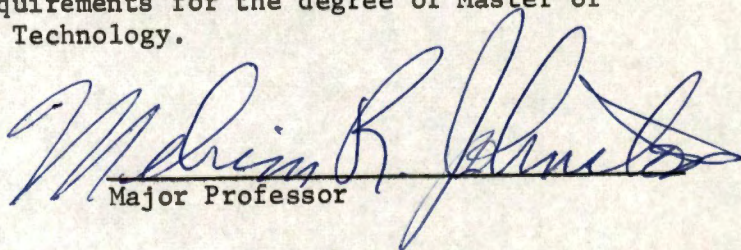


176
CRANES CREST
July 31, 1972

To the Graduate Council:

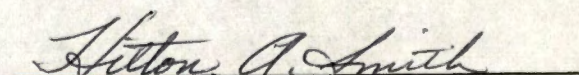
I am submitting herewith a thesis written by Maury Britton Kelly entitled "The Interaction of Thermal Process and Storage On The Quality of Chocolate-Flavored Beverage." I recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Food Technology.


Major Professor

We have read this thesis and
recommend its acceptance:

Curtis C. Melton

Ivan E. McCarty


Vice Chancellor for
Graduate Studies and Research

THE INTERACTION OF THERMAL PROCESS AND STORAGE ON THE
QUALITY OF CHOCOLATE-FLAVORED BEVERAGES

A Thesis

Presented to
the Graduate Council of
The University of Tennessee

In Partial Fulfillment
of the Requirements for the Degree
Master of Science

by
Maury Britton Kelly
August 1972

ACKNOWLEDGMENT

The author is sincerely grateful to Dr. M. R. Johnston, Major Professor, Professor I. E. McCarty, and Dr. Jimmy L. Collins of the Food Technology Department for their invaluable guidance and assistance throughout the entire graduate program and in the preparation of this thesis.

A sincere thanks is extended to Dr. J. O. Mundt, Professor of Food Microbiology, for his assistance in conducting the microbiological aspects of this experiment and to Dr. C. C. Melton of the Animal Husbandry-Veterinary Science Department who served on the graduate committee. Thanks also to Mr. Louis A. Enhema, President, Universal Flavor Corporation for his interest and support in conducting the experiment.

Appreciation is due the State of Alabama, Department of Health, for financial assistance and, particularly, Mr. G. R. Wright, Director of the Division of Inspection of the Bureau of Environmental Health, for his support and encouragement.

Finally, a special thanks is expressed to the author's wife, Thelia, for her confidence and reassurance throughout the year.

ABSTRACT

This research project was designed to evaluate the effects on chocolate-flavored drink of two thermal processes and subsequent storage at three different temperatures. Each process was conducted in both still and rotating retorts.

Process A was designed to approximate a conventional process using an initial temperature (IT) of 150°F, a retort temperature (RT) of 248°F, and a holding time (B_p) of 20 minutes. The samples in this process received no supplemental cooling.

Process B was calculated to produce a sterilizing value of eleven ($F_0 = 11$). An initial temperature (IT) of 170°F, a retort temperature (RT) of 245°F, and a holding time (B_p) of 37 minutes were used. This process also incorporated a cooling cycle.

Samples from both processes were stored at 10°C, 33°C, and 55°C with evaluations being made at the end of 24 hours, 7 days, and 14 days. Samples from both processes were subjected to microbiological analyses as well as to evaluations of pH, color, soluble solids, vacuum, and taste.

In this experiment both processes yielded a product that was free of microbial contaminants. The factors of pH and color were affected according to the severity of the thermal processes. The pH values decreased with increases in storage temperature and/or time.

TABLE OF CONTENTS

CHAPTER	PAGE
I. INTRODUCTION	1
II. REVIEW OF THE LITERATURE	5
Thermal Processing	5
Microbiological Considerations of Thermal	
Processing	6
Thermal Death Time Curves	8
Heat Penetration Curves	9
Process Calculations	9
Physical Plant and Equipment Requirements	10
Quality Control and Sanitary Practices	11
Effects of Heat on the Physical and Chemical	
Properties of Food	12
Significance of Vacuum in Canned Products	13
Cooling and Storage of Canned Foods	14
III. MATERIALS AND METHODS	15
Materials	15
Methods	16
IV. EXPERIMENTAL RESULTS	21
Bacteria	21
pH	21
Color	23

CHAPTER	PAGE
Soluble Solids	23
Vacuum	27
Taste	27
V. DISCUSSION	30
VI. SUMMARY	36
BIBLIOGRAPHY	38
APPENDIX	43
VITA	52

LIST OF TABLES

TABLE		PAGE
I.	Effects of Thermal Processing on pH of Chocolate	
	Drink After 24 Hours Storage at 10°C	22
II.	Effects of Storage Time and Temperatures on pH	
	Values of Chocolate Drink	24
III.	Effects of Storage Times and Temperatures on	
	Color Values of Chocolate Drink	25
IV.	Effects of Storage Times and Temperatures on	
	Soluble Solids of Chocolate Drink	26
V.	Effects of Storage Temperatures on Vacuum in	
	Containers of Chocolate Drink	28
VI.	Results of Triangle Taste Test Evaluations	29
VII.	pH of Chocolate Drink After 24 Hours and After	
	14 Days of Storage at 10°C, 33°C, and 55°C	44
VIII.	Color Measurement of Chocolate Drink After 24 Hours	
	of Storage at Ambient Temperature	46
IX.	Color Measurement of Chocolate Drink After 14 Days	
	Storage at 10°C, 33°C, and 55°C	47
X.	Soluble Solids of Chocolate Drink After 24 Hours	
	and After 14 Days of Storage at 10°C, 33°C, and 55°C . .	49
XI.	Vacuum of Container of Chocolate Drink Samples	
	After 24 Hours Storage and After 14 Days Storage	
	at 10°C, 33°C, and 55°C	51

CHAPTER I

INTRODUCTION

"Sterilized" chocolate-flavored drink is processed and marketed throughout the United States. This product is consumed as a refreshment item, but it has not enjoyed the wide range of acceptance as has the more popular carbonated beverages. Pasteurized chocolate-flavored milk is the chocolate beverage most preferred by consumers.

"Sterilized" chocolate-flavored drink in crown-capped glass containers is processed by subjecting the sealed containers to temperatures of 240°F-245°F for 18-20 minutes in either still or rotating horizontal retorts. This has been the conventional process used in the Southeast United States.

Processors have experienced spoilage problems in varying degrees. The incidence of spoilage increases during the summer months when storage temperatures are elevated. This spoilage has been generally attributed to high initial bacterial spore counts in the raw ingredients, questionable sanitary practices during processing, inadequate heat treatment, and high storage temperatures.

Public health officials have placed significance upon spoilage as this indicates the survival of heat resistant spores which might include spores of the pathogenic organism, *Clostridium botulinum*.

"Sterilized" chocolate drink processors have exerted little effort to establish standards for ingredients and have inadequate (if any)

laboratory facilities for examining either raw ingredients or finished products. Equipment used for mixing, pumping, and filling are questionable as food contact surfaces. Many of the bottle fillers are designed for carbonated beverage products and are not easily disassembled for proper cleaning and sanitizing which are extremely important in the processing of milk products. The general assumption of "sterilized" chocolate drink processors has been that all organisms are destroyed during the heat process.

