EFFECT OF MODIFIED STARCH AND XANTHAN GUM ON PHYSICOCHEMICAL OF NON-DAIRY GLUTEN-FREE PANCAKES TEXTURE

BY

MS.MOLVATOU SURALERTRUNGSRI

ID: 541-5150

SPECIAL PROJECT SUBMTTED TO THE FACULTY OF BIOTECHNOLOGY, ASSUMPTION UNIVERSITY IN PART OF FULFULLMENT OF THE REQUIREMENT FOR THE DEGREE OF BACHELOR OF SCIENCE

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Title: Effect of Modified Starch and Xanthan Gum on Physicochemical of Non-dairy Gluten-Free

Pancakes Texture

By: Ms. Molvatou Suralertrungsri

Advisor: Dr. Tatsawan Tipvarakarnkoon

Level of study: Bachelor of Acience

Department: Food Technology

Faculty: Biotechnology

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Advisor
(Dr. Tatsawan Tipvarakarnkoon)

Abstract

Thailand is the first producer and exporter of tapioca starch-derived products in the world. The objectives of this project were to studied the effect of modified starch and xanthan gum on non-dairy gluten-free pancakes texture. Non-dairy pancakes were prepared by using soy bean milk instead of cow milk. Also, the use of edible oil instead of butter on the flavor and texture of pancake was also evaluated. Gluten-free pancake prepared by substitution of wheat flour by tapioca starch and modified starch. The study the effect of substitution, different ratio was studied using mixture design. The pasting properties were first determined using Rapid Visco Analyzer (RVA). Texture analysis was then used to evaluate texture profile and firmness of the developed pancake samples. From the results, higher in wheat still gave higher liking over softness and firmness and overall texture. The different concentration of modified starch gave no significant different in texture. Higher amount in MS gave higher liking score on texture attributes. For the effect of xanthan gum, the higher amount of xanthan gum gave higher liking score on texture.

Acknowledgements

The project could not be completed successfully without all helpful recommendation and support. Firstly, I would like to express my sincere gratitude towards my advisor Dr. Tatsawan Tipvarakarnkoon from the Faculty of Biotechnology. Assumption University for her kindly recommended and suggested, helping to solve any problems I have faced, and also spent the worth time throughout the entire project. Furthermore, I would like to thank all Faculty members, teachers and technicians who always helped when there were any questions. Also, I would like to extend my gratitude towards my family who encouraged me and made it possible for giving good advice, willingness. In addition, I would like to thank all students, panelists and everyone else who took the time to participate in the many questionnaires and surveys that were required to complete the project. Lastly, I also like to thank you my friends for their kind and generous in helping me everything.

Ms. Molvatou Suralertrungsri
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Introduction

Tapioca starch is considered one of the most important commercial and economic crops in Thailand. It is known as tapioca or cassava. Thailand is major producers of tapioca starch, with an annual yield 16-18 million tons; compare to the global production around 10%. Approximately 40% of the tapioca produced in Thailand is processed into tapioca starch, for the domestic demand is as high as 1.3-1.7 million tons per year.
However, tapioca is not a staple food for Thai people. About 80% of the production is exported. Where the modification of starch alter the properties of tapioca starch to be more available in various product and found to be used to substitution to wheat flour. Tapioca from Thailand has resulted in the identification of a high yielding and very high-starch cultivars. Tapioca roots are utilized by making dry chips pellets, native starch, modified starch and other industrial products. This is to lower the raw material costs in many products.

Gluten-free diet is a diet that excludes the protein gluten. Gluten is found in grains such as wheat, barley, rye and a cross between wheat and rye called triticale. A gluten-free diet is primarily used to treat celiac disease. People with celiac disease, the immune system react to gluten and leads to damage to the lining of the gut. This causes symptoms of celiac disease bloating, diarrhea, nausea, tiredness and headaches. In some severe cases, a gluten free diet alone can't stop the symptoms and complications of celiac disease and additional treatment is needed. If people with celiac disease accidentally eat a product that contains gluten, they may experience abdominal pain and diarrhea. Some people experience no signs or any symptoms after eating gluten, but this doesn't mean it's not damaging their small intestines. Even trace amounts of gluten in the diet may be damaging, whether or not they cause signs or symptoms. Overtime, not following a gluten-free diet if they have celiac disease can lead to serious complications including small intestinal cancer. Eating a gluten-free diet helps people with celiac disease control their signs and symptoms and prevent complications. Initially, following a gluten-free diet may be frustrating. But with time, patience and creativity, patients that have celiac disease will find there are many foods that they already eat that are gluten-free and they will find substitutes for gluten-containing foods that they can enjoy. Some people who don't have celiac disease also may have symptoms when they eat gluten. However, this is called non-celiac gluten sensitivity. People with non-celiac gluten sensitivity may benefit from a gluten-free diet. But people with celiac disease must be gluten- free to prevent symptoms and disease-related complications. People with celiac disease must eat a strictly gluten-free diet and must remain on the diet for the remainder of their lives. Switching to a gluten-free diet is a big change, and like anything new, it takes some getting used to. They may initially feel deprived by the diet's restrictions, especially if they were not having troubling symptoms before their diagnosis. These studies also gluten-free substitute foods available, such as specially made gluten-free pancake. These studies will help to focus on substitution of wheat flour with tapioca starch and modified starch and increased variety of product for people with celiac disease.

Food labels can be confusing, especially if you are new to purchasing foods for a person with allergies or restricted diet. In the dairy-free community, they often use dairy-free, non-dairy, and lactose-free inter changeably, but these terms are actually interchangeable in terms of what they represent on food labels The difference between the terms dairy-free and non-dairy can

actually be huge to a person with a dairy allergy or sensitivity. While there is no actual FDA explanation of what Dairy-Free means on food labels, more often than not, a product with this label will, indeed, be Dairy-Free. (The same goes for the term Vegan). So what this means is that while you can feel relatively safe that when a label claims a product to be Dairy-Free it is dairy-free, label reading is still an essential for those on a dairy-free or vegan diet. On the other hand, there is an FDA regulatory explanation for the term Non-dairy, non-dairy definitely does not mean that the product is milk-free, but the regulation allows for the presence of milk protein such as casein, whey, and other derivatives.

In order to lower cost of pancake production, the addition of tapioca starch has been used to substitute wheat flour. Also, the addition of modified starch was needed to use to improve texture of developed pancake. Therefore, the effect of the addition of tapioca starch and their modified starch on texture of non-dairy pancake has been studied.

Objectives

1. To study physicochemical properties of flour and starch.
2. To comparison between vegetable oil and butter addition on flavor and texture of pancake.
3. To study wheat flour substitution using tapioca starch and modified starch for gluten-free and non-dairy pancakes production.
4. To study effect of xanthan gum on texture of gluten-free and non-dairy pancakes.

Literature review

Wheat flour

Wheat flour is used to make bread, biscuits, pasta, etc. Widely used of Wheat flour is inevitable for making bakery products. Wheat is the cereal that enables more adequately gluten formation. Gluten is paste formed by mixing glutenin and gliadin protein along with water gluten has certain plasticity and elasticity which allows it to by shape. Wheat flour obtained is very rich in carbohydrates but lacks minerals and vitamins that are found in the barn and germ. Fortunately, the legal obligation is some countries to include vitamin B compensates for the loss of this vitamin, but not the loss of most minerals and other vitamins

Tapioca starch

Tapioca flour, also known as tapioca starch, is starchy white flour that has a slight sweet flavor to it. Tapioca flour is an alternative to traditional wheat flours and has a variety of uses in baking. The flour is made from the starch extracted from the South American cassava plant. It basically the same as tapioca pearls, like you would use for pudding, but tapioca flour has been ground into a flour. When the roots have fully developed, they are harvested and processed to remove toxins. The starch is then extracted from the root by a repeated process of washing and pulping the mixture, then separating off the liquid. Tapioca starch adds structure to gluten-free baking. Tapioca flour helps bind gluten free recipes and improves the texture of baked goods. Tapioca helps add crispness to crusts and chew to baked goods. It also helps give things a chewy and/or crisp texture, especially in things like cookies and cakes. Tapioca flour can also be used as a thickener in sauces. It is a white to off-white powder with moisture below 13%. The pH of slurry in water is neutral. Tapioca Starch is very bland and clean in flavor and is not masking the flavors used. Tapioca flour is extremely smooth flour, which makes for a great thickener in sauces, pie, soups since it never discolors and contains no discernible taste or smell. It can also be used to replace corn starch. Moreover, it never coagulates or separates when refrigerated or frozen. Use in combination with other gluten-free flours for best results. It is Gluten free raw material; it can be used by those who are gluten intolerant. A few gluten-free people that do not like the flavor of tapioca flour in their gluten-free cooking and they often substitute corn starch. It is used as a water binding and texturizing agent. It has a high viscosity, water-holding capacity and binding abilities. Cooked, it forms a quite clear gel with a long and slightly stringy texture. Upon cooling, it sets to a soft gel. It loses most of its thickening properties during prolonged heating and under high acidic conditions. The cooked gel resambles that of potato, but the texture is less stringy and the flavor i more neutral, making it a preferred thickener in delicate foods and desserts. It produces a high gloss.

Modified starch

Modified Starch is the Native Starch being improved and changed the properties to be different from the Native Starch. Modified food starch is a chemically altered food ingredient made from starch. Because many starches may contain gluten or have been contaminated with gluten, be on the lookout for this ingredient in many of the foods sold today if you are eliminating gluten from your diet. Modified starch, also called starch derivatives are prepared by physically, enzymatically, or chemically treating native starch to change its properties. Physical or chemical changes of the starch properties cause the molecule structure change within the

starch. Modified starches are used in practically all starch applications, such as in food products as a thickening agent, stabilizer or emulsifier; in pharmaceuticals as disintegrant; as binder inciated paper. They are also used in many other applications. Starches are modified to enhance their performance in different applications. Starches may be modified to increase their stability against excessive heat, acid, shear, time, cooling, or freezing; to change their texture; to decrease or increase their viscosity to lengthen or shorten gelatinization time; or to increase their visco-stability.
This modified starch is etherified starches. This type of modification is conduct with the aim of increasing stability of the gel at low temperatures, preventing excess setback and water loss or syneresis, high viscosity. It can be differentiated sensory properties, provide soft, creamy texture and a clearer paste and also stable for products that require storage at low temperatures.

There are several methods of molecule structure change. Each method is different based on the present demand for use and could be categorized mainly as follows:

1. Chemical modified starches
2. Physical modified starch
3. Starch with molecule structure change within the starch and/or external structure change with biological method (Biological modified starch)

1. Starch with molecule structure change by mean of chemical (Chemicals modified starches)

Categorization of the modified starch by mean of chemical (Chemicals modified starches) is done in several methods.

A. Derivertization

This starch group is the starch caught be the chemical in the starch molecule in form of single molecule or more, causing the starch molecule to be larger

B. Converted starch

This starch group is the diminishing of starch molecule either by cutting between glucose unit or breaking the glucose unit

2. Molecule structure modified starch by physical mean (Physicals modified starch)

Modification of molecule structure within the starch by physical mean (Physical modified starch) causes change without using chemical mainly to change the molecule structure within the starch, but uses the heat or dynamic energy or both. When the molecule structure within the starch is changed, the properties of the starch are changed also.

3. Molecule structure modified starch by biological mean (Biological modified starch)

Presently, biological and genetic engineering technology is developed so much and is the main factor to cause the industrial development to obtain the starch with properties based on the application demand by using biological technology, and presently, we use the products from biological technology i.e. High amylase starch and Waxy starch. Change of the proportion of amylase and amylopectin shall change the properties of the starch.

There are three methods to make modified starch in Thailand:

1. Degradation or conversion: starch is rendered less sticky in three ways:
   a. Acid conversion: Hydrochloric and sulfuric acids react with starch liquid to decrease the degree of stickiness, and to reduce the temperature of gelatinization. This starch is called"acid modified starch".
   b. Oxidization: Starch reacts with chloride in alkaline starch liquid. The starch thus derived will become less sticky with the degree of chloride used and the reation time. This starch is called"oxidized starch" or "hypochlorite modified starch".
2. Pregelatinization: Liquid starch in 40-50% concentration is drum-dried. Starch is cooked and dried to form a thin crispy layer. It is ground and sifted to obtain a fine powder, which immediately becomes glue when cold water is added to it. The starch at this stage is called "cold water soluble starch" or "alpha starch".

Derivatives: These are processed starches whose molecular structures have been altered through chemical reactions. Examples in this group include esters, starch ether, and cross-linked starch

Amylose and amylopectin

Chemically, starches are polysaccharides that consist of repeating glucose units. Starch molecules have one of two molecular structures: a linear structure, known as amylose; and a branched structure, known as amylopectin. Amylose and amylopectin associate through hydrogen bonding and arrange themselves radially in layers to form granules. Starch granules come in a wide variety of sizes ranging from 3 microns to over 100 microns. With some starches the granule size is polymodal, meaning the granules can be grouped into more than one size range. Wheat starch, for example, has a distribution of both large and small granules. Granule shape also can be diverse. Granule shapes include symmetrical spheres, asymmetrical spheres, symmetrical disks and asymmetrical disks. Some granules exhibit their shape smoothly, while others are polyhedrons with a faceted surface. All starches are made up of varying proportions of amylose and amylopectin. This ratio varies not only among the different types of starch, but among the many plant varieties within a type. Tapioca starch has 15% to 18% amylose. Tapioca granules are smooth, irregular spheres with sizes ranging from 5 to 25 microns. Wheat flour has an amylose content of around 25%. Its granules are relatively thick at 5 to 15 microns with a smooth, round shape ranging from 22 to 36 microns in diameter. Wheat starch is bimodal in that it also has a group of starch granules of a different size. In this case, these other granules are very small, with diameters of only 2 to 3 microns.

Molecular structure of amylose and amylopectin, longer amylose molecules tend to make a product's texture stringy because of the way they associate. The molecular weight of the amylose also affects the elasticity of a gel. Longer molecules tend to associate more strongly and produce stronger, more brittle gels, but there is a limit to this effect. A longer amylose molecule will, to a point, have greater gel strength due to its increased ability to associate through hydrogen bonding. This increased ability to associate increases the molecule's tendency to retrograde. Smaller amylose molecules exhibit weaker association and, thus, are more resistant to retrogradation. Recent information indicates that amylopectin molecules with longer branches also are more susceptible to retrogradation. This is a particular concern to researchers trying to lengthen amylose molecules through cross-breeding.

