

**OPTIMIZATION OF COMMERCIAL STERILIZATION OF
CHICKEN MEAT AND TURKEY BERRY IN COCONUT MILK**



**A THESIS SUBMITTED IN PARTIAL FULFILLMENT
OF THE REQUIREMENT FOR THE DEGREE OF
MASTER OF ENGINEERING IN FOOD ENGINEERING
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KING MONGKUT'S INSTITUTE OF TECHNOLOGY LADKRABANG
2017
KMUTL-2017-EN-M-270-188**

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WAEWWAN WATTANASIRIWIT

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เอกสารนี้เป็นเอกสารที่สงวนไว้สำหรับการใช้งานเพื่อการศึกษาเท่านั้น ไม่อนุญาตให้นำไปใช้ประโยชน์ด้านการค้า
ไม่ว่ากรณีใดๆ ทั้งสิ้น อีกทั้งห้ามมิให้ตัดแปลงเนื้อหา และต้องอ้างอิงถึงเจ้าของเอกสารทุกครั้งที่มีการนำไปใช้



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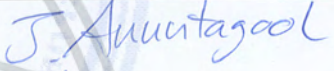




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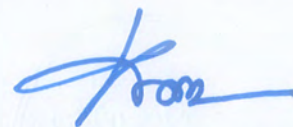
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หัวข้อวิทยานิพนธ์	การศึกษาสภาวะที่เหมาะสมการฆ่าเชื้อทางการค้าเนื้อไก่ และมะเขือพวงในน้ำกะทิ
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บทคัดย่อ

วิทยานิพนธ์ฉบับนี้ มีวัตถุประสงค์เพื่อศึกษาหาความสัมพันธ์ของส่วนประกอบของแกงกะทิกับระยะเวลาการให้ความร้อนในระดับการฆ่าเชื้อเชิงการค้า ลักษณะทางกายภาพ ของส่วนประกอบนั้นๆ โดยใช้แบบจำลองของแกงกะทิ ประกอบด้วยเนื้อไก่, มะเขือพวง และน้ำกะทิ และทำนายเวลาในการฆ่าเชื้อ ได้ออกแบบการทดลองแบบ CCD 2³ แฟคทอเรียล ปัจจัยที่ทำการศึกษา ได้แก่ ปริมาณน้ำกะทิ (อัตราส่วนหัวกะทิต่อน้ำ เท่ากับ 50 ต่อ 50) เนื้ออกไก่ทรงสี่เหลี่ยมลูกบาศก์ ขนาด 1.5±0.2 ลบ.ซม. และมะเขือพวง (ทรงกลมขนาดเส้นผ่านศูนย์กลาง 1.0±0.1 ซม.) โดยบรรจุในถุงรีโอร์ทอพาส (120×170×25 มม., น้ำหนักบรรจุ 110±2 กรัม) และให้ความร้อนในระดับการฆ่าเชื้อที่ F₀ = 4 ด้วยเครื่องฆ่าเชื้อแบบความดันเกิน ระบบสเปรย์น้ำ ผลการศึกษาพบว่า ปริมาณชิ้นไก่ที่เพิ่มขึ้น ทำให้เวลาการฆ่าเชื้อเพิ่มขึ้นอย่างมีนัยสำคัญ (p<0.05) ส่งผลให้เวลาการฆ่าเชื้อ, ค่าความสว่าง L* และ ค่าสี b* ของชิ้นเนื้อไก่ มีแนวโน้มค่าเพิ่มสูงขึ้น แต่ทำให้ค่าความสว่าง L* ของมะเขือพวง มีแนวโน้มลดลง ลักษณะเนื้อสัมผัสความแข็ง ของเนื้อไก่ และ มะเขือพวง มีแนวโน้มค่าลดลง สมการความสัมพันธ์ที่ได้ สามารถนำมาทำนายระยะเวลาในการฆ่าเชื้อสำหรับเนื้อไก่และมะเขือพวงในน้ำแกงเขียวหวานได้

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Student	Ms. Waewwan Wattanasiriwit
Student ID.	58601219
Degree	Master of Engineering
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Thesis Advisor	Asst.Prof.Dr.Teerin Chysirichote

ABSTRACT

This thesis aimed to study the relationship of compositions in coconut based curry and the sterilization time and physical properties of the modeled using the model curry consisting of chicken, turkey berry and coconut milk. The experiment was designed using CCD with 2^3 factorial design. The specified contents of coconut milk (coconut cream: water = 50:50), chicken breast cube ($1.50 \pm 0.02 \text{ cm}^3$) and turkey berry (sphere, diameter $1.0 \pm 0.1 \text{ cm}$) were packed in retort pouch ($120 \times 170 \times 25 \text{ mm}$ pouch size, Total filled weight $110 \pm 2 \text{ g}$), and then heated to target sterility value of $F_0 = 4$ using the water spray retort. The results showed that more numbers of chicken cube significantly increased the process time ($p < 0.05$), and the lightness (L^*) and the yellowness (b^*) of chicken; however, the lightness (L^*) of turkey berry decreased. Texture profile results indicated that increasing process time led to decrease the hardness of both chicken cube and turkey berry. The obtained empirical equation could be applied for predicting the process time of chicken cube and turkey berry in coconut milk based on green curry.

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Chapter 1

Introduction

1.1 Background and Motivation

As target goal of Thailand strategy as “Kitchen of the World”, Thailand is one of the world’s largest producers of food products such as rice, canned tuna, frozen seafood, chicken and canned pineapple. In 2011, the value of Thai food exports increased 20% from the previous year owing to strengthened economic performance amongst major food importers such as the US, Japan, and ASEAN countries. The retail market value of global packaged food has been predicted to grow by 9.74% from US\$1.95 trillion in 2010 and is expected to reach US\$2.14 trillion by 2015. In line with the global market, the local Thai market for package food products is also experiencing significant growth. As lifestyles continue to change, convenient and ready-to-eat processed food products will become increasingly popular. Demand from abroad is expanding as well. In 2011, the export value of ready-to-eat (RTE) products was US\$9.3 billion, 12% higher than in the previous year and Japan was Thailand’s biggest market for food products. Japan taking 15% of the total the export value, followed by the US at 13%, China at 7%, and Indonesia at 5%. [1]

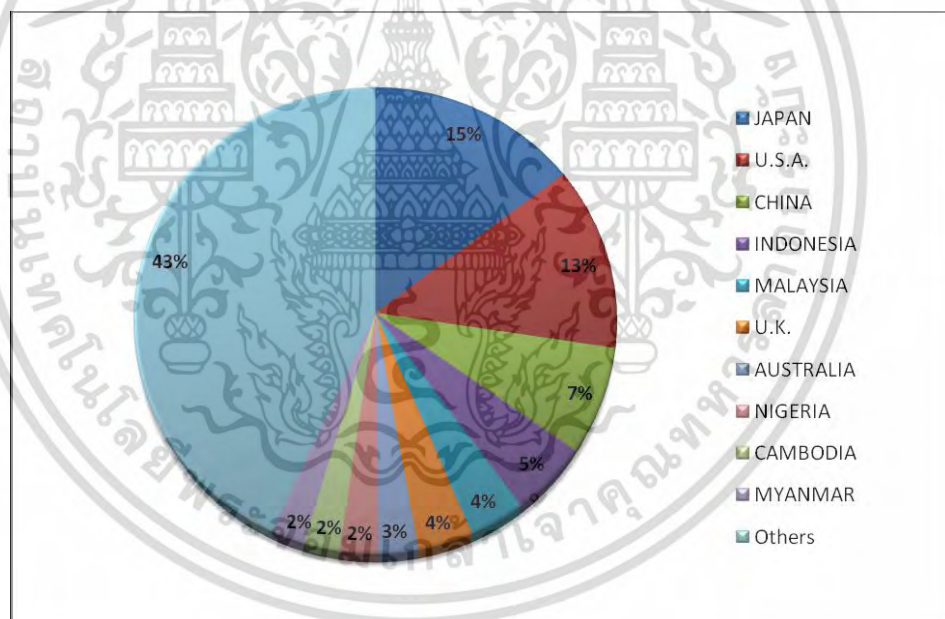


Figure 1.1 Percentage of exporting value by country in year 2011 [1]

Nowadays, the markets of RTE foods are growing. Market value of Thai RTE products have increased from 60 to 500 million yen from 2004 to 2012 in Japan market [2]. The market value of food product is predicted to reach US\$2.84 trillion or grow by 5.1% in 2017. The RTE is one major expanding market growth. [3]

Table 1.1 Thailand's Exported Food Products, 2008 – 2011

Export Items	2008		2009		2010		2011	
	Million		Million		Million		Million	
	Metric Ton	US\$	Metric Ton	US\$	Metric Ton	US\$	Metric Ton	US\$
Total Food	29,035,481	25,935	28,767,703	25,140	28,368,985	26,755	33,247,743	32,150
Fisheries	1,672,737	7,139	1,652,205	7,004	1,729,549	7,321	1,734,829	8,168
Shrimp	358,928	2,807	398,894	3,114	427,581	3,365	392,616	3,676
Tuna	506,097	2,152	534,878	1,915	588,727	1,981	594,751	2,357
Other canned fish	193,761	555	182,770	560	190,681	560	205,036	644
Frozen fish	408,117	781	343,833	670	325,476	643	303,853	651
Cuttlefish	81,778	449	78,400	400	73,638	413	67,269	447
Others	124,056	396	113,430	344	123,447	359	171,303	393
Cereal	10,376,414	6,830	8,677,883	5,757	8,983,099	5,625	11,121,224	6,717
Rice	10,218,286	6,775	8,638,842	5,741	8,939,630	5,606	10,706,229	6,537
Others	158,128	54	39,042	16	43,469	19	414,995	180
Meat	858,584	2,119	782,067	2,016	636,067	2,073	545,194	2,371
Chicken (Prepared/Prepared)	400,057	1,922	388,931	1,798	427,610	1,853	441,343	2,061
Others	458,527	198	393,136	217	208,457	219	103,851	310
Fruit	2,016,352	2,014	2,148,655	2,044	2,055,885	2,117	2,163,149	2,296
Pineapple (Canned/Prepared)	650,783	683	539,297	554	550,018	552	641,185	669
Pineapple Juice	152,793	183	151,396	217	139,877	220	146,771	227
Mango	36,333	48	45,343	53	42,987	50	59,691	56
Others	1,176,443	1,100	1,412,619	1,218	1,323,003	1,295	1,315,501	1,343
Vegetable	491,487	550	451,410	548	465,634	544	559,543	654
Sweet Corn (Canned)	172,872	173	170,179	182	182,821	182	184,178	190
Baby corn (Fresh/Canned)	48,615	52	44,523	49	45,587	49	46,092	51
Others	270,000	325	236,708	316	237,227	313	329,274	413
Others Food	13,619,908	7,283	15,055,482	7,773	14,498,751	9,075	18,858,632	20,112
Sugar	5,011,802	1,588	5,052,570	2,053	4,500,969	2,311	6,520,480	3,648
Non-Alcoholic Beverage	425,723	240	355,476	307	400,444	409	551,900	541
Seasoning	177,128	328	195,097	388	222,151	432	237,502	482
Palm oil	498,115	551	185,823	157	222,000	218	482,599	532
Tapioca (Flour/starch)	1,286,513	511	1,817,735	566	1,764,107	836	1,918,374	963
Tapioca (Pellet/chip)	2,851,433	524	4,357,028	682	4,273,225	866	3,731,027	985
Feed	695,028	289	796,044	274	988,775	417	878,463	409
Pet food	268,687	651	242,483	609	275,040	658	305,038	715
Others	2,405,478	2,601	2,053,227	2,738	1,852,040	2,927	4,233,249	11,837

Source: Thailand board of investment [1]

One of well-known products of Thai food is curry, especially, green curry with chicken. Commercial sterilization has been used to produce most RTE shelf-stable food products concerned about both qualities and safety of foods. Due to the changes

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ไม่ว่ากรณีใดๆ ทั้งสิ้น อีกทั้งห้ามมิให้ตัดแปลงเนื้อหา และต้องอ้างอิงถึงเจ้าของเอกสารทุกครั้งที่มีการนำไปใช้

of customers' behavior, the RTE products have been continuously developed; for instant, replacing tin can with pouch in order to decrease products' weights and be convenient for transportation [4]. Also, the advantages of using pouch are giving high heating rate resulting in a reduction of process time [5]. To achieve the safety of RTE shelf-stable foods, it is necessary to consider many factors for commercial sterilization such as ratio 1) ratio of solid food [6, 7], 2) an initial temperature [8], and 3) types of filling medium [9]. Although there were many researches related to thermal process of curry, there are a few reports determining relationship between curry compositions (chicken meat, turkey berry and coconut milk) and process time. In this work, the effect of curry compositions on process time of commercial sterilization and physical properties of the chicken and turkey berry in coconut milk will be study and using the empirical model for optimization the commercial sterilization of chicken and turkey berry in coconut milk which could be beneficial to research and develop the RTE Thai curry in retort pouch



Figure 1.2 Green curry with chicken, one kind of well-known Thai curry
(Source: Department of International Trade Promotion, Japan)

1.2 Objectives of the Research

- 1.2.1 To study the sterilization value (F_0) for the chicken meat and turkey berry in coconut milk
- 1.2.2 To study the effect of curry compositions on process time of commercial sterilization and physical properties of the chicken meat and turkey berry in coconut milk
- 1.2.3 To optimization the process time of the commercial sterilization of chicken meat and turkey berry in coconut milk curry focusing on the physical properties of materials

1.3 Scope of Study

- 1.3.1 Study the sterilization value (F_0) for the chicken meat and turkey berry in coconut milk

Independent variable: sterilization value (F_0) = 4 min

Dependent variable: the survival of spore *G. stearothermophilus*

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Controlled variables: fill weight per container, process temperature 121°C, initial product temperature 30±2 °C

- 1.3.2 Study the effect of curry compositions on process time of the chicken meat and turkey berry in coconut milk

Independent variable: coconut milk content, chicken meat content, and turkey berry content

Dependent variable: process time

Controlled Variables: fill weight per container, process temperature 121 °C, initial product temperature 30±2 °C, sterilization value (F_0) refer to 1.3.1

- 1.3.3 Study the effect of curry compositions on physical properties of the chicken meat and turkey berry in coconut milk

Independent Variable: coconut milk content, chicken meat content, and turkey berry content

Dependent Variable: texture profile of chicken meat and turkey berry

Controlled Variables: fill weight per container, process temperature 121 °C, initial product temperature 30±2 °C, sterilization value (F_0) refer to 1.3.1

- 1.3.4 Validation the mathematic equation correlating the process time and the physical properties of materials

Optimization Target: process time, texture profile of chicken meat and turkey berry

Sample: Green curry with chicken (40.0% chicken meat, 15.0% turkey berry, and 45.0% green curry)

1.4 Expected Benefit

- 1.4.1 The relationship of process time and safety and quality of product which is beneficial for research and development of Thai Curry Product
- 1.4.2 The process guideline or recommendation of schedule process to manufacturer due to cost saving from the reduction of process time
- 1.4.3 The verified empirical model for optimizing the process time of the chicken and turkey berry in coconut milk

Chapter 2

Theory and Literature Reviews

2.1 Thai Curry

Thai curry can define as a watery dish to be eaten with rice, known as “*Kaeng*” or “*Gaeng*”. Normally Thai people ate Thai curry with rice. The main ingredients are shrimp paste, onions or shallots, chilies and garlic. Most Thai curries are made with meat, fish or shellfish and vegetables as their main ingredient. Thai curry refers to dishes in Thai cuisine that are made with various types of curry paste, example of well-known Thai curry as information below [10]:

Kaeng som or *Gaeng som* is a curry with sour and spicy taste, could be add fish or with vegetables. The characteristics of this curry is sour taste which from tamarin paste and little sweet taste by use plam sugar. This type was popular in Central area in Thailand.

Kaeng pa is spicy taste curry which main ingredients are vegetables with chili, kaffir lime, lemongrass, green pepper corns, galangal, garlic, pea and eggplant etc. The word “Pa” means “forest” which this curry found occur from the forested areas which in the northern part of Thailand.

Green curry is spicy and sweet taste curry. The word “Green” comes from the color of curry was creamy mild green color which from green chillies in curry paste. Coconut milk and fresh green chillies were important ingredient. This curry could be call in Thai name is “Sweet Green” or “*Gaeng Khaew Wan*”.

Red curry is also spicy curry which contains red curry paste, coconut milk and may be added meat such as chicken, beef, pork, duck or shrimp, or vegetable.

2.2 Introduction of Thermal Processing

Thermal processing is the most widely used method for preserving food and extending the shelf-life. Normally refers to in-container sterilization of food. Thermal processing relates to the determination of heating conditions required to produce microbiologically safe products of acceptable eating quality [11]. The fundamental concept is applying high temperature for a sufficiently long time to destroy microorganisms that can be a danger to public health or cause product spoilage. [12]. According to the Codex Alimentarius Commission [13], “commercial sterility of thermally processed food” means “the condition achieved by an application of heat, sufficient, alone or in combination with other appropriate treatments, to render the food free from microorganisms capable of growing in the food at normal non-refrigerated conditions at which the food is likely to be held during distribution and storage”.

The United States Food and Drug Administration (USFDA) [14] has classified foods in the federal register (21 CFR Part 114) as follows: (i) *acid foods*, (ii) *acidified foods* and (iii) *low acid foods*. Acid foods are those that have a natural pH of 4.6 or below. Acidified foods are low acid foods to which acid(s) or acid foods are added with a water activity greater than 0.85 and a finished equilibrium pH of 4.6 or below.

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ไม่ว่ากรณีใดๆ ทั้งสิ้น อีกทั้งห้ามมิให้ดัดแปลงเนื้อหา และต้องอ้างอิงถึงเจ้าของเอกสารทุกครั้งที่มีการนำไปใช้

Low-acid foods have been defined as foods with a finished equilibrium pH greater than 4.6 and a water activity greater than 0.85. Scientific investigations have revealed that spores of *Clostridium botulinum* will not germinate and grow in food which its pH value was lower than 4.8. To provide sufficient safety, a pH lower than 4.6 has generally been accepted as the point indicating for acid-food that inhibits the growth of *C. botulinum* [14]. *C. botulinum* is highly heat resistant and spore former could grow under anaerobic conditions to produce the *botulism* toxin. Commercial sterility is achieved when *C. botulinum* spores are inactivated to satisfy regulatory requirements. However, other heat resistant spores (generally referred to as thermophiles) such as *C. thermosaccharolyticum*, *B. stearothermophilus*, and *Bacillus thermoacidurans* have the potential to cause spoilage and economic losses when processed cans are stored under “abuse” storage conditions of temperature.

Thermal inactivation kinetics of microorganisms are obtained by first establishing a survivor curve, which is a logarithmic plot of the number of microorganisms surviving a given heat treatment at a given temperature against the heating time. This pre-supposes that microbial destruction generally follows a first order reaction. Two key parameters (D and z values) are then determined from the survivor and resistance curves, respectively. The D -value represents a heating time that results in 90% reduction of the existing microbial population where the z -value represents the temperature change required to destruct 1 log of microorganism.

The operating temperature and pH are the most important factors as thermal resistance of microorganisms in low-acid foods is appreciably higher than the resistance of those found in high-acid foods and in both cases it is highly temperature dependent. Selection of a reference temperature for thermal processing is primarily based on the heat resistance of a target pathogenic microorganism that could be present in the product as shown in table 2.1. Decimal reduction times are highest for thermophilic and mesophilic spores in low-acid foods, lower for mesophilic spores in pH range 4.0 – 4.6, and lowest for yeasts, molds, and non-spore-forming mesophilic bacteria in high-acid foods. Thus, for a minimal process, heating low-acid foods at high temperatures under sterilization conditions is necessary, while a lower level of thermal treatment at pasteurization conditions is enough for high-acid foods [15–21].

In order to determine the processing time, it is important to understand the concept of process lethality (F_0). Process lethality can be defined as the equivalent time of heating at reference temperature (250 °F for sterilization) which kill the same amount of microorganism. The desired degree of lethality (F_0) in terms of an equivalent time at a reference temperature is generally pre-established for a given product, and processes are designed to deliver a minimum of this preset value at the slowest heating location of the product.

2.3 Lethality Requirement for Thermal Process

The phrase of “*minimal thermal process*” was introduced by the US Food and Drugs Administration in 1977 and is defined as “*the application of heat to food, either before or after sealing in a hermetically sealed container, for a period of time and at temperature scientifically determined to be adequate to ensure the destruction of microorganisms of public health concern*”.

In general, a minimum $F_0 = 3$ min is required to achieve “bot cook” or 12-D reduction of *C. botulinum* spores; although, a higher lethality is usually applied in practical. Different kinds of products like fish, meat, milk and dairy products etc.

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require different levels of minimal treatments due to specific statutory laws in place for them. Some of the general principles on which these values must be selected have been highlighted for low-acid foods in table 2.2 [15-21].

On the other hand, a less severe heat treatment is necessary for high-acid foods as *C. botulinum* spores cannot survive in a high-acid environment. The target lethality requirements at different operating temperatures for acidified foods at different operating temperatures and temperature-sensitivity (*z*-value) of target microorganism have been given by various researchers and are presented in table 2.3. For high-acid products, temperatures below 100 °C are usually adequate; however, heat-resistant fungi may survive and germinate to cause spoilage in some food products [15-21].

Table 2.1 Heat resistant of bacteria important to thermally processed foods

Class of Food	Type of Microbes	Microorganism(s)	Reference Temperature (°F)	D-Value (min)	Z-Value (°F)
Low-acid food (pH>4.6)	Thermophiles	Flat-sour group (<i>B.stearothermophilus</i>)	250	4.0-5.0	14-22
	Mesophiles	Putrefactive anaerobes (<i>C.botulinum</i> –A and B)	250	0.1-0.2	14-18
		<i>C.sporogenes</i> group (including P.A. 3679)	250	0.1-1.5	14-18
Acid food and Acidified food (pH4.0-4.6)	Thermophiles	<i>B. coagulans</i> (facultatively mesophilic)	250	0.01-0.07	14-18
	Mesophiles	<i>B.polymyxa</i> and <i>B. macerans</i>	212	0.1-0.5	12-16
		Butyric anaerobes (<i>C.pasteurianum</i>)	212	0.1-0.5	12-16
		<i>B.licheniformis</i>	200	4.5	27
Acid food and Acidified food (pH<4.0)	Yeast, molds and mesophilic bacteria	<i>Lactobacillus</i> species, <i>Leuconostoc</i> species	150	0.5-1.0	8-10

Sources: [17-19]

Table 2.2 Principle for minimum lethality requirements for low-acid foods (pH.4.5)

Minimum Lethality Requirement	Recommend for	References
Small can (54.0 mm dia & 57.2 mm height) $F_{10/121.1} \geq 2.8$ min	12 log reduction in <i>C. botulinum</i> spores. Spoilage still possible.	Stumbo <i>et al.</i> [16],[22]
Big can (157.2 mm dia & 177.8 mm height) $F_{10/121.1} \geq 3.1$ min		

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Table 2.2 (Continued)

Minimum Lethality Requirement	Recommend for	References
Small can (54.0 mm dia & 57.2 mm height) $F_{10/121.1} \geq 9$ min	4 log reduction in <i>C. sporogenes</i> spores.	Stumbo <i>et al.</i> [16],[22]
Big can (157.2 mm dia & 177.8 mm height) $F_{10/121.1} \geq 11$ min		
$F_{10/121.1} \geq 3$ min	12 log reduction in <i>C. botulinum</i> spores. Spoilage still possible.	Holdsworth and Simson [12]
$F_{10/121.1} \geq 6$ min	To be safe and to prevent spoilage.	
$F_{10/121.1} \geq 0.5 - 1.5$ min	For cured meat product; Curing controls initial spore load & subsequent spore growth	
$F_{10/121.1} \geq 3-8$ min	Shelf life in moderate climate. 4 months to 4 years if storage temperature $T \leq 25$ °C	Sielaff [23]
$F_{10/121.1} \geq 16 - 20$ min	Microbial stable; 2-log reduction in thermophilic spoilage spores, which germinate at $T > 35$ °C Shelf life in tropical climate. 1 year at storage temperature $T \geq 35 - 40$ °C	
$F_{10/121.1} \geq 0.65 - 0.85$ min	Food is microbial stable; 6-log reduction in thermophilic spoilage spores, which germinate at $T > 35$ °C For cured meat products; 1 year storage life, if the product is cured and given this minimal treatment. Microbial stable; 2-log reduction in thermophilic spoilage spores, which germinate at $T > 35$ °C	
$F_{10/121.1} \geq 2.52$ min	To eliminate most heat resistant spores for pathogen (<i>C. botulinum</i>)	Heinz and Haultzinger [24]
$F_{10/121.1} \geq 2.58$ min	To eliminate most heat resistant spores for pathogen (<i>C. botulinum</i>)	
$F_{10/121.1} \geq 4 - 5.5$ min	For moderate climate Shelf life of up to 4 years at temperature < 25 °C can be achieved	
$F_{10/121.1} \geq 12 - 15$ min	For tropical climate F-value have to be increase for safe storage of the finished products under storage temperatures up to 40 °C.	

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Table 2.3 Minimum lethality requirements for low-acid foods (pH < 4.5)

pH range	Minimum Lethality	References
3.1 – 3.2	$F_{10/195} = 0.1 \text{ min}$	Odling and Pflug [17]
3.3 – 3.5	$F_{10/195} = 1.0 \text{ min}$	Nelson and Tressler [25]
3.5 – 4.0	$F_{10/195} = 16 - 23 \text{ min}$	Barrett <i>et al.</i> [26]
4.0 – 4.3	$F_{15/200} = F_{8.3/93.3} = 5 \text{ min}$	National Canner Association Research Laboratories [27]
4.3 – 4.4	$F_{15/200} = 23 \text{ min}$ $F_{15/212} = 10 \text{ min}$	Larousse and Brown [28]
	$F_{15/200} = F_{8.3/93.3} = 10 \text{ min}$	National Canner Association Research Laboratories [27]
4.5 – 4.6	$F_{15/212} = 10 \text{ min}$ $F_{18/230} = 1.6 \text{ min}$	Montville and Sapers [29]
	$F_{8.3/93.3} = 10 \text{ min}$	National Canner Association Research Laboratories [27]

2.4 Thermal Process Evaluation

A thermal process schedule is established from the product time–temperature history (heat penetration data) and kinetic data (z and F values) by the general or improved general methods. For flexibility in terms of establishing times required to achieve expected cumulative lethality, several formula methods have been developed. The Ball formula method was the most widely used in the food processing industry. Ball formula method is derived from the heat penetration curve. The Ball formula method allows the process time to be estimated for the target F_0 values (that embodies the D – z concept) and vice versa.

Calculating or determining the process schedule is required to kill or inactivate heat resistant and pathogenic bacteria in food. Determination of proper thermal process time and temperature for sterilization of a packaged food is a complex procedure with numerous factors involved like pH of the food, type and resistance of the target microorganism, storage conditions after the process, heating conditions, thermo-physical properties of the food, container shape, size, etc. [22].

2.4.1 General Method

The simplest of all methods, known as the general method, is universally used in experimental work, precisely because of its simplicity. It was devised by Bigelow *et al.* [11], and involves graphical or numerical integration of equation when the temperature distribution is known, either from heat transfer equations or experimental data. The lethal rate (L , min) could be calculated by equation (2.1). For a constant temperature (T), F -value is equal to L -value. Then F -value can be calculated from the area under the lethal rate curve as shown in Fig 2.1 and equation (2.2).

$$\text{Lethal rate} = L = 10^{(T-T_{\text{ref}})/z} \quad (2.1)$$

$$F = \int_0^t L dt \quad (2.2)$$

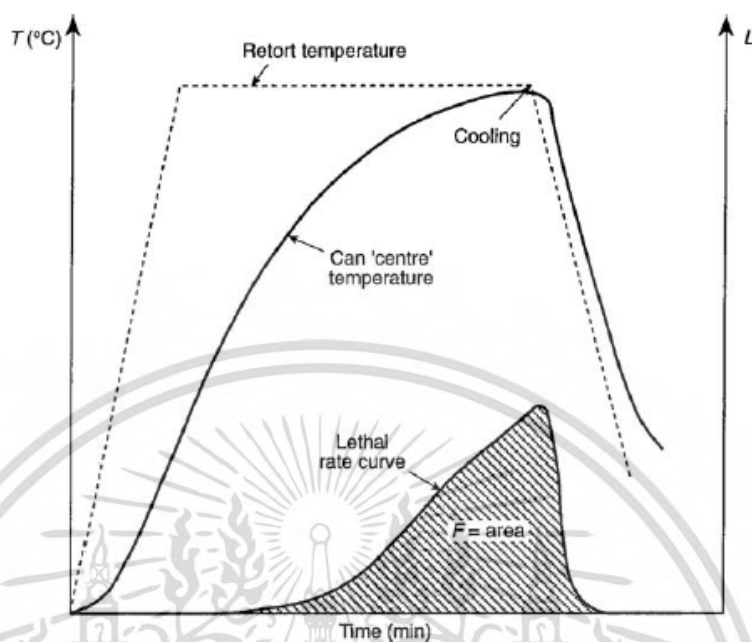


Figure 2.1 temperature (T) profile and the lethal rate (L) against time [12]

2.4.2 Ball Method

Ball method was developed by C.O. Ball. This method uses straight line in heating section of logarithmic heat penetration curve (Fig 2.2). The Ball methods involved f_h and j parameters and used theoretically derived equations based on conduction heat transfer into cylindrical containers which j is lag factor, which represent the initial phase of heating and f_h is time for one log cycle reduction.

The process time (t_p) is measured from the time when the retort start to the time which retort reaches to processing temperature, the steam was turned off and the cooling water was applied in retort. This phase is known as “come up time” (CUT) (t_c) which is the significant time for the retort to reach processing temperature, which makes a contribution to the total lethal effect. Ball [11] determined a value of $0.42t_c$ for the contribution to the lethal effect, so that the effective process time (t_B) was given by equation (2.3)

$$t_B = t_p + 0.42t_c \quad (2.3)$$

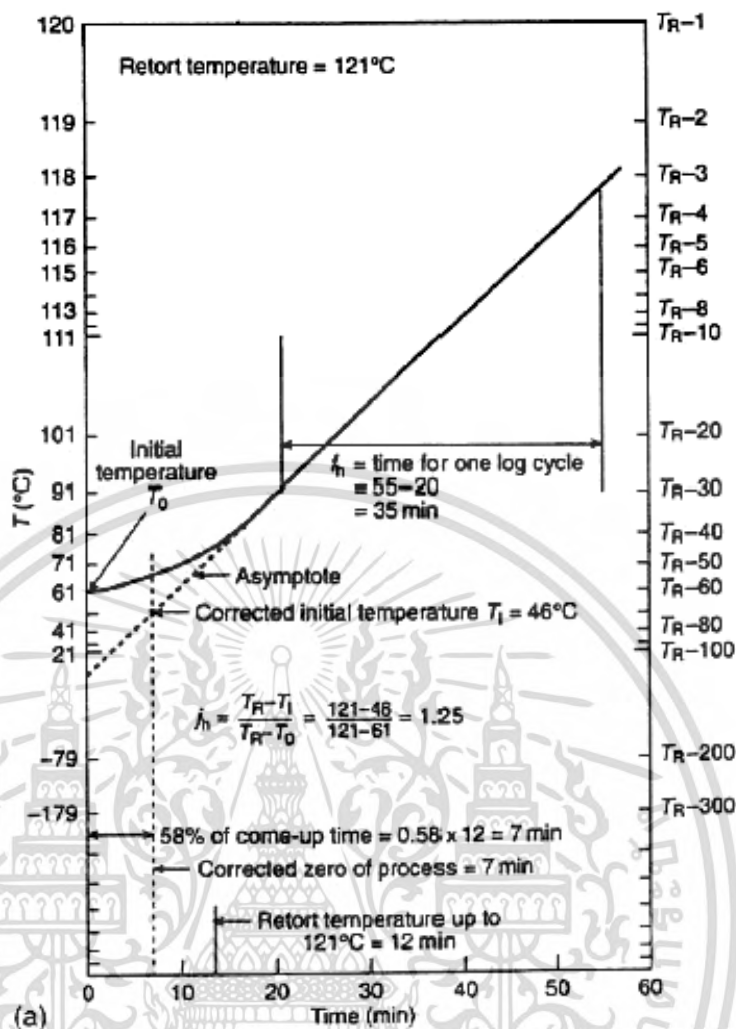


Figure 2.2 Semi-logarithmic heat penetration curve for Ball method [12]

For thin profile packaging, the lethal effect of CUT of plastic packages could be more significant than cans. With a linear heating profile, 42% CUT could be applied for reduce process time. The effectiveness of CUT varied from 35-77% and found that the effectiveness factor of 42% was very conservative for thin profile packages.

2.5 Canning Operation

Canning operation process can be divided into 5 stages processes as detail below [11]:

Stage 1 Selecting suitable foods, taking them in optimum maturity, if appropriate, followed by preparation of the foods as cleanly, rapidly and perfectly as possible with the least damage and loss with regard to the economy of the operation.

Stage 2 Packing the product in hermetically sealable containers—together with appropriate technological aids—followed by vacuum sealing the containers.

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Stage 3 Stabilizing the food by heat, while at the same time achieving the correct degree of sterilization, followed by cooling to below 38°C.

Stage 4 Storing at a suitable temperature (below 35°C) to prevent the growth of food spoilage organisms

Stage 5 Labeling, secondary packaging, distribution, marketing and consumption

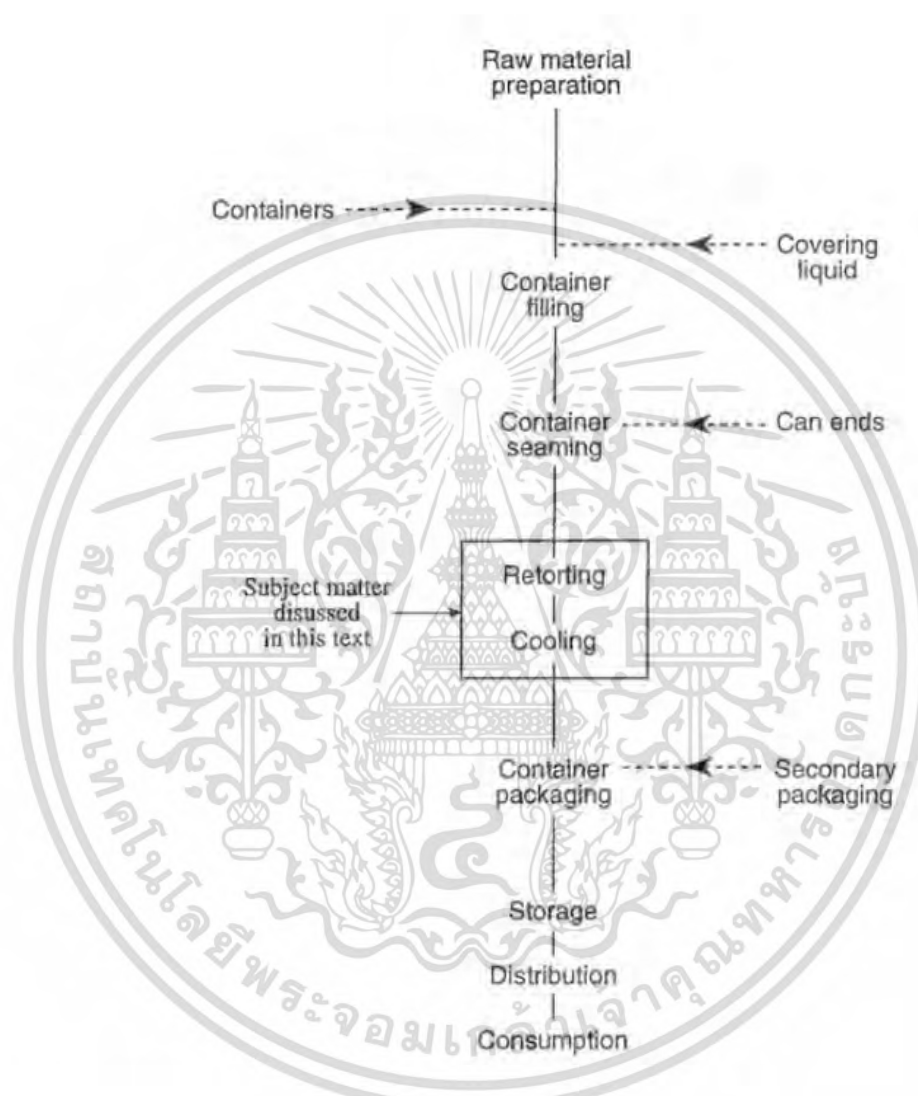


Figure 2.3 General simplified flow diagram for a canning line [12]

2.6 Water Spray Retort

Retorting is a common method for in-container sterilization of foods. In the traditional method, the food containers are placed on racks where they are kept still while heated by water, steam or a mixture of steam and air [12]. Water spray retort system is designed to process with overpressure. Overpressure refers to the pressure supplied to a retort in excess of that exerted by the heating medium at a given process temperature. The aim of overpressure during processing is to maintain the integrity of certain containers that, due to package construction, have a limited resistance to

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internal pressure. The pressure needed in the retort is approximately 10 psi above atmospheric pressure for sterilization at 116 °C, 15 psi at 121 °C and 20 psi at 127 °C [30].

