87

TABLE PAGE

XIX. Scored Placement and Ranked Preference of the Taste Panel for Cakes Browned for 4 Different Lengths of Time 89

XX. Arithmetic Means and Percentages of Weight Loss During Cooking in Cakes Browned for 4 Different Lengths of Time 90

XXI. Contingency Table of Judges' Ratings of Crust Tenderness of Cakes Containing 140 Gms. of Liquid and Browned for 4 Different Lengths of Time 95

XXII. Contingency Table of Judges' Ratings of Crust Color of Cakes Containing 140 Gms. of Liquid and Browned for 4 Different Lengths of Time 97

XXIII. Analysis of Variance of the Scores for Appearance and Palatability of Cakes Containing 140 Gms. of Liquid and Browned for 4 Different Lengths of Time 98

XXIV. Arithmetic Means of Scores for Appearance and Palatability of Cakes Containing 140 Gms. of Liquid and Browned for 4 Different Lengths of Time 99

XXV. Mean Scores of Cakes Judged by the 7 Judges in the Fourth Phase of the Experiment 101

XXVI. Sums of Ranks Assigned to Cakes Containing 140 Gms. of Liquid and Browned for 4 Different Lengths of Time 106

TABLE PAGE

XXVII. Scored Placement and Ranked Preference of the Taste Panel for Cakes Containing 140 Gms. of Liquid and Browned for 4 Different Lengths of Time 109

XXVIII. Arithmetic Means and Percentages of Weight Loss During Cooking in Cakes Containing 140 Gms. of Liquid and Browned for 4 Different Lengths of Time 109

XXIX. t-Test of the Differences Between the Mean Scores for Appearance and Palatability of the Conventional Control Cake and the Electronic Control Cake . . . 116

XXX. Sums of the Ratings Received by the Two Control Cakes for Each Quality of the Appearance and Palatability Factors 118

LIST OF FIGURES

FIGURE PAGE

1. The Balance Used for Weighing the Cake Ingredients . . . 22
2. The Food Mixer Used for Mixing the Cake Batters. 23
3. The Electronic Range Used for Cooking the Cakes. 24
4. Cake Samples Prepared for Judging, Representing One-sixteenth of a Layer, Coded, and in Random Order 27
5. Score Card Used by Judges in Assessing Appearance and Palatability Qualities of Cakes 28
6. Control Cake Containing 120 Gms. of Liquid and Baked in the Conventional Range 55
7. Control Cake Containing 120 Gms. of Liquid and Cooked in the Electronic Range. 55
8. Cake Containing 140 Gms. of Liquid and Cooked in the Electronic Range 56
9. Cake Containing 150 Gms. of Liquid and Cooked in the Electronic Range 56
10. Cake Containing 160 Gms. of Liquid and Cooked in the Electronic Range 57
11. Cake Containing 170 Gms. of Liquid and Cooked in the Electronic Range 57
12. Equipment Used in the Cooking of the Cakes 59
13. 9-inch Layer Cake Cooked in the Electronic Range. . . . 72
14. 6-ounce Cup Cake Cooked in the Electronic Range 72

FIGURE PAGE

15. $8\frac{1}{2}$-inch Loaf Cake Cooked in the Electronic Range . . . 72a

16. Top Crusts of Cakes Browned for 4 Different Lengths of Time 79

17. Top Crusts of Cakes Containing 140 Gms. of Liquid and Browned for 4 Different Lengths of Time 111

18. Crumb Faces of Cakes Containing 140 Gms. of Liquid and Browned for 4 Different Lengths of Time 113

CHAPTER I

INTRODUCTION

The magical quality of electronic cookery was first sensed by Percy Spencer of the Raytheon Manufacturing Company when he became conscious that the melting of a chocolate bar in his pocket was caused by its proximity to a magnetron tube. From such a beginning, the Radarange, the first electronic range, was developed and manufactured. This range, an institution-type, was first used on an experimental basis for approximately ten years. In 1954 the electronic range came on the market for commercial use by public eating places.

In the latter part of that same year, a home-style electronic range was introduced to the consumer by the Tappan Stove Company. To date, four companies - Kelvinator Division of American Motors Corporation, RCA Whirlpool Corporation, Westinghouse Electric Corporation, and Tappan Stove Company - have purchased the rights to the use of the magnetron, source of microwave energy, from the Raytheon Manufacturing Company.[1]

Electronic ranges have been sold to only a small percentage of all homemakers, but the prediction is for increasing thousands of sales. In March 1958, there were 10,000 electronic ranges in use in American homes. It is estimated that there will be 100,000 in use by 1960. The interest of North Carolina homemakers in the range has been indicated by the number of requests for information

---

[1]Hereafter, in this study the full name of a company will be stated only once. Subsequently, the companies will be referred to by an abbreviated name, such as "Raytheon."

that have been received by the School of Home Economics at The Woman's College.

In the spring of 1958, the School of Home Economics installed an electronic range for the purpose of experimentation and class instruction. Very little use of an electronic range is necessary to suggest that it has characteristics, advantages, and disadvantages that differ from those of a conventional range. The products of the electronic range vary in appearance from those cooked in a conventional oven because of the lack of browning. Cooking times required in the electronic range may vary from one-half to one-tenth of those required when using conventional methods. The likelihood of obtaining maximum palatability of foods cooked in the electronic range is based upon an understanding of the techniques in the use of the range. Cooking time instructions generally available for use with an electronic range seem to serve only as a guide. Although each company that has an electronic range on the market, as well as the Corning Glass Works, offers directions for electronic cookery and cooking times, the variety offered in these directions leads to uncertainty of procedure.

It is recognized that studies are needed to ascertain techniques to be used to obtain maximum palatability of various products cooked electronically. With this need in mind, the present study was undertaken to determine whether the appearance and palatability of a yellow cake cooked in an electronic range were affected by: (1) the amount of liquid in the batter, (2) the size and shape of the baking container, and (3) the length of time of use of the electrical browning unit.

CHAPTER II

REVIEW OF THE LITERATURE

A review of the literature revealed that during the past ten years reports on electronic cookery have appeared regularly. Up until 1957 information was primarily related to institutional electronic cookery. Since that date, research has been carried on in schools and colleges of home economics and home economics departments of commercial equipment companies to develop procedures for use of the electronic range in the home. A brief summary of the principles of electronic cookery and problems related to cake cookery in the electronic range will be presented in this chapter.

I. PRINCIPLES OF ELECTRONIC COOKERY

Electronic cookery is accomplished by the means of microwave energy, "a particular type of high-frequency radio energy."[2] In fact, it varies from the energy that carries radio and television programs only in that its frequency of vibration is considerably higher, or 2450 megacycles per second.

The electronic unit is basically a double frequency converter.

> When the electronic timer is operated, 60 cycle 220 volt ac current is changed by the high voltage section of the power pack to pulsating dc voltage from zero to negative 4800 volts, 220 times per second. This is the first frequency conversion.

---

[2]Raytheon, Principles of Microwave Cookery. (Waltham, Massachusetts: Radarange Department, Raytheon Manufacturing Company, 1958), p. 2.

The pulsating negative dc voltage is applied to the magnetron tube cathode--the anode is grounded--and the tube generates microwave power at 2450 megacycles per second. This is the second frequency conversion.[3]

Upon being beamed into the electronic range, microwaves may be either reflected, transmitted, or absorbed, depending upon the molecular structure of the material involved. Metals act as reflectors and are not recommended for electronic cookery in the home. Glass, china, paper, and some plastics allow the transmission of microwaves without appreciable absorption. Foods, on the other hand, absorb the microwaves and, therefore, if processed in a container that transmits but does not absorb microwaves, will cook and the container will remain cool.[4]

Distribution of Heat Within the Food

Due to its molecular structure food will absorb microwaves to the extent of two and one-half to three inches, and the waves penetrate toward the center of the food. As soon as the microwaves begin to penetrate the food, "The high frequency energy instantly agitates the molecules of the food. This molecular action within the food itself generates the heat that accomplishes the cooking."[5] Since the microwaves are absorbed as they penetrate, the heat produced causes the food to cook from the outside toward the center.

---

[3]The Tappan Stove Company, Appliance Manufacturer, Tappan's Electronic Range. /Mansfield, Ohio: The Tappan Stove Company/ (n.d.) (no page number.)

[4]Raytheon, op. cit., p. 3.

[5]Hotpoint Home Economics Institute, Use-Value Presentation 1958. (Chicago: Hotpoint Company, 1957), p. 75.

> However, the transfer of heat by conduction occurs at a much slower rate than the accumulation of heat in those areas penetrated by microwaves. If the item being heated is exposed to the microwave energy until conduction has raised the center temperature to the desired degree, the outer portion of the food will be overheated or overcooked. If the item is removed from the microwaves when the center temperature has come up only part way, the outer portions will not be overheated, yet will have accumulated sufficient heat, so that as the item stands the heat which flows by conduction toward the center will raise the center temperature to the desired point.[6]

The continuation of conduction of heat during this stand-by period is called carry-over heat. The factor of carry-over heating at times necessitates removing a food product from contact with the microwaves before it is completely cooked to allow for the redistribution of heat within the item. To follow such a procedure of removing the product from the range when its center temperature is lower than the temperature of its outer areas will prevent overcooking, and at the same time carry-over heat during the stand-by period will continue the cooking process. Several authorities show that carry-over heating is one of the most important concepts of electronic cookery, and that it is also one of the most difficult to gauge in effect. For larger items, as a roast, the effect of carry-over heating is more of a consideration than with an item such as a cup cake, as the range of temperatures decreases with the smaller product, and the effects of carry-over heating are reduced proportionately.[7] However, Marshall reported disagree-

---

[6]Raytheon, op. cit., p. 6.

[7]Ibid.

ment of the effects of carry-over heat in large roasts, stating that the temperature would drop instead of rising after removal of the roast from the range.[8]

The effect of radiation must also be taken into consideration in electronic cooking. Since the surface of the food will be hotter than the air surrounding it in the range, the food will radiate heat. If allowed to overheat, foods will burn first in the center since the outer edges will be cooled by radiation and be kept moist by steam drawn from the center to the outside.[9]

Browning of Food

The water content of foods normally prevents their reaching a temperature greater than 212°F. in electronic cooking. This property will result in a moist surface for short-time cooking periods, and a lack of crusting or browning of baked products as would be expected in cakes. There is no browning unless foods are exposed to the microwaves for a sufficient time to allow the normal chemical reaction that will produce browning to take place. A normal browning process will occur in electronic cooking when the cooking period extends for a period of 15 minutes or more as is necessary for large roast or fowl.[10] Proctor and Goldblith stated:

> The significant difference between food products cooked in the radar oven and those cooked by conventional methods is that

---

[8]Nancy Marshall, "Electronic Cookery of Top Round of Beef," Journal of Home Economics, 52:33, January, 1960.

[9]Raytheon, op. cit., p. 7.

[10]Ibid., p. 8.

> in the former case no crust or carbonized surface is formed because the heating is uniform throughout the product.[11]

If in an effort to brown food the cooking time is increased until dehydration has occurred, the food will burn from the center out and in spots according to the concentration of the microwave energy.[12]

The manufacturers of home-style electronic ranges have installed an electrical browning unit in the range or have provided an auxiliary electric oven for the browning of foods that are cooked in a few minutes. When the browning unit within the electronic oven is turned on, it can no longer be considered a cool oven.

There was agreement among the authorities as to the desirability of baking one layer of food only. A publication of Raytheon stated:

> So far as possible, foods should be placed in the oven of the RADARANGE(R) in such a manner that they are not stacked, but rather are on the same level and well separated. When food is stacked, the upper layers will absorb part or even all of the microwave energy coming from the top of the oven and will effectively shield the bottom layers and retard or prevent heating. For this reason, it is impractical to put shelves in the oven.[13]

However, in some ranges a shelf is provided. It may be made of fiberglass or of a glass and plastic combination, and is recommended for use when the browning unit is employed. According to the recommendation of Westinghouse, "The shelf is always used when making cakes

---

[11]Bernard E. Proctor and Samuel A. Goldlith, "Radar Energy for Rapid Food Cooking and Blanching, and Its Effect on Vitamin Content," Food Technology, II (1948), 95-104.

[12]Raytheon, loc. cit.

[13]Raytheon, op. cit., p. 25.

and the more delicate things, so that the microwaves will 'bounce' up off the bottom of the range and thoroughly cook the bottom of the cake."[14]

Timing of Electronic Cooking

The literature revealed that there are a number of factors which influence the cooking time for specific foods. These factors are: the weight or amount of food placed in the range, the temperature of the food when placed in the range, the position of the heat switch setting, and the desired degree of doneness. Each of these will have an effect upon the time required for a cooking process.

As the weight of food is increased, the time needed for processing is increased almost in direct proportion to the increase in weight.[15] Raytheon Radarange department stated: "Portion control is important. Careful control of weight means that the heating time for a given dish will always be the same."[16]

Most of the available instruction manuals stated that the temperature of food when placed in the range, whether cold, warm, or at room temperature, controls the length of time necessary to raise the temperature to the desired degree of doneness.

The position of the heat selector at "Hi" or "Lo" speed controls

---

[14]Westinghouse, "Home Call" Demonstration For Westinghouse Electronic Range. /Mansfield: Westinghouse Electric Corporation/ (n.d.) p. 8.

[15]Raytheon, op. cit., p. 12

[16]Ibid., p. 13.

the rate at which heat is produced in the food being cooked.[17] Van Zante and Nakayama found that "heating time of 65 seconds on 'Lo' was equivalent to 52 seconds on 'Hi'."[18]

The degree of doneness of the food is controlled not only by the length of time of contact with the microwaves, but is also influenced by carry-over heating. Raytheon stated that: "correct results will be obtained when food is taken from the range slightly undercooked."[19] Proctor and Goldblith found that slight over-cooking may "have a severe effect on the appearance and edibility of the product."[20]

The type of food controls the length of time required in cooking. Both the density of the food and the readiness with which the microwaves are absorbed have their effect upon cooking time.

In addition to the above factors, Van Zante indicated that:

> The microwave power varies from time to time on the same electronic range. The condition of the magnetron, the magnetron current adjustment, voltage extremes, and power tube conditions all affect the actual cooking power.[21]

Heat Distribution in the Electronic Range

Studies also indicated that heat distribution and heat patterns within the electronic range affect the degree of doneness

---

[17] Ibid., p. 15.

[18] Helen J. Van Zante and Hisako Nakayama, "The Effect of Microwave Energy on the Internal Temperatures of Agar and Food Cylinders," Journal of Home Economics, 51:173, March, 1959.

[19] Raytheon, loc. cit.

[20] Bernard E. Proctor and Samuel A. Goldblith, loc. cit.

[21] Helen J. Van Zante, "Techniques for Electronic Cooking Research," Journal of Home Economics, 51:458, June, 1959.

and palatability of food products. In a special problem by a graduate student at Woman's College in which six 4-ounce custards were cooked electronically, it was found that the microwave energy was unevenly distributed throughout the range as was revealed by the varying degrees of firmness in the custards.[22] It was observed that custards placed in certain positions curdled more readily than those in other positions.

Van Zante and Nakayama found that load size and position affected the cooking time and evenness of heating of each individual portion of the load.

> When the potato load was increased from 1 to 8, it was found necessary to move the potatoes around on the oven shelf during the cooking process in order to get them baked evenly. . . . Furthermore, a difference in doneness was observed among the potatoes baked at the back of the oven and those baked at the front as well as among those at the right and those at the left side. Also, the degree of doneness varied with each potato.[23]

A research problem conducted by two graduate students at Woman's College concerning the baking of cup cakes confirmed the fact that position affected the cooking time of individual portions of a load. The findings of the study were that the position in the range affected the speed of rising, the loss of moisture, and the browning of the individual cup cakes. It was reported that in the three rows of cup cakes, evenly distributed through the range, the cake located in the center back position rose first, and those in the right and left

---

[22]Thelma Hinson, "Electronic Cookery of Baked Custards" (Unpublished Special Problem, School of Home Economics, Woman's College, University of North Carolina, Greensboro, 1959), p. 4.

[23]Helen J. Van Zante and Hisako Nakayama, "The Effect of Microwave Energy on the Internal Temperature of Agar and Food Cylinders," p. 174.

positions at the front of the range rose last. The cakes located in the back row averaged the greatest loss of moisture in cooking, and those in the front averaged the smallest amount of moisture loss. Corresponding cup cakes on the left and right and at the front and back of the range did not brown alike. The most acceptable browning positions were in the center directly under the browning unit.[24]

II. CAKE COOKERY IN THE ELECTRONIC RANGE

In the literature directing the use of the electronic range for cooking of cakes, the Home Economics Institute of the Hotpoint Company stated that cakes "are all tender crumb when cooked electronically, light in texture and truly delicious,"[25] and "Electronically baked cakes are in general, more tender, light, and higher in volume than cakes baked by conventional methods."[26] The Institute stated that cakes cooked in the electronic range would be "approximately one-third higher in volume than cakes baked in your conventional oven"[27] and "lighter,

---

[24]Patricia E. Godwin and Mary Kathryn Nicholson, "The Effect of Electronic Cooking on a Group of Cup Cakes" (Unpublished Special Problem, School of Home Economics, Woman's College, University of North Carolina, Greensboro, 1959), p. 5.

[25]Hotpoint Home Economics Institute, Use-Value Presentation 1958, p. 76.

[26]Hotpoint Home Economics Institute, Let's Get Acquainted With Your Hotpoint Electronic Cooking Center, (n.d.) (no page number.)

[27]Hotpoint Home Economics Institute, Let's Get Acquainted With Your Hotpoint Electronic Cooking Center, (No page number.)

perhaps, because the rising is not limited by the formation of a crust."[28] The same source, however, stated that the angel food cake cooked too quickly in the electronic range to produce a product of high quality.[29]

In the literature reviewed, there were no directions found concerning browning of cakes cooked electronically. A Tappan publication stated that "cakes need not be browned because the brown color is lost after the frosting covers the cake,"[30] and a Hotpoint publication was in agreement with this statement.[31] However, Proctor and Goldblith stated:

> The radar-baked cakes were cooked evenly throughout and differed from cakes baked in the gas oven mainly in that they lacked a crust. Hence the radar oven is recommended for cakes that are normally to be covered with whipped cream or a frosting. A crust may be obtained easily, however, by exposing the upper surface of a radar-baked cake to the heat radiations of a fine-wire heating element for one to one and one-half minutes.[32]

Varied directions for the preparation and cooking of cakes electronically were found in information prepared by the manufacturing and equipment companies for demonstrating to the consumer the operation

---

[28]Hotpoint Home Economics Institute, "One Million Years New," Electronic Cooking Center Script For 1958 Regional Use-Value Meetings, p. 5.

[29]Hotpoint Home Economics Institute, Let's Get Acquainted With Your Hotpoint Electronic Cooking Center, (no page number.)

[30]The Tappan Stove Company, "Tappan Electronic Range Homemaker Bulletin," Bulletin No. 4, July, 1957, (no page number.)

[31]Hotpoint Home Economics Institute, Use-Value Presentation 1958, p. 76.

[32]Bernard E. Proctor and Samuel A. Goldblith, "Radar Energy for Rapid Food Cooking and Blanching, and Its Effect on Vitamin Content," p. 95.

and use of the electronic range. Differences in procedures occurred in: (1) proportion of ingredients in the batter, (2) preparation of the cooking container, (3) use of a cover in cooking a cake, (4) cooking load for a specific product, (5) cooking position in the range, (6) heat selector switch setting, (7) electronic timer setting, and (8) cooling the cake in the container.

Proportion of Ingredients

Westinghouse recommended a reduced amount of leavening for home-mixed cakes, but no change in the directions with prepared mixes.[33] Hotpoint advised the homemaker to use cake recipes designed specifically for electronic range cooking or to adjust recipes established for conventional cooking "by the addition of more liquid and shortening and in some instances, less baking powder is necessary."[34] It was advised that mixes be used as directed on the package, but "for greater volume and tenderness to cake mixes not requiring eggs, measure in one egg as part of second addition of liquid."[35] The Home Economics Department of Corning Glass Works recommended following the directions found on the package for the mixing procedure and addition of ingredients.[36] In

---

[33]Westinghouse Electric Corporation, The Miracle of SPEED-O-LIGHT Cooking, (n.d.), p. 13.

[34]Hotpoint Home Economics Institute, "One Million Years New," Electronic Cooking Center Script for 1958 Regional Use-Value Meetings, p. 5.

[35]Hotpoint Home Economics Institute, Let's Get Acquainted With Your Hotpoint Electronic Cooking Center, (no page number.)