The heat process used by chocolate drink manufacturers consists of filling the retort with cased and palletized bottles of product and bringing the retort to prescribed pressure and corresponding temperature and maintaining this condition for 18-20 minutes. This is accomplished by manual manipulation of the controls. Very few, if any, processors have incorporated automatic temperature and pressure controlling and recording devices. Indicating thermometers and pressure gauges are the solitary source of information pertaining to the functions of the retorts. These instruments are rarely, if ever, calibrated for accuracy.

Federal, state, and local regulatory agencies have contributed very little towards the elimination of the possibilities of contamination and the ultimate destruction of microorganisms that may be present at the time of processing.

Aaron (1)* indicated that, while a reduced process time might be sufficient for products with a minimal initial spore count, this same

*The numbers in parentheses represent similarly numbered references in the Bibliography.

process would not be sufficient for products with higher initial spore counts. Due to the fact that no control measures have been exercised on raw ingredients and that sanitation practices have been questionable, extended heat process times have been suggested (27). The extended process time exerts a logarithmic lethality rate upon the organisms present.

Extended process times, while reducing the possibilities of microbial spoilage, tend to bring about certain undesirable chemical and physical changes. Processors have been hesitant to adopt the extended process times as this would slow down the production rate as well as result in a product which would be somewhat less appealing in appearance. A rapid-cool technique has also been suggested as a means of reducing spoilage but has also failed to be adopted due, primarily, to economic reasons.

This research project was designed to evaluate the effects of two different process times and three different storage temperatures on chocolate drink. Process A was designed to approximate a conventional process. This process consisted of a heat treatment of 20 minutes at a retort temperature of 248°F with no supplemental cooling procedure. Process B was calculated to produce a sterilizing value of eleven ($F_0 = 11$) and incorporated a rapid cool procedure.

Microbiological tests were conducted to detect the survival of heat resistant organisms or postprocessing contamination. Evaluations of pH, color, Brix, vacuum, and taste were made.

This research was conducted with the idea that the resulting data might be of some value to the chocolate drink industry, regulatory agencies, and others interested in thermal processing of chocolate-flavored drink.



CHAPTER II

REVIEW OF THE LITERATURE

1. THERMAL PROCESSING

Nicholas Appert is recognized as the originator of thermal processing or, as he called it, the art of "Appertizing." Appert was born in Chalon-sur-Maine, France, in 1750. He began working in food areas at an early age and in 1810 published his book, The Art of Preserving Animal and Vegetable Substances For Many Years (5).

"Appertizing" consisted of heating foods in a sealed container in what Appert called a "water bath." The foods remained preserved as long as the seal was not broken. Appert observed that prior to his discoveries the only methods for preserving foods were drying, salting, pickling, or fermenting all of which altered the appearance, texture, and flavor of the food items (5).

Appert's discoveries were made without knowledge of the fact that bacteria, molds, and yeast were causative agents of spoilage. Appert (5) stated that "the absolute deprivation from exterior air (that which is found in the interior need not cause anxiety because it has been rendered harmless by the action of the heat) and application of the heat in the water-bath are indispensable to each other for the perfect preservation of foods."

Chevalier-Appert invented the autoclave in 1851. This device enabled processors to reach higher temperatures with less danger of

explosion. It had been observed that certain foods could be processed for shorter periods if the temperature was increased. These shorter process times facilitated greater production by the food processing industry (19).

The pressure steam retort was invented in 1874 by Shriver (20). The retort was equipped with pressure control valves which enabled processors to regulate the steam pressure and corresponding temperatures.

Many improvements have been made in the types of equipment used for thermal processing. Shriver's retort was not equipped to agitate the product while heating. This invention came some ten years later and further reduced the come-up time as well as the degradation effect of heat on the product.

Another development has been the adoption of aseptic fill methods for products that are degraded in aesthetic quality by extended thermal processing. Aseptic fill procedures consist of heating the materials to much higher temperatures in a matter of seconds and immediately reducing the temperature to optimum storage levels. The product is then introduced into sterile containers and sealed (6, 20, 28).

2. MICROBIOLOGICAL CONSIDERATIONS OF THERMAL PROCESSING

Today, more than one hundred years after Pasteur's identification of microscopic organisms as the agent of food spoilage, processors continue to experience problems in controlling them. Microorganisms responsible for food spoilage have been generally recognized as yeast,

molds, and bacteria. The canning industry has been chiefly concerned with controlling or destroying bacteria, as yeast and molds are particularly susceptible to heat (9, 20).

Bacteria have been categorized according to (1) their particular requirements for growth, (2) their ability to cause illness or death to man, and (3) their ability to withstand adverse conditions by sporulation. Bacteria in the vegetative form are more easily controlled or destroyed than the spore forms of those bacteria capable of sporulation. The spores of thermophilic bacteria are the most heat resistant (20, 23, 30, 39). Canners have based their calculations of times and temperatures for "commercially sterile" products on the destruction of these heat-resistant spores. "Commercially sterile" is a term which applies to products that have received sufficient heat to cause them to be practically sterile. Spores of flat sour organisms might survive the process. These organisms are controlled by storing the product at temperatures below 95°F (13, 14, 23, 39).

Frazier (23) gives the following examples of thermal death times for bacterial spores:

<u>Spores of</u>	<u>Time (minutes) to kill at 100°C</u>
Bacillus anthracis	1.7
Bacillus subtilis	15-20
Clostridium botulinum	100-330
Clostridium calidotalerans	520
Flat sour bacteria	Over 1,030

Clostridium botulinum, a toxin producing, spore forming, anaerobe, has received particular attention from public health authorities due to the lethality of the toxin. Optimum conditions for the vegetative form of this organism exist in low acid "canned" food items. All "canned" products having a pH above 4.5 must be subjected to a "botch cook." A "botch cook" implies a heat treatment sufficient to reduce 10^{12} spores per milliliter to one spore per milliliter (11, 20, 23, 39).

3. THERMAL DEATH TIME CURVES

Bacteriologists associated with the canning industry have been charged with the task of determining the heat resistance of bacterial spores. Knowledge as to the degree of heat which must be applied to effect the destruction of certain bacterial types or their spores is absolutely necessary for canners.

"Thermal death time" curves have been established by subjecting a large number of tubes, with known spore populations suspended in a favorable media, to an experimental temperature. Tubes are withdrawn in groups at specified time intervals and immediately cooled. The contents of the tubes are then subjected to laboratory analysis to detect the survival of spores. The time and temperature combination at which no viable spores are observed has been termed "thermal death time." This same procedure, performed at varying temperatures, has indicated that the higher the temperature the shorter the time required to effect destruction. This time-temperature relationship is called the "thermal death time curve."

"Thermal death time" curves must be established for each type, variety, and strain of organism and for each suspension media encountered by the canning industry (23).

4. HEAT PENETRATION CURVES

All process time calculations are dependent upon the heating characteristics of the product and its container. This characteristic is measured by inserting thermocouples (by means of a stuffing box) at the "cold point" (last to reach retort temperature) of a series of containers. The thermocouples are connected to a potentiometer which is equipped with a selector switch. This equipment facilitates the recording of the temperatures of the series of cans, at specified intervals (one minute), until retort temperature has been reached by all. Data from the container exhibiting the slowest heat penetration is used as a safety measure and, when plotted, represents a "heat penetration" curve.

Heat penetration curves must be established for each product, formula, or style of pack and for each type of container (12, 22, 24).