Water spray system pumps water from the bottom of the retort and recirculating the water through atomizing nozzles placed around the circumference of the vessel to heat or cool the containers. The water is heated by steam spreader installed inside the retort or by external heat exchanger and air is the source of overpressure. After the process is completed, the hot process water is cooled by the heat exchanger and serves as the cooling water [31].



Figure 2.4 Water spray retort [31]

2.7 Packaging materials

2.7.1 Metal Containers

Metal cans are the most common metal containers used for shelf-stable food packaging. Double seam was a more reliable closure method for producing a hermetic seal. In present, innovations have been made in the open top can; however, the traditional three-piece can (open or sanitary) is still very widely used for thermal-processed foods [31].

2.7.2 Glass Containers

Glass container used for food product both low acid and acidified food. Normally, glass package separate to 2 elements which are essential for hermetic seal glass, there are container and metal closure. The advantage of glass container is providing the image of quality of product which could be able to see product inside container however it need carefully processing and handling. Glass containers are applied to use for canned food, beverage, baby food, pickles and meat product etc. [31]

2.7.3 Flexible/Semi-rigid Container

Flexible and semi-rigid packages are primarily composed of single or multi-layers of different types of materials such as plastic polymers (i.e. polyethylene, polypropylene (PP), polyethylene terephthalate (PET)), paperboard, aluminum foil and/or silicon oxide. Each layer in the multi-layer package material is added for a specific function to achieve the desired performance criteria such as polyester film provides strength and toughness, PP provides good heat-sealing properties, strength, flexibility and compatibility with all foodstuffs.

2.7.3.1 Retort Pouch

Retort pouch is a flexible laminated pouch consists of many layers of laminated materials. Most retort pouches are constructed as four laminates of different packaging films that can withstand high process temperature and pressure. The typical pouch has an outer polyester (polyethylene terephthalate) layer for heat resistance and printability, an aluminum foil layer as a barrier for oxygen and light, biaxial oriented nylon for resilience, and an inner layer of cast polypropylene for pack sealing [11]. An adhesive between each layer bind the materials. The pouch structure is illustrated in fig. 2.5.

These consist of laminated materials that provide an oxygen barrier as well as a moisture barrier. The advantage of retort pouch is allows faster heat transfer than the traditional metal or glass containers, with thin packaging and higher surface area to volume ratio than other container. Comparison for lethal rate and process time found that retort pouch can be achieved with a 30-50 % shorter processing time, compared to retorting of metal cans [12].

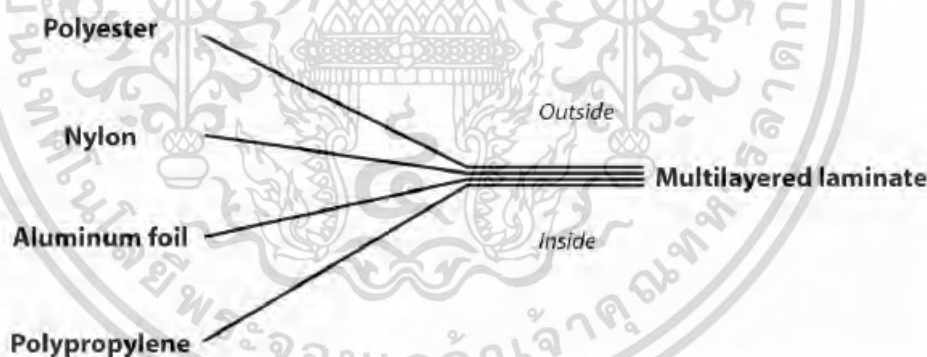


Figure 2.5 Cross-section sketch of retort pouch [13]

Before sealing the packages, the amount of inside air should be minimized to avoid negative effects on sensory properties and nutrient levels [32]. The risks of adverse effects from oxidation during processing and storage can be minimized by removing oxygen by vacuum suction (non-liquid products) or steam flushing. Removal of air has been shown to increase the shelf-life of retort products. In addition to reducing oxidation effects, e.g. on color and nutrients, it also reduces bacterial growth compared to aerobic packaging. What is more, minimizing the residual gas increases the heating rate of the product substantially and reduces the risk of pouch damage from gas expansion during heating [33].

The complete of pouch should be concerned to avoid puncture, breakage, oxygen entrance, migration of chemical compounds etc. The seal integrity can be

tested by conducting bursting tests by injecting gas under pressure, measuring seal thickness and testing seal strength. The suitability of the pouches can also be ascertained by measuring properties such as overall migration residue, sterility, process resistance and tensile strength at break [33]. The key bottlenecks that have been identified for retort pouches are entrapment of product at the seal interface and possible leaking channels allowing microbial invasion [12]. A contamination-free seal is crucial for the shelf-life [11].

Various types of pouch geometry are available, such as the *pillow pouch*, which consists of a rectangular-shaped container with one side left open for filling and subsequent sealing. Another pouch geometry is the *gusset pouch*, which is similar to the above but has a bottom on which the container can stand. Pouches are usually sterilized in over-pressure retorts. Retortable pouches have several advantages over traditional cans. Slender pouches are more easily disposed of than comparatively bulky cans. Shipping them is easier. In addition, the “fresher” retortable pouch product obviously required significantly less heat to achieve commercial sterility. Furthermore, cooking time is about half that required for traditional cans, resulting in tremendous energy savings. Now that retort pouches of low-acid solid foods appear to have attained some commercial acceptance and recognition of their superior quality and more convenient packaging, the expectation is that other heat-sterilized foods will appear in pouches, creating a new segment within the canned foods category [11].

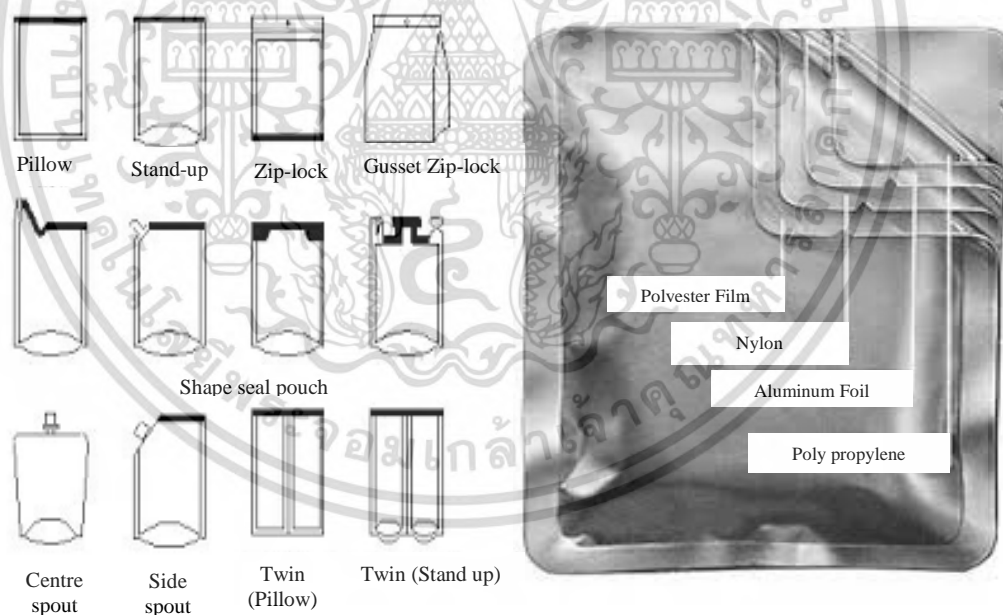


Figure 2.6 Retort Pouch
(Source: Holdsworth D, Simpson R [11])

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Table 2.4 Material specification of retort pouch used in this study (PPpack company)

Pouch Properties	Specification
Pouch Material	PET12/AL7/NY15/RCP80
Pouch Thickness	135 mm
Dimension	120 width 200 length
Side seal	10 mm
Bottom Seal	30 mm
Water test	PASS
Drop test	1.5 mm
Leak test	No leak - PASS

2.8 Heat Transfer in Canned Products

In canned foods, heat is mainly transferred by two basic mechanisms, convection and conduction. Therefore, the way in which products heat is major importance in determining the length of the sterilization process. Thermal conduction means heat transfer through the product is by direct contacting from molecule to molecule and there is no relative movement of any part of the product. The slowest heating point in the product is the geometric center of the container. In contrast, thermal convection is the phenomenon that heat is rapidly transferred by fluid movement due to a change in density as the liquid is heated. In fig. 2.7 shows the main modes for heat transfer in the processing of packaged foods are illustrated. The first mode is heat transfer to the container or packaging from the heating and cooling medium. The second mode of heat transfer is through the container wall. The third mode of heat transfer is into the product from the container wall. For products which are fluid product or solid-liquid food could be heated or cooled rapidly by convection, while other products which contain more solid mainly heated by conduction. However, a combination of conduction and convection is occurred and in some processes, a thermal convection is occurred at the beginning but finished with conduction mode because of physico-chemical changes. Thus the internal mechanisms of heat transfer are complicated [11].

In conventional cylindrical cans of a uniformly convecting product the slowest heating point is along the central vertical axis approximately 1/5 up from the base. In additional, mixed convection and conduction heating occurs when both conduction and convection have a significant effect on the rate of heat transfer to the slowest heating point. Products heated by mixed convection/conduction are usually two phase system, convection occurring in the liquid phase and conduction in the solid. The slowest heating point is usually at or near the center of the largest solid mass [34].

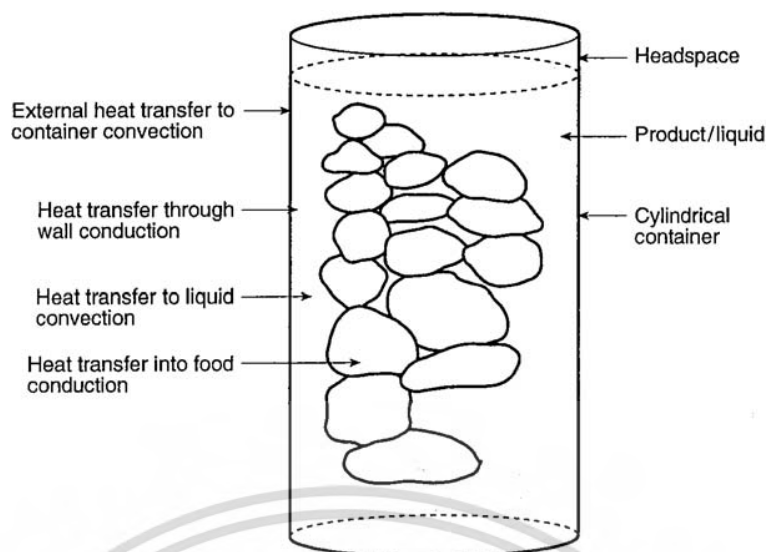


Figure 2.7 Heat Transfer in Canned Food [11]

The heat transfer mechanisms important for retort products are conduction and convection. In conduction, heat moves from one particle to another in more or less straight lines. This is the case in solid foods and other situations when the food does not move. Convection, on the other hand, involves movement of the food. Natural convection occurs when the heated parts of the food rises due to decreasing density, causing circulation within the product. The circulation speeds up the heat transfer throughout the entire product. Forced convection occurs when circulation is created mechanically, e.g. by agitation. In Thai food such as Gaeng Phed Gai in coconut milk, heating profile was convection heating motion due to the heat received through the package wall. In contrast, the solid pieces of chicken meat and bamboo shoots will only be heated by conduction of heat received from the surroundings. Convection heating is much more rapid, so the liquid is heated more quickly than the pieces [35].

2.9 Gathering Heat Penetration

Generation of heat penetration profile is important for establishing a thermal process. This involves carrying out experiments for measuring the time-temperature profiles at slowest point of heating for retort, liquid and food particles. Traditionally thermocouples are used for measuring temperature data. Thermocouple-based approaches for data gathering generally use various thermocouple connectors and extension wires to transport temperature signals to a data logger or data acquisition system. Inaccuracies in temperature measurements may result in errors in process evaluation; hence, frequent calibration is essential to provide reliable data. Thermocouples should be calibrated in place as part of the complete data acquisition system against a traceable calibration standard (thermometer, RTD, thermistor) [36-38].

2.10 CalSoft 5 Software

The CALSoft™ software was the one recognize software of thermal process evaluation which designed by TechniCAL company. This program could be use specifically for Process Authorities in the retorted canned foods industry. To do

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collect heat penetration data, thermocouple wire and CALPlex datalogger will be set together to collect heat penetration or temperature distribution test data. There are 32 channels of data. CALSoft's data, it showed temperatures and accumulated lethality values in real-time during the test CALSoft uses the Ball Formula for establishing thermal process schedules and evaluating process deviations. [39].

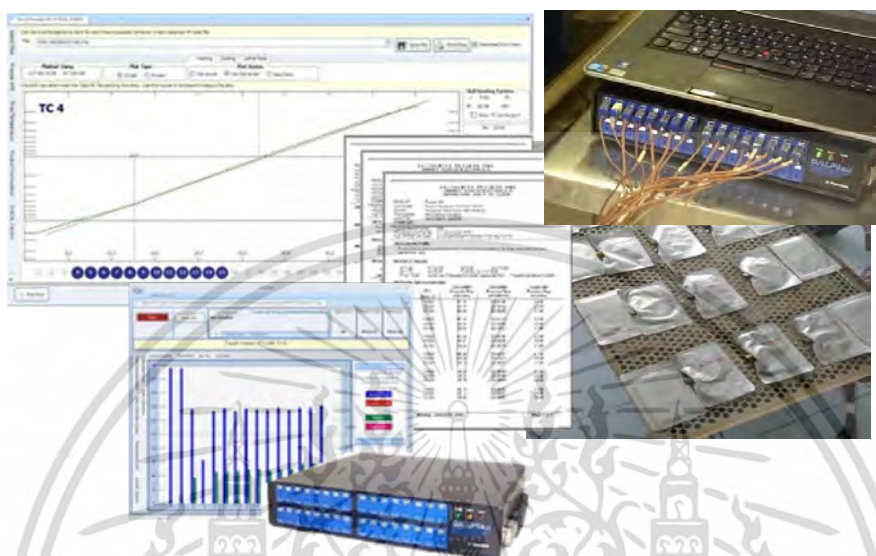


Figure 2.8 CALSoft™ software and CALPlex datalogger used for heat distribution test [39]

2.11 Heat Penetration Study and Product Quality

Besides microbiological concern, sensory and nutritional qualities of product must be also considered. The high temperature and time needed to achieve a shelf-stable product will cause reactions affecting the quality. The outcome of the thermal process depends on physical properties of the product, the size and shape of the packaging, the type of microorganisms present and their heat resistance. The effects are both of a qualitative and quantitative nature. Changes in appearance, taste and texture are examples of qualitative losses [12]. Advancements have been made through optimizing temperatures and reducing heating time. The retortable pouch is one of the advancements enabling rapid heating. [12].

Tawipat [40] studied fried rice with shrimp in retort pouch at target process $116\text{ }^{\circ}\text{C}$ for $F_0 = 5.1$ minute compared with $F_0 = 10.0$ and 15.2 min. The highest score of sensory test and color was processed product at $F_0 = 5.1$ min. It was the best score of appearance, color, taste, texture and overall acceptance and brightness.

Bindu et al. [5] studied heat penetration and evaluate the shelf life of RTE black clam (*Villorita cyprinoides*) product in indigenous retort pouch (12.5 μm polyester/ 12.5 μm aluminum foil/ 80 μm cast polypropylene). The results showed that the product processed by overpressure retort at target process $121\text{ }^{\circ}\text{C}$ for 44 min (equivalent $F_0 = 9$ min and cook value = 99) could be stored at ambient temperature ($28\pm 2\text{ }^{\circ}\text{C}$) for 12 months. These samples remained a good quality and still acceptance from taste panel.

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Shini et al.[41] study heat penetration of fish ball in curry in retort pouch 15×20 cm. (12.5µm PET/ 19µm Al foil/ 15µm biaxial oriented nylon/70µm CPP) which processed at target temperature 115 °C for $F_0 = 8$ and 6 min. The result found $F_0 = 6$ min was effective for commercial sterilization and quality of product was accepted by customer [41]. Charoen and Phingamngoen [6] studied the product developed 4 canned Thai foods (Moo-kra-tium, Pa-nang, Gaeng-Phed and Gaeng-jued) in 307×409 can . They were processed at 121 °C, $F_0 = 5$ min, the score of sensory test showed high likeliness score. Heating profile found low heating rate in the sample with high content of meat.

Gokhale and Lele [7] found that the initial temperature, retort temperature and solid content were the critical factors of heating process in commercial sterilization. Moreover, Mohan et al. [8] indicated that the type of oil affected the heating profile during commercial sterilization.

2.12 Product Quality Analysis

2.12.1 Color Measurement

Change of color is generally accompanied with flavor change and nutrient loss. Therefore, color can be used as an index for product quality. Hunter L, a, b and CIE 1976 $L^*a^*b^*$ (CIELAB) are both color scales based on the Opponent-Color Theory. This theory assumes that the receptors in the human eye perceive color as the following pairs of opposites. That could be measure in three scales; **L* scale:** Light vs. dark where a low number (0-50) indicates dark and a high number (51-100) indicates light, **a* scale:** Red vs. green where a positive number indicates red and a negative number indicates green. **b* scale:** Yellow vs. blue where a positive number indicates yellow and a negative number indicates blue [42].



Figure 2.9 ColorFlex EZ [42]

The delta values included ΔL , Δa , and Δb were often used for evaluate quality of product which indicate the change or different of color between standard and samples. The total color difference, ΔE , may also be calculated from as equation below;

$$\Delta E_{ab}^* = \sqrt{(L_2^* - L_1^*)^2 + (a_2^* - a_1^*)^2 + (b_2^* - b_1^*)^2} \quad (2.4)$$

2.12.2 Texture Analysis

Texture profile of food product could be analyzed by mechanical testing principle. This method use texture analyzer which measure texture properties by compression and tensile strength and evaluated for many properties, such as hardness, brittleness, spread ability, adhesiveness, tensile strength, extensibility etc. The application of texture analysis could be applied in food, cosmetics, pharmaceuticals, adhesives and other consumer products.

Texture analyzer have two models, there are TA.XTplus and TA.HDplus model. Analyzers could be select based on required test method which different probe and fixture. This machine works with fully integrated Exponent 32-bit software. To measure textural properties, each probe or fixture is designed or selected for a specific applications, and can be attached to the texture analyser's base and/or arm. Samples could be placed on the base of the texture analyser or on the lower fixture or held between two fixtures. Start compression test, the arm with load cell will be move down then compress on the product, after that will be return to setting initial position. [43]. Machines will be capturing force, distance and time data at a rate of up to 500 points per second which is then displayed by software related to setting parameter by single or multifunctional controlled instruments to carry out a wide range of measurements.

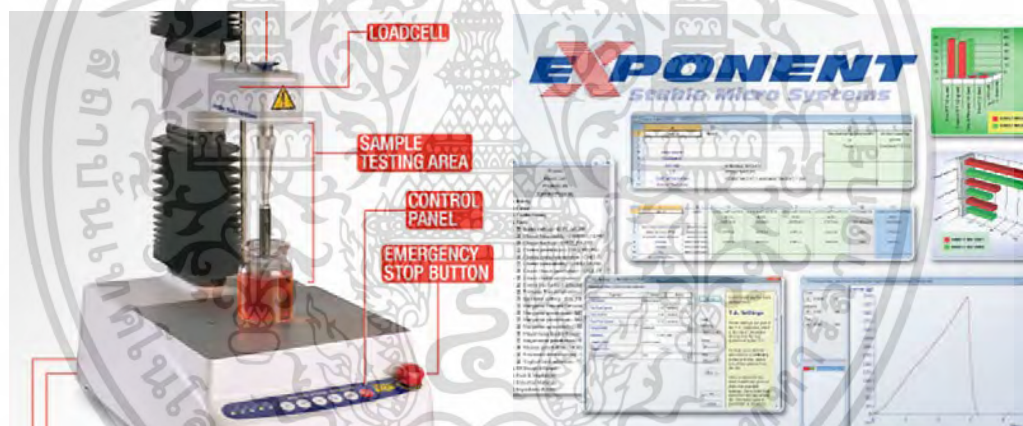


Figure 2.10 Texture Analyzer (TA.XT plus) [43]

One of popular evaluation method of texture profile is Texture Profile Analysis (TPA) by double compression test for determining the textural properties of foods. Sample will be compressed by twice times like a human chew then this method sometimes call “two-bite test” because the texture analyzer mimics the mouth's biting action. TPA parameter and textural properties as TPA analysis could be evaluate and calculate as shown in table 2.5 and fig. 2.11 [44].



Figure 2.11 Texture Profile Analysis (TPA) [44]

Table 2.5 Parameters in Texture Profile Analysis (TPA)

Parameters	Explanation	How Expressed	How Measured (Plot #2)
Hardness	The Hardness value is the peak force that occurs during the first compression. The hardness need not occur at the point of deepest compression, although it typically does for most products.	The maximum force of the 1st compression.	Same
Fracturability	Fracturability not have this value on all products. This point occurs where the plot has its first significant peak (where the force falls off) while the probe's first compression of the product.	The force at the first peak	Peak Force at F1
Cohesiveness	Cohesiveness is how well the product withstands a second deformation relative to its resistance under the first deformation.	The area of work during the second compression divided by the area of work during the first compression.	Area 2/Area 1 Optional (similar, not identical): Area 5/Area 4

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Table 2.5 Parameters in Texture Profile Analysis (TPA) (continued)

Parameters	Explanation	How Expressed	How Measured (Plot #2)
Springiness	Springiness is shown product physically springs back after it has been deformed during the first compression and has been allowed to wait for the target wait time between strokes. The spring back is measured at the down-stroke of the second compression. In some cases, an excessively long wait time will allow a product to spring back more than it might under the conditions being researched	Springiness is now expressed as a ratio or percentage of a product's original height. Springiness is measured several ways, but most typically, by the distance of the detected height during the second compression divided by the original compression distance.	Distance 2 / Distance 1 Optional (same value): Time 2/Time 1
Gumminess (semi-solids)	Gumminess applies only to semi-solid products and is calculated as Hardness \times Cohesiveness (which is Area 2/Area 1).	Hardness \times (Area 2/Area 1) Optional (similar value):Hardness \times (Area 5/Area 4)	Hardness \times Cohesiveness
Chewiness (solids)	Chewiness applies only to solid products and is calculated as Gumminess \times Springiness (which is Distance2/Distance1).	Gumminess \times Distance 2 / Distance 1	Hardness \times Cohesiveness \times Springiness
Resilience	Resilience is how well a product "fights to regain its original height". Resilience is measured on the withdrawal of the first penetration, before the waiting period is started. Resilience can be measured with a single compression; however, the withdrawal speed must be the same as the compression speed.	It is calculated by dividing the upstroke energy of the first compression by the down stroke energy of the first compression.	Area 4/Area 3

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Chapter 3

Materials and Methods

3.1 Machines and Equipment

- 1) Water Spray retort (KM Grand Pack with Allen-Bralley Panel view 550)
- 2) Standing retort pouch (120×170×25 mm.)(PET12/AL7/NY15/RCP80)
- 3) Raw materials: Pasteurized coconut milk (Chaokoh brand), blanched chicken cube 1.5×1.5×1.5 cm., turkey berry 1 cm diameter and fileted water
- 4) Dummy (retort pouch, water filled 110 g)
- 5) Digital scale
- 6) Vacuum sealing machine
- 7) CALPlex™ data logger (Techni Cal, Inc., USA)
- 8) Cal Soft 5 software (Techni Cal, Inc., USA)
- 9) Biological Indicator (Mesa Biological Indicators, ProSpore2, *G.stearothermophilus*)
- 10) Texture Analyzer (TA.XT plus, Stable Micro System)
- 11) Color Flex Ez Spectrophotometer

3.2 Overall Research Process

Overall process of the experiment is shown as Fig 3.1. Firstly, the temperature distribution of retort was investigated to set up the process step, including the retort temperature and time. The obtained steps were used for all experiments. The design of experiment (DOE) was conducted by Minitab® program. For finding the optimum condition of process time of chicken meat and turkey berry in coconut milk, the central composite design (CCD) with 2³ factorial design was used to design the treatment in this study as shown in 3.3.

Each material was prepared before filling in the 120×170×25 mm. retort pouch. Prepared materials with specified contents were packed in the retort pouch (fill weight 110 ± 2 g). After sealing, they were sterilized in the water spray retort and cooked at 121°C to achieve target sterilizing value of F₀ equivalent $F_0 = 4$ min. During processing, Cal Soft 5 thermal process software was used to evaluate the process time of each treatment from the heat penetration data. Colors and hardness of chicken cube and turkey berry were investigated. All data were used to statistically analyzed the regression and plotted the contour plots.

3.3 Temperature Distribution in Retort

The overpressure retort (1 trolley with 10 layers, KM Grand Pack, Thailand) with PLC control system was used for thermal processing. Two hundreds pouches of dummy (110 ± 2 g water in retort pouch) were loaded into the retort. Twelve thermocouples were placed in different location as shown in fig. 3.2 to evaluate the cold zone. Minimum flow rate around 27.6-27.9 l/s and minimum steam pressure 8 bar before starting come up step were controlled. PLC setting program was used to control process step of heat penetration test (table 2.1). The temperature distribution obviously showed that there were no cold zone.

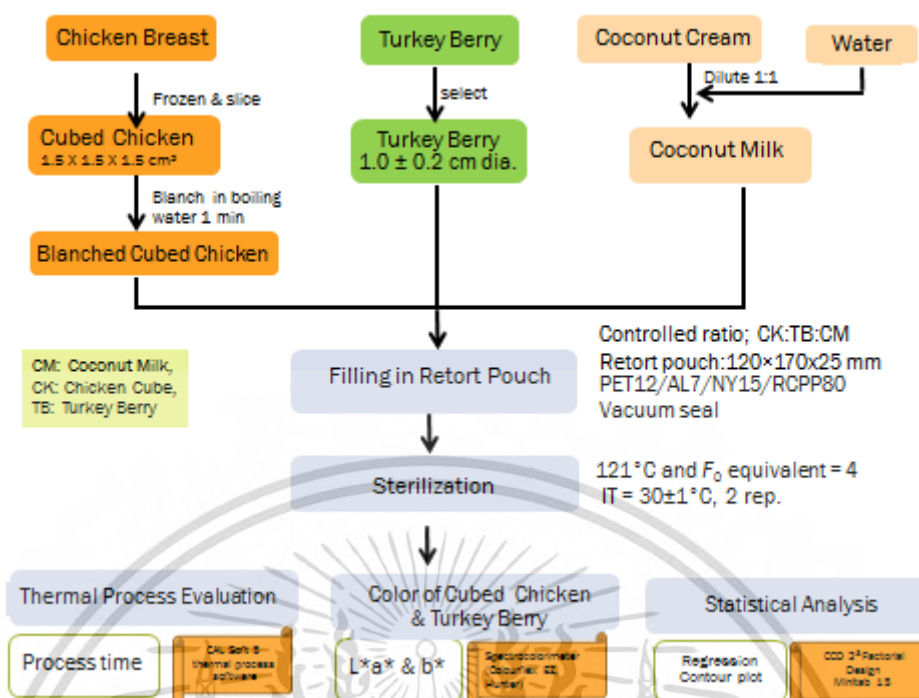


Figure 3.1 Flow diagram

3.4 Raw Material Preparation

Chicken breast, turkey berry and pasteurized coconut cream were used in this research. The chicken breast was cut into 1.5×1.5×1.5 cm³ cube and then blanched in boiling water for 1 minute (core temperature 65± 3 °C). The coconut milk was prepared by diluting the pasteurized coconut cream (Chao koh brand, 16% fat) with water at the ratio of 1:1. The diameter of turkey berry was controlled at 1.0 ± 0.1 cm. The compositions of curry were studied by varying the contents of chicken meat, turkey berry and coconut milk as shown in table 3.3. Laminated standing retort pouches used in this study shown in table 3.1 were PET12/AL7/NY15/RCP80. The dimension of retort pouch was 120×170×25 mm. Pouch thickness, sides seal and bottom seal were 135, 10 and 30 mm., respectively. The curry was filled in the retort pouch and vacuum sealed before sterilization.

3.5 Sterilization Value (F_0) for chicken meat and turkey berry in coconut milk

The sample selected for this experiment was the highest content of solid food which was the sample in treatment number 15 in Table 3.1 containing 46.8% chicken meat, 12.5% turkey berry, 35% coconut milk and 5.7% water. Five samples were prepared as described in 3.2. Thermocouple needles were used to measure the core temperature of chicken cube. Each sample contains 1 piece of biological indicator (Mesa Biological Indicators, ProSpore2, *G. stearothermophilus*). During sterilization the temperature of chicken cube was monitored and calculated the accumulated F_0 in real time using Calsoft 5 software. After the F_0 reached the target $F_0 = 4$ min, the process step was switched to cooling one. The test was conducted in duplicate.

Table 3.1 Pouch properties

Pouch Properties	Specification
Pouch Material	PET12/AL7/NY15/RCPP80
Pouch Thickness	135 mm
Dimension	120 mm width and 170 mm length
Side seal	10 mm
Bottom Seal	30 mm
Water test	PASS
Drop test	1.5 mm
Leak test	No leak – PASS

3.6 Heat Penetration Test and Thermal Process Evaluation

Thermocouples type T connected to a 32-channel CALPlex™ data logger (TechniCal, Inc., USA) via type T extension wire (Ecklund Harrison Technologies, USA) were used to measure and record the temperature of retort and products during sterilization. The data collection was interval scanned every 15 sec, all leads and thermocouple were calibrated against a reference MIG thermometer (TID) before testing. The 4.3 cm Thermocouple needles were used to measure the core temperature of chicken cube which located at center of retort pouch. The samples were controlled initial temperature at $30 \pm 2^\circ\text{C}$. Heat penetration was done in duplicate. The results were evaluated by CAL Soft 5 thermal process software for process time by formula method (Ball method) used 42% CUT credited.

3.7 Colors Analysis

Colors of chicken meat and turkey berry were measured using Spectrocolorimeter (Colourflex EZ, Hunter Associates Laboratory, Inc.) A glass cell containing the ground chicken and peeled turkey berry. L^* a^* b^* value were recorded. Each treatment was analyzed in triplicate. See appendix-C for setting equipment and parameter. Calculated ΔE^* for the total color different.

3.8 Texture Analysis

Texture profile of chicken meat and turkey berry were measured using Texture Analyzer (TA.XT plus, Stable Micro System). Texture profile of chicken cube was analyzed by TPA setting and turkey berry used return to start setting. See appendix-C for setting equipment and parameter.

3.9 Response Surface Regression and Optimization Analysis

The response surface regression and contour plot were analyzed by Minitab program. Empirical equation were done. Optimizer response tool in this software was used to optimize the process time of chicken meat and turkey berry in coconut milk curry (green curry based). The criteria for verifying base on the optimum percentage of solid content (chicken meat and turkey berry) related to Thai FDA regulation, food law 355 B.E. 2556 (2013) for *Food in a Hermetically Sealed Container*. Green curry should be more than 55% drain weight. Then starting point for the optimization was 40.0% chicken meat, 15.0% turkey berry, 45.0% green curry (25%coconut milk). Target process time was 8 minutes. Response optimization were analysis. Prepared samples for heat penetration test as global solution to verify the empirical equation.

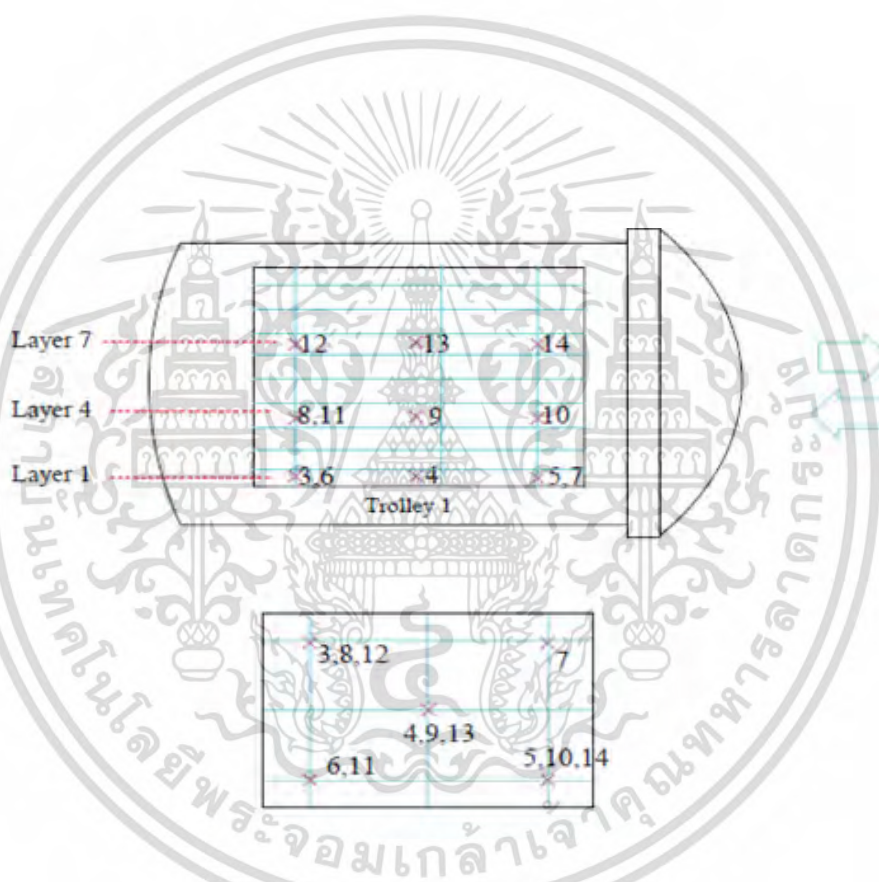


Figure 3.2 Location of Thermocouples
Number 1-12 are the number of thermocouples

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Table 3.2 PLC setting program.