During starch gelatinization: starch is dispersed into water and heated, the water penetrates into the starch granule from the outside inward until the granule is fully hydrated.

Once hydrated, the hydrogen bonding between the amylose and the amylopectin maintains the integrity of the granule and it begins to swell from the hilum (center). Once gelatinized, the swollen granules may increase the viscosity of the dispersion, and/or associate to form gels and films.

RapidVisco Analyser (RVA)

The RapidVisco Analyser is a rotational viscometer that incorporates variable heating, cooling and shear capabilities. It is suitable for a variety of applications requiring accurate viscosity information, such as the testing of starch-bases products for quality control. Standardized test profiles are available, including those approved by the American Association of Cereal Chemists (AACC International) and the International Association for Cereal Science and Technology (ICC). The RapidVisco Analyser is a rotational viscometer that continuously records the viscosity as a sample under conditions of controlled temperature and shear. The ability of the RVA to suspend samples in the test and apply an appropriate amount of shear to match processing conditions makes it particularly valuable in many process and research applications. The combination of shearing, heating and cooling, applied over time, creates a viscosity curve for the material.

During a standard starch analysis, the starch is heated in an aqueous environment. The starch granule imbibes water and swells, the internal crystalline structure melts (gelatinization), the granule itself breaks down and a continuous gel forms. The viscosity changes produced by heating and cooling starch in water generally provide a similar characteristic pasting curve.

- Pasting temperature, which provides an indication of the minimum temperature required to cook a given sample, can have implications for the stability of other components in a formula, and also indicate energy costs.
- Peak viscosity indicates the water-holding capacity of the starch or mixture. It is often correlated with final product quality, and also provides an indication of the viscous load likely to be encountered by a mixing cooker.
- The rate of breakdown in viscosity to a holding strength, hot paste viscosity or trough, depends on the temperature and degree of mixing, or shear stress, applied to the mixture, and the nature of the material itself. The ability of a sample to withstand this heating and shear stress is an important factor for many processes.
- The re-association between starch molecules during cooling is commonly referred to as the setback. It involves retrogradation, or re-ordering, of the starch molecules, and has been correlated with texture of various products.
- Final viscosity is the most commonly used parameter to define a particular sample's quality, as it indicates the ability of the material to form a viscous paste or gel after cooking and cooling.

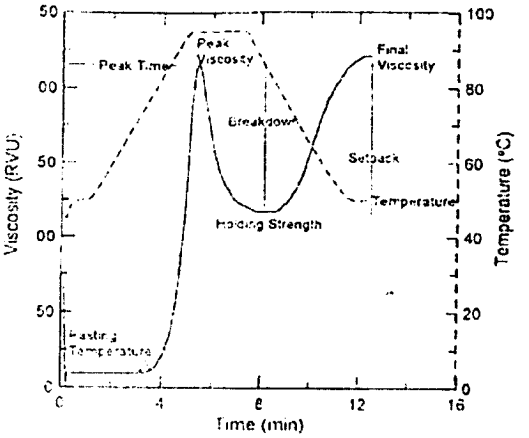


Fig.1 Typical pasting profile by RVA

Material and Methods

1. The study physicochemical properties of flour and starch.

The RapidVisco Analyser (RVA) can be used to assess the quality of any product where the coked viscosity is important. The precise linear lamped heating and cooling abilities of the RVA, along with steady rate temperature control, allow careful control of the cooking environment, whilst changes in viscosity are continuously recorded.

The pasting properties of starch and starch-containing products are readily assessed in the RVA. During the test, the starch is gelatinized with consequent rise in viscosity, subject to high temperature and controlled shear during which its stability is revealed, and then cooled to provide an indication of setback during gelation. Samples can be assessed for pasting temperature, peak paste viscosity, time to peak, temperature at peak, hot and cold paste viscosity, breakdown, setback, final viscosity and other parameters.

The method is applicable to any ground material including, but not limited to, cereal and other starches, flours, whole meals and formulations. It may also be used to assess amylase activity.

Methods

Switching on the RVA model 3D or 4 allow 30 min warm up. Switch on associated computer, run the RVA control software, enter the profiles shown below and enter a file name to save the data to. Then, measure 25.0 ± 0.1ml of distilled water (corrected to compensate for 14% moisture basis correction of sample) into a new canister. If necessary, grind a representative sample on a hammer mill (0.8 mm sieve). Then weigh X ± 0.01g sample (14% moisture basis) into a weighing vessel and transfer sample onto the water surface. The amount of material to use depends on the material. The following table may be used as a general guide.

Table 1. Amount of flour used in RVA measurement

Material	Amount (g)
Wheat flour	3.50
Native starch: Tapioca starch	2.50
Modified starch: Substituted	2.50

Then place a paddle into the canister and vigorously jog the blade through the sample up and down 10 times. It any lumps remain on the water surface or adhere to the paddle then repeat the jogging action. Then, the paddle was placed into the canister and canister was inserted into the instrument. Then canister was removed on completion of test and discarded. From the pasting curve, the pasting temperature, peak viscosity, time to peak, breakdown, minimum viscosity, setback and final viscosity may be measured

PROFILES
STD

Time	Type	Value
00:00:00	Temp	50 °C
00:00:00	Speed	960 rpm
00:00:10	Speed	160 rpm
00:01:00	Temp	50 °C
00:04:42	Temp	95 °C
00:07:12	Temp	95 °C
00:11:00	Temp	50 °C

Idle temperature: 50 ± 1 °C
End of test: 13minutes
Time between readings: 4 seconds

NOTES
This method is approved as ICC Standard Method No. 162. The method can be used for quality control, to compare samples, to assess amylase activity in flour, to investigate effect of formulation, to determine degree of modification during starch manufacture, and so on.

For best results, sample weights and the water added should be corrected for the sample moisture content, to give a constant dry weight. The moisture basis normally used is 14% as is, and correction tables are available from Newport Scientific. The correction formula for 14% moisture basis is

$M_2 = (100 - 14) \times M_1 / (100 - W_1)$
$W_2 = 25.0 + (M_1 - M_2)$

Where M_1 = sample mass for the material as listed in the above table (g)
M_2 = corrected sample mass (g)
W_1 = actual moisture content of sample (% as is)

2. **The comparison between vegetable oil and butter addition on flavor and texture of pancake.**

Preparation of dry non-dairy pancakes mix ingredient

The ingredients 96g of wheat flour/ tapioca starch/ modified starch, 1.6g of xanthan gum, 4.3g of baking powder, 1.6g of salt, and 3.3 g of white granulated sugar were sieved with 0.25mm of sieve and combined and mixed with a whisk and scrape down the sides of the mixing bowl.

Preparation of wet non-dairy pancakes mix ingredient

The ingredients 163g of soybean milk, 2 eggs or 60g of eggs, 25g of vegetable oil, and 3.3g of vanilla flavor were combined and mixed with a whisk until it completely mixed.

Non-dairy pancake procedure

Table.2 Basic formulation of non-dairy pancake

Basic formula for non-dairy pancake		
Ingredients	Grams	%
Flour (Wheat flour)	96	25.98
Xantan gum	1.6	0.45
Baking Powder	4.2	1.17
Salt	1.6	0.45
Sugar	3.3	0.92
Soybean milk	163	45.53
Egg	60	16.76
Vegetable oil	25	6.98
Vanilla flavor	3.3	0.92
Total	358	99.16

In the first mixing bowl, sift together 96g of flour, 4.3g of baking powder, 1.6g of salt, 3.3g of sugar and 1.6g of xanthan gum. But for better mixing must mix xanthan gum and sugar first and then sift with dry ingredients with 0.25mm of sieve. In a separate bowl, combine 163g of soybean milk, 60g of eggs, 25 g of vegetable oil, and 3.3g of vanilla flavor. Then slowly mix in half of the liquid into dry bowl, stirring continuously, and the rest ¼ at a time to avoid runny batter. Mix until you get the lumps out of the batter. Heated pan to 80 degree Celsius and begin to put 30grams of batter for one piece. Cook 1-2 minutes until it star to bubble around the edges and flip. Cook for another 2 minutes and then remove from pan and serve.

3. The study wheat flour substitution using tapioca starch and modified starch for gluten-free and non-dairy pancakes production.

Table.3. Pancake formulations at different ratio of flour using mixture design

Experimental Plan			
	Wheat flour (%)	Tapioca starch (%)	Modified starch (%)
A	50	40	10
B	50	30	20
C	40	30	30
D	0	70	30
E	0	80	20
F	10	80	10
G	25	55	20

Use mixture design for adjust the formulation; the sum total of these ingredients will be same as pancake basic formula. Wheat flour, tapioca starch and Modified starch were the component subjected that I want to study. The amount of flour range used in this study is 0 – 50% of wheat flour, tapioca starch is 30-80%, and Ms is 10-40%. By using Mixture Design, the formulation used in this experiment is shown in this Table. While Formula A-C = high wheat flour, D and E are gluten-free pancake sample, F-G = low amount of wheat flour.

4. The study effect of xanthan gum on texture of gluten-free and non-dairy pancakes.

Table4. Pancake formulation at different percentage of xanthan gum

Percentage of Xanthan gum	
% Xanthan gum	grams
0	0
0.25	0.89
0.5	1.78
0.75	2.67
1	3.56

The amounts of Xanthan Gum were used to verified as the table above.

Texture Profile Analysis (TPA) of non-dairy pancakes

A texture analyzer TA-XT plus, Charpa Techcenter Co.,Ltd) was used to perform the TPA on the non-dairy pancakes. The texture analyzer was equipped with a 50-kg load cell and a round 75-mm diameter compression platen probe. The TPA computer software was Texture Exponent 32 (Stable Micro Systems). A stack of three pancakes was oriented first baked-side up on the texture analyzer platform. The pancake stack was compressed to 50% of it original height at a constant rate of 1mm/sec. After the initial compression, the probe retracted off the pancakes and remained stationary for 5 sec followed by a second compression to 50% of original height.

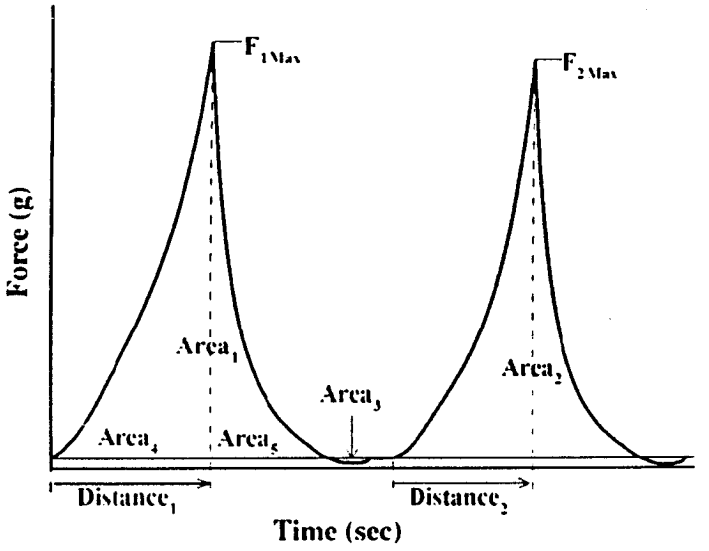


Fig.2Texture profile curve

A number of texture parameters were derived from the TPA curve. The figure 2. show how the different parameters were either directly obtained or calculated from the TPA curve. The non-dairy pancakes' height was also measured by the texture analyzer by determining the distance the probe traveled for 50% compression and multiplying by two-thirds

Firmness of non-dairy pancakes

A texture analyzer TA-XT plus, Charpa Techcenter Co.,Ltd) was used to perform the firmness on the non-dairy pancakes. The texture analyzer was equipped with a 50-kg load cell and a round 36mm cylindrical radius probe. The firmness computer software was Texture Exponent 32 (Stable Micro Systems). A piece of pancakes was oriented first baked-side up on the texture analyzer platform. A non-dairy pancake was compressed to 30% of its original height at a constant rate of 1mm/sec.

Results and Discussion

Texture Analyzer

Table 5. The result of non-dairy pancakes basic formula

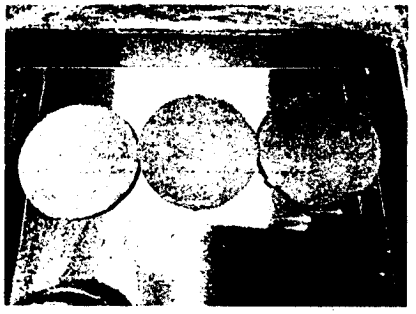
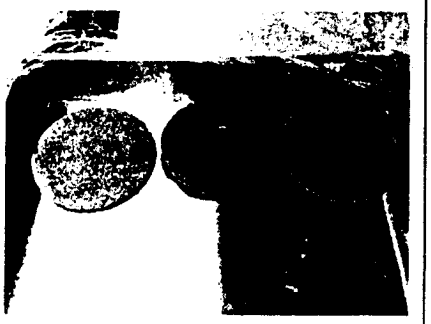
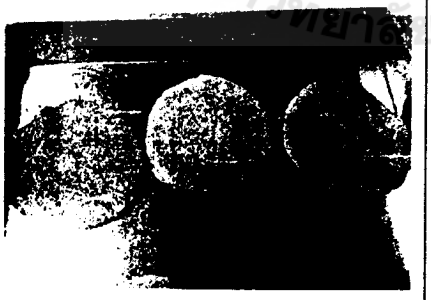
Sample	Figure	Description	Thickness	Diameter
Basic Formula (Oil)		Soft, texture rise equally, vanilla texture, a lot of pore	0.87±0.15	7.63±0.092

Table 6. The result of non dairy pancake substitution of oil and butter)

Sample	Figure	Description	Thickness	Diameter
Basic Formula using vegetable oil		Soft, texture rise equally, vanilla flavor, a lot of pore	0.80±0.09	7.31±0.06
Basic Formula using butter		Soft, texture rise equally, vanilla flavor, butter flavor a lot of pore	0.84±0.04	7.67±0.08

Table 7. The result of wheat flour substitution using tapioca starch and modified starch, A-G)

Sample	Figure	Description	Thickness	Diameter
A		Rarely soft, texture fully rise when it's hot , high amount of pore	0.63±0.03	7.73±0.13
B		Soft, texture rise a little bit when it's hot, high amount of pore	0.74±0.06	7.77±0.15
C		Flat texture, dry, sticky,	0.795±0.14	7.47±0.14
D		Flat texture, dry, sticky, too less amount of pore,	0.83±0.08	7.80±0.07
E		Too less amount of pore, too soft,	0.61±0.05	7.74±0.21

