FORMULATION AND DEVELOPMENT OF BATTER AND BREADING FOR MEAT BASED PRODUCTS

BY

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DECLARATION

The work described in this thesis was carried out by me at the Research and Development Division, Ceylon Agro Industry Private Limited under the supervision of Mr. P.F.S. Pemasiri and Mr. M.C.N. Jayasuriya A report on this has not been submitted to any other university or another degree.

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AFFECTIONATELY DEDICATED TO
MY PARENTS AND TEACHERS

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ABSTRACT

The function of batter and/or breading is defined as a coating adhering to the food product after cooking. The batter can be defined, as a liquid mixture comprised of water, flour, starch, and seasonings into which food products are dipped prior to cooking" and Breading is referred to as "a dry mixture of flour, starch and seasonings, coarse in nature and applied to moistened or battered food products prior to cooking.

In Sri Lanka food manufacturing companies still do not have strong branded product and expend billion of rupees to import batter and breading mixture to the country. Local consumers are preferred to eat more hot spices with meat product but they are not satisfied with currently available foreign sweet batter mix for meat product.

Experiments were carried out for the formulation and development of batter and breading mixture for meat based products. The specific objectives were to determine the best seasoning, optimum wheat/ corn flour combination for batter, determine optimum water percentage for batter mix, optimum wheat/ corn flour combination for breading, optimum salt percentage for breading mix, analyses of physiochemical properties of products and shelf life evaluation.

Sensory evaluation tests were conducted to find out optimum levels and conditions for the above factors using 9-point Hedonic scale subjectively. Shelf life evaluation studies were carried out in chemical and microbiological aspects. Results were analyzed using computer aided MINITAB Statistical Analysis package according to One-way ANOVA after confirming normal distribution by normality test at 5 % level of significance.

The conclusion of the studies can be interpreted as pungency spicy note 65 %, Full-bodied spicy notes 30%, Medium aromatic notes 1.7% and Light sweet top notes 1.6% were selected as a best seasoning. The best wheat flour and corn flour ratio was identified as 30% and 25% respectively to obtain optimum coating characteristic for batter. The experiment shows 65 ml of water and 100g of batter is the best combination for obtaining optimum coating performance. Best wheat flour and corn flour combination is 62% and 26% respectively. 14% of salt for breading mix is the best salt combination for end product. The quality parameters of the batter and breading were retained constant for 2 ½ months.

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ABBREVIATIONS

USDA:	United States Department of Agriculture
MCB:	Multiple Comparisons with the Best
HPLC:	High Performance Liquid Chromatography
CMC:	Carboxy Methy-Cellulose
HPMC:	Hydroxy propyl Methylcellulose
MC:	Methyl Cellulose
FFAs:	Free-Fatty Acids
DFF:	Deep Fat Frying
App.:	Appendix
D:	Dilution
et al.,	And others

CHAPTER 01

INTRODUCTION

1.1 Introduction

An important consideration in the marketing and development of food based products and will continue to be taste there are no better way to enhance flavor and different food then with coatings. The changing demographics of the consumption and constant evaluation of lifestyle will present the grates challenge and opportunities that this industry has ever had to face.

KFC and McDonalds are well establishing Food Companies in worldwide. They have strong international brand equity as manufacturers of unique coated food product with distinguish characteristic of flavor and taste. Sri Lankan coated food manufacturing companies still haven't strong branded product for batter mix, expend billion of rupee for import batter mix. Sri Lankan consumers are culturally eating more hot spices with meat product and not satisfied with currently available foreign sweet batter mix for meat product. Understanding the above circumstance Ceylon Agro Industries limited wanted to develop and formulate new batter mix for meat product to enhance consumer satisfaction.

Consumers will praise or condemn a battered food base on several general factors appearance, with the exception of flavor and mouth feels this takes in to an account all the separate qualities that dictate overall acceptance. This could be summarized as tenderness, texture and translucency. These properties are largely affected by the amount and uniformity of the coating adhering to food substrate. Thicker coating made from a mixture of waxy rice flour and corn flour is very smooth and poor texture.

This is due in part to the formulation of heavily gelatinized starch film. By contrast a thinner less viscous coating from these same ingredients will allow air bubble to appear on the surface and result in a more appealing texture. There are no exact recipes existing for batter systems.

Batter depending on the food substrate, desired coating on the food substrate and the desired coating appearance. Formulae can be extremely flexible to allow for maximum adaptability in product development research.

1.2 Objectives

Formulation and Development of batter and breading for Meat based Products

1.2.1 Specific Objectives

(1) To determine the best seasoning for batter

(2) To determine the best wheat flour and corn flour combination for batter

(3) To determine the best batter and water combinations

(4) To determine the best corn and wheat flour combinations for breading

(5) To determine the best salt and breading Combinations

(6) Shelf life evaluation of the product.

CHAPTER 02

REVIEW OF LITERATURE

2.1 Coating Products

Defined a coating as the batter and/or breading adhering to the food product after cooking (Suderman and Cunningham ,1983).A batter was defined as "a liquid mixture comprised of water, flour, starch and seasonings into which food products are dipped prior to cooking (Suderman and Cunningham ,1983).Breading was referred to as a dry mixture of flour, starch and seasonings, coarse in nature, and applied to moistened or battered food products prior to cooking.

According to its cereal origin, breading could be classified as wheat and corn breading and according to the functionality, breading could be classified into "free flowing breading" and "non free flowing breading" (Suderman and Cunningham ,1983).A free flowing breading means that breading flows from the hand if a person holding the batter makes a fist, which is referred to as a "hand test". If the breading packs in the fist then it is considered non-free flowing. Batters can be classified as "conventional", "traditional" and "leavened" batters (also called tempura).
(Suderman 1983).

2.2 Coating Objectives

Another factor to consider when selecting the correct batter or breading is the specific coating objective(s) for the finish product. Specific objectives should be outlined for texture, crispiness, color, flavor, appearance, functionality, cooking characteristics (backing frying, micro waving, and convection oven preparation) and special conditions.

2.3 Processing Objective

Processing objective that should be considered during the development process of batter and breaded food are: desired amount of batter or breeding pick up (percentage of finished weighted weight), coating texture, fry color, and processing steps (e.g., pre frying, complete cooking, freezing, packaging, and single- or double-pass coating operation). Once the processing objectives have been determined, a batter or breeding should be selected or developed that holds up best under all processing conditions (Kulp and Loewe , 1996).

Table 2.1 Classification for batter and breading

Category	Classification	Type
Breading	Cereal grain-based	Wheat flour-based
		Corn flour-based
		Other flour based
	Functionality Free flowing	Free flowing
		Fine
		Medium
		Course
		Bakeable
		Non free-flowing
	Specialty	Green bread crumb
		Potato flakes
		Cereals
		Cracker crumbs
		Dry Sauces
		Predusts
Batter (dry mixes)	Conventional (unleavened)	Wheat flour based
		Corn flour-based
		Starch based Modified Unmodified
		Traditional Egg and milk based
	Tempura (leavened)	
		(May include all conventional batters, with leavening agents)

(Source: Kulp and Loewe , 1996).

2.4 Critical Coating Characteristic

2.4.1 Appearance

With the exception of the flavor and mouth feel these tasks in to account all the separate qualities that dictate overall acceptance, these could be summarized as: Tenderness, Toughness, Thickness, Texture and Translucency. This properties largely affected by the amount and uniformity of the coating adhering to the food substrate (Kulp and Loewe , 1996).

2.4.2 Color

Cook color is closely tied with coating appearance. It results from the absorption of frying oil, the density (based on the coating thickness), and chemical browning reactions of reducing sugars and protein sources. Color can be controlled by cooking method and medium, content of the frying oil, ingredient composition, and selection of a supplemental breading. Fried coated foods are also affected by the type and age of the frying oil (Kulp and Loewe , 1996).

2.4.3 Crispiness

Although it may be a difficult sensory impression to quantify, crispiness is certainly one, if not the most, critical coating characteristic. A lack of crispiness may be defined either as a chewy toughness or mouth softness. The coating should ideally exhibit a structure that sufficiently resist the initial bite but then disappears with quick melt away in the mouth. A coating that not readily breaks down during subsequent mastication will be rated chewy, heavy, undesirable, and perhaps even lacking in freshness (Kulp and Loewe , 1996).

2.4.4 Adhesion

During frozen storage and transportation, it is especially important for both the breading and the batter coating to maintain uniform adhesion to the food substrate under the stress involved. Lost breadcrumbs or dislodged pieces of the frozen batter coating become a waste at the bottom of the package (Kulp and Loewe , 1996).

This is not only uneconomical but yield a visually unappealing product with a patchy, uneven coating and such a product might not be repurchase by the consumer. Typically deep fat frying can cause poor adhesion due to shrinkage of the substrate away from the cooked, coagulation coating.

2.4.5 Flavor

This factor certainly affects the human senses and stimulates our desire to eat or reject various foods. Even if a coated food has exceptionally good color, texture, and crispness, a weak flavor can yield an indifferent response at best, while off-flavours will be rated distasteful at worst. Although a fixed recipe of additives and seasonings may be used, flavor is still dependent upon the method, time, and temperature of cooking, the composition and characteristics of the frying oil, and the type of supplemental breading (Kulp and Loewe , 1996).

2.5 Ingredients of batters & Breading

Flour constitutes the major ingredient of batters. Normally there are no fixed and exact recipes needed for batter systems and batters are adjusted just according to specific needs.