Step*	Controller Setting* temperature (°C)	Set time* (min)	Pressure* (bar)	Action
CUT 1	90	5	0.8	CUT 1
CUT 2	121	6	2.0	CUT 2
CUT 3	121	2	2.0	CUT 3
STERIZE	121	Process time	2.0	Sterilization
Cool 1	105	4	1.6	Cooling
Cool 2	90	4	1.0	Cooling
Cool 3	70	5	1.0	Cooling
Cool 4	60	3	0.5	Cooling
Cool 5	40	3	0.2	Cooling
Cool 6	30	5	0.05	Cooling

Table 3.3 Treatment at different curry composition

Treatment	Code Unit			(CM)	(CK)	(TB)	(W)
	<u>A</u>	<u>B</u>	<u>C</u>	%	%	%	%
1	0	0	0	35.0	30.0	12.5	22.5
2	0	0	-1.68	35.0	30.0	8.3	26.7
3	0	0	0	35.0	30.0	12.5	22.5
4	1	-1	1	45.0	20.0	15.0	20.0
5	0	-1.68	0	35.0	13.2	12.5	39.3
6	1	1	1	45.0	40.0	15.0	0.0
7	-1	1	-1	25.0	40.0	10.0	25.0
8	0	0	0	35.0	30.0	12.5	22.5
9	1	-1	-1	45.0	20.0	10.0	25.0
10	0	0	0	35.0	30.0	12.5	22.5
11	-1.68	0	0	18.2	30.0	12.5	39.3
12	1	1	-1	45.0	40.0	10.0	5.0
13	-1	-1	1	25.0	20.0	15.0	40.0
14	1.68	0	0	51.8	30.0	12.5	5.7
15	0	1.68	0	35.0	46.8	12.5	5.7
16	-1	-1	-1	25.0	20.0	10.0	45.0
17	-1	1	1	25.0	40.0	15.0	20.0
18	0	0	0	35.0	30.0	12.5	22.5
19	0	0	1.68	35.0	30.0	16.7	18.3
20	0	0	0	35.0	30.0	12.5	22.5

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Chapter 4

Results and Discussion

4.1 Sterilization Value for Chicken Meat and Turkey Berry in Coconut Milk

The results of five samples in two test run (46.8% chicken meat, 12.5% turkey berry, 35% coconut milk and 5.7% water) which contain biological indicator (Mesa Biological Indicators, ProSpore2, *G. stearothermophilus*) are shown as table 4.1. It was found that at the end of heating (EOH), F_0 approximately 4 min. From experimental data, it was found that the temperature of retort was slowly cooled down in cooling period of process, because of the heat accumulation in the product. Therefore, the high value of F_0 was detected at the end of process ($F_0 = 6 - 9$). Final F_0 at the end of heating (EOH) was effective for commercial sterilization.

Table 4.1 Sterilization value

Test Run	Sample	Sterilization level $F_0 = 4$ minutes		BI Result
		F_{0at} EOH (min)	F_{0at} EOP (min)	
1	1	4.06	6.48	Positive (+)
	2	4.05	7.31	Positive (+)
	3	4.16	9.30	Positive (+)
	4	4.06	6.48	Positive (+)
	5	4.12	9.46	Positive (+)
2	1	4.15	9.52	Positive (+)
	2	4.17	9.23	Positive (+)
	3	4.05	7.55	Positive (+)
	4	4.12	9.47	Positive (+)
	5	4.07	6.78	Positive (+)

Remark: EOH = Ending of heat period,
EOP = Ending of process (after finish retorted)

4.2 Heat Penetration and Process Time Evaluation

As a result, increasing amount of chicken cube led to increase the process time. The amount of chicken showed the significant effects on the process time (p -value < 0.05)(table 4.8).

Process time of samples containing different amounts of chicken, coconut milk and turkey berry which were processed at the same F_0 (target $F_0 = 4$ min) shown in table 3.1. The process time obtained from different treatments were varied from 5 to 12 min. The contour plot of process time is shown in fig. 4.3 as the same direction. Increasing amount of chicken meat resulted in an increase of process time (fig. 4.3a)

while a slight increase of process time was observed with an increase of turkey berry amount (fig. 4.3b).

Process time was based on the thermal properties of food and chemical compositions which effect to heat transfer into the food. For transient heat transfer, the important thermo-physical property is thermal diffusivity (α) which appear in Fourier equation [11]:

$$\frac{\partial T}{\partial \theta} = \alpha \left[\frac{\partial^2 T}{\partial x^2} + \frac{\partial^2 T}{\partial y^2} + \frac{\partial^2 T}{\partial z^2} \right] \quad (4.1)$$

where x, y, z are rectangular coordinates, T is temperature, and θ is time (sec). Thermal diffusivity can be defined as follows;

$$\alpha = \frac{k}{\rho c} \quad (4.2)$$

where α is thermal diffusivity, k is thermal conductivity, ρ is density, and c is specific heat.

The heat transfers into chicken meat and turkey berry in coconut milk product were conduction and convection. The solid pieces of chicken were heated by a conduction of heat received from the medium. When there is relative motion between the solid and surrounding medium by free convection heating [45]. For explanation of calculation F_0 by Ball formula method, f_h is the time for one log cycle reduction expressed in minutes. The value of f is depend on thermal properties in particular the thermal diffusivity as equation 4.2 and 4.3 which applied for the conduction heat transfer in can and pouch respectively [11].

$$f = \frac{2.303}{\alpha \left[R_1^2 / a^2 + \pi^2 / 4b^2 \right]} \quad (4.3)$$

$$f = \frac{0.933}{\left[\alpha(1/a^2 + 1/b^2 + 1/c^2) \right]} \quad (4.4)$$

However, thermal diffusivity is relates to the thermal conductivity (k) which effect to conduction heat transfer rate to the temperature gradient. As moisture content in food was important factor of thermal conductivity value, then k value of water and coconut milk were higher than chicken meat and turkey berry. The result showed that the longest process time (12 min) was found in the sample contained 46.8% chicken, 12.5% turkey berry and 35% coconut milk which affected from highest solid content that main heat transfer of conduction heating [6]. However, thermal convection was much more rapid, resulting that the liquid was heated quicker than solid [6]. For convection heat transfer, f value could explain as equation 4.5. In table 4.2 shown f_h value in different treatments which high f_h value in high solid content treatment.

$$f = 2.303 / K = \frac{2.303 c_p \rho v}{UA} \quad (4.5)$$

where U is the overall heat-transfer coefficient, A is the internal surface area of the container, c_p is the specific heat and ρ is the density. As compare between No. 3 and No. 12 in table 4.2, found the increasing of chicken cube was effect to process

time because of chicken was low thermal conductivity ($k = 0.366 \text{ W/m K}$) [46] then low value of thermal diffusion, resulted to high f_h value in high chicken content treatment.

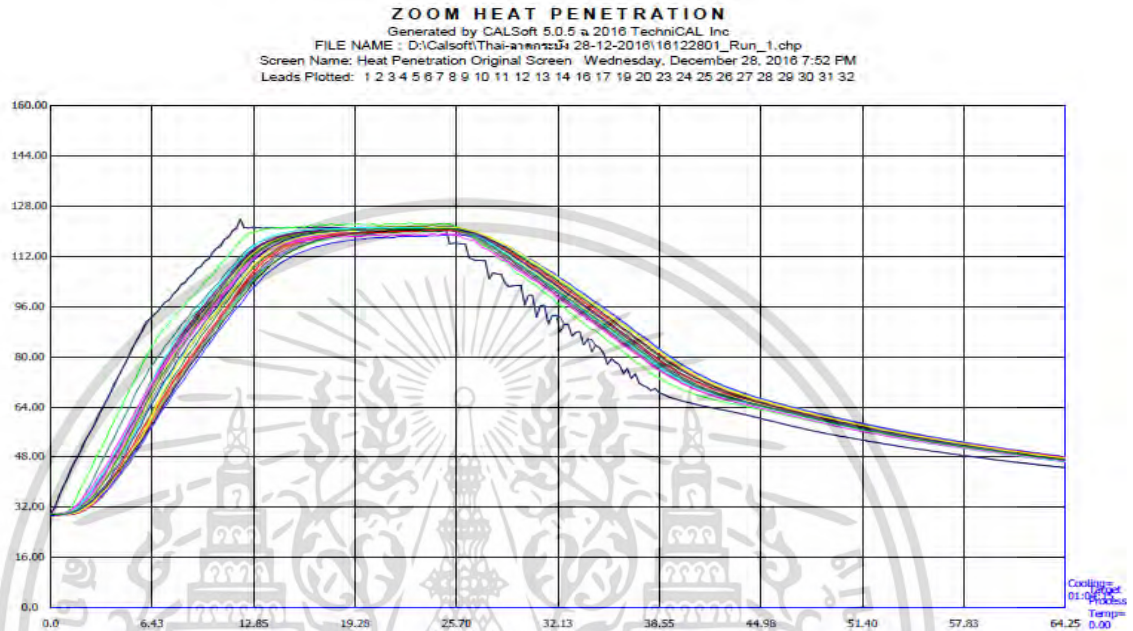


Figure 4.1 Heat penetration profile at the different amount of chicken meat, coconut milk and turkey berry.

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 ไม่ว่ากรณีใดๆ ทั้งสิ้น อีกทั้งห้ามมิให้ดัดแปลงเนื้อหา และต้องอ้างอิงถึงเจ้าของเอกสารทุกครั้งที่มีการนำไปใช้

Table 4.2 Process time at the different amount of chicken meat, coconut milk and turkey berry.

No.	Chicken (%)	Turkey Berry (%)	Coconut milk (%)	Solid (%)	Liquid (%)	Maximum Process Time (min), $F_0=4$ min	Heating Factor (Ball Method)			
							j	f_h	f_2	X_{bh}
1	13.20	12.50	35.00	25.70	74.30	6	1.12-1.32	4.77-5.75		
2	20.00	10.00	25.00	30.00	70.00	7	0.31-0.44	9.55-10.49	2.33-3.32	2.66-3.86
3	20.00	10.00	45.00	30.00	70.00	7	0.97-1.24	4.62-4.86		
4	20.00	15.00	45.00	35.00	65.00	6	1.30-1.19	4.43-4.60		
5	20.00	15.00	25.00	35.00	65.00	6	0.71-1.24	3.94-6.01	36.48	9.57
6	30.00	8.30	35.00	38.30	61.70	7	0.62-1.21	4.21-5.46		
7	30.00	12.50	18.20	42.50	57.50	8	0.67-1.46	4.18-5.52		
8	30.00	12.50	35.00	42.50	57.50	6	0.63-1.46	4.43-7.62	16.37	7.82
9	30.00	12.50	51.80	42.50	57.50	7	0.83-0.94	6.20-7.11		
10	30.00	16.70	35.00	46.70	53.30	9	0.66-1.29	6.31-6.73		
11	40.00	10.00	25.00	50.00	50.00	8	0.99-1.23	4.72-5.88		
12	40.00	10.00	45.00	50.00	50.00	8	0.97-1.25	5.46-6.28	11.67	8.7
13	40.00	15.00	25.00	55.00	45.00	9	0.67-1.27	5.96-7.64		
14	40.00	15.00	45.00	55.00	45.00	8	0.79-0.91	6.87-7.53		
15	46.80	12.50	35.00	59.30	40.70	12	0.71-0.90	8.44-11.01	23.90-30.52	10.76-11.40

Remark: CK=Cubed chicken, TB=Turkey Berry, CM=Coconut Milk, W=Water
 Factor of Ball calculation method; j , f_h , f_2 , X_{bh}

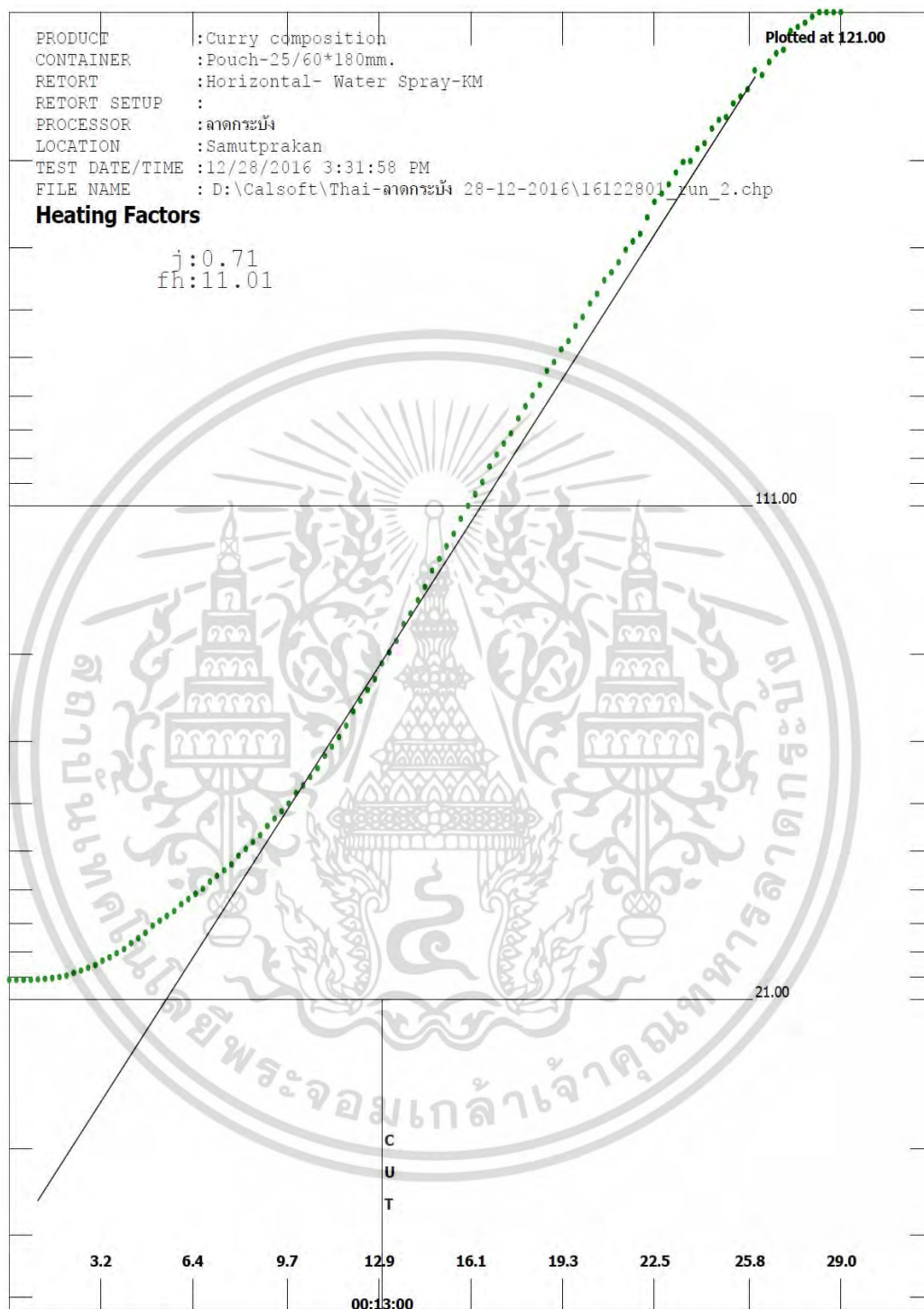


Figure 4.2 Semi-logarithmic curve of slowest process time treatment (Treatment 15) consist 46.8% chicken, 12.5% turkey berry and 35% coconut milk.

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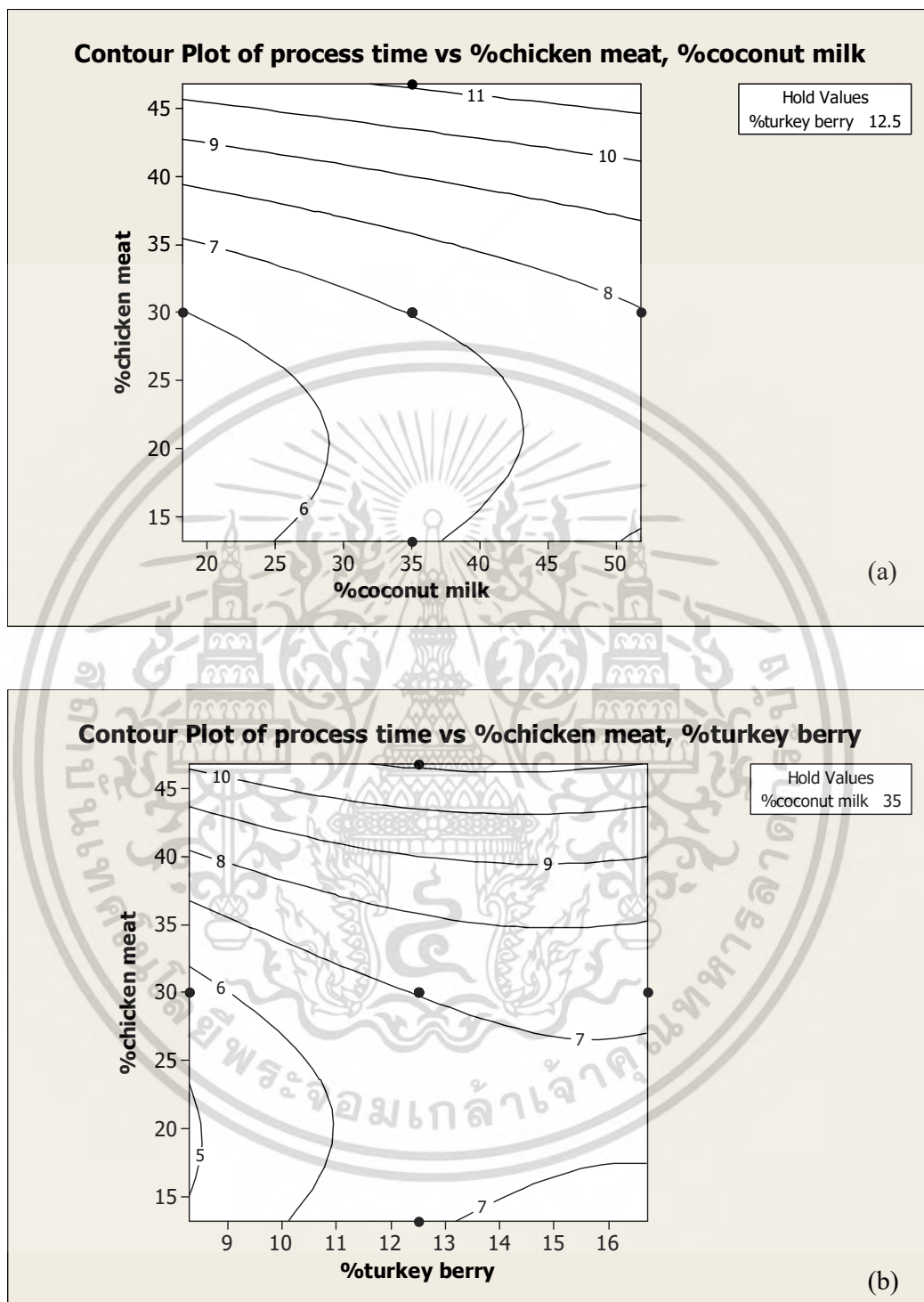


Figure 4.3 Contour plot of process time (a) process time versus chicken meat and coconut milk (b) process time versus chicken meat and turkey berry.

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4.3 Color Value (L*, a* and b*) of Chicken Cube and Turkey Berry

Color value of sample shown in table 4.3. The ranges of L* value of chicken and turkey berry were from 67.15 to 73.11 and from 38.32 to 44.76, respectively. The amount of chicken showed the significant effects on the L* value of both chicken and turkey berry (p-value < 0.05). The interaction effect between coconut milk and turkey berry contents was found in the L* value of turkey berry (table 4.7).

The contour plots of color of chicken and turkey berry are shown in Figure 4.4 to 4.9, respectively. It was observed with an increase amount of chicken amount and turkey berry led to an increase of process time which affect to increasing of L* and b* value of chicken meat (fig. 4.4 and fig. 4.6). It was possibly due to the leaching of muscle pigment and a denaturation of myoglobin [47]. L*value of turkey berry was found to be reduced (fig. 4.8). The darker turkey berry (decreasing L* value) was detected when process time increased because of the chemical changes in chlorophyll molecules [49].

Table 4.3 Color value (L*, a* and b*) at the different amount of chicken meat, coconut milk and turkey berry.

Treatment	% (CK)	% (TB)	% (CM)	% (W)	L* (CK)	a* (CK)	b* (CK)	L* (TB)	a* (TB)	b* (TB)
1	30.0	12.5	35.0	22.5	69.32	0.45	15.51	42.04	1.464	38.06
2	30.0	8.3	35.0	26.7	72.93	0.81	16.75	41.50	0.870	36.04
3	30.0	12.5	35.0	22.5	69.61	0.49	15.63	41.40	1.420	37.38
4	20.0	15.0	45.0	20.0	68.87	0.44	14.47	42.04	0.664	34.66
5	13.2	12.5	35.0	39.3	70.21	0.31	14.61	44.37	1.107	38.50
6	40.0	15.0	45.0	0.0	72.44	0.40	15.30	41.20	0.940	37.19
7	40.0	10.0	25.0	25.0	72.46	0.65	16.26	39.50	1.070	35.93
8	30.0	12.5	35.0	22.5	69.89	0.42	15.66	41.37	1.39	37.27
9	20.0	10.0	45.0	25.0	68.92	0.62	14.95	44.76	1.03	34.61
10	30.0	12.5	35.0	22.5	70.30	0.38	15.62	41.27	1.35	37.09
11	30.0	12.5	18.2	39.3	68.27	0.22	14.44	42.04	1.18	42.13
12	40.0	10.0	45.0	5.0	72.66	0.94	16.84	41.19	0.75	36.19
13	20.0	15.0	25.0	40.0	69.68	0.26	14.35	43.40	1.13	39.46
14	30.0	12.5	51.8	5.7	73.11	0.56	15.28	38.32	0.90	36.87
15	46.8	12.5	35.0	5.7	71.74	0.31	15.37	39.46	1.11	35.93
16	20.0	10.0	25.0	45.0	67.15	0.39	14.31	42.78	1.01	32.99
17	40.0	15.0	25.0	20.0	72.36	0.69	15.84	43.48	0.930	36.13
18	30.0	12.5	35.0	22.5	70.34	0.38	15.65	40.91	1.30	36.10
19	30.0	16.7	35.0	18.3	71.31	1.06	15.42	41.75	0.93	37.51
20	30.0	12.5	35.0	22.5	70.41	0.36	15.62	41.13	1.32	36.52

Remark: CK=Cubed chicken, TB=Turkey Berry, CM=Coconut Milk, W=Water

Table 4.4 shown the ΔE of sample at the different amount of chicken meat, turkey berry in coconut milk. ΔE of chicken color were varied from 4.79 to 10.80. There are high different color different (ΔE) compared with controlled sample in high amount chicken content sample. From regression analysis shown significant effects from chicken meat content (p-value < 0.05). However, ΔE of turkey berry color slightly different. There are not significant. The contour plots of ΔE of chicken and turkey berry color are shown in Fig 4.7 and 4.11, respectively. The calculation of ΔE were calculation from the different of lightness value, a value and b value as equation 2.4 in chapter 2. Then even treatment No.16 was low process time, however it was the most ΔE chicken because the effect from all three value.

Table 4.4 ΔE at the different amount of chicken meat, coconut milk and turkey berry.

Treatment	Solid (%)	Liquid (%)	Coconut Milk (%)	Chicken (%)	Maximum Process Time (min), $F_0=4$	ΔE Chicken	ΔE Turkey Berry
15	59.32	40.68	35.00	46.82	12	6.19±0.35	28.85±0.12
14	42.50	57.50	51.82	30.00	9	4.79±0.28	29.86±0.16
6	55.00	45.00	45.00	40.00	9	5.49±0.16	29.04±0.11
19	46.70	53.30	35.00	30.00	8	6.55±0.33	29.05±0.08
7	50.00	50.00	25.00	40.00	8	5.52±0.14	28.72±0.12
12	50.00	50.00	45.00	40.00	8	5.41±0.46	28.72±0.12
17	55.00	45.00	25.00	40.00	8	5.54±0.22	27.97±0.09
5	25.68	74.32	35.00	13.18	7	7.74±0.41	28.86±0.07
4	35.00	65.00	45.00	20.00	7	9.07±1.66	28.03±0.46
1	42.50	57.50	35.00	30.00	7	8.57±0.30	28.84±0.45
3	42.50	57.50	35.00	30.00	7	8.28±0.32	28.69±0.35
8	42.50	57.50	35.00	30.00	7	8.01±0.48	28.67±0.34
10	42.50	57.50	35.00	30.00	7	7.61±0.41	28.64±0.36
18	42.50	57.50	35.00	30.00	7	7.57±0.30	28.32±0.31
20	42.50	57.50	35.00	30.00	7	7.50±0.40	28.42±0.23
9	30.00	70.00	45.00	20.00	6	8.96±0.32	26.94±0.07
13	35.00	65.00	25.00	20.00	6	8.30±0.33	29.54±0.10
2	38.30	61.70	35.00	30.00	6	5.12±0.15	28.46±0.06
11	42.50	57.50	18.18	30.00	6	9.68±0.43	31.38±0.18
16	30.00	70.00	25.00	20.00	5	10.80±0.12	26.79±0.65

Remark: CK=Cubed chicken, TB=Turkey Berry, CM=Coconut Milk, W=Water

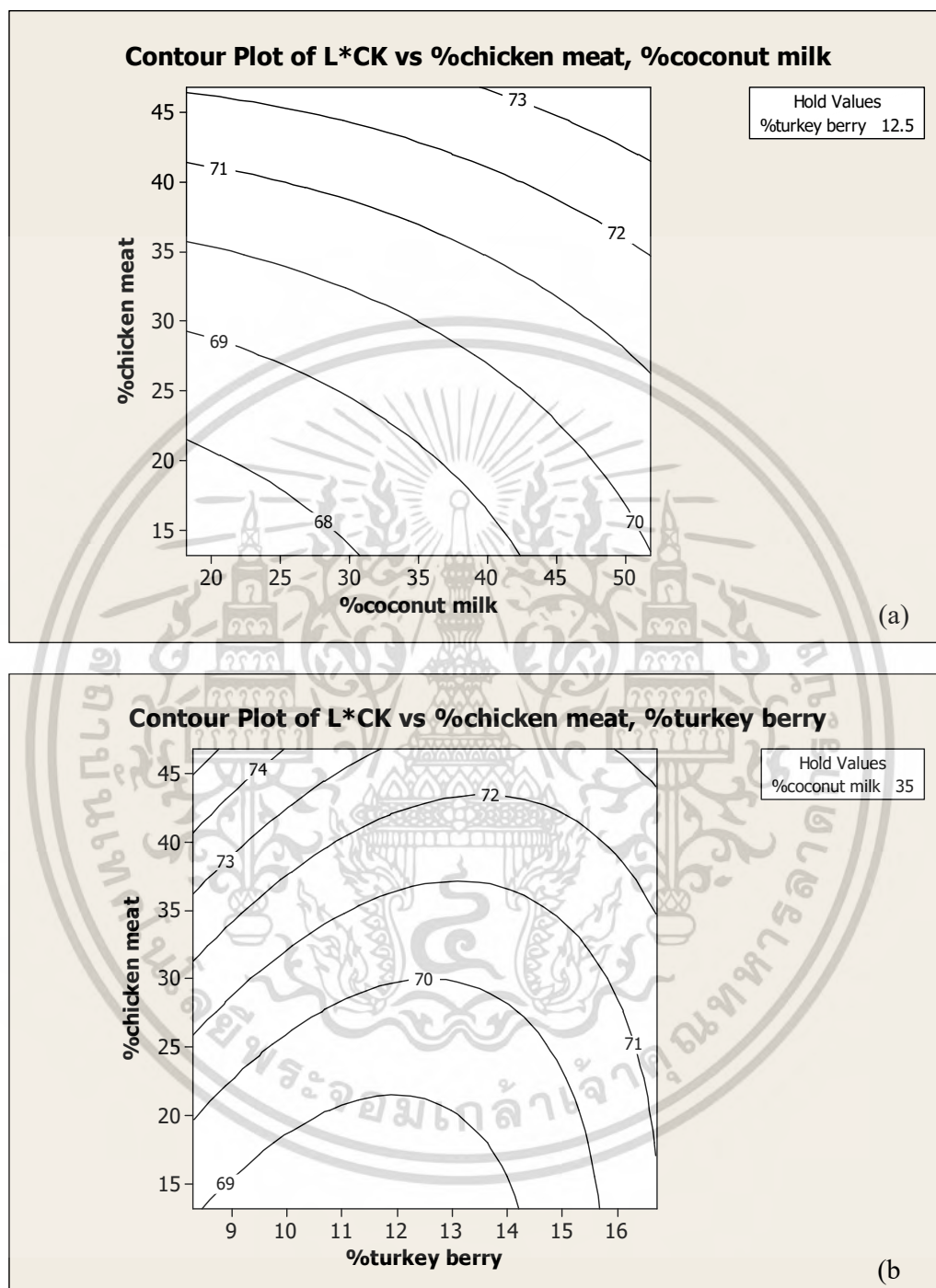


Figure 4.4 Contour plot L* value of chicken meat (a) L* value versus CK and CM (b) L* value versus CK and TB

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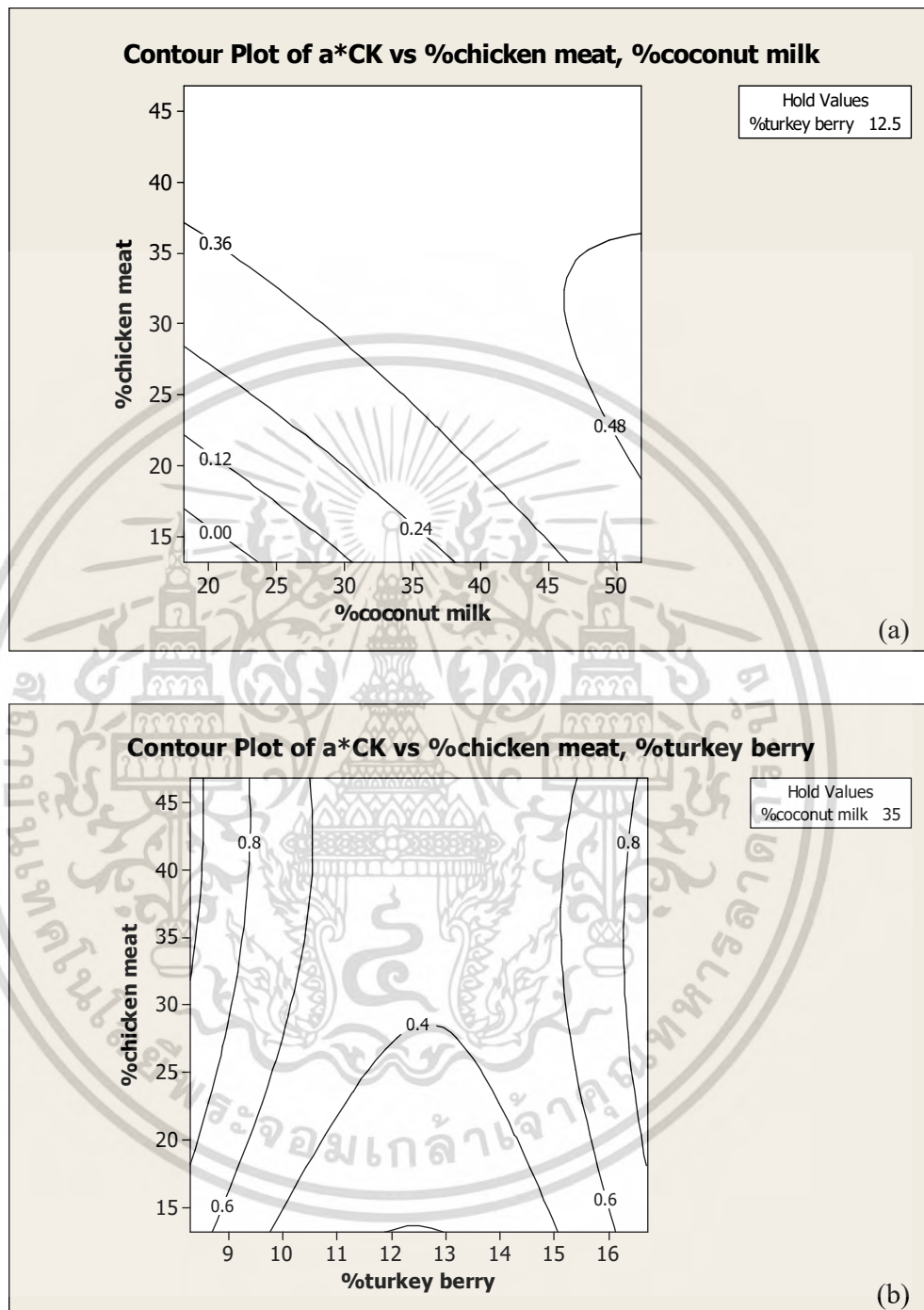


Figure 4.5 Contour plot a* value of chicken meat (a) a* value versus CK and CM (b) a* value versus CK and TB

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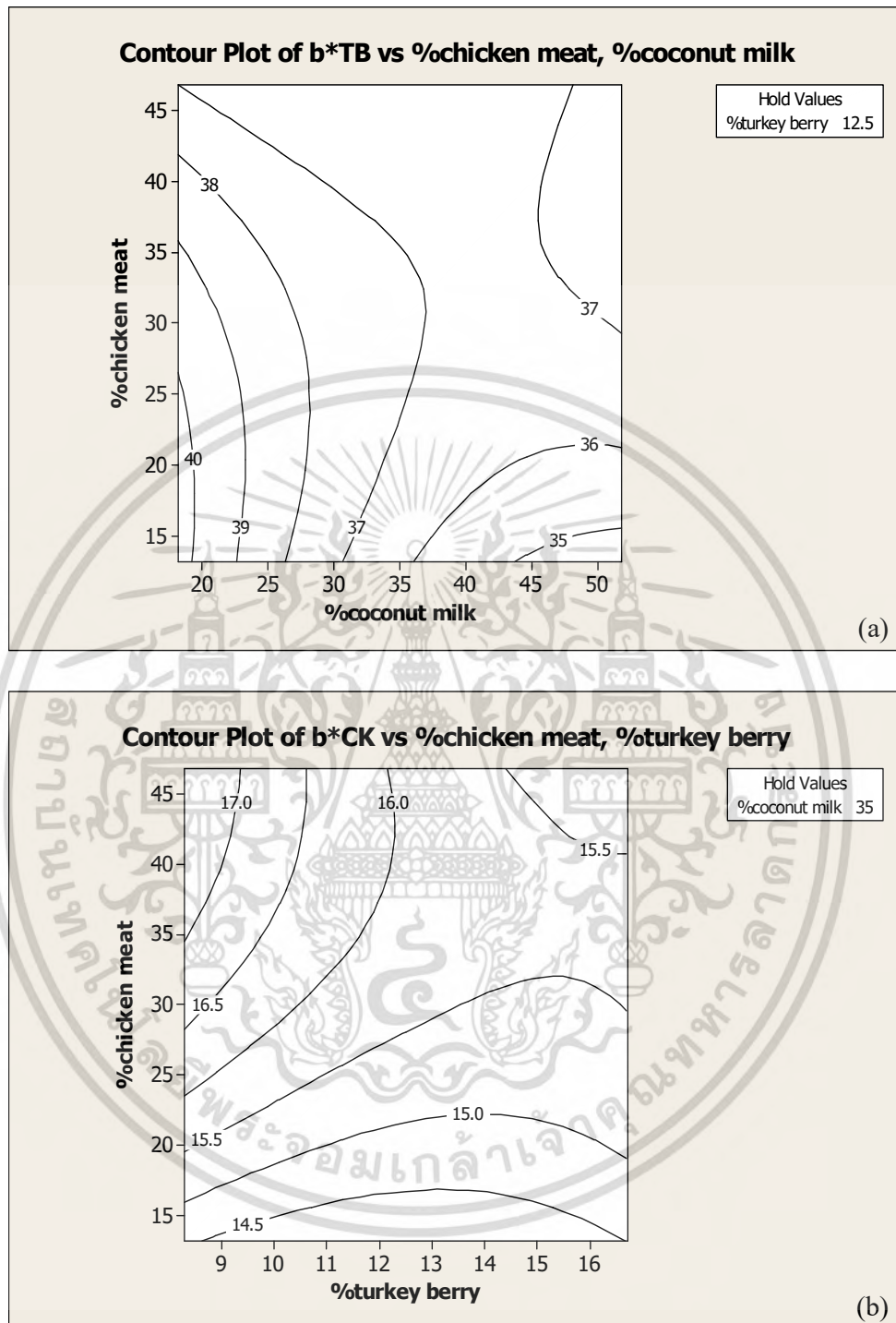


Figure 4.6 Contour plot b^* value of chicken meat (e) b^* value versus CK and CM (f) b^* value versus CK and TB.

