Report of Cooperative Education

Texture Analysis of Bouillon Cube

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Co-operative Title: Texture Analysis of Pasty Cube

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ABSTRACT

The inconsistence of product quality such underweight, overweight, harder or softer texture of pork bouillon cube causes economic losses in manufacturing process. Unilever Thai Services Limited is interested to investigate the effect of 4 ingredients, i.e., crystals, palm fat, starch and water on hardness, adhesiveness and cohesiveness of bouillon cube. The experiment was designed by using a 24 full factorial design with 2 replications. Bouillon cube was prepared by using Z-Arm mixer and the Texture Profile Analysis Method was used to investigate the texture of bouillon cube. The results from ANOVA reveal that starch is a main factor that affected on hardness. There is no main factor that affected adhesiveness of cube. There are only 2 ways interaction of starch and water that affected on adhesiveness. For cohesiveness, starch and palm fat are main factors that affected. Results from prediction profiler are also revealed that starch has influence on both hardness and cohesiveness and no main ingredient that make change in adhesiveness of product. The results from this study could give recommendations for manufacturing scale. The problem on hardness or cohesiveness of product could be solved by adjusting an amount of starch while adhesiveness of product could be adjusted by modifying amount of starch and water.

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First, I gratefully acknowledge to Unilever Thai Services Limited that see my potential and provide me into cooperative education. I am so proud to learn about the mass texture of pasty cube from here and thanks to my mentors, Mr. Amnat Saiamwong (Product Development Technician) and Mr. Keerathi Thiptinnakorn (Process Development Manager) who has been giving knowledge and experience to me, which has always made me develop. In addition, I would like to thank to all the staff in this company for their support.

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Poomipat Jumpa

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CHAPTER I

INTRODUCTION

1.1 Background [1]

Unilever is a British-Dutch International consumer goods company. Unilever produces variety of products including food and beverages (about 40 percent of its revenue), cleaning agents and personal care products. Their products are available in around 190 countries including Thailand. In Thailand, there are several well-recognized product/brands such as soap (Lux), detergent (Breeze), toothpaste (Close up), food (Knorr), etc. Knorr is originally a German food and beverage brand and later owned by Unilever since 2000. Unilever produces dehydrated soup and meal mixes, bouillon cubes and condiments in a brand "Knorr".

Bouillon cube or broth cube is a cooking ingredient that provides an augment of food taste. The ingredients of bouillon cube are dehydrated meat, dehydrated vegetables, salt, sugar, MSG, oil, fat, starch, flavors and color. The manufacturing process of the cube are mixing of dry ingredients, followed by mixing with molten fat, and other flavors. The mixture is then cooled, shaped, wrapped and packed. However, problems are often taking place in packing machine. The very hard cube made the consumer difficulties to crumble and soft cube made complication during wrapping and packing process. The undesired properties of product made losses in economics for the company. Unilever Thai Services Limited is interested to investigate the causes of defects on mass texture of their product. The four main ingredients, i.e., crystals, palm fat, starch and water are chosen to analyze their influence on hardness, adhesiveness and cohesiveness of bouillon cube. This study will be carried out in a laboratory scale to find the significant factors that affected mass texture of the bouillon cube and give a recommendation to a manufacturing scale.

1.2 Objectives

1) to study mass texture properties of pasty cube by using Texture Profile Analysis Method.

2) to study effect of ingredients on hardness, adhesiveness and cohesiveness of bouillon cube.

1.3 Scopes of Work

This work is carried out only in a laboratory scale and focuses on the four main ingredients including crystal, palm fat, starch, water that affected on hardness, adhesiveness and cohesiveness of bouillon cube.

1.4 Expected Outputs

1) Company will find the significant factors that affected mass texture of the bouillon cube and apply to solve problems in manufacturing scale.

2) Student will gain knowledge in planning and designing the experiment, as well as testing, and analyzing data.

CHAPTER II

THEORY AND LITERATURE REVIEW

This chapter provide background information for texture analysis of bouillon cube such as bouillon cube, and ingredients, manufacturing process of bouillon cube, principle of equipment, analysis of texture profile, design of experiment, JMP and Minitab program and literature review.

2.1 Bouillon cube and ingredients

Bouillon, commonly known as broth, is made from meat, or vegetables and other ingredients such as crystals (salt, sugar, monosodium glutamate), water and fat. The broth can be dehydrated and compressed to be cubes. There are various recipes of Bouillon cubes such as vegetable, pork, chicken, Tomyum based. These recipes mainly contain salt, sugar, MSG, oil and fat, starch, flavors and color.[1][2]

2.1.1 Crystal

Crystals consist of salt, sugar and MSG. There are perhaps most well known as food preservative and flavoring agent. They are widely used to preserve food for thousand years and are the most common seasoning. They are also play another lesser-known role in the food by improving texture of food products. Salt alters the structure of proteins and the interaction of proteins with other components such as water and fat, which impacts the texture of foods.[3] Sugar helps provide the soft structure in baked goods by softening starch gels or gluten networks in puddings and doughs. Too much gluten formation will cause the dough or batter to become rigid and tough. With a right portion of sugar is added into the recipe, an appropriate amount of gluten develops and optimum elasticity results.[4] The crystals provide hardness and sandiness to bouillon cube. They cause a little stronger texture and impact the shelf life

2.1.2 Palm fat

Oils and fats serve many functions in the food. In food products, palm oil is often combined with other oils and fats, which together determine the fatty acid composition and functionality of the product.[5] Its main advantages are

1) Provide stability to food at high cooking temperatures: palm oil performs better at high temperatures than some other oils and fats

2) Provide stability over time: palm oil is very suitable for use in products with a long shelf life.

3) Neutral taste and smell: palm oil can be used in many different foods without affecting their taste or smell.