Table 2.2 Typical formulation of batter system

Ingredient	Addition Range (%)
Major ingredient	
Wheat flour	30-50
Corn flour	30-50
Sodium Bicarbonate	Up to 3
Acid phosphate	Adjust based on neutralizing value
Optional ingredients	
Flours from rice, soy, barley	0-5
Oil shortening	0-10
Dairy powders	0-3
Starches	0-5
Gums; emulsifiers, col	Less than 1
Salt	Up to 5
Sugars, dextrin's	0-3
Flavorings, seasonings, breading	Open

(Source: Kulp and Loewe,1996)

2.5.1 Functionality of wheat flour protein and starch

The theoretical explanation of how wheat flour affects the structure of batter coating systems focuses upon the complementary action of the protein and starch compound.

2.5.1.1 Protein

During batter mixing at ambient or refrigerated temperatures, the viscosity increases, chiefly due to development of gluten protein and starch compound. Hard wheat flours, due to their high protein content require more water than soft wheat flours to yield comparable viscosities when used in a batter (Kulp and Loewe , 1996).

Viscosity is essential to a hydrated batter since many ingredients are insoluble at ambient or refrigerated temperatures. A more viscose batter brings about the suspension of these ingredients, preventing undesirable stratification. The absorptive capacity of flour protein aids in marinating uniform dispersion of such ingredients for optimum performance. In puff/ tempura batters, gluten proteins provide gas retention during leavening. The resulting formation of an aerated, porous, cooked batter is essential to proper texture and crispiness (Kulp and Loewe , 1996).

2.5.1.2 Starch

Wheat starch is made up of linear branched and branched polymers (amylase and amylopectin respectively) of glucose. In some application, the ratio of this polymer has profound effects upon the functionalities of the starch. Indeed high amylase (70%) starched has been developed by a number of companies.

"Starch is made up of granules that occur in varying sizes. The range and distribution of granule size depend on the source from which starch is derived. Within the intact cereal grains, the starch granules are embedded in a protein matrix. Both starch damage and flour particle size affects the functional properties of flours. These damaged starch granules have greatly increased water absorption capacities over undamaged starch granules (Kulp and Loewe , 1996).

2.5.2 General function of corn in batter and breading.

2.5.2.1 Color

Corn serves several key functions in batter and breading. The most obvious is color. The carotenes contained in yellow corn provide a natural color source with no reference to added color required in the ingredient label. Combined with reducing sugars in batter mixes, yellow corn yields a highly desirable, golden brown surface color (Kulp and Loewe , 1996).)

2.5.2.2 Flavor

Corn should be added to the list of flavoring ingredient used in batter and breading. It is often used as a carrier for spice blends. Although it does not have a significant flavor impact at the low levels of spices and herbs, corn does function as a flavor addition/ enhancer at levels where other functional properties covered in this section are realized. "The flavor of corn also helps to minimize the starchy note that is associated with some coating systems that contain high level of wheat flour and/ or starch (Kulp and Loewe , 1996).

2.5.2.3 Structure/ Texture

"Corn interacts with wheat flour in batters to affect the structure and texture of batter coatings. Batter composed of wheat corn blends can be tailored by varying the ratio of these two ingredients. In general, adding or increasing corn will increase crispness and decrease puff in batter systems. This due to the diluting effect of corn on wheat gluten (which can cause tough coatings when used at high levels) (Kulp and Loewe , 1996).

2.5.2.4 Viscosity

Since water dispersions of corn flour and coating batter do not exhibit Newtonian viscosity characteristics, "apparent viscosity" is used in the literature to distinguish their behavior.

2.5.3 Egg and Milk Products

"Egg contains albumin, a heat-coagulable protein that is useful in binding the breading / batter to the product and to itself. The yolk portion contains lecithin, which may contribute to batter stability as an emulsifier. The addition of eggs to a batter tends to darken the final product as well as add a characteristic "eggy" note to its flavor (Kulp and Loewe , 1996).

2.5.4 Milk and Whey

Added as liquids or dry powders, these provided lactose, a reducing sugar that is involved in browning reactions and protein which provides structure and additional non enzymatic browning

2.5.5 Chemical Leavening

Depending upon the food to be coated, a batter can range in viscosity from a thin "milk wash" suspension to thick, viscous slurry. Such coatings are amenable to the acid / base leaving system, which is the usual choice. Here, carbon dioxide is released from sodium bicarbonate through reaction with acid salt during the heat process. This release is controlled by the addition level, based on neutralized value, and the rate of reaction of the leavening acids with sodium bicarbonate. The term "neutralized value" is defined as the part of leavening acid require reacting completely with the 100 parts of sodium bicarbonate.

Table: 2.3 Typical Leavening Acids-Batter Systems

Reaction Rate	Leaving Acid/ Neutralizing value
Very rapid	Tartaric acid/ 116
Rapid	Potassium hydrogen tartrate/ 45
Intermediate	Monosodium phosphate monohydrate/ 80
Intermediate to slow	Monosodium phosphate anhydrous, coated/ 83
Slow	Sodium acid pyrophosphate/ 72
	Glucono -δ- lactone/ 45
Very slow	Sodium aluminum phosphate/ 100
	Dicalcium phosphate dehydrate/ 33
	Sodium aluminum sulfate/ 100

(Source: Kulp and Loewe , 1996).

2.6 Effective Use of Flavorings and Seasonings in Batter and Breading Systems

2.6.1 Seasonings

Herbs and spices are rarely used singly and often complement each other when used in well-balanced mixtures or seasonings. Depending on the intrinsic flavor character and strength of the main food component of a dish (i.e., beef, pork, poultry, fish), the seasoning used should aim to enhance any natural flavors present but not to overpower them.

However, there are certain well-known dishes in which high levels of spicing are traditional, though sometimes the exported versions of these dishes differ very considerably from their true native concept. Chili con carne and curry are excellent examples of this. Mexican dishes are generally hot but more subtly spiced than their fiery Texan equivalents. In India curries are generally only moderately spiced though they may demonstrate a wide range of piquancy (Heath and Reineccius, 1996).

It is the judicious use of capsicums, which can give an effective level of pungency without unduly affecting the more delicate flavors. In Mexican cooking, full flavored chilies are extensively used whereas in Texas the very pungent and less flavorful varieties of chili are preferred.

A seasoning may be considered to have four main flavoring contributions:

A). Light, sweetly herbaceous or aromatic notes which give instant impact when the food is served and when being conveyed to the mouth.

B) Medium aromatic, herby and spicy notes selected to bring out the finer flavors in the main food ingredients (e.g., the sweetness of pork with coriander, the delicate flavor of chicken with sage and thyme);

C) Heavy, full-bodied spicy notes which add depth, richness and full flavor character to the dish.

D) Pungency or piquancy which, in the case of ginger and pepper, is accompanied by a characteristic flavor, but with chilies the additional flavor is minimal.
(Henry B. et al., 1996)

2.6.2 Flavor Index and Formulation

Not all spices have the same flavoring power and this is at once obvious when one considers the flavor impact of say an equal weight of chilies and sage. It is possible to rate or classify herbs and spices allocating to each an approximate flavor index and to list these in increasing order of flavoring strength. The system cannot be precise as the judgments are entirely subjective and may vary in different hands and spices allocating to each an approximate flavor index and to list these in increasing order of flavoring strength.

The system cannot be precise and the judgments are entirely subjective and may vary in different hands under different test conditions. But, using such a classification, one can convert any seasoning formulation from a weight relationship to a flavoring profile. To achieve this, the percentage weight of each item is multiplied by the respective flavor index to give the flavor contribution, which in turn can be converted into a percentage figure. The reverse calculation can be made to formulate a seasoning having specified sensory attributes. (Heath and Reineccius, 1996).

Table 2.4 Flavor impacts of Herbs and Spices

Type	Flavor Index	Type	Flavor Index
Freshly cut herbs		Spices	
Chervil	45	paprika	50
Chives	50	Cardamom Seeds	125
Coriander leaves	80	Dill	160
Fennel leaves	80	Fenugreek	200
Sage	95	Coriander	230
Sweet marjoram	100	Allspice	260
Thyme	125	Cumin	290
Rosemary	130	Celery	300
Sweet bay leaves	140	Anise	320
		Caraway	330
		Fennel	330
Dry, broken herbs		Mace	340
Garden mint	50	Nutmeg	350
Savory	60	Turmeric	400
Tarragon	60	Black Pepper	450
Dalmatian sage	80	White Pepper	460
Marjoram	80	Cinnamon / Cassia	460
Oregano	85	Ginger (dried)	475
Thyme	85	Clove	560
Rosemary	90	Mustard	800
Sweet bay	100	Cayenne (red pepper)	900
		Chilies	1000

(Source: Heath and Reineccius, 1996).

Table 2.5 Flavor Characteristics

Light, sweet herbaceous, fresh	Heavy, fully bodied, spicy
Coriander	Allspice (pimento)
Marjoram	Anise
Rosemary	Cumin
Sweet bay	Clove
Spanish sage	Fenugreek
Medium aromatic	Mace
Caraway	Nutmeg
Cardamom	Origanum
Celery	Thyme
Cinnamon/cassia	Turmeric
Dalmatian sage	Spicy, pungent
Lovage	
Mint	Ginger
Oregano	Horseradish
Paprika	Mustard
Sweetly piquant	Black and white pepper
Basil	Capsicum
Savory	Cayenne (red pepper)
	Chilies

(Source: Heath and Reineccius, 1996).