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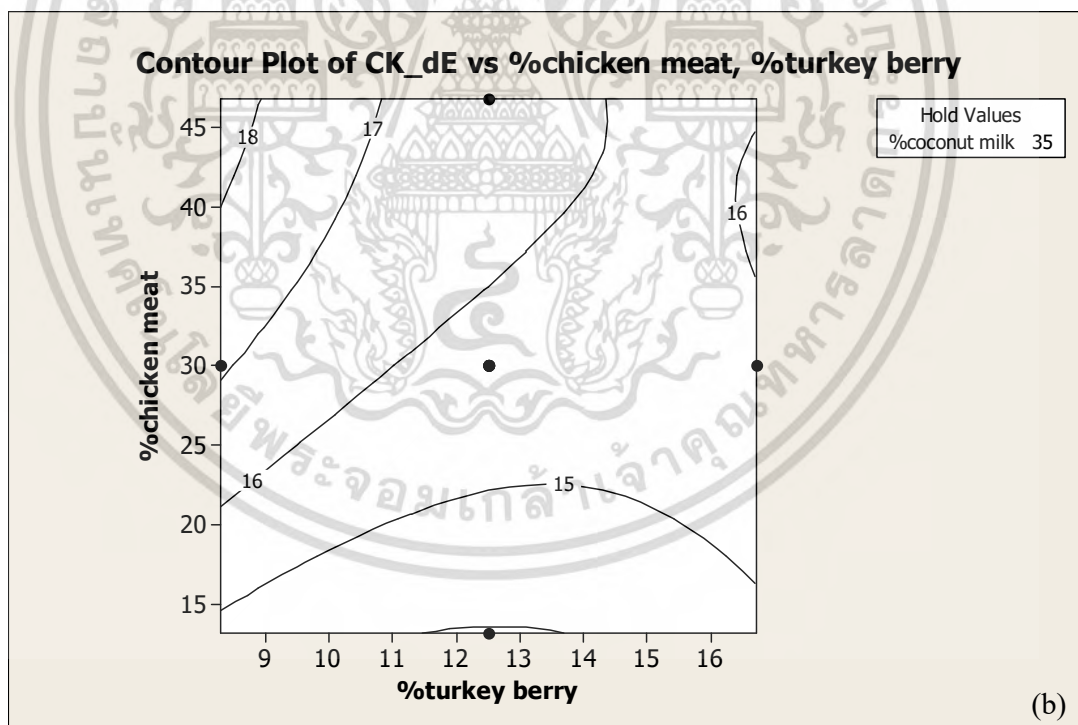
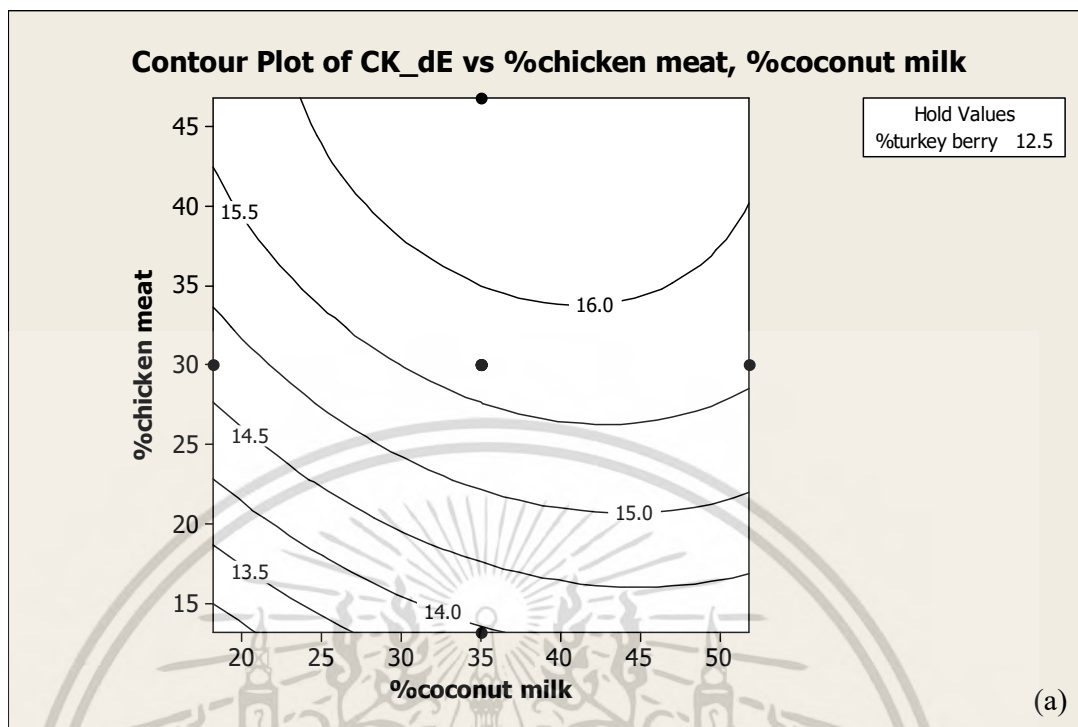


Figure 4.7 Contour plot delta E* value of chicken meat (a) ΔE^* value versus CK and CM (b) ΔE^* value versus CK and TB.

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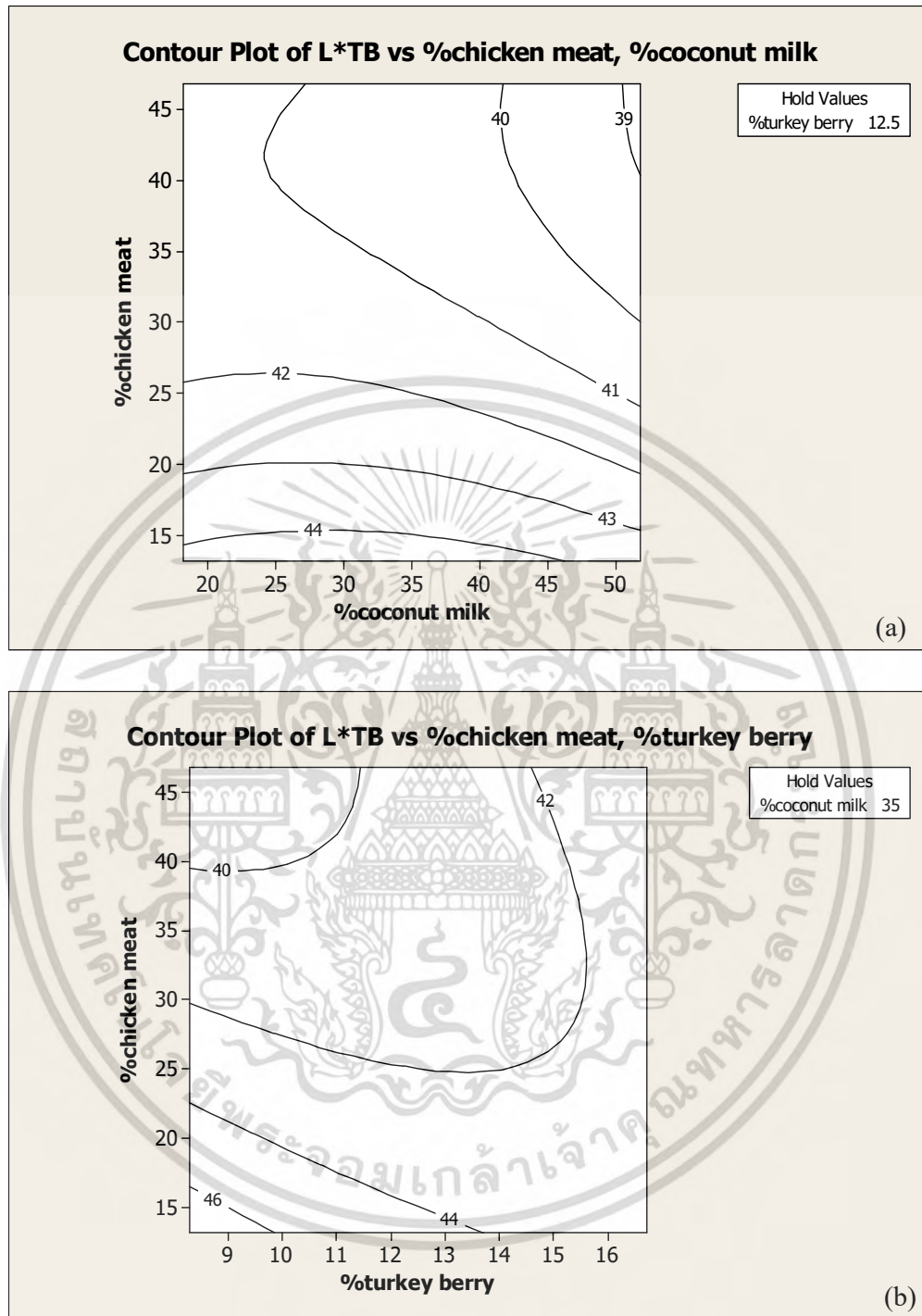


Figure 4.8 Contour plot L* value of turkey berry (a) L* value versus CK and CM
(b) L* value versus CK and TB

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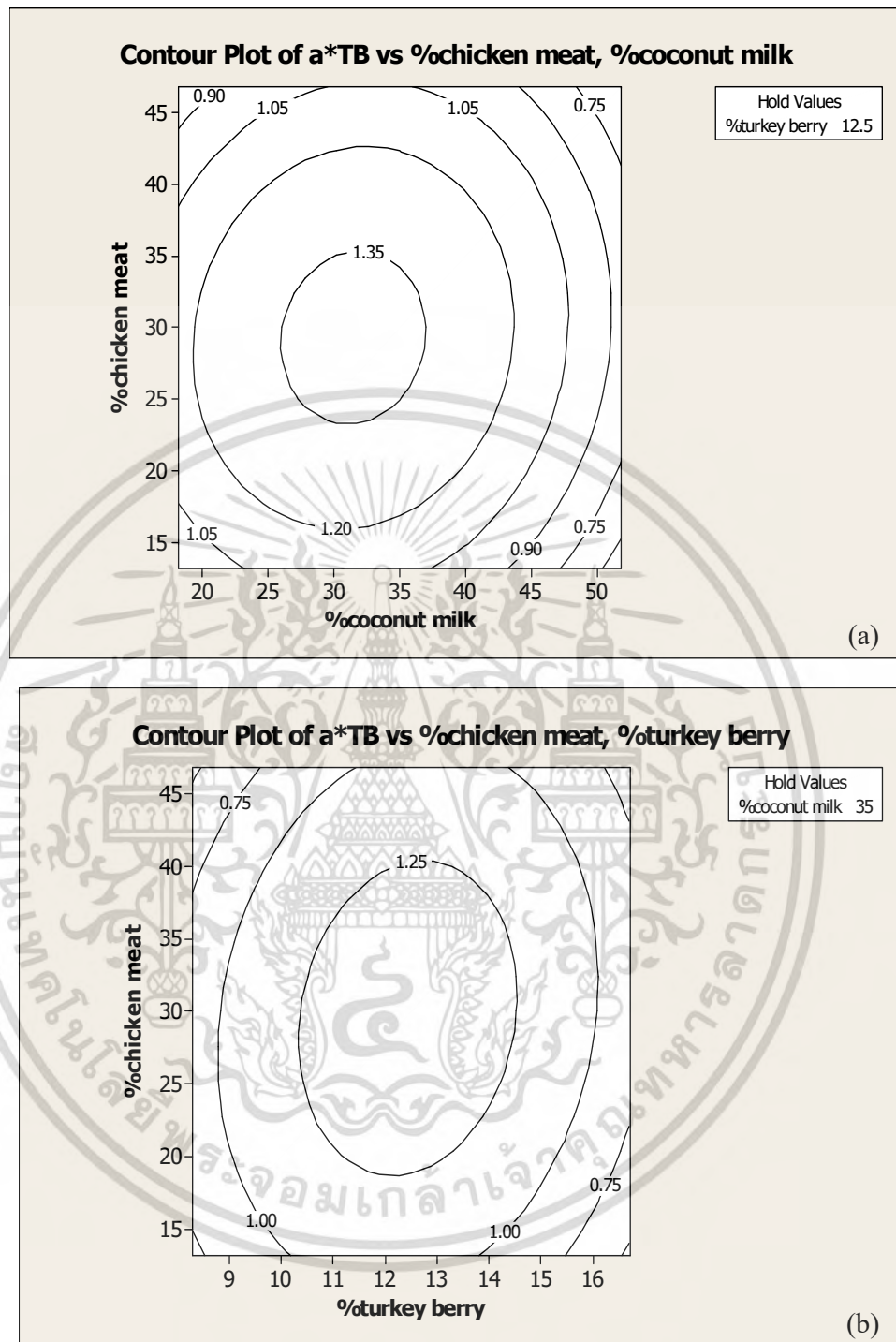


Figure 4.9 Contour plot a* value of turkey berry (a) a* value versus CK and CM
(b) a* value versus CK and TB

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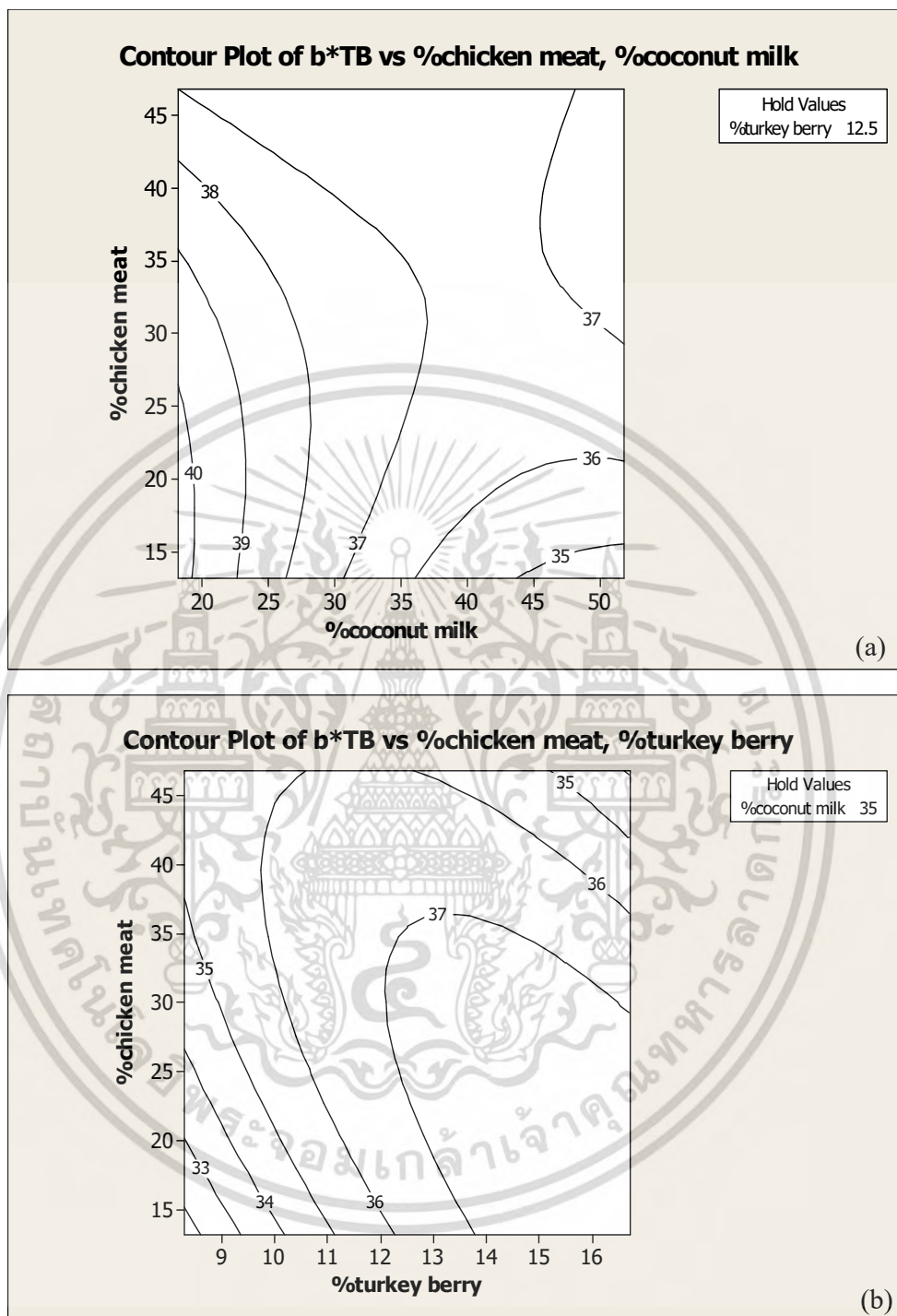


Figure 4.10 Contour plot b^* value of turkey berry (a) b^* value versus CK and CM
(b) b^* value versus CK and TB.

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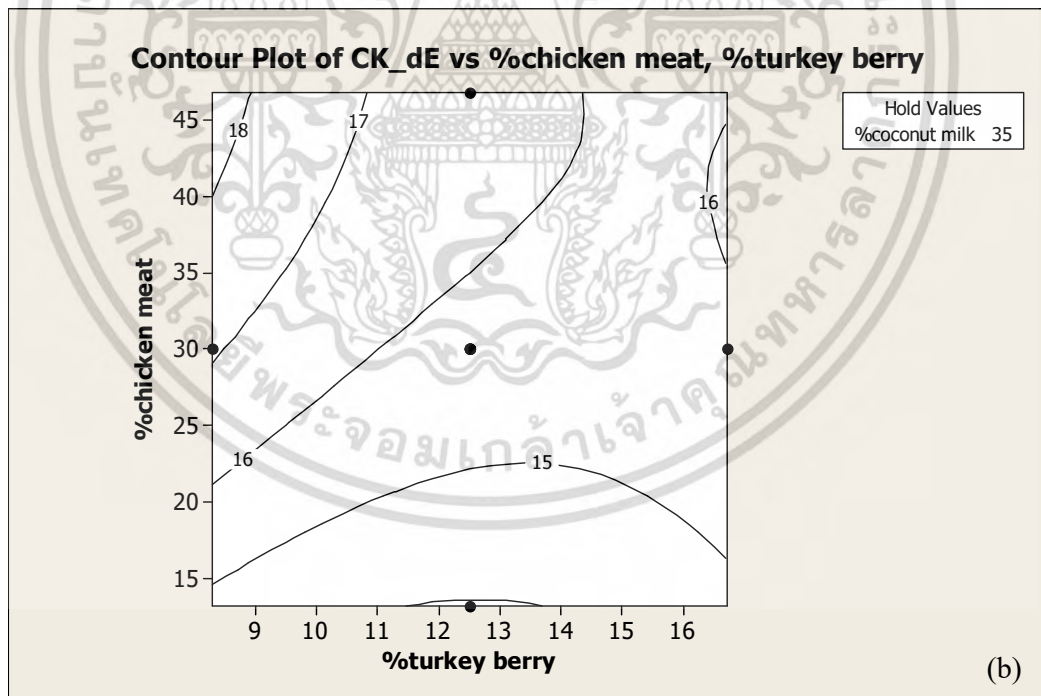
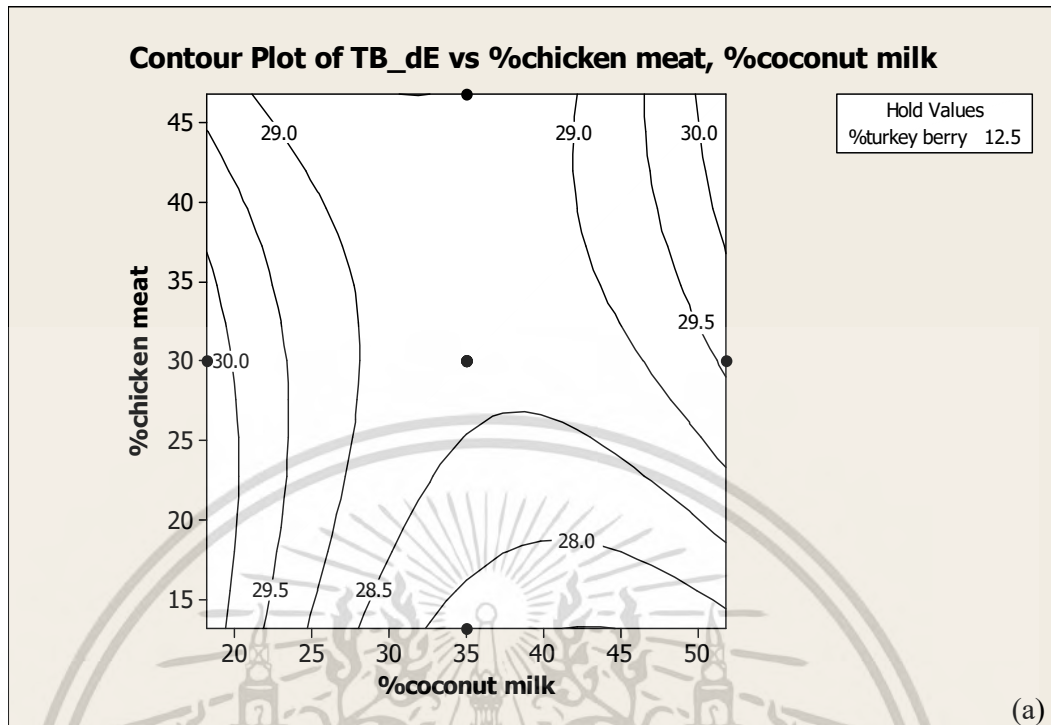


Figure 4.11 Contour plot delta E* value of turkey berry (a) ΔE^* value versus CK and CM

(b) ΔE^* value versus CK and TB.

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ไม่ว่ากรณีใดๆ ทั้งสิ้น อีกทั้งห้ามมิให้ดัดแปลงเนื้อหา และต้องอ้างอิงถึงเจ้าของเอกสารทุกครั้งที่มีการนำไปใช้

4.4 Texture Profile of Chicken Cube and Turkey Berry

Texture profile of sample shown in table 4.4. The amount of chicken and turkey berry (solid content) showed the significant effects on the hardness of both chicken and turkey berry ($p < 0.05$) (table 4.5). The contour plots of hardness of chicken and turkey berry are shown in fig. 4.12 and 4.13, respectively.

It was observed that an increasing amount of chicken and turkey berry led to increase the process time which affected to decrease the hardnesses of chicken meat and turkey berry. The decreasing hardness of chicken meat was possibly due to the heat causing the destruction of collagen, connective tissue. Hence, the tight muscular fibers became weak and easy to break down [47]. Inside of turkey berry, heat affect to the hydrolysis of pectin polysaccharide of the cell wall [49]. There are also found that high percentage of solid (chicken meat and turkey berry) led to high process time which effect to hardness both chicken meat and turkey berry.

Table 4.5 Texture profile (Hardness) at the different amount of chicken meat, coconut milk and turkey berry.

Treat ment	Solid (%)	Liquid (%)	Coconut milk (%)	Chicken (%)	Maximum Process Time (min), $F_0=4$	Hardness Chicken (60%Strain):g	Hardness Turkey berry (95%Distance): g/sec
15	59.32	40.68	35.00	46.82	12	1,377.35±129.56	1,603.34±105.24
6	55.00	45.00	45.00	40.00	9	1,637.03±104.99	1,939.37±111.77
17	55.00	45.00	25.00	40.00	8	1,756.67±186.25	1,983.66±171.57
7	50.00	50.00	25.00	40.00	8	1,527.82±191.47	1,938.08±104.69
12	50.00	50.00	45.00	40.00	8	1,543.06±149.69	1,953.66±134.96
19	46.70	53.30	35.00	30.00	8	1,536.92±179.68	2,008.09±151.81
1	42.50	57.50	35.00	30.00	7	1,536.58±192.26	2,115.43±157.71
3	42.50	57.50	35.00	30.00	7	1,688.16±147.40	2,143.61±134.29
8	42.50	57.50	35.00	30.00	7	1,681.10±106.99	2,290.17±169.99
10	42.50	57.50	35.00	30.00	7	1,750.11±195.42	2,340.21±138.67
11	42.50	57.50	18.18	30.00	6	1,762.49±125.57	2,293.21±175.22
14	42.50	57.50	51.82	30.00	9	1,652.73±119.26	1,872.46±117.93
18	42.50	57.50	35.00	30.00	7	1,756.67±186.25	2,268.83±173.55
20	42.50	57.50	35.00	30.00	7	1,743.11±112.66	2,158.90±196.39
2	38.30	61.70	35.00	30.00	6	1,753.82±153.81	2,223.26±159.64
4	35.00	65.00	45.00	20.00	7	1,772.40±193.37	2,396.51±154.88
13	35.00	65.00	25.00	20.00	6	1,613.01±174.03	2,196.55±176.93
9	30.00	70.00	45.00	20.00	6	1,773.44±158.87	2,186.27±117.35
16	30.00	70.00	25.00	20.00	5	1,784.44±197.74	2,263.32±173.68
5	25.68	74.32	35.00	13.80	7	1,628.69±185.78	2,250.28±141.93

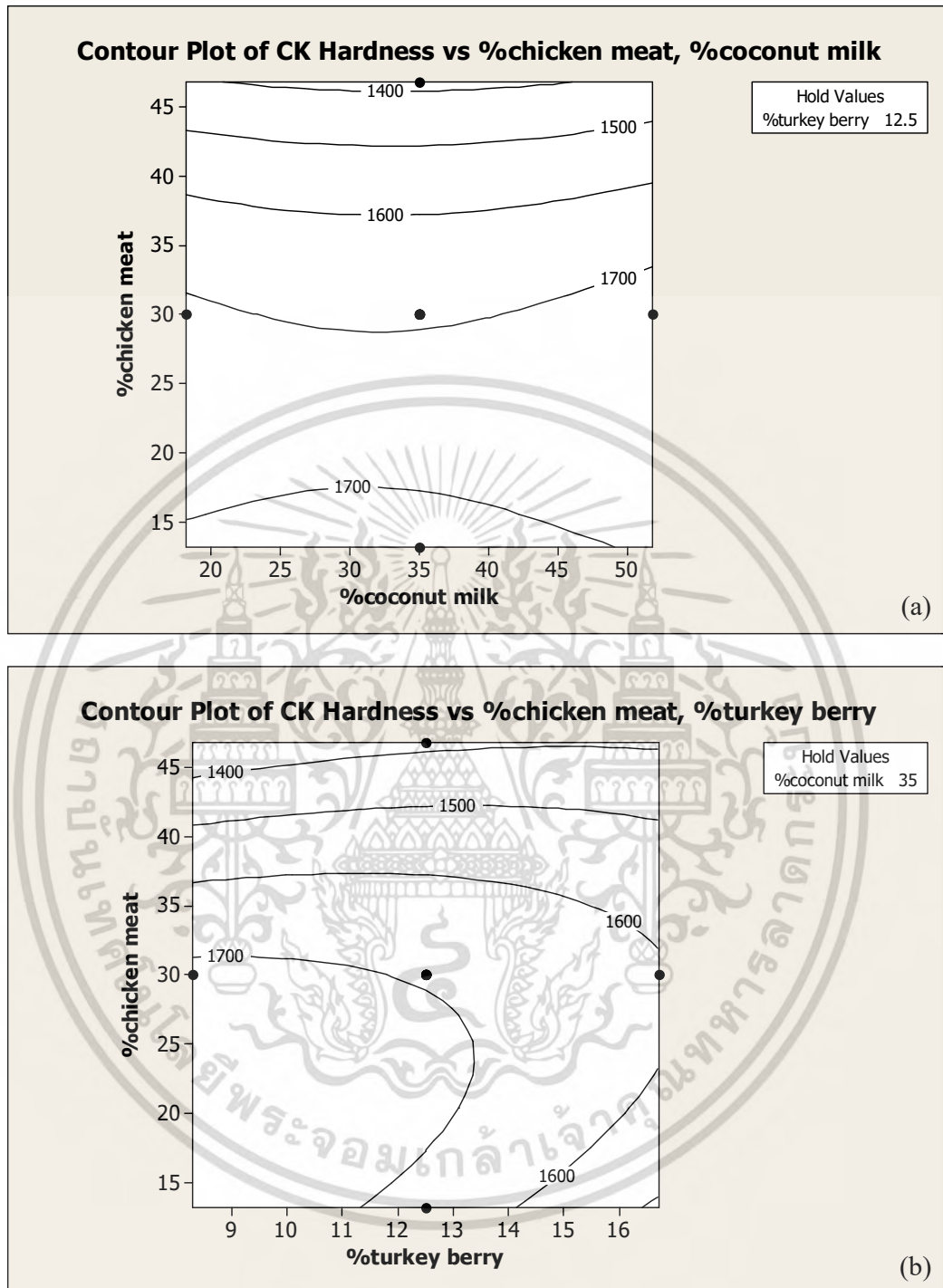


Figure 4.12 Contour plot – Hardness of Chicken (a) CK hardness profile versus chicken meat and coconut milk (b) CK hardness profile versus chicken meat and turkey berry.

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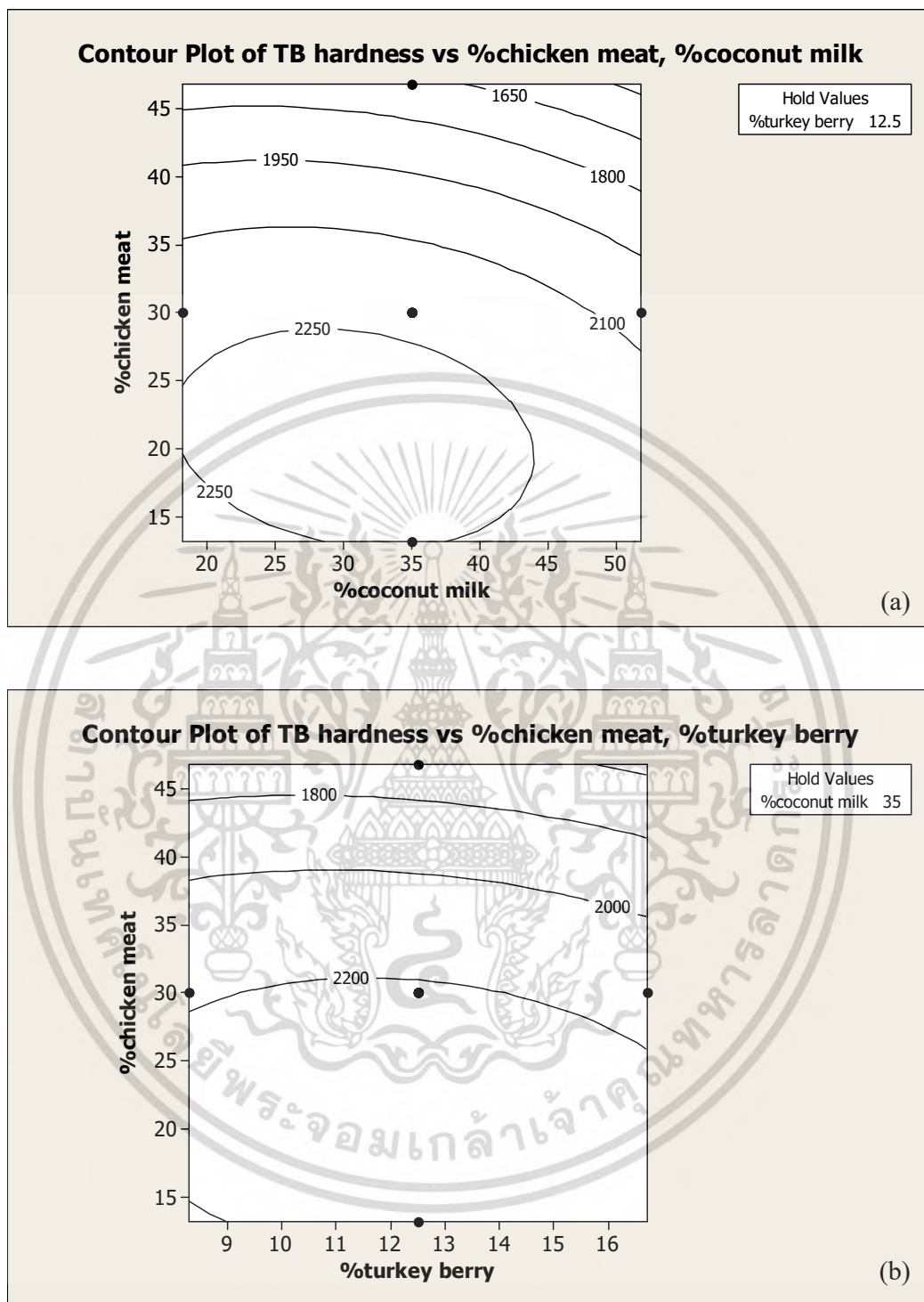


Figure 4.13 Contour plot – Hardness of Turkey Berry (a) TB hardness profile versus chicken meat and coconut milk (b) TB hardness profile versus chicken meat and turkey berry.

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4.5 Response Surface Regression

The experimental results statistically analyzed by response surface method are shown Table 4.7 and 4.8.

