PRODUCT DEVELOPMENT OF FRUIT-CIDER JELLIES

BY
MR. SAMNANG HAY
564-8005

A Special Project in Partial Fulfillment of the Requirement for the Degree
of Bachelor of Science in Biotechnology
Assumption University

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Samnang Hay

Abstract

Gummy jelly is a confectionery gel that contains high sugar components of sucrose and gelatin. Gelatin is often used as a gelling component. Food acid, flavoring and coloring agents also play an important role as flavor components . Fruit vinegar is a condiment produced from various sugary and starchy materials through a double fermentation (i.e., alcoholic and subsequent acetic fermentation). The goal of this project was aimed to develop two new products: fruit-cider – infused jellies by introducing coconut vinegar and lychee vinegar as an acidity component to replace fruit juices. In addition, instead of sugar, honey was used as a sweetener. Initially, after developing a suitable formula, the jelly products were tested using a 9-point hedonic liking scale questionnaire to compare the impacts of gelatin powder and gelatin sheets based on the liking score of various attributes (i.e., color, aroma, chewiness, sweetness, tartness, overall consistency, and overall liking). Results showed no significant difference in liking scores of any attributes ($P>0.05$). Different types of gelatin do have an impact on the final products' appearance due to the fact that the gelatin powder was pretreated with acid, giving it a more yellow color. Appropriateness level of each attribute was also surveyed using Just-About-Right paired samples t-test to analyze. Results showed that all products required no formula adjustment – having above 70% respondents who picked just right. On top of that, all net penalty scores fell below 0.5 and less than 20% non-JAR respondent, which further indicates that the extent to which the problem affects the liking score is not particularly large enough to the need of adjustment of any kinds. Findings from consumer's test analysis targeted demographically at students showed that overall liking score of each product similarly averaged roughly at 7.5, with the product acceptance at approximately 80%, and just a little below – at about 75% on purchase intent percentage. The developed jellies were accepted by approximately 80 percent of the 100 panelists with both products averaged at approximately 7.5 out of 9 in liking score. Sensory study's findings showed that there were significant sensory profile attribute differences comparing among coconut, lychee flavored jellies, and Yoyo's strawberry jelly ($P<0.05$).

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Introduction

Coconut (*Cocos nucifera*) is the only species of the genus *Cocos* among the members of the family *Arecaceae* (Anonymous, 1899). It provides a nutritious source of meat (flesh) juice, milk, and oil that have been feeding and nourishing the world for generations. Thailand is one of the leading coconut growers in the world. For that reason, a lot of products were created from coconut as a result. Its benefits, however, do not stop at being an important food produce, such produce can also be used for other purposes ranging from cosmetic to pharmaceutical. Among other notable Thai produce, the pervasiveness of this staple produce is undoubtedly an indicator that it plays an integral role in the nation's economy.

Lychee or Litchi (*L. chinensis*) is the only member of the genus litchi in the soapberry family, *Sapindacae* (Koul, 2017). Lychee is a tropical tree originating from the Guangdong and Fujian provinces of China. Apart from China, lychee trees are also found in India, South Africa, and other countries of Southeast Asia. The bright color and delicious taste are each important factors of lychee that make it popular among Asian populations. The fleshy fruit of lychee is often enjoyed fresh. Because of its ample supply, lychee is easily accessible in Thailand. Like coconut, lychee's sweet flavor and flesh is often found incorporated in many different Thai dessert dishes and confectionary products.

One of the notable products made from coconut is coconut vinegar. Similar to other fruit vinegars, from which the fermentation is done with the fruit, coconut vinegar is made from coconut water. Being a staple condiment in Southeast Asia and some regions of India, coconut vinegar is a natural source of probiotics, low on the glycemic index, and contains all nine essential amino acids (Padechia, 1970). Similar to coconut vinegar, lychee vinegar is also a fruit vinegar. This particular type of vinegar is a result of a double-fermentation process using lychee fruit pulp as a carbohydrate source. However, being new to the industry, lychee vinegar is not often found on the shelves of supermarkets.

Gummy jellies are a broad category of gelatin-based confectioneries. They are a fun and popular confectionary product that appeal to children and adults alike owing to their chewable texture, wide range of flavors, and broad selection of sizes and shapes from adorable animals to favorite cartoon characters (Jacqueline, 2014). Gelatin is one of the main ingredients responsible for the chewy texture of gummy jellies. In addition, gummy jellies use sugar as sweetener and fruit juice as an acidic component, therefore this can be replaced by fruit vinegar. Common confectionary products are jelly snakes, jelly beans, gummy bears, and so on.

Confectionary gel products constitute a large portion of the confectionary market, however, there are still continual demands for more exciting textures, flavors, and appearances (Jacqueline, 2014). Developing new flavors to the product can help satisfy these demands. Fruit-cider vinegar are often used to make gummy jellies. However, one major problem that such product faced was that vinegar tends to give a very strong tangy and acidic aroma that was off-putting to consumers.

Therefore, this project was aimed to develop a new desirable product: fruit-cider infused jellies by using coco-cider and lychee-cider. In addition, the consumer acceptance and some properties of the products were also investigated.

Objectives

1. To formulate coco-cider jelly and lychee-cider jelly.
2. To determine some properties of the products.
3. To study consumer acceptance of the products.

Literature Review

1. Vinegar

Vinegar is a condiment produced from various sugary and starchy materials through a double fermentation (i.e., alcoholic and subsequent acetic fermentation). A wide range of raw materials can be used to produce vinegar. As substrates, fruit juices, sap, musts, malted barley, rice, and wine have been used in the fermentation process. (Orthaman et al., 2014) Natural vinegar is superior as a food additive than synthetic vinegar due to its amino acid content from its fruit source that is reported to be medicinally beneficial for various illnesses. Acetic acid in vinegar are beneficial to the gastrointestinal tract and liver by altering their metabolic processes. Vinegar also helps in controlling blood sugar levels and lowering the risk of heart disease (Jonston et al., 2006). There are various types of vinegar varying by the process and raw material.

1.1 Cider Vinegar

Cider vinegar is usually made from apples. This variation is the most popular vinegar used for cooking in the United States. It contains at least 1.6 grams of apple solids per 100 ml of which more than 50% are reducing sugars, and at least 4 grams of acetic acid per 100 ml at 20°C (Suman et al., 2014).

1.2 Distilled Vinegar

Distilled Vinegar is a harsh type of vinegar that is made grains and is usually colorless. Its flavor is extremely strong and not desirable for most cooking uses, but it is good for pickling and cleaning areas (Suman et al., 2014).

1.3 Fruit vinegar

Fruit Vinegar is a kind of fruit beverage that is a result of acetic fermentation using bacteria. The fermentation retains abundant nutrient components such as vitamin, mineral, and amino acid. It is widely acknowledged in the academic area that, in addition to its physiological and health care functions, fruit vinegar is superior to conventional grain vinegar. (Ahmad et al., 2015)

1.3.1 Coconut Vinegar

Coconut vinegar is low in acidity, with a musty flavor and unique aftertaste. It is used in many Thai dishes (Suman et al., 2014). Compared to two conventional substrates for vinegar production such as coconut sap and pineapple, coconut water has been used to test as an alternative substrate for the vinegar production. As substrates to the production of coconut vinegar, both the coconut water and sap are found to possess a high amount of total soluble solids which corresponds to a higher sugar content more than 14-degree Brix. For this reason, both substrates could be used to produce the vinegar without the requirement of other carbon-sources. Two steps of fermentation are required in the production of coconut vinegar. The first step of the two is alcohol fermentation. Coconut water, which has a lower Brix value, needs to be adjusted to 14-degree Brix by addition of sucrose prior to the first of the two-step fermentation process. The first step of fermentation with *Saccharomyces cerevisiae* have yielded 7-8% in alcohol percentage within one week to ten days. In addition, in the second fermentation, acetic fermentation is done with *Acetobactor aceti* using the alcoholic medium obtained from the first fermentation as seed broth. This particular fermentation takes approximately two months to obtain at least 4% acetic acid (Orthaman et al., 2014).

1.3.2 Lychee Vinegar

Lychee is an evergreen sub-tropical fruit that belongs in the family *Sapindaceae*. It has been planted widely in countries of Southeast Asia. Thailand, amongst other countries in southeast Asia, is the main producer of lychee. The vibrant color that makes lychee stand out and the delicious taste makes the staple fruit vastly accepted by consumers all over the world. As a result, it has established great popularity in the international market. Lychee is rich in nutrients and has very high value on food and medical care (Sui, 2015). Apart from its nutritive value, lychee has a pleasant rose flavor, making its juice a delicacy. The fruit provides carbohydrates, organic acids (i.e. lactic, acetic, succinic, citric, ascorbic, and phosphoric) and aroma compounds (β-damascenone, linalool, furaneol, ethyl hexanoate, geraniol, etc.) (Su, 2014). To further enhance the efficiency of the lychee industry, lychee fruit flesh is used as a carbon source in the preliminary step of the double fermentation process in the production of vinegar (Duenas et al., 2015). Various products can be made from fruit vinegar. Gummy jelly is one of the notable products that can be made from fruit-cider vinegar.

2. Gummy jelly

Gummy jelly is a confectionery gel that contains high sugar components of sucrose and gelatin, which is used as a gelling component. Furthermore, food acid, flavoring and coloring play an important role as a flavor component in the product. Common confectionary gel products include "jelly snakes", "jelly babies", "jelly beans", and gummy bears, and form a big portion on the confectionary market; though, there are continual consumer demands for more variety of interesting textures, flavors, and appearances. To meet these constant recurring demands, new products are innovated. Companies that are able to actively manipulate and control sensory properties to meet the such customer demands will take a competitive advantage (P. Burey, 2010).

3. Gelatin as gelling agent

There are several ways to define a gel. According to Hermans (1949), a gel must be a coherent two component system formed by a solid substance finely dispersed, or dissolved in, a liquid phase that also exhibits solid-like behavior under mechanical forces. One other way to define it is that all gels are solid, as they are self-supporting and can recover their elasticity after a deformation, though, some may deform in a brittle manner such as in agar or kappa-carrageenan gels (Stainsby, 1971). According to National Formulary, the definition of gelatin is best described as a product obtained by the partial hydrolysis of collagen derived from the skin, white connective tissue and bones of animals. Gelatin derived from acid-treated pre-curser is known as Type A and gelatin derived from alkali-treated process or also known as Type B. According to Food Chemicals Codex, gelatin is defined as the product resulting from the acid, alkaline, or enzymatic collagen hydrolysis, the chief protein component of the skin, bones, and connective tissue of animals, including fish and poultry (Bogue et al., 1922). Gelatin is a translucent, colorless, brittle (when dry), flavorless, solid substance. Gelatin is commonly used as gelling agents in the food and pharmaceutical areas. It retains informational signals, including an arginine–glycine–aspartic acid (RGD) sequence, which promotes cell adhesion, proliferation, and stem cell differentiation (Kanka, 1989). Gelling agents also function as stabilizers and thickeners to provide thickening without stiffness through the formation of gel in jellies, jams, desserts, yogurts and candies. Gums, starches, pectin, agar-agar and gelatin are common gelling agents (Kathleen, 2017). Gels can be found in many material systems involving varied media such as polymers, pant, animal tissues, and food. The majority of foods contains gels. (Yuyev et al., 1995) The varied tastes based on cultural difference can dictate which gelling ingredients are more desirable in a particular region.

4. Honey as Sweetener

Honey is a valued natural product that has been appreciated since it was introduced to humankind since the ancient times. Honey is used as a nutritional product and also health described in traditional medicine as an alternative treatment for clinical conditions ranging from wound healing to cancer treatment. According to modern scientific literature, many types of antioxidants are presented in honey and they are found to be useful and has protective effects for treatment of various diseases ranging from respriratory, gastrointestinal, to many more. Honey could be considered as a natural theurapeutic agent for various medicinal purposes. Sufficient evidence that are present reccomends the use of honey in the management of disease conditions. The use of honey in clinical wards is highly reccomended (Samarghandian et al., 2017).

As a natural sweetener, honey contains calories and nutrients. It can be metabolized and change as it passes through the body. Honey is made by honey bees from the nectar of flowers. It is sweeter and higher in calories compared to white sugar. In addition, it contains some enzyme and minerals. It is recommended to use about ¾ cups of honey to substitute 1 cup of white sugar in recipes and the amount of liquid is reduced by about three to four tablespoons (Jacqueline, 2013).