Table 2.6 Formulations for a Seasoning

Spice	Type	% by Weight	Flavor Index	Flavor Contribution	Flavor Contribution (%)
Coriander	a	10	230	2300	7.0
Celery	b	2	300	600	1.8
Dalmatian sage	b	10	80	800	2.4
Allspice	c	10	260	2600	7.9
Mace	c	5	340	1700	5.1
Nutmeg	c	10	350	3500	10.6
Thyme	c	5	85	425	1.3
Black Pepper	d	45	450	20250	61.2
Cayenne pepper	d	1	900	900	2.7
		100		33075	100

(Source: Heath and Reineccius, 1996).

Profile: a. Light sweet top notes 7.0%
b. Medium aromatic notes 4.2%
c. Full-bodied spicy notes 24.9%
d. Pungent spicy notes 63.9%

One must stress that too high a degree of contification cannot be placed on this system but the idea, couple with the undertanding of flavour balance, is capable of giving a much better impression of what a seasoning can achieve than can be obtained by merely examination the percentage formulation. (Heath and Reineccius, 1996).

CHAPTER 3

Material and Methodology

3.1 Materials

3.1.1 Materials for the formulation and development of batter system

Ingredients	**Materials and Apparatus**
Corn Flour	Electronic balance (MS -100, Capacity 2g, 100)
Wheat Flour	Polyethylene bags
Milk Powder	Stainless steel spoon
Chili Powder	Petridish (Borosil)
White Pepper Powder	Measuring cylinder (500ml)
Ginger Powder	Stainless steel mixing pan
Clove Powder	Chicken drumsticks
Cumin Powder	Chicken wings
Nutmeg Powder	Chicken thigh
Coriander Powder	Deep fryer
Cardamom Powder	Thermometer
Celery Powder	Clock
Garlic Powder	Deep frying oil
B-Onion Powder	Microwave Oven
Eggs	Serviette
Water	Plastic tray

3.1.2 Materials for the formulation and development of breading system

Ingredient	**Material and Apparatus**
Corn Flour	Electronic balance
Wheat Flour	Stainless steel mixing pan
Acid Phosphate	Stainless steel spoon
CMC	Petridish (Borosil)
Sodium bicarbonate	Deep fryer
Sodium chloride	Thermometer
Food color	Deep frying oil
	Chicken drumsticks
	Microwave Oven

3.1.3 Materials for the determination of optimum water level for batter system.

Electronic balance (MS – 100, Capacity 2g – 100g, 100 mg)
Measuring cylinder (MC 100 ml ± 0.5 ml)
Plastic jug
Stainless steel spoon
Potable water
Stainless steel mixing pan
Chicken drumsticks
Deep fryer

3.1.4 Materials for Sensory Evaluation

Sensory evaluation ballet paper
Coded fried drumstick samples
Serviette
Glasses of potable water
Fork and spoon

3.1.5 Materials for Determination of Water Activity

Electric balance (MS – 100, Capacity 2g – 100g, 100 mg)
Test tube with lid
LiCl, $MgCl_2$, K_2CO_3, NaOH,

3.1.6 Materials for Determination of pH

pH meter (pH Scan WP2, +0.1pH)

3.1.7 Materials for Determination Moisture

Electric balance (MS – 100, Capacity 2g – 100g, 100 mg)
Automate moisture detector

3.1.8 Materials for Determination Ash

Electric Balance (MS – 100, Capacity 2g – 100g, 100 mg)
Muffle Furnace
Porcelain crucibles with lids

3.1.9 Materials for Evaluation of final Product Pick up and Yield

Formulated batter and breading mix
Stainless steel mixing pan
Electronic balance
Deep fryer
Chicken drumsticks
Stainless steel spoon

3.1.10 Materials for Determination of Yeast and Molds:

Nutrient medium
Peptone water
Measuring cylinder
Magnetic stirrer
Petridish
Small Conical flask (ISO lab, Germany, 250ml)
Conical flask
Incubator
Pipette (ISO lab, Germany, 10ml ± 0.05ml)

3.2 Methodology

3.2.1 Preparation of seasoning

According to following four tables different four seasoning were prepared. (Heath and Reineccius,1996)

Table 3.2.1 Flavor profile a

Profile:a	a.	Light sweet top notes	12.3 %
	b	Medium aromatic notes	5.2 %
	c.	Full-bodied spicy notes	30.2 %
	d.	Pungent spicy notes	52.24 %

Pungency spicy note 52.24 %, Full-bodied spicy notes 30.2%, Medium aromatic notes 5.2 % and Light sweet top notes 12.3% was formulated as the 1st sesoning and amount of spicey ingredients were taken by back calculation and seasoning were prepared by mixing those ingrdients together.

Table 3.2.2 Formulations for a Seasoning A

Spice	Type	% by Weight	Flavor Index	Flavor Contribution	Flavor Contribution (%)
Chili	d	8	1000	8000	26.25
White pepper	d	10	460	4600	15.09
Ginger	d	7	475	3325	10.9
Clove powder	c	5	560	2800	9.2
Cumin	c	10	290	2900	9.5
Nutmeg	c	10	350	3500	11.5
Cardamom	b	30	125	3750	12.3
Coriander	a	20	80	1600	5.2
		100		30475	100

Table 3.2.3 Flavor profile b

Profile:b	a.	Light sweet top notes	0.6 %
	b	Medium aromatic notes	0.3 %
	c.	Full-bodied spicy notes	57.7%
	d.	Pungent spicy notes	41.3 %

Pungency spicy note 41.3 %, Full-bodied spicy notes 57.7%, Medium aromatic notes 0.3 % and Ligh sweet top notes 0.6% was formulated as a second sesoning and amount of spicey ingredients were taken by back calculation and seasoning were prepared by mixing those ingrdient together.

Table 3.2.4 Formulations for a Seasoning B

Spice	Type	% by Weight	Flavor Index	Flavor Contribution	Flavor Contribution (%)
Chili	d	6	1000	6000	14
White pepper	d	12	460	5520	12.9
Ginger	d	13	475	6175	14.4
Clove powder	c	20	560	11200	26
Cumin	c	35	290	10150	23.6
Nutmeg	c	10	350	3500	8.1
Cardamom	b	2	125	250	0.6
Coriander	a	2	80	160	0.3
		100		42955	100

Table 3.2.5 Flavor profile c

Profile:d	a.	Light sweet top notes	0.76 %
	b	Medium aromatic notes	22.3 %
	c.	Full-bodied spicy notes	17.7%
	d.	Pungent spicy notes	59.2 %

Pungency spicy note 59.2 %, Full-bodied spicy notes 17.7 %, Medium aromatic notes 22.3 % and Light sweet top notes 0.76 % was formulated as a 3rd sesoning and amount of spicey ingredients were taken by back calculation and seasoning were prepared by mixing those ingrdient together.

Table 3.2.6 Formulations for a Seasoning C

Spice	Type	% by Weight	Flavor Index	Flavor Contribution	Flavor Contribution (%)
Chili	d	18	1000	18000	42.8
White pepper	d	15	460	6900	16.4
Cumin	c	10	290	2900	6.9
Nutmeg	c	13	350	4550	10.8
Celery	b	25	300	7500	17.8
Cardamom	b	15	125	1875	4.5
Coriander	a	4	80	320	0.76
		100		42045	100

Table 3.2.7 flavor profile d

Profile:a	a.	Light sweet top notes	1.6%
	b	Medium aromatic notes	1.7%
	c.	Full-bodied spicy notes	30%
	d.	Pungent spicy notes	65 %

Pungency spicy note 65 %, Full-bodied spicy notes 30%, Medium aromatic notes 1.7% and Light sweet top notes 1.6% was formulated as a 4th sesoning and amount of spicy ingredients were taken by back calculation and seasoning were prepared by mixing those ingrdient together.

Table 3.2.8 Formulations for a Seasoning D

Spice	Type	% by Weight	Flavor Index	Flavor Contribution	Flavor Contribution (%)
Chili	d	14	1000	14000	30
White pepper	d	29	460	13340	28
Ginger	d	7	475	3325	7
Clove powder	c	11	560	6160	13.2
Cumin	c	10	290	2900	6.2
Nutmeg	c	15	350	5250	11.3
Cardamom	b	4	125	750	1.6
Coriander	a	10	80	800	1.7
		100		46525	100

3.2.1.1 Batter mixes with different seasoning to determine the best combination

Constant amount of wheat flour, corn flour, milk powder, CMC and salt were mixed with above four different types of seasoning as following table. At the same time 50 ml of water was added to each four different batter sample and it was mixed with beaten eggs and was prepared ready to fry batter mixed.

Table 3.2.9 Ingredients for the formulation of Batter mix with different seasoning.

Sample code / Ingredients	584	365	685	953
Wheat flour	30 g	30 g	30 g	30 g
Corn flour	25 g	25 g	25 g	25 g
Milk powder	10g	10 g	10 g	10 g
Seasoning	30 g	30g	30 g	30 g
CMC	0.35mg	0.35mg	0.35mg	0.35mg
Salt	5 g	5 g	5 g	5 g
	100g	100g	100g	100g

3.2.1.2 Evaluation of Sensory appeal to determine the best seasoning (spiciness, hotness)

Chicken drumsticks were kept in microwave until thawed and then dipped separately in each four batter mix and kept for 10 minutes. Chicken drumsticks were fried at 180 C° for 15 minutes. Sensory evaluation was carried out by using ballot papers in 30 trained panelists of Ceylon Agro Industry.

Four samples were coded as three digits number (See App. I) Coded samples, ballot papers and acceptability of 4 samples were evaluated using 9 – point hedonics scale subjectively. Water glasses were given for each and every panelist Results were analyzed using computer aided MINITAB Statistical Analysis package according to One-way ANOVA after confirming normal distribution by normality test at 5 % significant level.