5. PROCESS CALCULATIONS

The calculation of total process times, using data from "thermal death times" and "heat penetration curves," may be made by one of three methods. These methods are:

1. The graphical method, or the method of Bigelow (13)
2. The formula method, or the method of Ball (3, 7, 9)

3. The nomagram method, or the method of Olson, Stevens, and Roberts (32).

Complete and detailed information and instructions for process calculations may be found in the American Can Company publication, Calculation of Processes for Canned Foods, published in 1952 (4).

6. PHYSICAL PLANT AND EQUIPMENT REQUIREMENTS

Conscientious commercial food processors have long recognized the importance of properly designed and constructed buildings and equipment. All facilities should provide for the most efficient function and flow of personnel and product. Economic losses from breakage, spillage, and microbial spoilage have been substantially reduced when adequate, properly constructed facilities are provided.

Buildings should be properly constructed of durable, impervious, and easily cleaned materials. Adequate ventilation and lighting are important factors in controlling the atmosphere for food processing and handling.

Food contact surfaces of equipment should be constructed of noncorrosive, impervious, and durable materials and should be designed for ease of cleaning and sanitizing (17, 43).

The ultimate destruction of existing organisms in the sealed container of food products is accomplished in the retort. The proper functioning of this piece of equipment is critical in the production of "commercially sterile" products.

Steam, water, and, in some cases, pressurized air must be introduced at strategic points. The source for each of these must be adequate to complete the process. Vents and bleeders must be provided and located so as to insure the proper distribution of heat. Indicating thermometers and pressure gauges must be properly installed and calibrated periodically. Temperature and pressure recording and controlling devices are essential in providing records on each batch of the product (17, 31, 32).

Excellent detailed information on retort equipment operation has been published by The Canning Trade, Inc., under the title, A Complete Course in Canning, ninth Edition, 1969 (17).

7. QUALITY CONTROL AND SANITARY PRACTICES

Quality control procedures begin with assimilation of raw ingredients. These raw ingredients, when received by the food processor, contain varying degrees of microbial contaminants. It is essential that standards be established to minimize initial contamination.

Sanitary practices should be incorporated into the operating procedures to preclude further contamination of formulated products (16, 20, 23, 24, 40, 41).

Laboratory facilities for examining samples and sampling schedules and procedures should be provided. Critical control points should be recognized and samples taken from these points.

Samples of processed items should be incubated at optimum temperatures (37°C-55°C) for growth of any spoilage organisms that may

have survived the process or gained entrance after processing. Data from these analyses are most beneficial in determining the critical control points for reducing microbial populations (10, 15, 40).

Microbial spoilage of processed foods might be attributed to either postprocess contamination or underprocessing. Spoilage due to underprocessing results from a malfunction of the retort, the retort operator, or inordinately high initial bacterial populations. If sporeformers are detected in spoiled samples, underprocessing is suspected. The identification of nonsporeformers as the agent of spoilage indicates postprocess contamination.

8. EFFECTS OF HEAT ON THE PHYSICAL AND CHEMICAL PROPERTIES OF FOOD

The sterilizing process required for low-acid (above pH 4.5) foods causes an adverse effect upon the aesthetic quality of many products. The canning industry has sponsored much research aimed at solving this problem. It has been established that equivalent sterilizing values at higher temperatures tend to reduce the ill effects while exerting a logarithmic lethality on microbial populations. Ball (6) states that "For production of retort-processed foods having color and flavor which are most nearly like those of home-cooked foods, retort operation must be such that (1) every container receives the same treatment, (2) the retort is heated rapidly to its holding temperature, and (3) the containers are cooled rapidly."

Milk, when sterilized, might undergo several undesirable changes.

Some of these changes are listed below:

1. Development of a characteristic "boiled" odor and taste
2. Darker color
3. Precipitation of calcium and phosphorus
4. Coagulation
5. Increased acidity--lactic acid.

Davies (19) discusses each of these factors in his book, The Chemistry of Milk.

9. SIGNIFICANCE OF VACUUM IN CANNED PRODUCTS

The benefits of vacuum in commercially canned products are varied. The removal of oxygen is important to processors of products that are subject to oxidation degradation. The growth of aerobic bacteria is inhibited by the absence of oxygen. The absence of oxygen is most important in metal containers where redox reactions are possible (3, 9, 20, 40).

Physically, a vacuum is beneficial in that it holds seals in place, holds can ends in a concave position, and reduces internal pressure during processing (20). In processing operations, where head space and temperature at instant of sealing are fairly constant, the average vacuum at normal storage temperatures may be predicted. Deviations from this norm might indicate either improper seal or internal gas production.

10. COOLING AND STORAGE OF CANNED FOODS

Viable spores of thermophilic organisms might survive a heat treatment. If canned products are not cooled and stored at temperatures below optimum for thermophilic growth, spoilage may occur. If the product is rendered sterile by the heat process, it might still be subject to spoilage resulting from chemical changes. Chemical changes which are accelerated by heat may be minimized by supplemental cooling procedures following the completion of the thermal process. Products packed in metal containers present few problems when cooling procedures are incorporated (17, 20).

Products packed in glass containers require numerous considerations if supplemental cooling is to be used. The retort must be especially equipped to maintain a constant pressure with air upon completion of the thermal process and throughout the cooling cycle. The retort must be equipped to allow the introduction of cooling water at strategic points within the retort. A large volume of water is required in this process and considerations must be made for recovery of this water.

CHAPTER III

MATERIALS AND METHODS

1. MATERIALS

Twenty pounds of dry chocolate base mix was obtained from Mays Beverage Company, Atlanta, Georgia. This base mix was composed of non-fat dry milk, cocoa, salt, carrageenan, and vanillin.

Directions accompanying the mix stated that the twenty pounds of mix was to be combined with 42.18 gallons of water and 4.18 gallons of syrup (sugar). Four gallons of syrup was obtained from Kern's Bakery, Knoxville, Tennessee.

Seven cases of ten-ounce bottles (24 bottles per case) and sufficient caps were obtained from the Royal Crown Bottling Company, Knoxville, Tennessee.

Equipment used in formulating and processing the chocolate drink for this experiment consisted of the following:

1. Autoclave--for sterilizing bottles and caps
2. Steam-jacketed kettle--for mixing and heating product
3. Agitator--to facilitate mixing
4. Sanitary, flow controlled pump--for transferring product from kettle to bottles
5. Bottle sealer
6. Retorts (still and rotating)--for conducting the thermal processes.

The vertical (still) retort used in this experiment was provided by the University of Tennessee. This retort was well equipped with the necessities for conducting and controlling thermal processes, but it was not equipped to provide agitation.

The agitating retort which was used was located at the Universal Flavor Corporation plant in Bensenville, Illinois.

The equipment used to evaluate and analyze factors of pH, color, soluble solids, and vacuum was as follows:

1. pH--Ionalyzer, Orion Research, Model 801/digital pH
2. Color--Hunterlab Model D25D2M
3. Soluble solids--Busch and Lomb Refractometer, Type 33-45-56
4. Vacuum--Pressure vacuum gauge.

Laboratory facilities for conducting microbiological analyses of raw materials and finished product were provided by the University of Tennessee.

2. METHODS

Four thermal processes were used in conducting this experiment. The experimental processes were assigned symbols for convenience in recording and reporting data. The processes will subsequently be referred to by the following symbols:

- A(s) = Process A, still retort.
- A(r) = Process A, rotating retort.
- B(s) = Process B, still retort
- B(r) = Process B, rotating retort.