4) Solid or semi-solid state at room temperature

In addition, Palm fat is a processing aid that provides cohesion for help forming the ingredients to be cube.

2.3.3 Starch

Starch is a storage product found in all plants containing chlorophyll. Two types of starch molecules are amylose and amylopectin. They are polyhydroxy compounds which be hydrated when heated in water. When the starch molecules hydrate, they increase in size and immobilize most of the free water, thickening the solution towards to texture. For this reason, corn starch is used as a thickening agent in bouillon cube.

Corn starch is a fine, powdery substance derived from the endosperm of the corn kernel. It is commonly used as a thickener in pudding, gravies, sauces and fruit compotes. Cornstarch is consisted of long chains of starch molecules, which will swell when heated with water. This swelling action causes the thickening to occur. Cornstarch should not be added straight into a hot liquid as this can cause it to form lumps. The main function of corn starch is its thickening capabilities. It is also able to assist different ingredients in binding together. In addition, corn starch serves to disperse food ingredients within a mixture. The physiochemical property of corn starch's ability is to form strong adhesive films. When mixing with water, they will effect on adhesion.[5]

2.1.4 Water

Water plays many important roles in food. It affects texture (dry and brittle versus moist and soft), makes it possible for large molecules to move and interact, and conducts heat within food.[6] Water provides cohesion because its molecules stay close to each other, and due to the collective action of hydrogen bonds between water molecules. Water also has high adhesion property because of its polar nature. In addition, water is the processing aids with can interact with other ingredients to make the impact on mass texture properties.

2.2 Manufacturing Process of Bouillon Cube[1]

Manufacturing process of bouillon cube is simple. First, all the crystals and color are mixed together, followed by mixing with liquid and fat. Flavors are the last to add into a mixture. This mixture is then cooled, shaped, wrapped and packed. A simplified process flow diagram is shown in Figure 2.1.

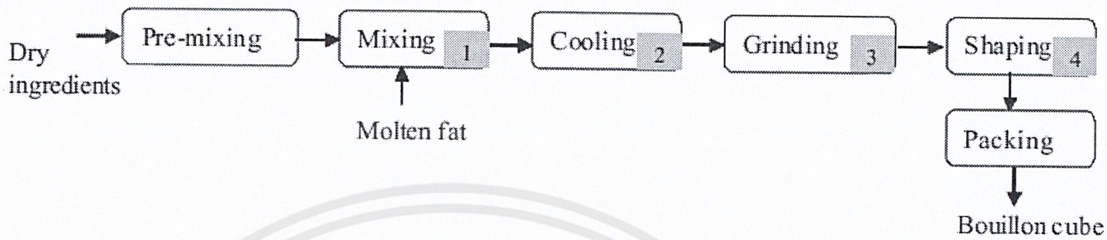


Figure 2.1 Simplified process flow diagram of bouillon cube production process.[1]

First, dry ingredients were mixed in a pre-mixing process. Then a mixed powder and water are mixed in a Mixer and molten fat are fed over the chopper blades. Target of mixing process is to produce a homogeneous mixture. The mixture is then cooled for 20-30 hrs to get freely flowing homogeneous mixture at appropriated temperature. Next is grinding, shaping and compaction of the mixer into cubes. Finally, packaging is wrapped on a cube.

Mass texture properties of cube are important related to the bulk flow properties and bulk density of the mixture after cooling. Therefore, the mixture should be homogeneous and have a good flow ability to go to the shaping machine.[1]

In addition, the conceptual design of bouillon cube process is focusing on the physical transformations from raw materials to a desired product during processing.

2.3 Analysis of texture

2.3.1 Texture Analyzer [7]

The principle of Texture Analyzer is to compress the product by using fix force or distance to observe the force that product returns in the relation of force and time. It has a function that can measure texture properties including fracturability, hardness, cohesiveness, adhesiveness, springiness, gumminess and chewiness called "Texture Profile Analysis". Picture of texture analyzer is shown in Figure 2.2

Figure 2.2 Texture Analyzer[7]

2.3.2 Texture Profile Analysis

Texture Profile Analysis (TPA) is a popular double compression test for determining the textural properties of foods by using a mechanical texture analyzer. TPA is often called the "two bite tests" because during a TPA test samples are compressed twice.[8] There are 7 values that can get from TPA including fracturability, hardness, cohesiveness, adhesiveness, springiness, gumminess and chewiness. In this project, the interested properties are hardness, adhesiveness and cohesiveness. The graphical example result from Texture Profile Analysis is shown in figure 2.3.

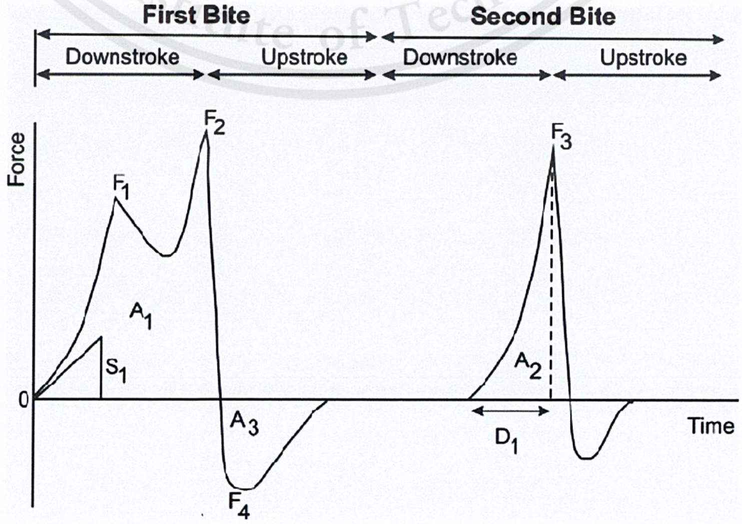


Figure 2.3 The graphical example result from Texture Profile Analysis [9]

1) Hardness

Hardness is force required to compress a food between the molars.[10] For TPA graph, it can be found from the peak force of the first compression cycle that is F2 in figure 2.4.