Materials and Methods

1. Formulation of coco-cider jelly and lychee-cider jelly

1.1 Sample preparation

The original formula was taken from ricenflour.com, an article named "How to Make Gumdrops (Gummy Candy Recipe with Video) written in 2016 by Xuan Tran. To produce coco-cider jelly and lychee-cider jelly, the original formula is modified by using honey as sweetener and fruit-cider vinegar as acid component replacing fruit juice. The modified formula is presented in (Table 1).

Table 1: Formula for coco-cider jelly and lychee-cider jelly

Ingredients	Coco-cider jelly (%)	Lychee-cider jelly (%)
Water	52.87	53.15
Gelatin	8.81	8.86
Honey	35.25	35.43
5% Coconut/Lychee Vinegar	1.83	1.84
Malic Acid	0.18	0.18
Flavor	0.70	0.35
Color	0.35	0.18

Coco-cider jelly and lychee-cider jelly were produced by using the formula in Table 1. Two types of gelatin as gelatin sheet (GELATIN, USA) and gelatin powder (McGarrett, country) were used as gelling agents. For gelatin sheet, 25 g of gelatin sheets was soaked in 70 g of cold water for 10 minutes. This step is important to avoid clumpy consistency by hydrating its dried protein network so that it can easily dissolve at a later step. Next, 80 g of water was poured into a pot and 100 g of honey was added. Subsequently, the mixture was brought to a boil on medium high heat and the heat was turned down to let simmer. The heat level in this step is crucial because color will change

if the heat is too high due to Maillard reaction. Immediately, the soaked gelatin that was done at an earlier step was added into the pot and stirred well until it was completely dissolved. After the mixture was completely dissolved, the heat was turned off and 0.52 grams of malic acid was added following by 5.2 ml of coco-cider vinegar, 2 grams of coconut extract flavor (McCormick, USA) and 1 g blue food coloring (Phurin&Phurich, Thailand) and stirred well. The bubbles on top of the mixture was removed using a spoon and the mixture was filtered using a sieve and poured into a metal jar. The filtering step is necessary to get rid of all the clumps left behind if there is any. After that, the mixture was poured into a silicone mold and let set in the fridge for at least 4 hours. Lastly, the jelly was removed from the mold and dusted with maize flour and sieved to get rid of the excess. The jellies were then stored in a cool and dry place.

For lychee-cider jelly, the same method was used but food coloring and flavoring additive were reduced to 1 and 0.5 grams, respectively.

2. Determination of some properties of coco-cider and lychee-cider jellies

2.1 Physical properties

2.1.1 Color

The color of fruit-cider jellies produced by using different types of gelatin were measured using HunterLab MinScan EZ A60-1014-085 Firmware version 2.18 from Hunter Associates Laboratory. CIE L* a* b* system, D65/10 standard light source (outdoor daylight), 45°/0° angle of illumination/observer. The measurements were at the top and bottom parts of the sample. All measurements were done in five replications. Each individual sample was measured 3 times at the top and at the bottom. Comparison between treatments (gelatin powder and gelatin sheets) was done using RCBD with paired t-test comparison on SAS.

2.1.2 *Fundamental test and texture profile analysis (TPA)*

Textural analysis was done using TA. XT plus 50kg Texture Analyzer from Stable Micro Systems. The texture profiles were measured using TPA method. SMSP/100 base and probe were used to measure the jelly samples. First, the probe height was calibrated with the return distance at 20 mm, return speed 10 mm/sec and, contact force at 10 g. Following by, in the sequence menu, the settings were set using pre-test speed at 1.00 mm/sec, test speed at 5.00 mm/sec, post-test speed at 5.00 mm/sec, target mode at strain, strain at 85%, time at 5.00 sec, trigger type at auto (force), trigger force at 5.0 g and, tare mode at auto. All the measurements were performed with five replications. Comparison between treatments is done using RCBD with paired t-test comparison on SAS.

2.2 Chemical properties

2.2.1 Total acidity (Tomovska, 2016)

NaOH solution with a normality of 0.1N was prepared and standardized by titration using a prepared KHP solution. The actual normality of NaOH was then calculated using the recorded amount of NaOH used in the standardization procedure. The prepared solution was to be used in the actual total acidity analysis in the next step. Following by, 10 g of sample was melted in a microwave. The melted sample was then mixed with 10 ml of distilled water. Next, the mixture was transferred to a 250 ml Erlenmeyer flask. Next, two to three drops of indicator (phenolphthalein) was added to the mixture. Afterwards, the mixture was titrated with a prepared and standardized 0.1N NaOH solution. This was done by slowly introducing the NaOH solution (alkaline) to the sample (acidic). Endpoint was obtained when the solution turned slightly pink and remained constant. Next, the volume of NaOH used was recorded by the reading on the burette. All samples were titrated in triplicate. Finally, the percentage acidity was determined using the percentage acidity equation. The predominant acid of the jelly samples is malic Acid with an equivalent weight of 67.05. The following equation was used to calculate the percentage acidity.

$$\% \text{ acidity} = \frac{Volume\ of\ Titrate * N\ of\ Titrate * Eq\ Weight\ of\ Malic\ Acid * 100}{Volume\ of\ Sample * 1000}$$

Comparison of percentage acidity was done using paired t-test comparison on SAS.

2.2.2 Determination of reducing sugar by DNS method (Miller, 1959)

The amount of reducing sugar was determined using standard reducing sugar curve as reference. The standard reducing sugar curve was constructed using calibration standards. To begin, the calibration standards were prepared using DNS reagent and stock solution. The DNS reagent was prepared using sodium hydroxide, sodium potassium tartrate, DNS acid, Phenol crystals, and sodium sulphite. Subsequently, the stock solution was prepared using glucose and distilled water. This would make a 0.1g/ml concentration. Following by, a working solution was prepared by diluting the stock solution by 1:9-stock solution to distilled water ratio. Next, six standard dilutions were made using 0:5, 1:4, 2:3, 3:2, 4:1, and 5:0 working standard to distilled water ratio. Next, 3ml of each dilution was added into 3ml of DNS reagent in their own tube in triplicate. All tubes were put into a water bath at 100°C for 10 min until the color turns brown. following, one milliliter of prepared 40% potassium sodium tartrate was added into each tube to stabilize the color change. All test-tubes were cooled down immediately after. The calibration standards were transferred into different cuvettes and they were read in a spectrophotometer at 575 nm absorbance. Meanwhile, supernatants of each sample were prepared using 3 ml of melted sample and 3ml distilled water to create internal standards. This was done to dilute the samples in order for the machine to be able to read each one more precisely. The internal standards that were used to run were prepared the same way by using 3ml of DNS reagent and 3 ml of supernatant (1:1 diluted sample from the earlier step). They were then treated the same way as the calibration curve standards and run at the same absorbance. The calculation was done by first constructing a calibration curve to find the response factor. The response factor was calculated from the equation generated by the calibration curve. The concentration was then determined using slope and intercept from the equation

and absorbance from the reading. The equation formula that was used to calculate the concentration is shown in the following.

$$\text{Concentration (x)} = \frac{Absorbance - Slope}{Intercept} * Dilution\ Factor$$

Where: y (absorbance) = b (intercept) * x (concentration) + a (slope)

Comparison of reducing sugar concentration between treatments was done using RCBD with paired t-test comparison on SAS.

3. Sensory evaluation

Coco-cider and lychee-cider jellies produced by using gelatin sheet and gelatin powder were sensory analyzed by using 9-point hedonic scale preference test. Thirty panelists were selected to complete this questionnaire. Each panelist was asked to rate attributes of each sample from 1 to 9 (1 being dislike extremely to 9 being like extremely based on their liking). Attributes include color, aroma, chewiness, sweetness, sourness, overall consistency (mouthfeel), and overall liking. The data obtained from the questionnaire was analyzed with SAS program using random complete block design (RCBD) with t-test comparison.

3.1 Just-about-right test

Coco-cider and lychee-cider jellies were sensory evaluated by using Just About Right (JAR) test. questionnaire was developed. Coco-cider and lychee-cider jellies produced by using gelatin powder were used as the test samples. Thirty panelists were selected to complete this questionnaire. They were asked to give a liking score on various attributes and answer Just About Right questions. These attributes were color, aroma, chewiness, sweetness, sourness, and overall liking.

4. Consumer test

A consumer test type questionnaire was designed. This set of questionnaires was done on 100 panelists. The questionnaire was ivided into three parts; consumer's behavior, general information, and attitude towards the product. The data obtained from the questionnaire was later analyzed and interpreted into bar and pie charts accordingly based on percentage and mean liking scores.

5. Sensory profile determination

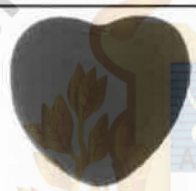
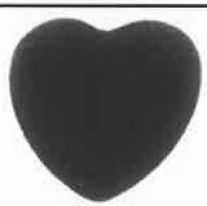
Sensory profile analysis was done by asking 100 panelists to give an intensity score to each attribute. Each panelist was asked to give an intensity scale from 0 to 15 in 0.5 intervals. Attributes asked were appearance, texture, flavor, and taste. All raw data obtained from the questionnaire was analyzed using RCBD with LSD comparison on SAS program. The result obtained compares the difference between the intensity scale of fruit-cider – jellies to a commercial jelly product that is available on the market. Yoyo's strawberry flavored gummy jelly was used to compare as a commercial product.

Results and Discussion

1. Effect of gelatin type on some properties of fruit-cider jelly

There were two types of gelatin used to produce fruit-cider jellies as coco-cider and lychee-cider. These were gelatin sheet and gelatin powder. It was recognized that different types of gelatin provided the effect on color of the product in both coco-cider and lychee-cider (Table 2).

Table 2: Effect of gelatin types on the characteristics of fruit-cider jellies

Gelatin type	Appearance	Details
Gelatin powder (Coconut)		• Green final product
Gelatin sheets (Coconut)		• Blue final product
Gelatin powder (Lychee)		• Pink final product
Gelatin sheets (Lychee)		• Pink final product

When it comes to coco-cider jelly, gelatin powder provided a green final product while gelatin sheets produced blue product. There are 2 types of gelatin used in the food industry as Type A (Acid treated) and Type B (Alkaline treated). Gelatin powder is the kind of gelatin that has been dried and broken up to smaller individual particles, which is advantageous due to its easier dispersibility compared to that of gelatin sheets. Whereas, gelatin sheets are made from gelatin that is dried in a flat sheet. Therefore, final products that are made from gelatin sheets are clearer and more transparent than powder (Christensen, 2009). The brand of the gelatin powder used is McCormick, this particular gelatin type is acid treated making it type A with pH at approximately 5 (Cole, 2000). After wetting with cold water, gelatin powder gave a more yellow and turbid appearance in comparison to gelatin sheets which gave a more transparent and less yellow appearance. To emphasize, the more yellow appearance belonging to gelatin powder is responsible for the color change in the final product color because the blue coloring turned green when mixed with yellow. On the other hand, there was no visible color change when sheet gelatin was used, which correlates with the theory. The effect on color was also perceived in lychee-flavored jellies. Because of the pink color used on the lychee-flavored jelly, the gelatin powder interacted with this particular coloring giving it a darker shade of pink while gelatin sheets gave a more subtle and bright pink.