The empirical equations was done using code unit (table 3.3) for the relationship between three factors and experimental results are demonstrated as followed:

$$[\text{Process time}] = 7.03 + 0.58 [\text{CM}] + 1.27[\text{CK}] + 0.46 [\text{TB}] - 0.02[\text{CM}]^2 + 0.68 [\text{CK}]^2 - 0.19 [\text{TB}]^2 + 0.12 [\text{CM}][\text{CK}] - 0.12[\text{CM}][\text{TB}] - 0.12 [\text{CM}][\text{TB}] \quad (4.6)$$

$$[L^*_{\text{CK}}] = 70.03 + 0.68[\text{CM}] + 1.30[\text{CK}] - 0.04 [\text{TB}] + 0.08 [\text{CM}]^2 + 0.18 [\text{CK}]^2 - 0.59[\text{TB}]^2 - 0.08 [\text{CM}][\text{CK}] - 0.33[\text{CM}][\text{TB}] - 0.35[\text{CM}][\text{TB}] \quad (4.7)$$

$$[a^*_{\text{CK}}] = 0.41 + 0.071[\text{CM}] + 0.070[\text{CK}] - 0.02[\text{TB}] - 0.01[\text{CM}]^2 - 0.03[\text{CK}]^2 + 0.18[\text{TB}]^2 - 0.05[\text{CM}][\text{CK}] - 0.08[\text{CM}][\text{TB}] - 0.02[\text{CM}][\text{TB}] \quad (4.8)$$

$$[b^*_{\text{CK}}] = 15.61 + 0.16[\text{CM}] + 0.54[\text{CK}] - 0.34[\text{TB}] - 0.26[\text{CM}]^2 - 0.22[\text{CK}]^2 + 0.16[\text{TB}]^2 - 0.09[\text{CM}][\text{CK}] - 0.20[\text{CM}][\text{TB}] - 0.18[\text{CM}][\text{TB}] \quad (4.9)$$

$$[\Delta E^*_{\text{CK}}] = 7.90 - 0.69[\text{CM}] - 1.30[\text{CK}] + 0.01[\text{TB}] - 0.07[\text{CM}]^2 - 0.17[\text{CK}]^2 - 0.57[\text{TB}]^2 + 0.11[\text{CM}][\text{CK}] + 0.33[\text{CM}][\text{TB}] + 0.31[\text{CM}][\text{TB}] \quad (4.10)$$

$$[L^*_{\text{TB}}] = 41.31 - 0.45[\text{CM}] - 1.16[\text{CK}] + 0.16[\text{TB}] - 0.19[\text{CM}]^2 + 0.42[\text{CK}]^2 + 0.31[\text{TB}] - 1.15[\text{CM}][\text{CK}] - 0.91[\text{CM}][\text{TB}] + 0.76 [\text{CM}][\text{TB}] \quad (4.11)$$

$$[a^*_{\text{TB}}] = 1.37 - 0.08[\text{CM}] - 0.01[\text{CK}] - 0.01[\text{TB}] - 0.12[\text{CM}]^2 - 0.11[\text{CK}]^2 - 0.17[\text{TB}]^2 + 0.02 [\text{CM}][\text{CK}] - 0.02[\text{CM}][\text{TB}] + 0.04[\text{CM}][\text{TB}] \quad (4.12)$$

$$[b^*_{\text{TB}}] = 37.13 - 0.78[\text{CM}] - 0.04[\text{CK}] + 0.74[\text{TB}] + 0.44[\text{CM}]^2 - 0.36[\text{CK}]^2 - 0.52[\text{TB}]^2 + 0.56[\text{CM}][\text{CK}] - 0.70[\text{CM}][\text{TB}] - 0.66[\text{CM}][\text{TB}] \quad (4.13)$$

$$[\Delta E^*_{\text{TB}}] = 28.64 - 0.20[\text{CM}] + 0.23[\text{CK}] + 0.32[\text{TB}] + 0.45[\text{CM}]^2 - 0.17[\text{CK}]^2 - 0.20[\text{TB}]^2 + 0.30[\text{CM}][\text{CK}] - 0.07[\text{CM}][\text{TB}] - 0.53[\text{CM}][\text{TB}] \quad (4.14)$$

$$[\text{Hardness}_{\text{CK}}] = 1691.59 + 7.06 [\text{CM}] - 83.36 [\text{CK}] - 33.06 [\text{TB}] + 12.09[\text{CM}]^2 - 60.24[\text{CK}]^2 - 9.92 [\text{TB}]^2 - 1.97[\text{CM}][\text{CK}] + 34.07[\text{CM}][\text{TB}] + 32.28[\text{CM}][\text{TB}] \quad (4.15)$$

$$[\text{Hardness}_{\text{TB}}] = 2217.07 - 44.92[\text{CM}] - 169.58[\text{CK}] - 13.70[\text{TB}] - 32.25[\text{CM}]^2 - 87.41[\text{CK}]^2 - 20.64[\text{TB}]^2 - 18.95[\text{CM}][\text{CK}] + 27.14[\text{CM}][\text{TB}] - 14.02[\text{CM}][\text{TB}] \quad (4.16)$$

The R squares of equation (4.8) to (4.16) were 0.86, 0.67, 0.79, 0.88, 0.67, 0.80, 0.87, 0.52, 0.58, 0.74 and 0.77 respectively, demonstrating well correlation for an explanation of this evident.

4.6 Optimization of Process Time

The response surface regression, and the contour plot were analyzed by Minitab® program. The optimizer response tool in this software was used to optimize the process time of the chicken and turkey berry in coconut milk curry (green curry based). The sample as starting point (40.0% chicken meat, 15.0% turkey berry, 45.0% green curry soup) were prepared for heat penetration test as 3.6 for the target $F_0 = 4$ min. Optimized process were verified. From the result in table 4.6 shown that the validated result could be indicate that empirical equations from 4.5 could be used for predicted time. However a few difference of process time was occurred. There are 5.16%, 3.30% and 12% difference for process time, hardness of chicken cube and hardness of turkey berry respectively. In green curry soup, vegetable oil and curry paste were added, therefore effect to increase process time by thermal properties of added raw materials. For hardness of turkey berry and lower value from predicted because effect from process time led to slightly more heat effect. The results of predicted process time was deviated from the experiment because the sample of green curry with chicken contained vegetable oil and curry paste which affected the thermal properties of curry. Consequently, the physical properties including the texture of chicken and turkey berry were deviated from the experimental result of green curry with chicken.

Table 4.6 Comparison optimization and verified result of chicken meat and turkey berry in coconut milk curry (Green curry based)

Details	Predicted Result	Experimental Result
Predicted Chicken (%)	40.00	40.00
Predicted Turkey Berry (%)	15.00	15.00
Predicted Coconut milk (%)	25.00	25.00
Process Time (min), $F_0=4$ min	8.52	8.96 $j = 0.76$ $f_h = 8.96$
Hardness chicken	1510.00 g	1460.02 g
Hardness turkey berry	1916.19 g.sec	1675.45 g.sec



Figure 4.14 Chicken cube and turkey berry in coconut milk curry
(Green curry based)

Response Optimization of Process Time

Response Optimization

Starting Point

%coconut milk = 25
%chicken meat = 40
%turkey berry = 15

Global Solution

%coconut milk = 25
%chicken meat = 40
%turkey berry = 15

Predicted Responses

process time = 8.52000 , desirability = 1.000000
CK Hardness = 1510.00 , desirability = 1.000000
TB hardness = 1916.19 , desirability = 1.000000

Composite Desirability = 1.000000

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Table 4.7 Response surface regression (Coef)

Term	Process time	[L* _{CK}]	[a* _{CK}]	[b* _{CK}]	[ΔE* CK]	[L* _{TB}]	[a* _{TB}]	[b* _{TB}]	[ΔE* TB]	[Hardness _{CK}]	[Hardness _{TB}]
Constant	7.03	70.00	0.41	15.61	7.90	41.31	1.37	37.13	28.64	1691.59	0.72
CM	0.58	0.68	0.07	0.16	-0.69	-0.45	-0.08	-0.78	-0.20	7.06	-0.02
CK	1.27	1.30	0.07	0.54	-1.30	-1.16	-0.00	-0.04	0.23	-83.36	-0.01
TB	0.46	-0.04	-0.02	-0.34	0.01	0.16	-0.00	0.74	0.32	-33.06	-0.01
CM×CM	-0.02	0.08	-0.00	-0.26	-0.07	-0.19	-0.12	0.44	0.45	12.09	0.01
CK×CK	0.68	0.18	-0.03	-0.2	-0.17	0.42	-0.10	-0.36	-0.17	-60.24	-0.02
TB×TB	-0.19	0.59	0.18	0.16	-0.57	0.31	-0.17	-0.52	-0.20	-9.92	-0.01
CM×CK	0.12	-0.08	-0.05	-0.09	0.11	-1.15	0.01	0.56	0.30	-1.97	0.01
CM×TB	-0.12	-0.33	-0.08	-0.20	0.33	-0.91	-0.01	-0.70	-0.07	34.07	0.01
CK×TB	-0.12	-0.35	-0.02	-0.18	0.31	0.76	0.03	-0.66	-0.53	32.28	-0.01

Table 4.8 Response surface regression (p-value)

Term	Process time	[L* _{CK}]	[a* _{CK}]	[b* _{CK}]	[ΔE* CK]	[L* _{TB}]	[a* _{TB}]	[b* _{TB}]	[ΔE* TB]	[Hardness _{CK}]	[Hardness _{TB}]
Constant	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
CM	0.008	0.088	0.095	0.107	0.085	0.113	0.012	0.143	0.393	0.751	0.148
CK	0.000	0.005	0.099	0.000	0.005	0.001	0.771	0.930	0.345	0.003	0.881
TB	0.027	0.912	0.486	0.004	0.986	0.533	0.829	0.160	0.196	0.157	0.949
CM×CM	0.908	0.807	0.814	0.013	0.831	0.472	0.001	0.378	0.073	0.578	0.640
CK×CK	0.003	0.604	0.364	0.033	0.633	0.129	0.004	0.462	0.468	0.017	0.211
TB×TB	0.285	0.124	0.001	0.093	0.134	0.239	0.000	0.303	0.385	0.648	0.375
CM×CK	0.606	0.861	0.331	0.463	0.815	0.668	0.640	0.402	0.339	0.946	0.518
CM×TB	0.606	0.493	0.14	0.119	0.496	0.024	0.630	0.302	0.810	0.255	0.847
CK×TB	0.606	0.478	0.646	0.144	0.525	0.051	0.337	0.327	0.108	0.280	0.831

Chapter 5

Conclusion and Recommendation

From the results (in chapter 4) included the regressions and the contour analyses analysis could be summarized as below:

5.1 Conclusion

1) The significant factor relating to process time, color and texture was the amount of chicken meat. The increase of chicken meat amount trended to increase of process time, L* value and b* value of chicken meat, but L* value of turkey berry reduced. Increasing process time also led to decrease hardness of chicken and turkey berry.

2) The relationship of compositions of curry on process time and physical properties including color and texture profile of chicken meat and turkey berry can be explained by the empirical equations.

3) These empirical equations could be further applied to estimate process time and quality of curry in thermal processing, based on the studied curry compositions such as chicken, coconut milk and other vegetables' contents.

5.2 Recommendation

1) The color of chicken and turkey berry had interfere effect by used curry paste in product. The further study in various types of curry paste was suggested.

2) The next research could be developed in other packing size of container which be beneficial for Thai curry product.

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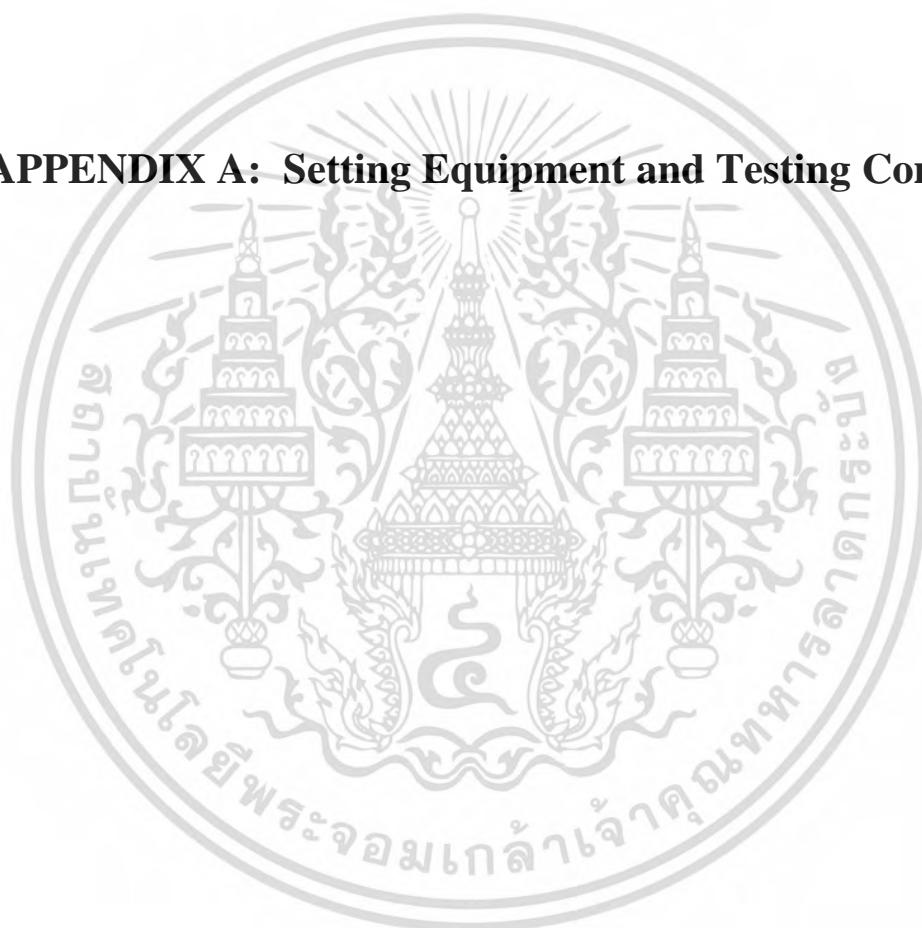
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เอกสารนี้เป็นเอกสารที่สงวนไว้สำหรับการใช้งานเพื่อการศึกษาเท่านั้น ไม่อนุญาตให้นำไปใช้ประโยชน์ด้านการค้า
ไม่ว่ากรณีใดๆ ทั้งสิ้น อีกทั้งห้ามมิให้ตัดแปลงเนื้อหา และต้องอ้างอิงถึงเจ้าของเอกสารทุกครั้งที่มีการนำไปใช้

APPENDIX A: Setting Equipment and Testing Condition



เอกสารนี้เป็นเอกสารที่สงวนไว้สำหรับการใช้งานเพื่อการศึกษาเท่านั้น ไม่อนุญาตให้นำไปใช้ประโยชน์ด้านการค้า
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A.1 Color Analysis

Machines/Equipment:

1. ColorFlex EZ
2. Clear plastic petri dishes (5-cm diameter)
3. Black and white color calibration tiles
4. Sample Cup Opaque Cover

Procedures:

- (1) Prepare sample step by step; washing chicken and turkey berry with potable water then blending cube chicken into uniform and peeling turkey berry peel. Put blended chicken and turkey berry peel in petri dish.
- (2) Turn on the colorimeter and computer. Wait 30 min for the instrument to warm up. The instrument will start in “Read” mode.
- (3) Open the Hunter Lab program: Programs → HunterLab → Universal Software.
- (4) Calibrate equipment before testing.
 - a. Select the “Standardize” button from the menu. The instrument will prompt for the black and white tiles in succession.
 - b. Install the black tile at the sample port and hit “OK” on prompt.
 - c. Repeat step b with the white color tile, as prompted.
 - d. A message indicating successful calibration should appear. The L^* , a^* , and b^* values will be displayed in the table on the screen.
 - e. Compare the values displayed to those provided on the back of the white tile.
 - i. Measured values should be within 0.4 units of those provided. If the difference exceeds 0.4 units, clean the standard tiles and re-measure.
- (5) Center the petri dish over the sample port and cover with the black cover.
- (6) Press “Read sam”, Enter a sample ID for the sample just tested. The colorimeter will save the CIE L^* a^* b^* values.
- (7) Replicate sample measurements as necessary, depending on sample homogeneity.
- (8) Gently clean the lens and the petri dish between samples. When the dish becomes soiled, cracked or scratched, discard and use a new one.
- (9) After analyzing all samples, data may be copied to an Excel file for viewing on any computer, or saved to a file on the hard drive by selecting “File → Save as”.
- (10) When finished, clean the lens and replace the white tile over the sample port on the colorimeter to prevent the lens from getting scratched.

A.2 Texture Analysis

Machines/Equipment:

- (1) Texture analyzer (TA.XT plus, Stable Micro system Ltd., UK)
- (2) Probe P/65; 65mm cylinder stainless
- (3) Base
- (4) 10 kg balance

Procedures:

- (11) Setting equipment by fix probe with arm and fix the base.
- (12) Open computer and go through Texture Exponent 32 software.
- (13) Sample preparation by washing with water and select the same size sample
- (14) Calibrate force by 10 kg balance and calibrate height
- (15) Fill product configuration such as File name, Probe used; File location etc.
- (16) Setting parameter
- (17) Place sample at the base and press “Run a test”
- (18) Do triplicate for each sample.

Testing steps and Setting parameters:

(1) Turkey Berry

T.A. Setting : 1 Return To Start
 Test Mode: Compression
 Pre test speed: 1 mm/s
 Test speed: 1 mm/s
 Post test speed: 10 mm/s
 Distance: 95%
 Trigger Type: Auto Force
 Trigger Force : 5 g

(2) Cube chicken

Test Mode and Option: TPA

Parameters

Pre test speed: 12 mm/s
 Test speed: 12 mm/s
 Post test speed: 12 mm/s
 Target Mode: Strain
 Strain: 60%
 Time: 0.01670 min
 Trigger Force: 5.0 g
 Tare Mode: Auto

APPENDIX B: Studied Treatments and Experimental Data



เอกสารนี้เป็นเอกสารที่สงวนไว้สำหรับการใช้งานเพื่อการศึกษาเท่านั้น ไม่อนุญาตให้นำไปใช้ประโยชน์ด้านการค้า
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B1- Studied Treatment

Table B-1 Studied Treatment

Treatment	% (CK)	% (TB)	% (CM)	% (W)
1	30.0	12.5	35.0	22.5
2	30.0	8.3	35.0	26.7
3	30.0	12.5	35.0	22.5
4	20.0	15.0	45.0	20.0
5	13.2	12.5	35.0	39.3
6	40.0	15.0	45.0	0.0
7	40.0	10.0	25.0	25.0
8	30.0	12.5	35.0	22.5
9	20.0	10.0	45.0	25.0
10	30.0	12.5	35.0	22.5
11	30.0	12.5	18.2	39.3
12	40.0	10.0	45.0	5.0
13	20.0	15.0	25.0	40.0
14	30.0	12.5	51.8	5.7
15	46.8	12.5	35.0	5.7
16	20.0	10.0	25.0	45.0
17	40.0	15.0	25.0	20.0
18	30.0	12.5	35.0	22.5
19	30.0	16.7	35.0	18.3
20	30.0	12.5	35.0	22.5

Remark: CK=Cubed chicken, TB=Turkey Berry, CM=Coconut Milk, W=Water

เอกสารนี้เป็นเอกสารที่สงวนไว้สำหรับการใช้งานเพื่อการศึกษาเท่านั้น ไม่อนุญาตให้นำไปใช้ประโยชน์ด้านการค้า
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B2-Experimental Data

Table B-2.1 Process Time

Treatment	Process time (min)/ Rep 1			Process time (min)/ Rep 2			Process time (min)/ Rep 3			Maximum Process Time
	Sample 1	Sample 2	Sample 3	Sample 1	Sample 2	Sample 3	Sample 1	Sample 2	Sample 3	
1	7	6	6	6	6	7	7	7	7	7
2	6	6	5	6	6	6	6	5	6	6
3	7	7	7	7	7	6	6	6	6	7
4	7	6	6	6	6	7	6	6	7	7
5	7	6	7	6	6	6	6	7	7	7
6	9	9	9	8	8	8	9	9	9	9
7	8	7	7	8	8	8	8	8	7	8
8	7	6	7	6	7	6	7	6	7	7
9	6	6	6	6	6	6	6	6	6	6
10	7	7	7	6	6	7	7	6	6	7
11	6	6	6	6	6	6	6	6	6	6
12	8	8	8	8	7	7	7	8	8	8
13	6	6	6	6	5	5	5	6	6	6
14	9	8	7	8	8	9	9	9	8	9
15	12	11	12	10	11	12	12	11	12	12
16	5	4	5	4	5	5	5	5	5	5
17	8	8	8	8	8	8	8	7	8	8
18	7	7	7	7	6	6	6	6	7	7
19	8	8	8	8	7	7	8	7	8	8
20	7	6	7	6	7	7	6	7	6	7

Table B-2.2 L* value of Chicken

Treatment	L* value / Rep 1			L* value / Rep 2			L* value / Rep 3			Average L* ±SD
	Sample 1	Sample 2	Sample 3	Sample 1	Sample 2	Sample 3	Sample 1	Sample 2	Sample 3	
1	69.29	69.34	69.43	69.11	69.13	69.24	70.11	69.22	69.01	69.32±0.32
2	73.05	72.75	73.06	73.22	72.97	72.93	72.82	72.81	72.78	72.93±0.16
3	69.62	69.60	69.43	69.54	69.13	69.24	70.11	70.12	69.78	69.61±0.34
4	71.80	69.95	69.85	70.93	67.38	66.92	67.6	67.66	67.77	68.87±1.77
5	70.52	70.63	70.67	69.7	69.59	69.97	69.96	70.31	70.61	70.21±0.42
6	72.34	72.34	72.61	72.64	72.62	72.61	72.19	72.34	72.27	72.44±0.18
7	72.34	72.25	72.29	72.25	72.26	72.79	72.52	72.70	72.74	72.46±0.23
8	69.56	70.22	70.47	70.76	69.43	69.64	69.53	70.15	69.31	69.89±0.51
9	69.05	68.39	69.02	69.02	68.5	68.59	69.22	69.22	69.28	68.92±0.34
10	70.22	70.37	69.74	70.11	70.92	70.47	70.65	70.64	69.57	70.30±0.44
11	67.69	67.58	68.12	68.08	68.38	68.31	68.72	68.72	68.87	68.27±0.45
12	72.90	72.92	72.92	72.7	73.02	72.86	72.20	72.19	72.26	72.66±0.35
13	70.02	70.08	70.18	69.46	69.52	69.32	69.79	69.12	69.69	69.68±0.36
14	73.24	73.54	72.97	73.18	73.24	72.68	73.39	72.65	73.18	73.11±0.30
15	72.60	72.10	71.42	71.55	71.72	71.72	71.36	71.56	71.65	71.74±0.39
16	67.11	66.99	67.15	67.15	67.27	67.25	67.14	67.17	67.15	67.15±0.081
17	72.09	72.19	72.28	72.23	72.6	72.69	72.58	72.50	72.10	72.36±0.23
18	70.26	70.41	70.25	69.92	70.17	70.85	70.69	70.57	69.94	70.34±0.32
19	71.6	71.43	71.32	71.28	70.61	70.97	71.8	71.46	71.37	71.31±0.35
20	70.87	69.74	70.43	70.17	70.95	70.69	69.95	70.14	70.77	70.41±0.43

Table B-2.3 a* value of Chicken

Treatment	a* value / Rep 1			a* value / Rep 2			a* value / Rep 3			Average±SD
	Sample 1	Sample 2	Sample 3	Sample 1	Sample 2	Sample 3	Sample 1	Sample 2	Sample 3	
1	0.43	0.46	0.40	0.45	0.41	0.48	0.49	0.47	0.49	0.45±0.03
2	0.74	0.82	0.74	0.72	0.88	0.87	0.9	0.87	0.77	0.81±0.07
3	0.47	0.52	0.49	0.49	0.52	0.49	0.47	0.51	0.50	0.49±0.02
4	0.31	0.43	0.42	0.46	0.49	0.44	0.52	0.50	0.46	0.44±0.06
5	0.48	0.5	0.47	0.13	0.17	0.49	0.18	0.22	0.16	0.31±0.17
6	0.35	0.36	0.37	0.38	0.4	0.35	0.48	0.41	0.47	0.40±0.05
7	0.62	0.61	0.58	0.61	0.59	0.66	0.73	0.69	0.72	0.65±0.06
8	0.47	0.36	0.39	0.49	0.52	0.36	0.42	0.39	0.36	0.42±0.06
9	0.58	0.60	0.59	0.59	0.57	0.60	0.73	0.68	0.70	0.62±0.06
10	0.36	0.40	0.39	0.49	0.42	0.36	0.32	0.31	0.40	0.38±0.05
11	0.28	0.23	0.29	0.23	0.21	0.18	0.17	0.18	0.22	0.22±0.04
12	0.76	0.76	0.77	0.8	0.79	0.77	1.27	1.27	1.27	0.94±0.25
13	0.27	0.28	0.28	0.24	0.22	0.27	0.25	0.27	0.27	0.26±0.02
14	0.54	0.58	0.59	0.49	0.55	0.59	0.56	0.55	0.55	0.56±0.03
15	0.25	0.25	0.25	0.42	0.32	0.31	0.49	0.27	0.31	0.31±0.08
16	0.29	0.3	0.30	0.47	0.47	0.49	0.3	0.47	0.35	0.39±0.09
17	0.69	0.67	0.66	0.67	0.72	0.67	0.71	0.75	0.68	0.69±0.03
18	0.39	0.36	0.31	0.39	0.42	0.36	0.42	0.36	0.42	0.38±0.04
19	1.08	0.92	0.93	1.17	1.27	1.21	1.07	1.01	0.91	1.06±0.13
20	0.39	0.36	0.31	0.42	0.36	0.32	0.33	0.42	0.36	0.36±0.04

Table B-2.4 b* value of Chicken

Treatment	b* value / Rep 1			b* value / Rep 2			b* value / Rep 3			Average±SD
	Sample 1	Sample 2	Sample 3	Sample 1	Sample 2	Sample 3	Sample 1	Sample 2	Sample 3	
1	15.46	15.56	15.36	15.55	15.11	15.67	15.55	15.92	15.37	15.51±0.22
2	16.72	16.84	16.72	16.65	16.82	16.73	16.84	16.77	16.68	16.75±0.07
3	15.55	15.71	15.36	15.94	15.11	15.97	15.95	15.65	15.48	15.63±0.29
4	14.64	14.48	14.55	14.50	14.24	14.28	14.62	14.51	14.39	14.47±0.14
5	14.93	14.89	14.82	14.89	14.33	14.24	14.45	14.66	14.27	14.61±0.29
6	14.98	14.97	15.26	15.28	15.37	15.11	15.72	15.35	15.67	15.30±0.27
7	15.78	15.93	15.72	15.74	15.68	16.79	16.99	16.85	16.89	16.26±0.59
8	15.67	15.65	15.98	15.54	15.97	15.24	15.85	15.51	15.56	15.66±0.24
9	14.83	14.85	15.06	15.06	15.12	15.15	14.73	14.88	14.82	14.95±0.15
10	15.55	15.68	15.54	15.88	15.64	15.97	15.14	15.67	15.52	15.62±0.24
11	14.05	14.4	14.44	14.35	14.42	14.62	14.49	14.49	14.68	14.44±0.18
12	16.42	16.38	16.38	16.59	16.29	16.53	17.59	17.67	17.68	16.84±0.61
13	14.36	14.31	14.29	14.42	14.34	14.51	14.2	14.27	14.43	14.35±0.09
14	15.23	15.25	15.24	15.39	15.28	15.29	15.27	15.31	15.24	15.28±0.05
15	15.03	15.04	15.39	15.53	15.46	15.52	15.45	15.42	15.49	15.37±0.20
16	13.92	13.83	13.88	14.72	14.64	14.84	14.12	14.94	13.84	14.31±0.47
17	15.91	15.85	15.78	15.83	15.85	15.66	15.82	15.95	15.91	15.84±0.09
18	15.67	15.62	15.94	15.29	15.34	15.97	15.32	15.91	15.83	15.65±0.28
19	15.06	15.2	15.08	15.72	16.08	15.84	15.43	15.07	15.28	15.42±0.38
20	15.5	15.52	15.91	15.65	15.98	15.74	15.17	15.65	15.48	15.62±0.24

Table B-2.5 ΔE^* value of Chicken (Compare with control sample (before retorted), $L^*=77.85$, $a^*=1.32$, $b^*=15.41$)

Treatment	L* value / Rep 1			L* value / Rep 2			L* value / Rep 3			Average L* ±SD
	Sample 1	Sample 2	Sample 3	Sample 1	Sample 2	Sample 3	Sample 1	Sample 2	Sample 3	
1	8.61	8.55	8.47	8.78	8.77	8.65	7.79	8.69	8.88	8.57±0.30
2	5.01	5.32	5.00	4.83	5.10	5.11	5.25	5.24	5.26	5.12±0.15
3	8.27	8.29	8.46	8.37	8.76	8.67	7.81	7.78	8.11	8.28±0.32
4	6.18	8.00	8.10	7.03	10.57	11.02	10.31	10.26	10.17	9.07±1.66
5	7.39	7.28	7.25	8.25	8.41	8.01	8.03	7.66	7.42	7.74±0.41
6	5.61	5.61	5.33	5.30	5.31	5.34	5.73	5.58	5.65	5.49±0.16
7	5.57	5.67	5.62	5.65	5.64	5.29	5.59	5.38	5.35	5.52±0.14
8	8.34	7.69	7.46	7.14	8.48	8.27	8.38	7.76	8.60	8.01±0.48
9	8.85	9.50	8.87	8.87	9.38	9.29	8.68	8.67	8.61	8.96±0.32
10	7.69	7.54	8.16	7.80	6.99	7.46	7.27	7.29	8.33	7.61±0.41
11	10.30	10.38	9.83	9.89	9.59	9.64	9.25	9.25	9.08	9.68±0.43
12	5.08	5.06	5.05	5.31	4.94	5.14	6.06	6.09	6.03	5.41±0.46
13	7.97	7.92	7.82	8.52	8.47	8.64	8.22	8.87	8.29	8.30±0.33
14	4.68	4.38	4.94	4.74	4.68	5.22	4.53	5.26	4.74	4.79±0.28
15	5.37	5.86	6.52	6.37	6.21	6.21	6.54	6.38	6.28	6.19±0.35
16	10.89	11.02	10.86	10.76	10.64	10.65	10.84	10.72	10.86	10.80±0.12
17	5.82	5.71	5.62	5.67	5.30	5.21	5.32	5.41	5.81	5.540±0.22
18	7.65	7.50	7.69	7.99	7.73	7.09	7.22	7.36	7.97	7.57±0.30
19	6.26	6.44	6.55	6.58	7.27	6.89	6.06	6.41	6.49	6.55±0.33
20	7.04	8.17	7.51	7.74	6.99	7.24	7.97	7.77	7.15	7.50±0.40

Table B-2.6 Hardness value of Chicken

Treatment	Hardness value / Rep 1			Hardness value / Rep 2			Hardness value / Rep 3			Average±SD
	Sample 1	Sample 2	Sample 3	Sample 1	Sample 2	Sample 3	Sample 1	Sample 2	Sample 3	
1	1,423.53	1,723.37	1,412.573	1,213.41	1,552.17	1,708.15	1,562.36	1,410.73	1,822.98	1,536.58±192.26
2	1,856.60	1,722.66	1,775.02	1,880.05	1,503.21	1,690.57	2,027.58	1,706.66	1,622.02	1,753.82±153.81
3	1,722.53	1,823.18	1,712.383	1,613.41	1,551.17	1,477.22	1,562.26	1,810.43	1,920.88	1,688.16±147.40
4	1,731.12	1,692.75	1,608.861	1,853.74	1,677.32	1,443.61	1,916.77	2,054.11	1,973.37	1,772.40±193.37
5	1,793.95	1,568.87	1,450.94	1,611.52	1,890.31	1,522.66	1,446.75	1,470.05	1,903.21	1,628.69±185.78
6	1,681.67	1,741.42	1,423.87	1,616.97	1,525.41	1,656.37	1,643.51	1,754.68	1,689.38	1,637.03±104.99
7	1,093.02	1,676.77	1,422.062	1,634.64	1,655.66	1,455.19	1,522.47	1,573.87	1,716.76	1,527.82±191.47
8	1,521.43	1,823.18	1,612.283	1,763.36	1,551.17	1,683.27	1,662.26	1,810.23	1,702.78	1,681.10±106.99
9	1,606.11	1,822.34	1,658.98	1,948.30	1,913.01	1,701.81	1,625.98	1,649.12	2,035.35	1,773.44±158.87
10	1,987.88	1,875.71	1,877.27	1,772.26	1,970.43	1,523.53	1,725.37	1,515.83	1,502.78	1,750.11±195.42
11	2,047.50	1,770.96	1,776.81	1,706.21	1,833.47	1,737.98	1,676.70	1,711.01	1,601.81	1,762.49±125.57
12	1,443.93	1,323.77	1,616.573	1,625.41	1,656.37	1,308.55	1,569.36	1,610.63	1,732.98	1,543.06±149.69
13	1,531.22	1,842.18	1,651.94	1,717.38	1,524.46	1,445.55	1,490.54	1,897.68	1,416.16	1,613.01±174.03
14	1,463.46	1,553.86	1,527.98	1,746.38	1,720.05	1,592.61	1,774.71	1,710.67	1,784.92	1,652.73±119.26
15	1,223.53	1,541.47	1,252.59	1,241.94	1,492.06	1,363.67	1,535.76	1,447.76	1,297.39	1,377.35±129.56
16	2,081.67	1,622.06	1,831.44	1,408.67	1,888.82	1,922.43	1,641.89	1,831.81	1,831.23	1,784.44±197.74
17	1,428.67	1,710.12	1,433.01	1,566.33	1,686.97	1,306.07	1,513.76	1,561.26	1,470.57	1,519.64±128.47
18	1,887.48	1,375.41	1,977.27	1,687.86	1,770.73	1,863.53	1,925.17	1,619.83	1,702.78	1,756.67±186.25
19	1,552.22	1,266.85	1,471.26	1,686.58	1,331.63	1,670.31	1,392.58	1,767.39	1,693.51	1,536.92±179.68
20	1,943.48	1,775.41	1,777.07	1,617.86	1,620.71	1,732.53	1,812.17	1,806.03	1,602.78	1,743.11±112.66

Table B-2.7 Springiness value of Chicken

Treatment	Springiness value / Rep 1			Springiness value / Rep 2			Springiness value / Rep 3			Average±SD
	Sample 1	Sample 2	Sample 3	Sample 1	Sample 2	Sample 3	Sample 1	Sample 2	Sample 3	
1	0.59	0.73	0.85	0.72	0.24	0.62	0.71	0.72	0.64	0.65±0.17
2	0.63	0.58	0.45	0.86	0.81	0.76	0.75	0.70	0.67	0.70±0.12
3	0.69	0.73	0.75	0.72	0.84	0.62	0.71	0.72	0.84	0.74±0.07
4	0.72	0.54	0.76	0.82	0.86	0.56	0.77	0.79	0.73	0.73±0.11
5	0.77	0.33	0.63	0.76	0.84	0.44	0.47	0.66	0.71	0.63±0.17
6	0.71	0.83	0.79	0.81	0.36	0.50	0.29	0.81	0.64	0.64±0.21
7	0.80	0.39	0.81	0.39	0.77	0.79	0.44	0.82	0.75	0.67±0.19
8	0.83	0.79	0.75	0.72	0.76	0.82	0.6	0.62	0.84	0.75±0.09
9	0.82	0.78	0.61	0.48	0.78	0.53	0.24	0.77	0.62	0.63±0.19
10	0.83	0.89	0.75	0.82	0.76	0.72	0.86	0.62	0.84	0.79±0.08
11	0.81	0.74	0.85	0.81	0.77	0.60	0.81	0.65	0.76	0.76±0.08
12	0.59	0.78	0.85	0.8	0.24	0.64	0.83	0.82	0.64	0.70±0.19
13	0.48	0.85	0.77	0.75	0.73	0.75	0.71	0.72	0.70	0.73±0.10
14	0.50	0.83	0.68	0.41	0.76	0.83	0.77	0.85	0.70	0.71±0.15
15	0.50	0.62	0.75	0.80	0.77	0.65	0.74	0.69	0.64	0.69±0.09
16	0.78	0.81	0.86	0.83	0.76	0.76	0.66	0.67	0.83	0.78±0.07
17	0.73	0.73	0.85	0.79	0.77	0.66	0.54	0.74	0.73	0.73±0.09
18	0.73	0.69	0.66	0.82	0.76	0.62	0.66	0.62	0.84	0.71±0.08
19	0.59	0.82	0.82	0.82	0.33	0.59	0.64	0.66	0.66	0.66±0.16
20	0.63	0.69	0.56	0.82	0.76	0.62	0.76	0.62	0.84	0.70±0.10