3.2.2 Wheat flour and corn flour combination to determine the best combination

Wheat flour and corn flour ratios changed according to the following table. Best seasoning ratio found by statistical analysis. Milk powder, seasoning, CMC and salt were taken in constant amounts and four different batter mixes were prepared. Water, beaten eggs were added above referenced amount and ready to fry batter mix was prepared.

Table 3.2.10 Wheat/ Corn combinations of batter

Sample Code / Ingredients	746	542	323	525
Wheat flour	50 g	40 g	30 g	20 g
Corn flour	5 g	15 g	25 g	35 g
Milk powder	10g	10 g	10 g	10 g
Seasoning	30 g	30g	30 g	30 g
CMC	0.35mg	0.35mg	0.35mg	0.35mg
Salt	5 g	5 g	5 g	5 g
	100g	100g	100g	100g

3.2.2.1 Evaluation of Sensory appeal to determine the best Critical Coating Characteristic (Color, adhesion, crispiness)

Sensory evaluation was carried out by using ballot papers in 30 trained panelists of Ceylon Agro Industry. Acceptability of 4 samples was evaluated using 9 – point hedonics scale subjectively (Heymann and Lawless,1999).Four samples were coded as three digits number (See App. II). Coded samples, ballot papers and water glasses were given for each and every panelist Results were analyzed using computer aided MINITAB Statistical Analysis package according to One-way ANOVA after confirmed normal distribution by normality test at 5 % significant level.

3.2.3 Water and batter mix combination to determine the best combination

Water and batter mix ratios were changed according to the following table. Best mix was found by statistical analysis. Water was added to the above referenced amount with one beaten egg separately and ready to fry batter mixes were prepared.

Table 3.2.11 Batter mixed with different water combinations.

Sample code / Ingredients	453	156	843	486
Batter mix	100g	100g	100g	100g
Water	50 ml	65 ml	80 ml	95 ml

3.2.3.1 Evaluation of Sensory appeal to determine the best Critical Coating Characteristic (Appearance, Adhesion, Crispiness and Color)

Sensory evaluation was carried out by using ballot papers in 30 trained panelists of Ceylon Agro Industry. Four samples were coded as three digits number (See App. III). Coded samples, ballot papers and water glasses were given for each and every panelis. Acceptability of 4 samples was evaluated using 9 – point hedonics scale subjectively (Heymann and Lawless,1999). Results were analyzed using computer aided MINITAB Statistical Analysis package according to One-way ANOVA after confirmed normal distribution by normality test at 5 % significant level

3.2.4 Wheat flour and Corn flour combination to determine the best combination

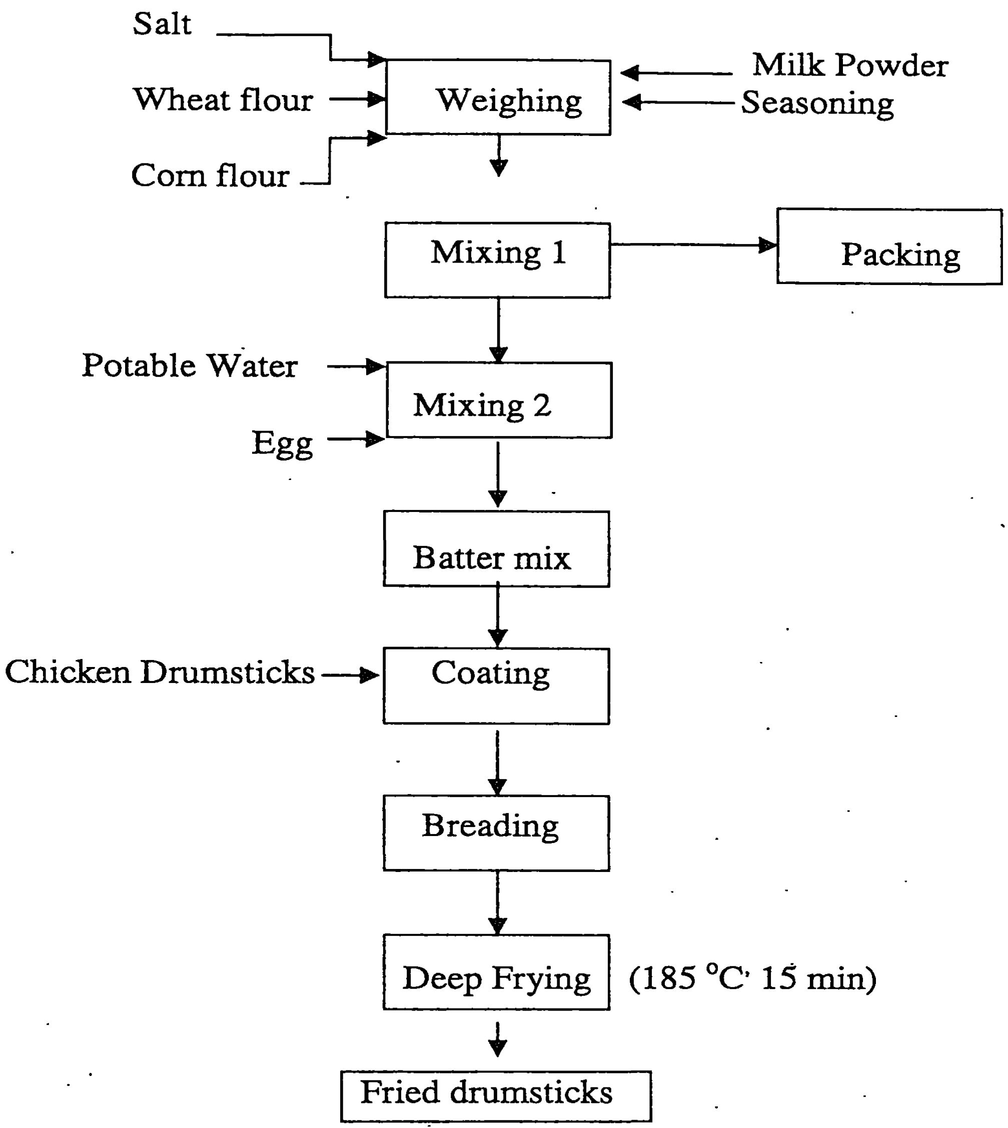

Fig 3.1 Process flow chart of batter & breading coated fried chicken drumsticks

Wheat flour and corn flour ratios were changed according to the following table and constant amount of Sodium bicarbonate, Acid phosphate; Tarter Zen and Salt were mixed with above four different types of breading as following table. Ingredients were measured using electrical balance and measured ingredients were taken in to polyethylene bags and mixed well. Chicken drumsticks were kept in microwave until thawed and then dipped in selected batter mix and kept for10 minutes. After that batter and breading were applied to chicken drumsticks. It was fried at 180 °C for 15 minutes

Table 3.2.12 Wheat/ Corn combinations for obtaining optimum coating performance for breading

Sample Code / Ingredients	746	542	323	525
Wheat flour	72	62	52	42
Corn flour	16	26	36	46
Sodium bicarbonate	0.11g	0.11g	0.11g	0.11g
Acid phosphate	110mg	110mg	110mg	110mg
Tarter Zen	0.015	0.015	0.015	0.015
Salt	12g	12g	12g	12g

3.2.4.1 Evaluation of Sensory appeal to determine the best Wheat/ Corn combinations of Breading (Appearance, Adhesion, Crispiness and Color)

Sensory evaluation was carried out by using ballot papers in 30 trained panelists of Ceylon Agro Industry. Four samples were coded as three digits number (See App. IV). Coded samples, ballot papers and water glasses were given for each and every panelis. Acceptability of 4 samples was evaluated using 9 – point hedonics scale subjectively (Heymann and Lawless,1999). Results were analyzed using computer aided MINITAB Statistical Analysis package according to One-way ANOVA after confirmed normal distribution by normality test at 5 % significant level

3.2.5 Breading mixes with different salt to determine the Best Combination

Selected breading mix recipe (without salt) and salt ratios were changed while selected breading mix was kept constant according to the following table.

Table 3.2.13 Breading mixes with different salt combination

Sample Code / Ingredients	452	542	634	384
Breading mix	100g	100g	100g	100g
Salt	10g	12g	14g	16g

3.2.5.1 Evaluation of Sensory appeal to determine the Best Saltiness

Sensory evaluation was carried out by using ballot papers in 30 trained panelists of Ceylon Agro Industry. Four samples were coded as three digits number (See App. V). Coded samples, ballot papers and water glasses were given for each and every panelis. Acceptability of 4 samples was evaluated using 9 – point hedonics scale subjectively (Heymann and Lawless,1999). Results were analyzed using computer aided MINITAB Statistical Analysis package according to One-way ANOVA after confirmed normal distribution by normality test at 5 % significant level

3.2.6 Analyses of Physiochemical Properties

3.2.6.1 Moisture Determination

Five gram of final batter mix and breading mix sample were measured in to separately Petri dishes separately and automated moisture detector directly took amount of moisture percentage. Calculate average moisture percentage was taken by repeated three time of same procedure.

3.2.6.2 Ash Determination of final Batter and Breading mixed

Ten gram of batter and breading samples were accurately weighted in to crucibles and mass of the crucible was weighed. Then crucibles were heated until black fumes were over. Muffle furnace at 520 C ° for 24 hours samples were ignited. Then cooled in desiccated, weighted and the constant weighted was recorded (Nielson, 1998).