2. Properties of fruit-cider jellies

2.1 Physical properties

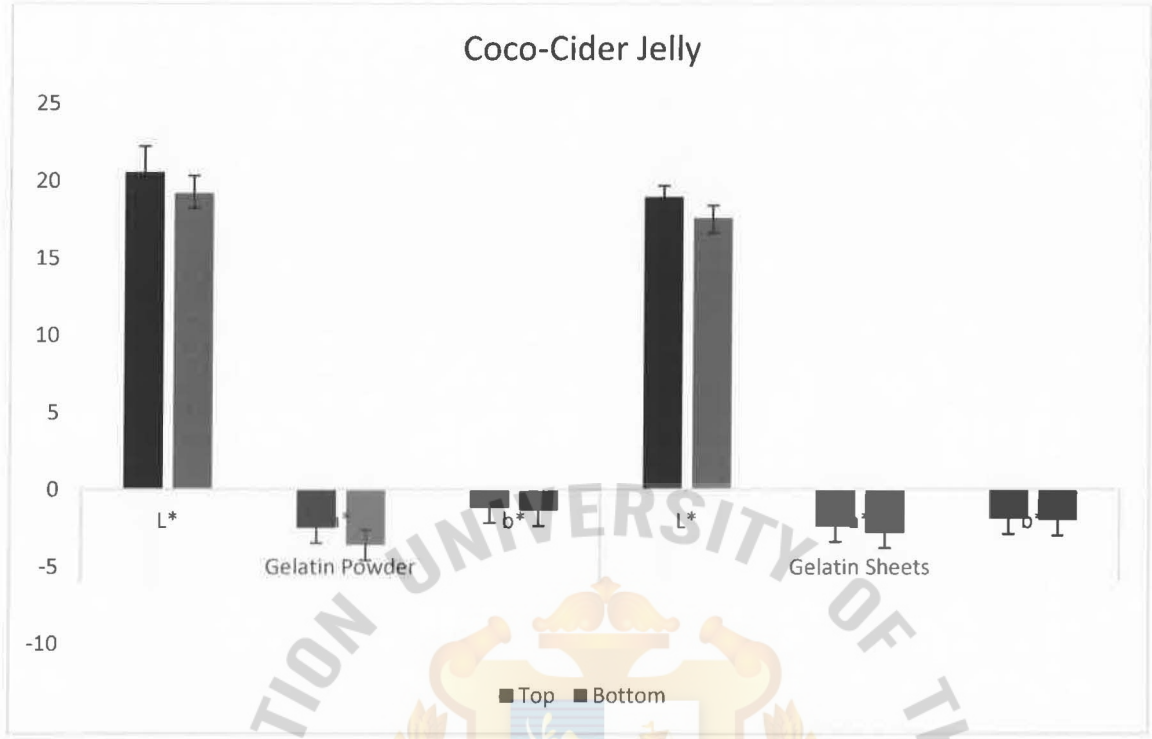
2.1.1 Color

Color measurements were done using three measurements at top and three measurements at bottom. Five samples of each treatment were used. The results of color measurements for each jelly sample are demonstrated in (Table 3). The measurement was done on top and bottom because there is a difference when measured from either direction.

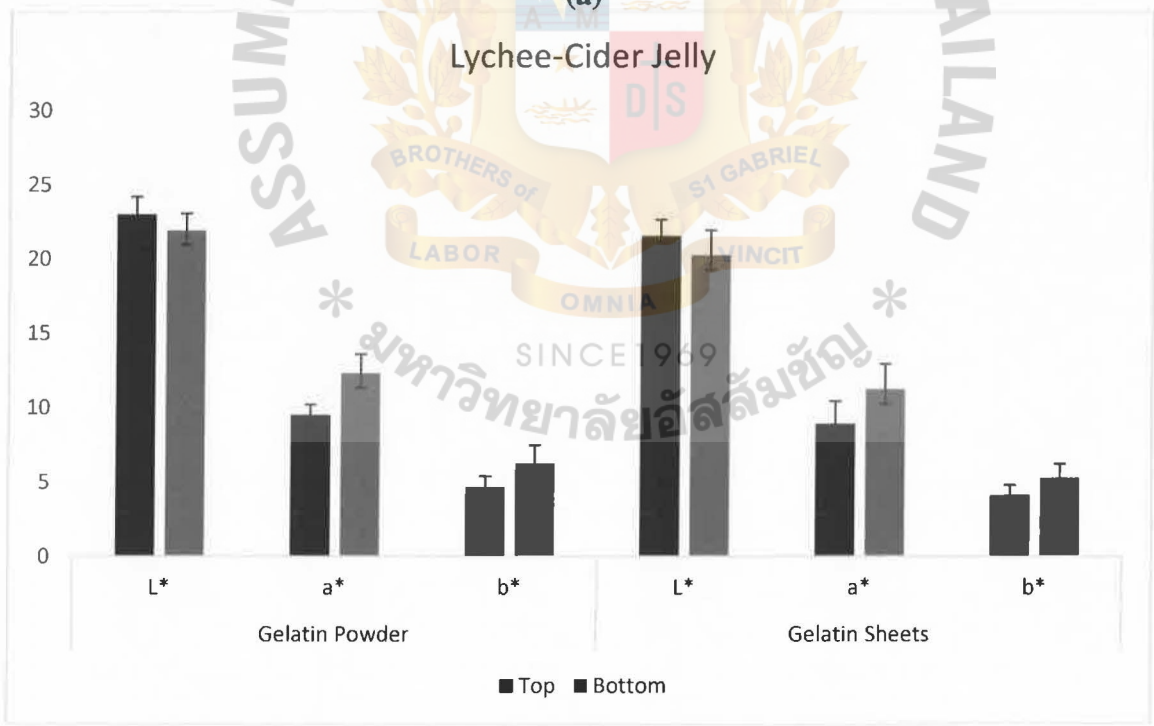
Table 3: Color characteristics of fruit-cider jellies

Jelly	Type of gelatin	Color parameters	Top measurement	Bottom measurement
Coco-cider	Powder	L*	20.50 ± 1.70	19.15 ± 1.13
		a*	-2.50 ± 0.31	-3.59 ± 0.96
		b*	-1.17 ± 0.21	-1.34 ± 0.20
	Sheet	L*	18.90 ± 0.73	17.56 ± 0.78
		a*	-2.38 ± 0.27	-2.80 ± 0.32
		b*	-1.89 ± 0.21	-1.98 ± 0.20
Lychee-cider	Powder	L*	22.97 ± 1.19	21.91 ± 1.13
		a*	9.50 ± 0.69	12.32 ± 1.27
		b*	4.64 ± 0.75	6.25 ± 1.24
	Sheet	L*	21.53 ± 1.10	20.24 ± 1.68
		a*	8.89 ± 1.52	11.22 ± 1.68
		b*	4.11 ± 0.67	5.27 ± 0.93

Results showed that there was a significant difference between treatments on b* (top and bottom) of coco-cider jellies and L* (top) of lychee-cider jelly ($P<0.05$). This indicated that products made with different types of gelatin varied in the final products' appearance. Coco-cider jelly made with gelatin powder had a green finish whereas that of gelatin sheet had blue. The color difference is due to the fact that gelatin powder was pre-treated with acid giving it a more yellow appearance and the fact that blue was mixed with yellow giving it a green finish. Lychee-cider jelly made with gelatin powder is slightly darker because red did not change color when mixed with yellow, instead, it turned darker. Each of the graphs below compare L*, b*, and a*. The comparisons of the difference between the gelatin powder and gelatin sheet are illustrated side-by-side in (Figure 1).



(a)



(b)

Figure 1: Side-by-side comparison of fruit-cider jellies' color parameters made using different types of gelatin: (a) coco-cider jelly, (b) lychee-cider jelly.

2.1.2 Texture

Texture profiles were determined using TA. XT plus 50kg Texture Analyzer from Stable Micro Systems. The texture profiles were measured using TPA method. SMSP/100 base and probe were used to measure the jelly samples. Six attributes were determined (i.e., hardness, springiness, cohesiveness, gumminess, chewiness, and resilience). Adhesiveness and fracturability were dismissed because they were not presented in jelly samples in particular and not unnecessary (Figures 2 and 3).

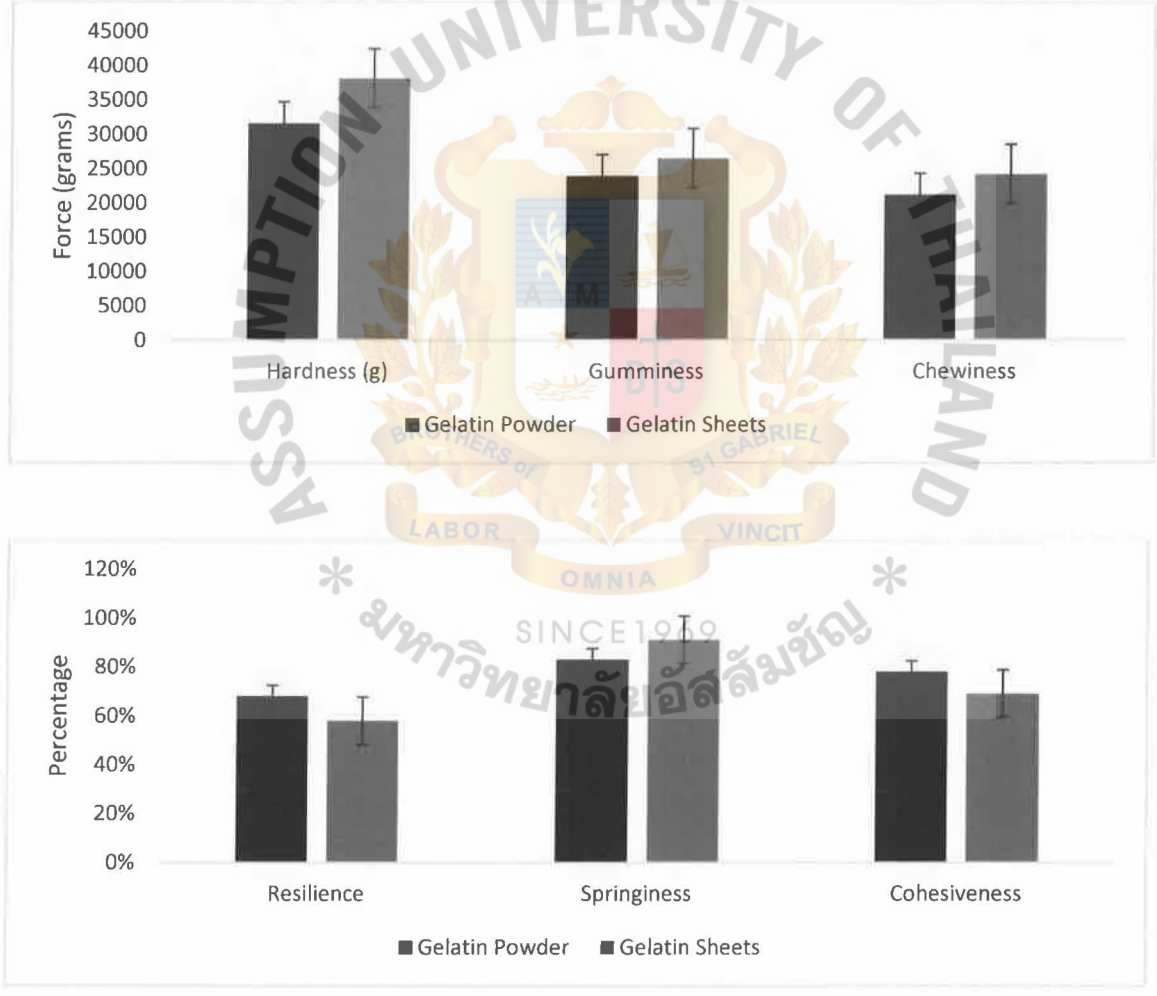


Figure 2: Texture profile of coco-cider jellies made using different types of gelatin