[36]Corning Glass Works, Home Economics Department, Cooking With The Electronic Range, (Corning, New York: Corning Glass Works, 1956), p. 8.

directions given for Angel Food cake mix to be cooked electronically, Tappan advised "follow direction on box for mixing the high altitude cake."[37] These directions included the addition of one-third cup of extra liquid. Kelvinator suggested that recipes are altered for this method of cooking, but that "prepared cake mixes can be cooked without any alterations."[38] It was also suggested that some package cakes give more volume than others.[39]

Preparation of the Cake Dish

The majority of the directions given for preparing the cake dish agreed in the use of an ungreased container with a layer of wax paper on the bottom for easy removal of the cake. Since electronically baked butter cakes are so soft and without crust, Tappan recommended that two layers of wax paper be used, with the supposition that one would stick to the dish and the second to the cake, thus making it easier to turn the layer right side up.[40] Hotpoint also gave directions for the use of two layers of paper.[41]

---

[37]The Tappan Stove Company, "Tappan Electronic Range Homemaker Bulletin," Bulletin No. 5, (no page number.)

[38]Kelvinator Institute, Electronic Range Demonstration, [Detroit: American Motors Corporation,] p. 6.

[39]The Tappan Stove Company, "Tappan Electronic Range Homemaker Bulletin," Bulletin No. 4, (no page number.)

[40]The Tappan Stove Company, Tappan Electronic Range Homemaker Bulletin," Bulletin No. 5, (no page number.)

[41]Hotpoint Home Economics Institute, Use-Value Presentation 1958, p. 95.

Use of a Cover

A publication of the Whirlpool Corporation suggested the use of wax paper over the top of the cake while cooking to eliminate a slightly uncooked appearance around the rim of the pan; however, it was also stated that "as good or better product may be obtained with no paper over the top, and is more convenient from the standpoint of handling the utensil."[42] Kelvinator suggested using a cover of wax paper or Saran Wrap.[43] Hotpoint stated that "when a cake is removed from the Electronic Compartment, it will be slightly moist on top. This is typical and it will dry off in a minute or two after being removed."[44] Recent publications from the Tappan[45] and Westinghouse[46] companies recommended the omission of the cover while cooking, and the use of the electrical browning unit for the last minute of the cooking time to dry the surface of the cake.

Cooking Load

There was general agreement among all sources consulted that each cake layer or loaf cake should be cooked individually. There was a

---

[42] Whirlpool Corporation, "General Guides to Cooking Foods Electronically," [St. Joseph, Michigan: Whirlpool Corporation] (n.d.), p. 6.

[43] Kelvinator, loc. cit.

[44] Hotpoint Home Economics Institute, "One Million Years New" Electronic Cooking Center Script for 1958 Regional Use-Value Meetings, p. 5.

[45] The Tappan Stove Company, "Tappan Electronic Range Homemaker Bulletin," Bulletin No. 4, (no page number.)

[46] Westinghouse Electric Corporation, (Miscellaneous Recipes for the Electronic Range), (n.d.), (no page number), (mimeographed).

difference of opinion as to the number of cup cakes that should be baked at one time. Publications of Westinghouse recommended eight cup cakes,[47] Whirlpool,[48] and Tappan[49] recommended six cup cakes per baking, and Hotpoint suggested that it was possible to cook one cup cake at a baking.[50]

Cooking Position

Directions varied for the location of a cake in the range while cooking. Tappan,[51] Kelvinator,[52] and Corning Glass[53] recommended the use of the shelf in the center position, while Whirlpool[54] and Westinghouse[55] suggested that the shelf be used in the bottom position for cooking cake. Hotpoint recommended the use of a shelf, but did not mention a choice of shelf position.[56]

---

[47] Westinghouse Electric Corporation, 7-Minute Electronic Range Demonstration, 1957, p. 5.

[48] Whirlpool Corporation, "General Guides to Cooking Foods Electronically," p. 6.

[49] The Tappan Stove Company, Recipe Card File, (Cake section, Index card).

[50] Hotpoint Home Economics Institute, Use-Value Presentation 1958, p. 77.

[51] The Tappan Stove Company, "Tappan Electronic Range Homemaker Bulletin," Bulletin No. 4, p. 1.

[52] Kelvinator Institute, loc. cit.

[53] Corning Glass Works, Home Economics Department, Cooking With the Electronic Range, p. 8.

[54] Whirlpool Corporation, "General Guides to Cooking Foods Electronically," p. 6.

[55] Westinghouse Electric Corporation, The Miracle of SPEED-O-LIGHT Cooking, p. 13.

[56] Hotpoint Home Economics Institute, Use-Value Presentation 1958, p. 83.

Heat Selector Switch

All directions agreed on the rate at which heat should be produced in the food and recommended setting the selector switch on "Hi."

Cooking Time

In the literature consulted, different directions were found for the length of the cooking period for cakes varying in form and shape. Tappan[57] directed from three to three and one-half minutes for cooking a layer of cake, Kelvinator,[58] Corning Glass,[59] and Hotpoint[60] three minutes, and Westinghouse[61] three and one-half minutes. Westinghouse[62] directed sixty seconds for cooking eight cup cakes, Hotpoint[63] thirty seconds for one cup cake, and Tappan[64] three minutes for six cup cakes.

---

[57]The Tappan Stove Company, "Tappan Electronic Range Homemaker Bulletin," Bulletin No. 4, p. 1.

[58]Kelvinator Institute, loc. cit.

[59]Corning Glass Works, Home Economics Department, Cooking With the Electronic Range, p. 8.

[60]Hotpoint Home Economics Institute, Use-Value Presentation 1958 p. 78.

[61]Westinghouse Electric Corporation, (Miscellaneous Recipes for the Electronic Range,) (no page number.)

[62]Westinghouse Electric Corporation, 7-Minute Electronic Range Demonstration, p. 5.

[63]Hotpoint Home Economics Institute, Use-Value Presentation 1958 p. 77.

[64]The Tappan Stove Company, Recipe Card File, (Cake section, Index Card and p. F-1.)

Hotpoint[65] recommended seven minutes and Westinghouse[66] five minutes for cooking a loaf cake. Hotpoint suggested the following method for testing the doneness of a cake:

> To test cakes for doneness insert a toothpick into the center of the cake. If the bottom portion of toothpick comes out clean, then the cake is done. The upper portion of the toothpick will have cake adhering since the rapid cooking of the cake causes a condensation of moisture across the top of the cake. This will disappear as the cake cools.[67]

Cooling Cake

Recommendations for length of time to leave the cake in the dish for cooling varied from two minutes as directed by Tappan[68] to ten minutes by Hotpoint.[69]

III. PILOT STUDY

The wide variety of procedures recommended in the literature for the cooking of cakes in an electronic range prompted a study that was made at Woman's College to develop a procedure for mixing and cooking a cake to use as a control for further experimentation with a Tappan

---

65Hotpoint Home Economics Institute, Use-Value Presentation 1958, p. 76.

66Westinghouse Electric Corporation, (Miscellaneous Recipes for the Electronic Range,) (no page number.)

67Hotpoint Home Economics Institute, Let's Get Acquainted With Your Hotpoint Electronic Cooking Center, (Cake section, no page number.)

68The Tappan Stove Company, "Tappan Electronic Range Homemaker Bulletin," Bulletin No. 4, p. 1.

69Hotpoint Home Economics Institute, Let's Get Acquainted With Your Hotpoint Electronic Cooking Center, (no page number.)

electronic range.[70] The findings resulting from this study were as follows:

(1) A cake mixed on the lowest mixer speed gave the most desirable texture and volume,

(2) the use of a baking dish with sides untreated and a double layer of wax paper on the bottom resulted in ease of removal of the cake from the dish, and

(3) that the baking procedure be as follows: Electronic timer set for $3\frac{1}{2}$ minutes; Hi-Lo switch set on Hi; shelf placed in center position; dish centered on the shelf; cake baked uncovered; and browning timer used simultaneously during the last one minute of electronic cooking time.

---

[70]Madeleine Blakey Street, "Palatability of Cakes Baked in the Electronic Range" (unpublished Grant-in-Aid Project No. 49, Research Council, Woman's College, University of North Carolina, Greensboro, 1959), p. 1.

CHAPTER III

EXPERIMENTAL PROCEDURE

The procedures used for the preparation and baking of the cakes in this study were based upon the findings of a pilot study involving the use of the electronic range for cake cookery.[71] In this chapter, the procedures for preparation and baking of the cakes, the methods used in testing the cake for quality and acceptability, and the methods used in the analyses of the data will be discussed.

I. DESIGN OF THE EXPERIMENT

An experiment was designed to test the effect of electronic cookery upon cake quality when the treatment of the cake batter was varied. The variables used in this study were: (1) the amount of liquid in the batter, (2) the size and shape of the baking container, and (3) the length of time the cakes were browned with the electrical browning unit of the electronic range. The testing of each of the variables constituted a phase of the experiment. Cakes employing only one variable were baked and tested on four different days. Throughout this study each baking will be referred to as a replication. Each replication consisted of the cooking of four or six cakes, depending upon the variable under study. The preparation, baking, and scoring of the cakes for a replication were completed within one day. Four weeks were required for completion of the replications constituting a

---

[71] Cf. ante, p. 18.

phase of the experiment. Sixteen weeks were required for the total experiment. The order of preparation and baking was randomized within each replication in an effort to counteract the possibility of a change in microwave energy after continued use of the range. Whenever the cakes were browned in the electronic range, an interval of time was allowed between cookings to permit the electrical unit to cool. This interval decreased the possibility of there being sufficient heat left in the element to increase the degree of browning. In all phases of the experiment, one cake was mixed and baked before mixing another. Hereafter, in this study the cakes will be referred to as being "cooked" in the electronic range and "baked" in the conventional oven.

II. CAKE PREPARATION

Cake Batter

A yellow cake mix, taken from one sifting to eliminate variability in proportion of ingredients, was secured from the manufacturer.[72] The mix required the addition of whole eggs and water.

To establish the amounts of ingredients needed to produce the volume of batter desired for one layer of cake, a proportionate part of the ingredients recommended by the cake mix manufacturer for a two-layer cake was used. The proportions used in this study were:

---

[72]General Mills, Betty Crocker Yellow Cake Mix.

(1). 269.2 gms. cake mix, which approximated $\frac{1}{2}$ package of mix;

(2). 48 gms. eggs, which approximated 1 egg; and

(3). 120 gms. water, which approximated $\frac{1}{2}$ cup of water.

The volume of batter established for a layer of cake in this study was 425 gms. This volume was held constant for each cooking and baking throughout the experiment.

The ingredients were weighed to 0.1 gm. on a trip balance (Figure 1). All weighing was done on the day of baking. The water for each cake batter was weighed into two portions in separate containers to add in two stages of mixing as directed by the mix manufacturer. The eggs for the day's baking were broken into a mixing bowl and beaten slowly with a rotary beater until they were well combined. The amount needed for each batter was weighed into a small container. All ingredients were at room temperature at the time of mixing.

FIGURE 1

THE BALANCE USED FOR WEIGHING THE CAKE INGREDIENTS

Mixing of Batters

The batters were mixed in a household food mixer (Figure 2). The machine was equipped with a 3-quart bowl. The beater moved with full planetary action and traveled around the bowl in one direction while turning on its own axis in the opposite direction. The lowest speed was used for mixing.

FIGURE 2

THE FOOD MIXER USED FOR MIXING THE CAKE BATTERS

Cooking Procedure

For electronic cookery, oven-proof glass, paper, and some plastic containers were recommended, but glass was used since it was available in all types of containers contemplated for use. A double layer of wax paper was placed on the bottom of the cake dishes, and the sides remained untreated. A constant weight of 425 gms. of batter was used for each cooking.

The cakes were cooked in a Tappan electronic range, Model RL-4 (Figure 3).

FIGURE 3

THE ELECTRONIC RANGE USED FOR COOKING THE CAKES

The range was designed to operate on 208 volts, single phase, 60 cycle current. According to the Tappan manual, the range normally consumed approximately .7KW during the warm-up period and approximately 3.5KW during the cooking operation. The electrical browning unit, when used, required an additional 4KW.[73] "The electronic timer is in 10-second increments for the first 3 minutes and then 30-second increments up to 21 minutes. At 21 minutes the timer must be reset."[74] The browning timer was in 10-second increments

---

[73]The Tappan Stove Company, "Operation of the Tappan Electronic Range," p. 2.

[74]The Tappan Stove Company, Appliance Manufacturer, Tappan's Electronic Range, (no page number.)

for the first 3 minutes, 30-second increments up to 4 minutes, and 60-second increments up to 5 minutes. At the end of any timed electronic cooking or browning period a bell chimed continuously and had to be turned off manually.

The cooking procedure was as follows: Set electronic timer for $3\frac{1}{2}$ minutes; set Hi-Lo switch on Hi; place shelf in center position; center dish on the shelf; cook cake uncovered; use browning timer simultaneously during the last one minute of electronic cooking time.[75]

Treatment After Cooking

After cooking, the cakes were treated as follows: (1) weighed to determine the weight change during cooking, (2) cooled in the cooking dish on a rack for two minutes, (3) removed from the dish and cooled on a rack for ten minutes, and (4) placed in a plastic bag until ready for preparation for judging.

III. CONTROL CAKES

On each baking day, sufficient batter was prepared at one mixing for two layers of cake using the proportion of 120 gms. of liquid per layer of batter, as established by the cake mix manufacturer. One layer was cooked in the electronic range as outlined in the foregoing procedure for comparison with the cake variations. The other layer was baked in a conventional electric oven following the baking procedure recommended by the cake mix manufacturer and was used

---

[75]Cf. ante, p. 19.

throughout the study for comparison with cake cooked in the electronic range.

IV. SUBJECTIVE AND OBJECTIVE TESTS ON CAKES

Subjective Scoring of the Cakes

A taste panel scored the cakes subjectively within a two-hour period after baking. The judges composing the taste panel were five home economists and two commercial bakers. One baker was from a small "home-type" bakery, and one from a large commercial bakery who had previously been employed as a professional cake taster. During each judging session four or six samples of cake were presented to each judge, depending upon the number of cakes baked in an experimental phase. Each judge received one sample from each cake on the day it was baked. These samples included one from each of the two control cakes, and one from each of the experimental cakes. The cake samples given a judge were selected from the cakes in random fashion in relation to the baking position in the range. Each judge received a wedge of each cake representing one-sixteenth of a layer, coded, and in random order (Figure 4).

Replicate cakes were judged on four different baking days by the same judges. There was a total of twenty-eight judgments on each cake made in each experimental phase.

A score card was used for the recorded opinions of the judges in relation to: (1) crust tenderness, (2) crust color, (3) size of cells, (4) distribution of cells, (5) crumb characteristics, (6) tenderness, (7) moisture, (8) flavor, (9) judges' preference of cakes in rank order, and (10) judges' comments (Figure 5). This check-type score card was adapted from one used in a study of Cake Quality and Batter Structure[76] by Hunter, Briant, and Personius. Numerical values did not appear on the judges' score card; therefore, the judges did not know that their opinions were to be quantified.

FIGURE 4

CAKE SAMPLES PREPARED FOR JUDGING, REPRESENTING ONE-SIXTEENTH OF A LAYER, CODED, AND IN RANDOM ORDER

[76]Mildred B. Hunter, Alice M. Briant, and Catherine J. Personius, Cake Quality and Batter Structure, Bulletin 860, Ithaca, New York: Cornell University Agricultural Experiment Station, 1954, p. 17.

Qualities	Values used for statistical analysis*
Crust	
Tenderness	
Tender	
Slightly tender	
Tough	
Too moist	
Color	
Golden brown	
Pale	
Too dark	
No browning	
Size of Cells	
Large	3
Medium	10
Small	10
Very fine	3
Compact	1
Distribution of Cells	
Uniform	6
Irregular	4
Tunneled	2
Crumb Characteristics	
Velvety	10
Slightly harsh	8
Very harsh	2
Tenderness	
Crumbly	3
Very tender	6
Tender	10
Slightly tender	8
Tough	3
Moisture	
Moist	10
Dry	5
Wet	2
Flavor	
Well-balanced	10
Sweet	5
Salt	2
Bitter	2

FIGURE 5

SCORE CARD USED BY JUDGES IN ASSESSING APPEARANCE AND PALATABILITY QUALITIES OF CAKES

* These values did not appear on the judges' score card.

Weight Change During Cooking

Each cake was weighed before and after cooking to determine whether there was a change in weight during cooking. The weight of all cooking containers was permanently recorded on the container. The batter was weighed directly into the layer dish from the mixing bowl; however, for the cup cakes the batter was placed in a quart measuring cup for pouring into the cups with a minimum of handling. The cooked cakes were weighed immediately after removal from the range. The cup cakes were weighed individually, and then the total weight was computed for the eight cup cakes.

Photographs

In the variables employing different amounts of liquid and different sizes and shapes of containers, photographs were made of the crumb faces of the half-cakes that were not used for judging. The top crusts of cakes that were browned were photographed immediately before slicing the cake for judging.

V. METHODS FOR DATA ANALYSES

To statistically analyze the judges' opinions of the appearance and palatability qualities of the cakes, it was necessary to quantify the score card. The researcher used the same method of quantifying the score card as had been reported in the bulletin from which the score card was obtained. Although this quantifying was probably considered a continuous scale, each quality factor was assigned one numerical value. No intermediate values were used, and the intervals between score values varied in size. For example, the scores for cell size progressed as follows: large 3, medium 10, small 10, very fine 3, compact 1. With this method of quantifying, the higher the score received, the better the quality of the particular factor scored. The assigned values allowed a maximum total score of 56 and a maximum score of 10 for each of the appearance and palatability qualities, with the exception of cell distribution, which had a maximum score of 6.

Since cake mix from the same sifting was used for all of the cakes and no ingredients were added that would vary the flavor, no analysis was made of the scoring of flavor by the judges in any part of this study. Statistical analyses were made of each of the remaining appearance and palatability qualities and of the judges' rankings of the cakes. The different statistical methods used for the analyses will be discussed separately.

Subjective Scores

Analyses of variance were computed to determine the significance of the differences in the scores of cakes in each experimental phase among the cakes treated differently, among the seven judges, among the four replications, and of the interaction between cake treatments and judges. The method presented by Ostle was used in computing the analyses of variance.[77] The hypothesis that was tested was: the variance among the means of the scores assigned to

---

[77]Bernard Ostle, Statistics in Research, p. 344.

each of the appearance and palatability qualities of cakes treated differently was zero. The total scores were not analyzed because it was found in the first set of analyses that adding across the various appearance and palatability factors resulted in scores which differed less from treatment to treatment than did the scores of the analyses of each of the factors separately. The scores of the cakes baked in the conventional oven were not included in the analyses of variance since there were two control cakes and they differed from each other only in method of cooking. The differences in the conventionally baked cake and the electronic control cake will be discussed separately in Chapter IV.

To further describe differences among treatments and judges, arithmetic means were computed for the 28 scores assigned by the seven judges in the four replications to each appearance and palatability quality of each cake treatment within an experimental phase. In addition, the means of the scores assigned by each judge were computed by combining the scores assigned by him to each of the appearance and palatability factors of all cakes scored within an experimental phase. The means of the scores of the individual judges will be referred to in this study as "sub-scores."

The method presented by Walker and Lev was used to compute the chi-square values for crust tenderness and crust color.[78] The chi-square is a comparison between an actual occurrence and a hypothetical occurrence. The more closely the observed results

---

[78]Helen M. Walker and Joseph Lev, Statistical Inference, p. 85.

approximate the expected, the smaller is chi-square and the closer is the agreement between the observed data and the hypothesis being tested. The larger the chi-square, the greater the divergence of the observed frequencies from the expected and the greater the disagreement between the observed data and the hypothesis being tested. If each of the observed frequencies agreed exactly with the corresponding theoretical frequency, chi-square would be zero. The hypotheses being tested in this study were: (1) there was no difference in the tenderness of cake crusts browned for different lengths of time, and (2) there was no relationship between crust color and the length of time the browning unit was used. In this study some categories were combined because of the smallness of the frequencies. In testing the significance of crust tenderness, the frequencies for "tender" and "slightly tender" were combined and those for "tough" and "too moist" were combined. In testing the significance of crust color, the frequencies for "golden brown" and "too dark" were combined and those for "pale" and "no browning" were combined. In choosing the categories to combine, an effort was made to combine those qualities that were similar.

The t-test presented by Snedecor was used to test the significance of the differences between the mean scores of the control cake cooked in the electronic range and the control cake baked in the conventional oven.[79] Differences between the mean scores for each of the appearance and palatability factors were tested for significance. Also, the difference between the means of the weight loss

---

[79]George W. Snedecor, Statistical Methods, pp. 77 and 81.

during cooking of the control cakes cooked in two types of ranges was tested for significance. The hypotheses being tested were: (1) the difference between the mean scores of the control cake cooked in the electronic range and the control cake baked in the conventional oven was zero, and (2) the difference between the means of the weight loss during cooking of the control cake cooked in the electronic range and the control cake baked in the conventional oven was zero.

The values of each of the statistical analyses were considered to be significant if the computed value was equal to or larger than the value recorded at the five per cent level of the appropriate table, and highly significant if the computed value was equal to or larger than the value recorded at the one per cent level.