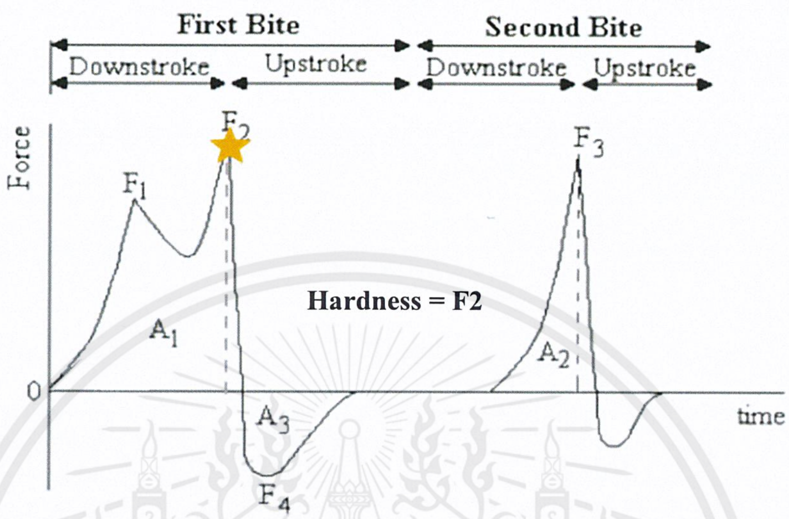


Figure 2.4 Peak force of Hardness

2) Adhesiveness

Adhesive is the work necessary to overcome the attractive forces between the surface of the food and the surface of other materials with which the food comes into contact. For TPA graph, it can be found from the negative area for the first compression that is A3 in figure 2.5, representing the work necessary to pull the compressing plunger away from the sample.

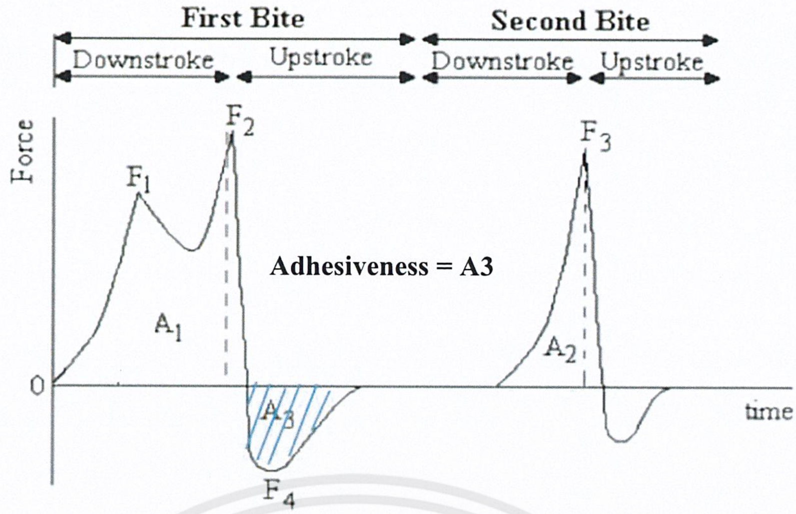


Figure 2.5 Negative area of Adhesiveness

3) Cohesiveness

Cohesive is the strength of internal bonds making up the body of the product.[10] For TPA graph, it was found from the ratio of the work during compression of the second cycle divided by first cycle or A2 divided by A1 in figure 2.6.

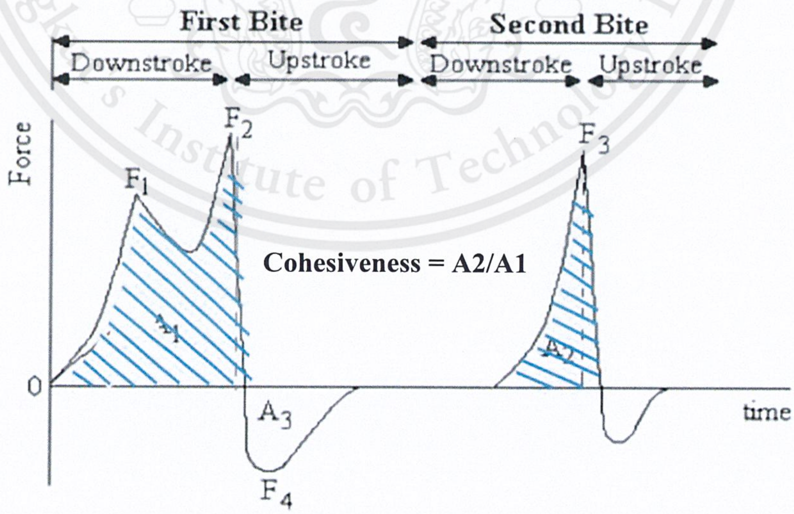


Figure 2.6 Ratio of both areas.

2.4 Design of Experiment[11],[12]

Design of experiments (DOE) is a systematic method to determine the relationship between factors affecting a process and the output of that process. In other words, it is used to find cause and affect relationships. This information is needed to manage process inputs in order to optimize the output.

In its simplest form, an experiment aims at predicting the outcome by introducing a change of the preconditions, which is represented by one or more independent variables, which are input variables or factors. The change in one or more independent variables makes result in a change in one or more dependent variables which are output variables or responses. The experimental design may also identify control variables that must be held constant to prevent external factors that can be affected to the results. The design of experiment involves not only the selection of suitable independent, dependent, and control variables, but planning the experiment under statistically optimal conditions.