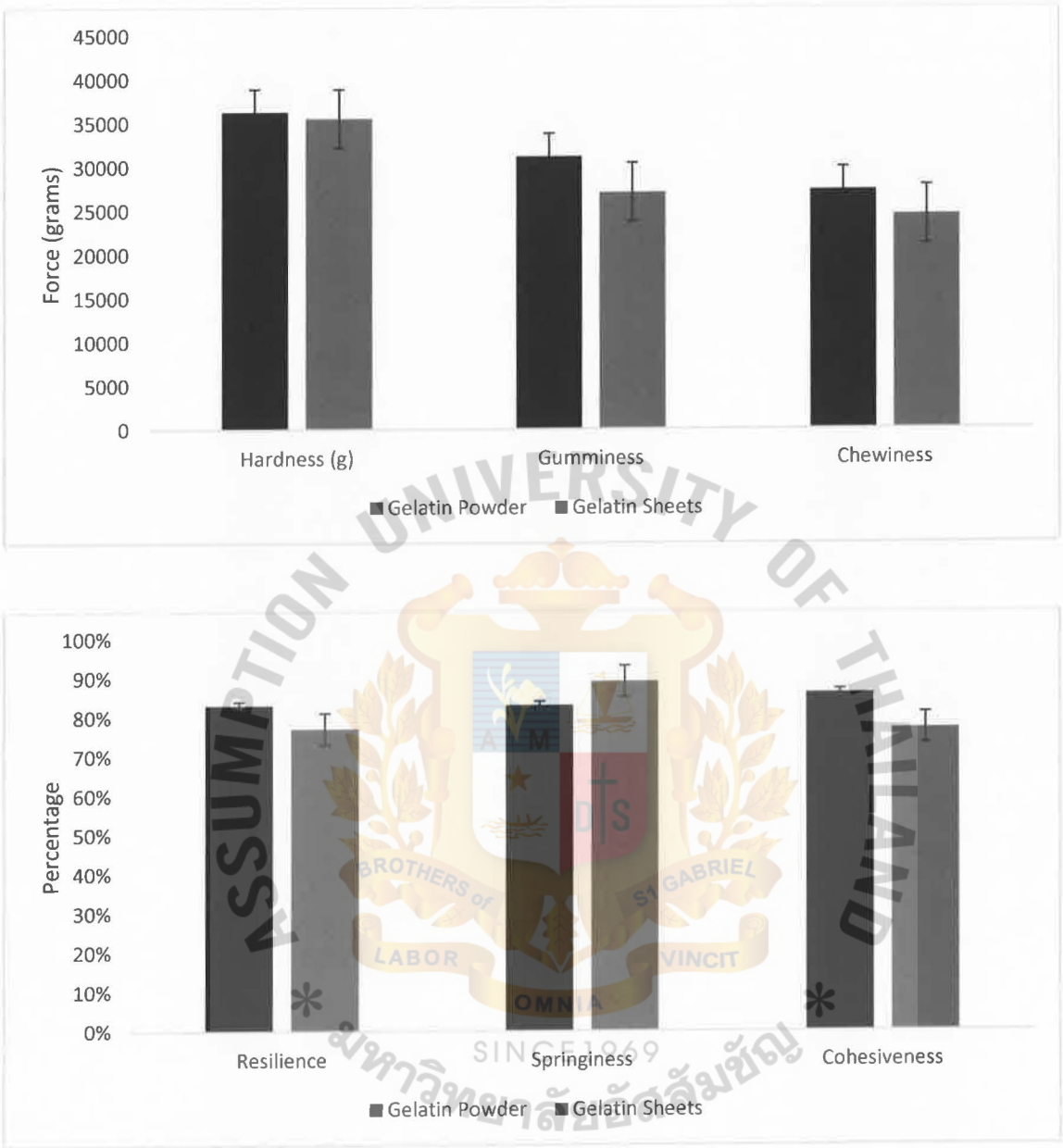


Figure 3: Texture profile of lychee-cider jellies made using different types of gelatin

According to the results determined from bot types of samples, gelatin sheets yielded final products with more hardness, gumminess, chewiness, and springiness, while the use of gelatin powder resulted in slightly more resilient and cohesive final products. This trend applied similarly to almost all the textural attributes belonging to both coco-cider and lychee-cider jellies except lychee-cider hardness profile. The difference was not significant (P>0.05), considering the overall proportion of force to the variance. Conferring to an article posted on finecooking.com, 4 gelatin sheets = 0.25 oz is equivalent to 2 and 1/2 tbsp, meaning, 7.5 grams of gelatin powder is equivalent to 7 grams of gelatin sheets. This suggests that more amount of gelatin powder must be used to make equal with a lesser amount by weight of gelatin sheets. From the data determined from the result, this principle correlated with the practice. With the same amount by weight (25 grams/batch) of gelatin powder and gelatin sheets, the hardness, gumminess, and chewiness of the final product made from gelatin sheets were considerably higher in force compared to those of the final product made from gelatin powder.

2.2 Chemical properties

2.2.1 Acidity

In theory, the determination of total acidity is done using classic acid-base titration method. The titrate can either be an alkaline or acidic solution while the sample is the opposite. In either case, the volume of standardized titrant used is put into the equation to determine the sample's normality. According to the equation, the percentage of acidity is determined by dividing the multiplication of the titrate volume with the normality of titrate, equivalent weight of malic acid (predominant acid), and one hundred by the multiplication of volume of the sample and a thousand. Total acidity determination was done by performing a titration of jelly sample with a standard NaOH solution. The prepared NaOH solution had a normality of 0.0930.

Some chemical properties of fruit-cider jellies were determined. There were acidity and reducing sugar, which are presented in (Table 4). It was perceived that the acidity of each jelly samples was 0.36% for coconut-cider jelly (powder) and 0.35% for coconut-cider jelly (sheets).

Table 4: Some chemical properties of fruit-cider jellies made using different types of gelatin

Jelly	Type of gelatin	Acid (%)	Reducing sugar (%)
Coconut-cider jelly	Powder	0.36	28.69
	Sheet	0.35	27.14
Lychee-cider jelly	Powder	0.36	25.78
	Sheet	0.35	26.41

There was no significant difference in percentage acidity between treatments for both samples (P>0.05). Although there were different types of gelatin used. Generally, acid treated gelatin (Type A) has lower pH than that of alkaline treated gelatin (Type B), the acidity of the products were not significantly differences, which might be caused by buffering effects of protein content of gelatin.

2.2.2 Reducing sugar

Reducing sugar determination was done using DNS method. Glucose is the predominant reducing sugar in honey-infused jellies. It was found that the concentration of each jelly sample was 286.92 g/L for powder coco-cider jelly, 271.36 g/L for sheets, 257.75 for powder lychee-cider jelly, and 264.14 for sheet lychee-cider jelly. The percentages of reducing sugar belonging to coconut-cider jelly and lychee-cider jelly made from gelatin powder and gelatin sheets were found to be 28.69, 27.14, 25.7%, and 26.41%, respectively. Residual sugar concentrations in grams per liter and percentages residual sugar are shown in (Table 4).

Results showed that there was no significant difference in percentage reducing sugar between treatments (P>0.05), indicating that the types of gelatin use had no effect on reducing sugar of the product, which was mainly due to the amount of honey used in the formula.

2.3 Sensory evaluation of fruit-cider jellies

The sensory evaluation of fruit-cider jellies was performed by using preference test 9-point hedonic scale and 30 panelists. The result is shown in (Table 5).

Table 5: Sensory evaluation of fruit-cider jellies made using different types of gelatin

Attribute	Coco-cider jelly		Lychee-cider jelly	
	Gelatin Powder	Gelatin Sheets	Gelatin Powder	Gelatin Sheets
Color	7.0 ± 1.2*	7.2 ± 1.0	7.6 ± 1.3	7.8 ± 1.2
Aroma	6.5 ± 1.5	6.5 ± 1.6	7.2 ± 1.1	7.3 ± 1.1
Chewiness	6.4 ± 1.2	6.7 ± 1.2	7.2 ± 1.6	6.9 ± 1.7
Sweetness	6.1 ± 1.5	6.7 ± 1.5	6.8 ± 1.9	6.9 ± 1.8
Tartness	6.0 ± 1.5	6.4 ± 1.4	6.5 ± 1.9	6.6 ± 1.8
Overall Consistency	6.7 ± 1.2	6.9 ± 1.1	6.9 ± 1.5	7.1 ± 1.4
Overall Liking	6.4 ± 1.1	6.8 ± 1.3	7.0 ± 1.3	7.3 ± 1.4

* There is no significant different between gelatin sheet and gelatin powder used at 95% confidential level.

3. Just-about-right

Fruit-cider jellies were produced by using gelatin powder. The products were then tested by using Just About Right (JAR) test to determine the appropriateness level of various attributes and whether any of attributes needs adjustment in the formula.

3.1 Coco-cider jelly

As a rule of thumb, if 70% or more of respondents state an attribute is just about right then no further action is required (Meullenet et al., 2007). Overall findings illustrated that all attributes of coco-cider jelly were more than 70% just about right (Figure 4), indicating that no adjustment in the formula was required. In addition to the percentage respondents, the net penalties were calculated. Overall, all net penalty scores of all attributes were below 0.5 despite the fact that the percentage respondent on too little sourness reached 20%, confirming that the formula needed no adjustment because the net penalty of each attribute falls under 0.5. The total penalty scores were sorted from high to low, along with the mean drop and respondent percentages as shown in (Figure 5).

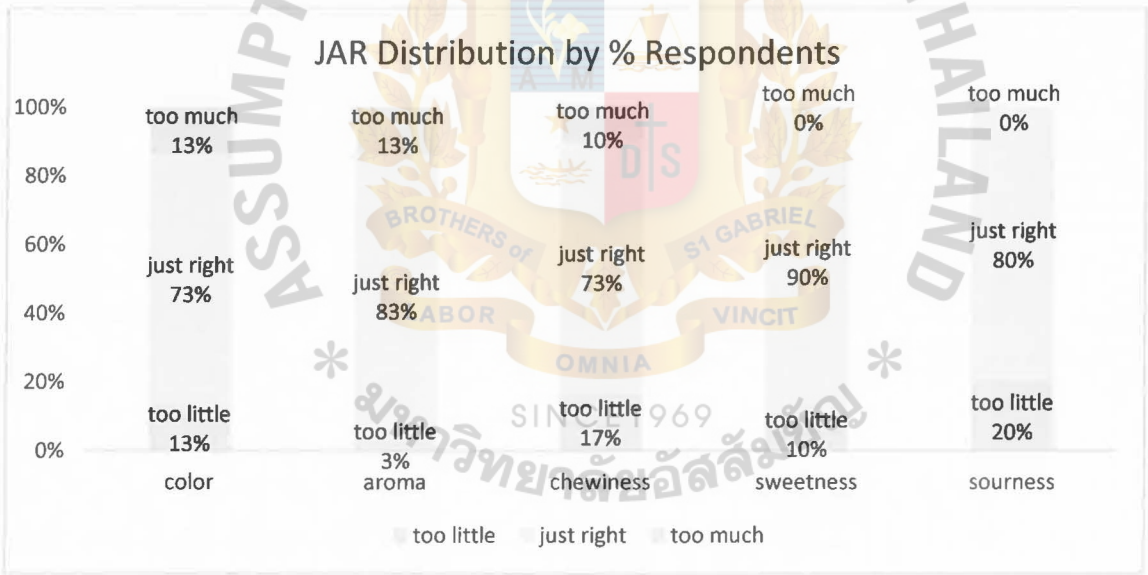


Figure 4: Just-about-right result of coco-cider jelly

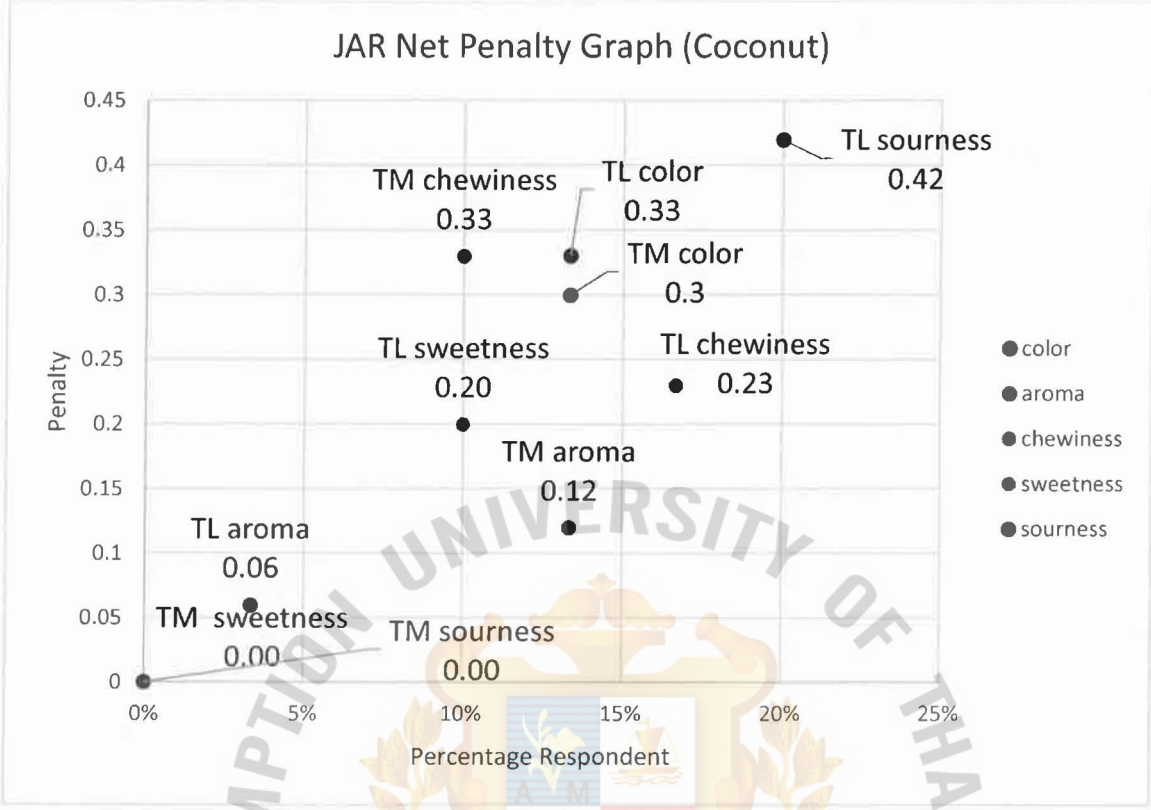


Figure 5: Net penalty graph of coco-cider jelly

3.2 Lychee-cider jelly

Like coconut-cider jellies, lychee-cider jellies showed the same results in the overall finding. All attributes were found to have more than 70% respondents choosing just right. This suggested that no further action was required. The percentage respondents on just about right score of lychee-cider jelly is shown in (Figure 6). On top of percentage respondents, the net penalties were calculated for lychee flavored jellies as were coconut flavored jellies. Overall, all net penalty scores are below 0.5. That further adds that the formula needs no adjustment because the net penalty of each attribute falls under 0.5 despite the fact that some of the non-JAR attributes reached 20% in percentage respondent. The total penalty scores are sorted from high to low, along with the mean drop and respondent percentages as shown in (Figure 7).