Calculation

$$\text{Ash percentages} = \frac{M_2 - M_1}{M_0} \times 100$$

M_0 – Initial mass of the sample

M_1 – Mass of the crucible

M_2 – Mass of the crucible and sample after igniting

3.2.6.3 Water Activity Determination

One gram of final batter and breading sample were measured and placed in the bottom of 20 ml test tubes with lids. Then selected salt with known a_w were placed in the middle of tubes without contacting the sample. Test tubes were placed with the lid well closed. Then closely observed after 2 hours to whether the salts are melted (Nielson, 1998).

3.2.6.4 Determination of pH

One gram of batter and breading samples were separately weighed and crushed. Then 100 ml distilled water measured using measuring cylinder and diluted the above two sample. Then it was strained by using filter paper. Then calibrated pH meter was inserted to the filtrate and took pH value directly.

3.2.6.5 Evaluate final product Pick up and Yield

Three chicken drumsticks were taken it was kept microwave until became a thawed. Using serviette cleaned surface moisture of chicken drumsticks. Raw weights of chicken drumsticks were measured by using electric balance. After chicken drumsticks were dipped in final batter mixed and kept 10 minute, batters were applied to the chicken drumsticks. After that the breading was applied to chicken drumsticks. It was weighted before and after fried at 180 C° for 15 minute. Pick up and yield were calculated using below equation
(Kulp and Loewe , 1996).

$$\text{Pick up} = \frac{\text{weight after coating} - \text{raw weight}}{\text{Weight after coating}}$$

$$\text{Yield} = \frac{\text{weight after processing}}{\text{Raw weight}}$$

(Source: Kulp and Loewe , 1996).

3.2.7 Determination of Yeast and Molds:

Peptone Water:

Five gram of peptone powder and 8.5g of salt were suspended in 1L of distilled water and boiled to dissolve completely. Then it was sterilized by autoclaving 121^0C for 15 minutes.

Nutrient Medium:

Thirteen gram of Agar, 20g of Dextrose and 5g of yeast was suspended in 1L-distilled water and boiled to dissolve completely. Then it was sterilized by autoclaving at 121^0C for 15 minutes.

Preparation of Serial Dilution:

Ten gram of final batter and breading samples were separately measured and separately mixed with 90ml of peptone water and shake well. It was labeled as D-1 dilution.
Second dilution prepared from the first dilution, 1ml was transferred in to second dilution tube containing 9 ml of peptone water and labeled as D-2 solution. Thus a serial dilution was done up to D-6.

Then 2-3 drops of chloromphenicol was added to the prepared medium and it was poured in to Petri dishes. Then 1ml from each batter and breading sample of serial dilutions were pipette out and introduced aseptically in to sterilized Petri dishes. It was labeled as D-1, D-2 ... and D6

One milliliter of original water sample was pippetted out in to the Petri dishes with fifteens milliliter of the medium and it was labeled as D-0.Without the sample only medium was kept as control. Then the dishes were incubated at 36^{0}C for 72 hours. After specified period of incubation, colonies were counted in each Petri dish using the colony counter.
(SLS 516: Part, 1991).

CHAPTER 04

RESULTS AND DISCUSSION

4.1. Result of Sensory evaluation for determine the best seasoning

Table 4.1 Determine the best seasoning

Sample code / Characteristics	Normality P-value	P-value	Best sample
Spiciness	0.150	0.003	953
Hotness		0.000	365
Overall Acceptability		0.026	953

Normality test's p-value indicates that, at 5% levels less than 0.150; there is evidence that the data follow a normal distribution. (See. App. VI).

4.1.1 Hotness

P-value (0.000) for indicates that there is sufficient evidence that not all the means are equal when alpha is set at 0.05. To explore the differences among the means, examine the multiple comparison results. Best spiciness was selected as 1st sample (sample code 365) by Hsu's MCB(Multiple Comparisons with the Best) (See. App. VII).

4.1.2 Spiciness

In the ANOVA table, the p-value (0.003) indicates that there is sufficient evidence that not all the means are equal when alpha is set at 0.05. To explore the differences among the means, examine the multiple comparison results. Best spiciness was selected as 4th sample (sample code 953) by Hsu's MCB (Multiple Comparisons with the Best) (See. App. VII).

4.1.3 Overall Acceptability of Seasoning

In the ANOVA table, the p-value (0.026) indicates that there is sufficient evidence that not all the means are equal when alpha is set at 0.05. To explore the differences among the means, examine the multiple comparison results. Best spiciness was selected as 4th sample (sample code 953) by Hsu's MCB (Multiple Comparisons with the Best) According to the final result overall acceptability and best hotness were recoded in the seasoning 4 (sample code 953) which contained the highest pungency spicy note (65 %) than other three seasonings. On the other hand 2nd sample (sample code 365) appears to have the best spicy taste; in fact that contains highest full-bodied spicy notes (57.7%) than others (See. App. VII).

4.2. Result of Sensory evaluation for determine the best wheat flour and corn flour combination for batter

Table 4.2 Determine the best wheat flour and corn flour combination

Sample code / Characteristics	Normality P-value	P-Value	Best Sample
Color	0.150	0.000	323
Adhesion		0.000	323
Overall acceptability		0.001	323

Normality test's p-value indicates that, at 5% levels less than 0.150; there is evidence that the data follow a normal distribution. (See. App. VI).

4.2.1 Color

In the ANOVA table, the p-value (0.000) indicates that there is sufficient evidence that not all the means are equal when alpha is set at 0.05. To explore the differences among the means, examine the multiple comparison results. Best color was selected as 2nd sample (sample code 323) by Hsu's MCB (Multiple Comparisons with the Best) the carotene contained in yellow corn provides a natural color source. Combined with reducing sugars in batter mixes, yellow corn yields a highly desirable, golden brown surface color. (See. App. VIII).

4.2.2 Adhesion

In the ANOVA table, the p-value (0.000) indicates that there is sufficient evidence that not all the means are equal when alpha is set at 0.05. To explore the differences among the means, examine the multiple comparison results. Best adhesion was selected as 2nd sample (sample code 323) by Hsu's MCB (Multiple Comparisons with the Best). This keeps the coating in closer contact with the food surface. An additional factor may be the complexion of protein to fat between the coating and substrate. (See. App. VIII).

4.2.3 Overall acceptability of wheat flour / corn flour combination for batter

In the ANOVA table, the p-value (0.001) indicates that there is sufficient evidence that not all the means are equal when alpha is set at 0.05. To explore the differences among the means, examine the multiple comparison results. Best Overall acceptability was selected as 2nd sample (sample code 323) by Hsu's MCB (Multiple Comparisons with the Best) (See. App. VIII).

The best wheat / corn flour combination of batter was selected as a second sample (sample code 323) which contains 6:5, wheat / corn combination.

4.3. Result of Sensory evaluation for determine the best batter\ water Combinations

Table 4.3 Determine the best batter/ water Combinations

Sample code / Characteristics	Normality P-value	P-Value	Best Sample
Color	0.150	0.001	843
Adhesion		0.048	156
Crispiness		0.000	156
Overall Acceptability		0.000	156

Normality test's p-value indicates that, at 5% levels less than 0.150; there is evidence that the data follow a normal distribution. (See. App. VI).

4.3.1 Color

In the ANOVA table, the p-value (0.001) indicates that there is sufficient evidence that not all the means are equal when alpha is set at 0.05. To explore the differences among the means, examine the multiple comparison results. Best color was selected as 3rd sample (sample code 843) by Hsu's MCB (Multiple Comparisons with the Best) (See. App. IX).

4.3.2 Adhesions

In the ANOVA table, the p-value (0.048) indicates that there is sufficient evidence that not all the means are equal when alpha is set at 0.05. To explore the differences among the means, examine the multiple comparison results. Best adhesion was selected as 2nd sample (sample code 156) by Hsu's MCB (Multiple Comparisons with the Best) (See. App. IX).

4.3.3 Crispiness

In the ANOVA table, the p-value (0.000) indicates that there is sufficient evidence that not all the means are equal when alpha is set at 0.05. To explore the differences among the means, examine the multiple comparison results. Best Overall acceptability was selected as 2nd sample (sample code 156) by Hsu's MCB (Multiple Comparisons with the Best) (See. App. IX).

4.3.4 Overall Acceptability of batter/ water Combinations

In the ANOVA table, the p-value (0.000) indicates that there is sufficient evidence that not all the means are equal when alpha is set at 0.05. To explore the differences among the means, examine the multiple comparison results. Best Overall acceptability was selected as 2nd sample (sample code 156) by Hsu's MCB (Multiple Comparisons with the Best) (See. App. IX)..

The best batter / water combination was selected as a second sample (sample code 156). Batter/ water ratio is 100: 65.

4.4 Result of Sensory evaluation for determine the best Corn/Wheat Combinations for breading

Table 4.4 Determine the best Corn/Wheat Combinations for breading

Sample code / Characteristics	Normality P-value	P-Value	Best Sample
Color	0.150	0.000	542
Adhesion		0.000	542
Crispiness		0.014	525
Overall acceptability		0.007	542

Normality test's p-value indicates that, at 5% levels less than 0.150; there is evidence that the data follow a normal distribution. (See. App. VI).