Process A was designed to approximate a conventional method for processing chocolate-flavored beverage in both still [A(s)] and rotating [A(r)] retorts. A retort temperature (RT) of 248°F, a process time (B_p) of 20 minutes, and an initial temperature (IT) of 150°F were used. In process A(r) the rotating rate was 6 rpm.

Process B was designed to effect a sterilizing value (F_0) of eleven (27) and was also performed in both still [B(s)] and rotating [B(r)] retorts. An initial temperature (IT) of 170°F and a retort temperature (RT) of 245°F were chosen. The holding time (B_p) was calculated to be 37 minutes. These calculations were made using heat penetration data for chocolate-flavored beverage in ten-ounce glass containers established by Aaron (1). Aaron reported a j [lag factor] value of 1.75 and f_h [heating curve slope] of ten minutes. Process B also incorporated a cooling procedure. This procedure called for the submerging of the glass containers in water during the process and maintaining exterior pressure on the bottles within the retort during the cooling cycle.

All processes contained the same ingredient formulation. A separate batch was formulated for each process. A batch consisted of 90 bottles. Each process required three sub-batches consisting of 30 ten-ounce bottles.

Bottles and caps used in this experiment were sterilized by autoclaving them for 20 minutes at 245°F. All product contact surfaces of equipment were cleaned and chemically sanitized prior to each use.

Each batch was formulated by combining the ingredients in the correct proportions following supplier's directions. The temperature of the water used in the mixture was 135°F. The ingredients were thoroughly blended by agitation.

No adjustments for fill temperature were made for processes A(s) and A(r). The fill temperatures for B(s) and B(r) were adjusted by heating the mix to 200°F in the steam-jacketed kettle and filling immediately into bottles.

Sub-batches for all four processes were handled in the same manner. This consisted of filling 90 bottles with the chocolate drink which had been mixed according to supplier's directions. Sixty (two sub-batches) of these bottles were immediately placed in a cooler for subsequent processing. Thirty bottles (one sub-batch) were placed in a water bath to adjust for initial temperature. When the designated initial temperature was attained, the bottles were immediately placed in a retort and the thermal processes were conducted.

The rapid cool procedure used in processes B(s) and B(r) consisted of (1) turning off the steam at the end of the holding time, (2) maintaining 15 pounds of pressure within the retort with air pressure, and (3) introducing cooling water at a slow but constant rate. When the temperature of the water within the retort was reduced to 140°F, the air pressure was relieved and the rate of cooling was speeded by increasing the cooling water flow. In the still retort, the cooling cycle required 50 minutes to complete; this time was reduced to 20 minutes in the rotating retort.

Three samples from each sub-batch were held at ambient temperature for color evaluations. Nine samples from each sub-batch were placed in 10°C, 33°C, and 55°C incubation, respectively.

The samples held at ambient temperature were evaluated for color and pH 24 hours after processing.

One sample of each sub-batch held at 10°C was analyzed for microbial survival 24 hours after processing. These samples were also evaluated for pH, color, Brix, and vacuum. The procedure for the microbiological analyses consisted of preparing duplicate culture tubes of sodium thioglycollate and dextrose broth for detecting anaerobes and tryptic soy broth for detecting aerobes. Tubes were incubated at both 33°C and at 55°C to provide optimum growth temperatures for both mesophilic and thermophilic organisms. These tubes were observed for seven days to allow time for recovery of damaged spores.

Seven days after processing, three samples from each sub-batch which had been incubated at 33°C and 55°C were subjected to microbial analyses. The procedure was identical to the procedure previously explained. These samples were also evaluated for pH, color, Brix, and vacuum.

Fourteen days after processing, three samples from each sub-batch which had been held at 10°C, 33°C, and 55°C were evaluated for pH, color, Brix, and vacuum.

The remaining samples which were held at 10°C were later subjected to taste panel evaluations. A triangle taste test was used to compare

the experimentally produced product to a commercially produced product. In this type test, tasters are presented three samples. Two of these samples are identical, and tasters are asked to identify the odd sample. Panelists were also asked to comment on factors of caramelization and mouth feel of the products.



CHAPTER IV

EXPERIMENTAL RESULTS

1. BACTERIA

Microbiological analyses of the chocolate drink samples revealed no surviving endospores and were deemed sterile. One sample from process B(r) spoiled after 20 days of incubation at 33°C. The agent of spoilage was identified, by the use of subculture techniques, as *Streptococcus faecalis*. This is a nonspore forming bacteria; therefore, its presence indicates postprocess contamination.

2. pH

The pH value of the chocolate drink decreased during the thermal process. The extent of this decline varied with the severity of the process.

The data in Table I shows the effect of the four processes on the pH value of the raw mix.

Storage temperatures had a direct effect on the pH value of the processed chocolate drink. At a storage temperature of 10°C the pH value was not affected. Samples stored at 33°C exhibited a gradual decline in the pH value over the 14-day period. The rate of decline in pH value increased at the 55°C storage temperature.

TABLE I
EFFECTS OF THERMAL PROCESSING ON pH OF CHOCOLATE DRINK
AFTER 24 HOURS STORAGE AT 10°C

¹ pH of Raw Mix	² A(s)	³ A(r)	² B(s)	³ B(r)
6.7	*6.16	*6.37	*6.14	*6.26

¹Value denotes the mean of 4 observations.

²Value denotes the mean of 9 observations.

³Value denotes the mean of 6 observations.

* Indicates that values are significantly different from pH values of raw mix at the 0.05 level of probability.

The effects of storage at 10°C, 33°C, and 55°C for 14 days on the pH values of chocolate drink which has been subjected to the four thermal processes are shown in Table II.

3. COLOR

The Hunter color values obtained in this experiment show that the chocolate drink darkened as the factors of heat and time of processing were increased. The initial color of the processed chocolate drink was established by allowing samples from each sub-batch to stand at ambient temperature for 24 hours and then subjecting them to color analysis.

Samples of processed chocolate drink were stored at 10°C, 33°C, and 55°C for 14 days and were again subjected to color evaluation. Results from this evaluation were erratic, as shown in Table III. Color values from samples stored at 33°C for 14 days indicate a color lighter than the initial color or those stored at 10°C and 55°C.

4. SOLUBLE SOLIDS

The soluble solids concentrations, expressed as °Brix, remained constant for all processes and throughout storage at all temperatures. Slight discrepancies in °Brix values, as shown in Table IV, may be attributed to human error in formulating the product and to interpolation of instrument readings.

TABLE II
EFFECTS OF STORAGE TIME AND TEMPERATURES ON pH VALUES
OF CHOCOLATE DRINK

	Process			
	A(s)	A(r)	B(s)	B(r)
Initial pH	^a 6.17	6.38	6.15	6.26
10°C, 14 days	6.15	6.38	6.13	6.26
33°C, 14 days	6.11*	6.33*	5.86*	6.19*
55°C, 14 days	5.87*	6.12*	5.59*	6.06*

^aValues denote a mean of 6 observations.

* Indicates that values are significantly different from initial pH values at the 0.05 level of probability.