Design of Experiment is a structured approach for conducting experiments. It's useful in product development, process development, and process improvement. Depending on the problem, it has benefits such as faster time to market, lower development costs, lower operating costs, and lower cost of poor quality.

DOE can be applied in any situation where you need to manipulate several independent variables (factors) in order to optimize one or more dependent variables.

2.5 Literature review

Gupta et al.[1], this paper studied about the conceptual design of bouillon cube manufacturing process that used the product driven process synthesis. It based on the consumer attributes and defined the fundamental tasks to convert raw materials to the desired product. Results showed that spraying the binder and using granulation of less flowing ingredients will be resulted into the higher hardness of bouillon cube which is the positive influent on the consumer attributes.

Ismail et al[2], this paper explained about evaluated bouillon cube by adding Thread Bream Hydrolysate(TBH) to improve physicochemical and functional properties, sensory properties and acceptability. Results showed that the solubility, hardness and fracturability of bouillon cubes with TBH were better than those incorporated with others. In addition, the taste of bouillon cube with TBH is delicious. Finally, it can be assume that TBH can be used as partial ingredient in the development of bouillon cube.

CHAPTER III
METHODOLOGY

From the objectives of this project that are to study about mass texture properties of pasty cube by using Texture Profile Analysis Method and to study the effect of ingredients on hardness, adhesiveness and cohesiveness.

3.1 Raw Materials

1. Salt
2. Monosodium Glutamate
3. Refined Sugar
4. Palm fat
5. Corn Starch
6. Powder x
7. Water
8. Mixer z

3.2 Equipment

1. Z-Arm Mixer
2. Sieve tray 4 mm.
3. Texture Analyzer

3.3 Procedure

Workflow diagram for this project is shown in Figure 3.1. The first step is design of experiment, follows by mixing of the sample, preparing of test sample, Analyze test sample using Texture Profile Analysis, analysis of experimental data, respectively.

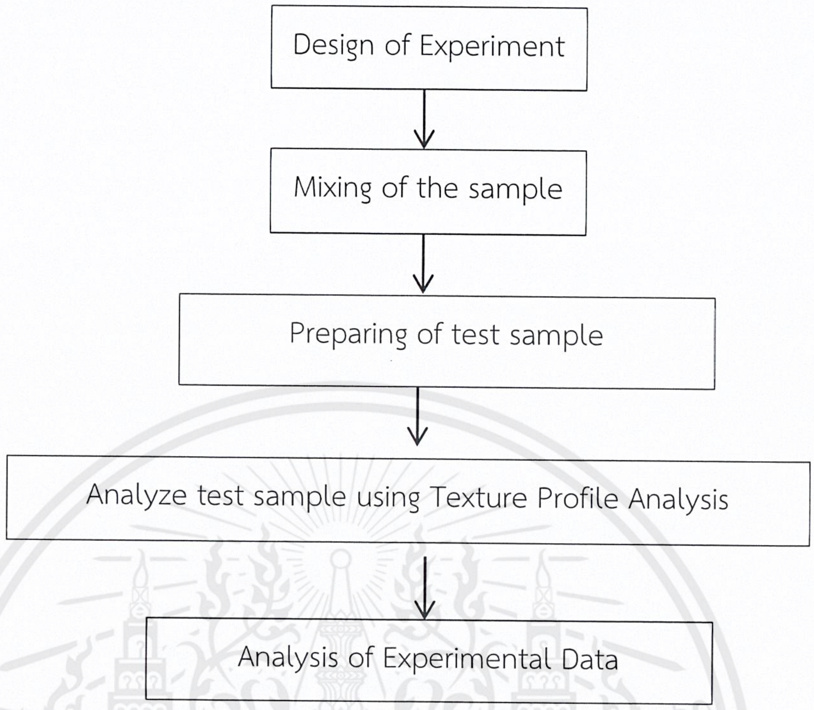


Figure 3.1 Workflow Diagram for this study

3.3.1 Design of Experiment

JMP Program (Statistical Program) is used for experimental design. The 2^4 full factorial design with 2 replications is yielded the total of 32 experiments. The coded values for minimum and maximum amount of 4 ingredients are listed in Table 3.1. The amount for 4 main ingredients added in each experiment is listed in Table 3.2.

Table 3.1 list of coded value for minimum and maximum amount of 4 ingredients

Factor	Min (g)	Max (g)
crystal	W1	W2
Palm fat	X1	X2
Starch	Y1	Y2
Water	Z1	Z2

Table 3.2 The amount of 4 main ingredients in each experiment

Batch No.	Crystal	Palm fat	Starch	Water
1	W1	X2	Y1	Z2
2	W1	X1	Y2	Z1
3	W2	X2	Y1	Z2
4	W1	X2	Y2	Z2
5	W1	X1	Y2	Z2
6	W2	X2	Y1	Z1
7	W2	X1	Y1	Z1
8	W1	X2	Y1	Z1
9	W2	X1	Y2	Z2

Batch No.	Crystal	Palm fat	Starch	Water
10	W2	X2	Y2	Z1
11	W1	X1	Y1	Z1
12	W2	X2	Y2	Z2
13	W2	X1	Y2	Z1
14	W1	X1	Y1	Z2
15	W1	X2	Y2	Z1
16	W2	X1	Y1	Z2
17	W1	X2	Y1	Z2
18	W1	X1	Y2	Z1
19	W2	X2	Y1	Z2
20	W1	X2	Y2	Z2
21	W1	X1	Y2	Z2
22	W2	X2	Y1	Z1
23	W2	X1	Y1	Z1
24	W1	X2	Y1	Z1
25	W2	X1	Y2	Z2
26	W2	X2	Y2	Z1
27	W1	X1	Y1	Z1

Batch No.	Crystal	Palm fat	Starch	Water
28	W2	X2	Y2	Z2
29	W2	X1	Y2	Z1
30	W1	X1	Y1	Z2
31	W1	X2	Y2	Z1
32	W2	X1	Y1	Z2

3.3.2 Mixing of Sample

Weigh all raw materials including powder, fat, oil and liquid according to company recipe and table 3.2. Mixing all ingredients according to step of mixing in Figure 3.2 by using Z-Arm Mixer.