Subjective Ranks

The judges were requested to rank the individual cake samples in rank order of preference. To compute the sums of ranks, numerical values were assigned to the rank placements. The cake sample receiving the highest rank from a judge placed first, with a numerical value of one; the cake sample receiving the lowest rank from a judge placed last, with a numerical value of six. The sum of the numerical values for 28 judgments for each cake sample, 7 judges and 4 replications, determined the rank placement assigned to a cake. In the experimental phases in which six cakes were baked, there was a possibility of a cake sample having a minimum sum of 28, a score indicating perfect agreement among the judges that this cake was best. A sum of 168 was the maximum score possible for sixth rank position, a score indicating perfect agreement among the judges that this cake was least desirable. In the experimental phase in which four cakes were baked, there was a possibility of a cake sample having a minimum sum of 28 and a maximum sum of 112.

The coefficient of concordance among the judges' ranks was computed, and the F test of significance was applied as recommended by Walker and Lev.[80] The coefficient of concordance is a measure of the degree of relationship among several sets of ranks. This coefficient of concordance is interpreted similarly to product moment coefficient of correlation except that it may have values ranging from zero to one, rather than from minus one to plus one. A coefficient of zero indicated that there was perfect disagreement among the judges, and a coefficient of one indicated that there was perfect agreement among the judges. The hypothesis tested in this study was: the concordance was zero among judges in the population of which judges in this study were a sample. The F test used to test this hypothesis determined whether the concordance among judges was significantly different from zero.

The coefficient of concordance was also computed and tested for significance for the individual judges' ranks to determine whether a judge was consistent in the way he ranked the cakes from one replication to the next within an experimental phase.

---

[80]Helen M. Walker and Joseph Lev, Statistical Inference, p. 284.

Subjective Comments

The judges' comments were limited, and when made, they primarily confirmed the scores that had been assigned to the cakes. The comments will not be discussed.

Weight Change During Cooking

In each experimental phase, the arithmetic means for the weight loss during cooking were computed for the four replicate cakes to determine the difference between the means of the weight loss of cakes treated differently within an experimental phase. The arithmetic means were then divided by the original weight of the batter to obtain the percentage weight loss during cooking in an effort to determine whether weight loss was related to the method of cooking, or to the treatment of the cake batter.

Photographs

The photographs of the crumb faces of the cakes were observed to: (1) analyze the contour of the top surface, (2) compare heights of the two sides of an individual cake, (3) compare volume of different cakes within a replication, and (4) compare the cell distribution of cakes within a replication. The photographs of the top crusts of the cakes were observed for the degree and pattern of browning. A descriptive analysis was made of all photographs.

CHAPTER IV

EXPERIMENTAL RESULTS

In this chapter, the findings of the experiment will be discussed in relation to the variable employed. However, there were some findings that applied to all variables studied. These will be discussed first.

One of the consistent findings throughout the study was that the judges differed significantly in the scores that they assigned to the cake characteristics.[81] This difference may have been due to the differences of opinion among the judges as to the appropriate descriptive term for a quality factor, such as cell size. There probably were differences also in their personal standard of a "good" cake and differences in their ability to discriminate among cakes which were much alike. It is also possible that differences among judges may have been magnified because of the nature of the method of quantifying the descriptive terms on the score card. For instance, a cake with cell size scored "small" became 10 when it was quantified, and a cake scored "very fine" became only 3 when it was quantified. The actual difference to the judges between a "small" and a "very fine" cell size in cakes might not have seemed as important as was the difference between a score of 10 and 3, values

---

[81]Hereafter, the ratings given by the judges to the appearance and palatability qualities of the cakes will be referred to as "the judges' scores."

assigned by an earlier researcher. Furthermore, it may have been possible that the significant difference that existed in the judges' scores was the result of a true difference in quality of the samples taken from the same cake. It was observed during cooking that the cake batter in the section of the container nearer the back of the electronic range rose more rapidly and to a greater height than in the section of the container nearer the front of the range. This difference indicated that the microwave energy was more concentrated in the area near the back of the range. Such difference would result in considerable variation among samples from the same cake.

Throughout the study, the scores assigned to the cake characteristics differed significantly from one replication to the next. This difference in scores possibly was due to the fluctuation of the microwave energy as a result of variation in the voltage input. This variation would make it difficult to secure uniform results from day to day even when ingredients had been weighed accurately to 0.1 gm. and when mixing procedures had been standardized.

The majority of the judges scored all of the cakes cooked in the electronic range more tender than those baked in the conventional oven, their scores ranging from "tender" to "very tender." This increased tenderness may have been due to the increased rising of the product in electronic cooking with a controlled amount of leavening agent, as in a commercial cake mix.

Many of the important outcomes of this study were observations of the researcher which could not be revealed by the statistical design.

I. THE EFFECT OF INCREASED LIQUID

To study the effect of an increase in liquid in the batter on the quality of cake cooked in the electronic range, the judges scored samples of cake made from experimental batters containing 140, 150, 160, and 170 gms. of liquid to the proportionate amount of cake mix used in this study. However, only 425 gms. of batter were used for each cooking. A total of six cakes were baked in each replication of this phase of the experiment. In this experimental phase, the electrical browning unit was used for one minute only, which dried rather than browned the surface of the cake. In preparing the samples for judging, the brown crust was removed from the cake baked in the conventional oven.

APPEARANCE AND PALATABILITY

In judging the effect of increased liquid on the quality of the cake, the following factors were scored: (1) cell size, (2) cell distribution, (3) crumb character, (4) tenderness, and (5) moisture. The analyses of each of these factors will be discussed separately.

Cell Size

Amount of liquid: There was no significant difference in cell size amoung cakes with different amounts of liquid (Table 1), as indicated by the F ratio of .82.[82] The arithmetic means of the

---

[82]Hereafter, "in the batter" will be omitted, and a cake will be referred to as "the cake containing a certain amount of liquid."

TABLE I

ANALYSIS OF VARIANCE OF THE SCORES FOR THE APPEARANCE AND PALATABILITY OF CAKES PREPARED WITH 5 AMOUNTS OF LIQUID (4 REPLICATES, AND 7 JUDGMENTS OF EACH REPLICATE)

Source of variance	Degrees of freedom	Appearance and Palatability of Cakes: Cell size		Cell distribution		Crumb character		Tenderness		Moisture	
		Mean square	F value	Mean square	F value	Mean square	F value	Mean square	F value	Mean square	F value
Total	139										
Replicates	3	39.84	3.69*	1.94	.58	39.65	4.66**	5.76	.71	2.59	.42
Treatments											
Amounts of liquid	4	8.84	.82	11.71	3.48*	8.11	.95	13.04	1.61	16.90	2.76*
Judges	6	74.74	6.92**	3.59	1.07	18.91	2.22*	15.11	1.87	45.71	7.46**
Interaction	24	10.53	.97	.51	.02	3.08	.36	4.38	.54	13.01	2.12
Experimental error	102	10.81		3.36		8.50		8.09		6.13	

* "Significant," probabilities between 0.05 and 0.01.
** "Highly significant," the F ratio indicated probabilities less than 0.01.

scores of cakes containing different amounts of liquid varied less than two points, as reported in Table II. The cell size was consistently rated by the judges as "very fine," "small," or "medium." An even distribution of ratings among these three cell sizes resulted in a similar mean score for all cakes.

Judges: There was a highly significant difference among the scores assigned by the seven judges (Table I), as indicated by the F ratio of 6.92. Differences such as these were significant, but there was also considerable variability among cakes supposedly treated alike and judged by the seven different judges as indicated by the large experimental error. There was a range of 5.4 in the means of the scores of the different judges, as reported in Column 1 of Table III. Judge six tended to rate all the cakes low on cell size regardless of the amount of liquid in the batter and of replication, as represented by his low mean score of 3.5. Judge four tended to rate all of the cakes very high as indicated by a mean score of 8.9 in a situation in which 10 was the maximum score.

It was observed in the original score cards that the judges did not agree on the cell size of the conventionally baked cake. This cake would not have been subject to the variability of distribution of heat energy that was found to exist in the electronic range. Two judges scored the cell size "compact," and two scored it "large." These are the two extreme qualities possible in the cake according to the score card. It is possible that these cakes did differ in cell size without the difference having been revealed in the analyses. The significantly different scores of the judges

TABLE II

ARITHMETIC MEANS OF SCORES FOR APPEARANCE AND PALATABILITY
OF CAKES PREPARED WITH 5 AMOUNTS OF LIQUID
(4 REPLICATES, AND 7 JUDGMENTS OF EACH REPLICATE)

Type of range	Grams of liquid per layer	Appearance and Palatability Qualities						
		Cell size	Cell distribution	Crumb character	Tenderness	Moisture	Flavor	Total
Conventional	120	7.11	5.03	8.97	7.17	7.81	9.32	43.42
Electronic	120	7.14	4.53	8.32	7.89	7.64	9.25	43.25
	140	7.10	5.14	9.20	7.86	8.64	8.84	45.60
	150	5.78	3.92	9.60	7.54	8.89	9.07	43.78
	160	6.78	3.64	9.53	7.37	8.14	9.07	42.71
	170	6.88	4.07	8.97	7.64	6.96	9.42	42.64
Maximum score		10.00	6.00	10.00	10.00	10.00	10.00	56.00

TABLE III

MEAN SCORES OF CAKES JUDGED BY THE 7 JUDGES IN THE FIRST PHASE OF THE EXPERIMENT

Judges	Cell** size	Cell distribution	Crumb* character	Tenderness	Moisture**
1	6.8	4.8	9.8	9.2	7.3
2	7.9	4.4	7.2	7.2	7.5
3	7.7	4.1	7.5	7.8	9.5
4	8.9	4.0	9.1	8.7	9.6
5	5.1	4.4	7.8	6.6	5.3
6	3.5	3.7	9.4	7.8	9.0
7	7.3	3.6	8,2	7.5	8.1

* "Significant," probabilities between 0.05 and 0.01.

** "Highly significant," the F ratio indicated probabilities less than 0.01.

may have interfered with attaining a good measure of the true differences in these cakes. It was observed by the researcher that the cell size decreased to a degree with each additional increase in the amount of liquid. This decrease was substantiated by the photographs of the crumb faces, but was not substantiated by the scores.

Replication: The judges' scores varied in a significant manner among replications (Table I), as shown by the F ratio of 3.69. Cakes containing the same amount of liquid did not, according to the judges' scores, possess the same cell size from one replication to the next.

Cell Distribution

Amount of liquid: The amount of liquid used in the batter produced a significant difference among the cakes in cell distribution (Table I), as indicated by the F ratio of 3.48. This subscore was one of the two in which there was significant difference among cakes made with different amounts of liquid. The mean score for cell distribution was highest for the cake containing 140 gms. of liquid (Table II), with a mean score of 5.14, and lowest for the cake containing 160 gms. of liquid, with a mean score of 3.64. The judges most often scored the cake containing 140 gms. of liquid as having "uniform" distribution of cells and, therefore, as being the least tunneled. The use of 140 gms. of liquid approximated the addition of $1\frac{1}{2}$ tablespoons of liquid per layer. The cake containing 160 gms. of liquid was the least often scored as "uniform" and, therefore, as being the most tunneled.

Judges: There was no significant difference among the scores assigned by the seven judges to cell distribution (Table I), as shown by the F ratio of 1.07. The mean score of each judge may be observed in Column 2 of Table III. The mean scores of the judges were very similar. The judges seemed to have similar standards for cell distribution.

Replication: Likewise, there was no significant difference in the scores for cell distribution among cakes made with the same amounts of liquid in the different replications (Table I), as represented by the F ratio of .58.

Crumb Character

Amount of liquid: The amount of liquid used in the batter did not, according to the judges' scores, produce a significant difference in the crumb character of the cakes (Table I), as indicated by the F ratio of .95. The means of the scores of the cakes had a range of 1.28, as reported in Table II. All of the cakes were scored within two points of the maximum score of 10. The high scores indicated that the crumb character of all of the cakes was more often rated "velvety" than "slightly harsh." It was interesting to observe that the judges more often scored the cakes containing more than 120 gms. of liquid "velvety" than either of the control cakes; however, the difference in the scores was not significant. The researcher agreed with the judges that an addition of liquid to the cake batter produced a cake with more desirable crumb characteristics than cakes without this addition. This improvement in the crumb characteristics was not shown by the statistical analyses.

Judges: There was a significant difference among judges in their scores assigned to crumb character (Table I), as indicated by the F ratio of 2.22. There was a range of 2.6 in the judges' scores, as reported in Column 3 of Table III. This range may have indicated a difference among the judges in their concept of crumb character. Judge one scored all cakes very high, with a mean score of 9.8, and judge two scored them lowest of all the judges, with a mean score of 7.2.

Replication: The judges' scores varied in a highly signifi- manner among replications (Table I), as indicated by the F ratio of 4.66. Cakes containing the same amount of liquid did not, according to the judges' scores, possess the same crumb character from one replication to the next.

Tenderness

Amount of liquid: There was no significant difference in the scores for tenderness of the cakes made with different amounts of liquid (Table I), as indicated by the F ratio of 1.61. There was a difference of only .72 between the highest and lowest mean scores for tenderness among the cakes, as reported in Table II. The judges agreed that the majority of the cakes scored from "tender" to "very tender," a range which may have been due in part to the increased rising obtained in electronic cooking with a controlled amount of leavening agent, as in a cake mix.

In slicing the cakes for judging, the researcher observed that the layers containing the larger amounts of liquid had less tendency to crumble than those containing less liquid.

Judges: There was no significant difference among the scores assigned by the seven judges to tenderness of the cakes (Table I), as indicated by the F ratio of 1.87. There was a range of 2.6 in the mean scores of the judges, as may be observed in Column 4, Table III.

Replication: There was no significant difference in the scores for tenderness among cakes made with the same amounts of liquid in the different replications (Table I), as indicated by the F ratio of .71.

Moisture

Amount of liquid: The amount of liquid used in the batter produced a significant difference in the scores for moisture content of the cakes (Table I), as indicated by the F ratio of 2.76. The mean score for moisture content was highest for the cake containing 150 gms. of liquid (Table II), with a mean of 8.89, and lowest for the cake containing 170 gms. of liquid, with a mean of 6.96. The moisture content for the cake containing 150 gms. of liquid was most often scored "moist." Likewise, the cake containing 170 gms. of liquid was most often scored "moist;" however, it was often scored "wet." These scores suggested that an increase in liquid was desired by the judges to eliminate the dryness which they indicated existed in the cakes containing 120 gms. of liquid, but that additional liquid should be limited to 40 gms. per layer, which approximates 3 tablespoons.

Judges: Variance in the scores for moisture content of cakes containing the same amount of liquid was highly significant among the judges (Table I), as indicated by the F ratio of 7.46. There was a range of 4.3 in the mean scores of the judges, as reported in Column 5 of Table III. This range raised the question of the relationship between the amount of rising and the moisture content of a given portion of cake and the location of the cake portion in the range during cooking. There was no effort made at any time to give a judge a portion of cake cooked in a given position in the range. Judge four scored the moisture of all cakes very high, with a mean of 9.6, and judge five scored the moisture low, with a mean of 5.3. These data indicated differences in the standards of the two judges for moisture in a cake, or a difference in the section of the cake from which the sample was taken.

Replication: There was no significant difference in the scores for moisture among cakes made with the same amounts of liquid in the different replications (Table I), as indicated by the F ratio of .42.

RANK PREFERENCE

The sums of the ranks (Table IV) indicated the judges' first preference for the cake containing 150 gms. of liquid, with a sum of 63, and last preference for the cake containing 170 gms. of liquid, with a sum of 122. There was a range of 59 in the sums of ranks whereas a range of 140 was possible.

It was observed in the compilation of the data that there was definite dissimilarity among the ranks accorded the same cake samples by different judges. As a means of further analyzing the

TABLE IV

SUMS OF RANKS ASSIGNED TO CAKES PREPARED WITH 5 AMOUNTS OF LIQUID
(4 REPLICATES, AND 7 JUDGMENTS OF EACH REPLICATE)

Type of range	Grams of liquid per layer	Sums of ranks Replicates 1	2	3	4	Total of sums of ranks	Rank order*
Conventional	120	19	25	19	18	81	3
Electronic	120	21	26	27	27	101	5
	140	18	19	16	25	78	2
	150	12	15	20	16	63	1
	160	21	17	30	28	96	4
	170	30	24	35	33	122	6

* The cake with the smallest total score is ranked first.

data, the coefficient of concordance was computed among ranks assigned by seven judges to cakes baked with the five different amounts of liquid. The coefficient of concordance of .299 among judges in replication one was less than one-third of the distance from zero to one. This coefficient did not indicate a high degree of concordance. The F ratio of 2.14 indicated there was no significant agreement among the judges in the way they ranked the cakes. The coefficient of concordance of .313 and the F ratio of 2.74 in replication three indicated there was significant agreement among the judges in the way they ranked the cakes in this replication. The coefficients of concordance and the F ratios for the remaining two replications did not indicate significant agreement among the judges. It was unknown to the researcher whether true differences of preference existed among the judges, or whether the samples from a given cake differed from each other, as may have been possible as a result of the location of each given portion of the cake within the range.[83]

A similar procedure was used to determine whether a judge was consistent in the order in which he ranked cakes with varying amounts of liquid from one replication to the next. The ranking of one judge proved to be highly significant with a coefficient of concordance of .746 and F ratio of 5.89. This judge was consistent in the ranking of the cakes from one replication to the next. The F ratio for the remainder of the judges did not indicate significant

---

[83] Cf. ante, p. 37.

concordance; that is, the judges did not agree with themselves in the ranking of the cakes from one replication to another.

It was interesting to observe that the cake ranked as first did not approximate the possible score of 28 for first position. In the opinion of the researcher, some of the cakes were superior, but this superiority was not shown in the statistical analyses because the judges apparently had different ideas of what they preferred in a cake.

A comparison of the ranks and scores accorded cakes containing varying amounts of liquid (Table V) indicated that when the judges scored the cakes, they scored highest the cake containing 140 gms. of liquid. However, when they ranked the cakes, they indicated a preference for the cake containing 150 gms. of liquid. The judges not only scored but also ranked as last the cake containing 170 gms. of liquid. The cake containing 120 gms. of liquid and baked in the conventional oven was placed third by the judges in score and in rank.

WEIGHT CHANGE DURING COOKING

Each cake was weighed before and after cooking to determine whether there was a change in weight during cooking. The means and the percentages of weight loss during cooking, due to a loss of moisture, are reported in Table VI. The loss of weight in the conventionally baked cakes was less than in the electronically cooked cakes even though the baking time was greater. The electronically cooked cakes cooked for the same length of time

TABLE V

SCORED PLACEMENT AND RANKED PREFERENCE OF THE TASTE PANEL FOR CAKES PREPARED WITH 5 AMOUNTS OF LIQUID (4 REPLICATES, AND 7 JUDGMENTS OF EACH REPLICATE)

Type of range	Grams of liquid per layer	Scored Placement	Ranked Preference
Conventional	120	3	3
Electronic	120	4	5
	140	1	2
	150	2	1
	160	5	4
	170	6	6

TABLE VI

ARITHMETIC MEANS AND PERCENTAGES OF WEIGHT LOSS DURING COOKING IN CAKES PREPARED WITH 5 AMOUNTS OF LIQUID (4 REPLICATES, AND 7 JUDGMENTS OF EACH REPLICATE)

Type of range	Grams of liquid per layer	Weight loss grams	Weight loss per cent
Conventional	120	29.1	6.85
Electronic	120	37.8	8.72
	140	34.9	8.21
	150	34.0	8.00
	160	35.9	8.45
	170	35.1	8.26

lost approximately the same number of grams per layer, irrespective of the original amount of liquid in the batter. However, the percentage weight loss in cakes cooked electronically was slightly less as the liquid was increased in the batter. These data indicated that the weight loss in a food cooked in the electronic range was controlled by the cooking time rather than the amount of liquid in the uncooked product. Since excessive moisture loss may be a problem in the preparation of some foods in the electronic range, as suggested by Marshall, an increase of liquid in a cake batter would decrease the tendency toward a dry crumb and thus improve cake quality.[84]

APPEARANCE OF CRUMB FACES OF CAKES

Appearance of the crumb faces of cakes prepared with varying amounts of liquid are shown in the photographs in Figures 7 - 11. Appearance may be described in terms of contour, volume, and cell distribution.

Contour

The photographic record graphically described the contour of the cakes. As the liquid was increased in the electronically cooked cakes the surface contour became increasingly more irregular (Figures 7 - 11), and the overall height became more uneven.

---

[84] Nancy Marshall, "Electronic Cookery of Top Round of Beef," p. 32.