4.4.1 Color

In the ANOVA table, the p-value (0.000) indicates that there is sufficient evidence that not all the means are equal when alpha is set at 0.05. To explore the differences among the means, examine the multiple comparison results. Best color was selected as 2nd sample (sample code 542) by Hsu's MCB (Multiple Comparisons with the Best) (See. App. X)

4.4. 2 Adhesion

In the ANOVA table, the p-value (0.000) indicates that there is sufficient evidence that not all the means are equal when alpha is set at 0.05. To explore the differences among the means, examine the multiple comparison results. Best adhesion was selected as 2nd sample (sample code 542) by Hsu's MCB (Multiple Comparisons with the Best) (See. App. X)

4.4.3 Crispiness

In the ANOVA table, the p-value (0.014) indicates that there is sufficient evidence that not all the means are equal when alpha is set at 0.05. To explore the differences among the means, examine the multiple comparison results.

Best crispiness was selected as 4th sample (sample code 525) by Hsu's MCB (Multiple Comparisons with the Best) (See. App. X)

4.4.4 Overall acceptability of Corn/Wheat Combinations for breading

In the ANOVA table, the p-value (0.007) indicates that there is sufficient evidence that not all the means are equal when alpha is set at 0.05. To explore the differences among the means, examine the multiple comparison results. Best overall acceptability was selected as 2nd sample (sample code 542) by Hsu's MCB (Multiple Comparisons with the Best)
(See. App. X)

The best wheat / corn combination of breading was selected as second sample (sample code 542) wheat / corn ratio is 62: 26.

4.5. Result of Sensory evaluation for determine the best salt/ breading Combinations

Table 4.5 Determine the best salt/ breading Combinations

Sample code / Characteristics	Normality P-value	P-Value	Best Sample
Saltiness	150	0.000	634

Normality test's p-value indicates that, at 5% levels less than 0.150; there is evidence that the data follow a normal distribution. (See. App. VI).

4.5.1 Saltiness

In the ANOVA table, the p-value (0.000) indicates that there is sufficient evidence that not all the means are equal when alpha is set at 0.05. To explore the differences among the means, examine the multiple comparison results. Best saltiness was selected as 3rd sample (sample code 634) by Hsu's MCB (Multiple Comparisons with the Best) (See. App .XI).

The best saltiness of breading was selected as 3rd sample (sample code 634) Breading/ salt ratio was 100: 14.

4.6 Result of yeast and molds:

Table 4.6 Result of yeast and molds

Microbial count	CFU per gram		Yeast and Moulds/g of samples	
	Batter Mix	Breading Mix	Batter Mix	Breading Mix
D-0	25	240	250	240
D-1	3	68	30	680
D-2	-	12	-	1.2×10^3
D-3	-	2	-	2×10^3
D-4	-	-	-	-
D-5	-	-	-	-

The yeast and moulds count of the batter and breeding were identified as 250 and 2×10^3 cells per 1 gram of samples. Comparatively there were higher yeast and moulds count in breading rather than batter.

It reason batter ingredient contained spicy seasoning. It has anti oxidant properties and inhibits growth of microorganisms. Mold, yeast, and bacteria were found in a variety of spices in numbers ranging from a few hundred to 10 million per gram. A bacteria level of 1×10^7 per milliliter or gram of food is considered very high and is approaching the spoilage point of food. (Kulp and Loewe , 1996)

4.6.1 Self-life evaluation of Breading

Final breading sample was stored 10 weeks under room temperature and evaluated their chemical changes (Moisture and Ph), physical changes (color and texture) and microbiological changes (Yeast & Moulds). According to following table there were not significant changes in breading until 10 weeks. The result revealed that product was acceptable for 10 weeks. (Man and Jones, 1990)

Table 4.7 Self-life evaluation of Breading

Time (week)	Moisture	Texture	Ph	Color	Yeast & Moulds
2nd week	14.31	No change	6.6	No change	2×10^3
4th week	14.32	No change	6.5	No change	1.8×10^3
6th week	14.11	No change	6.6	No change	2.1×10^3
8th week	14.21	No change	6.5	No change	2×10^3
10th week	14.45	No change	6.6	No change	2.2×10^3

4.6.2 Self-life evaluation of batter

Final batter sample was stored 10 weeks under room temperature and evaluated their chemical changes (Moisture and PH), physical changes (color and texture) and microbiological changes (Yeast & Moulds). According to following table there were not significant changes in breading until 10 weeks. The result revealed that product was acceptable for 10 weeks. (Man and Jones, 1990)

Table 4.8 Self-life evaluation of Batter

Time (week)	Moisture	Ph	Color	Yeast & Moulds
2nd week	21.01	6.3	No change	240
4th week	21.31	6.4	No change	800
6th week	21.30	6.3	No change	453
8th week	21.35	6.3	No change	298
10th week	21.34	6.4	No change	419

4.7 Analyses of physiochemical properties

Moisture, ash, water activity, Ph, Pick up and yield were measured and following tables contained their final result.

Table 4.9 Analyses of physiochemical properties

Properties	Batter	Breading	Standard
Moisture	21.74 %	14.38 %	
Ash	2.1	1.8	Max: 2.5 (codex)
Water activity	0.22	0.22	
PH	6.4	6.62	
Pick up	24 %		Max: 30 % (USDA)
Yield	24.5 %		Max: 30 % (USDA)

Average percentage of ash in selected batter was 2.1 % and according to the codex standard maximum ash percentage 2.5 %. Selected batter and breading Pick up in meat is 24 % and currently, the United States Department of Agriculture (USDA) limits batter pickup and Yield in meat and poultry product to 30% (USDA, 1986)

CHAPTER 05

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

01. Pungency spicy note 65 %, Full-bodied spicy notes 30%, Medium aromatic notes 1.7% and Light sweet top notes 1.6% were selected as a best seasoning and their spices mixed according to the following table.

Table 5.1 Best seasoning

Spices	Amount
Chili	14g
White pepper	29g
Ginger	7g
Clove powder	11g
Cumin	10g
Nutmeg	15g
Cardamom	4g
Coriander	10g

02. Best wheat flour and corn flour combinations to obtained best critical coating characteristic for batter are 30% and 25%.

03. Water and batter mixed combination to the obtained optimum coating performance is 65ml of water for 100g of batter mixed.

04. Best wheat flour and corn flour combination to the obtained best critical coating characteristic for breading 62% and 26%.

05. Optimum breading mix and salt combination 14 % for 100g of breading mixed.

06. The quality parameters of the batter and breading retained constant for 2 ½ months.

07. The pick up and yield of the final product are 24% and 24.5%.

5.2 Recommendations

01. The effect of freezing poultry parts before applying batters and breading should be study.

02. The precise amount of capsaicin present in chilies should be measured by a high performance liquid chromatography (HPLC) and select high concentration capsaicin varieties.

03. Should be select best packaging material for batter.

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Appendix I

SABARAGAMUWA UNIVERSITY OF SRI LNKA

Department of Food Science & Technology

Ballot sheet for Sensory Evaluation of best Batter seasoning for Meat base Product.

Name: - ....

Date: -................................

Please evaluate sample for characters given below and indicate your acceptability for each sample using scoring scale.

1. Extremely Dissatisfied
2. Very much Dissatisfied
3. Moderately Dissatisfied
4. Slightly Dissatisfied
5. Neither Satisfied nor Dissatisfied
6. Slightly Satisfied
7. Moderately Satisfied
8. Very much Satisfied
9. Extremely Satisfied

Sample code / characteristics	584	365	685	953
Spiciness				
Hotness				
Overall Acceptability				

Your comments

....

....

....

Thank you

Appendix II

SABARAGAMUWA UNIVERSITY OF SRI LNKA

Department of Food Science & Technology

Ballot sheet for sensory evaluation for determine the best wheat flour and corn flour combination for Batter.

Name: - ....

Date: -...............................

Please evaluate sample for characters given below and indicate your acceptability for each sample using scoring scale.

1. Extremely Dissatisfied
2. Very much Dissatisfied
3. Moderately Dissatisfied
4. Slightly Dissatisfied
5. Neither Satisfied nor Dissatisfied
6. Slightly Satisfied
7. Moderately Satisfied
8. Very much Satisfied
9. Extremely Satisfied

Sample code / characteristics	746	542	323	525
Color				
Adhesion				
Overall acceptability				

Your comments

....

....

....

Thank you

Appendix III

SABARAGAMUWA UNIVERSITY OF SRI LNKA

Department of Food Science & Technology

Ballot sheet for sensory evaluation for determine the best Batter and water combination.

Name: - ....

Date: -..............................

Please evaluate sample for characters given below and indicate your acceptability for each sample using scoring scale.

1. Extremely Dissatisfied
2. Very much Dissatisfied
3. Moderately Dissatisfied
4. Slightly Dissatisfied
5. Neither Satisfied nor Dissatisfied
6. Slightly Satisfied
7. Moderately Satisfied
8. Very much Satisfied
9. Extremely Satisfied

Sample code / characteristics	453	156	843	486
Color				
Adhesion				
Crispiness				
Overall Acceptability				

Your comments

....

....

....

Thank you

Appendix IV

SABARAGAMUWA UNIVERSITY OF SRI LNKA

Department of Food Science & Technology

Ballot sheet for Sensory Evaluation of Critical Coating Characteristic of Breading System. (CORN/WHEAT)

Name: - ....

Date: -...

Please evaluate sample for characters given below and indicate your acceptability for each sample using scoring scale.

1. Extremely Dissatisfied
2. Very much Dissatisfied
3. Moderately Dissatisfied
4. Slightly Dissatisfied
5. Neither Satisfied nor Dissatisfied
6. Slightly Satisfied
7. Moderately Satisfied
8. Very much Satisfied
9. Extremely Satisfied

Sample code / Characteristics	746	542	323	525
Color				
Adhesion				
Crispiness				
Overall acceptability				

Your comments

....