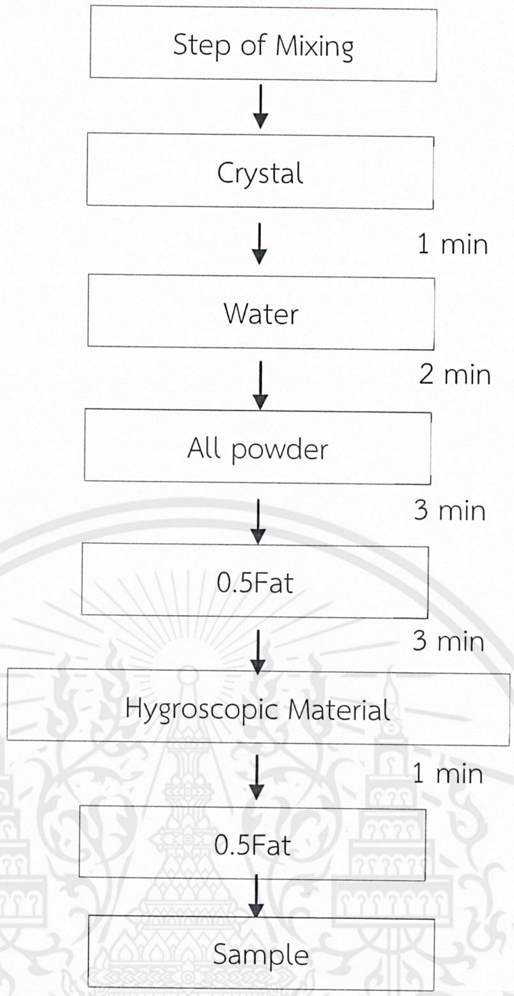


Figure 3.2 Step of Mixing

3.3.3 Preparing of test sample

The sample from previous step was left to maturation for 24 hours and then made the test sample according to sample preparation steps as shown in figure 3.3.

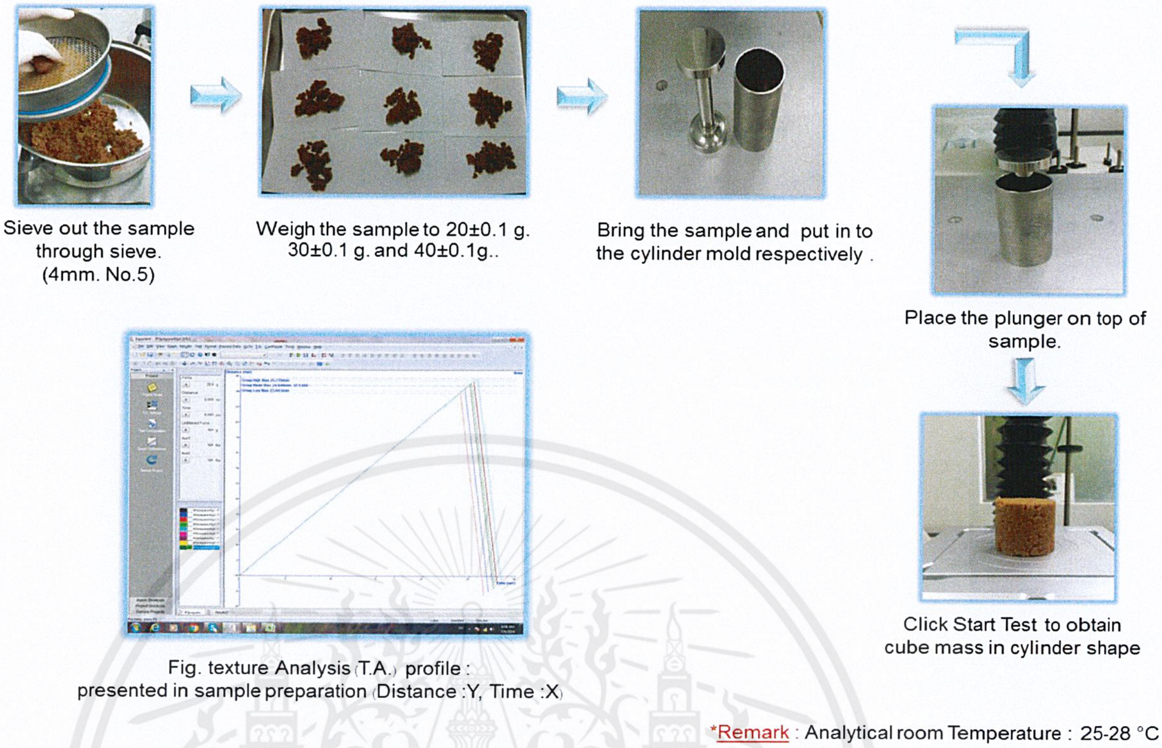


Figure 3.3 Sample Preparation Steps

3.3.4 Analyze test sample using Texture Profile Analysis (TPA) Method

Texture of test sample was analyzed by using TPA Method of Texture Analyzer The example results are shown in graph and table as shown in figure 3.4 and 3.5 respectively. The hardness, adhesiveness, and cohesiveness of test sample were estimated based on the method as explained in section 2.3.