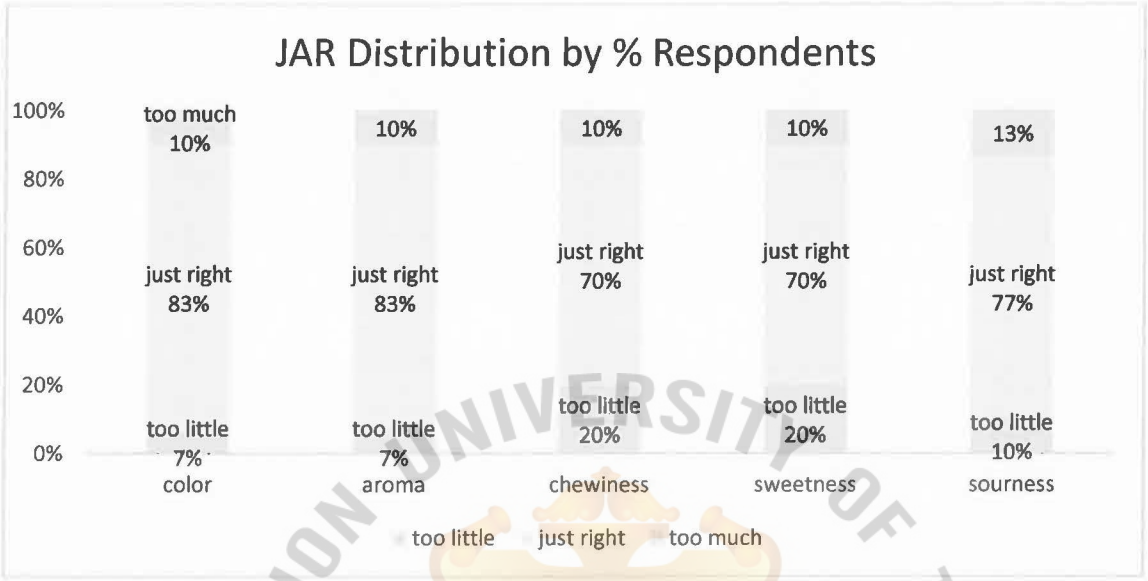


Figure 6: Just-about-right result of lychee-cider jelly

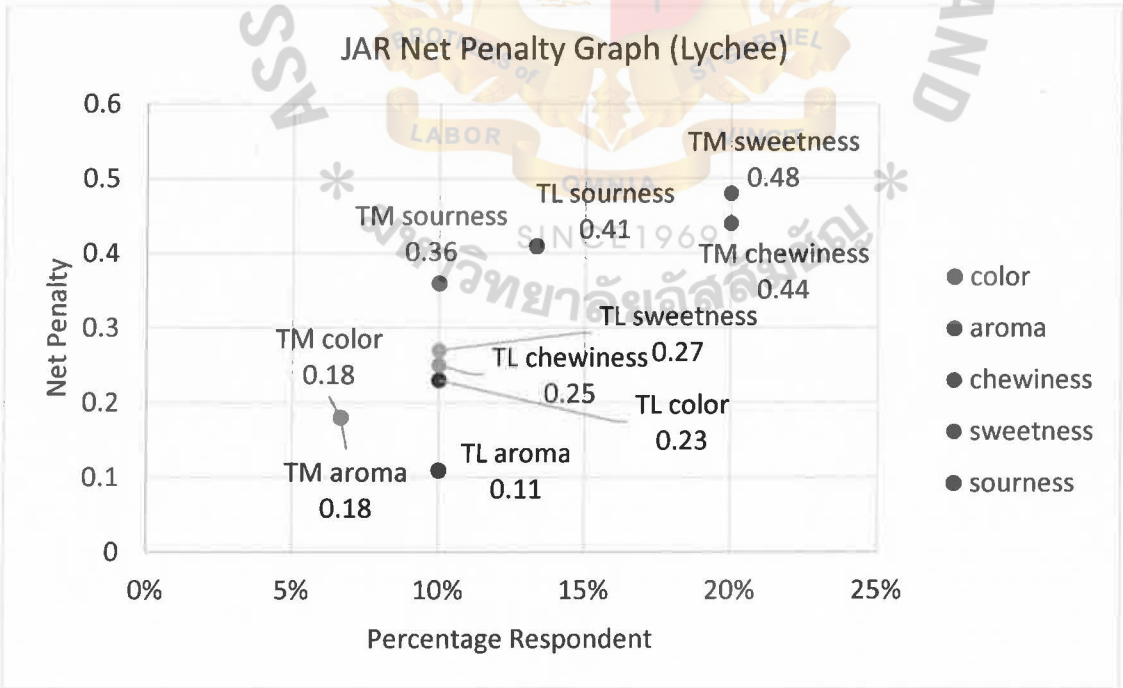


Figure 7: Net penalty graph of lychee-cider jelly

It was recognized that there were no significant differences between gelatin sheet and powder used for making fruit-cider jellies in all attributes, although gelatin sheet had slightly higher overall liking score. As a result, other factors were put into consideration to decide on which gelatin type to use. Cost of raw material was considered because the cost of each gelatin type is largely different. Gelatin sheets are rarer and considerably much more expensive than gelatin powder. The reason why sheet gelatin is much more expensive than gelatin powder is because only European countries use that kind of gelatin, therefore, it has to be imported. On the other hand, gelatin powder is made in the country and is inexpensive. As a result, gelatin powder was used to make the fruit-cider jellies for the further experiment.

4 Consumer Test

One hundred panelists, who were mostly students were asked to answer a consumer test questionnaire. The questionnaire was divided into three parts; consumer's behavior, general information, and attitude towards the product. The demographic group of the panelists was student and workers with an age range from 15 to 24 years old. This particular demographic group was selected is due to the fact that the popularity of confectionary products towards this group is higher than any other groups.

4.1 Consumer's behavior

Considering the first part of the questionnaire, an overall 58% percent of the panelists like to consume candy, 20% of which like it very much. While 18% asked did not like to consume candy, 24% are neutral towards the sweet treat. Further findings showed that out of 100 panelists, 27% of them consume candy 2-3 times per month while 24% of them consume it 2-3 times per week. This result shows that the frequency of candy consumption is varied among each individual. At 49% popularity, convenience store is a place where most people buy candies from. Coming at second is supermarket with a percentage of approximately 32 percent. The most popular kind of candy among this group of people is chocolate with a 37% popularity. The next most popular products are gummy

jelly and hard candy, possessing approximately 24% popularity (Figure 8). The most important factors affecting the consumer's behavior towards the product were appearance and taste, with more than an average of 4 out of 5 level of importance. Next important factors are ingredient, packaging, and shop location (Figure 9).

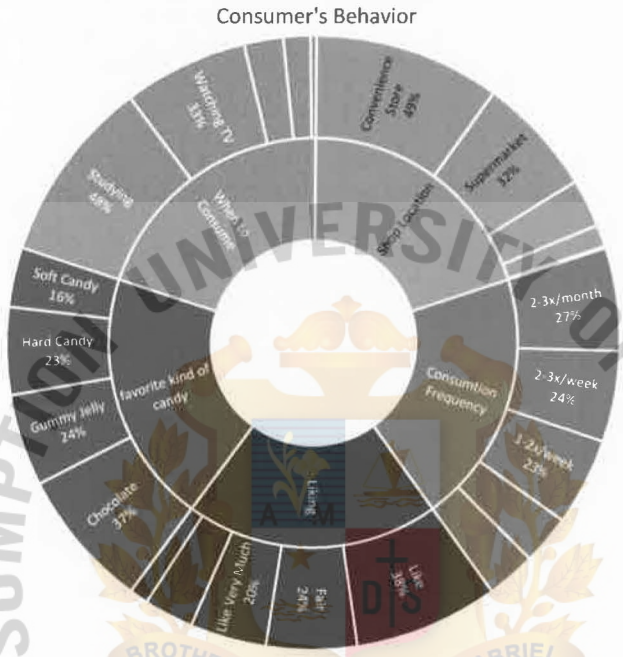


Figure 8: Consumer's behavior

Figure 9: Consumer's behavior – important factors

4.2 Demographics

Most that answered the questionnaire were Thai females with an age range between 15-24 years old. Most of which have less than 15,000 baht per month income. With an accumulated 71%, most of them would pay 50-55 baht for a 120 gram-box of the jelly products. (Figure 10) demonstrates the demographic group of the panelists and how much they would pay for the products.

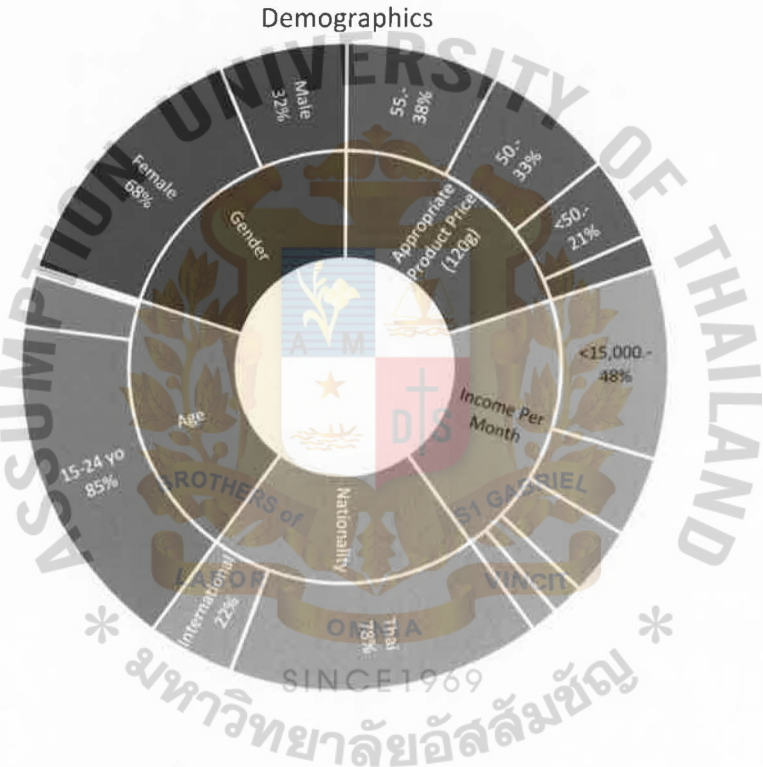


Figure 10: Demographics

4.3 Behavior towards products

Coconut-cider jelly had an average liking score of 7.54, an acceptance percentage of 90% and purchase intent percentage of 77%. Lychee-cider jelly had about the same liking score at 7.58, acceptance percentage at 89% and purchase intend at 76%. These products can be compared to Yoyo strawberry gummy jelly which has a liking score of 7.15, acceptance percentage of 92% and purchase intent percentage of 76%. According to the questionnaire, people who did not accept and did not want to purchase the coconut jelly reported that they did not like the product's color. Some people who did not accept and were not going to purchase lychee-cider jelly claimed that it has a slight bitter after taste. On the other hand, if compared to Yoyo's strawberry jelly, people who did not accept and had no intention of buying the product claimed that the texture was too hard while some other say that it has a similar taste to medicinal syrup (Table 6).