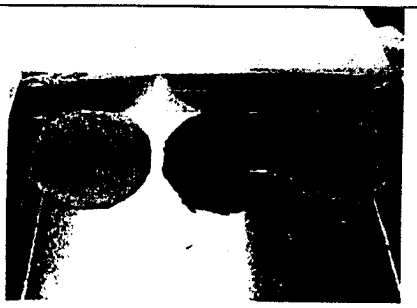
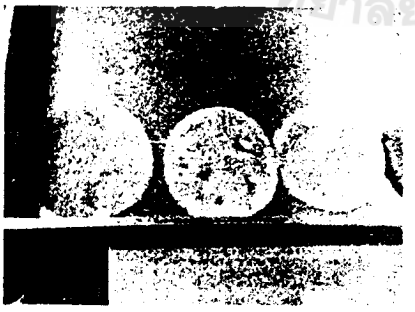
				
F		Less amount of pore, hard in texture	0.70±0.10	7.86±0.66
G		Less amount of pore, soft in texture	0.74±0.07	7.81±0.18

Table 8. The effect of xanthan gum on texture of gluten-free and non-dairy pancakes of Formula C varies% Xanthan Gum)

Sample	Figure	Description	Thickness	Diameter
C (0%)		Less sticky, less in amount of pore	0.48±0.01	7.93±0.14
C (0.25%)		Less sticky, less in amount of pore	0.58±0.07	7.7±0.06

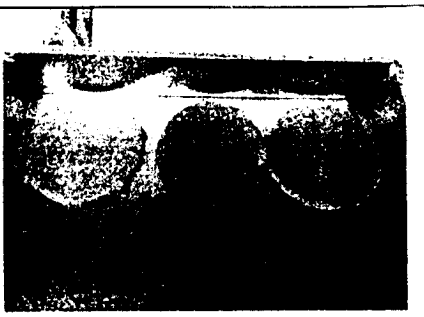
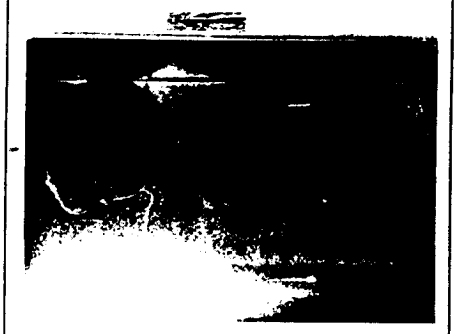
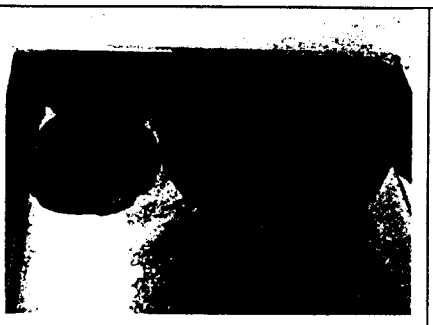
				
C (0.5%)		Moderately sticky, less in amount of pore	0.73±0.02	7.79±0.17
C (0.75%)		Moderately sticky, too less in amount of pore	0.77±0.04	7.72±0.07
C (1%)		Too sticky, too less in amount of pore	0.68±0.02	7.69±0.25

Table 9. Theeffect of xanthan gum on texture of gluten-free and non-dairy pancakes of Formula D varies% Xanthan Gum)

Sample	Figure	Description	Thickness	Diameter
D (0%)		Soft in texture, less amount of pore	0.48±0.04	7.99±0.13
D (0.25%)		Soft in texture, less amount of pore	0.54±0.03	7.25±0.22
D (0.5%)		Soft in texture, less amount of pore	0.70±0.08	7.15±0.05
D (0.75%)		Hard in texture, less amount of pore	0.72±0.03	7.06±0.07
D (1%)		Hard in texture, No pore	0.76±0.05	7.30±0.16

TPA

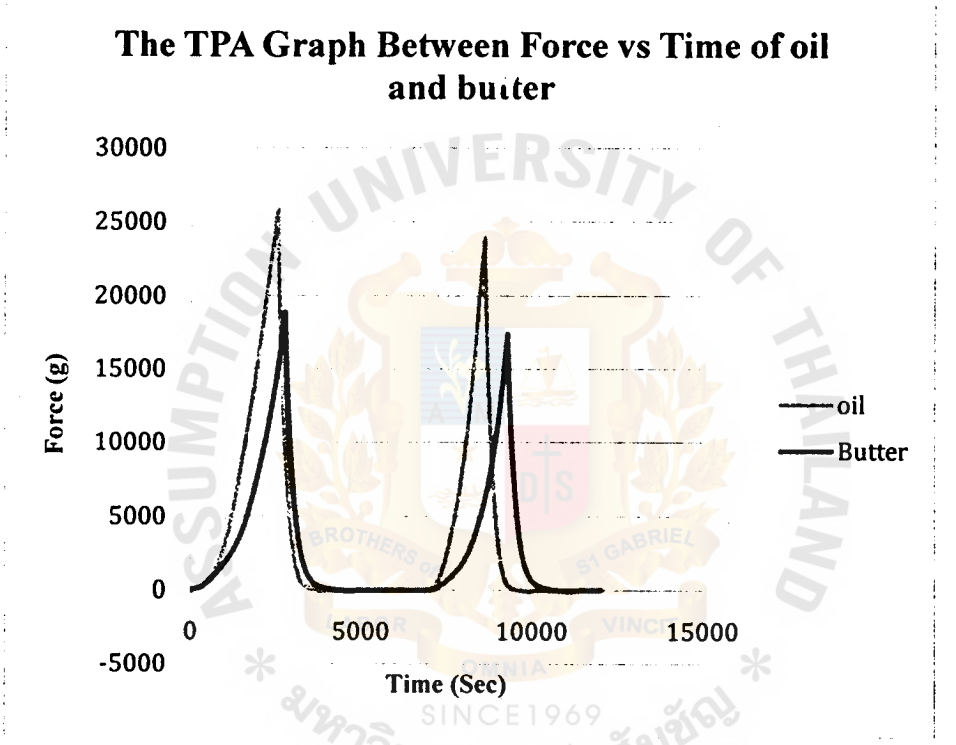


Fig3. The TPA graph between force vs time of oil and butter

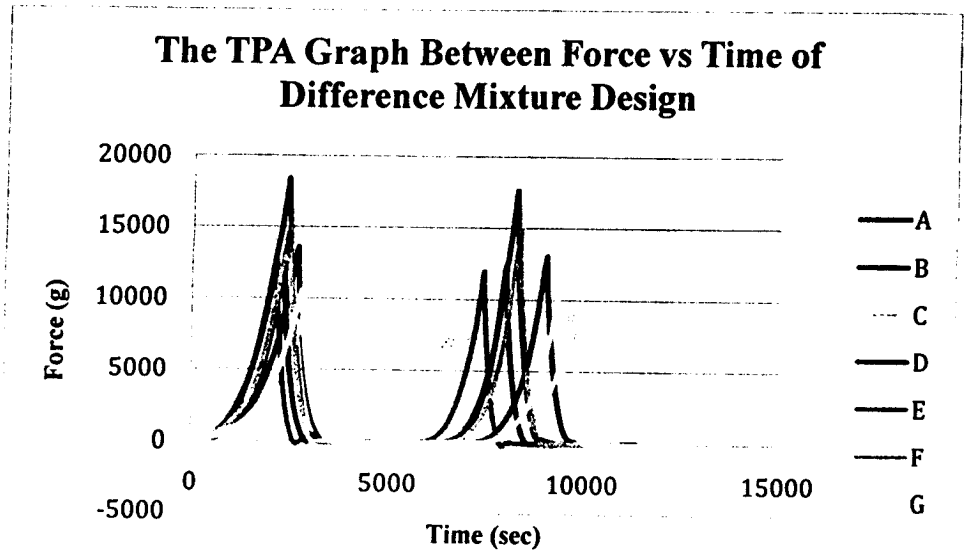


Fig4. The TPA graph between force vs time of difference in mixture design

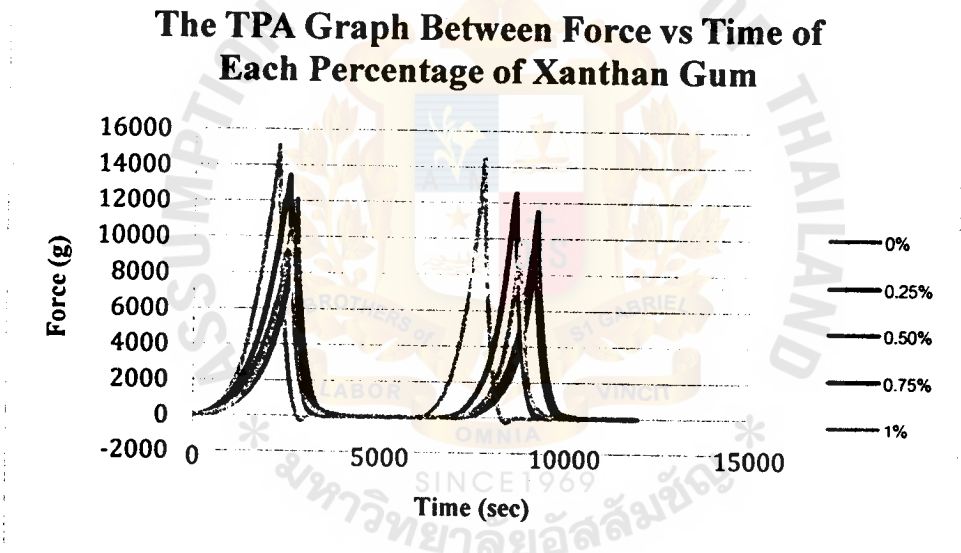


Fig5. The TPA graph between force vs time of each percentage of xanthan gum formula C

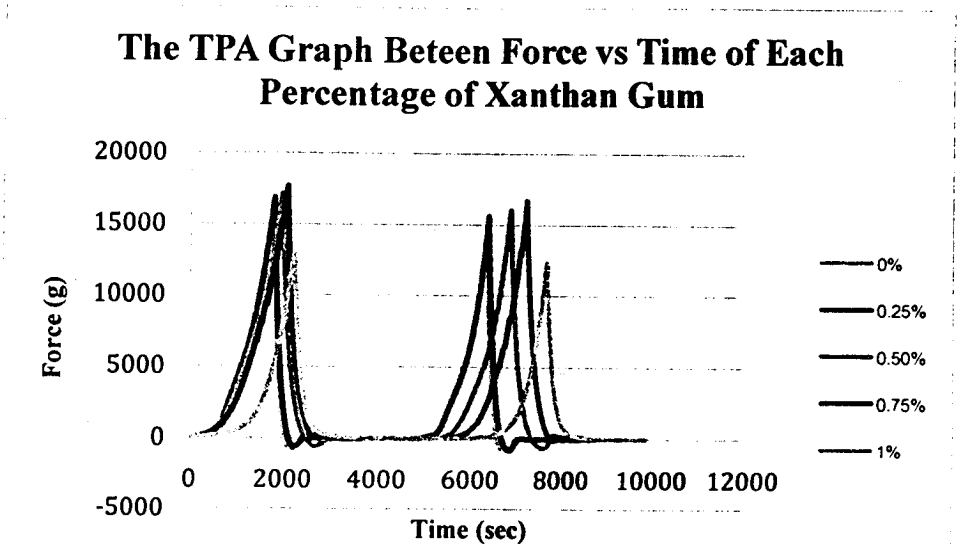


Fig6. The TPA graph between force vs time of each percentage of xanthan gum formula D