Volume

In contrast with the cake containing 120 gms. of liquid, the cakes containing increasingly larger amounts of liquid and cooked in the electronic range were progressively lower in height (Figures 7 - 11). It was observed that there was a decrease of approximately one-half inch in the height of the cakes. The height ranged from 1 3/4 inches in the cake containing 120 gms. of liquid to 1¼ inches in the cake containing 170 gms. of liquid. It was observed during the cooking period that the portion of the cake placed toward the rear of the range rose more evenly and more rapidly and had attained greater height at the completion of the cooking. This uneven rising may confirm the probability of a differing concentration of the microwave energy within the range as found by Van Zante and Nakayama.[85] The cake containing 170 gms. of liquid and cooked in the electronic range more nearly approached the height of the cake baked in the conventional range (Figures 6 and 11).

Cell Distribution

The photographs of the cakes cooked in the electronic range (Figures 7 - 11) indicated that cell distribution became more irregular with the addition of liquid to the batter of the cakes. The researcher observed that the cakes cooked from batter containing greater amounts of liquid contained finer cells but an increased number of tunnels, which was substantiated by the photographs.

---

[85] Helen J. Van Zante and Hisako Nakayama, "The Effect of Microwave Energy on the Internal Temperatures of Agar and Food Cylinders," p. 174.

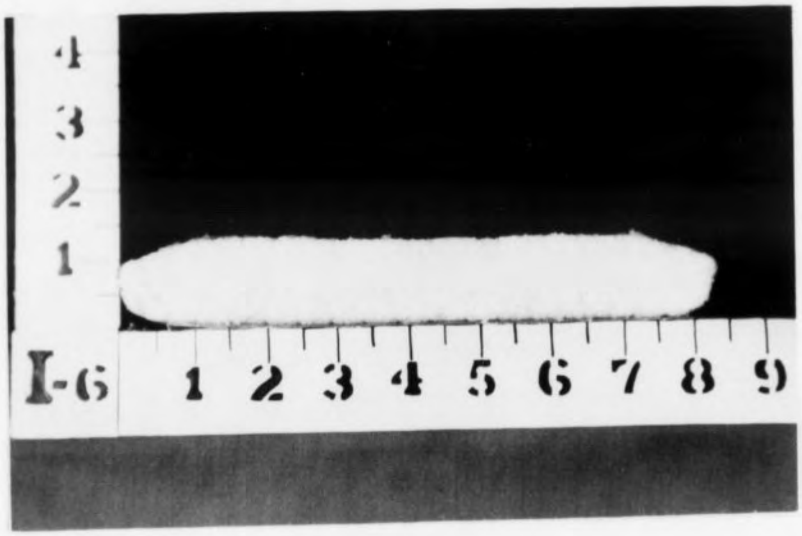

FIGURE 6

CONTROL CAKE CONTAINING 120 GMS. OF LIQUID AND BAKED IN THE CONVENTIONAL RANGE

FIGURE 7

CONTROL CAKE CONTAINING 120 GMS. OF LIQUID AND COOKED IN THE ELECTRONIC RANGE

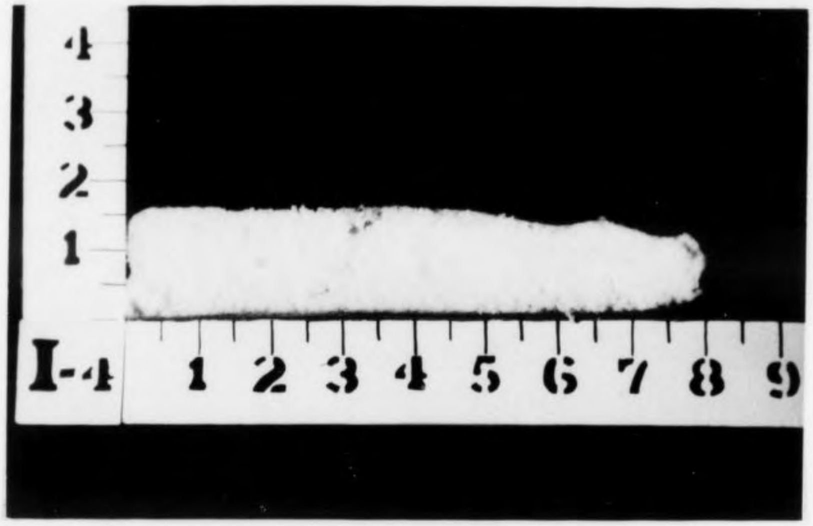

FIGURE 8

CAKE CONTAINING 140 GMS. OF LIQUID AND COOKED
IN THE ELECTRONIC RANGE

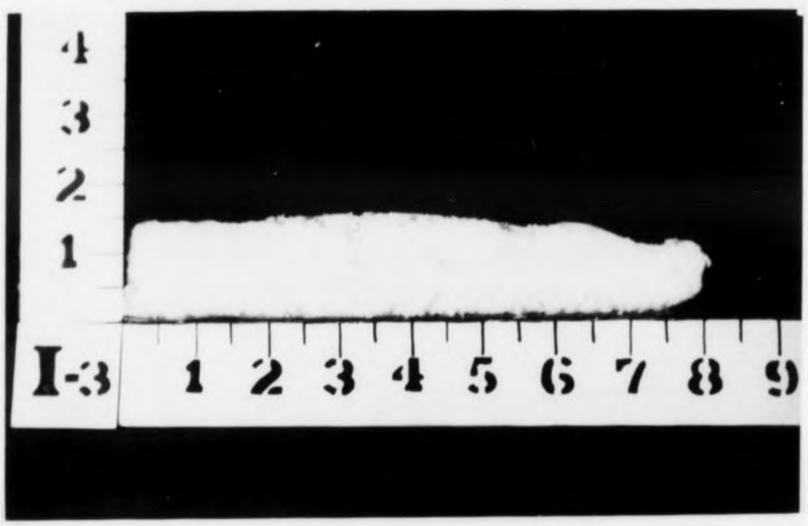

FIGURE 9

CAKE CONTAINING 150 GMS. OF LIQUID AND COOKED
IN THE ELECTRONIC RANGE

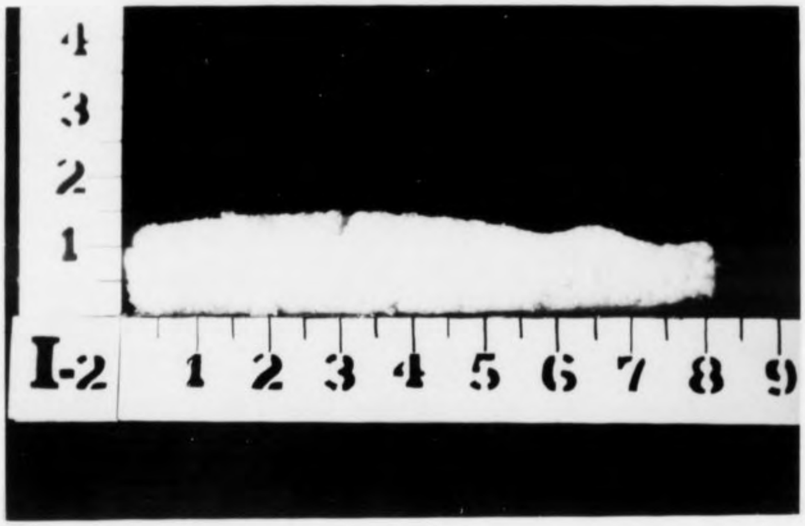

FIGURE 10

CAKE CONTAINING 160 GMS. OF LIQUID AND COOKED
IN THE ELECTRONIC RANGE

FIGURE 11

CAKE CONTAINING 170 GMS. OF LIQUID AND COOKED
IN THE ELECTRONIC RANGE

SUMMARY

From the data, it appeared that in this experiment the amount of liquid in the batter exerted a significant effect on the cell distribution of the cake. It was indicated that with an increase in liquid, limited to 20 gms. (approximately $1\frac{1}{2}$ tablespoons) per layer, the cell distribution became more regular. The data also indicated that the amount of liquid in the batter had a significant effect on the moisture content of the cake. The cakes were judged as more desirable in moisture content with an addition of liquid up to 40 gms. (approximately 3 tablespoons) per layer.

The data indicated the amount of liquid had no significant effect upon cell size, crumb character, and tenderness.

The judges scored as first the cake containing 140 gms. of liquid, and ranked as first the cake containing 150 gms. of liquid.

One of the important findings of this phase of the experiment was that the loss of moisture in the cakes during cooking in the electronic range was controlled by the cooking time rather than the amount of liquid in the batter; therefore, additional liquid in the batter would remain in the cooked product to increase its moisture content.

The photographs revealed that as the liquid in the batter was increased the volume of the cake decreased, and with a decrease in volume the surface contour became more irregular and the cell size became smaller.

II. THE EFFECT OF THE SIZE AND SHAPE OF THE CONTAINER

To study the effect of the size and shape of the container on the quality of cake cooked in the electronic range, the judges scored samples from cakes that had been cooked in the form of a layer, a loaf, or as cup cakes. The same volume of batter, 425 gms., was used for each type of cake. The layer was cooked in a 9-inch round dish, the loaf in a $1\frac{1}{2}$ quart, rectangular dish, and the cup cakes in eight 6-ounce custard cups, as shown in Figure 12.

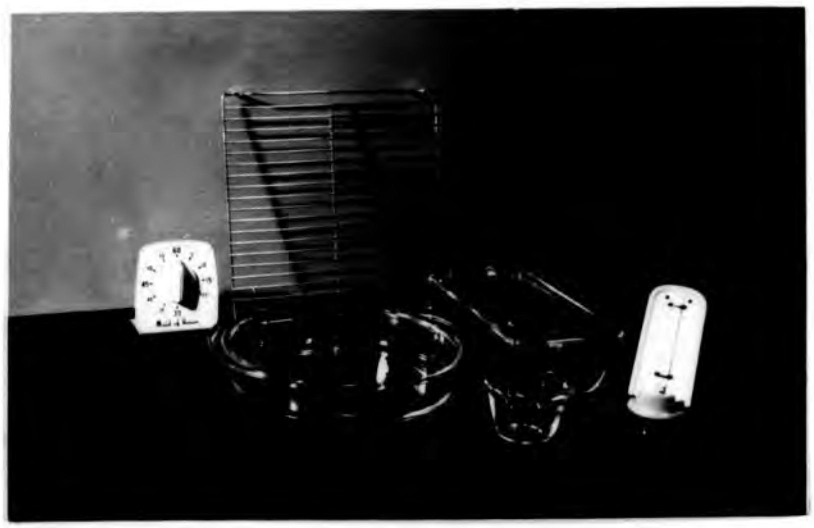

FIGURE 12

EQUIPMENT USED IN THE COOKING OF THE CAKES

All cakes were cooked by the standard procedure established for this study except for the placement of the cup cakes in the range. The cups were placed equidistant from each other over the entire shelf surface. All cakes were baked for the same length of time in an effort to determine whether the cooking time was controlled either by the size and shape of the container, the number of containers, or by the volume of cake being cooked. A total of four cake samples were judged in each replication of this phase of the experiment. In preparing the samples for judging, all crusts were removed and all cakes were cut into wedges of similar shape and size in order that the manner of baking would not be recognized.

APPEARANCE AND PALATABILITY

To judge the effect of the size and shape of the container on cake quality, the following factors were scored: (1) cell size, (2) cell distribution, (3) crumb character, (4) tenderness, and (5) moisture. The analyses of each of these factors will be discussed separately.

Cell Size

Size and Shape of the Container: There was no significant difference in cell size among cakes prepared in containers of different sizes and shapes (Table VII), as indicated by the F ratio of .86. There was a difference of 1.00 between the highest and lowest mean scores for cell size among the cakes, as reported in Table VIII. The scores for the cell size of the electronically cooked cakes ranged from "very fine" to "medium," with more cakes being scored as having cells of "small" size.

TABLE VII

ANALYSIS OF VARIANCE OF THE SCORES FOR THE APPEARANCE AND PALATABILITY OF CAKES BAKED IN CONTAINERS OF 3 SIZES AND SHAPES (4 REPLICATES, AND 7 JUDGMENTS OF EACH REPLICATE)

		Appearance and Palatability of Cakes									
		Cell size		Cell distribution		Crumb character		Tenderness		Moisture	
Source of variance	Degrees of freedom	Mean square	F value	Mean square	F value	Mean square	F value	Mean square	F value	Mean square	F value
Total	83										
Replicates	3	13.85	1.48	1.65	1.14	1.70	.45	10.03	2.22	3.93	.73
Treatments Containers	2	7.96	.86	4.00	2.76	.90	.24	3.65	.81	11.50	2.14
Judges	6	20.05	2.16	7.60	5.24**	3.30	.87	10.47	2.32*	25.53	4.75**
Interaction	12	12.34	1.33	2.06	1.42	1.68	.44	2.96	.66	2.92	.54
Experimental error	60	9.30		1.45		3.80		4.51		5.37	

* "Significant," probabilities between 0.05 and 0.01.

** "Highly significant," the F ratio indicated probabilities less than 0.01.

TABLE VIII

ARITHMETIC MEANS OF SCORES FOR APPEARANCE AND PALATABILITY OF CAKES PREPARED IN CONTAINERS OF 3 SIZES AND SHAPES (4 REPLICATES, 7 JUDGMENTS OF EACH REPLICATE)

Type of range	Type of container	Appearance and Palatability Qualities						
		Cell size	Cell distribution	Crumb character	Tender-ness	Moisture	Flavor	Total
Conventional	Layer	8.36	5.50	9.28	7.03	8.21	9.82	48.21
Electronic	Layer	7.68	4.42	8.71	8.54	8.11	8.89	46.43
	Cup cake	8.50	5.14	8.71	8.85	6.96	9.53	47.76
	Loaf	7.50	4.92	8.78	8.89	8.02	9.53	47.41
Maximum score		10.00	6.00	10.00	10.00	10.00	10.00	56.00

Judges: There was no significant difference among the scores assigned by the different judges (Table VII), as indicated by the F ratio of 2.16. A difference existed in the judges' scores, as may be observed in Column 1 of Table IX, but the difference was .09 below the significant value. Judge two scored the cell size of the cakes very high, with a mean score of 9.56, and judge five scored the cell size low, with a mean of 6.06.

Replication: There was no significant difference in the judges' scores for cell size among cakes made in the containers of the same size and shape in the different replications (Table VII), as indicated by the F ratio of 1.48.

Cell Distribution

Size and Shape of the Container: The size and shape of the container produced no significant difference in cell distribution among the cakes (Table VII), as indicated by the F ratio of 2.76; however, there was a difference in the scores since the F ratio was only .39 below the significant value. The means of the scores for the cakes baked in containers of different sizes and shapes varied only .72, as may be observed in Table VIII. The cell distribution of all cakes was most frequently scored "uniform" and least frequently scored "tunneled."

Judges: There was a highly significant difference among the scores assigned by the different judges (Table VII), as indicated by the F ratio of 5.24. Judge four rated the cell distribution very high (Column 2 of Table IX), with a mean score of 5.88, whereas

TABLE IX

MEAN SCORES OF CAKES JUDGED BY THE 7 JUDGES IN THE SECOND PHASE OF THE EXPERIMENT

Judge	Cell Size	Cell** distribution	Crumb character	Tenderness*	Moisture*
1	8.56	5.63	8.50	8.31	6.50
2	9.56	5.38	9.13	9.40	8.25
3	7.81	5.75	9.63	9.38	8.13
4	9.13	5.88	9.50	9.50	10.00
5	6.06	5.50	8.13	7.25	7.56
6	6.38	4.38	9.13	7.50	8.13
7	8.56	4.38	8.75	8.63	6.25

* "Significant," probabilities between 0.05 and 0.01.

** "Highly significant," the F ratio indicated probabilities less than 0.01.

a maximum score of 6 was possible. Judges six and seven tended to rate the cell distribution low, with identical mean scores of 4.38. All of the judges scored cell distribution higher in the second phase than in the first phase of the experiment (Table III, page 42 and Table IX, page 64).

Replication: There was no significant difference in the judges' scores for cell distribution among cakes made in containers of the same size and shape in the different replications (Table VII), as indicated by the F ratio of 1.14.

Crumb Character

Size and Shape of the Container: There was no significant difference in the crumb character of cakes prepared in containers of different sizes and shapes (Table VII), as indicated by the F ratio of .24. There was a difference of only .17 (Table VIII) between the highest and lowest mean scores among the electronically cooked cakes. The judges agreed that the majority of the cakes were "velvety" in crumb character.

Judges: There was no significant difference among the scores assigned by the different judges (Table VII), as indicated by the F ratio of .87. There was a difference of only 1.50 between the highest and lowest mean scores among the judges as may be observed in Column 3 of Table IX. All of the judges scored the crumb character of the cakes high, as indicated by the lowest mean score of 8.13.

Replication: There was no significant difference in the judges' scores for crumb character in the different replications (Table VII), as indicated by the F ratio of .45.

Tenderness

Size and Shape of the Container: The size and shape of the container did not produce a significant difference among the cakes in tenderness (Table VII), as indicated by the F ratio of .81. There was a range of .35 in the mean scores of the cakes, as reported in Table VIII. The judges scored the majority of the electronically cooked cakes from "tender" to "very tender."

Judges: There was a significant differente among the scores assigned by the seven judges (Table VII), as indicated by the F ratio of 2.32. The difference in the concentration of microwave energy within the range may have resulted in a difference in tenderness within cakes, or it is possible that the judges had different standards for tenderness. Judge four scored the tenderness very high, with a mean score of 9.50 (Column 4, Table IX), and judge five scored the tenderness low, with a mean score of 7.25.

Replication: There was no significant difference in the judges' scores for tenderness among cakes prepared in containers of the same size and shape in the different replications (Table VII), as indicated by the F ratio of 2.22.

Moisture

Size and Shape of the Container: There was no significant difference in the judges' scores for moisture content among cakes prepared in containers of different sizes and shapes (Table VII), as indicated by the F ratio of 2.14. The means of the scores varied 1.15 (Table VIII) with the majority of the cakes scored "moist." This was interesting to observe since the cakes were cooked for the same length of time, irrespective of the size and shape of the container. Recommended cooking times for the loaf cake ranged from 5 to 8 minutes. The $3\frac{1}{2}$ minutes of cooking time that was used did not result in either a cake too moist or a cake with uncooked batter, as might have been expected.

Judges: There was a highly significant difference among the judges' scores for moisture content of the cakes (Table VIII), as indicated by the F ratio of 4.75. This difference was also observed in compilation of the raw scores. Some of the judges consistently scored the cakes "moist," while other consistently scored the same cakes "dry." Judge four rated the cakes as high as possible in moisture content, with a mean score of 10.00 (Column 5, Table IX), and judge seven scored them low, with a mean score of 6.25. This difference of opinion among the judges raised the question of a greater moisture loss in those cup cakes or portions of a layer rising more rapidly than others. An irregularity in the rising and in the loss of moisture among the cakes would be in agreement with the findings of Godwin and Nicholson in relation to the moisture loss within a group of cup cakes.[86]

---

[86]Patricia E. Goodwin and Mary Kathryn Nicholson, "The Effect of Electronic Cooking on a Group of Cup Cakes," p. 3.

Replication: There was no significant difference in the judges' scores for moisture content among cakes prepared in containers of the same size and shape in the different replications (Table VII), as indicated by the F ratio of .73.

RANK PREFERENCE

The sums of the ranks (Table X) indicated the judges' first choice for the cake baked in the conventional oven, with a sum of 54. Their first choice among cakes cooked in containers of different sizes and shapes was for the loaf cake, with a sum of 69. Their last preference was for the cup cake, with a sum of 75. There was a range of 21 in the sums of the ranks. This range suggested a lack of concordance among the judges when a range of 84 was possible.

TABLE X

SUMS OF RANKS ASSIGNED TO CAKES PREPARED IN CONTAINERS OF 3 SIZES AND SHAPES (4 REPLICATES, AND 7 JUDGMENTS OF EACH REPLICATE)

Type of range	Type of container	Sums of ranks Replicates 1	2	3	4	Total of sums of ranks	Rank order*
Conventional	Layer	14	12	15	13	54	1
Electronic	Layer	15	22	16	19	72	3
	Cup	17	18	20	20	75	4
	Loaf	14	18	19	18	69	2

* The cake with the smallest total score is ranked first.

The coefficient of concordance value of .027 and F ratio of .147 in replication one indicated that the judges approached perfect disagreement in the way they ranked the cakes prepared in containers of different sizes and shapes. The coefficients of concordance and the F ratios indicated that there was no significant concordance among the judges in the ranking of the cakes in the remaining three replications. The judges probably experienced difficulty in ranking the cakes because of the lack of difference among the cakes as indicated by the statistical analyses. This lack of difference in the cakes would result in a lack of concordance among the judges.

The coefficients of concordance for the individual judges revealed that two judges had a high degree of concordance with themselves in the ranking of the cakes from one replication to the next. The ranking of one judge proved to be highly significant, with a coefficient of concordance of .805 and F ratio of 12.38. The ranking of another judge proved to be significant, with a coefficient of concordance of .598 and F ratio of 4.46. The rankings of each of the remaining judges did not significantly agree with themselves from one replication to the next.