Table 6: Consumer test - liking score, acceptance, and purchase intent

		Coco-cider jelly	**Lychee-cider jelly**	**Strawberry jelly**
Liking score		7.54 ± 1.33	7.58 ± 1.16	7.15 ± 1.21
Acceptance (%)	Yes	90	89	92
	No	10	11	8
Purchase intent (%)	Yes	77	76	76
	Maybe	17	14	16
	No	6	10	8

5 Sensory profiles of the products

Comparison of sensory attribute intensity scales was done between three samples as coco-cider jelly, lychee-cider jelly, and strawberry jelly (commercial product). One hundred panelists were asked to taste and give an intensity score from 0 to 15 with 0.5 intervals for each sample. Data obtained was analyzed in SAS using RCBD experimental design along with LSD (Table 7).

Table 7: Sensory attribute of jelly samples

Category	Attribute*	Coconut	Lychee	Strawberry
Appearance	Opacity	6.7 ± 1.4 a*	6.4 ± 1.1 a	4.7 ± 2.7 b
Aroma	Fruitiness	8.4 ± 1.8 b	8.9 ± 2.0 b	9.5 ± 1.9 a
	Honey	4.6 ± 1.7 a	4.2 ± 1.6 a	1.6 ± 1.8 b
	Coconut/Lychee/Straw	8.6 ± 2.4 b	8.7 ± 2.6 b	10.3 ± 2.1 a
Texture	Firmness	8.7 ± 2.2 b	9.8 ± 9.9 ab	11.3 ± 2.0 a
	Chewiness	7.4 ± 1.6 b	7.5 ± 1.6 b	11.7 ± 2.3 a
	Springiness	10.5 ± 2.6 a	10.3 ± 2.6 a	7.7 ± 2.4 b
Taste	Sweetness	8.9 ± 2.1 b	8.6 ± 2.3 b	10.9 ± 2.0 a
	Sourness	6.4 ± 2.0 b	6.5 ± 2.3 b	8.8 ± 2.52 a
Flavor	Fruitiness	6.4 ± 1.9 b	6.4 ± 2.0 b	8.8 ± 1.9 a
	Tartness	6.6 ± 2.0 b	6.6 ± 2.1 b	8.9 ± 2.9 a
	Honey	5.4 ± 1.7 a	5.23 ± 1.7 a	1.5 ± 1.6 b
	Coconut/Lychee/Straw	9.4 ± 2.2 b	9.7 ± 2.5 b	10.9 ± 1.9 a
	Vinegar	2.0 ± 1.8 a	1.8 ± 1.7 a	1.2 ± 1.7 b

Remarks: * The same letters denote there is no significant difference

Conclusion

In conclusion, the most desirable jelly formula is composed of 52.9% water, 8.8% gelatin powder, 35.3% honey, 1.8% of 5% fruit-cider vinegar, 0.18% malic acid, 0.7 flavoring for coconut (half for lychee), and 0.35% color for coconut (half for lychee).

Final products differed in colors when different gelatin types were used; gelatin powder (Type A) and gelatin sheets (Type B) due to their acidity and alkalinity. Texture profiles of both coconut-cider jelly and lychee-cider jelly were determined with hardness averaging at around 35 kg, gumminess at 30 kg, chewiness at 25 kg, resilience at 60%, springiness at 80%, and cohesiveness at 75%. Further findings showed that both coco-cider jelly and lychee-cider jelly have approximately 0.35% acidity and 27%% reducing sugar.

Consumer acceptance study showed that the developed jellies were accepted by approximately 80 percent of the 100 panelists with both products have approximately 7.5 out of 9 liking scores.

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Appendix

Appendix A: SAS Paired Samples T-Test Results

The SAS System

The TTEST Procedure

Difference: color1 - color2

N	Mean	Std Dev	Std Err	Minimum	Maximum
30	-0.2333	0.9353	0.1708	-4.0000	1.0000

Mean	95% CL Mean		Std Dev	95% CL Std Dev	
-0.2333	-0.5826	0.1159	0.9353	0.7448	1.2573

DF	t Value	Pr > |t|
29	-1.37	0.1823

The SAS System

The TTEST Procedure

Difference: aroma1 - aroma2

N	Mean	Std Dev	Std Err	Minimum	Maximum
30	0	1.8194	0.3322	-6.0000	4.0000

Mean	95% CL Mean		Std Dev	95% CL Std Dev	
0	-0.6794	0.6794	1.8194	1.4490	2.4459

DF	t Value	Pr > |t|
29	0.00	1.0000

The SAS System

The TTEST Procedure

Difference: chew1 - chew2

N	Mean	Std Dev	Std Err	Minimum	Maximum
30	-0.3000	1.4657	0.2676	-3.0000	3.0000

Mean	95% CL Mean		Std Dev	95% CL Std Dev	
-0.3000	-0.8473	0.2473	1.4657	1.1673	1.9704

DF	t Value	Pr > |t|
29	-1.12	0.2715

The SAS System

The TTEST Procedure

Difference: sweet1 - sweet2

N	Mean	Std Dev	Std Err	Minimum	Maximum
30	-0.5667	1.7555	0.3205	-4.0000	3.0000

Mean	95% CL Mean		Std Dev	95% CL Std Dev	
-0.5667	-1.2222	0.0888	1.7555	1.3981	2.3599

DF	t Value	Pr > |t|
29	-1.77	0.0876

The SAS System

The TTEST Procedure

Difference: tart1 - tart2

N	Mean	Std Dev	Std Err	Minimum	Maximum
30	-0.4333	2.1121	0.3856	-7.0000	3.0000

Mean	95% CL Mean		Std Dev	95% CL Std Dev	
-0.4333	-1.2220	0.3553	2.1121	1.6821	2.8393

DF	t Value	Pr > |t|
29	-1.12	0.2703

The SAS System

The TTEST Procedure

Difference: cons1 - cons2

N	Mean	Std Dev	Std Err	Minimum	Maximum
30	-0.2667	1.2576	0.2296	-3.0000	3.0000

Mean	95% CL Mean		Std Dev	95% CL Std Dev	
-0.2667	-0.7363	0.2029	1.2576	1.0016	1.6906

DF	t Value	Pr > |t|
29	-1.16	0.2550

The SAS System

The TTEST Procedure

Difference: liking1 - liking2

N	Mean	Std Dev	Std Err	Minimum	Maximum
30	-0.4000	1.4288	0.2609	-3.0000	3.0000

Mean	95% CL Mean		Std Dev	95% CL Std Dev	
-0.4000	-0.9335	0.1335	1.4288	1.1379	1.9207

DF	t Value	Pr > |t|
29	-1.53	0.1360

The SAS System

The TTEST Procedure

Difference: color1 - color2

N	Mean	Std Dev	Std Err	Minimum	Maximum
30	-0.2333	0.6789	0.1240	-1.0000	2.0000

Mean	95% CL Mean		Std Dev	95% CL Std Dev	
-0.2333	-0.4868	0.0202	0.6789	0.5407	0.9127

DF	t Value	Pr > |t|
29	-1.88	0.0698

The SAS System

The TTEST Procedure

Difference: aroma1 - aroma2

N	Mean	Std Dev	Std Err	Minimum	Maximum
30	-0.0333	0.9279	0.1694	-2.0000	2.0000

Mean	95% CL Mean		Std Dev	95% CL Std Dev	
-0.0333	-0.3798	0.3131	0.9279	0.7390	1.2473

DF	t Value	Pr > |t|
29	-0.20	0.8454

The SAS System

The TTEST Procedure

Difference: chew1 - chew2

N	Mean	Std Dev	Std Err	Minimum	Maximum
30	0.3333	1.3218	0.2413	-2.0000	4.0000

Mean	95% CL Mean		Std Dev	95% CL Std Dev	
0.3333	-0.1602	0.8269	1.3218	1.0527	1.7769

DF	t Value	Pr > |t|
29	1.38	0.1777

The SAS System

The TTEST Procedure

Difference: sweet1 - sweet2

N	Mean	Std Dev	Std Err	Minimum	Maximum
30	-0.1000	0.9229	0.1685	-2.0000	2.0000

Mean	95% CL Mean		Std Dev	95% CL Std Dev	
-0.1000	-0.4446	0.2446	0.9229	0.7350	1.2407

DF	t Value	Pr > |t|
29	-0.59	0.5575

The SAS System

The TTEST Procedure

Difference: tart1 - tart2

N	Mean	Std Dev	Std Err	Minimum	Maximum
30	-0.0333	0.8503	0.1552	-2.0000	2.0000

Mean	95% CL Mean		Std Dev	95% CL Std Dev	
-0.0333	-0.3508	0.2842	0.8503	0.6772	1.1431

DF	t Value	Pr > |t|
29	-0.21	0.8315

The SAS System

The TTEST Procedure

Difference: cons1 - cons2

N	Mean	Std Dev	Std Err	Minimum	Maximum
30	-0.2333	1.1043	0.2016	-2.0000	2.0000

Mean	95% CL Mean		Std Dev	95% CL Std Dev	
-0.2333	-0.6457	0.1790	1.1043	0.8795	1.4846

DF	t Value	Pr > |t|
29	-1.16	0.2566

The SAS System

The TTEST Procedure

Difference: liking1 - liking2

N	Mean	Std Dev	Std Err	Minimum	Maximum
30	-0.3000	0.9879	0.1804	-2.0000	2.0000

Mean	95% CL Mean		Std Dev	95% CL Std Dev	
-0.3000	-0.6689	0.0689	0.9879	0.7867	1.3280

DF	t Value	Pr > |t|
29	-1.66	0.1070

Appendix B: JAR Raw Data

Coconut		Score	Much too little	Somewhat too little	Just right	Somewhat too strong	Much too strong
Color	Mean/Total	7.10	0	4	22	3	1
	SD/Percentage	1.37	0%	13%	73%	10%	3%
	Group Mean		5.25		7.73	5.50	
	Grand Mean		6.16				
Aroma	Mean/Total	7.50	0	1	25	4	0
	SD/Percentage	1.14	0%	3%	83%	13%	0%
	Group Mean		6.00		7.68	6.75	
	Grand Mean		6.81				
Chewiness	Mean/Total	7.03	0	5	22	2	1
	SD/Percentage	1.47	0%	17%	73%	7%	3%
	Group Mean		6.20		7.59	4.33	
	Grand Mean		6.04				
Sweetness	Mean/Total	7.77	0	3	27	0	0
	SD/Percentage	1.04	0%	10%	90%	0%	0%
	Group Mean		6.00		7.96	0.00	
	Grand Mean		4.65				
Sourness	Mean/Total	7.67	2	4	24	0	0
	SD/Percentage	1.24	7%	13%	80%	0%	0%
	Group Mean		6.00		8.08	0.00	
	Grand Mean		4.69				
Overall Liking	Mean	7.67					
	SD	1.12					

Lychee		Score	Much too little	Somewhat too little	Just right	Somewhat too strong	Much too strong
Color	Mean/Total	7.43	0	2	25	3	0
	SD/Percentage	1.25	0%	7%	83%	10%	0%
	Group Mean		5		7.77	5.5	
	Grand Mean		6.09				
Aroma	Mean/Total	7.43	0	2	25	3	0
	SD/Percentage	1.17	0%	7%	83%	10%	0%
	Group Mean		5		7.72	6.67	
	Grand Mean		6.46				
Chewiness	Mean/Total	6.83	1	5	21	2	1
	SD/Percentage	1.78	3%	17%	70%	7%	3%
	Group Mean		5.33		7.52	5.00	
	Grand Mean		5.95				
Sweetness	Mean/Total	6.97	3	3	21	2	1
	SD/Percentage	1.47	10%	10%	70%	7%	3%
	Group Mean		5.33		7.71	5	
	Grand Mean		6.02				
Sourness	Mean/Total	6.77	1	2	23	3	1
	SD/Percentage	1.87	3%	7%	77%	10%	3%
	Group Mean		4		7.56	4.5	
	Grand Mean		5.35				
Overal Liking	Mean	7.33					
	SD	0.88					