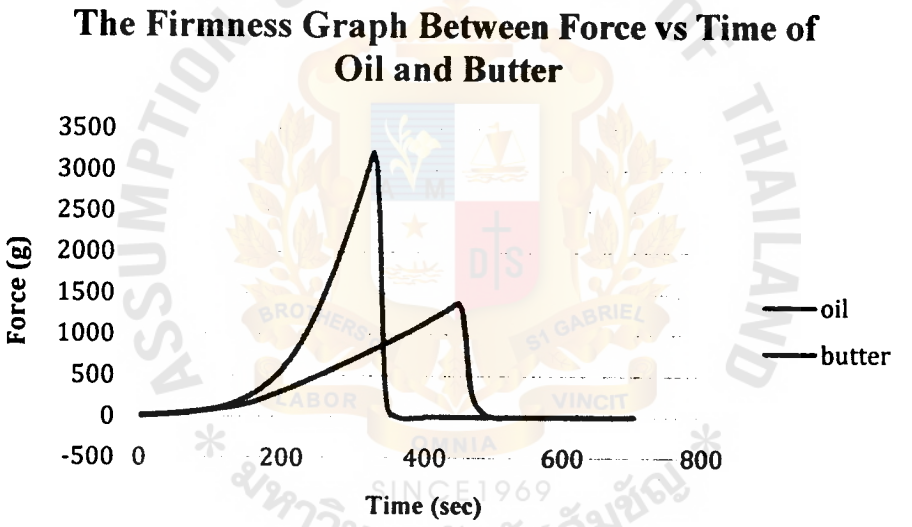


Fig7. The firmness graph between force vs time of oil and butter

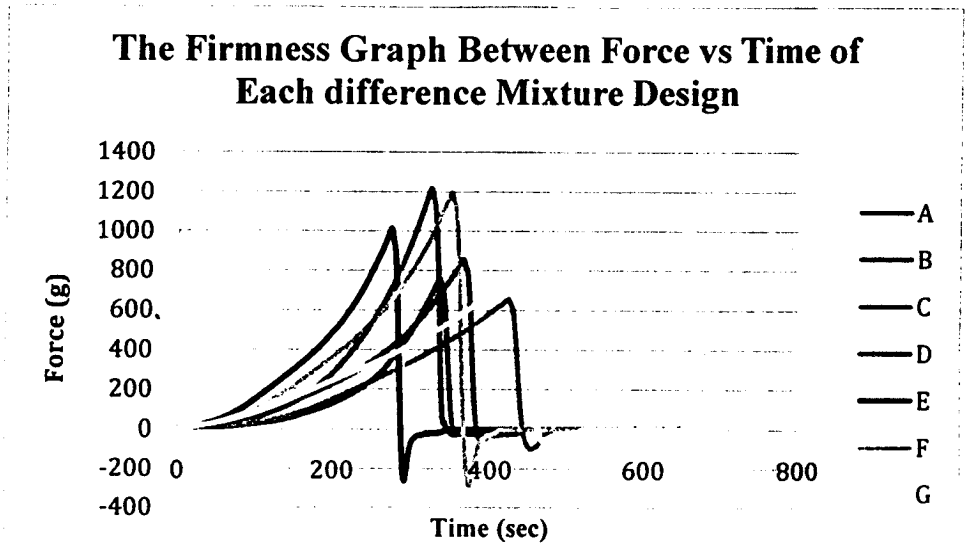


Fig8. The firmness graph between force vs time of each difference Mixture Design

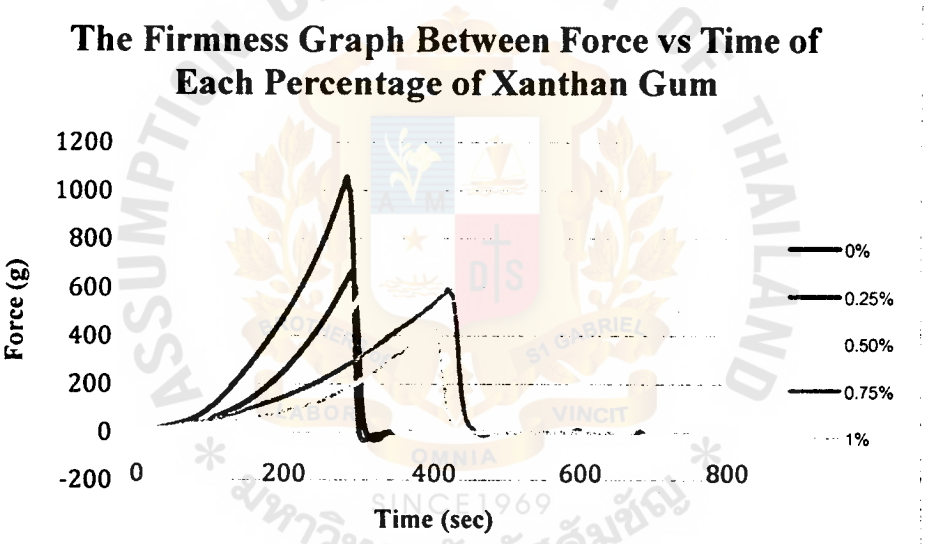


Fig9. The firmness graph between force vs time of each percentage of xanthan gum of formula C

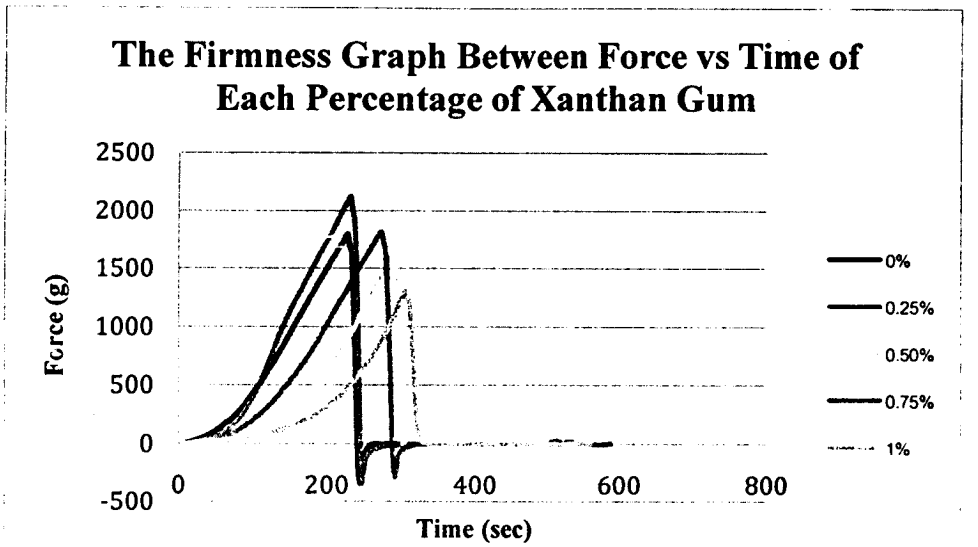


Fig10. The firmness graph between force vs time of each percentage of xanthan gum of formula D

RVA graph

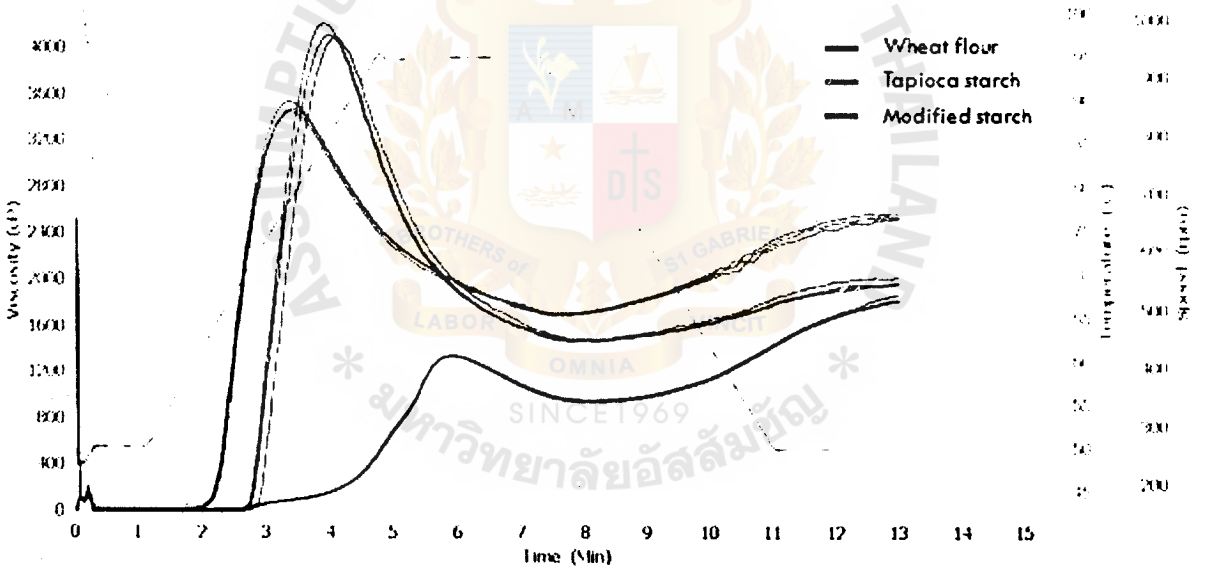


Fig11. The RVA graph between wheat flour, tapioca starch and modified starch

Sensory

Table10. The average and SD of sensory test of non-dairy pancake

Sample	Attributes								
	Color	Amount of pore	Vanilla flavor	Sweetness	Saltiness	Softness	Firmness	Overall texture	Overall
Basic Formula (Vegetable Oil)	6.57±1.0	6.77±1.0	3.13±1.33	5.73±1.14	6.03±1.19	7.4±0.50	7.43±0.62	7.07±0.64	6.17±0.83

Table11. The average and SD of sensory test in substitution of oil and butter

Sample	Attributes									
	Color	Amount of pore	Vanilla flavor	Butter flavor	Sweetness	Saltiness	Softness	Firmness	Overall texture	Overall
Basic Formula using vegetable oil	6.93±0.7b	7.6±0.7a	6.37±1.0a	2.3±0.9b	5.77±1.0	6.1±1.4	7.47±0.7a	7.53±0.6a	7.53±0.5	6.77±0.7
Basic Formula using butter	7.27±0.6a	7.2±0.8b	5.67±0.7b	4.97±0.8a	5.9±0.7	6.1±0.9	7.03±0.8b	7.2±0.7b	7.4±0.6	6.73±0.7

Table12. The average and SD of sensory test in substitution of wheat flour substitution using tapioca starch and modified starch,A-G

Sample	Attributes								
	Color	Amount of pore	Vanilla flavor	Sweetness	Saltiness	Softness	Firmness	Overall texture	Overall
A	5.95±0.9cd	3.7±0.7abc	6.35±0.5a	6±0.8	5.25±0.7ab	5.6±0.8a	5.25±0.9a	5.8±0.8a	6.1±0.6a
B	6.85±0.7a	2.3±0.6c	5.95±0.7b	5.15±0.8	4.85±0.9abc	4.8±1.2b	4.7±0.9b	4.95±0.7b	5.25±0.6bc
C	0.75±0.8ab	4.65±0.8a	6.75±0.7a	5.75±0.8	4.45±1.1c	4.75±1.2b	3.95±0.6cde	5±0.7b	6±0.7a
D	5.6±0.7d	2.85±1.1c	6±0.8a	5.85±0.8	5±0.8abc	3.6±0.6c	3.6±0.7de	3.9±0.6c	4.45±0.6de
E	6.15±0.6c	2.8±0.8bc	6.15±0.7a	5.7±0.7	5.1±0.9ab	3.7±0.6c	4.05±0.9cd	3.8±0.7c	4.1±1.2e
F	6.35±0.7bc	3.5±1.1bc	6.2±0.6ab	5.5±0.7ab	5.45±0.9a	5±1.3ab	3.45±0.7e	4±0.8c	4.8±0.9cd
G	6.9±1.6a	4.25±1.2ab	6.5±1.6a	5.85±1.5	4.8±1.4bc	5.05±1.5ab	4.3±1.5bc	5.15±1.3b	5.5±1.4b

Table13. The average and SD of sensory test in of each percentage of xanthan gum of formula C

Sample	Attribute								
	Color	Amount of pore	Vanilla flavor	Sweetness	Saltiness	Softness	Firmness	Overall texture	Overall
C0%	6.73±0.6a	2.8±0.6c	6.17±0.7a	5.77±0.7a	4.97±0.6b	3.73±1.0d	3.63±0.8c	3.43±0.6d	4.73±0.8c
C0.25%	6.6±0.7ab	3.07±0.6c	6.13±0.8a	5.8±0.7a	4.97±0.9b	3.6±0.8d	3.87±0.7c	3.93±0.8c	4.87±0.7c
C0.5%	6.870.6a	5.13±0.7b	6.37±0.6a	6.03±0.7a	5.63±0.5a	4.53±0.9c	3.8±0.8c	4.47±0.7b	5.53±0.7ab
C0.75%	6.8±0.7a	5.73±0.8a	6.23±0.7a	6.00±0.6a	5.63±0.7a	5.97±0.6a	4.77±0.6b	5.13±0.6a	5.27±0.5b
C1%	6.33±0.7b	5.63±0.7a	6.17±0.7a	5.93±0.5a	5.07±0.8b	5.47±0.9b	5.17±0.8a	5.4±0.7a	5.8±0.7a

Table14. The average and SD of sensory test in of each percentage of xanthan gum of formula C

Sample	Attributes								
	Color	Amount of pore	Vanilla flavor	Sweetness	Saltiness	Softness	Firmness	Overall texture	Overall
D0%	6.73±0.5ab	2.17±0.8c	6.87±0.5a	5.97±0.6b	6.00±0.7a	4.27±0.7b	2.70±0.6d	3.23±0.6d	3.20±0.6c
D0.25%	7.03±0.6a	2.20±0.7c	7.03±0.6a	6.50±0.8a	5.90±0.8a	5.70±0.5a	2.90±0.6d	3.10±0.8d	4.40±0.5b
D0.5%	6.87±0.6ab	3.3±0.8b	6.37±0.7b	6.27±0.6ab	5.73±0.7ab	5.5±0.6a	3.7±0.7c	3.93±0.7c	4.57±0.6b
D0.75%	6.70±0.7b	3.83±0.7a	6.33±0.6b	6.00±0.6b	5.87±0.8a	5.67±0.6a	5.13±0.6b	4.63±0.5b	4.40±0.7b
D1%	6.4±0.75	4.20±0.7a	5.97±0.5c	5.97±0.6b	5.40±0.6b	4.5±0.6b	5.47±0.7a	5.57±0.6a	5.10±0.7a

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Table15. The just about right test of non-dairy pancake

Attribute	Much too little	Moderately too little	Somewhat too little	Just right	Somewhat too much	Moderately too much	Much too much
Color	0	3.33	6.67	73.33	20	0	0
Amount of pore	0	0	13.33	80	6.67	0	0
Vanilla flavor	13.33	43.33	33.33	10	0	0	0
Sweetness	0	0	16.67	66.67	16.67	0	0
Saltiness	0	0	23.33	60	16.67	0	0
Softness	0	0	0	100	0	0	0
Firmness	0	0	6.67	93.33	0	0	0
Overall texture	0	0	0	93.33	6.67	0	0
Overall	0	0	0	96.67	3.33	0	0

Table16. The just about right test in substitution of oil

Attribute	Much too little	Moderately too little	Somewhat too little	Just right	Somewhat too much	Moderately too much	Much too much
Color	0	0	6.67	86.67	6.67	0	0
Amount of pore	0	0	6.67	90	3.33	0	0
Vanilla flavor	0	16.67	40	43.33	0	0	0
Butter flavor	3.33	63.33	30	3.33	0	0	0
Sweetness	0	3.33	33.33	63.33	0	0	0
Saltiness	0	0	20	76.67	3.33	0	0
Softness	0	0	3.33	90	6.67	0	0
Firmness	0	0	6.67	86.67	6.67	0	0
Overall	0	3.33	6.67	60	30	0	0

texture							
Overall	0	0	6.67	80	13.33	0	0

Table17. The just about right test in substitution of butter

Attribute	Much too little	Moderately too little	Somewhat too little	Just right	Somewhat too much	Moderately too much	Much too much
Color	0	0	10	83.33	6.67	0	0
Amount of pore	0	0	13.33	80	6.67	0	0
Vanilla flavor	0	6.67	60	33.33	0	0	0
Butter flavor	0	0	46.67	53.33	0	0	0
Sweetness	0	0	26.67	70	3.33	0	0
Saltiness	0	0	26.67	70	3.33	0	0
Softness	0	0	3.33	90	6.67	0	0
Firmness	0	0	3.33	93.33	3.33	0	0
Overall texture	0	0	26.67	73.33	0	0	0
Overall	0	0	6.67	93.33	0	0	0

Table18. The just about right test in substitution of wheat flour substitution using tapioca starch and modified starch A