A comparison of the ranks and scores accorded the cakes prepared in containers of different sizes and shapes (Table XI) indicated that the judges not only scored but also ranked as first the cake baked in the conventional oven. In comparing the electronically cooked cakes, the judges scored as first the cup cake and ranked as first the loaf cake. The control layer

TABLE XI

SCORED PLACEMENT AND RANKED PREFERENCE OF THE TASTE PANEL FOR CAKES PREPARED IN CONTAINERS OF 3 SIZES AND SHAPES (4 REPLICATES, AND 7 JUDGMENTS OF EACH REPLICATE)

Type of range	Type of container	Scored Placement	Ranked Preference
Conventional	Layer	1	1
Electronic	Layer	4	3
	Cup	2	4
	Loaf	3	2

cooked in the electronic range was placed last by the judges in score, and the cup cakes were placed last in rank.

WEIGHT CHANGE DURING COOKING

The means and the percentages of weight loss during cooking are reported in Table XII. Of the electronically cooked cakes, the loaf and the layer lost approximately the same amount of weight, which was a greater amount than that lost by the group of cup cakes. A smaller loss of weight by the cup cakes may have been due to the even distribution of the cup cakes in the range. Some of the cup cakes rose more rapidly than others. Apparently, in the locations in the range where rising occurred more slowly there was less loss of moisture in the product being cooked. The amount of surface area of the food exposed in cooking would be greater in eight cup cakes than in the other types of containers used in this experiment.

TABLE XII

ARITHMETIC MEANS AND PERCENTAGES OF WEIGHT LOSS DURING COOKING IN CAKES PREPARED IN CONTAINERS OF 3 SIZES AND SHAPES (4 REPLICATES, AND 7 JUDGMENT OF EACH REPLICATE)

Type of range	Type of container	Moisture loss grams	Moisture loss per cent
Conventional	9-in. layer	24.0	5.65
Electronic	9-in. layer	40.8	9.60
	8-6 oz. cups	34.2	8.05
	$8\frac{1}{2}$ in. loaf	40.9	9.62

It is possible that the change in weight was not due to evaporation from the surface area, but was due to the difference in concentration of microwave energy in certain areas of the range as suggested by Van Zante and Nakayama.[87]

APPEARANCE OF CRUMB FACES OF CAKES

Appearance of the crumb faces of cakes prepared in containers of different sizes and shapes and baked in the electronic range are shown in the photographs in Figures 13 - 15. The contour and cell distribution of these cakes will be discussed.

Contour

The layer approached the slightly rounded symmetry normally

---

[87]Helen J. Van Zante and Hisako Nakayama, "The Effect of Microwave Energy on the Internal Temperatures of Agar and Food Cylinders," p. 174.

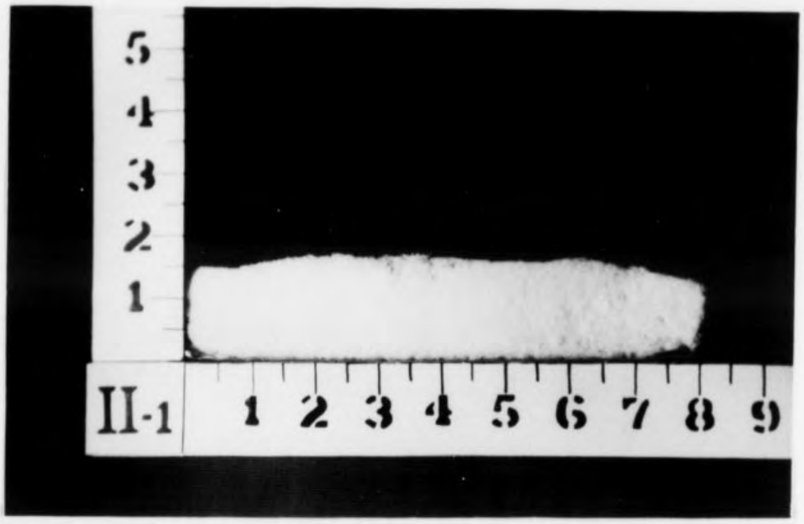

FIGURE 13

9-INCH LAYER CAKE COOKED IN THE ELECTRONIC RANGE

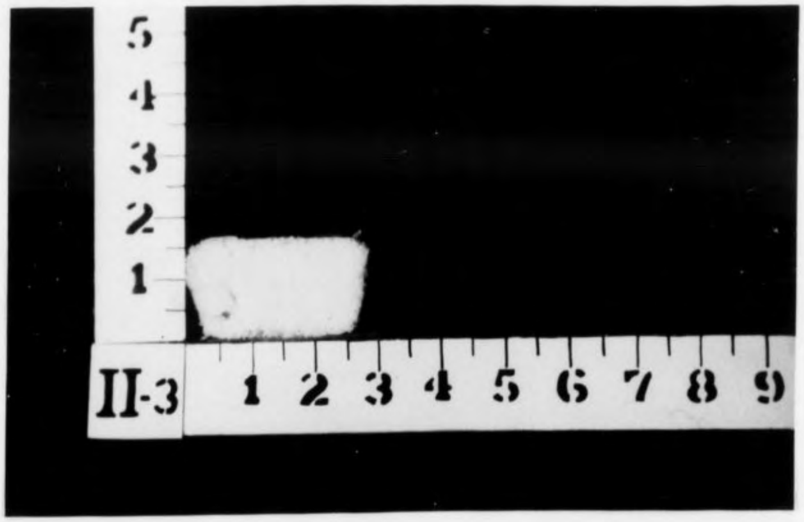

FIGURE 14

6-OUNCE CUP CAKE COOKED IN THE ELECTRONIC RANGE

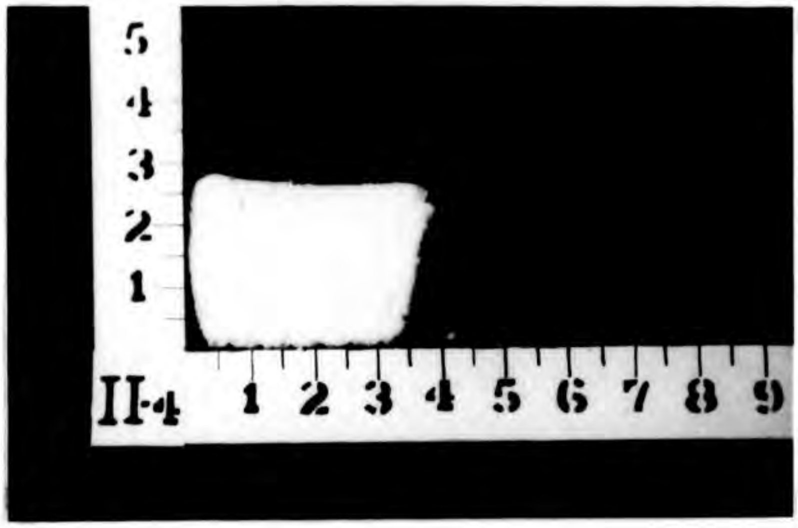

FIGURE 15

$8\frac{1}{2}$-INCH LOAF CAKE COOKED IN THE ELECTRONIC RANGE

associated with cake surfaces. The cup cake had a flat surface, and the loaf had a slightly concave surface. It was observed during cooking that the loaf rose quite irregularly. The batter in the corners of the container rose rapidly and in peaks extending from 2 to $2\frac{1}{2}$ inches above the sides of the container. This extension was contrary to the rising pattern in conventional baking where the batter may spill over the sides of the container if more batter is used than needed to fill the container. Obviously, the absorption of microwave energy from the two sides as well as from the top and bottom of the cake accelerated the rising of the batter in the corners of the loaf. The center of the loaf at no time during cooking reached the height attained in the corners.

However, with continued cooking the difference in height of the corners and center became less exaggerated as may be observed in Figure 15.

Cell Distribution

The cell distribution of the layer appeared to be more regular than in the cup or loaf cakes (Figures 13-15). Large air holes were apparent in the cup and loaf cakes. These holes may have been due to the air incorporated when pouring the batter into a deeper container such as a cup or loaf dish. The usual procedure of dropping lightly a cake dish to remove the air bubbles may have been ineffective in the batter in the deeper containers.

SUMMARY

The data indicated that there was no significant difference in cell size, cell distribution, crumb character, tenderness, and moisture content of the cakes due to the size and shape of the cooking container. One of the important findings of this phase of the experiment was that the same volume of batter would cook to approximately the same degree of doneness in an identical cooking time in the form of a loaf, a layer, or eight cup cakes.

In comparing the electronically cooked cakes, the judges scored as first the cup cake and ranked as first the loaf cake. The lack of difference among the cakes as shown by the statistical analyses would suggest that the judges experienced difficulty in the scoring and ranking of the cakes.

The data indicated there was less loss of moisture in the eight cup cakes than in either the loaf or the layer cake. These data would suggest that the amount of moisture lost in the cake during cooking in the electronic range was related to the concentration of the microwave energy in a given location within the range.

The photographs of the surface contour revealed that the loaf was elevated at the corners. The design of a loaf dish would control the absorption of the microwave energy in such a manner that there would be a greater concentration of the microwave energy in the corners than in the center of a loaf dish. This design would result in uneven rising of the cake.

III. THE EFFECT OF THE ELECTRICAL BROWNING UNIT

To determine the length of time to use the electrical browning unit to develop crust and color in cakes cooked in the electronic range, the judges scored samples from cakes that had been cooked electronically using the electrical browning unit of the electronic range simultaneously with the microwaves for either 2 minutes 10 seconds, 2 minutes 20 seconds, 2 minutes 25 seconds, or 2 minutes 30 seconds. The browning unit was used during the latter part of the cooking period, and the cakes were centered under the unit. A total of six cakes was baked in each replication of this phase of the experiment. The crusts were left on all samples for judging.

APPEARANCE AND PALATABILITY

To judge the effect of the use of the electrical browning unit for different lengths of time on the quality of the cake, the following factors were scored: (1) crust tenderness, (2) crust color, (3) cell size, (4) cell distribution, (5) crumb character, (6) tenderness, and (7) moisture. The analyses of each of these factors will be discussed.

Crust Tenderness

The differences in the judges' ratings for tenderness of the crusts of cakes browned for different lengths of time (Table XIII) were not significant as indicated by the chi-square value of 2.88. It was observed that as the browning time was increased, some differences did occur in the ratings of crust tenderness. The cake crusts were more often rated "slightly tender" or "tough" with an increase in browning time; however, the differences in the ratings were not significant. The use of the electrical browning unit for 2 minutes 10 seconds greatly reduced, according to the judges' scores, the undesirable high moisture content of the crust. The data indicated that cakes may be browned for 2 minutes 30 seconds without decreasing the tenderness of the crust.

Crust Color

There was a highly significant difference in the degree of browning of the cakes with the use of the electrical browning unit for the different lengths of time as indicated by a chi-square value

TABLE XIII

CONTINGENCY TABLE OF JUDGES' RATINGS OF CRUST TENDERNESS
OF CAKES BROWNED FOR 4 DIFFERENT LENGTHS OF TIME
(28 RATINGS OF EACH CAKE)

Cake number	Length of browning	Number of ratings received: Tender	Slightly tender	Tough	Too moist
IV-1	Electronic control	11	0	1	16
IV-2	2 min. 10 sec.	10	10	4	4
IV-3	2 min. 20 sec.	8	16	3	1
IV-4	2 min. 25 sec.	7	15	5	1
IV-5	2 min. 30 sec.	9	10	8	1
IV-6	Conventional control	24	2	0	2

of 15.81. The ratings of the judges for crust color may be observed in Table XIV. The cake browned 2 minutes 30 seconds was most frequently scored "golden brown;" however, only two more judges rated the cake browned 2 minutes 30 seconds as "golden brown" than rated the cake browned 2 minutes 20 seconds in this way. There was a slight trend toward a "too-dark" crust as the browning time was increased beyond 2 minutes 20 seconds. The cake browned 2 minutes 10 seconds was most frequently rated "pale." It was observed that there was a difference of opinion among the judges on crust color of the cakes. This difference was to be expected because of the small electrical browning unit of the electronic range which did not extend over a cake 9 inches in diameter. The pattern of browning may be observed in Figure 16. Using the established procedure of cutting the cake samples from one-half of the cake layer, some samples necessarily possessed browner crusts than others. This variation in browning would result in different ratings for crust color of different samples from the same cake.

Cell Size

Length of browning: There was no significant difference in the judges' scores for cell size among cakes browned for different lengths of time (Table XV), as indicated by the F ratio of 1.25. The means of the scores of cakes browned for different lengths of time varied only 1.50, as may be observed in Table XVI. The judges most often scored the cell size for all cakes as "small." The scores ranged from "very fine" to "medium." The data indicated

TABLE XIV

CONTINGENCY TABLE OF JUDGES' RATINGS OF CRUST COLOR OF CAKES BROWNED FOR 4 DIFFERENT LENGTHS OF TIME (28 RATINGS OF EACH CAKE)

Cake number	Length of browning	Number of ratings received			
		Golden brown	Pale	Too dark	No browning
IV-1	Electronic control	0	7	0	21
IV-2	2 min. 10 sec.	9	19	0	0
IV-3	2 min. 20 sec.	17	9	1	1
IV-4	2 min. 25 sec.	16	9	3	0
IV-5	2 min. 30 sec.	19	5	4	0
IV-6	Conventional control	28	0	0	0

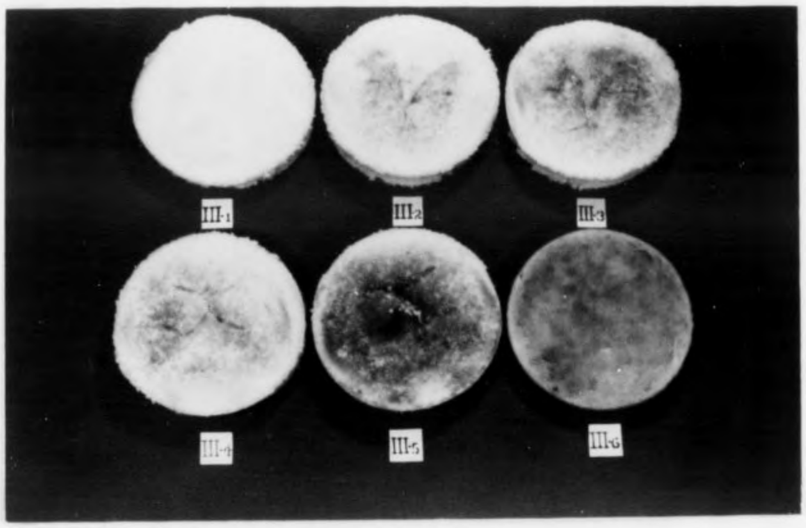

FIGURE 16

TOP CRUSTS OF CAKES BROWNED FOR
4 DIFFERENT LENGTHS OF TIME

Cake Number	Range	Length of Browning
Cake III-1	Electronic	Control
Cake III-2	Electronic	2 minutes 10 seconds
Cake III-3	Electronic	2 minutes 20 seconds
Cake III-4	Electronic	2 minutes 25 seconds
Cake III-5	Electronic	2 minutes 30 seconds
Cake III-6	Conventional	Control

TABLE XV

ANALYSIS OF VARIANCE OF THE SCORES FOR THE APPEARANCE AND PALATABILITY
OF CAKES BROWNED 4 DIFFERENT LENGTHS OF TIME
(4 REPLICATES, 7 JUDGMENTS OF EACH REPLICATE)

		Appearance and Palatability of Cakes									
		Cell size		Cell distribution		Crumb character		Tenderness		Moisture	
Source of variance	**Degrees** of freedom	Mean square	F value	Mean square	F value	Mean square	F value	Mean square	F value	Mean square	F value
Total	139										
Replicates	3	20.59	2.93*	11.96	6.16**	7.73	2.36	.92	.25	9.76	3.23*
Treatments											
Browning time	4	8.79	1.25	4.00	2.06	3.11	.95	2.92	.79	2.05	.68
Judges	6	62.77	8.93**	6.27	3.23**	12.11	3.69**	17.63	4.79**	50.42	16.69**
Interaction	24	6.08	.86	1.68	.86	2.20	.67	5.85	1.59	3.62	1.20
Experimental error	102	7.03		1.94		3.28		3.68		3.02	

* "Significant," probabilities between 0.05 and 0.01.
** "Highly significant," the F ratio indicated probabilities less than 0.01.

TABLE XVI

ARITHMETIC MEANS OF SCORES FOR APPEARANCE AND PALATABILITY OF CAKES BROWNED FOR 4 DIFFERENT LENGTHS OF TIME (4 REPLICATES, 7 JUDGMENTS OF EACH REPLICATE)

Type of range	Length of browning	Appearance and palatability qualities						
		Cell size	Cell distribution	Crumb character	Tenderness	Moisture	Flavor	Total
Conventional	Control	7.85	6.00	8.78	6.96	8.20	9.14	47.43
Electronic	Control	9.18	3.50	9.26	8.26	8.21	9.64	47.27
	2 min. 10 sec.	8.18	3.78	8.64	8.77	8.75	9.35	47.43
	2 min. 20 sec.	8.00	4.07	9.21	8.89	8.75	9.35	48.28
	2 min. 25 sec.	7.68	4.14	8.69	8.62	8.57	9.35	47.05
	2 min. 30 sec.	8.25	4.49	9.00	8.25	8.21	9.82	48.18
Maximum score		10.00	6.00	10.00	10.00	10.00	10.00	56.00

that the amount of rising that had occurred when the cake crust was formed by use of the electrical browning unit had no significant effect upon cell size.

Judges: There was a highly significant difference among the scores assigned by the different judges (Table XV), as indicated by the F ratio of 8.93. There was a range of 4.33 in the mean scores of the individual judges, as reported in Column 1 of Table XVII. Judge two rated the cell size of all the cakes as high as the score card allowed, as indicated by his mean score of 10.00. Judge five tended to rate all the cakes low, with a mean score of 5.67.

Replication: The judges' scores varied in a significant manner among replications (Table XV), as indicated by the F ratio of 2.93. Cakes browned for the same length of time did not, according to the judges' scores, possess the same cell size from one replication to the next. In replications one and two the judges consistently scored the cell size as "small." In replications three and four the scores ranged from "very fine" to "medium."

Cell Distribution

Length of browning: There was no significant difference in the judges' scores for cell distribution among cakes browned for different lengths of time (Table XV), as indicated by the F ratio of 2.06. The means of the scores had a range of .99, as reported in Table XVI. The cell distribution was most often scored "irregular," but scores ranged from "tunneled" to "uniform" for cakes browned for the same length of time.

TABLE XVII

MEAN SCORES OF CAKES JUDGED BY THE 7 JUDGES IN THE THIRD PHASE OF THE EXPERIMENT

Judge	Cell** size	Cell** distribution	Crumb** character	Tenderness**	Moisture**
1	9.42	5.00	9.42	9.08	9.17
2	10.00	4.58	9.75	6.91	9.58
3	6.79	4.17	9.48	8.78	8.96
4	9.71	3.92	9.50	9.46	10.00
5	5.67	4.63	7.42	6.96	8.33
6	9.13	3.83	9.00	8.50	8.12
7	6.63	4.25	7.91	8.29	5.62

** "Highly significant," the F ratio indicated probabilities less than 0.01.

Judges: There was a highly significant difference among the scores assigned by the different judges (Table XV), as indicated by the F ratio of 3.23. There was a range of 1.17 in the mean scores of the individual judges for cell distribution, as reported in Column 2 of Table XVII. Judge two tended to rate all of the cakes high on cell distribution, with a mean score of 5.00 whereas a maximum score of 6.00 was possible. Judge six tended to rate all of the cakes low, with a mean score of 3.83.

Replication: There was a highly significant difference in the judges' scores for cell distribution among cakes browned for the same length of time in the different replications (Table XV), as indicated by the F ratio of 6.16.

Crumb Character

Length of browning: There was no significant difference in crumb character among cakes browned for different lengths of time (Table XV), as indicated by the F ratio of .95. There was a difference of only .62 between the highest and lowest mean scores for crumb character, as may be observed in Table XVI. The cakes were most often scored "velvety" as indicated by the high mean scores ranging from 8.64 to 9.26.

Judges: There was a highly significant difference among judges in their scores assigned to crumb character (Table XV), as indicated by the F ratio of 3.69. There was a range of 2.33 in the mean scores of the individual judges, as reported in Column 3 of Table XVII. Judge two tended to rate all of the cakes very high in crumb character, with a mean score of 9.75, and judge five tended to rate all of the cakes low, with a mean of 7.42.

Replication: There was no significant difference in the judges' scores for crumb character among cakes browned for the same length of time in the different replications (Table XV). There was a difference, as indicated by the F ratio of 2.36, but the difference was .34 below the significant value.