Appendix C: Color Determination

	ID	L*	a*	b*
CP1	CPT11	22.75	-2.25	-1.01
	CPT12	23.03	-2.84	-1.18
	CPT13	22.86	-2.56	-0.97
	CPB11	20.06	-3.33	-1.3
	CPB12	20.06	-5.99	-1.71
	CPB13	20.05	-4.85	-1.57
CP2	CPT21	19.15	-2.26	-1.18
	CPT22	18.66	-2.47	-1
	CPT23	21.85	-1.99	-0.88
	CPB21	19.63	-3.83	-1.62
	CPB22	18.21	-2.57	-1.18
	CPB23	17.94	-2.6	-1.15
CP3	CPT31	20.18	-2.42	-1.35
	CPT32	19.67	-2.54	-1.33
	CPT33	18.18	-2.72	-1.47
	CPB31	18.57	-2.67	-1.19
	CPB32	18	-2.93	-1.11
	CPB33	18.35	-4.11	-1.49
CP4	CPT41	20.51	-2.08	-1
	CPT42	20.94	-2.61	-1.02
	CPT43	22.49	-2.2	-0.98
	CPB41	20.6	-3.12	-1.25
	CPB42	21.16	-4.03	-1.48
	CPB43	20.03	-3.4	-1.34
CP5	CPT51	19.31	-2.55	-1.25
	CPT52	18.89	-2.95	-1.57
	CPT53	19.08	-3.06	-1.33
	CPB51	18.78	-4.33	-1.43
	CPB52	18.34	-2.76	-1.01
	CPB53	17.46	-3.37	-1.25
CS1	CST11	18.98	-2.4	-2.01
	CST12	18.52	-2.82	-2.17
	CST13	18.92	-2.74	-2.03
	CSB11	17.92	-3.41	-2.18
	CSB12	17.8	-2.41	-1.61
	CSB13	17.69	-2.67	-1.86

CS2	CST21	19.92	-2.27	-2.15
	CST22	19.63	-2.42	-2
	CST23	18.95	-2.43	-2.02
	CSB21	16.22	-2.72	-1.88
	CSB22	16.16	-2.38	-1.89
	CSB23	16.99	-2.66	-1.95
CS3	CST31	18.75	-2.43	-2.06
	CST32	18.72	-2.43	-1.97
	CST33	19.74	-2.59	-1.75
	CSB31	17.37	-2.72	-2.07
	CSB32	17.27	-2.92	-1.93
	CSB33	18.4	-2.89	-2.12
CS4	CST41	17.98	-1.9	-1.41
	CST42	17.87	-2.04	-1.74
	CST43	17.63	-2.35	-1.75
	CSB41	17.29	-2.93	-2.21
	CSB42	17.79	-2.86	-1.94
	CSB43	17	-2.54	-2.05
CS5	CST51	19.76	-2.1	-1.77
	CST52	19.62	-2.1	-1.67
	CST53	18.47	-2.74	-1.79
	CSB51	18.29	-2.41	-1.63
	CSB52	19.01	-3.4	-2.28
	CSB53	18.18	-3.03	-2.13
LP1	LBT11	21.49	9.48	4.45
	LBT12	22.13	9.65	4.66
	LBT13	21.35	10.16	5.3
	LBB11	22.08	10.49	5
	LBB12	21.92	10.71	5.03
	LBB13	21.98	10.89	5.45
LP2	LBT21	23.55	7.98	3.36
	LBT22	24.34	9.13	3.68
	LBT23	24.62	8.8	3.7
	LBB21	21.04	13.44	6.64
	LBB22	21.74	14.98	6.85
	LBB23	21.3	13.36	6.57
LP3	LBT31	23.27	9.7	5.28
	LBT32	23.28	10.13	5.45
	LBT33	22.52	10.42	5.84
	LBB31	21.69	12.82	7.33

	LBB32	21.67	12.96	7.6
	LBB33	21.83	13.82	8.07
	LBT41	21.27	10.05	4.8
	LBT42	24.62	8.94	3.69
	LBT43	24.56	10.47	4.41
LP4	LBB41	23.29	11.9	4.97
	LBB42	24.2	11.1	4.14
	LBB43	24.03	11.99	4.71
	LBT51	22.1	8.9	4.81
	LBT52	22.73	9.26	5.09
	LBT53	22.78	9.41	5.13
LP5	LBB51	20.88	11.74	6.83
	LBB52	20.39	11.88	7.08
	LBB53	20.64	12.66	7.43
	LST11	19.85	7.24	3.48
	LST12	20.5	7.82	3.91
	LST13	21.62	8.11	3.74
LS1	LSB11	19.13	10.63	5.56
	LSB12	16.86	12.42	6.47
	LSB13	16.54	14.67	7.72
	LST21	20.61	8.56	3.88
	LST22	21.44	7.48	3.55
	LST23	20.32	9.01	4.46
LS2	LSB21	20.42	9.29	4.47
	LSB22	19.25	10.59	5.02
	LSB23	20.09	9.67	4.58
	LST31	21.72	7.66	3.48
	LST32	22.66	7.38	3.17
	LST33	22.35	8.25	3.7
LS3	LSB31	19.96	10.45	5.13
	LSB32	20.69	8.78	4.15
	LSB33	21.69	9.4	3.95
	LST41	20.94	11.13	4.93
	LST42	23.34	11.4	5.36
	LST43	23.6	11.96	5.32
LS4	LSB41	21.54	11.38	5.17
	LSB42	21.23	11.29	5.16
	LSB43	21.47	13.13	5.68
	LST51	21.52	8.54	4.09
LS5	LST52	20.67	9.63	4.47

LST53	21.85	9.21	4.15
LSB51	22.12	12.81	5.29
LSB52	21.15	10.79	5.01
LSB53	21.4	12.99	5.75

Remarks:

C = Coconut L = Lychee

P = Gelatin powder S = Gelatin sheets

T = Measured from top B = Measured from bottom

First number = Sample number (5 samples each)

Second number = Rep number

ANOVA Table

Coconut

Top L*

Source	DF	Anova SS	Mean Square	F Value	Pr > F
rep	4	3.67640000	0.91910000	0.46	0.7663
trt	1	6.43204000	6.43204000	3.20	0.1481

Top a*

Source	DF	Anova SS	Mean Square	F Value	Pr > F
rep	4	0.25484000	0.06371000	1.73	0.3050
trt	1	0.03481000	0.03481000	0.94	0.3865

Top b*

Source	DF	Anova SS	Mean Square	F Value	Pr > F
rep	4	0.12734000	0.03183500	0.71	0.6263
trt	1	1.29600000	1.29600000	28.88	0.0058

Bottom L*

Source	DF	Anova SS	Mean Square	F Value	Pr > F
rep	4	3.07994000	0.76998500	0.77	0.5949
trt	1	6.33616000	6.33616000	6.37	0.0651

Bottom a*

Source	DF	Anova SS	Mean Square	F Value	Pr > F
rep	4	1.04614000	0.26153500	1.33	0.3941
trt	1	1.58404000	1.58404000	8.06	0.0469

Bottom b*

Source	DF	Anova SS	Mean Square	F Value	Pr > F
rep	4	0.01754000	0.00438500	0.27	0.8846
trt	1	1.03041000	1.03041000	63.08	0.0014

Remarks:

Highlighted area = P<0.05. There is a significant difference

Lychee

Top L*

Source	DF	Anova SS	Mean Square	F Value	Pr > F
rep	4	4.25274000	1.06318500	1.77	0.2968
trt	1	5.18400000	5.18400000	8.63	0.0425

Top a*

Source	DF	Anova SS	Mean Square	F Value	Pr > F
rep	4	5.84020000	1.46005000	1.10	0.4643
trt	1	0.91809000	0.91809000	0.69	0.4523

Top b*

Source	DF	Anova SS	Mean Square	F Value	Pr > F
rep	4	1.19126000	0.29781500	0.42	0.7867
trt	1	0.70225000	0.70225000	1.00	0.3738

Bottom L*

Source	DF	Anova SS	Mean Square	F Value	Pr > F
rep	4	8.76074000	2.19018500	1.11	0.4602
trt	1	7.02244000	7.02244000	3.57	0.1320

Bottom a*

Source	DF	Anova SS	Mean Square	F Value	Pr > F
rep	4	0.66766000	0.16691500	0.05	0.9938
trt	1	3.01401000	3.01401000	0.87	0.4028

Bottom b*

Source	DF	Anova SS	Mean Square	F Value	Pr > F
rep	4	1.86504000	0.46626000	0.24	0.9020
trt	1	2.37169000	2.37169000	1.22	0.3310

Remarks:

Highlighted area = P<0.05. There is a significant difference

Appendix D: Texture Profile Analysis Raw Data

Test ID	Hardness (g) Force 2	Springiness J#/F#	Cohesiveness I#/G#	Gumminess K#*O#	Chewiness P#*N#	Resilience H#/E#
Start Batch CP1_						
CP1_1	38052.87	0.914	0.793	30178.877	27579.73	0.517
CP1_2	31286.95	0.96	0.704	22040.615	21165.98	0.52
CP1_3	13850.36	0.493	0.914	12664.225	6246.045	0.92
CP1_4	**9042.85**	**0.413**	**0.908**	**8213.757**	**3388.89**	**0.97**
CP1_5	**69.692**	**0.708**	**0.859**	**59.897**	**42.405**	**0.86**
CP1_6	43048.61	0.964	0.714	30740.982	29627.79	0.75
End Batch CP1_						
Average:	31560	0.83	0.78	23906.17	21154.89	0.68
S.D.	12752	0.23	0.10	8483.77	10572.65	0.20
Coef. of Variation	76.78	32.902	11.427	71.677	88.574	26.35
Start Batch CS1_						
CS1_1	36307.68	0.877	0.671	24376.396	21385.03	0.536
CS1_2	40033.52	0.958	0.718	28733.279	27519.19	0.588
CS1_3	37238.45	0.934	0.698	25986.114	24275.63	0.548
CS1_4	**14059.44**	**0.474**	**0.9**	**12658.15**	**6002.61**	**0.88**
CS1_5	38844.60	0.875	0.691	26830.387	23476.58	0.661
End Batch CS1_						
Average:	38106.07	0.91	0.69	26481.54	24164.11	0.58
S.D.	1658.06	0.04	0.02	1813.75	2547.22	0.06
Coef. of Variation	32.584	24.115	12.72	26.894	40.992	22.189
Start Batch LP1_						
LP1_1	42533.93	0.947	0.82	34877.247	33018.30	0.793
LP1_2	21791.96	0.589	0.9	19620.509	11560.63	0.885
LP1_3	**11011.52**	**0.45**	**0.942**	**10369.75**	**4669.94**	**0.93**
LP1_4	**14801.29**	**0.527**	**0.929**	**13749.12**	**7242.84**	**0.94**
LP1_5	44389.47	0.955	0.874	38778.715	37045.58	0.812
End Batch LP1_						
Average:	36238.46	0.83	0.86	31092.16	27208.18	0.83
S.D.	12545.38	0.21	0.04	10124.45	13699.96	0.05
Coef. of Variation	58.033	34.602	5.436	54.101	81.097	7.977
Start Batch LS1_						
LS1_1	40393.16	0.947	0.644	26004.4	24615.44	0.788
LS1_2	39757.17	0.958	0.792	31489.181	30155.52	0.751
LS1_3	39089.39	0.949	0.779	30456.742	28902.10	0.7

LS1_4	22604.77	0.695	0.884	19991.336	13894.68	0.837
LS1_5	13708.51	0.518	0.906	12418.29	6438.34	0.91
End Batch LS1_						
Average:	35461.13	0.89	0.77	26985.41	24391.94	0.77
S.D.	8587.42	0.13	0.10	5234.93	7389.24	0.06
Coef. of Variation	39.36	24.43	12.978	32.971	49.359	10.10

Remarks

C = Coconut L = Lychee

P = Gelatin powder S = Gelatin sheets

The last number that follows after _ are rep numbers

Red highlighted cells are errors and not included in the calculation

ANOVA Table

Coconut

Hardness

Source	DF	Anova SS	Mean Square	F Value	Pr > F
rep	3	259696442.9	86565481.0	1.10	0.4701
trt	1	85709828.7	85709828.7	1.09	0.3736

Springiness

Source	DF	Anova SS	Mean Square	F Value	Pr > F
rep	3	0.07099937	0.02366646	0.79	0.5737
trt	1	0.01224612	0.01224612	0.41	0.5676