Attribute	Much too little	Moderately too little	Somewhat too little	Just right	Somewhat too much	Moderately too much	Much too much
Color	0	0	20	6	20	0	0
Amount of pore	0	0	15	85	0	0	0
Vanilla flavor	0	0	20	80	0	0	0
Sweetness	0	0	15	80	5	0	0
Saltiness	0	0	0	80	20	0	0
Softness	0	0	0	20	65	25	0
Firmness	15	75	20	0	0	0	0
Overall texture	10	70	20	0	0	0	0
Overall	10	25	60	5	0	00	0

Table19. The just about right test in substitution of wheat flour substitution using tapioca starch and modified starch B

Attribute	Much too little	Moderately too little	Somewhat too little	Just right	Somewhat too much	Moderately too much	Much too much
Color	0	0	0	90	10	0	0
Amount of pore	0	0	20	80		0	0
Vanilla flavor	0	0	0	90	10	0	0
Sweetness	0	0	25	65	10	0	0
Saltiness	0	0	0	60	40	0	0
Softness	0	0	0	35	50	15	0
Firmness	0	0	0	20	35	35	10

Overall texture	0	0	0	45	35	20	0
Overall	0	5	55	35	5	0	0

Table20. The just about right test in substitution of wheat flour substitution using tapioca starch and modified starch C

Attribute	Much too little	Moderately too little	Somewhat too little	Just right	Somewhat too much	Moderately too much	Much too much
Color	0	0	5	90	5	0	0
Amount of pore	0	25	45	30	0	0	0
Vanilla flavor	0	0	0	95	5	0	0
Sweetness	0	0	10	90	0	0	0
Saltiness	0	0	5	55	45	5	0
Softness	0	5	10	40	45	0	0
Firmness	5	25	55	15	0	0	0
Overall texture	0	35	50	15	0	0	0
Overall	0	5	15	80	0	0	0

Table21. The just about right test in substitution of wheat flour substitution using tapioca starch and modified starch D

Attribute	Much too little	Moderately too little	Somewhat too little	Just right	Somewhat too much	Moderately too much	Much too much
Color	0	0	65	35	0	0	0
Amount of pore	60	40	0	0	0	0	0
Vanilla flavor	0	0	30	70	0	0	0
Sweetness	0	0	25	70	5	0	0
Saltiness	0	0	0	40	45	15	0
Softness	0	60	40	0	0	0	0
Firmness	35	55	10	0	0	0	0
Overall texture	0	10	55	35	0	0	0
Overall	0	20	65	15	0	0	0

Table22. The just about right test in substitution of wheat flour substitution using tapioca starch and modified starch E

Attribute	Much too little	Moderately too little	Somewhat too little	Just right	Somewhat too much	Moderately too much	Much too much
Color	0	0	15	85	0	0	0
Amount of pore	0	50	35	15	0	0	0
Vanilla flavor	0	0	10	90	0	0	0
Sweetness	0	0	20	80	0	0	0

Saltiness	0	0	0	40	50	10	0
Softness	0	0	0	35	65	0	0
Firmness	0	0	0	40	60	0	0
Overall texture	0	0	15	50	35	0	0
Overall	*0*	*0*	*50*	*50*	*0*	*0*	*0*

Table23. The just about right test in substitution of wheat flour substitution using tapioca starch and modified starch F

Attribute	Much too little	Moderately too little	Somewhat too little	Just right	Somewhat too much	Moderately too much	Much too much
Color	0	0	0	90	10	0	0
Amount of pore	0	35	65	0	0	0	0
Vanilla flavor	0	0	10	90	0	0	0
Sweetness	0	0	30	65	5	0	0
Saltiness	0	0	0	70	30	0	0
Softness	0	0	0	15	55	30	0
Firmness	0	25	50	25	0	0	0
Overall texture	0	0	45	40	15	0	0
Overall	0	20	50	30	0	0	0

Table24. The just about right test in substitution of wheat flour substitution using tapioca starch and modified starch G

Attribute	Much too little	Moderately too little	Somewhat too little	Just right	Somewhat too much	Moderately too much	Much too much
Color	0	0	0	90	10	0	0
Amount of pore	0	15	50	35	0	0	0
Vanilla flavor	0	0	10	85	5	0	0
Sweetness	0	0	15	80	5	0	0
Saltiness	0	0	0	65	35	0	0
Softness	0	0	0	40	45	15	0
Firmness	0	15	45	40	0	0	0
Overall texture	0	5	50	55	0	0	0
Overall	0	5	35	60	0	0	0

Table25. The just about right test in substitution of 0% percentage of xanthan gum of formula C

Attribute	Much too little	Moderately too little	Somewhat too little	Just right	Somewhat too much	Moderately too much	Much too much
Color	0	0	3.33	90	6.67	0	0
Amount of pore	0	6.67	36.67	56.67	0	0	0
Vanilla	0	0	10	86.67	3.33	0	0

flavor							
Sweetness	0	0	43.33	56.67	0	0	0
Saltiness	0	0	3.33	80	13.33	3.33	0
Softness	0	0	0	30	56.67	13.33	0
Firmness	26.67	60	10	3.33	0	0	0
Overall texture	0	16.67	56.67	26.67	0	0	0
Overall	0	0	63.33	36.67	0	0	0

Table26. The just about right test in substitution of 0.25% percentage of xanthan gum of formula C

Attribute	Much too little	Moderately too little	Somewhat too little	Just right	Somewhat too much	Moderately too much	Much too much
Color	0	0	10	80	10	0	0
Amount of pore	0	13.33	50	36.67	0	0	0
Vanilla flavor	0	0	3.33	90	6.67	0	0
Sweetness	0	3.33	6.67	90	0	0	0
Saltiness	0	0	3.33	86.67	10	0	0
Softness	0	0	3.33	50	48.67	0	0
Firmness	26.67	56.67	13.33	3.33	0	0	0
Overall texture	0	13.33	46.67	36.67	3.33	0	0
Overall	0	6.67	43.33	46.67	3.33	0	0

Table27. The just about right test in substitution of 0.5% percentage of xanthan gum of formula C

Attribute	Much too little	Moderately too little	Somewhat too little	Just right	Somewhat too much	Moderately too much	Much too much
Color	0	0	6.67	86.67	6.67	0	0
Amount of pore	0	20	60	20	0	0	0
Vanilla flavor	0	0	6.67	93.33	0	0	0
Sweetness	0	0	6.67	93.33	0	0	0
Saltiness	0	0	0	93.33	6.67	0	0
Softness	0	3.33	10	50	36.67	0	0
Firmness	10	30	53.33	6.67	0	0	0
Overall texture	0	30	50	20	0	0	0
Overall	0	10	33.33	56.67	0	0	0

Table28. The just about right test in substitution of 0.75% percentage of xanthan gum of formula C

Attribute	Much too little	Moderately too little	Somewhat too little	Just right	Somewhat too much	Moderately too much	Much too much
Color	0	0	6.67	90	3.33	0	0
Amount	0	30	53.33	16.67	0	0	0

of pore							
Vanilla flavor	0	0	10	90	0	0	0
Sweetness	0	0	10	86.67	3.33	0	0
Saltiness	0	0	0	80	13.33	3.33	0
Softness	0	13.33	53.33	30	3.33	0	0
Firmness	0	23.33	53.33	20	3.33	0	0
Overall texture	0	0	20	73.33	6.67	0	0
Overall	0	0	13.33	73.33	13.33	0	0

Table28. The just about right test in substitution of 1% percentage of xanthan gum of formula C

Attribute	Much too little	Moderately too little	Somewhat too little	Just right	Somewhat too much	Moderately too much	Much too much
Color	0	0	10	83.33	6.67	0	0
Amount of pore	6.67	36.67	50	6.67	0	0	0
Vanilla flavor	0	0	16.67	80	3.33	0	0
Sweetness	0	0	10	90	0	0	0
Saltiness	0	0	0	90	10	0	0
Softness	0	36.67	53.33	10	0	0	0
Firmness	0	0	6.67	53.33	40	0	0
Overall texture	0	0	10	66.67	23.33	0	0
Overall	0	0	10	66.67	23.33	0	0

Table29. The just about right test in substitution of 0% percentage of xanthan gum of formula D

Attribute	Much too little	Moderately too little	Somewhat too little	Just right	Somewhat too much	Moderately too much	Much too much
Color	0	0	23.33	73.33	3.33	0	0
Amount of pore	3.33	20	40	35.67	0	0	0
Vanilla flavor	0	0	10	90	0	0	0
Sweetness	0	0	13.33	86.67	0	0	0
Saltiness	0	3.33	10	66.67	20	0	0
Softness	13.33	60	23.33	3.33	0		0
Firmness	0	46.67	43.33	10	0	0	0
Overall texture	0	33.33	60	6.67	0	0	0
Overall	0	43.44	46.67	10	0	0	0

Table30. The just about right test in substitution of 0.25% percentage of xanthan gum of formula D

Attribute	Much too little	Moderately too little	Somewhat too little	Just right	Somewhat too much	Moderately too much	Much too much
Color	0	0	40	53.33	6.67	0	0

Amount of pore	0	36.67	36.67	23.33	0	0	0
Vanilla flavor	0	0	16.67	76.67	6.67	0	0
Sweetness	0	3.33	16.67	80	0	0	0
Saltiness	0	0	3.33	73.33	20	3.33	0
Softness	6.67	63.33	26.67	3.33	0	0	0
Firmness	20	63.33	16.67	0	0	0	0
Overall texture	0	23.33	63.33	13.33	0	0	0
Overall	0	20	60	20	0	0	0

Table31. The just about right test in substitution of 0.5% percentage of xanthan gum of formula D

Attribute	Much too little	Moderately too little	Somewhat too little	Just right	Somewhat too much	Moderately too much	Much too much
Color	0	3.33	36.67	60	0	0	0
Amount of pore	23.33	60	16.67	0	0	0	0
Vanilla flavor	0	0	20	80	0	0	0
Sweetness	0	3.33	13.33	83.33	0	0	0
Saltiness	0	0	0	70	26.67	3.33	0
Softness	0	456.67	40	3.33	0	0	0
Firmness	26.67	56.67	13.33	3.33	0	0	0
Overall texture	0	10	66.67	23.33	0	0	0
Overall	0	23.33	63.333	13.33	0	0	0

Table32. The just about right test in substitution of 0.75% percentage of xanthan gum of formula D

Attribute	Much too little	Moderately too little	Somewhat too little	Just right	Somewhat too much	Moderately too much	Much too much
Color	0	3.33	23.33	7	3.33	0	0
Amount of pore	36.67	53.33	6.67	3.33	0	0	0
Vanilla flavor	0	0	10	83.33	6.67	0	0
Sweetness	0	3.33	13.33	83.33	0	0	0
Saltiness	0	0	6.67	73.33	16.67	3.33	0
Softness	0	30	63.33	6.67	0	0	0
Firmness	16.67	50	30	3.33	0	0	0
Overall texture	0	10	60	30	0	0	0
Overall	0	23.33	56.67	20	0	0	0

Table31. The just about right test in substitution of 1% percentage of xanthan gum of formula D

Attribute	Much too	Moderately too little	Somewhat too little	Just right	Somewhat too much	Moderately too much	Much too

	little						much
Color	0	3.33	16.67	70	10	0	0
Amount of pore	56.67	43.33	6.67	3.33	0	0	0
Vanilla flavor	0	0	6.67	93.33	0	0	0
Sweetness	0	0	26.67	73.33	0	0	0
Saltiness	0	0	6.67	66.67	23.33	3.33	0
Softness	0	23.33	63.33	13.33	0	0	0
Firmness	10	46.67	36.67	6.67	0	0	0
Overall texture	0	40	56.67	3.33	0	0	0
Overall	0	6.67	83.33	10	0	0	0

Moisture content

Table32. The percentage of moisture content of wheat flour, tapioca starch, and modified starch

Sample	Moisture content (%)
Wheat flour	11.34±0.5
Tapioca starch	10.50±0.8
Modified starch	8.23±0.2

TPA Result

Table33. The TPA result of non-dairy pancakes substitution by oil and butter

Sample	Attributes ns				
	Hardness	**Springiness**	**Cohesiveness**	**Chewiness**	**Resilience**
oil	25161.6±3446.8	0.874±0.254	0.637±0.036	13612.3±1676.29	0.251±0.035
butter	19667.6±2493.77	0.899±0.011	0.724±0.018	12779.7±1339.6	0.306±0.01

Table34. The Firmness result of non-dairy pancakes substitution by oil and butter

Sample	Attributens
	Firmness
Oil	3221.9±154.2
Butter	1384.627±289.9

Table35.The TPA result in substitution of wheat flour substitution using tapioca starch and modified starch formula A-G

Sample	Attributes				
	hardness	Springiness ns	Cohesiveness	Chewiness	Resilience
50:40:10	18424.5±1655.3a	0.8±0.04	0.7±0.004a	11952.2±1547.7a	0.319±0.007a
50:30:20	13649.2±542.498bc	0.827±0.007	0.7±0.01ab	8628.8±329.6bc	0.3±0.007b
40:30:30	11025.8±2523.8c	0.7±0.06	0.75±0.005ab	6448.6±1992.1bc	0.2±0.01c
0:70:30	11375.4±2647.7c	0.7±0.1	0.7±0.04ab	6947.3±2422.0bc	0.2±0.01b
0:80:20	11339.4±2013.2c	0.7±0.007	0.7±0.01ab	6212.6±1330.6bc	0.2±0.006c
10:80:10	15186.8±296.0ab	0.8±0.02	0.7±0.01ab	9695.8±358.2ab	0.2±0.01b
25:55:20	11193.6±2786.6c	0.8±0.1	0.7±0.01b	7300.5±2486.5c	0.2±0.01b

Table36.The Firmness result in substitution of wheat flour substitution using tapioca starch and modified starch formula A-G

Sample W:T:MS	Attributens
	Firmness
50:40:10	1182.4±146.6

50:30:20	1415.3±1250.3
40:30:30	666.5±64.3
0:70:30	825.5±90.0
0:80:20	938.0±369.5
10:80:10	1198.0±131.1
25:55:20	867.5±73.5

Table37. The TPA result in substitution of each percentage of xanthan gum of formula C

Sample 40:30:30	Attributes				
	hardness	Springiness ns	Cohesiveness	Chewiness	Resilience ns
0%	15176.9±2313.9a	0.8±0.01	0.7±0.01a	10507.6±1447.2a	0.2±0.01
0.25%	10529.5±2352.8b	0.8±0.01	0.74±0.004b	6675.4±1536.3bc	0.2±0.01
0.5%	11995.5±748.8ab	0.8±0.006	0.7±0.01b	6864.8±415.1bc	0.2±0.009
0.75%	13536.7±703.2ab	0.7±0.07	0.7±0.02b	7776.3±1308.6b	0.2±0.01
1%	10047.6±808.1b	0.7±0.1	0.9±0.01c	5165.3±723.6c	0.2±0.02

Table38. The firmness result in substitution of each percentage of xanthan gum of formula C

Sample W:T:MS 40:30:30	Attribute
	Firmness
0%	2.0±0.2ab
0.25%	2.1±0.1a

0.5%	2.2±0.1ab
0.75%	2.5±0.5ab
1%	2.89±0.19b

Table39. The TPA result in substitution of each percentage of xanthan gum of formula D

Sample 0:70:30	Attributes				
	hardness	Springiness ns	Cohesiveness	Chewiness	Resilience ns
0%	14274.5±840.7a	0.9±0.02	0.7±0.005a	10699.1±489.7a	0.2±0.01
0.25%	16628.3±837.3b	0.9±0.01	0.7±0.004b	12273.2±434.3bc	0.2±0.007
0.5%	17057.1±479.3ab	0.8±0.03	0.7±0.01b	11875.2±689.5bc	0.2±0.004
0.75%	10936±2199.4ab	0.9±0.04	0.7±0.01b	7685.0±1860.6b	0.26±0.016
1%	13010.7±918.7b	0.9±0.04	0.7±0.01c	9456.4±840.2c	0.3±0.01

Table40. The firmness result in substitution of each percentage of xanthan gum of formula D

Sample W:T:MS 0:70:30	Attribute
	Firmness
0%	1812.2±286.4ab
0.25%	1091.4±1251.1a
0.5%	1599.2±215.2ab
0.75%	2072.1±461.6ab
1%	1464.8±676.6b

The textures of the addition of oil have higher peak force which is firmer texture than the addition of butter. This also correlate to the sensory result which sample adding oil showed higher liking score over softness and firmness attributes.