Tenderness

Length of browning: There was no significant difference in the judges' scores assigned to tenderness among cakes browned for different lengths of time (Table XV), as indicated by the F ratio of .79. There was a difference of only .64 between the highest and lowest mean scores for tenderness among the cakes, as may be observed in Table XVI. The cakes were most often scored "tender." It was interesting to note that tenderness was not affected by the increased cooking that resulted from the use of the electrical browning unit in combination with the microwave energy.

Judges: There was a highly significant difference among the scores assigned by the different judges (Table XV), as indicated by the F ratio of 4.79. There was a range of 2.55 among the judges' scores, as reported in Column 4 of Table XVII. Judge four scored the cakes very high, with a mean score of 9.46, and judge two scored the cakes low, with a mean score of 6.91.

Replication: There was no significant difference in the judges' scores for tenderness among cakes browned for the same length of time in the different replications (Table XV). The F ratio of .25 indicated the similarity of the judges' opinions as to tenderness of the cakes.

Moisture

Length of browning: There was no significant difference in the moisture content of cakes browned for different lengths of time (Table XV), as indicated by the F ratio of .68. The mean scores for moisture were quite similar for all cakes, with a difference of only .54 between the highest and lowest scores, as reported in Table XVI. The moisture content of the cakes was most frequently scored "moist."

Judges: There was a highly significant difference among the scores assigned by the different judges (Table XV), as indicated by the F ratio of 16.69. There was a range of 4.38 in the judges' scores, as may be observed in Column 5 of Table XVII. Judge four scored all of the cakes "moist," with a mean score of 10.00 and judge seven consistently scored the cakes "dry," with a mean score of 5.62.

Replication: The judges' scores for cakes browned for the same length of time varied significantly from one replication to the next (Table XV), as indicated by the F ratio of 3.23. The judges scored the cakes "moist" less frequently in replications one and two.

RANK PREFERENCE

The sums of the ranks (Table XVIII) indicated the judges' first choice for the conventionally baked cake, with a sum of 55. Their first preference of the electronically cooked cakes was for the cake browned for 2 minutes 25 seconds, with a sum of 87. Their last preference was for the electronic control cake, with a sum of 105. The range of the sums was 50, which indicated a lack of concordance among the judges.

TABLE XVIII

SUMS OF RANKS ASSIGNED TO CAKES BROWNED FOR 4 DIFFERENT LENGTHS OF TIME (4 REPLICATES, AND 7 JUDGMENTS OF EACH REPLICATE)

Type of range	Length of browning	Sums of ranks Replicates 1	2	3	4	Total of sums of ranks	Rank order*
Conventional	Control	17	9	16	13	55	1
Electronic	Control	30	18	32	25	105	6
	2 min. 10 sec.	22	24	23	25	94	4
	2 min. 20 sec.	24	26	17	22	89	3
	2 min. 25 sec.	24	23	18	22	87	2
	2 min. 30 sec.	30	26	20	19	95	5

* The cake with the smallest total score is ranked first.

The coefficient of concordance of .141 among judges in replication one and the F ratio of .984 indicated there was no significant agreement among the judges in the ranking of the cakes. The F ratio of 2.58 in replication two indicated there was agreement among the judges in their rankings. The ratio was only .02 below the significant value. There was no significant agreement among the judges in the ranking of the cakes in the remaining two replications.

The coefficients of concordance for the individual judges revealed that the ranking of one judge proved to be highly significant, with a coefficient of concordance of .709 and F ratio of 7.31. The F ratio for the remainder of the judges did not indicate significant concordance with themselves in the ranking of the cakes from one replication to another.

A comparison of the ranks and scores assigned cakes browned for different lengths of time (Table XIX) indicated that the judges scored as first the cake browned for 2 minutes and 20 seconds and ranked as first the cake browned for 2 minutes 25 seconds. However, the difference between the mean total scores of 1.23 and difference of 2.0 between the sums of ranks for these two cakes indicated that there was little difference in the appearance, palatability, and acceptability of these cakes. The judges not only scored but also ranked as last the cake browned for 1 minute. This judgment was to be expected when the crusts were not removed from the cakes when some cakes were browned and others were not.

TABLE XIX

SCORED PLACEMENT AND RANKED PREFERENCE OF THE TASTE PANEL FOR CAKES BROWNED FOR 4 DIFFERENT LENGTHS OF TIME (4 REPLICATES, AND 7 JUDGMENTS OF EACH REPLICATE)

Type of range	Length of browning	Scored Placement	Rank Preference
Conventional	Control	3 (tie)	1
Electronic	Control	5	6
	2 min. 10 sec.	3 (tie)	4
	2 min. 20 sec.	1	3
	2 min. 25 sec.	6	2
	2 min. 30 sec.	2	5

WEIGHT CHANGE DURING COOKING

The means and the percentages of weight loss during cooking, due to a loss of moisture, are reported in Table XX. There was a range of 7.3 in the mean weight loss in the electronically cooked cakes browned for different lengths of time with the electrical browning unit. The electronic control cake lost the smallest number of grams of weight, with a mean loss of 41.1 gms., and the cake browned for 2 minutes and 30 seconds lost the largest amount of weight, with a mean loss of 48.4 gms. It was observed that there was an increased loss of weight as the use of the electrical browning unit was extended beyond a 1-minute period. There was a smaller loss of weight in the cakes browned beyond the 2-minute

TABLE XX

ARITHMETIC MEANS AND PERCENTAGES OF WEIGHT LOSS DURING COOKING IN CAKES BROWNED FOR 4 DIFFERENT LENGTHS OF TIME (4 REPLICATES, AND 7 JUDGMENTS OF EACH REPLICATE)

Type of range	Length of browning	Moisture loss grams	Moisture loss per cent
Conventional	Control	27.4	6.5
Electronic	Control	41.1	9.7
	2 min. 10 sec.	47.5	11.2
	2 min. 20 sec.	47.1	11.1
	2 min. 25 sec.	46.2	10.9
	2 min. 30 sec.	48.4	11.4

10-second period. However, the increase of browning time for only 10 seconds after browning the cake for 2 minutes 10 seconds resulted in a marked increase in browning (Table XIV) but a small increase in weight loss. It was interesting to note that a cake may be browned without increasing the moisture loss.

APPEARANCE OF TOP CRUSTS OF CAKES

Appearance of the top crusts of cakes browned for different lengths of time may be observed in Figure 16. Top crust appearance may be described in terms of: (1) degree and pattern of browning, and (2) surface regularity.

Degree and Pattern of Browning

It was observed that no browning occurred with the use of the electrical browning unit for 1 minute (Cake III-1). Some browning occurred with the use of the unit for 2 minutes 10 seconds (Cake III-2). The use of the unit for 2 minutes 30 seconds (Cake III-5) resulted in a darker brown than was obtained in the conventional oven (Cake III-6). The size of the electrical browning unit in the electronic range made an even brown over the entire layer impossible as the unit did not produce a 9-inch width of browning. None of the cakes cooked electronically and browned with the electrical unit in the range approached the evenness of browning observed in the cake baked in the conventional oven.

Surface Regularity

The photographs revealed an increase in the development of cracks in the surface of the cakes with the lengthening of the browning period. The cracks apparently resulted from the formation of a crust before the cake had completely risen. It is possible that the formation of the cracks could have been prevented by delaying the use of the electrical browning unit until the cake structure was formed. This delay would have necessitated the continuation of the use of the electrical unit after completion of the cooking of the cake by microwave energy.

The researcher observed that cakes cooked electronically were increasingly firm as the crust developed, and that the cakes could have been frosted with ease. The firmness of crust and the development of color would make the electronically cooked cakes more appealing to the homemaker since they would meet an acceptable standard for layer cake.

SUMMARY

The data indicated that the length of time the electrical browning unit of the electronic range was used did not result in significant difference in the tenderness of the crust, and that the cakes may be browned for a period of at least 2 minutes 30 second without decreasing the tenderness of the crust.

The data also indicated there was a highly significant difference in the degree of browning of the cake with the use of the electrical browning unit for different lengths of time. A preference was indicated by the judges for cakes browned for either 2 minutes 20 seconds, 2 minutes 25 seconds, or 2 minutes 30 seconds.

The data implied that the amount of rising that nad occurred when the crust was formed by use of the electrical browning unit had no significant effect upon the appearance and palatability of the cake crumb. There was no significant difference in the scores for cell size, cell distribution, crumb character, tenderness, and moisture content of the cakes.

The judges scored as first the cake browned 2 minutes 20 seconds and ranked as first the cake browned 2 minutes 25 seconds. However, the difference of 1.23 in the mean total scores and of 2.0 in the sums of ranks of these two cakes indicated that the cakes varied little in appearance, palatability, and acceptability.

There was no increase in the weight loss as the browning time was increased from 2 minutes 10 seconds to 2 minutes 30 seconds. The data indicated that a cake may be browned without producing a dry crumb. However, the photographs revealed that the use of the electrical browning unit for the period of time necessary to secure browning resulted in the development of cracks in the surface of the cakes.

The important finding of this phase of the experiment was that sufficient browning of the crust was attained to improve the appearance of the cake without producing a dry crumb; however, the electrical browning unit of the electronic range used for this study was too small in size to result in an even browning of a 9-inch layer cake.

IV. THE EFFECT OF THE ELECTRICAL BROWNING UNIT ON CAKE BATTER CONTAINING 140 GMS. OF LIQUID

The data in a preceding phase of the experiment indicated that the judges preferred the cakes containing either 140 gms. or 150 gms. of liquid rather than the cake containing 120 gms. of liquid, as recommended by the cake mix manufacturer. The data also indicated that the judges preferred the cake browned for either 2 minutes 20 seconds or 2 minutes 25 seconds rather than the unbrowned cake. The researcher was interested in establishing a standard procedure to use in cooking electronically a cake batter containing 140 gms. of liquid, and to secure an acceptable brown crust with the use of the electrical browning unit installed in the electronic range. This interest resulted in experimenting with a cake batter containing 140 gms. of liquid, rather than the 120 gms. of liquid used in the cakes in the preceding chapter, in relation to the use of the electrical browning unit of the electronic range for 2 minutes 20 seconds, 2 minutes 30 seconds, 2 minutes 40 seconds, and 2 minutes 50 seconds simultaneously with the microwave energy. The browning unit was used during the latter part of the cooking period. A total of six cakes was baked in each replication. The crusts were left on all samples for judging.

APPEARANCE AND PALATABILITY

To study the effect of the use of the electrical browning unit on quality of cakes made with 140 gms. of liquid, the following factors were scored: (1) crust tenderness, (2) crust color, (3) cell size, (4) cell distribution, (5) crumb character, (6) tenderness, and (7) moisture.

Crust Tenderness

The differences in the judges' ratings for tenderness of the crusts of cakes containing 140 gms. of liquid and browned for different lengths of time were not significant as indicated by a low chi-square value of .49. The number of ratings assigned by the judges to the crust tenderness of cakes in each of the categories for tenderness may be observed in Table XXI. It was observed that as the

TABLE XXI

CONTINGENCY TABLE OF JUDGES' RATINGS OF CRUST TENDERNESS OF CAKES CONTAINING 140 GMS. OF LIQUID AND BROWNED FOR 4 DIFFERENT LENGTHS OF TIME
(27 RATINGS OF EACH CAKE)

Cake number	Length of browning	Gms. of liquid	Number of ratings received			
			Tender	Slightly tender	Tough	Too moist
IV-1	Electronic control	Control	14	1	2	10
IV-2	2 min. 20 sec.	140	13	6	1	7
IV-3	2 min. 30 sec.	140	11	7	3	6
IV-4	2 min. 40 sec.	140	9	11	3	4
IV-5	2 min. 50 sec.	140	11	9	4	3
IV-6	Conventional control	Control	22	1	1	3

browning time was increased the cake crusts were more often rated "slightly tender" than "moist," even though the difference in the number of ratings was not significant. These data indicated that a cake may be browned for a period of at least 2 minutes 50 seconds without a significant decrease in the tenderness of the crust.

Crust Color

There was a highly significant difference in the degree of browning of the cakes with the use of the electrical browning unit for different lengths of time as indicated by a chi-square value of 30.26. The number of judges' ratings for crust color in each of the categories for color may be observed in Table XXII. The cake browned for 2 minutes 50 seconds was most often rated "golden brown," and the cakes browned for 2 minutes 20 seconds, 2 minutes 30 seconds, or 2 minutes 40 seconds were most often rated "pale" or "unbrowned." Therefore, it was determined that with the use of 140 gms. of liquid in the cake batter an increase in the browning time up to 2 minutes 50 seconds was necessary to secure a crust color rated by the judges as "golden brown."

Cell Size

Length of browning: There was no significant difference in cell size among cakes browned for different lengths of time (Table XXIII), as indicated by the F value of 1.71. The means of the scores varied 1.57, as may be observed in Table XXIV. The cell size of the cakes was rated by the judges as "very fine" to "small."

TABLE XXII

CONTINGENCY TABLE OF JUDGES' RATINGS OF CRUST COLOR OF CAKES CONTAINING 140 GMS. OF LIQUID AND BROWNED FOR 4 DIFFERENT LENGTHS OF TIME (28 RATINGS OF EACH CAKE)

Cake number	Length of browning	Gms. of liquid	Number of ratings received: Golden brown	Pale	Too dark	No browning
IV-1	Electronic control	Control	0	3	0	25
IV-2	2 min. 20 sec.	140	2	14	0	12
IV-3	2 min. 30 sec.	140	9	19	0	0
IV-4	2 min. 40 sec.	140	8	19	1	0
IV-5	2 min. 50 sec.	140	19	7	2	0
IV-6	Conventional control	Control	27	1	0	0

TABLE XXIII

ANALYSIS OF VARIANCE OF THE SCORES FOR THE APPEARANCE AND PALATABILITY OF CAKES CONTAINING 140 GMS. OF LIQUID AND BROWNED FOR 4 DIFFERENT LENGTHS OF TIME (4 REPLICATES, 7 JUDGMENTS OF EACH REPLICATE)

Source of variance	Degrees of freedom	Appearance and Palatability of Cakes									
		Cell size		Cell distribution		Crumb character		Tenderness		Moisture	
		Mean square	F value	Mean square	F value	Mean square	F value	Mean square	F value	Mean square	F value
Total	139										
Replicates	3	24.51	3.80*	16.87	8.83**	2.24	.91	.96	.17	3.66	.81
Treatments											
Browning time	4	10.99	1.71	4.64	2.43	1.17	.48	3.37	.61	3.76	.83
Judges	6	92.73	14.40**	10.46	5.48**	9.31	3.80**	49.31	8.95**	46.92	10.40**
Interaction	24	6.53	1.01	1.91	1.00	1.50	.61	3.12	.57	4.66	1.03
Experimental error	102	6.44		1.91		2.45		5.51		4.51	

* "Significant," probabilities between 0.05 and 0.01.

** "Highly significant," the F ratio indicated probabilities less than 0.01

TABLE XXIV

ARITHMETIC MEANS OF SCORES FOR APPEARANCE AND PALATABILITY OF CAKES CONTAINING 140 GMS. OF LIQUID AND BROWNED FOR 4 DIFFERENT LENGTHS OF TIME (4 REPLICATES, AND 7 JUDGMENTS OF EACH REPLICATE)

Type of range	Length of browning	Appearance and palatability qualities: Cell size	Cell distribution	Crumb character	Tenderness	Moisture	Flavor	Total
Conventional	Control	9.25	6.00	9.00	6.82	9.25	9.17	49.50
Electronic	Control	8.75	4.28	9.28	7.92	7.68	9.53	47.51
	2 min. 20 sec.	7.18	3.71	9.43	8.10	8.60	9.82	46.68
	2 min. 30 sec.	8.25	3.78	9.28	7.82	8.64	9.46	47.25
	2 min. 40 sec.	7.50	4.21	9.26	8.71	8.39	10.00	47.75
	2 min. 50 sec.	7.68	2.71	9.42	8.03	8.39	9.53	47.82
Maximum score		10.00	6.00	10.00	10.00	10.00	10.00	56.00

The use of the browning unit for 2 minutes 50 seconds, which resulted in the formation of a crust early in the cooking period, did not interfere with the rising of the cake.

Judges: There was a highly significant difference among the scores assigned by the different judges to cakes browned the same length of time (Table XXIII), as indicated by the F value of 14.40. There was a range of 2.41 in the mean scores of the individual judges, as reported in Column 1 of Table XXV. Judges two and seven rated the cell size high, with identical mean scores of 8.04, and judge five tended to rate the cakes low in cell size, with a mean score of 5.63.

Replication: The judges' scores for cell size among cakes browned for the same length of time differed significantly from one replication to the next (Table XXIII), as indicated by the F value of 3.80.

Cell Distribution:

Length of browning: The length of time the cake containing 140 gms. of liquid was browned approached significance in the judges' scores for cell distribution (XXIII). The F value of 2.43 was only .03 below the significant value. There was a difference in the mean scores (Column 2, Table XXV), as indicated by the range of 1.57. Although the judges' scores were distributed in approximately the same proportion among the quality factors for cell distribution,

TABLE XXV

MEAN SCORES OF CAKES JUDGED BY THE 7 JUDGES IN THE FOURTH PHASE OF THE EXPERIMENT

Judge	Cell** size	Cell** distribution	Crumb** character	Tenderness**	Moisture**
1	7.58	4.17	9.17	8.67	8.75
2	8.04	4.33	8.78	8.17	7.33
3	4.04	4.50	9.17	5.83	9.17
4	6.88	3.92	9.00	6.83	9.17
5	5.63	4.58	6.58	5.21	5.88
6	7.46	4.17	9.50	9.00	7.50
7	8.04	3.58	7.42	7.42	6.04

** "Highly significant," the F ratio indicated probabilities less than 0.01.

the electronic control cake was more often scored "irregular" and the cake browned for 2 minutes 50 seconds was more often scored "uniform" than any of the other cakes.

Judges: There was a highly significant difference among the scores assigned by the different judges to cakes browned for the same length of time (Table XXIII), as indicated by the F ratio of 5.48. There was a difference of 1.00 in the highest and lowest scores assigned to cell distribution by the different judges, as reported in Column 2 of Table XXV. Judge five scored the cell distribution highest, with a mean score of 4.58, and judge seven scored it lowest, with a mean score of 3.58.

Replication: The judges' scores for cakes browned for the same length of time varied in a highly significant manner among replications (Table XXIII), as indicated by the F ratio of 8.83.

Crumb Character

Length of browning: There was no significant difference in the crumb character of the cakes containing 140 gms. of liquid and browned for different lengths of time (Table XXIII), as indicated by the low F ratio of .48. The difference between the highest and lowest mean scores was only .17, as reported in Table XXIV. All of the cakes had a mean score within .74 of the maximum possible score. These high scores may have been due to the assigned numerical values of 10 to "velvety" and 8 to "slightly harsh." The crumb character of all cakes, with the exception of only two, was rated as "velvety" or "slightly harsh." The difference of only two points in the numerical value of these two qualities for crumb character resulted in a score higher than was expected by the researcher. However, it was possible that the cakes were more velvety and that these scores confirmed the judges' preference for 140 gms. of liquid in a cake mix batter cooked electronically.

Judges: There was a highly significant difference in the scores assigned by the different judges to crumb character (Table XXIII), as indicated by the F ratio of 3.80. There was a range of 2.59 in the mean scores of the different judges, as reported in Column 3, Table XXV. Judges one and three consistently rated the crumb character of the cakes "velvety," as indicated by their identical mean scores of 9.17, and judge five rated the crumb character "slightly harsh" to "very harsh," as indicated by a mean score of 6.58.

Replication: The judges' scores did not differ significantly from one replication to the next (Table XXIII). The F ratio of .91 indicated a high degree of similarity in the scores assigned to crumb character among cakes browned for the same length of time in the different replications.

Tenderness

Length of browning: There was no significant difference in the judges' scores for tenderness among the cakes (Table XXIII), as indicated by the F ratio of .61. There was a range of only .89 in the mean scores, as reported in Table XXIV. The cakes were rated from "tender" to "very tender." The researcher was interested that the increased cooking which would result from the use of the electrical browning unit for a longer period of time did not decrease the tenderness of the cake.

Judges: The judges differed significantly in their scores for tenderness among cakes browned for the same length of time (Table XXIII), as indicated by the F ratio of 8.95. There was a range of 3.17 in the individual judges' scores, as reported in Column 4 of Table XXV. Judge six rated the cakes higher in tenderness, with a mean score of 9.00, and judge five rated them low in tenderness, with a mean score of 5.21.

Replication: There was no significant difference in the scores for tenderness among cakes browned for the same length of time in the different replications (Table XXIII), as indicated by the F ratio of .17. This low ratio indicated there was very little difference in the scores for the same cake from one replication to the next.

Moisture

Length of browning: There was no significant difference in the judges' scores for moisture content among cakes browned for different lengths of time (Table XXIII), as indicated by the F ratio of .83. There was a difference of only .96 in the mean scores for moisture, as may be observed in Table XXIV. All of the cakes were most often scored "moist;" however, the electronic control cake was more often scored "dry" than any of the other cakes, which was confirmed by its low mean score. This slight difference in moisture indicated that the use of the electrical browning unit early in the cooking period formed a crust at the beginning of the rising of the cake which probably lessened the loss of moisture. This difference in moisture, however, was not significant as shown by the analysis of variance.