Table B-2.8 Cohesiveness value of Chicken

Treatment	Cohesiveness value / Rep 1			Cohesiveness value / Rep 2			Cohesiveness value / Rep 3			Average±SD
	Sample 1	Sample 2	Sample 3	Sample 1	Sample 2	Sample 3	Sample 1	Sample 2	Sample 3	
1	0.39	0.56	0.50	0.47	0.68	0.53	0.49	0.50	0.50	0.52±0.08
2	0.41	0.21	0.39	0.42	0.29	0.31	0.33	0.40	0.29	0.35±0.07
3	0.49	0.56	0.50	0.47	0.58	0.53	0.49	0.40	0.45	0.50±0.05
4	0.49	0.39	0.59	0.38	0.51	0.48	0.52	0.53	0.61	0.50±0.08
5	0.44	0.63	0.53	0.52	0.53	0.59	0.51	0.53	0.52	0.54±0.05
6	0.54	0.52	0.44	0.48	0.69	0.55	0.70	0.47	0.49	0.55±0.09
7	0.42	0.62	0.61	0.59	0.51	0.47	0.67	0.44	0.53	0.54±0.09
8	0.39	0.52	0.49	0.37	0.34	0.53	0.49	0.37	0.35	0.43±0.08
9	0.44	0.52	0.51	0.55	0.51	0.64	0.89	0.73	0.60	0.60±0.14
10	0.59	0.52	0.49	0.56	0.34	0.53	0.49	0.47	0.45	0.49±0.07
11	0.57	0.45	0.51	0.47	0.47	0.52	0.38	0.53	0.49	0.49±0.05
12	0.49	0.46	0.50	0.47	0.88	0.53	0.42	0.50	0.50	0.54±0.13
13	0.51	0.50	0.43	0.54	0.41	0.4	0.52	0.44	0.46	0.47±0.05
14	0.61	0.42	0.35	0.46	0.46	0.43	0.46	0.45	0.43	0.46±0.07
15	0.54	0.45	0.43	0.49	0.44	0.51	0.49	0.37	0.47	0.47±0.05
16	0.53	0.43	0.47	0.52	0.51	0.49	0.50	0.55	0.51	0.50±0.04
17	0.48	0.513	0.44	0.41	0.46	0.414	0.61	0.51	0.45	0.48±0.06
18	0.59	0.42	0.41	0.56	0.34	0.57	0.59	0.57	0.59	0.52±0.10
19	0.36	0.42	0.53	0.55	0.68	0.41	0.31	0.54	0.47	0.48±0.11
20	0.69	0.42	0.41	0.66	0.54	0.57	0.59	0.67	0.59	0.57±0.10

T.A SETTINGS & PARAMETERS

Sequence Title: TPA 1

T.A. Variable No: 1: Compression

Pre-Test Speed: 0.20 mm/sec

Test Speed: 0.20 mm/sec

Post-Test Speed: 0.20 mm/sec

T.A. Variable No: 5: 0.0 g

Target Mode: Strain

Distance: 10.000 mm

Strain: 40.0 %

Trigger Type: Auto (Force)

Trigger Force: 5.0 g

Probe: P/50 ; 50mm DIA

CYLINDER ALUMINIUM

Batch: poultry A

Points per second: 200

Test Run by: foodscience

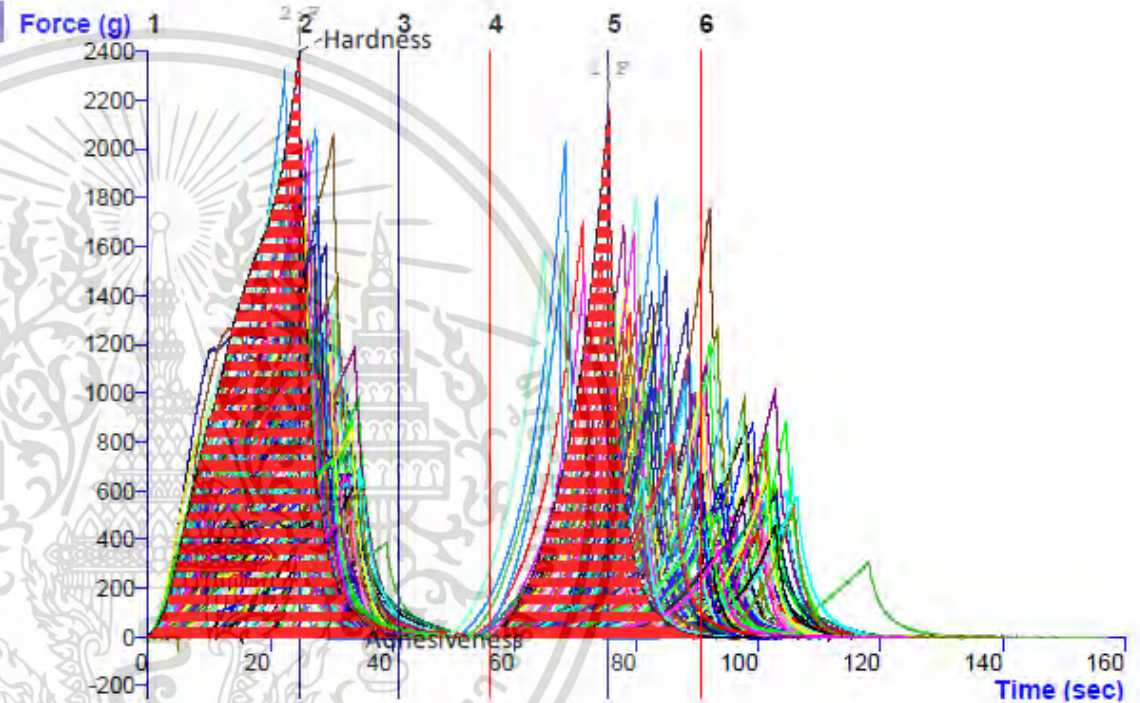


Fig A-1. Texture Profile Graph-Cubed Chicken

Table B-2.9 L* value of Turkey Berry

Treatment	L* value / Rep 1			L* value / Rep 2			L* value / Rep 3			Average±SD
	Sample 1	Sample 2	Sample 3	Sample 1	Sample 2	Sample 3	Sample 1	Sample 2	Sample 3	
1	42.27	41.77	42.13	40.83	42.91	42.49	42.05	42.01	41.74	42.04±0.58
2	41.71	41.56	41.7	41.68	41.26	41.33	41.32	41.61	41.36	41.50±0.18
3	41.46	41.34	40.98	41.77	41.13	41.75	42.11	41.22	40.86	41.40±0.41
4	37.69	43.71	43.66	42.64	43.71	43.65	43.31	42.49	37.69	42.04±2.57
5	44.82	43.77	43.76	44.26	43.99	44.55	44.72	44.49	45.01	44.37±0.46
6	41.33	41.02	40.87	41.12	41.02	41.25	41.08	41.4	41.67	41.20±0.24
7	39.65	39.62	39.32	39.35	39.26	39.35	39.16	39.67	40.09	39.50±0.29
8	41.32	41.41	41.86	40.83	42.01	41.19	41.25	42.21	40.22	41.37±0.61
9	44.85	44.76	44.7	44.68	44.74	44.82	44.84	44.7	44.75	44.76±0.06
10	41.27	41.32	41.41	41.96	40.83	41.01	42.29	40.11	41.23	41.27±0.63
11	42.16	42.02	41.95	42.05	42.02	41.9	42.09	42.04	42.13	42.04±0.08
12	41.09	41.35	41.33	41.28	41.09	41.03	41.01	41.13	41.41	41.19±0.15
13	43.28	43.37	43.46	43.44	43.51	43.33	43.3	43.5	43.45	43.40±0.09
14	38.44	38.29	38.23	38.16	38.21	38.56	38.55	38.39	38.07	38.32±0.17
15	39.41	39.4	39.35	39.41	39.48	39.49	39.46	39.61	39.41	39.46±0.08
16	41.83	41.71	41.68	41.93	43.55	43.5	43.66	43.7	43.43	42.78±0.94
17	43.84	43.64	43.58	43.23	43.37	43.25	43.63	43.44	43.37	43.48±0.20
18	40.91	42.97	40.55	41.21	41.63	40.19	40.21	40.31	40.22	40.91±0.92
19	41.7	41.62	41.71	41.83	41.84	41.77	41.75	41.76	41.78	41.75±0.07
20	41.13	40.19	40.21	41.34	40.68	41.77	41.13	41.65	42.11	41.13±0.67

Table B-2.10 a* value of Turkey Berry

Treatment	a* value / Rep 1			a* value / Rep 2			a* value / Rep 3			Average±SD
	Sample 1	Sample 2	Sample 3	Sample 1	Sample 2	Sample 3	Sample 1	Sample 2	Sample 3	
1	1.47	1.44	1.49	1.43	1.44	1.46	1.42	1.48	1.49	1.464±0.03
2	0.82	0.81	0.84	0.86	0.93	0.87	0.89	0.87	0.92	0.870±0.04
3	1.42	1.41	1.40	1.49	1.42	1.44	1.4	1.41	1.42	1.420±0.03
4	0.83	0.6	0.59	0.59	0.71	0.61	0.6	0.66	0.77	0.664±0.09
5	1.14	1.07	1.06	1.08	1.07	1.11	1.12	1.09	1.12	1.107±0.03
6	0.93	0.96	0.98	0.94	0.96	0.93	0.95	0.93	0.9	0.940±0.02
7	1.05	1.05	1.110	1.10	1.11	1.08	1.12	1.03	0.95	1.070±0.05
8	1.38	1.39	1.32	1.40	1.49	1.42	1.34	1.46	1.31	1.39±0.06
9	1.09	1.04	1.02	1.02	1.01	1.02	1.03	1.00	1.02	1.03±0.03
10	1.35	1.38	1.39	1.42	1.34	1.31	1.34	1.31	1.3	1.35±0.04
11	1.07	1.21	1.23	1.17	1.21	1.25	1.16	1.17	1.14	1.18±0.05
12	0.75	0.75	0.75	0.75	0.75	0.74	0.74	0.77	0.77	0.75±0.01
13	1.12	1.12	1.13	1.13	1.13	1.13	1.11	1.13	1.13	1.13±0.01
14	0.92	0.86	0.81	0.93	0.96	0.87	0.89	0.87	1.03	0.90±0.06
15	1.10	1.09	1.10	1.10	1.12	1.11	1.13	1.11	1.10	1.11±0.01
16	1.38	1.37	1.37	1.37	0.73	0.74	0.66	0.74	0.76	1.01±0.34
17	0.94	0.93	0.91	0.9	0.93	0.93	0.95	0.94	0.94	0.93±0.02
18	1.30	1.32	1.30	1.30	1.31	1.30	1.30	1.30	1.31	1.30±0.01
19	0.98	0.96	0.95	0.91	0.89	0.94	0.92	0.95	0.91	0.93±0.03
20	1.32	1.30	1.34	1.30	1.31	1.42	1.31	1.30	1.32	1.32±0.04

Table B-2.11 b* value of Turkey Berry

Treatment	b* value / Rep 1			b* value / Rep 2			b* value / Rep 3			Average±SD
	Sample 1	Sample 2	Sample 3	Sample 1	Sample 2	Sample 3	Sample 1	Sample 2	Sample 3	
1	38.31	37.81	38.86	38.74	36.96	38.16	38.11	37.05	38.54	38.06±0.68
2	36.02	35.76	36.08	36.09	36.21	35.93	36.09	36.23	35.93	36.04±0.15
3	37.41	37.35	38.31	37.81	37.38	36.16	38.16	37.31	36.56	37.38±0.69
4	33.00	31.93	36.57	36.62	34.29	35.32	35.3	34.91	34.04	34.66±1.55
5	38.89	38.29	38.08	38.42	38.1	38.59	38.77	38.54	38.82	38.50±0.30
6	37.31	37.28	37.38	37.29	37.33	36.89	36.95	37.1	37.22	37.19±0.17
7	35.97	35.77	35.99	36.02	36.06	36.07	35.89	35.93	35.65	35.93±0.14
8	37.22	37.31	37.29	37.45	37.38	36.16	38.16	37.21	37.27	37.27±0.51
9	34.74	34.51	34.55	34.49	34.87	34.55	34.45	34.71	34.61	34.61±0.14
10	37.09	37.96	36.82	37.31	37.29	37.77	36.16	36.16	37.21	37.09±0.62
11	41.29	42.39	42.39	42.12	42.35	42.28	42.18	42.20	42.01	42.13±0.34
12	35.78	35.90	36.18	36.3	36.36	36.07	36.01	36.65	36.48	36.19±0.28
13	39.47	39.56	39.48	39.39	39.26	39.59	39.67	39.29	39.42	39.46±0.14
14	37.03	36.44	36.05	36.83	37.25	37.01	36.99	36.83	37.43	36.87±0.42
15	35.98	36.02	35.52	36.04	36.17	36.27	36.03	35.70	35.63	35.93±0.25
16	34.81	34.98	34.56	35.37	31.33	31.32	30.83	31.69	32.05	32.99±1.88
17	36.14	35.94	36.02	35.8	36.05	36.09	36.54	36.27	36.32	36.13±0.22
18	36.1	36.42	35.13	36.21	36.38	36.16	36.76	35.34	36.41	36.10±0.53
19	37.68	37.53	37.58	37.48	37.61	37.58	37.3	37.69	37.18	37.51±0.17
20	36.52	36.76	36.09	36.16	36.72	37.31	36.19	36.17	36.76	36.52±0.41

Table B-2.12 ΔE^* value of Turkey Berry (Compare with control sample (before retorted), $L^*=49.45$, $a^*=24.80$, $b^*=15.41$)

Treatment	L* value / Rep 1			L* value / Rep 2			L* value / Rep 3			Average L* ±SD
	Sample 1	Sample 2	Sample 3	Sample 1	Sample 2	Sample 3	Sample 1	Sample 2	Sample 3	
1	28.90	28.79	29.22	29.55	28.07	28.77	28.89	28.31	29.14	28.85±0.12
2	28.44	28.37	28.46	28.45	28.56	28.47	28.52	28.53	28.41	29.86±0.16
3	28.69	28.70	29.30	28.75	28.76	27.98	28.92	28.71	28.44	29.04±0.11
4	28.67	28.42	28.42	28.46	27.54	27.83	27.84	27.69	27.42	29.05±0.08
5	28.96	28.88	28.78	28.85	28.74	28.87	28.93	28.87	28.91	28.72±0.12
6	29.07	29.12	29.20	29.11	29.15	28.89	28.95	28.95	28.96	28.72±0.12
7	28.57	28.55	28.68	28.75	28.83	28.73	28.70	28.94	28.78	27.97±0.09
8	28.66	28.67	28.60	28.90	28.46	28.15	29.20	28.35	29.07	28.86±0.07
9	26.93	26.89	26.94	26.92	27.08	26.92	26.86	27.03	26.96	28.03±0.46
10	28.64	29.04	28.43	28.50	28.87	29.09	27.92	28.58	28.75	28.84±0.45
11	30.92	31.52	31.52	31.38	31.49	31.45	31.41	31.43	31.31	28.69±0.35
12	28.57	28.55	28.68	28.75	28.83	28.73	28.70	28.94	28.78	28.67±0.34
13	29.58	29.62	29.55	29.50	29.41	29.63	29.70	29.43	29.51	28.64±0.36
14	29.88	29.71	29.60	29.89	30.04	29.87	29.85	29.85	30.13	28.32±0.31
15	28.90	28.93	28.72	28.93	28.95	29.00	28.89	28.70	28.70	28.42±0.23
16	27.39	27.51	27.33	27.62	26.21	26.21	26.10	26.29	26.45	26.94±0.07
17	27.89	27.85	27.91	27.90	27.96	28.00	28.12	28.04	28.08	29.54±0.10
18	28.31	27.89	27.98	28.27	28.22	28.56	28.84	28.15	28.66	28.46±0.06
19	29.12	29.08	29.09	29.04	29.12	29.08	28.96	29.13	28.90	31.38±0.18
20	28.42	28.84	28.49	28.21	28.66	28.55	28.28	28.13	28.27	26.79±0.65

Table B-2.13 Hardness value of Turkey Berry

Treatment	Hardness / Rep 1			Hardness / Rep 2			Hardness / Rep 3			Average±SD
	Sample 1	Sample 2	Sample 3	Sample 1	Sample 2	Sample 3	Sample 1	Sample 2	Sample 3	
1	1,995.45	2,156.35	2063.55	2,220.87	2,079.48	2,435.20	1,926.37	2,197.91	1,963.76	2,093.21±259.52
2	2,283.99	2,340.46	1932.23	2,489.32	2,192.03	2,258.50	2,287.47	2,122.12	2,103.25	2,001.04±519.25
3	1,968.25	2,158.25	2185.25	2,289.77	2,379.38	2,139.20	2,028.67	1,997.41	2,146.37	2,154.73±347.91
4	2,558.73	2,181.12	2245.66	2,269.62	2,495.51	2,573.44	2,511.01	2,477.12	2,256.42	2,007.62±493.29
5	2,339.86	2,570.00	2168.13	2,140.16	2,181.99	2,260.88	2,215.65	2,092.32	2,283.61	2,083.62±289.91
6	2,016.28	1,882.67	2044.93	1,836.17	1,849.13	2,097.14	1,822.27	2,057.56	1,848.25	1,872.72±420.27
7	2,036.04	1,938.27	2168.23	1,881.63	1,877.53	1,821.13	1,935.55	1,878.71	1,905.65	1,963.64±334.35
8	2,265.45	2,423.57	2379.38	2,365.55	2,097.57	2,379.38	2,537.20	2,026.27	2,137.20	2,301.28±306.63
9	2,299.70	2,245.95	2357.79	2,214.96	2,027.00	2,059.37	2,054.36	2,251.18	2,166.16	2,075.16±242.35
10	2,365.45	2,483.47	2379.38	2,385.55	2,287.57	2,359.38	2,537.62	2,126.27	2,137.20	2,329.09±269.28
11	2,295.45	2,296.85	2133.65	2,220.70	2,386.48	2,235.20	2,276.37	2,697.91	2,096.35	2,093.21±337.26
12	2,011.52	2,165.50	1894.62	1,845.05	1,987.56	2,158.95	1,831.95	1,841.98	1,845.83	1,864.78±512.86
13	2,011.82	2,057.95	2335.38	2,195.17	2,192.98	2,578.33	2,060.08	2,245.74	2,091.58	2,052.12±431.98
14	1,741.94	2,049.48	2027.87	1,780.92	1,883.35	1,894.69	1,932.18	1,718.27	1,823.51	1,861.36±127.44
15	1,675.82	1,549.77	1539.38	1,780.92	1,699.55	1,594.69	1,420.44	1,611.09	1,558.48	1,658.90±399.74
16	2,148.41	2,234.12	1925.79	2,298.40	2,282.70	2,391.80	2,346.92	2,190.51	2,551.28	1,796.66±224.90
17	1,964.17	1,860.21	1745.03	2,245.62	1,880.39	1,870.03	2,004.75	2,242.66	2,040.12	1,939.22±400.76
18	2,267.25	2,385.25	2498.77	2,459.38	2,159.20	2,329.28	2,237.32	1,946.07	2,137.02	2,346.61±252.67
19	1,869.55	2,030.32	2239.14	2,201.78	1,963.20	1,874.50	2,143.80	1,864.66	1,885.86	1,808.09±389.91
20	2,016.28	2,436.32	1947.07	2,077.14	2,489.77	2,036.74	2,117.42	2,025.22	2,284.19	2,181.12±281.85

T.A SETTINGS & PARAMETERS

Sequence Title: Return to Start (Set Dist)

Test Mode: Compression

Pre-Test Speed: 1.00 mm/sec

Test Speed: 0.50 mm/sec

Post-Test Speed: 10.00 mm/sec

T.A. Variable No: 5: 0.0 g

Target Mode: Strain

Distance: 2.000 mm

Strain: 50.0 %

Trigger Type: Auto (Force)

Trigger Force: 5.0 g

Probe: P/50 ; 50mm DIA

CYLINDER ALUMINIUM

Batch: TK berry A

Points per second: 500

Test Run by: foodscience

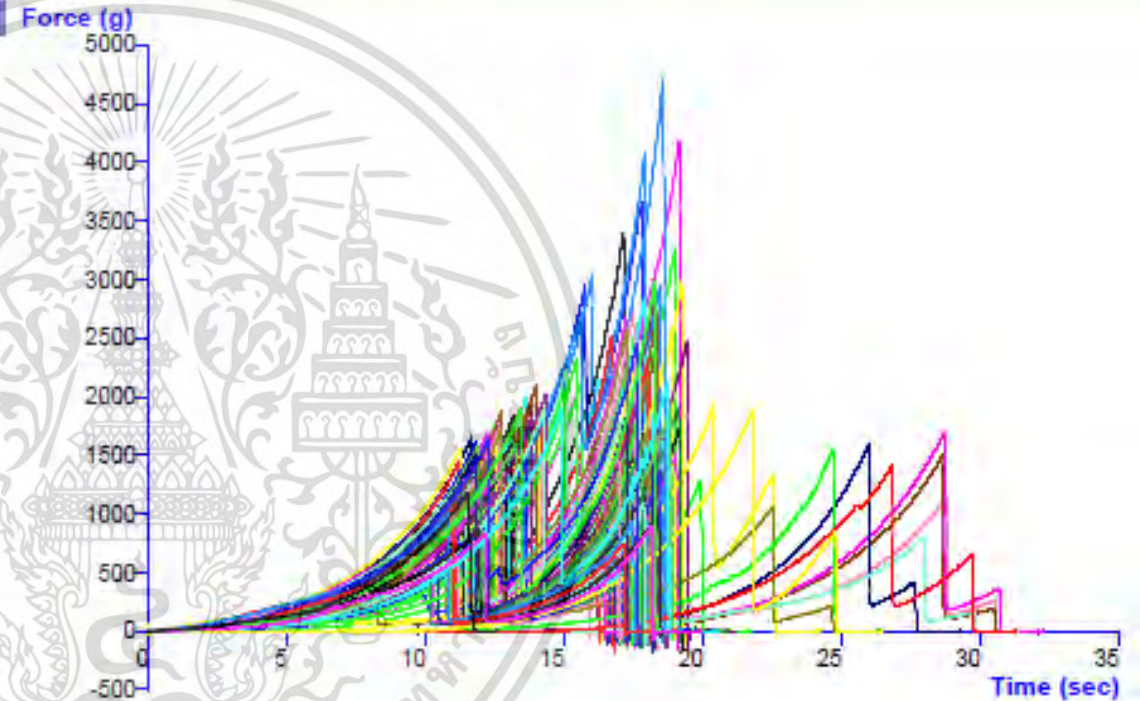


Fig A-2 Texture Profile Graph- Hardness value of Turkey Berry

APPENDIX C: Statistical Data: Regression Analysis



เอกสารนี้เป็นเอกสารที่สงวนไว้สำหรับการใช้งานเพื่อการศึกษาเท่านั้น ไม่อนุญาตให้นำไปใช้ประโยชน์ด้านการค้า
ไม่ว่ากรณีใดๆ ทั้งสิ้น อีกทั้งห้ามมิให้ตัดแปลงเนื้อหา และต้องอ้างอิงถึงเจ้าของเอกสารทุกครั้งที่มีการนำไปใช้

Response Surface Regression: process time versus %coconut milk, %chicken meat, %turkey berry

The analysis was done using coded units.

Estimated Regression Coefficients for process time

Term	Coef	SE Coef	T	P
Constant	7.03021	0.2705	25.988	0.000
%coconut milk	0.58911	0.1795	3.282	0.008
%chicken meat	1.27474	0.1795	7.102	0.000
%turkey berry	0.46596	0.1795	2.596	0.027
%coconut milk*%coconut milk	-0.02067	0.1747	-0.118	0.908
%chicken meat*%chicken meat	0.68644	0.1747	3.929	0.003
%turkey berry*%turkey berry	-0.19745	0.1747	-1.130	0.285
%coconut milk*%chicken meat	-0.12500	0.2345	-0.533	0.606
%coconut milk*%turkey berry	0.12500	0.2345	0.533	0.606
%chicken meat*%turkey berry	-0.12500	0.2345	-0.533	0.606

S = 0.663268 PRESS = 33.4769
 R-Sq = 89.66% R-Sq(pred) = 21.32% R-Sq(adj) = 80.36%

Analysis of Variance for process time

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Regression	9	38.1508	38.1508	4.23897	9.64	0.001
Linear	3	29.8967	29.8967	9.96558	22.65	0.000
Square	3	7.8790	7.8790	2.62634	5.97	0.013
Interaction	3	0.3750	0.3750	0.12500	0.28	0.836
Residual Error	10	4.3992	4.3992	0.43992		
Lack-of-Fit	5	4.3992	4.3992	0.87985	*	*
Pure Error	5	0.0000	0.0000	0.00000		
Total	19	42.5500				

Obs	StdOrder	process time	Fit	SE Fit	Residual	St Resid
1	1	7.000	7.030	0.271	-0.030	-0.05
2	2	6.000	5.688	0.517	0.312	0.75
3	3	7.000	7.030	0.271	-0.030	-0.05
4	4	7.000	7.654	0.543	-0.654	-1.72
5	5	7.000	6.828	0.517	0.172	0.41
6	6	9.000	9.703	0.543	-0.703	-1.85
7	7	8.000	8.093	0.543	-0.093	-0.24
8	8	7.000	7.030	0.271	-0.030	-0.05
9	9	6.000	6.222	0.543	-0.222	-0.58
10	10	7.000	7.030	0.271	-0.030	-0.05
11	11	6.000	5.981	0.517	0.019	0.05
12	12	8.000	8.771	0.543	-0.771	-2.02 R
13	13	6.000	5.976	0.543	0.024	0.06
14	14	9.000	7.963	0.517	1.037	2.50 R
15	15	12.000	11.116	0.517	0.884	2.13 R
16	16	5.000	5.044	0.543	-0.044	-0.11
17	17	8.000	8.525	0.543	-0.525	-1.38
18	18	7.000	7.030	0.271	-0.030	-0.05
19	19	8.000	7.255	0.517	0.745	1.79
20	20	7.000	7.030	0.271	-0.030	-0.05

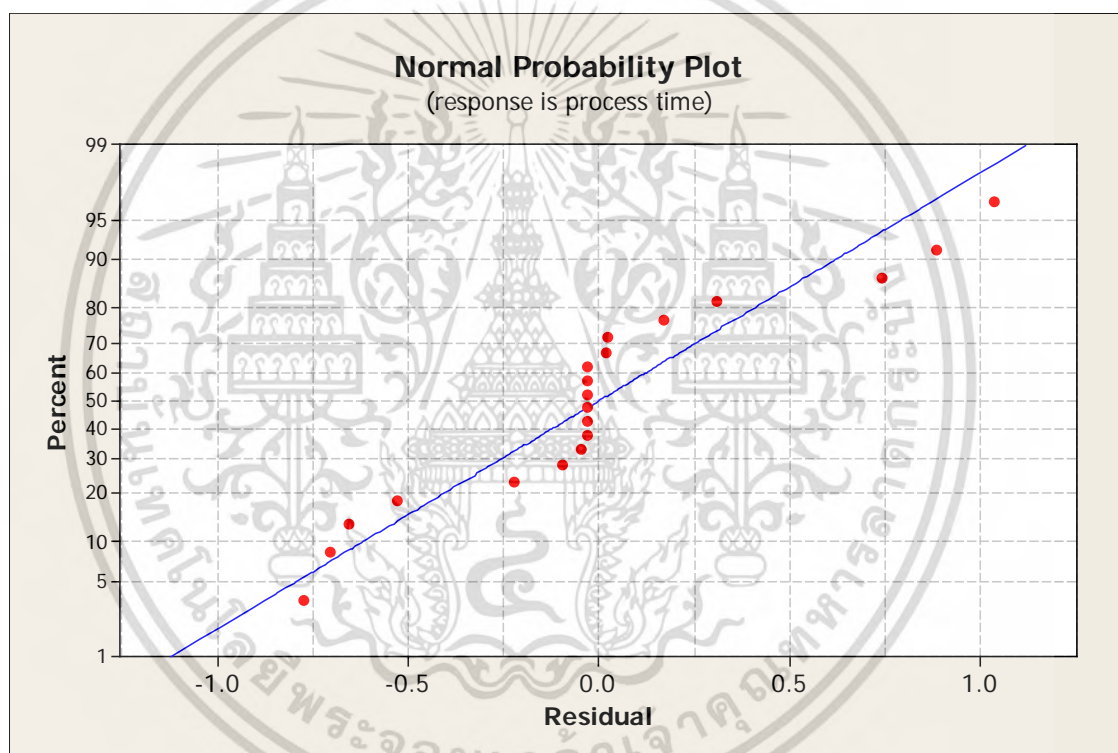
R denotes an observation with a large standardized residual.

เอกสารนี้เป็นเอกสารที่สงวนไว้สำหรับการใช้งานเพื่อการศึกษาเท่านั้น ไม่อนุญาตให้นำไปใช้ประโยชน์ด้านการค้า
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Estimated Regression Coefficients for process time using data in uncoded units

Term	Coef
Constant	-1.19716
%coconut milk	0.0483800
%chicken meat	-0.178138
%turkey berry	0.951172
%coconut milk*%coconut milk	-2.06701E-04
%chicken meat*%chicken meat	0.00686437
%turkey berry*%turkey berry	-0.0315915
%coconut milk*%chicken meat	-0.00125000
%coconut milk*%turkey berry	0.00500000
%chicken meat*%turkey berry	-0.00500000

Normal plot of Residuals for process time



เอกสารนี้เป็นเอกสารที่สงวนไว้สำหรับการใช้งานเพื่อการศึกษาเท่านั้น ไม่อนุญาตให้นำไปใช้ประโยชน์ด้านการค้า
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Response Surface Regression: L* Chicken versus %coconut milk, %chicken meat, %turkey berry

The analysis was done using coded units.

Estimated Regression Coefficients for L*CK

Term	Coef	SE Coef	T	P
Constant	70.0033	0.5477	127.817	0.000
%coconut milk	0.6868	0.3634	1.890	0.088
%chicken meat	1.3087	0.3634	3.602	0.005
%turkey berry	-0.0413	0.3634	-0.114	0.912
%coconut milk*%coconut milk	0.0887	0.3537	0.251	0.807
%chicken meat*%chicken meat	0.1895	0.3537	0.536	0.604
%turkey berry*%turkey berry	0.5943	0.3537	1.680	0.124
%coconut milk*%chicken meat	-0.0850	0.4748	-0.179	0.861
%coconut milk*%turkey berry	-0.3375	0.4748	-0.711	0.493
%chicken meat*%turkey berry	-0.3500	0.4748	-0.737	0.478

S = 1.34286 PRESS = 131.944
R-Sq = 67.32% R-Sq(pred) = 0.00% R-Sq(adj) = 37.91%

Analysis of Variance for L*CK

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Regression	9	37.1479	37.1479	4.1275	2.29	0.107
Linear	3	29.8568	29.8568	9.9523	5.52	0.017
Square	3	5.3420	5.3420	1.7807	0.99	0.437
Interaction	3	1.9490	1.9490	0.6497	0.36	0.783
Residual Error	10	18.0327	18.0327	1.8033		
Lack-of-Fit	5	17.0352	17.0352	3.4070	17.08	0.004
Pure Error	5	0.9975	0.9975	0.1995		
Total	19	55.1806				

Obs	StdOrder	L*CK	Fit	SE Fit	Residual	St Resid
1	1	69.320	70.003	0.548	-0.683	-0.56
2	2	72.930	71.754	1.046	1.176	1.40
3	3	69.610	70.003	0.548	-0.393	-0.32
4	4	68.870	70.310	1.099	-1.440	-1.87
5	5	70.210	68.338	1.046	1.872	2.22 R
6	6	72.440	72.057	1.099	0.383	0.50
7	7	72.460	71.636	1.099	0.824	1.07
8	8	69.890	70.003	0.548	-0.113	-0.09
9	9	68.920	70.368	1.099	-1.448	-1.88
10	10	70.300	70.003	0.548	0.297	0.24
11	11	68.270	69.099	1.046	-0.829	-0.99
12	12	72.660	73.515	1.099	-0.855	-1.11
13	13	69.680	69.441	1.099	0.239	0.31
14	14	73.110	71.409	1.046	1.701	2.02 R
15	15	71.740	72.740	1.046	-1.000	-1.19
16	16	67.150	68.149	1.099	-0.999	-1.29
17	17	72.360	71.529	1.099	0.831	1.08
18	18	70.340	70.003	0.548	0.337	0.27
19	19	71.310	71.615	1.046	-0.305	-0.36
20	20	70.410	70.003	0.548	0.407	0.33

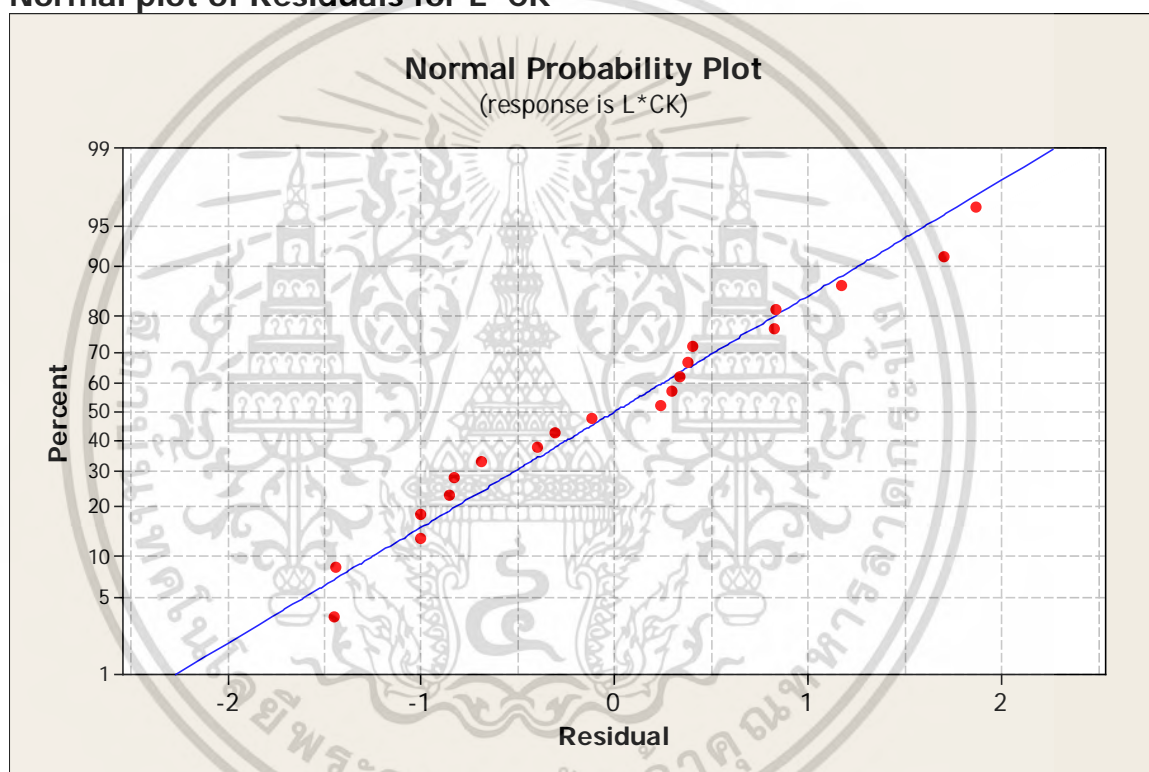
R denotes an observation with a large standardized residual.

เอกสารนี้เป็นเอกสารที่สงวนไว้สำหรับการใช้งานเพื่อการศึกษาเท่านั้น ไม่อนุญาตให้นำไปใช้ประโยชน์ด้านการค้า
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Estimated Regression Coefficients for L*CK using data in uncoded units

Term	Coef
Constant	69.4798
%coconut milk	0.200844
%chicken meat	0.221946
%turkey berry	-1.50115
%coconut milk*%coconut milk	0.000886987
%chicken meat*%chicken meat	0.00189461
%turkey berry*%turkey berry	0.0950848
%coconut milk*%chicken meat	-8.50000E-04
%coconut milk*%turkey berry	-0.0135000
%chicken meat*%turkey berry	-0.0140000

Normal plot of Residuals for L*CK



เอกสารนี้เป็นเอกสารที่สงวนไว้สำหรับการใช้งานเพื่อการศึกษาเท่านั้น ไม่อนุญาตให้นำไปใช้ประโยชน์ด้านการค้า
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Response Surface Regression: a*CK versus %coconut milk, %chicken meat, %turkey berry

The analysis was done using coded units.