The TPA graph, the formula A, which added 50 percent of wheat flour in the starch mix has the highest hardness, cohesive, chewiness texture. For the formula F, which added about 55% of tapioca starch in the starch, gave less in non- dairy pancake texture. Formula C&D are 0% wheat flour which is non-dairy gluten-free pancake that mean no wheat flour added and it make the texture of hardness are very low when compare to other formula. So wheat flour raises all the texture parameter of non- dairy pancake. Adding amount of Xanthan gum has high effect on the non-dairy pancake texture a lot. The 0% of xanthan gum makes the non-dairy pancake texture improve a lot when compare with basic pancake formula C and D. Non-dairy gluten-free pancake, at 1% added of xanthan gum made the texture in resilience and cohesiveness parameter not improved but other deteriorate were improved, which mean the high percent of xanthan gum were added, the lower texture of non-dairy pancake are.

For the firmness, oil gives more firmness than the butter due to the structure of the vegetable oil. Formula A, which added 50% of wheat flour in the starch mix give highest firmness to the pancake texture because wheat flour contain high amount of protein that called gluten. Wheat flour also contain amylose is an unbranched chain which is coiled in the shape of helix and amylopectin is branching molecule, which does not form a helial coil so Amylose contributes to the gelling property of starch whereas amylopectin contributes high viscosity. Formula D has no wheat flour in the formula, it gave less firmness in the texture.

For sensory test, there is well correlate between texture analyzer and sensory liking score. The Higher in wheat still gave higher liking over softness and firmness and overall texture. From C – E, the different concentration of modified starch gave no significant different in texture. However, at low amount in wheat flour in sample, higher amount in modified starch gave higher liking score on texture attributes. Formula G as low amount of wheat (25%), substituted wheat with tapioca starch and quite high amount of 20% of modified starch showed liking score same as high amount of wheat at 50%. For the effect of xanthan gum, it is clearly seen that higher amount of xanthan gum gave higher liking score on texture. 1% gave highest liking score for all texture attributes.

For the RVA graph, at the peak viscosity, the Tapioca starch has the highest peak viscosity. The breakdown point, the different between peak viscosity and lowest viscosity. Wheat flour has lowest breakdown which mean wheat flour has high resistance to the temperature. Wheat flour showed much lower viscosity because it is high in amylose content, much slower in gelatinized temp and time. And also low in breakdown by the effect of gluten. It is form and stable shape for final product. At the final viscosity, Modified starch has the highest final viscosity, which means the strong gel for final product. For the first setback, it is the difference between final viscosity setback and lowest viscosity. And wheat flour has the highest setback which mean flour has highest ability to rearrange the amylase and amylopectin than other kind of sample. The second setback, it is the different between final viscosity and the highest viscosity. Wheat flour has high positive value, which means the gel become hard but Tapioca starch has high negative value which mean gel has low ability to form hard gel.

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Appendix I: Just about right and 9-point scaling of pancake

Just about right and 9-point Hedonic Scaling of Pancake

Date: _____

Part A

Instruction: Please rinse your mouth with water before starting. Then evaluate the Just about right test by marking **x** in the channel, which is related to your feeling, and score the hedonic scale by this below following score.

1 = dislike extremely
2 = dislike very much
3 = dislike moderately
4 = dislike slightly
5 = neither like or dislike
6 = like slightly
7 = like moderately
8 = like very much
9 = like extremely

Sample Code : _____

Attribute	Just about right test							Hedonic Scaling Test
	Much too little	Moderately too little	Somewhat too little	Just right	Somewhat too much	Moderately too much	Much too much	
Color (yellow-brown)								
Amount of pore								
Vanilla flavor								
Sweetness								
Saltiness								
Softness								
Firmness								
Overall Texture								
Overall								

Comment:

_____

_____

Part B

Instruction: Please rinse your mouth with water before starting. Please test the sample with honey then score the hedonic scale by this below following score.

1 = dislike extremely
2 = dislike very much
3 = dislike moderately
4 = dislike slightly
5 = neither like or dislike
6 = like slightly
7 = like moderately
8 = like very much
9 = like extremely

Attribute	Hedonic Scaling test
Overall Texture	
Overall	

Comment:

_____

_____

Appendix II: SAS Data Analysis

The basic formulation of non-dairy pancake

Non-dairy Gluten-free Pancakes

The ANOVA Procedure

Class Level Information

Class	Levels	Values
Treatment	1	1
Panel	30	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30

Number of Observations Read	30
Number of Observations Used	30

Non-dairy Gluten-free Pancakes

The ANOVA Procedure

Dependent Variable: Color

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	29	31.36666667	1.08160920	.	.
Error	0	0.00000000	.		
Corrected Total	29	31.36666667			

R-Square	Coeff Var	Root MSE	Color Mean
1.000000	.	.	6.566667

Source	DF	Anova SS	Mean Square	F Value	Pr > F
Treatment	0	0.00000000		.	.
Panel	29	31.36666667	1.08160920	.	.

Non-dairy Gluten-free Pancakes

The ANOVA Procedure

Dependent Variable: AmountofPore

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	29	27.36666667	0.94367816	.	.
Error	0	0.00000000		.	
Corrected Total	29	27.36666667			

R-Square	Coeff Var	Root MSE	AmountofPore Mean
1.000000	.	.	6.766667

Source	DF	Anova SS	Mean Square	F Value	Pr > F
Treatment	0	0.00000000	.	.	.
Panel	29	27.36666667	0.94367816	.	.

Non-dairy Gluten-free Pancakes

The ANOVA Procedure

Dependent Variable: VanillaFlavor

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	29	51.46666667	1.77471264	.	.
Error	0	0.00000000	.		
Corrected Total	29	51.46666667			

R-Square	Coeff Var	Root MSE	VanillaFlavor Mean
1.000000	.	.	3.133333

Source	DF	Anova SS	Mean Square	F Value	Pr > F
Treatment	0	0.00000000	.	.	.
Panel	29	51.46666667	1.77471264	.	.

Non-dairy Gluten-free Pancakes

The ANOVA Procedure

Dependent Variable: Sweetness

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	29	37.86666667	1.30574713	.	.
Error	0	0.00000000	.		
Corrected Total	29	37.86666667			

R-Square	Coeff Var	Root MSE	Sweetness Mean

R-Square	Coeff Var	Root MSE	Sweetness Mean
1.000000	.	.	5.733333

Source	DF	Anova SS	Mean Square	F Value	Pr > F
Treatment	0	0.00000000	.	.	.
Panel	29	37.86666667	1.30574713	.	.

Non-dairy Gluten-free Pancakes

The ANOVA Procedure

Dependent Variable: Saltiness

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	29	40.96666667	1.41264368	.	.
Error	0	0.00000000	.		
Corrected Total	29	40.96666667			

R-Square	Coeff Var	Root MSE	Saltiness Mean
1.000000	.	.	6.033333

Source	DF	Anova SS	Mean Square	F Value	Pr > F
Treatment	0	0.00000000	.	.	.
Panel	29	40.96666667	1.41264368	.	.

Non-dairy Gluten-free Pancakes

The ANOVA Procedure

Dependent Variable: Softness

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	29	7.20000000	0.24827586	.	.
Error	0	0.00000000	.		
Corrected Total	29	7.20000000			

R-Square	Coeff Var	Root MSE	Softness Mean
1.000000	.	.	7.400000

Source	DF	Anova SS	Mean Square	F Value	Pr > F
Treatment	0	0.00000000	.	.	.
Panel	29	7.20000000	0.24827586	.	.

Non-dairy Gluten-free Pancakes

The ANOVA Procedure

Dependent Variable: Firmness

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	29	11.36666667	0.39195402	.	.
Error	0	0.00000000	.		
Corrected Total	29	11.36666667			

R-Square	Coeff Var	Root MSE	Firmness Mean
1.000000	.	.	7.433333

Source	DF	Anova SS	Mean Square	F Value	Pr > F
Treatment	0	0.00000000	.	.	.
Panel	29	11.36666667	0.39195402	.	.

Non-dairy Gluten-free Pancakes

The ANOVA Procedure

Dependent Variable: OverallTexture

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	29	11.86666667	0.40919540	.	.
Error	0	0.00000000	.		
Corrected Total	29	11.86666667			

R-Square	Coeff Var	Root MSE	OverallTexture Mean
1.000000	.	.	7.066667

Source	DF	Anova SS	Mean Square	F Value	Pr > F

Source	DF	Anova SS	Mean Square	F Value	Pr > F
Treatment	0	0.00000000	.	.	.
Panel	29	11.86666667	0.40919540	.	.

Non-dairy Gluten-free Pancakes

The ANOVA Procedure

Dependent Variable: Overall

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	29	20.16666667	0.69540230	.	.
Error	0	0.00000000	.		
Corrected Total	29	20.16666667			

R-Square	Coeff Var	Root MSE	Overall Mean
1.000000	.	.	6.166667

Source	DF	Anova SS	Mean Square	F Value	Pr > F
Treatment	0	0.00000000	.	.	.
Panel	29	20.16666667	0.69540230	.	.

The comparison between vegetable oil and butter addition on flavor and texture of pancake.

Non-dairy Gluten-free Pancakes

The ANOVA Procedure

Class Level Information

Class	Levels	Values
Treatment	1	1
Panel	30	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30

Number of Observations Read 30

Number of Observations Used 30

Non-dairy Gluten-free Pancakes

The ANOVA Procedure

Dependent Variable: Color

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	29	31.36666667	1.08160920	.	.
Error	0	0.00000000	.		
Corrected Total	29	31.36666667			

R-Square	Coeff Var	Root MSE	Color Mean
1.000000	.	.	6.566667

Source	DF	Anova SS	Mean Square	F Value	Pr > F
Treatment	0	0.00000000	.	.	.
Panel	29	31.36666667	1.08160920	.	.

Non-dairy Gluten-free Pancakes

The ANOVA Procedure

Dependent Variable: AmountofPore

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	29	27.36666667	0.94367816	.	.
Error	0	0.00000000	.		
Corrected Total	29	27.36666667			

R-Square	Coeff Var	Root MSE	AmountofPore Mean
1.000000	.	.	6.766667

Source	DF	Anova SS	Mean Square	F Value	Pr > F
Treatment	0	0.00000000	.	.	.
Panel	29	27.36666667	0.94367816	.	.

Non-dairy Gluten-free Pancakes

The ANOVA Procedure

Dependent Variable: VanillaFlavor

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	29	51.46666667	1.77471264	.	.
Error	0	0.00000000	.		
Corrected Total	29	51.46666667			

R-Square	Coeff Var	Root MSE	VanillaFlavor Mean
1.000000	.	.	3.133333

Source	DF	Anova SS	Mean Square	F Value	Pr > F
Treatment	0	0.00000000	.	.	.
Panel	29	51.46666667	1.77471264	.	.

Non-dairy Gluten-free Pancakes

The ANOVA Procedure

Dependent Variable: Sweetness

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	29	37.86666667	1.30574713	.	.
Error	0	0.00000000	.		
Corrected Total	29	37.86666667			

R-Square	Coeff Var	Root MSE	Sweetness Mean
1.000000	.	.	5.733333

Source	DF	Anova SS	Mean Square	F Value	Pr > F
Treatment	0	0.00000000	.	.	.
Panel	29	37.86666667	1.30574713	.	.

Non-dairy Gluten-free Pancakes

The ANOVA Procedure

Dependent Variable: Saltiness

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	29	40.96666667	1.41264368	.	.
Error	0	0.00000000	.		
Corrected Total	29	40.96666667			

R-Square	Coeff Var	Root MSE	Saltiness Mean
1.000000	.	.	6.033333

Source	DF	Anova SS	Mean Square	F Value	Pr > F
Treatment	0	0.00000000	.	.	.
Panel	29	40.96666667	1.41264368	.	.

Non-dairy Gluten-free Pancakes

The ANOVA Procedure

Dependent Variable: Softness

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	29	7.20000000	0.24827586	.	.

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Error	0	0.00000000	.		
Corrected Total	29	7.20000000			

R-Square	Coeff Var	Root MSE	Softness Mean
1.000000	.	.	7.400000

Source	DF	Anova SS	Mean Square	F Value	Pr > F
Treatment	0	0.00000000	.	.	.
Panel	29	7.20000000	0.24827586	.	.