....

....

Thank you

Appendix V

SABARAGAMUWA UNIVERSITY OF SRI LNKA

Department of Food Science & Technology

Ballot sheet for Sensory Evaluation for best saltiness of breading.

Name: - ....

Date: -...............................

Please evaluate sample for characters given below and indicate your acceptability for each sample using scoring scale.

1. Extremely Dissatisfied
2. Very much Dissatisfied
3. Moderately Dissatisfied
4. Slightly Dissatisfied
5. Neither Satisfied nor Dissatisfied
6. Slightly Satisfied
7. Moderately Satisfied
8. Very much Satisfied
9. Extremely Satisfied

Sample code / characteristics	452	542	634	384
Saltiness				

Your comments

....

....

....

Thank you

Appendix VI

Normality test

Generates a normal probability plot and performs a hypothesis test to examine whether or not the observations follow a normal distribution. For the normality test, the hypotheses are,

H_0: data follow a normal distribution

H_1: data do not follow a normal distribution

P-value = 0.150, α = 0.05. P > α

Ho: Accepted

The Anderson-Darling test's p-value indicates that, at 5% levels less than p-value, there is evidence that the data follow a normal distribution. According to following tables' alls P-values equal to 0.150, which mean following all data, obey Normal distribution

Result of Normality Test

Events	Characters	Mean	StDev	P-Value
Batter seasoning	Hotness	6.417	0.9578	0.150
	Spiciness	5.825	1.424	0.150
	Overall	6.325	1.094	0.150
wheat flour and corn flour (Batter)	Color	6.483	1.223	0.150
	Adhesion	6.133	0.8881	0.150
	Overall	6.225	0.7155	0.150
Batter / Water combination	Color	6.125	0.7731	0.150
	Adhesion	6.458	0.9429	0.150
	Crispiness	6.375	1.189	0.150
	Overall	6.383	0.9365	0.150
Wheat flour and corn flour (Batter)	Color	6.183	0.9872	0.150
	Adhesion	6.292	0.9736	0.150
	Crispiness	6.492	0.8696	0.150
	Overall	6.317	0.9347	0.150
Best saltiness for batter	Saltiness	6.325	0.8997	0.150

Appendix VII

One-way ANOVA: Response-Hotness versus sample

Source	DF	SS	MS	F	P
sample	3	18.033	6.011	7.65	0.000
Error	116	91.133	0.786		
Total	119	109.167			

S = 0.8864 R-Sq = 16.52% R-Sq(adj) = 14.36%

H_0: There is sufficient evidence that all the means are equal

H_1: There is sufficient evidence that not all the means are equal

At 5% significant levels, P-value = 0.000

$P > \alpha$,

H_0 - rejected

At 5% significant levels, there is sufficient evidence that not all the means are equal

Hsu's MCB (Multiple Comparisons with the Best)

Family error rate = 0.05
Critical value = 2.08

Intervals for level mean minus largest of other level means

```
Level    Lower    Center    Upper   -----+---------+---------+---------+----
584     -1.5102  -1.0333  0.0000    (-------*---------------)
365     -0.1435   0.3333  0.8102                          (-------*-------)
685     -0.8102  -0.3333  0.1435                (-------*-------)
953     -1.1769  -0.7000  0.0000          (-------*-----------)
                                    -----+---------+---------+---------+----
                                      -1.20     -0.60      0.00      0.60
```

One-way ANOVA: Response (spiciness) versus sample

Source	DF	SS	MS	F	P
sample	3	27.09	9.03	4.89	0.003
Error	116	214.23	1.85		
Total	119	241.33			

S = 1.359 R-Sq = 11.23% R-Sq(adj) = 8.93%

H_0: There is sufficient evidence that all the means are equal

H_1: There is sufficient evidence that not all the means are equal

At 5% significant levels, P-value = 0.003

$P > \alpha$,

H_0 - rejected

At 5% significant levels, there is sufficient evidence that not all the means are equal

```
Hsu's MCB (Multiple Comparisons with the Best)

Family error rate = 0.05
Critical value = 2.08

Intervals for level mean minus largest of other level means

Level   Lower   Center   Upper  -----+---------+---------+---------+----
584    -1.031   -0.300   0.431              (--------*--------)
365    -1.998   -1.267   0.000   (--------*---------------)
685    -1.064   -0.333   0.398              (--------*--------)
953    -0.431    0.300   1.031                      (--------*--------)
                                -----+---------+---------+---------+----
                                   -1.60     -0.80     -0.00      0.80
```

One-way ANOVA: Response-Overall versus sample

```
Source   DF      SS     MS     F      P
sample    3   10.89   3.63  3.20  0.026
Error   116  131.43   1.13
Total   119  142.33

S = 1.064   R-Sq = 7.65%   R-Sq(adj) = 5.26%


Hsu's MCB (Multiple Comparisons with the Best)

Family error rate = 0.05
Critical value = 2.08

Intervals for level mean minus largest of other level means

Level   Lower   Center   Upper     +---------+---------+---------+---------
584    -1.073   -0.500   0.073           (-------*-------)
365    -1.406   -0.833   0.000      (-------*-----------)
685    -1.139   -0.567   0.006          (-------*-------)
953    -0.073    0.500   1.073                        (-------*-------)
                                   +---------+---------+---------+---------
                                 -1.40     -0.70      0.00      0.70
```

Appendix VIII

One-way ANOVA: Response-adhesion versus sample

Source	DF	SS	MS	F	P
sample	3	19.800	6.600	10.34	0.000
Error	116	74.067	0.639		
Total	119	93.867			

S = 0.7991 R-Sq = 21.09% R-Sq(adj) = 19.05%

H_0: There is sufficient evidence that all the means are equal

H_1: There is sufficient evidence that not all the means are equal

At 5% significant levels, P-value = 0.000

P > α ,

H_0 - rejected

At 5% significant levels, there is sufficient evidence that not all the means are equal

Hsu's MCB (Multiple Comparisons with the Best)

Family error rate = 0.05
Critical value = 2.08

Intervals for level mean minus largest of other level means

```
Level     Lower    Center    Upper    -+---------+---------+---------+--------
746     -1.3299   -0.9000   0.0000       (-----*------------)
542     -1.1299   -0.7000   0.0000          (-----*---------)
323      0.0000    0.7000   1.1299                         (---------*-----)
525     -1.4966   -1.0667   0.0000     (-----*--------------)
                                      -+---------+---------+---------+--------
                                    -1.40     -0.70      0.00      0.70
```

One-way ANOVA: Response (color) versus sample

Source	DF	SS	MS	F	P
sample	3	39.63	13.21	11.08	0.000
Error	116	138.33	1.19		
Total	119	177.97			

S = 1.092 R-Sq = 22.27% R-Sq(adj) = 20.26%

H_0: There is sufficient evidence that all the means are equal

H_1: There is sufficient evidence that not all the means are equal

At 5% significant levels, P-value = 0.000

P > α ,

H_0 - rejected

At 5% significant levels, there is sufficient evidence that not all the means are equal

```
Hsu's MCB (Multiple Comparisons with the Best)

Family error rate = 0.05
Critical value = 2.08

Intervals for level mean minus largest of other level means

Level    Lower   Center   Upper    -+---------+---------+---------+--------
746     -1.854   -1.267   0.000       (-----*------------)
542     -1.354   -0.767   0.000            (-----*-------)
323      0.000    0.767   1.354                          (-------*-----)
525     -2.088   -1.500   0.000     (-----*---------------)
                                   -+---------+---------+---------+--------
                                 -2.0      -1.0       0.0       1.0
```

One-way ANOVA: Response Overall versus sample

```
Source   DF      SS     MS     F      P
sample    3   8.025  2.675  5.87  0.001
Error   116  52.900  0.456
Total   119  60.925

S = 0.6753   R-Sq = 13.17%   R-Sq(adj) = 10.93%
```

H_0: There is sufficient evidence that all the means are equal

H_1: There is sufficient evidence that not all the means are equal

At 5% significant levels, P-value = 0.001

P > α ,

H_0 - rejected

At 5% significant levels, there is sufficient evidence that not all the means are equal

```
Hsu's MCB (Multiple Comparisons with the Best)

Family error rate = 0.05
Critical value = 2.08

Intervals for level mean minus largest of other level means

Level     Lower    Center    Upper    -+---------+---------+---------+--------
746     -1.0633  -0.7000   0.0000      (------*-------------)
542     -0.8633  -0.5000   0.0000          (------*---------)
323     -0.0633   0.3000   0.6633                         (------*------)
525     -0.6633  -0.3000   0.0633                (------*------)
                                      -+---------+---------+---------+--------
                                    -1.00     -0.50      0.00      0.50
```

Appendix IX

One-way ANOVA: Response (adhesions) versus sample

Source	DF	SS	MS	F	P
sample	3	6.958	2.319	2.72	0.048
Error	116	98.833	0.852		
Total	119	105.792			

S = 0.9230   R-Sq = 6.58%   R-Sq(adj) = 4.16%

H_0: There is sufficient evidence that all the means are equal

H_1: There is sufficient evidence that not all the means are equal

At 5% significant levels, P-value = 0.048

P > α ,

H_0 – rejected

At 5% significant levels, there is sufficient evidence that not all the means are equal

Hsu's MCB (Multiple Comparisons with the Best)