Estimated Regression Coefficients for a*CK

Term	Coef	SE Coef	T	P
Constant	0.411057	0.05828	7.053	0.000
%coconut milk	0.071194	0.03867	1.841	0.095
%chicken meat	0.070364	0.03867	1.820	0.099
%turkey berry	-0.027956	0.03867	-0.723	0.486
%coconut milk*%coconut milk	-0.009082	0.03764	-0.241	0.814
%chicken meat*%chicken meat	-0.035761	0.03764	-0.950	0.364
%turkey berry*%turkey berry	0.184842	0.03764	4.911	0.001
%coconut milk*%chicken meat	-0.051625	0.05052	-1.022	0.331
%coconut milk*%turkey berry	-0.081069	0.05052	-1.605	0.140
%chicken meat*%turkey berry	-0.023931	0.05052	-0.474	0.646

S = 0.142889 PRESS = 1.53058
R-Sq = 79.01% R-Sq(pred) = 0.00% R-Sq(adj) = 60.12%

Analysis of Variance for a*CK

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Regression	9	0.76846	0.76846	0.085384	4.18	0.018
Linear	3	0.14751	0.14751	0.049170	2.41	0.128
Square	3	0.54247	0.54247	0.180822	8.86	0.004
Interaction	3	0.07848	0.07848	0.026160	1.28	0.333
Residual Error	10	0.20417	0.20417	0.020417		
Lack-of-Fit	5	0.19190	0.19190	0.038381	15.64	0.005
Pure Error	5	0.01227	0.01227	0.002454		
Total	19	0.97263				

Obs	StdOrder	a*CK	Fit	SE Fit	Residual	St Resid
1	1	0.445	0.411	0.058	0.034	0.26
2	2	0.812	0.981	0.111	-0.169	-1.88
3	3	0.490	0.411	0.058	0.079	0.61
4	4	0.440	0.518	0.117	-0.078	-0.95
5	5	0.314	0.192	0.111	0.122	1.36
6	6	0.397	0.508	0.117	-0.111	-1.36
7	7	0.646	0.573	0.117	0.073	0.89
8	8	0.415	0.411	0.058	0.004	0.03
9	9	0.623	0.689	0.117	-0.066	-0.80
10	10	0.380	0.411	0.058	-0.031	-0.24
11	11	0.223	0.266	0.111	-0.043	-0.48
12	12	0.940	0.774	0.117	0.166	2.02 R
13	13	0.263	0.435	0.117	-0.172	-2.09 R
14	14	0.556	0.505	0.111	0.050	0.56
15	15	0.314	0.428	0.111	-0.114	-1.28
16	16	0.387	0.281	0.117	0.106	1.29
17	17	0.691	0.631	0.117	0.060	0.73
18	18	0.375	0.411	0.058	-0.036	-0.28
19	19	1.063	0.887	0.111	0.176	1.97
20	20	0.360	0.411	0.058	-0.051	-0.39

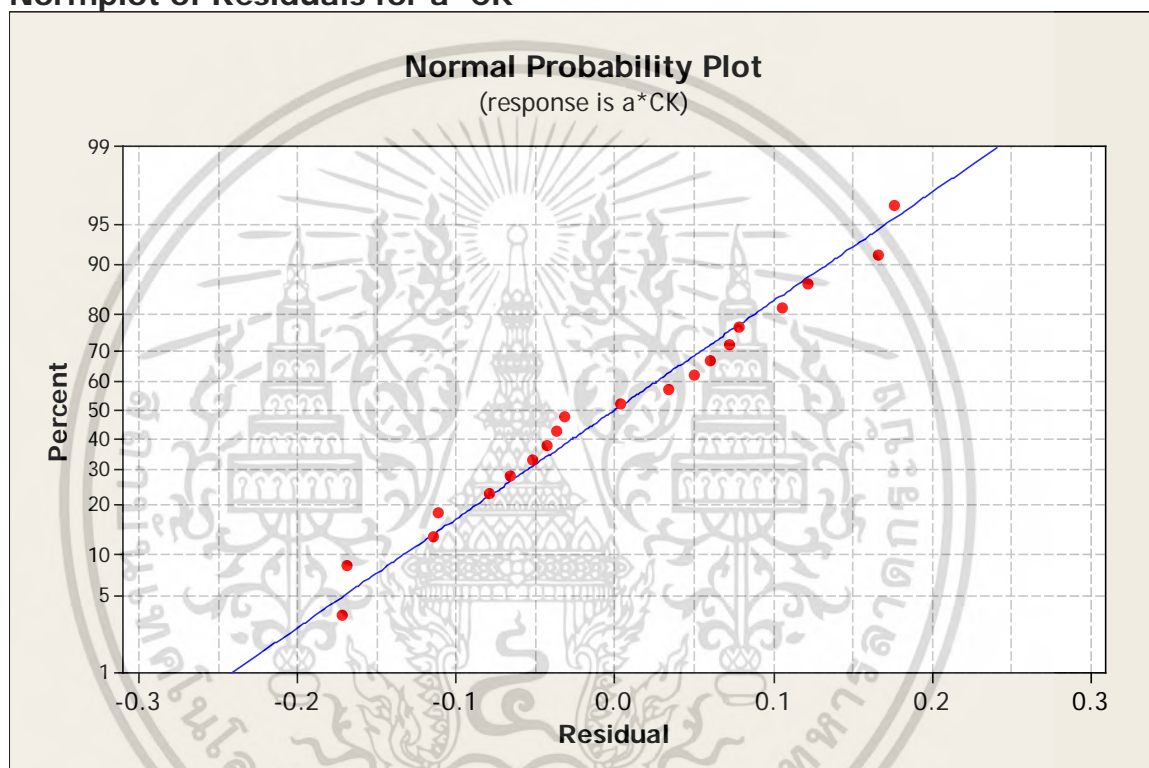
R denotes an observation with a large standardized residual.

เอกสารนี้เป็นเอกสารที่สงวนไว้สำหรับการใช้งานเพื่อการศึกษาเท่านั้น ไม่อนุญาตให้นำไปใช้ประโยชน์ด้านการค้า
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Estimated Regression Coefficients for a*CK using data in uncoded units

Term	Coef
Constant	1.95877
%coconut milk	0.0694991
%chicken meat	0.0585270
%turkey berry	-0.608336
%coconut milk*%coconut milk	-9.08208E-05
%chicken meat*%chicken meat	-3.57611E-04
%turkey berry*%turkey berry	0.0295747
%coconut milk*%chicken meat	-5.16250E-04
%coconut milk*%turkey berry	-0.00324278
%chicken meat*%turkey berry	-9.57222E-04

Normplot of Residuals for a*CK



เอกสารนี้เป็นเอกสารที่สงวนไว้สำหรับการใช้งานเพื่อการศึกษาเท่านั้น ไม่อนุญาตให้นำไปใช้ประโยชน์ด้านการค้า
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Response Surface Regression: b*CK versus %coconut milk, %chicken meat, %turkey berry

The analysis was done using coded units.

Estimated Regression Coefficients for b*CK

Term	Coef	SE Coef	T	P
Constant	15.6135	0.13825	112.938	0.000
%coconut milk	0.1623	0.09172	1.770	0.107
%chicken meat	0.5462	0.09172	5.954	0.000
%turkey berry	-0.3400	0.09172	-3.707	0.004
%coconut milk*%coconut milk	-0.2685	0.08929	-3.007	0.013
%chicken meat*%chicken meat	-0.2210	0.08929	-2.475	0.033
%turkey berry*%turkey berry	0.1659	0.08929	1.858	0.093
%coconut milk*%chicken meat	-0.0914	0.11984	-0.762	0.463
%coconut milk*%turkey berry	-0.2041	0.11984	-1.703	0.119
%chicken meat*%turkey berry	-0.1898	0.11984	-1.583	0.144

S = 0.338970 PRESS = 8.71031
 R-Sq = 88.61% R-Sq(pred) = 13.64% R-Sq(adj) = 78.36%

Analysis of Variance for b*CK

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Regression	9	8.9375	8.93749	0.99305	8.64	0.001
Linear	3	6.0128	6.01282	2.00427	17.44	0.000
Square	3	2.2365	2.23650	0.74550	6.49	0.010
Interaction	3	0.6882	0.68818	0.22939	2.00	0.179
Residual Error	10	1.1490	1.14901	0.11490		
Lack-of-Fit	5	1.1348	1.13483	0.22697	80.01	0.000
Pure Error	5	0.0142	0.01418	0.00284		
Total	19	10.0865				

Obs	StdOrder	b*CK	Fit	SE Fit	Residual	St Resid
1	1	15.510	15.613	0.138	-0.103	-0.33
2	2	16.752	16.655	0.264	0.098	0.46
3	3	15.630	15.613	0.138	0.017	0.05
4	4	14.467	14.643	0.277	-0.176	-0.90
5	5	14.609	14.070	0.264	0.539	2.54 R
6	6	15.301	15.173	0.277	0.128	0.66
7	7	16.263	16.091	0.277	0.173	0.89
8	8	15.660	15.613	0.138	0.047	0.15
9	9	14.948	15.352	0.277	-0.404	-2.07 R
10	10	15.615	15.613	0.138	0.002	0.00
11	11	14.435	14.581	0.264	-0.146	-0.69
12	12	16.837	16.641	0.277	0.196	1.00
13	13	14.345	14.544	0.277	-0.199	-1.02
14	14	15.278	15.127	0.264	0.151	0.71
15	15	15.372	15.907	0.264	-0.535	-2.52 R
16	16	14.305	14.436	0.277	-0.131	-0.67
17	17	15.840	15.439	0.277	0.401	2.06 R
18	18	15.645	15.613	0.138	0.032	0.10
19	19	15.418	15.511	0.264	-0.093	-0.44
20	20	15.620	15.613	0.138	0.007	0.02

R denotes an observation with a large standardized residual.

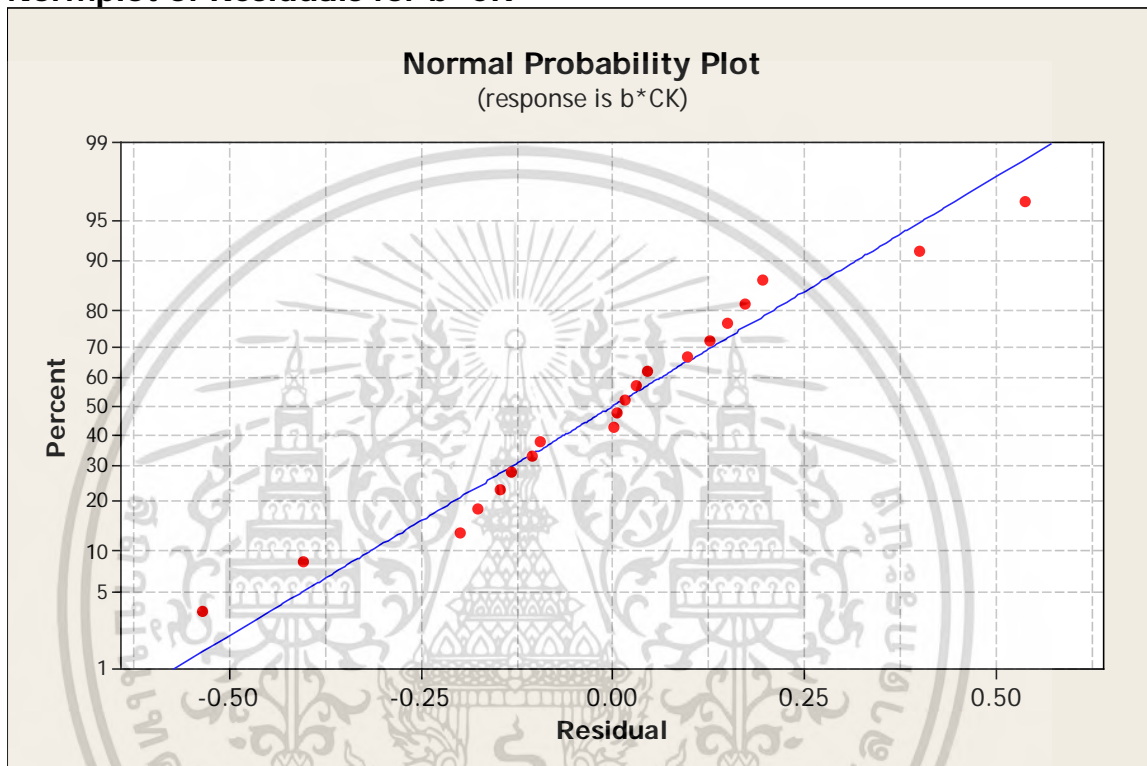
Estimated Regression Coefficients for b*CK using data in uncoded units

Term	Coef
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เอกสารนี้เป็นเอกสารที่สงวนไว้สำหรับการใช้งานเพื่อการศึกษาเท่านั้น ไม่อนุญาตให้นำไปใช้ประโยชน์ด้านการค้า
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%coconut milk	0.333623
%chicken meat	0.314093
%turkey berry	-0.286199
%coconut milk*%coconut milk	-0.00268461
%chicken meat*%chicken meat	-0.00221030
%turkey berry*%turkey berry	0.0265469
%coconut milk*%chicken meat	-9.13535E-04
%coconut milk*%turkey berry	-0.00816475
%chicken meat*%turkey berry	-0.00759081

Normplot of Residuals for b*CK



เอกสารนี้เป็นเอกสารที่สงวนไว้สำหรับการใช้งานเพื่อการศึกษาเท่านั้น ไม่อนุญาตให้นำไปใช้ประโยชน์ด้านการค้า
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Response Surface Regression: CK_dE versus %coconut milk, %chicken meat, %turkey berry

The analysis was done using coded units.

Estimated Regression Coefficients for CK_dE

Term	Coef	SE Coef	T	P
Constant	7.90272	0.5447	14.508	0.000
%coconut milk	-0.69196	0.3614	-1.915	0.085
%chicken meat	-1.30128	0.3614	-3.601	0.005
%turkey berry	0.00635	0.3614	0.018	0.986
%coconut milk*%coconut milk	-0.07717	0.3518	-0.219	0.831
%chicken meat*%chicken meat	-0.17339	0.3518	-0.493	0.633
%turkey berry*%turkey berry	-0.57387	0.3518	-1.631	0.134
%coconut milk*%chicken meat	0.11334	0.4722	0.240	0.815
%coconut milk*%turkey berry	0.33386	0.4722	0.707	0.496
%chicken meat*%turkey berry	0.31104	0.4722	0.659	0.525

S = 1.33562 PRESS = 130.833
 R-Sq = 67.10% R-Sq(pred) = 0.00% R-Sq(adj) = 37.49%

Analysis of Variance for CK_dE

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Regression	9	36.3782	36.3782	4.0420	2.27	0.109
Linear	3	29.6651	29.6651	9.8884	5.54	0.017
Square	3	4.9446	4.9446	1.6482	0.92	0.464
Interaction	3	1.7684	1.7684	0.5895	0.33	0.804
Residual Error	10	17.8387	17.8387	1.7839		
Lack-of-Fit	5	16.8877	16.8877	3.3775	17.76	0.003
Pure Error	5	0.9510	0.9510	0.1902		
Total	19	54.2169				

Obs	StdOrder	CK_dE	Fit	SE Fit	Residual	St Resid
1	1	8.577	7.903	0.545	0.674	0.55
2	2	5.124	6.269	1.041	-1.145	-1.37
3	3	8.280	7.903	0.545	0.377	0.31
4	4	9.072	7.603	1.093	1.469	1.91
5	5	7.746	9.601	1.041	-1.855	-2.22 R
6	6	5.495	5.850	1.093	-0.354	-0.46
7	7	5.530	6.372	1.093	-0.843	-1.10
8	8	8.012	7.903	0.545	0.109	0.09
9	9	8.969	7.545	1.093	1.424	1.86
10	10	7.616	7.903	0.545	-0.287	-0.24
11	11	9.689	8.848	1.041	0.840	1.00
12	12	5.419	4.547	1.093	0.872	1.14
13	13	8.301	8.546	1.093	-0.246	-0.32
14	14	4.795	6.521	1.041	-1.726	-2.06 R
15	15	6.194	5.224	1.041	0.970	1.16
16	16	10.804	9.823	1.093	0.980	1.28
17	17	5.541	6.339	1.093	-0.798	-1.04
18	18	7.577	7.903	0.545	-0.325	-0.27
19	19	6.550	6.290	1.041	0.260	0.31
20	20	7.506	7.903	0.545	-0.397	-0.33

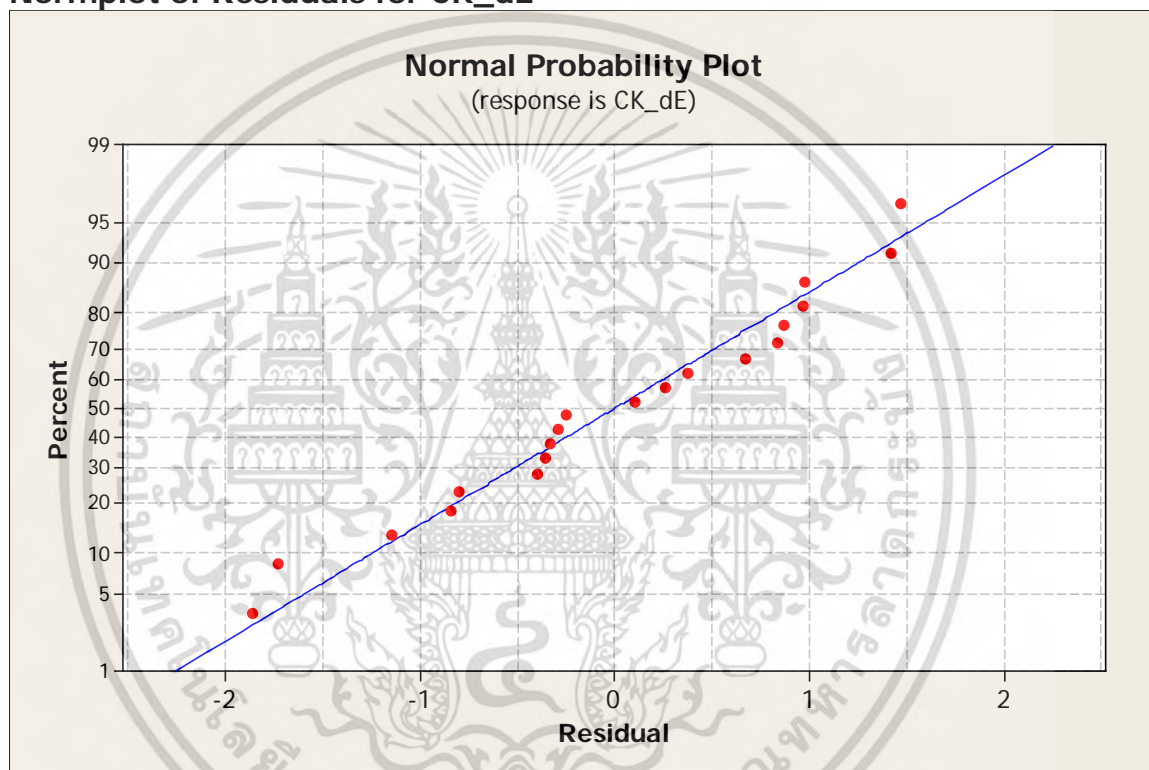
R denotes an observation with a large standardized residual.

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Estimated Regression Coefficients for CK_dE using data in uncoded units

Term	Coef
Constant	9.04222
%coconut milk	-0.216107
%chicken meat	-0.221284
%turkey berry	1.45738
%coconut milk*%coconut milk	-7.71746E-04
%chicken meat*%chicken meat	-0.00173388
%turkey berry*%turkey berry	-0.0918194
%coconut milk*%chicken meat	0.00113342
%coconut milk*%turkey berry	0.0133544
%chicken meat*%turkey berry	0.0124415

Normplot of Residuals for CK_dE



เอกสารนี้เป็นเอกสารที่สงวนไว้สำหรับการใช้งานเพื่อการศึกษาเท่านั้น ไม่อนุญาตให้นำไปใช้ประโยชน์ด้านการค้า
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Response Surface Regression: L*TB versus %coconut milk, %chicken meat, %turkey berry

The analysis was done using coded units.

Estimated Regression Coefficients for L*TB

Term	Coef	SE Coef	T	P
Constant	41.3191	0.3953	104.526	0.000
%coconut milk	-0.4559	0.2623	-1.738	0.113
%chicken meat	-1.1619	0.2623	-4.430	0.001
%turkey berry	0.1692	0.2623	0.645	0.533
%coconut milk*%coconut milk	-0.1910	0.2553	-0.748	0.472
%chicken meat*%chicken meat	0.4224	0.2553	1.654	0.129
%turkey berry*%turkey berry	0.3199	0.2553	1.253	0.239
%coconut milk*%chicken meat	-0.1512	0.3427	-0.441	0.668
%coconut milk*%turkey berry	-0.9137	0.3427	-2.667	0.024
%chicken meat*%turkey berry	0.7613	0.3427	2.221	0.051

S = 0.969231 PRESS = 66.7845
 R-Sq = 80.11% R-Sq(pred) = 0.00% R-Sq(adj) = 62.21%

Analysis of Variance for L*TB

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Regression	9	37.8370	37.8370	4.2041	4.48	0.014
Linear	3	21.6657	21.6657	7.2219	7.69	0.006
Square	3	4.6728	4.6728	1.5576	1.66	0.238
Interaction	3	11.4985	11.4985	3.8328	4.08	0.039
Residual Error	10	9.3941	9.3941	0.9394		
Lack-of-Fit	5	8.6668	8.6668	1.7334	11.92	0.008
Pure Error	5	0.7273	0.7273	0.1455		
Total	19	47.2311				

Obs	StdOrder	L*TB	Fit	SE Fit	Residual	St Resid
1	1	42.040	41.319	0.395	0.721	-0.81
2	2	41.500	41.939	0.755	-0.439	-0.72
3	3	41.400	41.319	0.395	0.081	0.09
4	4	42.040	41.222	0.793	0.818	1.47
5	5	44.370	44.468	0.755	-0.098	-0.16
6	6	41.200	40.118	0.793	1.082	1.94
7	7	39.500	39.471	0.793	0.029	0.05
8	8	41.370	41.319	0.395	0.051	0.06
9	9	44.760	44.233	0.793	0.527	0.95
10	10	41.270	41.319	0.395	-0.049	-0.06
11	11	42.040	41.546	0.755	0.494	0.81
12	12	41.190	40.085	0.793	1.105	1.98
13	13	43.400	43.659	0.793	-0.259	-0.46
14	14	38.320	40.012	0.755	-1.692	-2.79 R
15	15	39.460	40.560	0.755	-1.100	-1.81
16	16	42.780	43.015	0.793	-0.235	-0.42
17	17	43.480	43.160	0.793	0.320	0.57
18	18	40.910	41.319	0.395	-0.409	-0.46
19	19	41.750	42.508	0.755	-0.758	-1.25
20	20	41.130	41.319	0.395	-0.189	-0.21

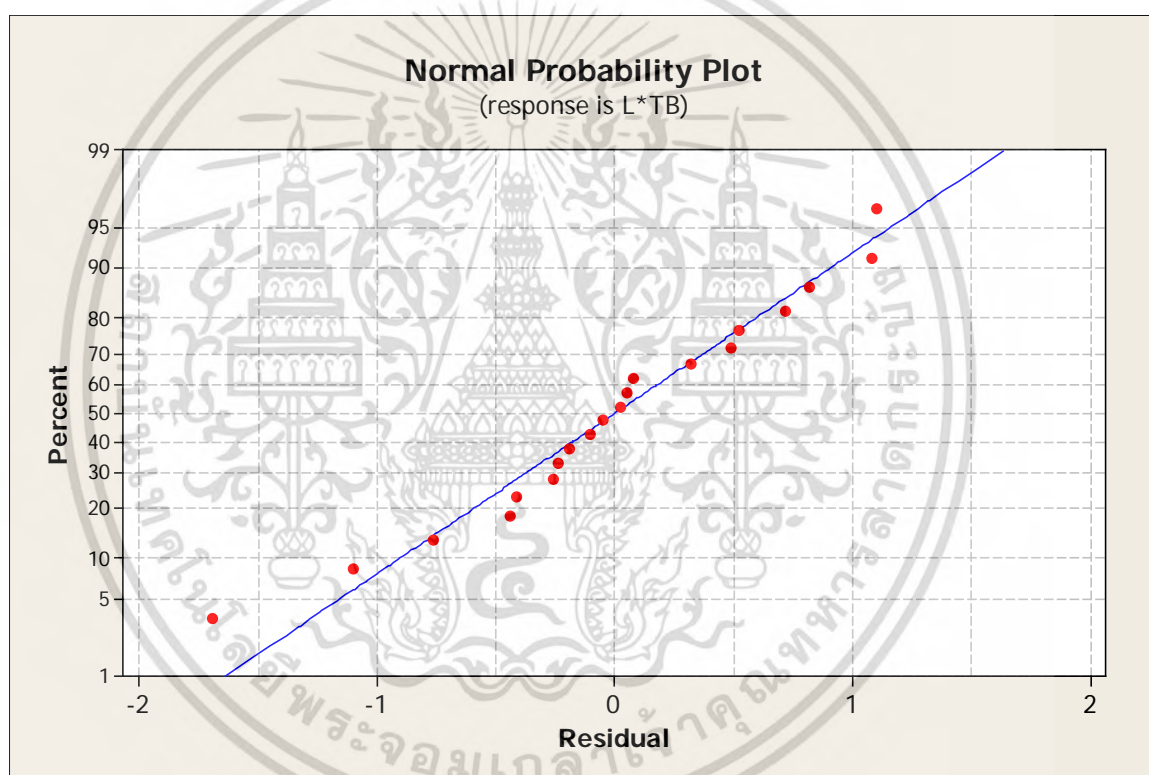
R denotes an observation with a large standardized residual.

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Estimated Regression Coefficients for L*TB using data in uncoded units

Term	Coef
Constant	48.8527
%coconut milk	0.590372
%chicken meat	-0.697313
%turkey berry	-0.846043
%coconut milk*%coconut milk	-0.00191019
%chicken meat*%chicken meat	0.00422397
%turkey berry*%turkey berry	0.0511786
%coconut milk*%chicken meat	-0.00151250
%coconut milk*%turkey berry	-0.0365500
%chicken meat*%turkey berry	0.0304500

Normal plot of Residuals for L*TB



เอกสารนี้เป็นเอกสารที่สงวนไว้สำหรับการใช้งานเพื่อการศึกษาเท่านั้น ไม่อนุญาตให้นำไปใช้ประโยชน์ด้านการค้า
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Response Surface Regression: a*TB versus %coconut milk, %chicken meat, %turkey berry

The analysis was done using coded units.

Estimated Regression Coefficients for a*TB

Term	Coef	SE Coef	T	P
Constant	1.37255	0.04387	31.288	0.000
%coconut milk	-0.08880	0.02911	-3.051	0.012
%chicken meat	-0.00872	0.02911	-0.300	0.771
%turkey berry	-0.00643	0.02911	-0.221	0.829
%coconut milk*%coconut milk	-0.12757	0.02833	-4.502	0.001
%chicken meat*%chicken meat	-0.10655	0.02833	-3.761	0.004
%turkey berry*%turkey berry	-0.17726	0.02833	-6.256	0.000
%coconut milk*%chicken meat	0.01833	0.03803	0.482	0.640
%coconut milk*%turkey berry	-0.01889	0.03803	-0.497	0.630
%chicken meat*%turkey berry	0.03833	0.03803	1.008	0.337

S = 0.107561 PRESS = 0.899352
 R-Sq = 87.98% R-Sq(pred) = 6.58% R-Sq(adj) = 77.17%

Analysis of Variance for a*TB

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Regression	9	0.84703	0.84703	0.094115	8.13	0.001
Linear	3	0.10928	0.10928	0.036428	3.15	0.073
Square	3	0.72045	0.72045	0.240150	20.76	0.000
Interaction	3	0.01730	0.01730	0.005766	0.50	0.692
Residual Error	10	0.11569	0.11569	0.011569		
Lack-of-Fit	5	0.09842	0.09842	0.019685	5.70	0.040
Pure Error	5	0.01727	0.01727	0.003454		
Total	19	0.96273				

Obs	StdOrder	a*TB	Fit	SE Fit	Residual	St Resid
1	1	1.455	1.373	0.044	0.082	0.84
2	2	0.868	0.882	0.084	-0.014	-0.21
3	3	1.415	1.373	0.044	0.042	0.43
4	4	0.662	0.799	0.088	-0.137	-2.21 R
5	5	1.096	1.086	0.084	0.010	0.14
6	6	0.942	0.895	0.088	0.047	0.76
7	7	1.067	0.972	0.088	0.095	1.53
8	8	1.385	1.373	0.044	0.012	0.13
9	9	1.028	0.926	0.088	0.101	1.64
10	10	1.350	1.373	0.044	-0.023	-0.23
11	11	1.179	1.161	0.084	0.018	0.26
12	12	0.752	0.869	0.088	-0.117	-1.89
13	13	1.126	1.051	0.088	0.074	1.20
14	14	0.904	0.862	0.084	0.042	0.62
15	15	1.107	1.057	0.084	0.050	0.74
16	16	1.013	1.103	0.088	-0.090	-1.45
17	17	0.930	1.074	0.088	-0.144	-2.32 R
18	18	1.300	1.373	0.044	-0.073	-0.74
19	19	0.934	0.860	0.084	0.074	1.10
20	20	1.320	1.373	0.044	-0.053	-0.54

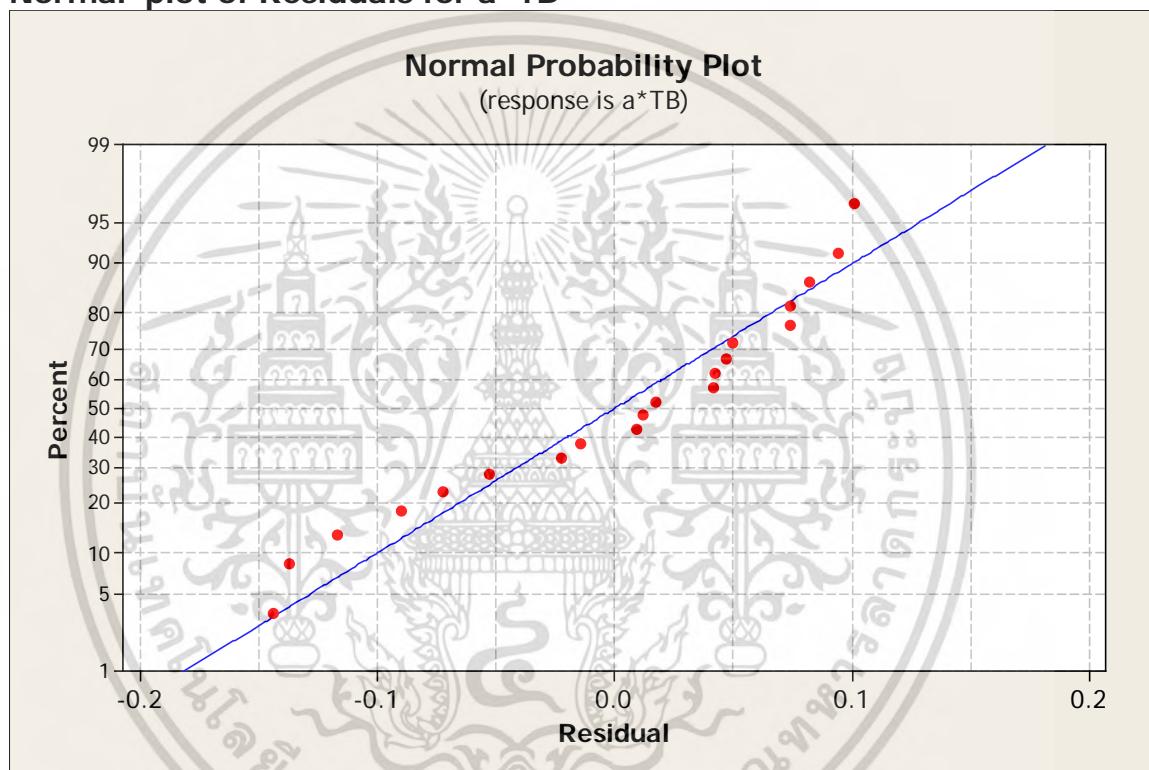
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Estimated Regression Coefficients for a*TB using data in uncoded units

Term	Coef
Constant	-4.77456
%coconut milk	0.0843617
%chicken meat	0.0374747
%turkey berry	0.686914
%coconut milk*%coconut milk	-0.00127567
%chicken meat*%chicken meat	-0.00106550
%turkey berry*%turkey berry	-0.0283617
%coconut milk*%chicken meat	0.000183333
%coconut milk*%turkey berry	-7.55556E-04
%chicken meat*%turkey berry	0.00153333

Normal plot of Residuals for a*TB



เอกสารนี้เป็นเอกสารที่สงวนไว้สำหรับการใช้งานเพื่อการศึกษาเท่านั้น ไม่อนุญาตให้นำไปใช้ประโยชน์ด้านการค้า
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Response Surface Regression: b*TB versus %coconut milk, %chicken meat, %turkey berry

The analysis was done using coded units.