TABLE III
EFFECTS OF STORAGE TIMES AND TEMPERATURES ON COLOR VALUES*
OF CHOCOLATE DRINK

	Process											
	$^1A(s)$			$^2A(r)$			$^1B(s)$			$^2B(r)$		
	L	a	b	L	a	b	L	a	b	L	a	b
Initial Color Values	34.60	8.18	12.63	37.01	8.73	13.06	33.66	9.00	13.80	36.99	9.20	13.15
10°C-14 Days	33.58	8.99	13.77	36.92	9.17	13.10	33.58	8.99	13.77	36.92	9.17	13.10
33°C-14 Days	37.68	8.25	13.80	37.34	8.77	13.40	35.44	8.91	14.31	38.63	9.07	13.29
55°C-14 Days	36.38	8.21	14.06	37.73	8.99	14.40	32.77	9.68	14.18	33.74	10.00	13.42

* All values are (+) positive (a indicating redness and b indicating yellowness).

^{1} Values denote a mean of 9 observations.

^{2} Values denote a mean of 6 observations.

TABLE IV
EFFECTS OF STORAGE TIMES AND TEMPERATURES ON
SOLUBLE SOLIDS OF CHOCOLATE DRINK*

	Process			
	¹ A(s)	² A(r)	¹ B(s)	² B(r)
	<u>24 Hours</u>			
10°C	12.74	12.83	12.69	12.90
	<u>14 Days</u>			
10°C	12.75	12.63	12.73	12.90
33°C	12.79	12.82	12.79	12.86
55°C	12.77	12.82	12.83	12.76

*All values denote °Brix of chocolate drink.

¹Values denote a mean of 9 observations.

²Values denote a mean of 6 observations.

5. VACUUM

The extent of vacuum found in the chocolate drink containers varied with the temperature at the instant of sealing, as shown in Table V. Laboratory methods for this procedure would not permit an accurate standardization for sealing temperature; therefore, the vacuum readings were not consistent. However, vacuum readings for each process did correspond with estimated temperatures at the instant of sealing. The temperature at instant of sealing for Process B(s) ranged from 170°F-180°F, resulting in a higher vacuum for this process.

6. TASTE

Results from the taste panel evaluations (triangle taste test) indicated that experimental samples were significantly different from commercial samples with which they were compared. Data from the taste panel is presented in Table VI. Comments from panelists pertaining to caramelization and mouth feel indicated that the experimental processes B(s) and B(r) had a slightly more cooked taste, but caramelization could not be defined; neither could a difference in mouth feel be defined.

TABLE V
EFFECTS OF STORAGE TEMPERATURES ON VACUUM IN
CONTAINERS OF CHOCOLATE DRINK*

	Process			
	¹ A(s)	² A(r)	¹ B(s)	² B(r)
	<u>24 Hours</u>			
10°C	6.1	6.3	11.16	7.5
	<u>14 Days</u>			
10°C	6.3	5.8	11.2	8.0
33°C	1.5	4.6	10.4	6.1
55°C	.1	3.5	8.9	6.2

*Each value denotes inches of mercury.

¹Values denote a mean of 9 observations.

²Values denote a mean of 6 observations.

TABLE VI
RESULTS OF TRIANGLE TASTE TEST EVALUATIONS

Process	^a Number of Responses	Number of Correct Choices
A(s)	24	^b ₁₈
A(r)	24	^b ₂₀
B(s)	24	^b ₂₃
B(r)	24	^b ₂₃

^aEvaluations were performed twice for each process.

^bSignificant at the 0.1 percent level.

CHAPTER V

DISCUSSION

The goal of all food processing enterprises is to produce products that are free of health hazards, palatable, appealing, and in most cases nutritious. These goals must be accomplished at minimal cost. Losses resulting from spillage, breakage, and spoilage can quickly reduce profits. The purchase of one spoiled product usually constitutes the loss of that customer, as well as many of his friends, for future sales. An incident of food borne disease or food poisoning can quickly decimate an entire industry as was recently evidenced in the canned soup industry.

Public health officials are charged with the responsibility of protecting the health of consumers. The magnitude of this assignment cannot be exaggerated. Millions of tons of foods are processed and consumed annually.

Records show that commercially produced canned food items have been responsible in only a very few incidences of food poisoning. This excellent record might be attributed to the conscientious efforts of responsible industries to protect the consumer. There are a few industries, however, who do not fully utilize the scientific and technological information for producing "commercially sterile" foods even though that information is available.

In establishing a "standard cook" or process for any given product, it is necessary to identify the most heat resistant organism

normally found in that product. A "standard cook" is also based on a maximum initial spore population. Laboratory analysis of raw ingredients facilitates the development of standards for these ingredients.

Times and temperatures established for a particular product are merely figures. The actual attainment of these figures is accomplished only in properly operating retorts. To insure the proper operation of a retort, it must be well equipped with vents, bleeders, and indicating and recording thermometers and pressure gauges. The steam capacity must be sufficient to quickly attain holding temperature and to maintain that temperature throughout the holding period.

Supplemental cooling upon completion of the process time is necessary to prevent spoilage by thermophilic organisms and to prevent other detrimental effects of heat, such as chemical changes. The shelf life of a product is greatly enhanced by rapid cooling and storing at favorable temperatures. Lower storage temperatures retard or inhibit chemical changes which tend to produce off odors, taste, and colors.

During this experiment it was observed that the product temperature of the processes which did not incorporate a supplemental cooling procedure [A(s) and A(r)] was 185°F one hour after removal from the retort. Two hours after removal the temperature was 160°F. The ambient room temperature was 80°F and a fan was creating some movement of air. This observation was made on a single case (24 bottles) of bottled product which was sitting alone on a table. There were no restrictions on the movement of air.

Industry is confronted with the problem of allowing the product to cool at ambient warehouse temperatures while stored in the cased and palletized state. This greatly increases the time required for cooling. The product may require as long as 24 hours to cool to a temperature of 100°F or less. The events of spoilage usually occur during this 24-hour period.

Processes B(s) and B(r) were cooled in the retort to a temperature of 80°F. This was accomplished in 50 minutes.

Products stored at 55°C for this experiment clearly illustrate the degradation effects of high temperature storage. The continual drop in the pH values was indicative of chemical change which was accelerated at higher temperatures. Products stored at this temperature were not presented to the taste panel for evaluation; however, the author tasted several of the samples and an off odor and taste were evident.

This decrease in pH value indicates increased acidity possibly due to the precipitation of calcium and phosphorus (19). These elements become insoluble at higher temperatures and precipitate out. When precipitation occurs, hydrogen ions are liberated.

Chocolate drink subjected to extended heat processing [Processes B(s) and B(r)] was darker in color, but the difference was not of sufficient magnitude to degrade the consumer appeal of the product.

The primary source of soluble solids in chocolate drink is the sugar that is added for flavor. The level of soluble solids was not affected by either heat process or by the experimental storage factors.

When chocolate drink is processed in glass containers, it is essential that sufficient vacuum be attained to prevent internal pressure during the thermal process. Caps or seals are held in place by vacuum, and a proper seal is necessary to prevent postprocess contamination. The single sample that spoiled in this experiment was first checked for vacuum. This test revealed that neither vacuum nor pressure existed. This sample was from process B(r) and had been stored at 33°C. Other samples from this process had a mean vacuum of 6 inches of mercury when stored at 33°C. The absence of vacuum indicated either internal gas production or the entrance of air via the seal. The agent of spoilage was identified as *Streptococcus faecalis*, a nonspore former whose presence indicates postprocess contamination.

Test procedures of this type could be of great value to industry in attempting to identify causative agents of spoilage. The identification of spoilage agents is essential in establishing critical control points in the processing and storing procedures of the chocolate drink industry.