Non-dairy Gluten-free Pancakes

The ANOVA Procedure

Dependent Variable: Firmness

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	29	11.36666667	0.39195402	.	.
Error	0	0.00000000	.		
Corrected Total	29	11.36666667			

R-Square	Coeff Var	Root MSE	Firmness Mean
1.000000	.	.	7.433333

Source	DF	Anova SS	Mean Square	F Value	Pr > F
Treatment	0	0.00000000	.	.	.
Panel	29	11.36666667	0.39195402	.	.

Non-dairy Gluten-free Pancakes

The ANOVA Procedure

Dependent Variable: OverallTexture

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	29	11.86666667	0.40919540	.	.
Error	0	0.00000000	.		
Corrected Total	29	11.86666667			

R-Square	Coeff Var	Root MSE	OverallTexture Mean
1.000000	.	.	7.066667

Source	DF	Anova SS	Mean Square	F Value	Pr > F
Treatment	0	0.00000000		.	.
Panel	29	11.86666667	0.40919540	.	.

Non-dairy Gluten-free Pancakes

The ANOVA Procedure

Dependent Variable: Overall

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	29	20.16666667	0.69540230	.	.
Error	0	0.00000000		.	
Corrected Total	29	20.16666667			

R-Square	Coeff Var	Root MSE	Overall Mean
1.000000	.	.	6.166667

Source	DF	Anova SS	Mean Square	F Value	Pr > F
Treatment	0	0.00000000		.	.
Panel	29	20.16666667	0.69540230	.	.

The study wheat flour substitution using tapioca starch and modified starch for gluten-free and non-dairy pancakes production.

Non-dairy Gluten-free Pancakes

The ANOVA Procedure

Class Level Information

Class	Levels	Values
Treatment	1	1

Class Level Information

Class	Levels	Values
Panel	30	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30

Number of Observations Read 30

Number of Observations Used 30

Non-dairy Gluten-free Pancakes

The ANOVA Procedure

Dependent Variable: Color

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	29	31.36666667	1.08160920	.	.
Error	0	0.00000000	.		
Corrected Total	29	31.36666667			

R-Square	Coeff Var	Root MSE	Color Mean
1.000000	.	.	6.566667

Source	DF	Anova SS	Mean Square	F Value	Pr > F
Treatment	0	0.00000000	.	.	.
Panel	29	31.36666667	1.08160920	.	.

Non-dairy Gluten-free Pancakes

The ANOVA Procedure

Dependent Variable: AmountofPore

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	29	27.36666667	0.94367816	.	.
Error	0	0.00000000	.		
Corrected Total	29	27.36666667			

R-Square	Coeff Var	Root MSE	AmountofPore Mean

R-Square	Coeff Var	Root MSE	AmountofPore Mean
1.000000	.	.	6.766667

Source	DF	Anova SS	Mean Square	F Value	Pr > F
Treatment	0	0.00000000	.	.	.
Panel	29	27.36666667	0.94367816	.	.

Non-dairy Gluten-free Pancakes

The ANOVA Procedure

Dependent Variable: VanillaFlavor

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	29	51.46666667	1.77471264	.	.
Error	0	0.00000000	.		
Corrected Total	29	51.46666667			

R-Square	Coeff Var	Root MSE	VanillaFlavor Mean
1.000000	.	.	3.133333

Source	DF	Anova SS	Mean Square	F Value	Pr > F
Treatment	0	0.00000000	.	.	.
Panel	29	51.46666667	1.77471264	.	.

Non-dairy Gluten-free Pancakes

The ANOVA Procedure

Dependent Variable: Sweetness

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	29	37.86666667	1.30574713	.	.
Error	0	0.00000000	.		
Corrected Total	29	37.86666667			

R-Square	Coeff Var	Root MSE	Sweetness Mean
1.000000	.	.	5.733333

Source	DF	Anova SS	Mean Square	F Value	Pr > F
Treatment	0	0.00000000	.	.	.
Panel	29	37.86666667	1.30574713	.	.

Non-dairy Gluten-free Pancakes

The ANOVA Procedure

Dependent Variable: Saltiness

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	29	40.96666667	1.41264368	.	.
Error	0	0.00000000	.		
Corrected Total	29	40.96666667			

R-Square	Coeff Var	Root MSE	Saltiness Mean
1.000000	.	.	6.033333

Source	DF	Anova SS	Mean Square	F Value	Pr > F
Treatment	0	0.00000000	.	.	.
Panel	29	40.96666667	1.41264368	.	.

Non-dairy Gluten-free Pancakes

The ANOVA Procedure

Dependent Variable: Softness

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	29	7.20000000	0.24827586	.	.
Error	0	0.00000000	.		
Corrected Total	29	7.20000000			

R-Square	Coeff Var	Root MSE	Softness Mean
1.000000	.	.	7.400000

Source	DF	Anova SS	Mean Square	F Value	Pr > F

Source	DF	Anova SS	Mean Square	F Value	Pr > F
Treatment	0	0.00000000	.	.	.
Panel	29	7.20000000	0.24827586	.	.

Non-dairy Gluten-free Pancakes

The ANOVA Procedure

Dependent Variable: Firmness

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	29	11.36666667	0.39195402	.	.
Error	0	0.00000000	.		
Corrected Total	29	11.36666667			

R-Square	Coeff Var	Root MSE	Firmness Mean
1.000000	.	.	7.433333

Source	DF	Anova SS	Mean Square	F Value	Pr > F
Treatment	0	0.00000000	.	.	.
Panel	29	11.36666667	0.39195402	.	.

Non-dairy Gluten-free Pancakes

The ANOVA Procedure

Dependent Variable: OverallTexture

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	29	11.86666667	0.40919540	.	.
Error	0	0.00000000	.		
Corrected Total	29	11.86666667			

R-Square	Coeff Var	Root MSE	OverallTexture Mean
1.000000	.	.	7.066667

Source	DF	Anova SS	Mean Square	F Value	Pr > F
Treatment	0	0.00000000	.	.	.

Source	DF	Anova SS	Mean Square	F Value	Pr > F
Panel	29	11.86666667	0.40919540	.	.

Non-dairy Gluten-free Pancakes

The ANOVA Procedure

Dependent Variable: Overall

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	29	20.16666667	0.69540230	.	.
Error	0	0.00000000	.		
Corrected Total	29	20.16666667			

R-Square	Coeff Var	Root MSE	Overall Mean
1.000000	.	.	6.166667

Source	DF	Anova SS	Mean Square	F Value	Pr > F
Treatment	0	0.00000000	.	.	.
Panel	29	20.16666667	0.69540230	.	.

The study effect of xanthan gum on texture of gluten-free and non-dairy pancakes

Formula C

Non-dairy Gluten-free Pancakes

The ANOVA Procedure

Class Level Information

Class	Levels	Values
Treatment	1	1
Panel	30	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30

Number of Observations Read 30

Number of Observations Used 30

Non-dairy Gluten-free Pancakes

The ANOVA Procedure

Dependent Variable: Color

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	29	31.36666667	1.08160920	.	.
Error	0	0.00000000	.		
Corrected Total	29	31.36666667			

R-Square	Coeff Var	Root MSE	Color Mean
1.000000	.	.	6.566667

Source	DF	Anova SS	Mean Square	F Value	Pr > F
Treatment	0	0.00000000	.	.	.
Panel	29	31.36666667	1.08160920	.	.

Non-dairy Gluten-free Pancakes

The ANOVA Procedure

Dependent Variable: AmountofPore

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	29	27.36666667	0.94367816	.	.
Error	0	0.00000000		.	
Corrected Total	29	27.36666667			

R-Square	Coeff Var	Root MSE	AmountofPore Mean
1.000000	.	.	6.766667

Source	DF	Anova SS	Mean Square	F Value	Pr > F
Treatment	0	0.00000000		.	.
Panel	29	27.36666667	0.94367816	.	.

Non-dairy Gluten-free Pancakes

The ANOVA Procedure

Dependent Variable: VanillaFlavor

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	29	51.46666667	1.77471264	.	.
Error	0	0.00000000		.	
Corrected Total	29	51.46666667			

R-Square	Coeff Var	Root MSE	VanillaFlavor Mean
1.000000	.	.	3.133333

Source	DF	Anova SS	Mean Square	F Value	Pr > F
Treatment	0	0.00000000		.	.
Panel	29	51.46666667	1.77471264	.	.

Non-dairy Gluten-free Pancakes

The ANOVA Procedure

Dependent Variable: Sweetness

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	29	37.86666667	1.30574713	.	.

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Error	0	0.00000000	.		
Corrected Total	29	37.86666667			

R-Square	Coeff Var	Root MSE	Sweetness Mean
1.000000	.	.	5.733333

Source	DF	Anova SS	Mean Square	F Value	Pr > F
Treatment	0	0.00000000	.	.	.
Panel	29	37.86666667	1.30574713	.	.

Non-dairy Gluten-free Pancakes

The ANOVA Procedure

Dependent Variable: Saltiness

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	29	40.96666667	1.41264368	.	.
Error	0	0.00000000	.		
Corrected Total	29	40.96666667			

R-Square	Coeff Var	Root MSE	Saltiness Mean
1.000000	.	.	6.033333

Source	DF	Anova SS	Mean Square	F Value	Pr > F
Treatment	0	0.00000000	.	.	.
Panel	29	40.96666667	1.41264368	.	.

Non-dairy Gluten-free Pancakes

The ANOVA Procedure

Dependent Variable: Softness

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	29	7.20000000	0.24827586	.	.
Error	0	0.00000000	.		

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Corrected Total	29	7.20000000			

R-Square	Coeff Var	Root MSE	Softness Mean
1.000000	.	.	7.400000

Source	DF	Anova SS	Mean Square	F Value	Pr > F
Treatment	0	0.00000000	.	.	.
Panel	29	7.20000000	0.24827586	.	.

Non-dairy Gluten-free Pancakes

The ANOVA Procedure

Dependent Variable: Firmness

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	29	11.36666667	0.39195402	.	.
Error	0	0.00000000	.		
Corrected Total	29	11.36666667			

R-Square	Coeff Var	Root MSE	Firmness Mean
1.000000	.	.	7.433333

Source	DF	Anova SS	Mean Square	F Value	Pr > F
Treatment	0	0.00000000	.	.	.
Panel	29	11.36666667	0.39195402	.	.

Non-dairy Gluten-free Pancakes

The ANOVA Procedure

Dependent Variable: OverallTexture

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	29	11.86666667	0.40919540	.	.
Error	0	0.00000000	.		
Corrected Total	29	11.86666667			

R-Square	Coeff Var	Root MSE	OverallTexture Mean
1.000000	.	.	7.066667

Source	DF	Anova SS	Mean Square	F Value	Pr > F
Treatment	0	0.00000000	.	.	.
Panel	29	11.86666667	0.40919540	.	.

Non-dairy Gluten-free Pancakes

The ANOVA Procedure

Dependent Variable: Overall

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	29	20.16666667	0.69540230	.	.
Error	0	0.00000000	.		
Corrected Total	29	20.16666667			

R-Square	Coeff Var	Root MSE	Overall Mean
1.000000	.	.	6.166667

Source	DF	Anova SS	Mean Square	F Value	Pr > F
Treatment	0	0.00000000	.	.	.
Panel	29	20.16666667	0.69540230	.	.

Formula D

Non-dairy Gluten-free Pancakes

The ANOVA Procedure

Class Level Information

Class	Levels	Values
Treatment	1	1
Panel	30	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30

Number of Observations Read 30

Number of Observations Used 30

Non-dairy Gluten-free Pancakes

The ANOVA Procedure

Dependent Variable: Color

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	29	31.36666667	1.08160920	.	.
Error	0	0.00000000	.		
Corrected Total	29	31.36666667			

R-Square	Coeff Var	Root MSE	Color Mean
1.000000	.	.	6.566667

Source	DF	Anova SS	Mean Square	F Value	Pr > F
Treatment	0	0.00000000	.	.	.
Panel	29	31.36666667	1.08160920	.	.

Non-dairy Gluten-free Pancakes

The ANOVA Procedure

Dependent Variable: AmountofPore

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	29	27.36666667	0.94367816	.	.
Error	0	0.00000000	.		
Corrected Total	29	27.36666667			

R-Square	Coeff Var	Root MSE	AmountofPore Mean
1.000000	.	.	6.766667

Source	DF	Anova SS	Mean Square	F Value	Pr > F
Treatment	0	0.00000000	.	.	.
Panel	29	27.36666667	0.94367816	.	.

Non-dairy Gluten-free Pancakes

The ANOVA Procedure

Dependent Variable: VanillaFlavor

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	29	51.46666667	1.77471264	.	.
Error	0	0.00000000	.		
Corrected Total	29	51.46666667			

R-Square	Coeff Var	Root MSE	VanillaFlavor Mean
1.000000	.	.	3.133333

Source	DF	Anova SS	Mean Square	F Value	Pr > F
Treatment	0	0.00000000	.	.	.
Panel	29	51.46666667	1.77471264	.	.

Non-dairy Gluten-free Pancakes

The ANOVA Procedure

Dependent Variable: Sweetness

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	29	37.86666667	1.30574713	.	.
Error	0	0.00000000	.		
Corrected Total	29	37.86666667			

R-Square	Coeff Var	Root MSE	Sweetness Mean
1.000000	.	.	5.733333

Source	DF	Anova SS	Mean Square	F Value	Pr > F
Treatment	0	0.00000000	.	.	.
Panel	29	37.86666667	1.30574713	.	.

Non-dairy Gluten-free Pancakes

The ANOVA Procedure

Dependent Variable: Saltiness

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	29	40.96666667	1.41264368	.	.
Error	0	0.00000000	.		
Corrected Total	29	40.96666667			

R-Square	Coeff Var	Root MSE	Saltiness Mean
1.000000	.	.	6.033333

Source	DF	Anova SS	Mean Square	F Value	Pr > F
Treatment	0	0.00000000	.	.	.
Panel	29	40.96666667	1.41264368	.	.

Non-dairy Gluten-free Pancakes

The ANOVA Procedure

Dependent Variable: Softness

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	29	7.20000000	0.24827586	.	.
Error	0	0.00000000	.		
Corrected Total	29	7.20000000			

R-Square	Coeff Var	Root MSE	Softness Mean
1.000000	.	.	7.400000

Source	DF	Anova SS	Mean Square	F Value	Pr > F
Treatment	0	0.00000000	.	.	.
Panel	29	7.20000000	0.24827586	.	.