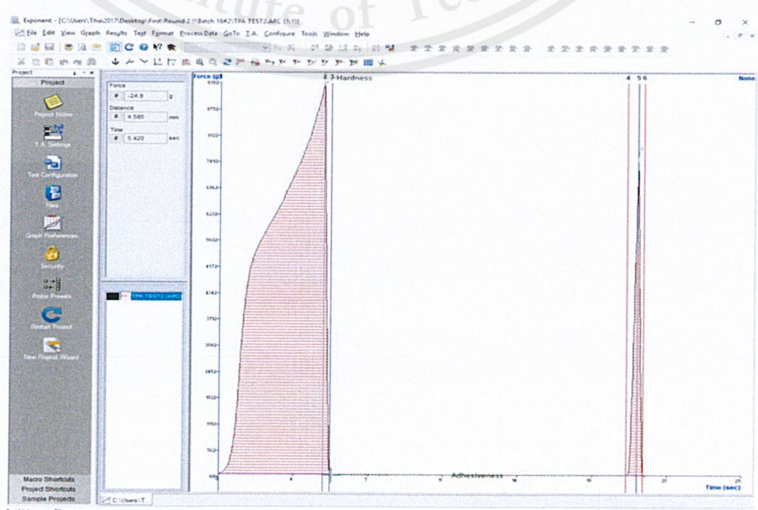


Figure 3.4 Graphical result from TPA Method

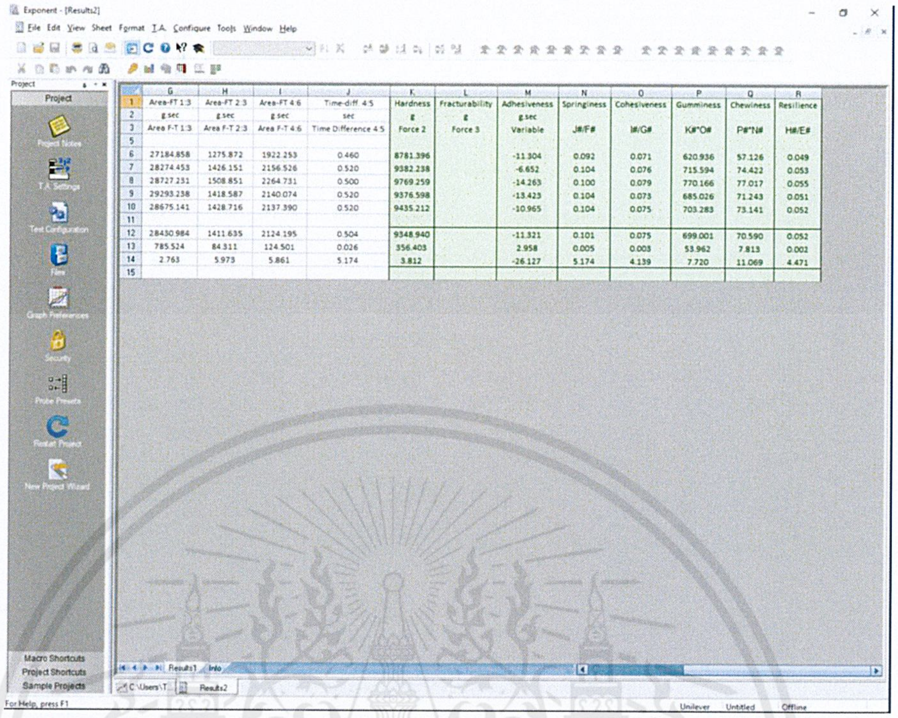


Figure 3.5 Table result from TPA Method

3.3.5 Analysis of Experimental Data

The hardness, adhesiveness, and cohesiveness of each test sample were recorded to a worksheet of JMP program of the 32 experiments for statistical analysis.

CHAPTER IV

RESULTS AND DISCUSSION

This chapter describes the modeled results by using JMP and Minitab Program compare with observation data.

4.1 Statistical Analysis of experimental data

The results from 32 experiments were analyzed by JMP program.

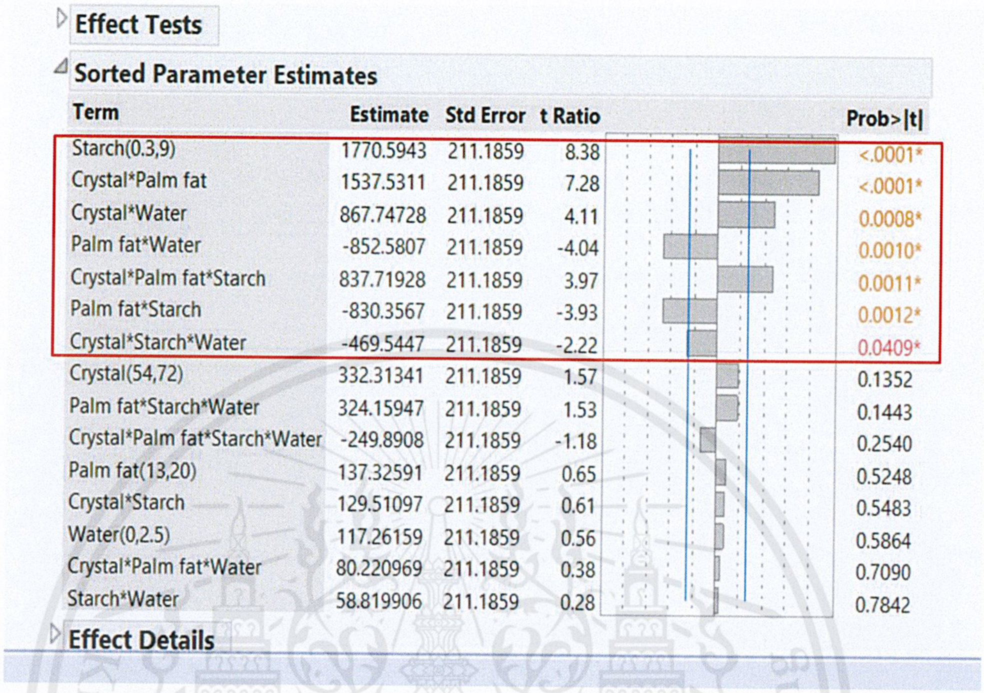
4.1.1 Probability Value (P-value)

The analysis of experimental data by P-value is used to screen significant parameters that affected to hardness, adhesives, and cohesiveness of bouillon cube. If the p-value of main parameter, 2 and 3-ways interaction is less than 0.05, that parameter has significant effect on the response. The P-value of hardness, adhesives, and cohesiveness are shown in Figure 4.1, 4.2, and 4.3, respectively.