Comments from taste panelists in this experiment indicated that the experimentally produced chocolate drink had a more cooked flavor than the commercial samples with which it was compared. Panelists also indicated that a difference in mouth feel or viscosity was difficult to detect. The experimentally produced chocolate drink was not found to be objectionable and, in some instances, was preferred. Results from the taste panel evaluation indicated that extended process times might be adopted without affecting the consumer appeal of the product.

In this experiment efforts were made to provide ideal conditions for formulating and processing the chocolate drink. Bacteriological examinations were performed on the dry base mix and the syrup (sugar). The sample of dry mix had a standard plate count of 1,000 per gram and the syrup 15 per gram. These counts were used to indicate the degree of contamination but do not reveal thermophilic spore counts which might have been present.

All bottles and caps were sterilized prior to filling and capping, and all product contact surfaces were cleaned and sanitized. The entire processing operation was conducted with meticulous attention to sanitation.

The fact that both the conventional process and the experimental process yielded a product free of microbial contaminants may be attributed to (1) low initial spore counts in the raw ingredients, (2) very little microbial contribution during formulation, filling, and capping, and (3) properly operating retorts.

In view of the fact that the conventional process in this experiment produced a commercially sterile product and considering the economic factors involved in extending process times and rapid cool procedures, the author can only conclude that when conditions are equivalent to those in this experiment, the conventional process is more economical for chocolate drink processors. To insure that these conditions are met, industry must provide adequately equipped and staffed laboratories for evaluating ingredients and finished products.

Equipment for formulating and processing must be properly designed and operated. A program of plant sanitation must be incorporated into the operating procedure.

Cooling and storing are important factors in maintaining chocolate drink at its optimum quality level. Heat has been proven to be detrimental to product quality. Chocolate drink, as it is conventionally handled, is susceptible to both microbial (thermophilic) and chemical spoilage. The adoption of rapid cool procedures for glass containers might prove to be economically unfeasible. A transition to the use of 12-ounce metal containers could help solve this problem.



CHAPTER VI

SUMMARY

This experiment was designed to evaluate the sterilizing and the degradation effects of two thermal processes on chocolate-flavored drink. One of the processes was designed to approximate a conventional process in regards to retort temperature and holding time. The other treatment was designed to provide a sterilizing value of eleven ($F_0 = 11$). This sterilizing value has been recommended by the National Canners Association (27).

Prior to making any concluding statements based on the results of this experiment, it was thought that published remarks of Dr. C. O. Ball of the Research Division of the American Can Company might be appropriate. Ball (8) stated that

Numerous ideas . . . have been shown to be absurd.
Among these are:

a. that a process can be established as safe by the results of a test on a few cans The fact cannot be too strongly emphasized that no test regardless of the number of cans involved can be sufficiently comprehensive in scope to give absolute assurance that a process will be satisfactory under all conditions.

The data collected in this experiment revealed the following:

1. All samples subjected to microbiological analyses were sterile.
2. The pH value of the chocolate-flavored drink was lowered by the thermal processes. The extent of the decrease was more pronounced as the process time was increased.

3. The pH value of processed samples stored at 10°C did not change over a 14-day storage period.
4. Samples stored at 33°C showed a gradual decline in pH value over the 14-day storage period.
5. Samples stored at 55°C for 14 days showed an accelerated rate in reduction of pH values.
6. The color of chocolate-flavored drink was darkened in accordance with the severity of the thermal process.
7. The concentration of soluble solids was not affected by the thermal processes or the various storage temperatures to which the samples were subjected.
8. The vacuum of the containers were generally consistent with the temperature at filling and capping.
9. The taste of the experimentally produced chocolate drink was significantly different from the commercial product with which it was compared.



BIBLIOGRAPHY



BIBLIOGRAPHY

1. Aaron, S. Carl. 1967. "Lethality of Various F_0 Values on Spores of Putrefactive Anaerobe 3679 and Thermophils in Chocolate Milk Drink." Master's thesis. University of Tennessee, Knoxville, Tennessee.
2. Alstrand, D. V. and O. F. Ecklund. 1952. The Mechanics and Interpretation of Heat Penetration Tests in Canned Foods. Food Technol. 6 (5), 185-189.
3. American Can Co. 1953. Sterilization of Canned Foods. Research and Technical Department. Maywood, Ill.
4. American Can Co. 1964. Calculation of Processes for Canned Foods. Technical Service Division Memorandum. Maywood, Ill.
5. Appert, N. 1812. The Art of Preserving. Printed for Black, Parry, and Kingsburg. London, England.
6. Ball, C. O. 1938. Advancement in Sterilization Methods for Canned Foods. Food Research 3 (1-2), 13.
7. Ball, C. O. 1923-1924. Determining, By Methods of Calculation, the Time Necessary to Process Canned Foods. National Research Council Bulletin 7 (37), 9-76.
8. Ball, C. O. 1927. Theory and Practice in Processing. The Canner. Vol. 64, 5, 27.
9. Ball, C. Olin and F. C. W. Olson. 1957. Sterilization in Food Technology. 1st ed. McGraw-Hill Book Co., New York, N. Y.
10. Bee, Gerald R. 1966. Head, Processing Section. National Canners Association. Personal communication.
11. Bigelow, W. D. and J. R. Esty. 1920. The Thermal Death Point in Relation to Time of Typical Thermophilic Organisms. J. Infectious Dis. 27 (6), 602-617.
12. Bigelow, W. D., G. S. Bohart, A. C. Richardson, and C. O. Ball. 1920. Heat Penetration in Processing Canned Foods. National Canners Association Bulletin 16-L, 128.
13. Bigelow, W. D. 1921. The Logarithmic Nature of Thermal Death Time Curves. J. Infectious Dis. 29 (5), 528-536.

14. Breed, Robert S., E. D. G. Murray and Nathan R. Smith. 1957. Bergey's Manual of Determinative Bacteriology. 7th ed. The Williams and Wilkins Co. Baltimore, Md.
15. Cameron, E. J. and J. R. Esty. 1926. The Examination of Spoiled Canned Foods. 2. Classification of Flat Sour, Spoilage Organisms from Nonacid Foods. J. Infectious Dis. 39 (2), 89-105.
16. Cameron, E. J. and C. C. Williams. 1928. The Thermophilic Flora of Sugar in its Relation to Canning. Centralblatt für Bakteriologie, Parasitenkunde und Infektionskrankheiten; Abt. II; 76, 28-37.
17. Canning Trade, The. 1969. A Complete Course in Canning. Ninth ed. The Canning Trade, Inc. Baltimore, Maryland.
18. Cox, H. E. and David Pearson. 1962. The Chemical Analysis of Foods. Chemical Publishing Co., Inc. New York, N. Y.
19. Davies, W. L. 1939. The Chemistry of Milk. 2nd ed. D. Van Nostrand Co., Inc. New York, New York.
20. Desrosier, Norman W. 1963. The Technology of Food Preservation. Rev. ed. The AVI Publishing Co. Westport, Conn.
21. Dubas, R. J. 1950. Louis Pasteur, Free Lance of Science, pp. 142-144. Little, Brown and Co. Boston, Mass.
22. Ecklund, O. F. 1949. Apparatus for the Measurement of the Rate of Heat Penetration in Canned Foods. Food Technol. 3 (7), 231-233.
23. Frazier, William Carroll. 1958. Food Microbiology. McGraw-Hill Book Co. New York, N. Y.
24. Frobisher, Martin. 1962. Fundamentals of Microbiology. 7th ed. W. B. Saunders Co. Philadelphia, Penn.
25. Graves, Roy R. 1963. Aseptic Packaging of Sterile Dairy Products. Food Technol. 17 (8), 49-52.
26. Jacobs, Morris B. 1944. The Chemistry and Technology of Food and Food Products, Vol. II. Interscience Publishers, Inc., New York, New York.
27. King, Paul H. 1966. Processing Section, National Cannery Association, Washington, D. C., personal communication.