Estimated Regression Coefficients for b*TB

Term	Coef	SE Coef	T	P
Constant	37.1331	0.7432	49.962	0.000
%coconut milk	-0.7834	0.4931	-1.589	0.143
%chicken meat	-0.0443	0.4931	-0.090	0.930
%turkey berry	0.7475	0.4931	1.516	0.160
%coconut milk*%coconut milk	0.4427	0.4800	0.922	0.378
%chicken meat*%chicken meat	-0.3668	0.4800	-0.764	0.462
%turkey berry*%turkey berry	-0.5217	0.4800	-1.087	0.303
%coconut milk*%chicken meat	0.5635	0.6443	0.875	0.402
%coconut milk*%turkey berry	-0.7012	0.6443	-1.088	0.302
%chicken meat*%turkey berry	-0.6646	0.6443	-1.031	0.327

S = 1.82233 PRESS = 247.355
 R-Sq = 51.62% R-Sq(pred) = 0.00% R-Sq(adj) = 8.07%

Analysis of Variance for b*TB

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Regression	9	35.426	35.426	3.9362	1.19	0.395
Linear	3	16.039	16.039	5.3463	1.61	0.248
Square	3	9.380	9.380	3.1266	0.94	0.457
Interaction	3	10.007	10.007	3.3358	1.00	0.431
Residual Error	10	33.209	33.209	3.3209		
Lack-of-Fit	5	30.851	30.851	6.1702	13.08	0.007
Pure Error	5	2.358	2.358	0.4716		
Total	19	68.635				

Obs	StdOrder	b*TB	Fit	SE Fit	Residual	St Resid
1	1	38.060	37.133	0.743	0.927	0.56
2	2	36.038	34.400	1.420	1.638	1.43
3	3	37.380	37.133	0.743	0.247	0.15
4	4	34.664	36.096	1.491	-1.431	-1.37
5	5	38.500	36.170	1.420	2.330	2.04 R
6	6	37.194	35.805	1.491	1.390	1.33
7	7	35.928	36.079	1.491	-0.151	-0.14
8	8	37.265	37.133	0.743	0.132	0.08
9	9	34.609	34.674	1.491	-0.065	-0.06
10	10	37.090	37.133	0.743	-0.043	-0.03
11	11	42.134	39.703	1.420	2.432	2.13 R
12	12	36.192	37.041	1.491	-0.849	-0.81
13	13	39.459	40.192	1.491	-0.733	-0.70
14	14	36.873	37.068	1.420	-0.194	-0.17
15	15	35.929	36.021	1.420	-0.092	-0.08
16	16	32.993	35.965	1.491	-2.972	-2.84 R
17	17	36.130	37.647	1.491	-1.517	-1.45
18	18	36.100	37.133	0.743	-1.033	-0.62
19	19	37.514	36.915	1.420	0.600	0.53
20	20	36.520	37.133	0.743	-0.613	-0.37

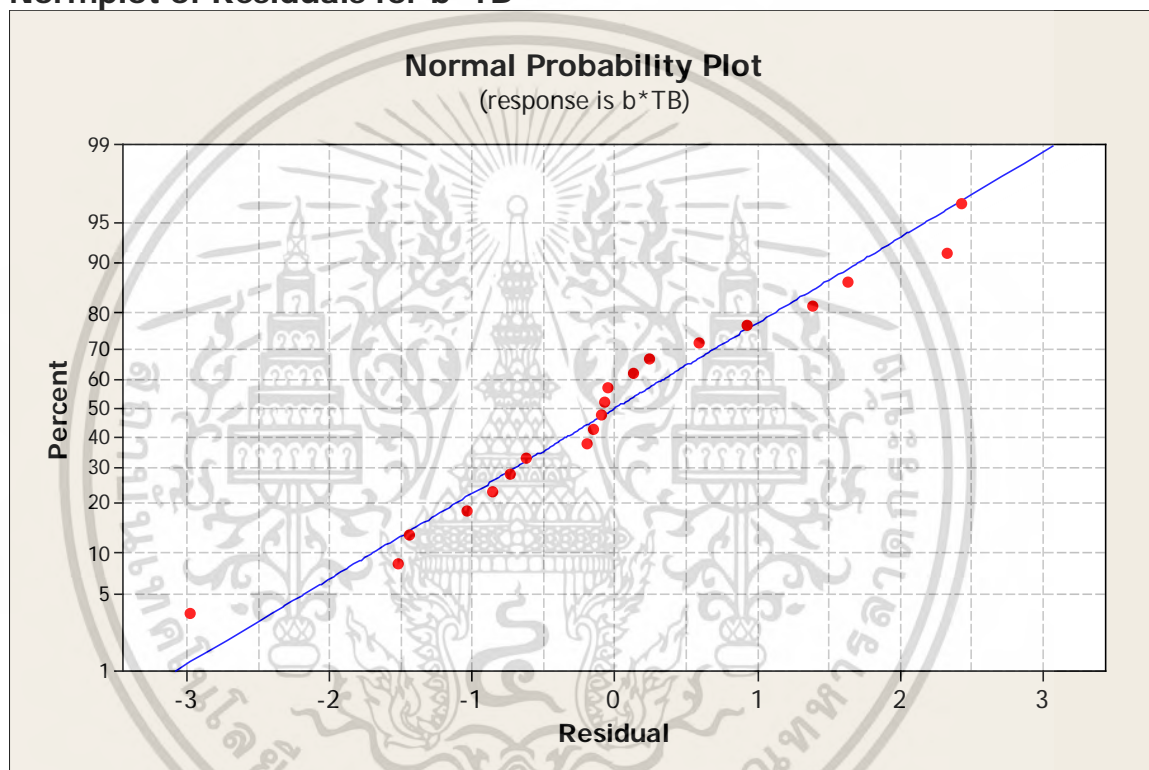
R denotes an observation with a large standardized residual.

เอกสารนี้เป็นเอกสารที่สงวนไว้สำหรับการใช้งานเพื่อการศึกษาเท่านั้น ไม่อนุญาตให้นำไปใช้ประโยชน์ด้านการค้า
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Estimated Regression Coefficients for b*TB using data in uncoded units

Term	Coef
Constant	9.02390
%coconut milk	-0.206618
%chicken meat	0.350710
%turkey berry	4.16526
%coconut milk*%coconut milk	0.00442666
%chicken meat*%chicken meat	-0.00366775
%turkey berry*%turkey berry	-0.0834799
%coconut milk*%chicken meat	0.00563472
%coconut milk*%turkey berry	-0.0280500
%chicken meat*%turkey berry	-0.0265833

Normplot of Residuals for b*TB



เอกสารนี้เป็นเอกสารที่สงวนไว้สำหรับการใช้งานเพื่อการศึกษาเท่านั้น ไม่อนุญาตให้นำไปใช้ประโยชน์ด้านการค้า
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Response Surface Regression: TB_dE versus %coconut milk %chicken meat, %turkey berry

The analysis was done using coded units.

Estimated Regression Coefficients for TB_dE

Term	Coef	SE Coef	T	P
Constant	28.6420	0.3499	81.869	0.000
%coconut milk	-0.2074	0.2321	-0.894	0.393
%chicken meat	0.2300	0.2321	0.991	0.345
%turkey berry	0.3219	0.2321	1.387	0.196
%coconut milk*%coconut milk	0.4531	0.2260	2.005	0.073
%chicken meat*%chicken meat	-0.1704	0.2260	-0.754	0.468
%turkey berry*%turkey berry	-0.2052	0.2260	-0.908	0.385
%coconut milk*%chicken meat	0.3046	0.3033	1.004	0.339
%coconut milk*%turkey berry	-0.0750	0.3033	-0.247	0.810
%chicken meat*%turkey berry	-0.5346	0.3033	-1.763	0.108

S = 0.857798 PRESS = 55.9885
R-Sq = 58.13% R-Sq(pred) = 0.00% R-Sq(adj) = 20.44%

Analysis of Variance for TB_dE

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Regression	9	10.2140	10.2140	1.13489	1.54	0.254
Linear	3	2.7254	2.7254	0.90847	1.23	0.348
Square	3	4.4150	4.4150	1.47168	2.00	0.178
Interaction	3	3.0736	3.0736	1.02452	1.39	0.301
Residual Error	10	7.3582	7.3582	0.73582		
Lack-of-Fit	5	7.1717	7.1717	1.43435	38.47	0.001
Pure Error	5	0.1864	0.1864	0.03729		
Total	19	17.5722				

Obs	StdOrder	TB_dE	Fit	SE Fit	Residual	St Resid
1	1	28.849	28.642	0.350	0.207	0.26
2	2	28.469	27.520	0.668	0.949	1.76
3	3	28.694	28.642	0.350	-0.052	0.07
4	4	28.030	28.759	0.702	-0.729	-1.48
5	5	28.865	27.773	0.668	1.092	2.03 R
6	6	29.045	28.759	0.702	0.286	0.58
7	7	28.726	28.990	0.702	-0.264	-0.54
8	8	28.675	28.642	0.350	0.033	0.04
9	9	26.947	27.196	0.702	-0.249	-0.51
10	10	28.645	28.642	0.350	0.003	0.00
11	11	31.382	30.272	0.668	1.109	2.06 R
12	12	28.726	29.334	0.702	-0.608	-1.23
13	13	29.549	29.933	0.702	-0.384	-0.78
14	14	29.869	29.575	0.668	0.294	0.55
15	15	28.859	28.547	0.668	0.312	0.58
16	16	26.791	28.070	0.702	-1.279	-2.59 R
17	17	27.971	28.715	0.702	-0.743	-1.51
18	18	28.320	28.642	0.350	-0.322	-0.41
19	19	29.058	28.603	0.668	0.455	0.85
20	20	28.428	28.642	0.350	-0.214	-0.27

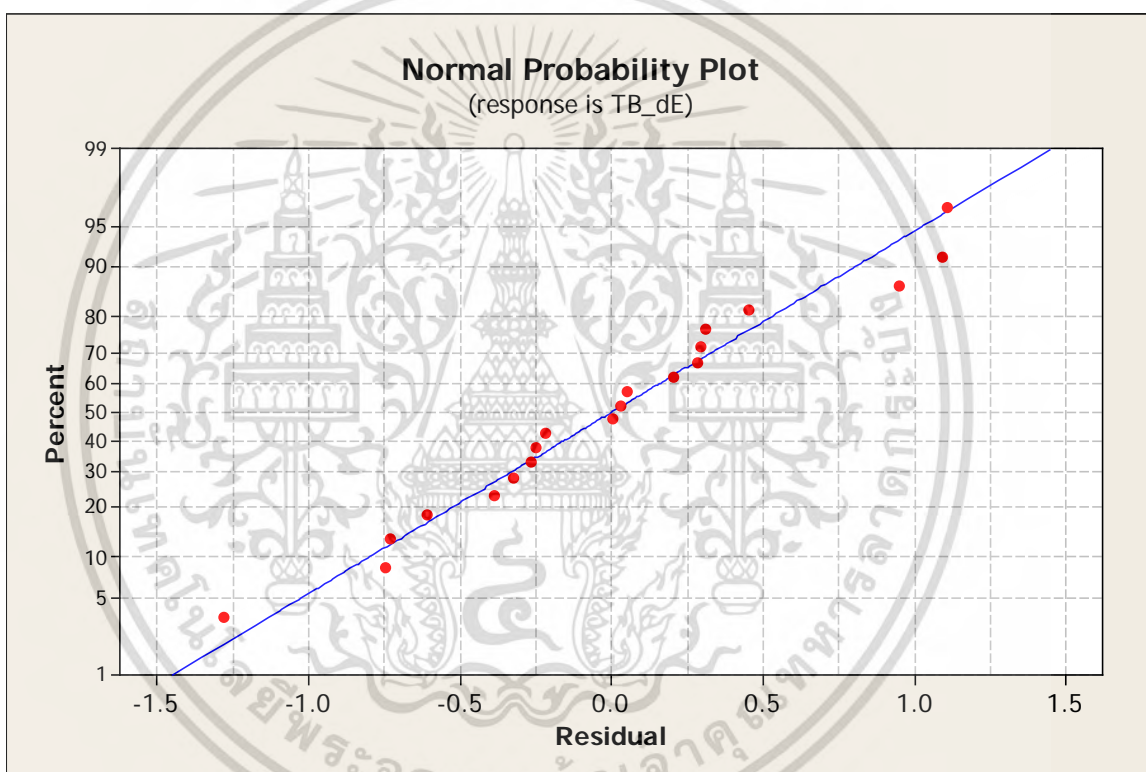
R denotes an observation with a large standardized residual.

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Estimated Regression Coefficients for TB_dE using data in uncoded units

Term	Coef
Constant	19.8227
%coconut milk	-0.391809
%chicken meat	0.285889
%turkey berry	1.69612
%coconut milk*%coconut milk	0.00453099
%chicken meat*%chicken meat	-0.00170361
%turkey berry*%turkey berry	-0.0328354
%coconut milk*%chicken meat	0.00304628
%coconut milk*%turkey berry	-0.00299913
%chicken meat*%turkey berry	-0.0213832

Normal plot of Residuals for TB_dE



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Response Surface Regression: CK Hardness versus %coconut milk, %chicken meat, %turkey berry

The analysis was done using coded units.

Estimated Regression Coefficients for CK Hardness

Term	Coef	SE Coef	T	P
Constant	1691.59	32.58	51.919	0.000
%coconut milk	7.06	21.62	0.327	0.751
%chicken meat	-83.36	21.62	-3.856	0.003
%turkey berry	-33.06	21.62	-1.529	0.157
%coconut milk*%coconut milk	12.09	21.04	0.575	0.578
%chicken meat*%chicken meat	-60.24	21.04	-2.863	0.017
%turkey berry*%turkey berry	-9.92	21.04	-0.471	0.648
%coconut milk*%chicken meat	-1.97	28.24	-0.070	0.946
%coconut milk*%turkey berry	34.07	28.24	1.206	0.255
%chicken meat*%turkey berry	32.28	28.24	1.143	0.280

S = 79.8852 PRESS = 273366
 R-Sq = 74.42% R-Sq(pred) = 0.00% R-Sq(adj) = 51.40%

Analysis of Variance for CK Hardness

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Regression	9	185675	185675	20631	3.23	0.041
Linear	3	110509	110509	36836	5.77	0.015
Square	3	57513	57513	19171	3.00	0.082
Interaction	3	17654	17654	5885	0.92	0.465
Residual Error	10	63816	63816	6382		
Lack-of-Fit	5	29359	29359	5872	0.85	0.568
Pure Error	5	34457	34457	6891		
Total	19	249492				

Obs	StdOrder	CK Hardness	Fit	SE Fit	Residual	St Resid
1	1	1536.587	1691.589	32.581	-155.002	-2.13 R
2	2	1753.821	1719.135	62.254	34.686	0.69
3	3	1688.164	1691.589	32.581	-3.425	-0.05
4	4	1772.407	1694.638	65.378	77.769	1.69
5	5	1628.698	1661.388	62.254	-32.689	-0.65
6	6	1637.034	1588.538	65.378	48.495	1.06
7	7	1527.829	1579.908	65.378	-52.080	-1.13
8	8	1681.107	1691.589	32.581	-10.481	-0.14
9	9	1773.448	1757.181	65.378	16.267	0.35
10	10	1750.118	1691.589	32.581	58.529	0.80
11	11	1762.497	1713.909	62.254	48.588	0.97
12	12	1543.065	1521.951	65.378	21.113	0.46
13	13	1613.014	1608.438	65.378	4.576	0.10
14	14	1652.739	1737.658	62.254	-84.919	-1.70
15	15	1377.353	1380.994	62.254	-3.641	-0.07
16	16	1784.449	1807.255	65.378	-22.806	-0.50
17	17	1519.644	1510.221	65.378	9.423	0.21
18	18	1756.673	1691.589	32.581	65.085	0.89
19	19	1536.927	1607.943	62.254	-71.016	-1.42
20	20	1743.116	1691.589	32.581	51.527	0.71

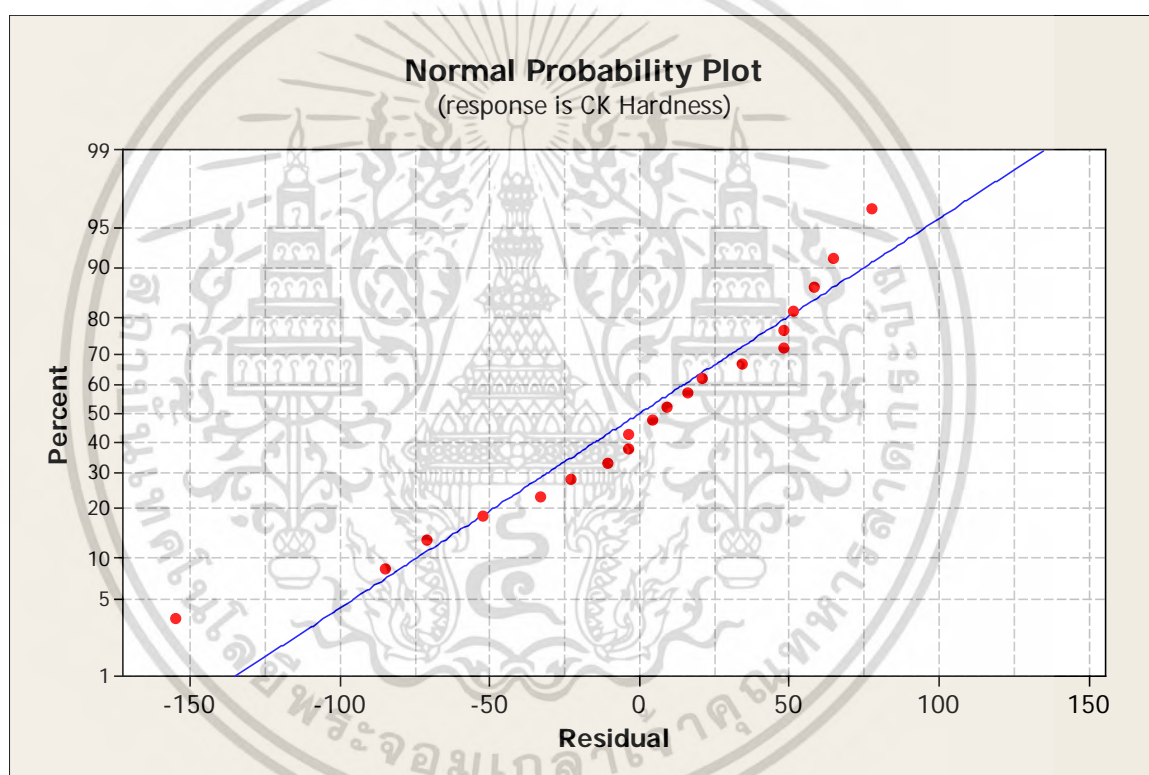
R denotes an observation with a large standardized residual.

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Estimated Regression Coefficients for CK Hardness using data in uncoded units

Term	Coef
Constant	2499.96
%coconut milk	-24.1998
%chicken meat	12.3591
%turkey berry	-59.9898
%coconut milk*%coconut milk	0.120897
%chicken meat*%chicken meat	-0.602447
%turkey berry*%turkey berry	-1.58672
%coconut milk*%chicken meat	-0.0197064
%coconut milk*%turkey berry	1.36274
%chicken meat*%turkey berry	1.29130

Normal plot of Residuals for CK Hardness



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Response Surface Regression: CK springiness versus %coconut milk, %chicken meat, %turkey berry

The analysis was done using coded units.

Estimated Regression Coefficients for CK springiness

Term	Coef	SE Coef	T	P
Constant	0.720610	0.02105	34.234	0.000
%coconut milk	-0.021923	0.01397	-1.570	0.148
%chicken meat	-0.002152	0.01397	-0.154	0.881
%turkey berry	-0.000920	0.01397	-0.066	0.949
%coconut milk*%coconut milk	0.006565	0.01360	0.483	0.640
%chicken meat*%chicken meat	-0.018162	0.01360	-1.336	0.211
%turkey berry*%turkey berry	-0.012615	0.01360	-0.928	0.375
%coconut milk*%chicken meat	0.012219	0.01825	0.670	0.518
%coconut milk*%turkey berry	0.003620	0.01825	0.198	0.847
%chicken meat*%turkey berry	-0.003989	0.01825	-0.219	0.831

S = 0.0516109 PRESS = 0.145593
 R-Sq = 37.23% R-Sq(pred) = 0.00% R-Sq(adj) = 0.00%

Analysis of Variance for CK springiness

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Regression	9	0.015802	0.015802	0.001756	0.66	0.729
Linear	3	0.006639	0.006639	0.002213	0.83	0.507
Square	3	0.007736	0.007736	0.002579	0.97	0.445
Interaction	3	0.001427	0.001427	0.000476	0.18	0.909
Residual Error	10	0.026637	0.026637	0.002664		
Lack-of-Fit	5	0.014956	0.014956	0.002991	1.28	0.396
Pure Error	5	0.011681	0.011681	0.002336		
Total	19	0.042439				

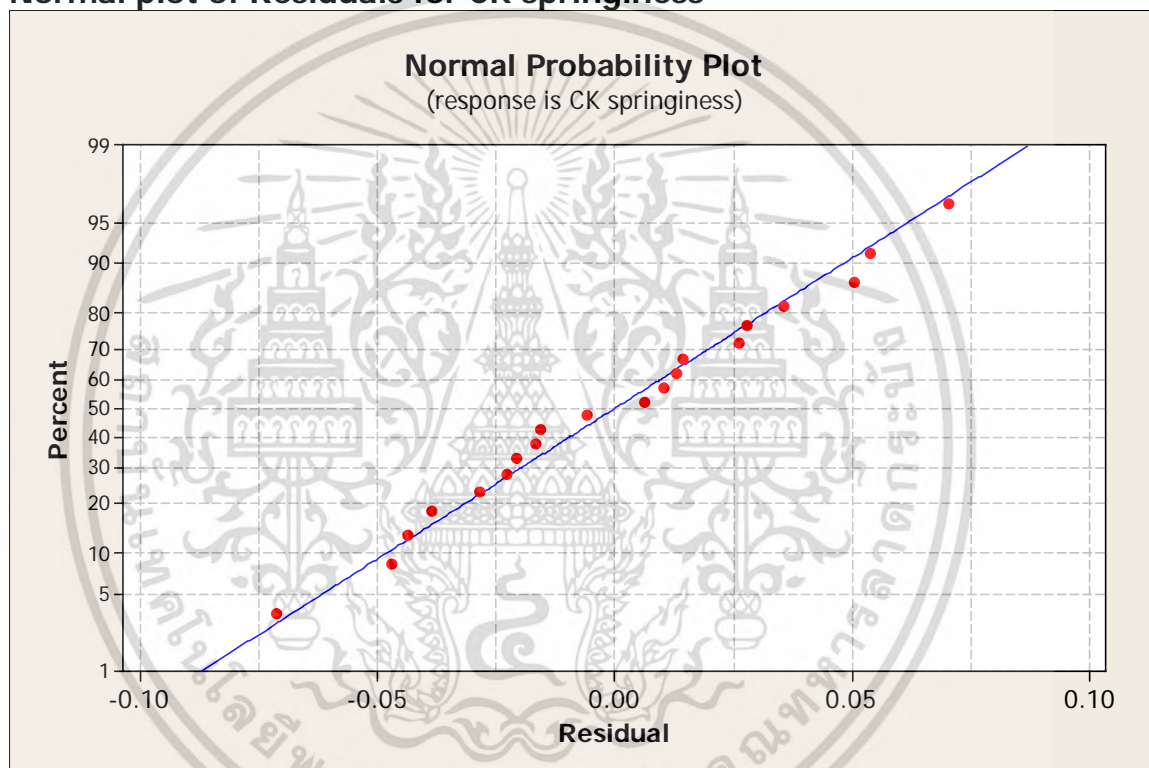
Obs	StdOrder	CK springiness	Fit	SE Fit	Residual	St Resid
1	1	0.649	0.721	0.021	-0.071	-1.51
2	2	0.697	0.686	0.040	0.010	0.32
3	3	0.735	0.721	0.021	0.014	0.31
4	4	0.725	0.671	0.042	0.054	1.82
5	5	0.634	0.673	0.040	-0.038	-1.19
6	6	0.640	0.683	0.042	-0.043	-1.46
7	7	0.666	0.712	0.042	-0.047	-1.58
8	8	0.747	0.721	0.021	0.026	0.56
9	9	0.629	0.658	0.042	-0.028	-0.96
10	10	0.791	0.721	0.021	0.070	1.49
11	11	0.759	0.776	0.040	-0.017	-0.51
12	12	0.699	0.686	0.042	0.013	0.44
13	13	0.726	0.732	0.042	-0.006	-0.20
14	14	0.709	0.702	0.040	0.006	0.20
15	15	0.694	0.666	0.040	0.028	0.87
16	16	0.784	0.733	0.042	0.051	1.71
17	17	0.731	0.695	0.042	0.036	1.20
18	18	0.705	0.721	0.021	-0.016	-0.33
19	19	0.663	0.683	0.040	-0.021	-0.64
20	20	0.698	0.721	0.021	-0.023	-0.48

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Estimated Regression Coefficients for CK springiness using data in uncoded units

Term	Coef
Constant	0.541797
%coconut milk	-0.0122635
%chicken meat	0.00839939
%turkey berry	0.0498123
%coconut milk*%coconut milk	6.56492E-05
%chicken meat*%chicken meat	-1.81617E-04
%turkey berry*%turkey berry	-0.00201846
%coconut milk*%chicken meat	0.000122195
%coconut milk*%turkey berry	0.000144792
%chicken meat*%turkey berry	-1.59554E-04

Normal plot of Residuals for CK springiness



เอกสารนี้เป็นเอกสารที่สงวนไว้สำหรับการใช้งานเพื่อการศึกษาเท่านั้น ไม่อนุญาตให้นำไปใช้ประโยชน์ด้านการค้า
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Response Surface Regression: CK cohesiveness versus %coconut milk, %chicken meat, %turkey berry

The analysis was done using coded units.

Estimated Regression Coefficients for CK cohesiveness

Term	Coef	SE Coef	T	P
Constant	0.502922	0.02700	18.628	0.000
%coconut milk	0.011118	0.01791	0.621	0.549
%chicken meat	-0.005328	0.01791	-0.297	0.772
%turkey berry	0.002969	0.01791	0.166	0.872
%coconut milk*%coconut milk	0.002314	0.01744	0.133	0.897
%chicken meat*%chicken meat	0.013576	0.01744	0.779	0.454
%turkey berry*%turkey berry	-0.019408	0.01744	-1.113	0.292
%coconut milk*%chicken meat	-0.009223	0.02340	-0.394	0.702
%coconut milk*%turkey berry	0.000285	0.02340	0.012	0.991
%chicken meat*%turkey berry	0.011361	0.02340	0.485	0.638

S = 0.0661976 PRESS = 0.270369
 R-Sq = 22.82% R-Sq(pred) = 0.00% R-Sq(adj) = 0.00%

Analysis of Variance for CK cohesiveness

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Regression	9	0.012954	0.012954	0.001439	0.33	0.946
Linear	3	0.002196	0.002196	0.000732	0.17	0.916
Square	3	0.009045	0.009045	0.003015	0.69	0.580
Interaction	3	0.001714	0.001714	0.000571	0.13	0.940
Residual Error	10	0.043821	0.043821	0.004382		
Lack-of-Fit	5	0.033030	0.033030	0.006606	3.06	0.122
Pure Error	5	0.010791	0.010791	0.002158		
Total	19	0.056776				

Obs	StdOrder	CK cohesiveness	Fit	SE Fit	Residual	St Resid
1	1	0.520	0.503	0.027	0.017	0.28
2	2	0.350	0.443	0.052	-0.093	-2.25 R
3	3	0.501	0.503	0.027	-0.002	-0.03
4	4	0.499	0.517	0.054	-0.018	-0.47
5	5	0.545	0.550	0.052	-0.005	-0.13
6	6	0.554	0.511	0.054	0.044	1.15
7	7	0.544	0.478	0.054	0.065	1.72
8	8	0.428	0.503	0.027	-0.075	-1.24
9	9	0.603	0.533	0.054	0.070	1.85
10	10	0.488	0.503	0.027	-0.015	-0.25
11	11	0.491	0.491	0.052	0.000	0.01
12	12	0.537	0.481	0.054	0.056	1.48
13	13	0.467	0.476	0.054	-0.009	-0.22
14	14	0.461	0.528	0.052	-0.068	-1.63
15	15	0.470	0.532	0.052	-0.062	-1.49
16	16	0.497	0.493	0.054	0.004	0.10
17	17	0.484	0.506	0.054	-0.023	-0.59
18	18	0.524	0.503	0.027	0.021	0.35
19	19	0.479	0.453	0.052	0.026	0.63
20	20	0.568	0.503	0.027	0.065	1.08

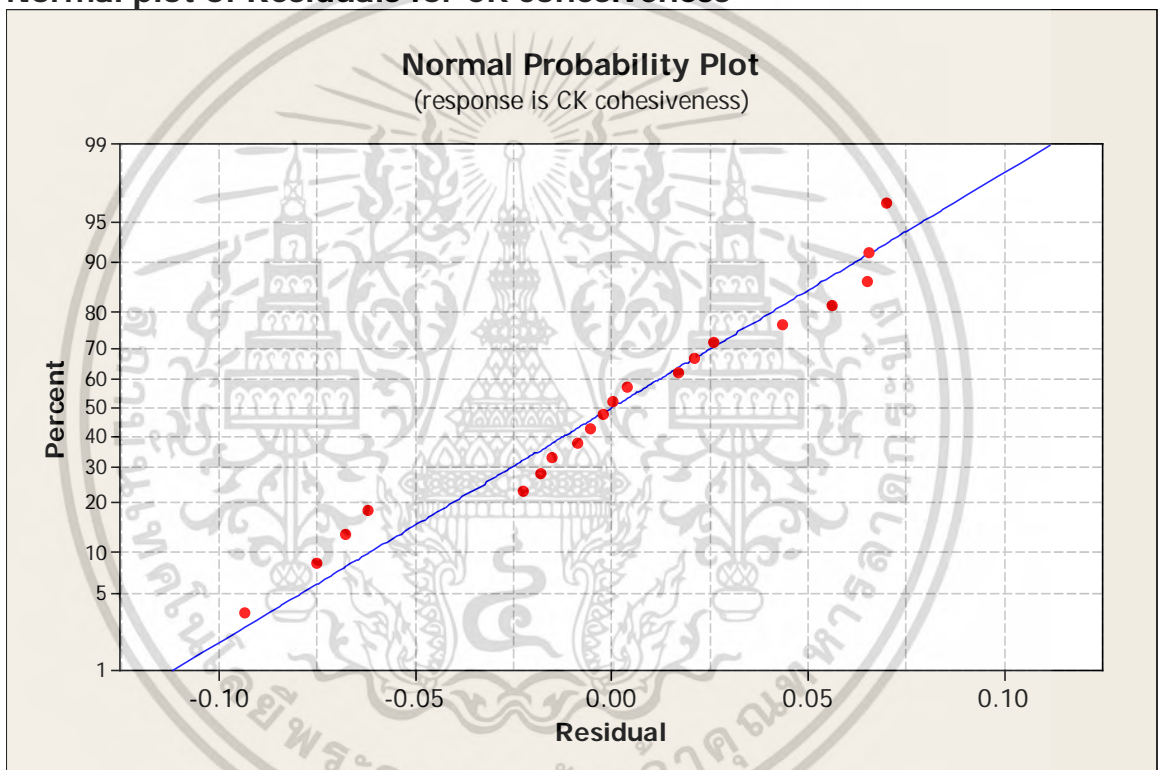
R denotes an observation with a large standardized residual.

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Estimated Regression Coefficients for CK cohesiveness using data in uncoded units

Term	Coef
Constant	0.209049
%coconut milk	0.00211634
%chicken meat	-0.0111308
%turkey berry	0.0647861
%coconut milk*%coconut milk	2.31380E-05
%chicken meat*%chicken meat	0.000135760
%turkey berry*%turkey berry	-0.00310522
%coconut milk*%chicken meat	-9.22272E-05
%coconut milk*%turkey berry	1.14087E-05
%chicken meat*%turkey berry	0.000454425

Normal plot of Residuals for CK cohesiveness



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Response Surface Regression: TB hardness versus %coconut milk, %chicken meat, %turkey berry

The analysis was done using coded units.

Estimated Regression Coefficients for TB hardness

Term	Coef	SE Coef	T	P
Constant	2217.07	52.62	42.133	0.000
%coconut milk	-44.92	34.91	-1.287	0.227
%chicken meat	-169.58	34.91	-4.857	0.001
%turkey berry	-13.70	34.91	-0.392	0.703
%coconut milk*%coconut milk	-32.25	33.99	-0.949	0.365
%chicken meat*%chicken meat	-87.41	33.99	-2.572	0.028
%turkey berry*%turkey berry	-20.64	33.99	-0.607	0.557
%coconut milk*%chicken meat	-18.95	45.62	-0.415	0.687
%coconut milk*%turkey berry	27.14	45.62	0.595	0.565
%chicken meat*%turkey berry	-14.02	45.62	-0.307	0.765

S = 129.019 PRESS = 1025724
R-Sq = 76.86% R-Sq(pred) = 0.00% R-Sq(adj) = 56.03%

Analysis of Variance for TB hardness

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Regression	9	552803	552803	61423	3.69	0.027
Linear	3	422843	422843	140948	8.47	0.004
Square	3	119619	119619	39873	2.40	0.129
Interaction	3	10340	10340	3447	0.21	0.889
Residual Error	10	166460	166460	16646		
Lack-of-Fit	5	124201	124201	24840	2.94	0.131
Pure Error	5	42259	42259	8452		
Total	19	719262				

Obs	StdOrder	TB hardness	Fit	SE Fit	Residual	St Resid
1	16	2115.438	2217.070	52.620	-101.633	-0.86
2	13	2223.263	2181.731	100.544	41.533	0.51
3	20	2143.617	2217.070	52.620	-73.454	-0.62
4	6	2396.514	2247.845	105.588	148.669	2.01 R
5	11	2250.289	2255.027	100.544	-4.738	-0.06
6	8	1939.378	1842.742	105.588	96.636	1.30
7	3	1938.082	2025.922	105.588	-87.840	-1.18
8	15	2290.174	2217.070	52.620	73.104	0.62
9	2	2186.274	2192.917	105.588	-6.643	-0.09
10	17	2340.210	2217.070	52.620	123.140	1.05
11	9	2293.218	2201.395	100.544	91.822	1.14
12	4	1953.662	1843.902	105.588	109.760	1.48
13	5	2196.559	2245.490	105.588	-48.931	-0.66
14	10	1872.468	2050.315	100.544	-177.848	-2.20 R
15	12	1603.349	1684.636	100.544	-81.287	-1.01
16	1	2263.326	2299.132	105.588	-35.807	-0.48
17	7	1983.664	1916.193	105.588	67.472	0.91
18	18	2268.838	2217.070	52.620	51.767	0.44
19	14	2008.090	2135.648	100.544	-127.558	-1.58
20	19	2158.906	2217.070	52.620	-58.165	-0.49

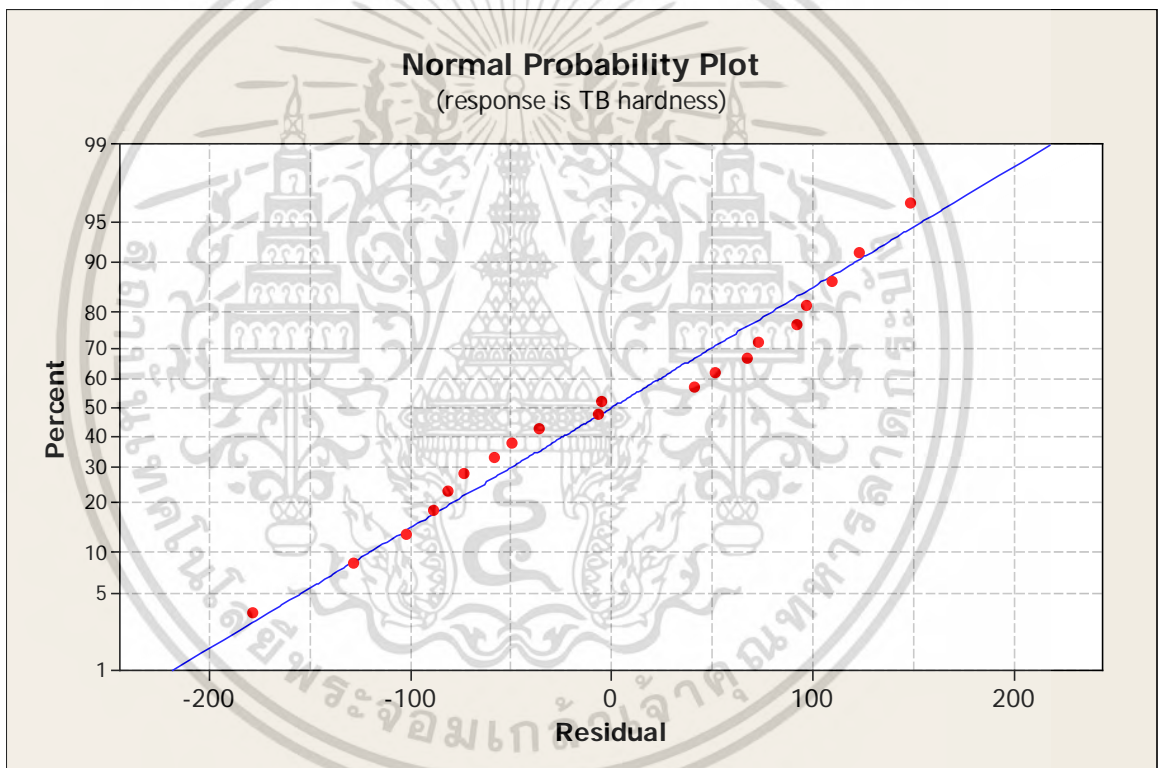
R denotes an observation with a large standardized residual.

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Estimated Regression Coefficients for TB hardness using data in uncoded units

Term	Coef
Constant	1319.40
%coconut milk	10.1971
%chicken meat	49.1334
%turkey berry	55.9101
%coconut milk*%coconut milk	-0.322494
%chicken meat*%chicken meat	-0.874121
%turkey berry*%turkey berry	-3.30254
%coconut milk*%chicken meat	-0.189514
%coconut milk*%turkey berry	1.08570
%chicken meat*%turkey berry	-0.560878

Normal plot of Residuals for TB hardness



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