The results from figure 4.1 reveal that starch is only main parameter that has significant impact on hardness, follows by 2-way interactions of crystal and palm fat; crystal and water; palm fat and water, 3-ways interactions of crystal, palm fat, and water, 2-way interactions of palm fat and starch, and 3-ways interactions of crystal, starch, and water.

The results from figure 4.2 show that no main parameter that has significant impact on adhesiveness. Only 2-way interactions of starch and water that affected on adhesiveness of bouillon cube.

The results from figure 4.3 reveal that starch and palm fat are two main parameters that has significant impact on cohesiveness. The 2-ways interactions of crystal and palm fat; palm fat and starch; crystal and water; and starch and water, and 3-ways interactions of crystal, palm fat, and starch; palm fat, starch, and water are also significant parameters.



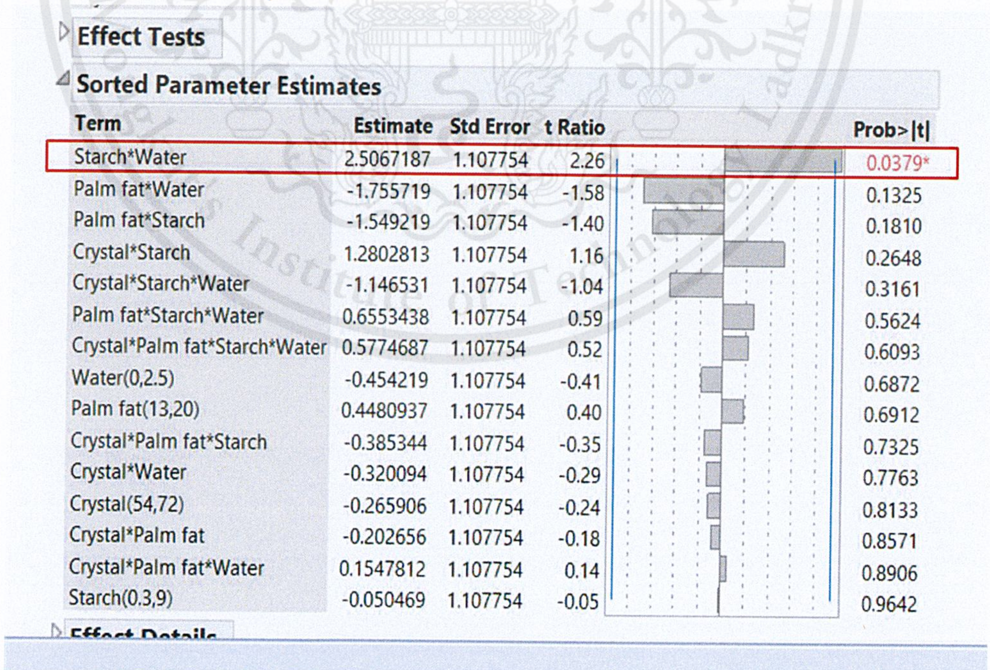
Effect Tests

Sorted Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Starch(0.3,9)	1770.5943	211.1859	8.38	<.0001*
Crystal*Palm fat	1537.5311	211.1859	7.28	<.0001*
Crystal*Water	867.74728	211.1859	4.11	0.0008*
Palm fat*Water	-852.5807	211.1859	-4.04	0.0010*
Crystal*Palm fat*Starch	837.71928	211.1859	3.97	0.0011*
Palm fat*Starch	-830.3567	211.1859	-3.93	0.0012*
Crystal*Starch*Water	-469.5447	211.1859	-2.22	0.0409*
Crystal(54,72)	332.31341	211.1859	1.57	0.1352
Palm fat*Starch*Water	324.15947	211.1859	1.53	0.1443
Crystal*Palm fat*Starch*Water	-249.8908	211.1859	-1.18	0.2540
Palm fat(13,20)	137.32591	211.1859	0.65	0.5248
Crystal*Starch	129.51097	211.1859	0.61	0.5483
Water(0,2.5)	117.26159	211.1859	0.56	0.5864
Crystal*Palm fat*Water	80.220969	211.1859	0.38	0.7090
Starch*Water	58.819906	211.1859	0.28	0.7842

Effect Details

Figure 4.1 p-values of factors that affected on the hardness.



Effect Tests

Sorted Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Starch*Water	2.5067187	1.107754	2.26	0.0379*
Palm fat*Water	-1.755719	1.107754	-1.58	0.1325
Palm fat*Starch	-1.549219	1.107754	-1.40	0.1810
Crystal*Starch	1.2802813	1.107754	1.16	0.2648
Crystal*Starch*Water	-1.146531	1.107754	-1.04	0.3161
Palm fat*Starch*Water	0.6553438	1.107754	0.59	0.5624
Crystal*Palm fat*Starch*Water	0.5774687	1.107754	0.52	0.6093
Water(0,2.5)	-0.454219	1.107754	-0.41	0.6872
Palm fat(13,20)	0.4480937	1.107754	0.40	0.6912
Crystal*Palm fat*Starch	-0.385344	1.107754	-0.35	0.7325
Crystal*Water	-0.320094	1.107754	-0.29	0.7763
Crystal(54,72)	-0.265906	1.107754	-0.24	0.8133
Crystal*Palm fat	-0.202656	1.107754	-0.18	0.8571
Crystal*Palm fat*Water	0.1547812	1.107754	0.14	0.8906
Starch(0.3,9)	-0.050469	1.107754	-0.05	0.9642

Effect Details

Figure 4.2 p-values of factors that affected on adhesiveness.