28. Magoon, C. A. and C. W. Culpepper. 1922. Relation of Initial Temperature to Pressure, Vacuum, and Temperature Changes in the Container During Canning Operations. USDA Bulletin 1022, 52.
29. Martin, W. M. 1948. Flash Process, Aseptic Fill are Used in New Canning Unit. Food Industries 20, 832-836.
30. Miller, W. T. 1967. Vice-President Production, Royal Crown Bottling Co. Columbus, Georgia. Personal communication.
31. National Canners Association. Bulletin 26-L. 1962. Processes for Low-Acid Canned Foods in Metal Containers. Tenth ed. Washington, D. C.
32. National Canners Association. Bulletin 30-L. Processes for Low-Acid Canned Foods in Glass Containers. Fourth ed. Washington, D. C.
33. Olson, F. C. W. and H. P. Stevens. 1939. Thermal Processing of Canned Foods in Tin Containers. II. Nomograms for Graphic Calculation of Thermal Processes for Nonacid Canned Foods Exhibiting Straight-Line Semilogarithmic Heating Curves. Food Research 4 (1), 1-20.
34. Pilcher, R. W. 1949. The Canned Food Reference Manual. 3rd ed. American Can Co. New York, N. Y.
35. Prescott, S. C. and W. L. Underwood. 1897. Microorganisms and Sterilizing Processes in the Canning Industry. Technology Quarterly II (1), 6-30.
36. Sair, Louis. 1966. Sensitivity of Salmonellae to Epoxides. Given at the Western Collaborators Conference on the Destruction of Salmonellae, Western Regional Research Laboratory, Albany, California.
37. Scott, H. C. 1966. Manager, Technical Services, Owens, Illinois. Personal communication.
38. Stumbo, C. R., J. R. Murphy and Jeane Cochran. 1950. Nature of Thermal Death Time Curves for P. A. 3679 and Clostridium Botulinum. Food Technol. 4 (8), 321-326.
39. Stumbo, C. R. 1948. Bacteriological Considerations Relating to Process Evaluation. Food Technol. 2 (2), 115-132.
40. Stumbo, C. R. 1965. Thermobacteriology in Food Processing. Academic Press, New York, N. Y.

41. Tanner, Fred W. 1944. The Microbiology of Foods. 2nd ed. Garrard Press, Champaign, Ill.
 42. Tanner, Fred W. 1950. The Microbiology of Foods. The Garrard Press, Champaign, Ill.
 43. Townsend, Charles T., Ira I. Somers, Frank C. Lamb, and Norman A. Olson. 1956. A Laboratory Manual for the Canning Industry. 2nd ed. Published by National Canners Assoc., Washington, D. C.
 44. U. S. Department of Health, Education, and Welfare. Proceedings of the 1971 National Conference on Food Protection. 1972.
- 

APPENDIX



TABLE VII

PH OF CHOCOLATE DRINK AFTER 24 HOURS AND AFTER
14 DAYS OF STORAGE AT 10°C, 33°C, AND 55°C

Storage Sub- Time batch		Process											
		A(s)			A(r)			B(s)			B(r)		
<u>10°C Storage Temperature</u>													
24 Hrs.	1	6.18	6.17	6.13	6.38	6.385	6.35	6.14	6.16	6.145	6.26	6.255	6.27
	2	6.17	6.20	6.17	6.39	6.375	6.385	6.17	6.175	6.14	6.28	6.27	6.26
	3	6.16	6.17	6.14				6.13	6.05	6.10			
14 Days	1	6.15	6.17	6.16	6.39	6.38	6.385	6.10	6.14	6.135	6.24	6.27	6.26
	2	6.10	6.15	6.17	6.375	6.395	6.395	6.14	6.135	6.12	6.27	6.28	6.24
	3	6.12	6.17	6.18				6.15	6.12	6.05			
<u>33°C Storage Temperature</u>													
24 Hrs.	1	6.15	6.16	6.165	6.38	6.35	6.36	6.10	6.10	6.09	6.20	6.18	6.21
	2	6.17	6.14	6.16	6.35	6.37	6.39	6.095	6.07	6.105	6.22	6.19	6.23
	3	6.15	6.155	6.13				6.08	6.065	6.10			
14 Days	1	6.13	6.12	6.10	6.35	6.35	6.30	5.97	5.90	5.60	6.18	6.175	6.19
	2	6.08	6.10	6.13	6.33	6.35	6.345	5.95	5.90	5.89	6.185	6.205	6.19
	3	6.10	6.12	6.10				6.00	5.89	5.87			

TABLE VIII
COLOR MEASUREMENT OF CHOCOLATE DRINK AFTER 24 HOURS
OF STORAGE AT AMBIENT TEMPERATURE

Sub- batch Sample	Process												
	A(s)			A(r)			B(s)			B(r)			
	L	a	b	L	a	b	L	a	b	L	a	b	
1	a	34.13*	8.29	12.85	38.5	8.07	12.31	33.77	8.87	13.70	36.59	9.34	13.49
	b	34.63	8.24	12.55	35.45	9.44	13.80	33.69	9.06	13.97	37.46	9.06	12.85
	c	35.36	7.95	12.41	38.45	8.07	12.28	33.34	9.10	13.69	36.47	9.31	13.42
2	a	34.17	8.29	12.89	35.42	9.43	13.78	33.76	8.85	13.67	36.51	9.36	13.44
	b	34.33	8.33	12.66	38.71	8.02	12.37	33.83	8.94	13.75	37.52	9.13	12.89
	c	34.90	8.04	12.53	35.58	9.38	13.86	33.39	9.12	13.73	37.43	9.03	12.83
3	a	34.13	8.28	12.82				33.73	9.11	14.03			
	b	34.58	8.27	12.59				33.69	9.06	13.97			
	c	35.23	7.96	12.45				33.80	8.91	13.72			

*Values represent instrument readings from Hunterlab Model D25D2M.