Judges: There was a highly significant difference in the scores assigned by the different judges to cakes browned for the same length of time (Table XXIII), as indicated by the F ratio of 10.40. There was a difference of 3.29 in the highest and lowest scores assigned to moisture. Judges three and four scored the moisture highest, with identical mean scores of 9.17, and judge five scored the moisture lowest, with a mean score of 5.88, as may be observed in Column 5 of Table XXV.

Replication: The F ratio of .81 indicated that there was no significant difference in the scores assigned to moisture among cakes browned for the same length of time in the different replications (Table XXIII).

RANK PREFERENCE

The sums of the ranks (Table XXVI) indicated the judges' first preference for the control cake baked in the conventional oven, with a sum of 67. The conventionally baked cake possessed

TABLE XXVI

SUMS OF RANKS ASSIGNED TO CAKES CONTAINING 140 GMS. OF LIQUID AND BROWNED FOR 4 DIFFERENT LENGTHS OF TIME (4 REPLICATES, AND 7 JUDGMENTS OF EACH REPLICATE)

Type of range	Length of browning	Sums of ranks Replicates 1	2	3	4	Total of sums of ranks	Rank order*
Conventional	Control	13	19	21	14	67	1
Electronic	Control	17	30	25	20	92	3
	2 min. 20 sec.	34	33	32	23	122	6
	2 min. 30 sec.	35	18	25	25	103	5
	2 min. 40 sec.	23	22	21	21	87	2
	2 min. 50 sec.	25	25	23	23	96	4

* The cake with the smallest total score is ranked first.

the characteristic golden brown color that is associated with cake. It was interesting to observe that all the judges did not rank the conventionally baked cake first, as would have been indicated by a sum of 28. Some of the judges preferred the electronically cooked cakes. The first preference among the electronically cooked cakes was the cake browned for 2 minutes 40 seconds, with a sum of 87. The sums of the ranks indicated the judges' last preference for the cake browned 2 minutes 20 seconds, with a sum of 122. There was a range of 35 in the sums of the ranks, whereas a range of 84 was possible.

The coefficient of concordance of .453 among judges in replication one indicated a high degree of concordance. The F ratio of 4.97 indicated that the judges agreed with each other in a highly significant manner in the ranking of the cakes. There was no significant agreement among the judges in the ranking of the cakes in the remaining three replications. The rankings in replication three approached complete disagreement, with a coefficient of concordance of value of .095 and F ratio of .63.

The coefficients of concordance for the individual judges revealed that two of the judges had a high degree of concordance with themselves in the ranking of the cakes from one replication to the next. The ranking of one judge proved to be highly significant, with a coefficient of concordance of .691 and F ratio of 6.71. The ranking of another judge proved to be significant with a coefficient of concordance of .549 and F ratio of 3.65. These judges agreed with themselves in the ranking of the cakes from one replication to another. The coefficients of concordance and F ratios for the remainder of the judges were not significant. However, though not significant, the coefficient of concordance values for all of the judges were higher in this phase than in other phases of the experiment.

A comparison of the ranks and scores assigned cakes containing 140 gms. of liquid and browned for different lengths of time (Table XXVII) indicated that the judges not only scored but also ranked as first the conventionally baked cake. Of the electronically cooked cakes, the judges scored as first the cake browned for 2 minutes 50 seconds and ranked as first the cake browned for 2 minutes 40 seconds. However, there was a difference of only .07 in the mean total scores and a difference of only 9.0 in the sums of ranks. These small differences indicated comparable appearance, palatability, and acceptability of these cakes. The judges scored and ranked as last the cake browned for 2 minutes 20 seconds. The researcher observed that the texture and flavor of the crust of the electronically cooked cake browned with the electrical browning unit differed from the crust of the conventionally baked cake. The crust of the electronically cooked cake lacked the smoothness of the crust of the conventionally baked cake, and it had a definite caramel flavor. Apparently, this difference was the result of the increased liquid in the batter and the increased browning time.

<u>WEIGHT CHANGE DURING COOKING</u>

The means and the percentages of weight loss during cooking are reported in Table XXVIII. There was a range of 13.2 gms. in

TABLE XXVII

SCORED PLACEMENT AND RANKED PREFERENCE OF THE TASTE PANEL FOR CAKES CONTAINING 140 GMS. OF LIQUID AND BROWNED FOR 4 DIFFERENT LENGTHS OF TIME (4 REPLICATES, AND 7 JUDGEMENTS OF EACH REPLICATE)

Type of range	Length of browning	Scored Placement	Ranked Preference
Conventional	Control	1	1
Electronic	Control	4	3
	2 min. 20 sec.	6	6
	2 min. 30 sec.	5	5
	2 min. 40 sec.	3	2
	2 min. 50 sec.	2	4

TABLE XXVIII

ARITHMETIC MEANS AND PERCENTAGES OF WEIGHT LOSS DURING COOKING IN CAKES CONTAINING 140 GMS. OF LIQUID AND BROWNED FOR 4 DIFFERENT LENGTHS OF TIME (4 REPLICATES, AND 7 JUDGMENTS OF EACH REPLICATE)

Type of range	Length of browning	Moisture loss grams	Moisture loss per cent
Conventional	Control	27.9	6.6
Electronic	Control	36.6	8.6
	2 min. 20 sec.	49.8	11.0
	2 min. 30 sec.	47.6	11.2
	2 min. 40 sec.	49.5	11.7
	2 min. 50 sec.	49.7	11.7

the means of the weight loss in the cakes browned for different lengths of time. As the use of the electrical browning unit was increased from a period of 1 minute to 2 minutes 20 seconds, the weight loss increased 13.2 gms; however, there was no increase in weight loss with the increase of browning time from 2 minutes 20 seconds up to a period of 2 minutes 50 seconds. These data corroborated the findings of an earlier phase of the experiment related to length of browning that a large amount of moisture was lost with an increase of the use of the electrical browning unit from 1 minute to 2 minutes 10 seconds, but that there was only a small increase in weight loss as the browning time was extended beyond a 2 minute 10 second period.

APPEARANCE OF TOP CRUSTS OF CAKES

The appearance of the top crusts of cakes browned for different lengths of time are shown in Figure 17. Top crust appearance may be described in terms of: (1) degree and pattern of browning, and (2) surface regularity.

Degree and Pattern of Browning

The photographs revealed that little browning occurred with the use of the electrical browning unit for 2 minutes 20 seconds (Cake IV-2). As the browning time was lengthened, the amount of browning increased proportionately (Cakes IV-3,4,5), as would have been expected. However, with the cake containing 140 gms. of liquid, the pattern of browning appeared to become more uneven with

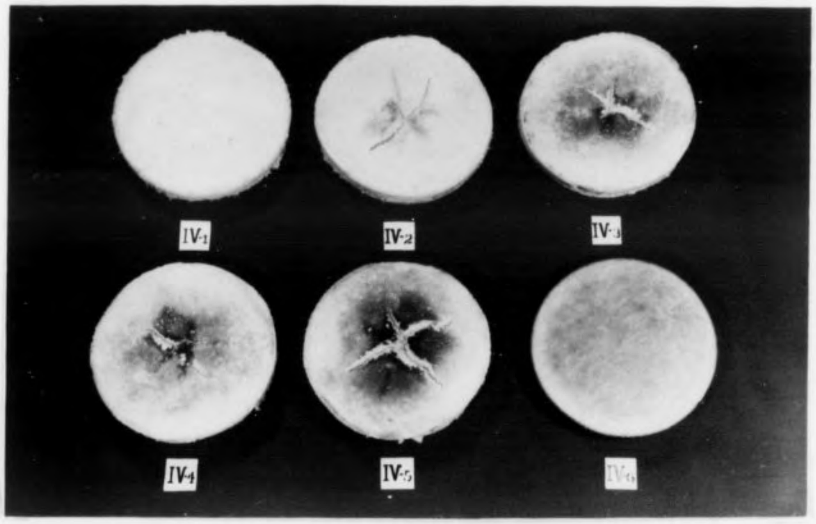

FIGURE 17

TOP CRUSTS OF CAKES CONTAINING 140 GMS. OF LIQUID AND BROWNED FOR 4 DIFFERENT LENGTHS OF TIME

Cake	Grams of liquid	Range	Length of browning
IV-1	120	Electronic	Control
IV-2	140	Electronic	2 minutes 20 seconds
IV-3	140	Electronic	2 minutes 30 seconds
IV-4	140	Electronic	2 minutes 40 seconds
IV-5	140	Electronic	2 minutes 50 seconds
IV-6	120	Conventional	Control

an increase in browning time than with cake containing 120 gms. of liquid.

Surface Regularity

The photographs also revealed that as the browning time was increased the surface cracks became broader and deeper. The increase in browning time necessitated turning on the electrical browning unit earlier in the cooking period. For instance, in the cake browned for 2 minutes 50 seconds, the microwave energy was used alone for only 40 seconds. It is possible that the cracks could have been avoided by delaying the browning period until the cake structure was formed by the microwave energy.

APPEARANCE OF CRUMB FACES OF CAKES

Appearance of the crumb faces of cakes browned for different lengths of time are shown in Figure 18. Surface contour only will be discussed.

Surface Contour

The photographs revealed that as the browning time was increased (Cakes V-2 through 5) the surface contour of each layer became more convex, and the surface peaks more pronounced. This contour was probably due to the formation of a crust after exposure to the electrical browning unit for a short period of time which may have interfered with the action of the leavening agent, as would occur in conventional baking with the use of a high oven temperature at the beginning of the baking period.

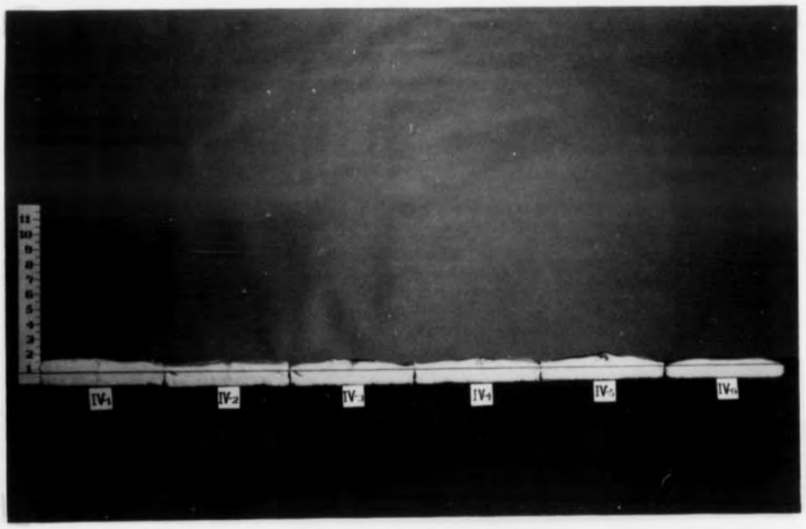

FIGURE 18

CRUMB FACES OF CAKES CONTAINING 140 GMS. OF LIQUID AND BROWNED FOR 4 DIFFERENT LENGTHS OF TIME

Cake	Grams of liquid	Range	Length of browning
IV-1	Control	Electronic	Control
IV-2	140	Electronic	2 minutes 20 seconds
IV-3	140	Electronic	2 minutes 30 seconds
IV-4	140	Electronic	2 minutes 40 seconds
IV-5	140	Electronic	2 minutes 50 seconds
IV-6	Control	Conventional	Control

SUMMARY

The important finding of this phase of the experiment was that an increase of 20 gms. of liquid in the cake batter required an increase of 20 to 30 seconds in the browning period to secure a degree of browning comparable to that attained in cake containing 20 gms. less liquid. The data indicated that cake containing 140 gms. of liquid required the use of the electrical browning unit for 2 minutes 50 seconds to secure a "golden brown" crust color.

The use of the browning unit within the range of 2 minutes 20 seconds to 2 minutes 50 seconds had little effect, according to the judges' scores, upon crust tenderness. The data also indicated that the length of time the electrical browning unit was used resulted in no significant difference in appearance and palatability of the cakes.

The judges scored as first the cake browned 2 minutes 50 seconds and ranked as first the cake browned for 2 minutes 40 seconds. However, the small difference in the mean total scores and the sums of ranks indicated that these two cakes were comparable in appearance, palatability, and acceptability.

The data indicated that there was no increased loss of moisture in the cakes browned for a period of 2 minutes 20 seconds up to 2 minutes 50 seconds. This range of browning time would result in browning variations from pale to golden brown. However, the photographs revealed that as the browning time was increased the pattern of browning became more uneven, the surface cracks became broader and deeper, and the surface peaks became more pronounced.

V. COMPARISON OF CONTROL CAKES

Throughout the study, batter was prepared for two identical layers of cake. One was cooked in the electronic range, and one was baked in a conventional electric oven. These layers were used as controls for comparison with the experimental cakes. The data for the control cakes were statistically analyzed to determine whether the cakes differed in: (1) the scores assigned by the judges for appearance and palatability, (2) the rank preference accorded by the judges, (3) weight change during cooking, and (4) the appearance of the crumb faces. The analysis of each factor will be discussed separately.

APPEARANCE AND PALATABILITY

The mean scores for the following appearance and palatability factors of the two cakes were analyzed: (1) cell size, (2) cell distribution, (3) crumb character, (4) tenderness, and (5) moisture. The analysis of each will be discussed separately.

Cell Size

There was no significant difference in the mean scores for cell size of the two cakes cooked by the different methods (Table XXIX), as indicated by the low t value of .12. There was a difference of only .06 in the means of the scores. However, there

TABLE XXIX

t-TEST OF THE DIFFERENCES BETWEEN THE MEAN SCORES FOR APPEARANCE AND PALATABILITY OF THE CONVENTIONAL CONTROL CAKE AND THE ELECTRONIC CONTROL CAKE (112 JUDGMENTS OF EACH CONTROL)

	Cell size	Cell distribution	Crumb character	Tenderness	Moisture	Total score
Mean scores:						
Conventional control	8.14	5.60	9.01	7.00	8.50	47.11
Electronic control	8.20	4.18	9.00	8.15	7.91	46.15
Difference between means	.06	1.42	.01	1.15	.59	.96
t value of differences	.12	8.45**	.04	3.69**	1.64	.93

** "Highly significant," the t value indicated probabilities less than 0.01.

seemed to be real differences in the subjective ratings made by the judges. Differences may have been obscured by the method of quantifying the score for cell size. The cell size of the conventionally baked cake received 41 ratings for "medium" and 42 for "small," as may be observed in Table XXX. The cell size of the electronically cooked cake received 26 ratings for "medium" and 57 for "small." Both of the descriptive terms "small" and "medium" had a numerical value of 10. Without the statistical analysis having shown it, the cell size of the electronically cooked cake was rated smaller than the cell size of the conventionally baked cake.

Cell Distribution

There was a highly significant difference in the cell distribution of the two cakes (Table XXIX), as indicated by the t value of 8.45. There was a difference of 1.42 in the mean scores for cell distribution. The cell distribution in the conventionally baked cake was scored "uniform" 94 out of 110 judgments, as may be observed in Table XXX, which resulted in a high mean score of 5.60 on a scale in which a score of 6.00 was possible. The judges' ratings for cell distribution among cakes cooked in the electronic range were more diversified, as indicated by the mean score of 4.18. The ratings ranged from "tunneled" to "uniform," with the cell distribution most often rated "irregular."

Crumb Character

There was no significant difference in the scores for crumb

TABLE XXX

SUMS OF THE RATINGS RECEIVED BY THE TWO CONTROL CAKES FOR EACH QUALITY OF THE APPEARANCE AND PALATABILITY FACTORS (112 JUDGMENTS OF EACH CONTROL)

Appearance and palatability factors	Numerical value	Sums of ratings: Conventional oven control	Sums of ratings: Electronic range control
Size of cells			
Large	3	8	5
Medium	10	41	26
Small	10	42	57
Very fine	3	15	20
Compact	1	6	3
Distribution of cells			
Uniform	6	94	33
Irregular	4	9	54
Tunneled	2	7	25
Crumb characteristics			
Velvety	10	77	73
Slightly harsh	8	23	31
Very harsh	2	9	4
Tenderness			
Crumbly	3	2	7
Very tender	6	57	30
Tender	10	34	62
Slightly tender	8	5	11
Tough	3	24	2
Moisture			
Moist	10	84	68
Dry	5	17	31
Wet	2	10	3

character of the two cakes (Tables XXIX), as indicated by the low t value of .04. The mean scores for both cakes were high and varied only .01. The crumb character for the conventionally baked cake had a mean score of 9.01, and the cell distribution of the electronically cooked cake had a mean score of 9.00, whereas a score of 10.00 was possible. Both of the cakes were most often rated "velvety" in crumb character.

Tenderness

There was a highly significant difference in the scores for tenderness of the two cakes (Table XXIX), as indicated by the t value of 3.69. There was a difference of 1.15 in the mean scores, with the conventionally baked cake having a mean score of 7.00 and the electronically cooked cake having a mean score of 8.15. The conventionally baked cake was most often rated "very tender," a rating having a numerical value of 6, and the electronically cooked cake was most often rated "tender," a rating having a numerical value of 10. The sums of the ratings for "tender" and "very tender" were approximately the same for the two cakes. One of the main differences in the tenderness among the cakes was the large number of ratings for "tough" received by the conventionally baked cake. The data indicated that the electronically cooked cake was more tender than the conventionally baked cake.

Moisture

There was no significant difference in the moisture content of the cakes (Table XXIX), as indicated by the t value of 1.64. There was a difference of .59 in the mean scores, with the conventionally baked cake having a mean score of 8.50 and the electronically cooked cake having a mean score of 7.91. The conventionally baked cake was rated "moist" more often than the electronically cooked cake (Table XXX). Although the statistical analysis did not reveal a significant difference in moisture of the two cakes, the judges' ratings revealed that there was a difference as shown by the 17 ratings given to "dry" for the conventionally baked cake and the 31 ratings given to "dry" for the electronically cooked cake.

RANK PREFERENCE

The sums of the ranks assigned to the control cakes cooked in the two ranges were as follows:

Type of range	Sums of ranks Experimental phase 1	2	3	4	Total of sums of ranks	Rank order*
Conventional	81	54	55	67	257	1
Electronic	101	72	105	92	370	2

* The cake with the smallest total score is ranked first.

The sums of the ranks indicated the judges' first preference for the control cake baked in the conventional oven. However, the difference in the mean total scores was only .96, a difference which was not significant as indicated by the t value of .93. The mean total scores were 47.11 for the conventionally baked control cake and 46.15 for the electronically cooked control cake.

WEIGHT CHANGE DURING COOKING

The t value of 5.90 indicated that there was a highly significant difference in the weight loss in the control cakes cooked by the different methods. The conventionally baked cake had a mean loss of 27.29, and the electronically cooked cake had a mean loss of 39.09. This difference in weight loss would indicate that the electronically cooked cake would be less moist than the conventionally baked cake.

APPEARANCE OF CRUMB FACES OF CAKES

Contour

It was observed that the two control cakes were different in contour (Figures 6 and 7, page 55). The cake baked in the conventional range was more symmetrical than the cake cooked in the electronic range, as the latter portrayed an irregular surface.

Volume

The two cakes differed in height (Figures 6 and 7). The conventionally baked cake attained a maximum height of 1¼ inches, and the electronically cooked cake attained a maximum of 1 3/4 inches. This difference indicated that greater volume resulted in a cake cooked in the electronic range.

Cell Distribution

The photograph of the cake baked in the conventional range revealed a more uniform cell distribution than was apparent in the cake cooked in the electronic range (Figures 6 and 7).

APPEARANCE OF TOP CRUSTS OF CAKES

The photographs revealed an even golden brown crust color of the conventionally baked cake and a lack of browning of the crust of the electronically cooked cake (Figure 16, Cakes III-1 and III-6, page 79).

SUMMARY

The data indicated that the cake baked in the conventional oven did not differ significantly from the cake cooked in the electronic range in either cell size, crumb character, or moisture content, but that they were highly significantly different in cell distribution and tenderness. The conventionally baked cake was rated "uniform" in cell distribution more often than the electronically cooked cake. The two cakes received approximately the same number of ratings for "tender" and "very tender;" however, the conventionally baked cake received 12 ratings for "tough" in contrast to the 2 ratings received by the electronically cooked cake.

The electronically cooked cake lost a significantly greater amount of weight during cooking than the conventionally baked cake, indicating an electronically cooked cake would be less moist than a conventionally baked cake.

The photographs revealed that the conventionally baked cake crust had an even golden brown color and that the electronically cooked cake was unbrowned. The photographs also revealed the electronically cooked cake was more irregular in surface contour, attained greater volume, and possessed more irregularity in cell distribution than the conventionally baked cake.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

I. SUMMARY

The purpose of this study was to test the effect of electronic cookery upon cake quality. Through the use of a yellow cake batter, an effort was made to determine whether the appearance and palatability of the cake cooked in the electronic range were affected by: (1) the amount of liquid in the batter, (2) the size and shape of the cooking container, and (3) the length of time of use of the electrical browning unit.