Sorted Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Starch(0.3,9)	0.0127188	0.001472	8.64	<.0001*
Crystal*Palm fat	0.0080312	0.001472	5.46	<.0001*
Crystal*Palm fat*Starch	0.0050938	0.001472	3.46	0.0032*
Palm fat*Starch	-0.005031	0.001472	-3.42	0.0035*
Crystal*Water	0.0048438	0.001472	3.29	0.0046*
Palm fat(13,20)	0.0042813	0.001472	2.91	0.0103*
Starch*Water	-0.003844	0.001472	-2.61	0.0189*
Palm fat*Starch*Water	0.0031562	0.001472	2.14	0.0477*
Palm fat*Water	-0.002781	0.001472	-1.89	0.0771
Water(0,2.5)	0.0027188	0.001472	1.85	0.0833
Crystal*Palm fat*Starch*Water	-0.002469	0.001472	-1.68	0.1130
Crystal(54,72)	-0.002344	0.001472	-1.59	0.1309
Crystal*Starch*Water	-0.001594	0.001472	-1.08	0.2950
Crystal*Starch	-0.000281	0.001472	-0.19	0.8509
Crystal*Palm fat*Water	-3.125e-5	0.001472	-0.02	0.9833

Figure 4.3 p-values of factors that affected on cohesiveness.

4.1.2 Prediction Profiler

Prediction profiler provide the graphical information of how each main parameter affected on hardness, adhesiveness, and cohesiveness in one graph as shown in Figure 4.4.

The top pictures confirm that starch have highest significant on hardness of bouillon cube from the steepest ascent of slope. The higher amount of starch yields the higher hardness. The flatted line of crystal, palm fat, and water means these parameters are not significant on hardness.

The middle pictures reveal similar results as p-value that there is no main parameter that has significant effect on adhesiveness.

The bottom pictures reveal that starch have highest significant on cohesiveness of bouillon cube from the steepest ascent of slope. Slope of crystal, palm fat, and water are too little to be observed.

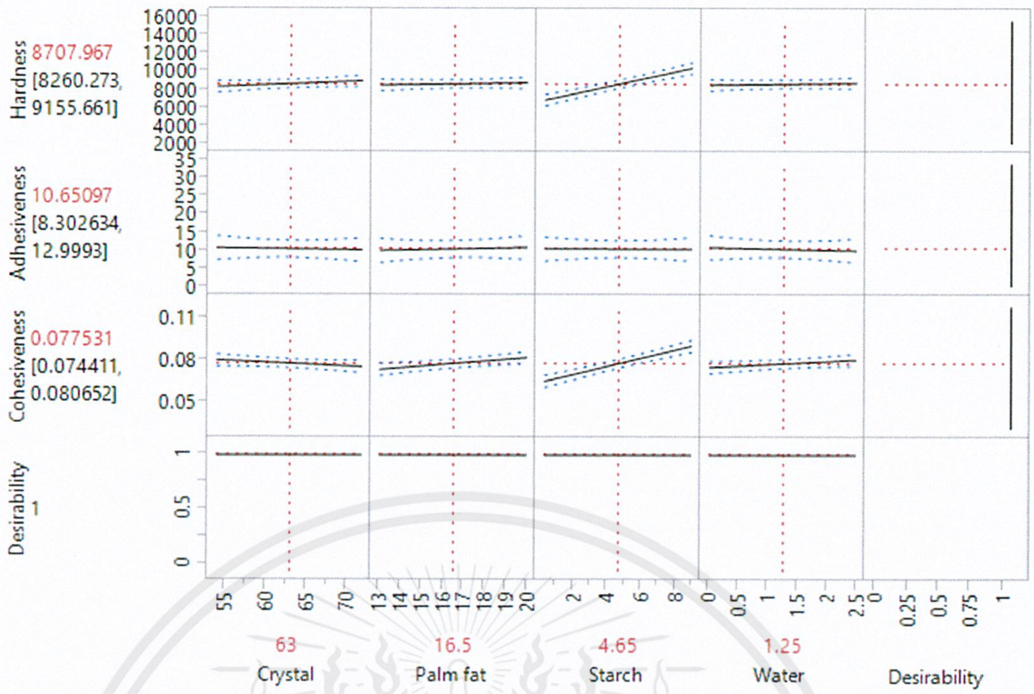


Figure 4.4 Prediction Profiler

CHAPTER V

Conclusion

5.1 Conclusions

In this project, JMP Program was used as a tool to design and analyze the mass texture properties including hardness, adhesiveness and cohesiveness in a pork bouillon cube with objectives to study mass texture properties of bouillon cube by using Texture Profile Analysis Method and to study the effect of ingredients on hardness, adhesiveness and cohesiveness. It was found that Texture Profile Analysis Method can be used for estimate mass texture properties of the bouillon cube.

From the total of 32 experiments, the results reveal that 4 ingredients have impact on hardness and cohesiveness, but starch has the most impact. For Adhesiveness, only starch and water that has impact. The results from this study could give recommendations for manufacturing scale. The problem on hardness or cohesiveness of product could be solved by adjusting an amount of starch while adhesiveness of product could be adjusted by modifying amount of starch and water. However, there are many important factors that should be taking in to consideration such as sensory and shelf life.

5.2 Suggestions

The results from this study are based on laboratory scale and the Z-arm mixer. If the company would like to apply the knowledge in manufacturing scale which uses the different mixer, recipes, processing conditions, the Evolutionary operation (EVOP) experimental design is recommended.

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