TABLE IX
COLOR MEASUREMENT OF CHOCOLATE DRINK AFTER 14 DAYS STORAGE AT
10°C, 33°C, AND 55°C

Sub- batch Sample	Process												
	A(s)			A(r)			B(s)			B(r)			
	L	a	b	L	a	b	L	a	b	L	a	b	
<u>10°C Storage Temperature</u>													
1	a	33.75*	8.81	13.66	36.47	9.31	13.42	33.75	8.81	13.66	36.40	9.32	13.36
	b	33.66	9.04	13.95	37.41	9.01	12.82	33.66	9.04	13.95	37.43	9.03	12.83
	c	33.32	9.08	13.67	36.42	9.32	13.38	33.32	9.08	13.67	37.41	9.01	12.82
2	a	33.77	8.87	13.70	36.40	9.32	13.36	33.34	9.10	13.69	36.47	9.31	13.42
	b	33.69	9.06	13.97	37.43	9.03	12.83	33.69	9.06	13.97	36.42	9.32	13.38
	c	33.34	9.10	13.69	37.42	9.03	12.82	33.77	8.87	13.70	37.42	9.03	12.82
3	a	33.76	8.85	13.67				33.68	9.06	13.96			
	b	33.68	9.06	13.98				33.32	9.10	13.68			
	c	33.32	9.10	13.68				33.76	8.85	13.67			
<u>33°C Storage Temperature</u>													
1	a	37.67	8.19	13.86	39.24	8.35	13.09	35.89	8.82	14.28	38.69	9.02	13.30
	b	37.12	8.11	13.51	35.48	9.20	13.73	34.95	8.86	14.17	38.57	9.09	13.29
	c	38.17	8.38	13.97	39.20	8.31	13.07	35.40	9.07	14.42	38.72	9.05	13.31
2	a	37.15	8.14	13.53	35.42	9.21	13.70	35.45	9.09	14.46	38.58	9.16	13.30
	b	37.75	8.23	13.91	39.31	8.37	13.14	35.01	8.86	14.21	38.67	9.00	13.28
	c	38.24	8.40	14.02	35.43	9.21	13.71	35.96	8.82	14.34	38.53	9.11	13.26

TABLE IX (continued)

Sub- batch Sample	Process											
	A(s)			A(r)			B(s)			B(r)		
	L	a	b	L	a	b	L	a	b	L	a	b
<u>33°C Storage Temperature</u>												
3	a	37.70	8.24	13.88			34.98	8.85	14.19			
	b	38.20	8.38	13.99			35.92	8.81	14.31			
	c	37.18	8.18	13.54			35.42	9.08	14.44			
<u>55°C Storage Temperature</u>												
1	a	36.34	9.73	14.03	39.06	8.42	13.87	33.07	9.82	14.36	33.99	10.44
	b	36.49	8.03	14.10	39.16	8.46	13.91	32.76	9.97	14.36	33.13	9.73
	c	36.41	7.98	14.06	39.28	8.50	13.99	33.41	9.74	14.36	34.37	10.26
2	a	36.63	8.10	14.20	36.38	9.57	14.94	32.41	9.87	14.19	33.33	9.66
	b	36.57	8.08	14.17	36.23	9.48	14.85	32.90	9.66	14.16	34.08	10.33
	c	36.70	8.13	14.23	36.30	9.53	14.89	32.64	9.76	14.18	33.55	9.62
3	a	36.05	7.90	13.90				32.36	9.56	14.03		
	b	36.19	8.01	13.98				32.84	9.35	14.01		
	c	36.12	7.95	13.93				32.60	9.45	14.02		

* Values represent instrument readings from Hunterlab Model D25D2M.

TABLE X

*SOLUBLE SOLIDS OF CHOCOLATE DRINK AFTER 24 HOURS AND AFTER 14 DAYS
OF STORAGE AT 10°C, 33°C, AND 55°C

Storage Sub- Time batch	Process											
	A(s)		A(r)		B(s)		B(r)					
	<u>10°C Storage Temperature</u>											
24 Hrs.	1	12.8	13.00	12.85	12.90	12.80	12.75	12.00	12.80	13.00	12.80	12.85
	2	13.0	12.75	12.80	12.70	12.95	12.90	12.85	12.60	12.75	13.05	12.95
	3	12.0	12.60	12.85				12.85	12.90	12.75		
14 Days	1	12.50	12.45	12.80	11.95	12.55	12.85	12.70	12.65	12.90	12.90	12.85
	2	12.85	12.80	12.75	12.80	12.85	12.80	12.90	12.85	12.65	12.85	13.00
	3	13.00	12.75	12.85				12.30	12.65	12.70		
	<u>33°C Storage Temperature</u>											
24 Hrs.	1	12.60	12.75	13.00	12.90	12.85	12.75	12.75	12.80	12.65	12.65	12.85
	2	12.90	12.95	12.80	12.90	12.95	12.80	12.90	12.95	12.85	12.90	12.80
	3	12.90	12.60	12.75				12.85	12.85	12.75		
14 Days	1	12.75	12.75	12.85	12.85	12.80	12.90	12.85	12.80	12.80	12.95	12.95
	2	12.80	12.85	12.65	12.75	12.85	12.80	12.80	12.75	12.65	12.85	12.65
	3	12.90	12.75	12.80				12.75	12.80	12.90		

TABLE X (continued)

Storage Sub- Time batch		Process											
		A(s)			A(r)			B(s)			B(r)		
55°C Storage Temperature													
24 Hrs.	1	12.80	13.00	12.85	12.90	12.80	12.75	12.00	12.75	12.80	13.00	12.80	12.85
	2	13.00	12.75	12.80	12.70	12.95	12.90	12.85	12.60	12.75	13.05	12.85	12.95
	3	12.00	12.60	12.85				12.85	12.90	12.75			
14 Days	1	12.50	12.45	12.80	11.95	12.55	12.85	12.70	12.65	12.90	12.90	12.95	12.85
	2	12.85	12.80	12.75	12.80	12.85	12.80	12.90	12.85	12.65	12.85	12.85	13.00
	3	13.00	12.75	12.85				12.30	12.65	12.70			

*Values denote °Brix.

TABLE XI

VACUUM OF CONTAINER OF CHOCOLATE DRINK SAMPLES AFTER 24 HOURS
STORAGE AND AFTER 14 DAYS STORAGE AT 10°C, 33°C, AND 55°C

Sub- batch	Temp.	Process											
		A(s)			A(r)			B(s)			B(r)		
<u>24 Hours</u>													
1	10°C	6*	7	5.5	8	4	6	12	11	11.5	10	6	7
2	10°C	7	5	5.5	5	8	7	10	10	11	8	7	7.5
3	10°C	6	6	7				10.5	13	11.5			
<u>14 Days</u>													
1	10°C	6	5	5.5	8	5	4	12	10	12	10	7	8
2	10°C	5	7	7	5	7	6	12	11	11.5	7	8	9
3	10°C	7	8	6				10	12	11			
1	33°C	1	1.5	3	5	7	3	9	12	10	7	5	6
2	33°C	1	1	1.5	6	4	3	10	9.5	11	5.5	6	7
3	33°C	2	1	1				11	9	12			
1	55°C	0	0	0	6	2	4	8	10	9.5	7	7	5
2	55°C	0	0	0	4	3	2	9	10	7.5	7	6	5.5
3	55°C	0	0	1				8	9.5	9			

*Each value denotes inches of mercury.

VITA

Maury Britton Kelly was born December 29, 1938, in Cortelyou, Alabama. Following graduation from Leroy High School, Leroy, Alabama, in 1956, he entered Livingston State University, Livingston, Alabama, from which he had received a football grant-in-aid. After receiving his B. S. degree from that Institution in August, 1960, he taught in the public schools of Baldwin and Monroe Counties, Alabama, for a total of six years.

In June, 1966, he accepted a position with the Alabama State Health Department as a Sanitarian in the Division of Inspection, Bureau of Environmental Health. He worked in shellfish sanitation for two years and then attended the Public Health Sanitation School at East Tennessee State University from June 17 to August 23, 1968. After completing that school, he was appointed District Sanitarian with the Alabama State Health Department.

In 1971, he received a stipend from the State of Alabama to work toward a Master of Science degree in Food Technology at the University of Tennessee. From September, 1971, to August, 1972, he has been working to complete the requirements for the degree.

The author is was married July 10, 1964, to Miss Thelia Whigham and is the father of three children, Lisa, Patrick, and Regina.