The experimentation was based upon a mixing and cooking procedure established through a research project conducted at Woman's College.[88] A yellow cake mix that required the addition of whole eggs and water was used. The batters were mixed in a household mixer using the lowest speed. The volume of batter established for a layer of cake in this study was 425 gms. This volume was held constant for each baking throughout the experiment. On each baking day, batters for two identical layers of cake were prepared using the established mixing procedure, one for cooking in the electronic range and one for baking in a conventional electric oven. These layers were used as controls for comparison with the experimental cakes. In the experimental phases where the variable employed did not involve a change in the proportion of ingredients,

---

[88] Cf. ante, p. 14.

the proportions recommended by the cake mix manufacturer were used for the experimental batters as well as for the control cakes.

All cakes were cooked in glass containers with two layers of wax paper placed in the bottom of the container. The cakes were cooked in a Tappan electronic range, Model RL-4, using the following procedure: set electronic timer for $3\frac{1}{2}$ minutes; set Hi-Lo switch on Hi; place shelf in center position; center dish on the shelf; cook cake uncovered; use browning timer simultaneously with the electronic timer during the last one minute of cooking.

Throughout the study, experimental cakes employing only one variable at a time were cooked and tested four times with the order of preparation and cooking being randomized.

Before and after cooking, the cakes were weighed to determine the weight change during cooking. Before the judges scored the cakes, photographs were made of the crumb faces to: (1) observe contour of top surface, (2) compare height of the two sides of an individual cake, (3) compare volume of the cakes within a replication, and (4) observe cell distribution within cakes. Photographs were also made of the top crusts of the cakes that were browned in order to observe the degree and pattern of browning.

The cakes were scored by a taste panel composed of five home economists and two commercial bakers. Each judge received a wedge of each cake cooked, representing one-sixteenth of a layer, coded, and in random order. There was a total of 28 judgments made of cakes employing each variable. During the study there was a total of 112 judgments made of each control cake. A check-type score card was used to record the judges' opinions in relation to: (1) tenderness of crust, (2) color of crust, (3) cell size, (4) cell distribution, (5) crumb character, (6) tenderness, (7) moisture, (8) flavor, (9) judges' preference of cakes in rank order, and (10) judges' comments. After the judges assigned the scores, the appearance and palatability qualities of the score card were quantified for the purpose of statistical analysis.

The data were statistically analyzed to determine the effect upon cake quality of: (1) the amount of liquid in the batter, (2) the size and shape of the cooking container, and (3) the length of time of use of the electrical browning unit. The arithmetic means were computed for the 28 scores (7 judges, 4 replications) for each appearance and palatability quality of each cake in an experimental phase. The means were also computed for the sums of the individual judges' scores for each of the appearance and palatability qualities for all cakes in an experimental phase. Analyses of variance were computed to determine whether there was any significant differences in the judges' scores for: cell size, cell distribution, crumb character, tenderness, and moisture of cakes treated differently within an experimental phase. Chi-square values for contingency tables were computed to determine whether there were significant differences in crust tenderness and crust color among cakes that had been browned for different lengths of time. The t values were computed to determine whether there was any significant difference between the means of the two control cakes for: (1) the judges' scores for cell size, cell distribution, crumb character, tenderness, and moisture, and (2) weight change during cooking. In each of the statistical analyses used, the values were considered to be significant if the computed value was equal to or larger than the value recorded at the five per cent level of the appropriate table, and highly significant if the computed value was equal to or larger than the value recorded at the one per cent level.

The sums of ranks, the coefficients of concordance among judges, and the F ratios of the ranks were computed for: (1) the seven judges to determine the significance of their agreement with each other in the ranking of the cakes, and (2) the individual judges to determine the significance of their agreement with themselves in the ranking of the cakes from one replication to the next. Also, the ranked preference of the judges was compared with their scored placement of the cakes.

The arithmetic means for weight loss during cooking and the percentages of weight loss were computed to determine whether the moisture loss was related to: (1) treatment of the cake batter, or (2) the method of cooking.

The photographs were descriptively analyzed to interpret the effect of cake treatment upon: (1) contour, (2) crumb character, (3) volume, and (4) top crusts of the cakes.

Effect of Increased Liquid

To study the effect of an increase in liquid in the batter on the quality of the cake cooked in the electronic range, the judges scored samples from experimental cake batters containing 140, 150, 160, and 170 gms. of liquid to the proportinate amount of cake mix used in this study per layer. However, only 425 gms. of batter were used for each cooking. A total of six cakes was cooked in each replication of this phase of the experiment. In this experimental phase, the electrical browning unit of the electronic range was used for one minute only, which dried rather than browned the surface of the cake. In preparing the samples for presentation to the judges, the brown crust was removed from the cake baked in the conventional oven.

It was found in this study that the cell distribution of the cakes became more regular with an increase of liquid in the batter, up to 20 gms. (approximately 1½ tablespoons) per layer beyond the amount recommended by the cake mix manufacturer, and that the cakes were more desirable in moisture content with an increase of liquid up to 40 gms. (approximately 3 tablespoons) per layer. However, the addition of 40 gms. of liquid per layer produced an increased number of tunnels. The five amounts of liquid used in this experiment produced no significant difference in cell size, crumb character, and tenderness of the cakes.

It was determined in this study that the loss of moisture in the cakes during cooking in the electronic range was controlled by the cooking time rather than the amount of liquid in the batter, thus, additional liquid in the batter would remain in the cooked product to increase its moisture content.

As the liquid was increased in the batter, the volume of the cake decreased and more nearly approached that of the conventionally baked cake; however, the surface contour became more irregular.

Effect of the Size and Shape of the Container

To study the effect of the size and shape of the container on the quality of the cake cooked in the electronic range, the judges scored samples from cake that had been baked in the form of a layer, a loaf, or as cup cakes. The same volume of batter, 425 gms., was used for each type of cake. The layer was cooked in a 9-inch round dish, the loaf in a $1\frac{1}{2}$ quart rectangular dish, and the cup cakes in eight 6-ounce custard cups. All cakes were cooked by the standard procedure established for this study except for the placement of the cup cakes in the range. The cups were placed equidistant over the entire shelf surface. All cakes were cooked for the same length of time in an effort to determine whether the cooking time was controlled either by the size and shape of the container, the number of containers, or by the volume of cake being cooked. A total of four cake samples was judged in each replication of this phase of the experiment. In preparing the samples for judging, all crusts were removed and all cakes were cut into wedges of similar size and shape in order that the manner of cooking would not be recognized.

The important finding of this phase of the experiment was that the same volume of batter would cook to approximately the same degree of doneness in an identical cooking time in the form of either a loaf, a layer, or eight cup cakes.

It was found that the size and shape of the cooking container had no significant effect upon the appearance and palatability qualities of the cake crumb.

The eight cup cakes lost less moisture than either the loaf or the layer cake. This smaller loss suggested that the amount of moisture lost in the cake during cooking in the electronic range was possibly related to the concentration of the microwave energy in a given location within the range.

The loaf cake rose to a greater height in the corners than in the center of the container, indicating that the concentration of microwave energy was less in the center than in the corners of a container having the dimensions of a loaf pan.

Effect of the Electrical Browning Unit

To determine the length of time to use the electrical browning unit to develop crust and color, the judges scored samples from cakes that had been cooked by the use of the electrical browning unit of the electronic range simultaneously with the microwaves for 2 minutes 10 seconds, 2 minutes 20 seconds, 2 minutes 25 seconds, and 2 minutes 30 seconds. The browning unit was used during the latter part of the $3\frac{1}{2}$ minute cooking period. The cakes were centered under the browning unit. A total of six cakes was cooked in each replication of this phase of the experiment. The crusts were left on all samples for judging.

An important finding of this phase of the experiment was that sufficient browning of the cake crust was attained to improve appearance and to increase firmness of the cake, resulting in a cake that would be more acceptable and easier to frost. It was found that the use of the electrical browning unit for a period of either 2 minutes 20 seconds, 2 minutes 25 seconds, or 2 minutes 30 seconds produced an acceptable crust color and firmness, without producing a dry crumb. However, it was found that the electrical browning unit installed in the electronic range used for this study was too small in size to produce an even browning of a 9-inch layer cake. The photographs confirmed the unevenness of browning as well as the fact that cracks developed in the surface of the cakes with browning. The cakes browned for different periods of time did not differ in either the palatability and appearance of the cake crumb, or in weight loss.

Effect of the Electrical Browning Unit on Cake Batter Containing 140 gms. of Liquid

The researcher was interested in establishing a standard procedure for browning an electronically cooked cake containing 140 gms. of liquid to the proportinate amount of cake mix used in this study through the use of the electrical browning unit installed in the electronic range. This interest resulted in experimenting with a cake batter containing 140 gms. of liquid and the use of the electrical browning unit for 2 minutes 20 seconds, 2 minutes 30 seconds, 2 minutes 40 seconds, and 2 minutes 50 seconds, simultaneously with the microwave energy. The browning unit was used during the latter part of the cooking period. A total of six cakes was cooked in each replication. The crusts were left on all samples for judging.

It was found that an increase of liquid in the batter, 20 gms. per layer, required an increase of 20 to 30 seconds in the browning period to secure a degree of browning similar to that attained in a cake that did not contain the additional liquid. The cake batter containing 140 gms. of liquid required the use of the electrical browning unit for 2 minutes 50 seconds to secure a crust color similar to that of a cake batter containing 120 gms. of liquid and browned for 2 minutes 20 seconds.

The different lengths of time the electrical browning unit was used did not result in significant difference in either the appearance and palatability of the cake crumb, or in weight loss. However, as the browning time was increased, the pattern of browning became more uneven, the surface cracks became broader and deeper, and the surface peaks became more pronounced.

Comparison of Control Cakes

Throughout the study, batters for two identical layers of cake were prepared, one for cooking in the electronic range and one for baking in a conventional electric oven. These layers were used as controls for comparison with the experimental cakes. The data of the entire experiment for these control cakes were statistically analyzed to determine whether the cakes differed in: (1) the scores accorded by the judges for appearance and palatability, (2) the rank preference accorded by the judges, (3) weight change during cooking, and (4) the appearance of the crumb faces.

It was found that the control cake cooked in the electronic range differed significantly from the control cake baked in the conventional electric oven in cell distribution and tenderness.

The conventional oven produced a cake with more uniform cell distribution than the electronic range, and the electronic range produced a more tender cake than the conventional oven. The two methods of cooking produced, according to the judges' scores, no significant differences in either cell size, crumb character, or moisture content of the cakes.

The electronically cooked control cake lost a significantly greater amount of weight during cooking than the conventionally baked cake. This loss indicated that the electronically cooked cake would necessarily be less moist than a conventionally baked cake unless additional liquid was added. This was an important finding since the electronically cooked cake required a cooking period of only $3\frac{1}{2}$ minutes, while the conventionally baked cake required a cooking period of 25 minutes.

The electronically cooked cake was more irregular in surface contour and was higher in volume than the conventionally baked cake.

The conventionally baked cake possessed a characteristic even brown crust color, while the electronically cooked cake remained unbrowned.

II. CONCLUSIONS

From the findings of this study, the researcher concludes that:

(1) An increase in liquid in the batter of an electronically cooked cake produces a cake similar in cell distribution,

moisture content, and volume to a cake baked conventionally. The addition of 40 gms. of liquid per layer results in increased moistness, but produces undesirable tunnels in the cake. The amount of liquid that should be added to the batter would fall within the range of 20 to 40 gms. ($1\frac{1}{2}$ to 3 tablespoons) per layer. The amount would be determined by an individual's choice of superior cell distribution or superior moistness.

(2) The same volume of cake batter may be cooked as a loaf, a layer, or eight cup cakes, in an identical cooking time to produce the same quality of cake crumb. However, the loaf dish does not produce a cake with as desirable surface contour as the other containers.

(3) If a browned cake is preferred, it may be accomplished without sacrificing cake quality. The browning pattern will not equal the even brown secured in conventional baking; however, an unevenly browned cake may be preferred to an unbrowned one. The crust formed during browning will give adequate support to cake frosting and icing.

(4) An increase of liquid in the batter requires an increase in the browning time to secure an acceptable brown crust color. A delay in the use of the electrical browning unit until the cake has completely risen would probably eliminate surface cracks, resulting in a cake more acceptable in appearance.

(5) The electronic range produces a cake more tender and less moist than the cake baked in the conventional oven. The greater loss of moisture in the electronically cooked products

is not easily detected in a fresh product, but would probably be more noticeable in a product after storage.

III. RECOMMENDATIONS

The need for additional study of cake cookery in the electronic range is evident. As a result of the findings of this study, the researcher recommends:

(1) That a study be made of the effect of carry-over heat upon the degree of doneness attained in a cake in an effort to reduce the cooking time of $3\frac{1}{2}$ minutes to minimize the loss of moisture in electronic cake cookery;

(2) That a study be made of delayed browning of cakes cooked electronically by use of the electrical browning unit of the electronic range after the use of the microwave energy in an effort to control surface cracks;

(3) That a study be made of the keeping qualities of electronically cooked cake;

(4) That a score card be developed that has assigned numerical values with intervals of the same size between the score values;

(5) That judges be selected in relation to their ability to readily recognize the different cake qualities; and

(6) That the knowledge of procedures gained in this study be used to develop procedures for cooking other kinds of cakes electronically.

BIBLIOGRAPHY

BIBLIOGRAPHY

A. BOOKS

Kendall, Maurice G., Rank Correlation Methods. New York: Hafner Publishing Company, 1955. pp. 94-106.

Lacey, Oliver L., Statistical Methods in Experimentation. New York: The Macmillan Company, 1953. pp. 132-143.

Ostle, Bernard. Statistics in Research. Ames: The Iowa State College Press, 1954. pp. 344, 454-457.

Snedecor, George W., Statistical Methods. Fourth Edition. Ames: The Iowa State College Press, 1946. pp. 65, 77, 81.

Walker, Helen M. and Joseph Lev., Statistical Inference. New York: Henry Holt and Company, 1953. pp. 278-287.

B. PUBLICATIONS OF THE GOVERNMENT, LEARNED SOCIETIES, AND OTHER ORGANIZATIONS

Corning Glass Works, Home Economics Department, Cooking With the Electronic Range. Corning, New York: Corning Glass Works, 1956.

Hotpoint Home Economics Institute, Hotpoint Electronic Cooking Center Service Manual. Chicago: Hotpoint Company, 1958.

_______, Let's Get Acquainted With Your Hotpoint Electronic Cooking Center. Chicago: Hotpoint Company, (n.d.).

_______, "One Million Years New," Electronic Cooking Center Script For 1958 Regional Use-Value Meetings. Chicago: Hotpoint Company, 1958.

_______, Use-Value Presentation 1958. Chicago: Hotpoint Company, 1957. pp. 69-97.

Kelvinator Institute, Electronic Range Demonstration. /Detroit: American Motors Corporation,/ 1956.

Raytheon Radarange Department, Principles of Microwave Cooking. Waltham, Massachusetts: Raytheon Manufacturing Company, 1958.

The Tappan Stove Company, Appliance Manufacturer, Tappan's Electronic Range. /Mansfield, Ohio: The Tappan Stove Company./ (n.d.).

The Tappan Stove Company, Recipe Card File, Cake Section, Index Card. /Mansfield, Ohio: The Tappan Stove Company./ (n.d.).

_______, What is Microwave Cooking? Mansfield, Ohio: The Tappan Stove Company, 1956.

Westinghouse Electric Corporation, "Home Call" Demonstration for Westinghouse Electronic Range. /Mansfield, Ohio: Westinghouse Electric Corporation./ (n.d.).

_______, 7-Minute Electronic Range Demonstration. Mansfield, Ohio: Westinghouse Electric Corporation, 1957.

_______, The Miracle of SPEED-O-LIGHT Cooking. Mansfield, Ohio: Westinghouse Electric Corporation, (n.d.)

C. BULLETINS

Briant, Alice M., Lola L. Weaver, and Helga E. Skodvin. Quality and Thiamine Retention in Plain and Chocolate Cakes and in Gingerbread, Memoir 332. Ithaca, New York: Cornell University Agricultural Experiment Station, 1954.

Hunter, Mildred B., Alice M. Briant, and Catherine J. Personius, Cake Quality and Batter Structure, Bulletin 860. Ithaca: New York: Cornell University Agricultural Experiment Station, 1950.

D. PERIODICALS

Bollman, Brenner, et al., "Application of Electronic Cooking to Largescale Feeding," Journal of the American Dietetic Association, 24:1041-1048.

Campbell, Carol L., Tung Yu Lin, and Bernard E. Proctor, "Microwave vs. Conventional Cooking," Journal of The American Dietetic Association, 34:365-369, April, 1958.

Chapman, Velma J., et al., "Electronic Cooking of Fresh and Frozen Broccoli," Journal of Home Economics, 52:161-165, March, 1960.

Copson, D. A., "Microwave Energy in Food Procedures," Reprinted from the IRE Transactions of the Professional Group on Medical Electronics, Volume PGME-4, February, 1956.

Copson, David A., Barbara R. Neumann, and Aaron L. Brody, "Browning Methods in Microwave Cooking," Reprinted from the Journal of Agricultural and Food Chemistry, 3:424-427, May, 1955.

Fenton, Faith, "Research on Electronic Cooking," Journal of Home Economics, 49:709-716, November, 1957.

Gordon, Joan and Isabel Noble, "Comparison of Electronic vs. Conventional Cooking of Vegetables," Journal of The American Dietetic Association, 35:3, 241.

Marshall, Nancy, "Electronic Cookery of Top Round of Beef," Journal of Home Economics, 52:31-34, January, 1960.

Noone, Anna A., "Alert Students Now to the Wonders of Electronic Cookery," Forecast for Home Economics, 72:34-37, November, 1956.

Proctor, Bernard E., and Samuel A. Goldblith, "Radar Energy for Rapid Food Cooking and Blanching, and Its Effect on Vitamin Content," Food Technology, 1:95-104, 1948.

Van Zante, Helen J., "Techniques for Electronic Cooking Research," Journal of Home Economics, 51:454-460, June, 1959.

Van Zante, Helen J., and Hisako Nakayama, "The Effect of Microwave Energy on the Internal Temperatures of Agar and Food Cylinders," Journal of Home Economics, 51:170-176, March, 1959.

E. UNPUBLISHED MATERIALS

Corning Glass Works, Home Economics Department, "Electronic or Microwave Cookery--A Peace-Time Application of Radar." [Corning, New York: Corning Glass Works,] (n.d.) (Mimeographed.)

Godwin, Patricia E., and Mary Kathryn Nicholson, "The Effect of Electronic Cooking on a Group of Cup Cakes," Unpublished Special Problem, School of Home Economics, The Woman's College of The University of North Carolina, Greensboro, 1959.

Hinson, Thelma, "Electronic Cookery of Baked Custards," Unpublished Special Problem, School of Home Economics, The Woman's College of The University of North Carolina, Greensboro, 1959.

Street, Madeleine Blakey, "Palatability of Cakes Baked in the Electronic Range," Unpublished Grant-in-aid Project No. 49, Research Council, The Woman's College of The University of North Carolina, Greensboro, 1959.

The Tappan Stove Company, "Operation of the Tappan Electronic Range." Mansfield, Ohio: The Tappan Stove Company, Public Relations Department, News Release, (n.d.) (Mimeographed.)

_______, "Tappan Electronic Range." Mansfield, Ohio: The Tappan Stove Company, Public Relations Department, News Release. (n.d.) (Mimeographed.)

_______, "Tappan Electronic Range Homemaker Bulletin." Mansfield, Ohio: The Tappan Stove Company, May, 1957.

_______, "Tappan Electronic Range Homemaker Bulletin," Bulletin No. 4. Mansfield, Ohio: The Tappan Stove Company, July, 1957.

_______, "Tappan Electronic Range Homemaker Bulletin," Bulletin No. 5. Mansfield, Ohio: The Tappan Stove Company, September, 1957.

The Tappan Stove Company, "The Mighty Conversion in the Tappan Electronic Range." Mansfield, Ohio: The Tappan Stove Company, Public Relations Department, News Release. (n.d.) (Mimeographed.)

Westinghouse Electric Corporation, [Miscellaneous Recipes for the Electronic Range.] [Mansfield, Ohio: Westinghouse Electric Corporation,] (n.d.) (Mimeographed.)

Whirlpool Corporation, "General Guides to Cooking Foods Electronically." [St. Joseph, Michigan: Whirlpool Corporation] (n.d.).

_______, "Basis Information of the RCA Whirlpool Electronic Range." [St. Joseph, Michigan: Whirlpool Corporation,] (n.d.).

Typed by

Mrs. Mary Jane V. Knight