Non-dairy Gluten-free Pancakes

The ANOVA Procedure

Dependent Variable: Firmness

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	29	11.36666667	0.39195402	.	.
Error	0	0.00000000	.		
Corrected Total	29	11.36666667			

R-Square	Coeff Var	Root MSE	Firmness Mean
1.000000	.	.	7.433333

Source	DF	Anova SS	Mean Square	F Value	Pr > F
Treatment	0	0.00000000	.	.	.
Panel	29	11.36666667	0.39195402	.	.

Non-dairy Gluten-free Pancakes

The ANOVA Procedure

Dependent Variable: OverallTexture

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	29	11.86666667	0.40919540	.	.
Error	0	0.00000000	.		
Corrected Total	29	11.86666667			

R-Square	Coeff Var	Root MSE	OverallTexture Mean
1.000000	.	.	7.066667

Source	DF	Anova SS	Mean Square	F Value	Pr > F
Treatment	0	0.00000000	.	.	.
Panel	29	11.86666667	0.40919540	.	.

Non-dairy Gluten-free Pancakes

The ANOVA Procedure

Dependent Variable: Overall

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	29	20.16666667	0.69540230	.	.

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Error	0	0.00000000	.		
Corrected Total	29	20.16666667			

R-Square	Coeff Var	Root MSE	Overall Mean
1.000000	.	.	6.166667

Source	DF	Anova SS	Mean Square	F Value	Pr > F
Treatment	0	0.00000000	.	.	.
Panel	29	20.16666667	0.69540230	.	.

TPA

A-G

Non-dairy Gluten-free Pancakes (AG)

The ANOVA Procedure

Class Level Information

Class	Levels	Values
trt	7	1 2 3 4 5 6 7
rep	3	1 2 3

Number of Observations Read 21

Number of Observations Used 21

Non-dairy Gluten-free Pancakes (AG)

The ANOVA Procedure

Dependent Variable: Hardness

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	8	149813856.1	18726732.0	4.70	0.0084
Error	12	47774402.1	3981200.2		
Corrected Total	20	197588258.2			

R-Square	Coeff Var	Root MSE	Hardness Mean
0.758212	15.14949	1995.295	13170.71

Source	DF	Anova SS	Mean Square	F Value	Pr > F
trt	6	140945177.2	23490862.9	5.90	0.0045
rep	2	8868678.9	4434339.5	1.11	0.3600

Non-dairy Gluten-free Pancakes (AG)

The ANOVA Procedure

Dependent Variable: Springiness

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	8	0.02445110	0.00305639	0.78	0.6315
Error	12	0.04726185	0.00393849		
Corrected Total	20	0.07171295			

R-Square	Coeff Var	Root MSE	Springiness Mean
0.340958	7.850746	0.062757	0.799381

Source	DF	Anova SS	Mean Square	F Value	Pr > F
trt	6	0.01691295	0.00281883	0.72	0.6445
rep	2	0.00753815	0.00376907	0.96	0.4115

Non-dairy Gluten-free Pancakes (AG)

The ANOVA Procedure

Dependent Variable: Cohesiveness

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	8	0.00504152	0.00063019	1.51	0.2517
Error	12	0.00501943	0.00041829		
Corrected Total	20	0.01006095			

R-Square	Coeff Var	Root MSE	Cohesiveness Mean
0.501098	2.666663	0.020452	0.766952

Source	DF	Anova SS	Mean Square	F Value	Pr > F
trt	6	0.00498629	0.00083105	1.99	0.1467
rep	2	0.00005524	0.00002762	0.07	0.9364

Non-dairy Gluten-free Pancakes (AG)

The ANOVA Procedure

Dependent Variable: Gumminess

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	8	104528846.1	13066105.8	5.52	0.0044
Error	12	28405584.0	2367132.0		
Corrected Total	20	132934430.1			

R-Square	Coeff Var	Root MSE	Gumminess Mean
0.786319	15.18803	1538.549	10130.01

Source	DF	Anova SS	Mean Square	F Value	Pr > F
trt	6	99569582.85	16594930.47	7.01	0.0022
rep	2	4959263.22	2479631.61	1.05	0.3808

Non-dairy Gluten-free Pancakes (AG)

The ANOVA Procedure

Dependent Variable: Chewiness

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	8	80572936.8	10071617.1	3.46	0.0262
Error	12	34895615.0	2907967.9		
Corrected Total	20	115468551.8			

R-Square	Coeff Var	Root MSE	Chewiness Mean
0.697791	20.87384	1705.276	8169.445

Source	DF	Anova SS	Mean Square	F Value	Pr > F
trt	6	77667110.07	12944518.35	4.45	0.0134
rep	2	2905826.72	1452913.36	0.50	0.6188

Non-dairy Gluten-free Pancakes (AG)

The ANOVA Procedure

Dependent Variable: Resilience

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	8	0.00714189	0.00089274	10.20	0.0003
Error	12	0.00104992	0.00008749		
Corrected Total	20	0.00819181			

R-Square	Coeff Var	Root MSE	Resilience Mean
0.871833	3.213312	0.009354	0.291095

Source	DF	Anova SS	Mean Square	F Value	Pr > F
trt	6	0.00651314	0.00108552	12.41	0.0002
rep	2	0.00062374	0.00031437	3.59	0.0599

Non-dairy Gluten-free Pancakes (AG)

The ANOVA Procedure

Dependent Variable: Firmness

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	8	1422264.303	177783.038	0.64	0.7285
Error	12	3310579.616	275881.635		
Corrected Total	20	4732843.919			

R-Square	Coeff Var	Root MSE	Firmness Mean
0.300509	51.83262	525.2444	1013.347

Source	DF	Anova SS	Mean Square	F Value	Pr > F
trt	6	1220208.888	203368.148	0.74	0.6299
rep	2	202055.415	101027.707	0.37	0.7009

Verification in Xanthan gum of formula C

Non-dairy Gluten-free Pancakes (C)

The ANOVA Procedure

Class Level Information

Class	Levels	Values

Class Level Information

Class	Levels	Values
trt	5	1 2 3 4 5
rep	3	1 2 3

Number of Observations Read 15

Number of Observations Used 15

Non-dairy Gluten-free Pancakes (C)

The ANOVA Procedure

Dependent Variable: Hardness

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	6	54563078.71	9093846.45	2.92	0.0818
Error	8	24927008.21	3115876.03		
Corrected Total	14	79490086.93			

R-Square	Coeff Var	Root MSE	Hardness Mean
0.686414	14.40112	1765.184	12257.27

Source	DF	Anova SS	Mean Square	F Value	Pr > F
trt	4	54292751.60	13573187.90	4.36	0.0367
rep	2	270327.12	135163.56	0.04	0.9578

Non-dairy Gluten-free Pancakes (C)

The ANOVA Procedure

Dependent Variable: Springiness

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	6	0.16275907	0.02712651	0.97	0.4987
Error	8	0.22289853	0.02786232		
Corrected Total	14	0.38565760			

R-Square	Coeff Var	Root MSE	Springiness Mean
0.422030	21.27455	0.166920	0.784600

Source	DF	Anova SS	Mean Square	F Value	Pr > F
trt	4	0.11740227	0.02935057	1.05	0.4381
rep	2	0.04535680	0.02267840	0.81	0.4767

Non-dairy Gluten-free Pancakes (C)

The ANOVA Procedure

Dependent Variable: Cohesiveness

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	6	0.01843187	0.00307198	12.21	0.0012
Error	8	0.00201307	0.00025163		
Corrected Total	14	0.02044493			

R-Square	Coeff Var	Root MSE	Cohesiveness Mean
0.901537	2.178778	0.015863	0.728067

Source	DF	Anova SS	Mean Square	F Value	Pr > F
trt	4	0.01790493	0.00447623	17.79	0.0005
rep	2	0.00052693	0.00026347	1.05	0.3945

Non-dairy Gluten-free Pancakes (C)

The ANOVA Procedure

Dependent Variable: Gumminess

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	6	59377572.83	9896262.14	12.62	0.0011
Error	8	6274318.81	784289.85		
Corrected Total	14	65651891.64			

R-Square	Coeff Var	Root MSE	Gumminess Mean
0.904430	10.12181	885.6014	8749.436

Source	DF	Anova SS	Mean Square	F Value	Pr > F
trt	4	56588736.65	14147184.16	18.04	0.0005
rep	2	2788836.18	1394418.09	1.78	0.2297

Non-dairy Gluten-free Pancakes (C)

The ANOVA Procedure

Dependent Variable: Chewiness

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	6	47406828.21	7901138.03	4.80	0.0229
Error	8	13159656.51	1644957.06		
Corrected Total	14	60566484.72			

R-Square	Coeff Var	Root MSE	Chewiness Mean
0.782724	17.33833	1282.559	7397.246

Source	DF	Anova SS	Mean Square	F Value	Pr > F
trt	4	46855391.30	11713847.83	7.12	0.0095
rep	2	551436.91	275718.45	0.17	0.8486

Non-dairy Gluten-free Pancakes (C)

The ANOVA Procedure

Dependent Variable: Resilience

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	6	0.00049120	0.00008187	0.30	0.9217
Error	8	0.00220373	0.00027547		
Corrected Total	14	0.00269493			

R-Square	Coeff Var	Root MSE	Resilience Mean
0.182268	6.014927	0.016597	0.275933

Source	DF	Anova SS	Mean Square	F Value	Pr > F
trt	4	0.00047627	0.00011907	0.43	0.7822
rep	2	0.00001493	0.00000747	0.03	0.9733

Non-dairy Gluten-free Pancakes (C)

The ANOVA Procedure

Dependent Variable: Firmness

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	6	535905.024	89317.504	1.53	0.2830
Error	8	468375.325	58546.916		
Corrected Total	14	1004280.349			

R-Square	Coeff Var	Root MSE	Firmness Mean
0.533621	33.21461	241.9647	728.4887

Source	DF	Anova SS	Mean Square	F Value	Pr > F
trt	4	525119.4280	131279.8570	2.24	0.1538
rep	2	10785.5963	5392.7981	0.09	0.9130

Verification in Xanthan gum of formula D

Non-dairy Gluten-free Pancakes (D)

The ANOVA Procedure

Class Level Information

Class	Levels	Values
trt	5	1 2 3 4 5
rep	3	1 2 3

Number of Observations Read 15

Number of Observations Used 15

Non-dairy Gluten-free Pancakes (D)

The ANOVA Procedure

Dependent Variable: Hardness

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	6	83662349.04	13943724.84	12.54	0.0011
Error	8	8892185.01	1111523.13		
Corrected Total	14	92554534.05			

R-Square	Coeff Var	Root MSE	Hardness Mean

R-Square	Coeff Var	Root MSE	Hardness Mean
0.903925	7.330872	1054.288	14381.48

Source	DF	Anova SS	Mean Square	F Value	Pr > F
trt	4	77916018.51	19479004.63	17.52	0.0005
rep	2	5746330.53	2873165.27	2.58	0.1362

Non-dairy Gluten-free Pancakes (D)

The ANOVA Procedure

Dependent Variable: Springiness

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	6	0.01292987	0.00215498	2.13	0.1585
Error	8	0.00807773	0.00100972		
Corrected Total	14	0.02100760			

R-Square	Coeff Var	Root MSE	Springiness Mean
0.615485	3.407984	0.031776	0.932400

Source	DF	Anova SS	Mean Square	F Value	Pr > F
trt	4	0.01049827	0.00262457	2.60	0.1166
rep	2	0.00243160	0.00121580	1.20	0.3490

Non-dairy Gluten-free Pancakes (D)

The ANOVA Procedure

Dependent Variable: Cohesiveness

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	6	0.00070720	0.00011787	2.91	0.0826
Error	8	0.00032453	0.00004057		
Corrected Total	14	0.00103173			

R-Square	Coeff Var	Root MSE	Cohesiveness Mean
0.685448	0.822752	0.006369	0.774133

Source	DF	Anova SS	Mean Square	F Value	Pr > F

Source	DF	Anova SS	Mean Square	F Value	Pr > F
trt	4	0.00063907	0.00015977	3.94	0.0470
rep	2	0.00006813	0.00003407	0.84	0.4666

Non-dairy Gluten-free Pancakes (D)

The ANOVA Procedure

Dependent Variable: Gumminess

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	6	50165037.18	8360839.53	11.84	0.0013
Error	8	5647181.72	705897.71		
Corrected Total	14	55812218.89			

R-Square	Coeff Var	Root MSE	Gumminess Mean
0.898818	7.543426	840.1772	11137.87

Source	DF	Anova SS	Mean Square	F Value	Pr > F
trt	4	47105314.00	11776328.50	16.68	0.0006
rep	2	3059723.18	1529861.59	2.17	0.1770

Non-dairy Gluten-free Pancakes (D)

The ANOVA Procedure

Dependent Variable: Chewiness

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	6	44639975.44	7439995.91	7.82	0.0053
Error	8	7612143.89	951517.99		
Corrected Total	14	52252119.33			

R-Square	Coeff Var	Root MSE	Chewiness Mean
0.854319	9.381376	975.4578	10397.81

Source	DF	Anova SS	Mean Square	F Value	Pr > F
trt	4	42107687.52	10526921.88	11.06	0.0024
rep	2	2532287.92	1266143.96	1.33	0.3170

Non-dairy Gluten-free Pancakes (D)

The ANOVA Procedure

Dependent Variable: Resilience

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	6	0.03909213	0.00651536	48.64	<.0001
Error	8	0.00107160	0.00013395		
Corrected Total	14	0.04016373			

R-Square	Coeff Var	Root MSE	Resilience Mean
0.973319	4.505714	0.011574	0.256867

Source	DF	Anova SS	Mean Square	F Value	Pr > F
trt	4	0.03889440	0.00972360	72.59	<.0001
rep	2	0.00019773	0.00009887	0.74	0.5080

Non-dairy Gluten-free Pancakes (D)

The ANOVA Procedure

Dependent Variable: Firmness

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	6	3381682.918	563613.820	1.01	0.4809
Error	8	4470416.799	558802.100		
Corrected Total	14	7852099.718			

R-Square	Coeff Var	Root MSE	Firmness Mean
0.430672	48.57757	747.5307	1538.839

Source	DF	Anova SS	Mean Square	F Value	Pr > F
trt	4	2991561.925	747890.481	1.34	0.3354
rep	2	390120.994	195060.497	0.35	0.7156