Family error rate = 0.05
Critical value = 2.08

Intervals for level mean minus largest of other level means

```
Level   Lower    Center   Upper   --------+---------+---------+---------+-
453    -1.0633  -0.5667  0.0000   (--------*--------)
156    -0.0299   0.4667  0.9633                      (-------*-------)
843    -0.9633  -0.4667  0.0299     (-------*-------)
486    -1.0966  -0.6000  0.0000   (-------*---------)
                                  --------+---------+---------+---------+-
                                       -0.60      0.00      0.60      1.20
```

One-way ANOVA: Response-Color versus Sample

Source	DF	SS	MS	F	P
Sample	3	9.825	3.275	6.20	0.001
Error	116	61.300	0.528		
Total	119	71.125			

S = 0.7269   R-Sq = 13.81%   R-Sq(adj) = 11.58%

H_0: There is sufficient evidence that all the means are equal

H_1: There is sufficient evidence that not all the means are equal

At 5% significant levels, P-value = 0.001

P > α ,

H_0 – rejected

At 5% significant levels, there is sufficient evidence that not all the means are equal

Hsu's MCB (Multiple Comparisons with the Best)

Family error rate = 0.05
Critical value = 2.08

Intervals for level mean minus largest of other level means

```
Level     Lower    Center    Upper   ----+---------+---------+---------+-----
453      -0.6911  -0.3000  0.0911             (-------*-------)
156      -0.7911  -0.4000  0.0000           (-------*-------)
843      -0.0911   0.3000  0.6911                          (-------*-------)
486      -1.1911  -0.8000  0.0000   (-------*---------------)
                                     ----+---------+---------+---------+-----
                                       -1.00     -0.50      0.00      0.50
```

One-way ANOVA: Response (Crispiness) versus sample

Source	DF	SS	MS	F	P
sample	3	28.49	9.50	7.89	0.000
Error	116	139.63	1.20		
Total	119	168.13			

S = 1.097   R-Sq = 16.95%   R-Sq(adj) = 14.80%

H_0: There is sufficient evidence that all the means are equal

H_1: There is sufficient evidence that not all the means are equal

At 5% significant levels, P-value = 0.000

P > α ,

H_0 - rejected

At 5% significant levels, there is sufficient evidence that not all the means are equal

Hsu's MCB (Multiple Comparisons with the Best)

Family error rate = 0.05
Critical value = 2.08

Intervals for level mean minus largest of other level means

```
Level   Lower   Center   Upper   --------+---------+---------+---------+-
453     -1.757  -1.167  0.000   (-----*-----------)
156      0.000   0.933  1.524                   (--------*-----)
843     -1.524  -0.933  0.000      (-----*--------)
486     -1.790  -1.200  0.000   (-----*-----------)
                                 --------+---------+---------+---------+-
                                       -1.0       0.0       1.0       2.0
```

One-way ANOVA: Overall Acceptability versus sample

Source	DF	SS	MS	F	P
sample	3	17.167	5.722	7.61	0.000
Error	116	87.200	0.752		
Total	119	104.367			

S = 0.8670   R-Sq = 16.45%   R-Sq(adj) = 14.29%

H_0: There is sufficient evidence that all the means are equal

H_1: There is sufficient evidence that not all the means are equal

At 5% significant levels, P-value = 0.000

$P > \alpha$,

H_0 - rejected

At 5% significant levels, there is sufficient evidence that not all the means are equal

```
Hsu's MCB (Multiple Comparisons with the Best)

Family error rate = 0.05
Critical value = 2.08

Intervals for level mean minus largest of other level means

Level     Lower    Center    Upper   --+---------+---------+---------+-------
453     -0.9998   -0.5333   0.0000           (-----*-------)
156      0.0000    0.5333   0.9998                          (-------*-----)
843     -1.0665   -0.6000   0.0000          (-----*--------)
486     -1.5331   -1.0667   0.0000    (------*--------------)
                                     --+---------+---------+---------+-------
                                    -1.40     -0.70      0.00      0.70
```

Appendix X

One-way ANOVA: Response (Adhesion) versus sample

```
Source    DF      SS     MS      F      P
Sample     3  23.892  7.964  10.39  0.000
Error    116  88.900  0.766
Total    119 112.792

S = 0.8754   R-Sq = 21.18%   R-Sq(adj) = 19.14%
```

H_0: There is sufficient evidence that all the means are equal

H_1: There is sufficient evidence that not all the means are equal

At 5% significant levels, P-value = 0.000

P > α ,

H_0 - rejected

At 5% significant levels, there is sufficient evidence that not all the means are equal

```
Hsu's MCB (Multiple Comparisons with the Best)

Family error rate = 0.05
Critical value = 2.08

Intervals for level mean minus largest of other level means

Level     Lower   Center   Upper  -------+---------+---------+---------+--
746     -0.7376  -0.2667  0.2043                  (--------*------)
542     -0.2043   0.2667  0.7376                           (-------*-------)
323     -1.2043  -0.7333  0.0000          (--------*-----------)
525     -1.6376  -1.1667  0.0000  (-------*------------------)
                                  -------+---------+---------+---------+--
                                     -1.20     -0.60      0.00      0.60
```

One-way ANOVA: Responses (Color) versus samples

```
Source    DF      SS     MS     F      P
samples    3  16.967  5.656  6.63  0.000
Error    116  99.000  0.853
Total    119 115.967

S = 0.9238   R-Sq = 14.63%   R-Sq(adj) = 12.42%
```

H_0: There is sufficient evidence that all the means are equal

H_1: There is sufficient evidence that not all the means are equal

At 5% significant levels, P-value = 0.000

P > α ,

H_0 - rejected

At 5% significant levels, there is sufficient evidence that not all the means are equal

```
Hsu's MCB (Multiple Comparisons with the Best)
```

Family error rate = 0.05
Critical value = 2.08

Intervals for level mean minus largest of other level means

```
Level     Lower    Center    Upper   -+---------+---------+---------+--------
746     -0.9303   -0.4333   0.0637             (------*------)
542     -0.0637    0.4333   0.9303                         (------*------)
323     -1.2637   -0.7667   0.0000        (------*----------)
525     -1.4970   -1.0000   0.0000     (------*-------------)
                                     -+---------+---------+---------+--------
                                   -1.40     -0.70      0.00      0.70
```

One-way ANOVA: Response (Crispiness) versus samples

Source	DF	SS	MS	F	P
samples	3	7.825	2.608	3.68	0.014
Error	116	82.167	0.708		
Total	119	89.992			

S = 0.8416   R-Sq = 8.70%   R-Sq(adj) = 6.33%

H_0: There is sufficient evidence that all the means are equal

H_1: There is sufficient evidence that not all the means are equal

At 5% significant levels, P-value = 0.014

P > α ,

H_0 _ rejected

At 5% significant levels, there is sufficient evidence that not all the means are equal

Hsu's MCB (Multiple Comparisons with the Best)

Family error rate = 0.05
Critical value = 2.08

Intervals for level mean minus largest of other level means

```
Level     Lower    Center    Upper   --+---------+---------+---------+-------
746     -1.1195   -0.6667   0.0000     (--------*------------)
542     -0.6528   -0.2000   0.2528              (--------*--------)
323     -0.5528   -0.1000   0.3528                (--------*--------)
525     -0.3528    0.1000   0.5528                    (--------*--------)
                                     --+---------+---------+---------+-------
                                     -1.00     -0.50      0.00      0.50
```

One-way ANOVA: Response (Overall Acceptability) versus sample

Source	DF	SS	MS	F	P
sample	3	10.167	3.389	4.19	0.007
Error	116	93.800	0.809		
Total	119	103.967			

S = 0.8992   R-Sq = 9.78%   R-Sq(adj) = 7.45%

H_0: There is sufficient evidence that all the means are equal

H_1: There is sufficient evidence that not all the means are equal

At 5% significant levels, P-value = 0.007

$P > \alpha$,

H_0 _ rejected

At 5% significant levels, there is sufficient evidence that not all the means are equal

```
Hsu's MCB (Multiple Comparisons with the Best)

Family error rate = 0.05
Critical value = 2.08

Intervals for level mean minus largest of other level means

Level     Lower    Center    Upper   -----+---------+---------+---------+----
746      -0.7171  -0.2333   0.2505              (--------*---------)
542      -0.2505   0.2333   0.7171                       (---------*--------)
323      -1.0171  -0.5333   0.0000         (---------*----------)
525      -1.2505  -0.7667   0.0000    (---------*--------------)
                                      -----+---------+---------+---------+----
                                        -1.00     -0.50      0.00      0.50
```

Appendix XI

One-way ANOVA: Response-salt versus Sample

Source	DF	SS	MS	F	P
Sample	3	16.425	5.475	7.95	0.000
Error	116	79.900	0.689		
Total	119	96.325			

S = 0.8299   R-Sq = 17.05%   R-Sq(adj) = 14.91%

H_0: There is sufficient evidence that all the means are equal

H_1: There is sufficient evidence that not all the means are equal

At 5% significant levels, P-value = 0.007

$P > \alpha$,

H_0 - rejected

At 5% significant levels, there is sufficient evidence that not all the means are equal

Hsu's MCB (Multiple Comparisons with the Best)

Family error rate = 0.05
Critical value = 2.08

Intervals for level mean minus largest of other level means

```
Level     Lower    Center    Upper   ----+---------+---------+---------+-----
452     -1.4465   -1.0000   0.0000  (------*-----------------)
542     -1.0465   -0.6000   0.0000         (------*----------)
634     -0.1465    0.3000   0.7465                         (------*------)
384     -0.7465   -0.3000   0.1465              (------*------)
                                    ----+---------+---------+---------+-----
                                     -1.20     -0.60      0.00      0.60
```

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