Cohesiveness

Source	DF	Anova SS	Mean Square	F Value	Pr > F
rep	3	0.01329837	0.00443279	0.83	0.5602
trt	1	0.01505112	0.01505112	2.81	0.1924

Gumminess

Source	DF	Anova SS	Mean Square	F Value	Pr > F
rep	3	103444277.0	34481425.7	0.85	0.5532
trt	1	13265053.5	13265053.5	0.33	0.6084

Chewiness

Source	DF	Anova SS	Mean Square	F Value	Pr > F
rep	3	152097885.2	50699295.1	0.75	0.5905
trt	1	18110831.1	18110831.1	0.27	0.6404

Resilience

Source	DF	Anova SS	Mean Square	F Value	Pr > F
rep	3	0.06677338	0.02225779	1.15	0.4561
trt	1	0.01795513	0.01795513	0.93	0.4068

Lychee

Hardness

Source	DF	Anova SS	Mean Square	F Value	Pr > F
rep	3	186685294.0	62228431.3	0.47	0.7257
trt	1	15849407.1	15849407.1	0.12	0.7528

Springiness

Source	DF	Anova SS	Mean Square	F Value	Pr > F
rep	3	0.04782737	0.01594246	0.48	0.7214
trt	1	0.00132612	0.00132612	0.04	0.8551

Cohesiveness

Source	DF	Anova SS	Mean Square	F Value	Pr > F
rep	3	0.02388038	0.00796013	2.69	0.2186
trt	1	0.01702012	0.01702012	5.76	0.0958

Gumminess

Source	DF	Anova SS	Mean Square	F Value	Pr > F
rep	3	83310675.69	27770225.23	0.34	0.8031
trt	1	72682773.05	72682773.05	0.88	0.4178

Chewiness

Source	DF	Anova SS	Mean Square	F Value	Pr > F
rep	3	158096071.9	52698690.6	0.35	0.7952
trt	1	55663705.0	55663705.0	0.37	0.5869

Resilience

Source	DF	Anova SS	Mean Square	F Value	Pr > F
rep	3	0.00584050	0.00194683	0.64	0.6407
trt	1	0.00638450	0.00638450	2.08	0.2446

Appendix E: Acidity

NaOH Standardization:

$$\text{N NaOH} = \frac{Volume\ NaOH\ Used}{N\ KHP}$$

Where N KHP = 0.004

% Acidity Calculation

1:9 Dilution	NaOH (ml)			N NaOH	Eq Weight Malic Acid	% Acidity			
	1	2	3			1	2	3	AVG
Coconut Powder	6	5.8	5.7	0.093	67.05	0.37	0.36	0.36	0.36
Coconut Sheets	5.6	5.7	5.7	0.093	67.05	0.35	0.36	0.36	0.35
Lychee Powder	5.8	5.7	5.7	0.093	67.05	0.36	0.36	0.36	0.36
Lychee Sheets	5.6	5.5	5.7	0.093	67.05	0.35	0.34	0.36	0.35

Remarks:

$$\%\ \text{acidity} = \frac{Volume\ of\ titrate * N\ of\ titrate * Eq\ weight\ of\ Malic\ acid * 100}{Volume\ of\ sample * 1000}$$

ANOVA Table

Coconut

Source	DF	Anova SS	Mean Square	F Value	Pr > F
rep	2	0.00003906	0.00001953	0.23	0.8110
trt	1	0.00016224	0.00016224	1.94	0.2987

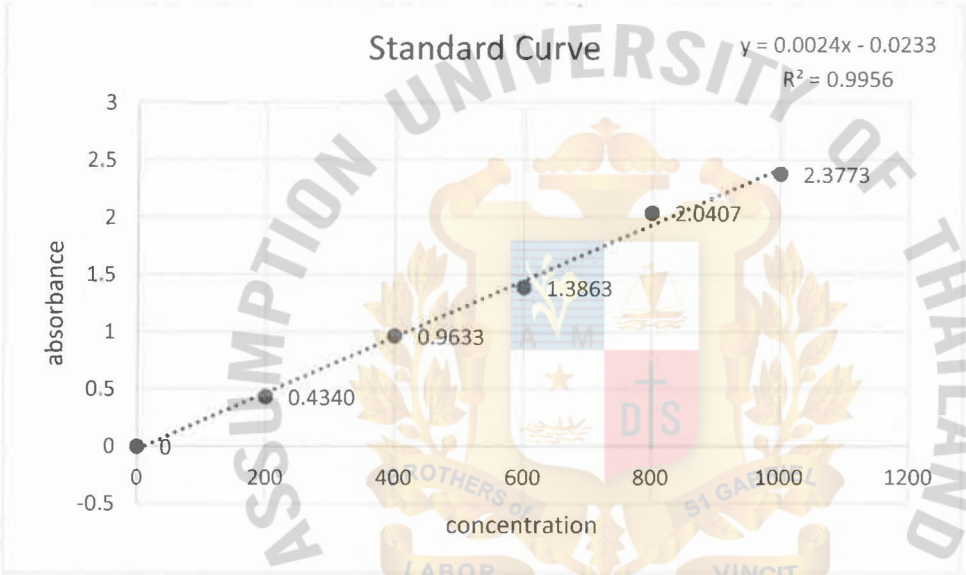
Lychee

Source	DF	Anova SS	Mean Square	F Value	Pr > F
rep	2	0.00005250	0.00002625	1.01	0.4980
trt	1	0.00010417	0.00010417	4.00	0.1835

Appendix F: Reducing Sugar

Calibration Curve

Test tube	Conc (mg/ml)	STD (ml)	H2O	1	2	3	Mean
1	0	0	10	0	0	0	0
2	200	2	8	0.43	0.42	0.45	0.43
3	400	4	6	0.991	0.923	0.976	0.96
4	600	6	4	1.640	1.069	1.45	1.39
5	800	8	2	2.133	1.996	1.993	2.04
6	1000	10	0	2.391	2.421	2.32	2.38



Sample Raw Data

Sample	Absorbance (575nm)			DF	Residual Sugar with DF (g/L)			
	1	2	3	1:1	1	2	3	AVG
Coconut Powder	0.325	0.322	0.315	2	290.25	287.75	281.92	286.64
Coconut Sheets	0.320	0.286	0.301	2	286.08	257.75	270.25	271.36
Lychee Powder	0.316	0.266	0.276	2	282.75	241.08	249.42	257.75
Lychee Sheets	0.316	0.289	0.276	2	282.75	260.25	249.42	264.14

Remarks:

Concentration (x) = $\frac{Absorbance - Slope}{Intercept} * Dilution\ Factor$

Where: y (absorbance) = b (intercept) *x (concentration) + a (slope)

ANOVA Table

Coconut

Source	DF	Anova SS	Mean Square	F Value	Pr > F
rep	2	2.62973333	1.31486667	1.49	0.4016
trt	1	3.49606667	3.49606667	3.96	0.1848

Lychee

Source	DF	Anova SS	Mean Square	F Value	Pr > F
rep	2	14.31773333	7.15886667	11.65	0.0790
trt	1	0.61440000	0.61440000	1.00	0.4226

Appendix G: Consumer Test

Liking (%)	Dislike Very Much	5
	Dislike	13
	Fair	24
	Like	38
	Like Very Much	20
Consumption Frequency (%)	Everyday	13
	2-3x/week	24
	1-2x/week	23
	2-3x/month	27
	1x/month	13
When to Consume	Studying	48.41
	Watching TV	32.54
	Drinking	1.59
	Special Occasions	7.14
	Others (Anytime, Working)	10.32
Shop Location	Supermarket	31.6091954
	Convenience Store	49.4252874
	Grocery Store	12.6436782
	Market	5.74712644
	Others	0.57471264
5. favorite kind of candy	Chocolate	36.99
	Hard Candy	23.12
	Gummy Jelly	24.28
	Soft Candy	15.61

Factor (Level of Importance)	Attribute	Mean	SD
	Appearance	4.10	0.87
	Taste	4.54	0.66
	Ingredient	3.60	0.79
	Price	2.94	0.87
	Brand	2.39	1.03
	Packaging	3.19	1.14
	Promotion	2.38	1.07

	Shop location	3.88	0.90
1. Gender	Male	32	
	Female	68	
2. Age	<15 yo	1	
	15-24 yo	85	
	25-34 yo	13	
	35-44 yo	1	
3. Nationality	Thai	78	
	International	22	
4. Income Per Month	<15,000.-	48	
	15,000-25,000.-	17	
	25,001-35,000.-	20	
	35,001-45,000.-	8	
	>45,000.-	7	
5. Price	<50.-	21	
	50.-	33	
	55.-	38	
	>60.-	8	
1. liking	Mean	7.54	
	SD	1.32893213	
Acceptance	Yes	90	
	No	10	
Purchase Intent	Yes	77	
	Maybe	17	
	No	6	
1. liking	Mean	7.58	
	SD	1.16497713	
Acceptance	Yes	89	
	No	11	
Purchase Intent	Yes	76	
	Maybe	14	
	No	10	

Strawberry Jelly Liking	Mean	7.15
	SD	1.20918204
Acceptance	Yes	92
	No	8
Purchase Intent	Yes	76
	Maybe	16
	No	8

Appendix H: Sensory Profile

ANOVA Table

Opacity

Source	DF	Anova SS	Mean Square	F Value	Pr > F
cons	99	485.8758333	4.9078367	1.76	0.0004
trt	2	225.9466667	112.9733333	40.57	<.0001

Fruitiness Aroma

Source	DF	Anova SS	Mean Square	F Value	Pr > F
cons	99	340.3425000	3.4378030	0.94	0.6299
trt	2	56.7150000	28.3575000	7.76	0.0006

Honey Aroma

Source	DF	Anova SS	Mean Square	F Value	Pr > F
cons	99	445.9491667	4.5045370	2.17	<.0001
trt	2	529.2116667	264.6058333	127.23	<.0001

Coconut/Lychee/Strawberry Aroma

Source	DF	Anova SS	Mean Square	F Value	Pr > F
cons	99	625.7291667	6.3204966	1.22	0.1180
trt	2	180.5866667	90.2933333	17.47	<.0001

Firmness

Source	DF	Anova SS	Mean Square	F Value	Pr > F
cons	99	3714.895833	37.524200	1.09	0.2985
trt	2	340.281667	170.140833	4.95	0.0080

Chewiness

Source	DF	Anova SS	Mean Square	F Value	Pr > F
cons	99	427.882500	4.322045	1.50	0.0088
trt	2	1205.146667	602.573333	208.58	<.0001

Springiness

Source	DF	Anova SS	Mean Square	F Value	Pr > F
cons	99	618.7800000	6.2503030	1.00	0.4986
trt	2	498.6816667	249.3408333	39.78	<.0001

Sweetness

Source	DF	Anova SS	Mean Square	F Value	Pr > F
cons	99	636.9366667	6.4337037	1.86	0.0001
trt	2	333.4216667	166.7108333	48.08	<.0001

Sourness

Source	DF	Anova SS	Mean Square	F Value	Pr > F
cons	99	805.1966667	8.1332997	2.43	<.0001
trt	2	362.1066667	181.0533333	54.20	<.0001

Fruitiness Flavor

Source	DF	Anova SS	Mean Square	F Value	Pr > F
cons	99	366.1158333	3.6981397	0.97	0.5672
trt	2	373.0616667	186.5308333	48.80	<.0001

Tartness

Source	DF	Anova SS	Mean Square	F Value	Pr > F
cons	99	996.0625000	10.0612374	3.02	<.0001
trt	2	338.2816667	169.1408333	50.83	<.0001

Honey Flavor

Source	DF	Anova SS	Mean Square	F Value	Pr > F
cons	99	410.7091667	4.1485774	1.89	<.0001
trt	2	977.3116667	488.6558333	222.33	<.0001

Coconut/Lychee/Strawberry Flavor

Source	DF	Anova SS	Mean Square	F Value	Pr > F
cons	99	706.7491667	7.1388805	1.92	<.0001
trt	2	133.9266667	66.9633333	18.01	<.0001

Vinegar

Source	DF	Anova SS	Mean Square	F Value	Pr > F
cons	99	477.1491667	4.8196886	2.36	<.0001
trt	2	36.1666667	18.0833333	8.87	0.0002

LSD Comparison

Opacity

Means with the same letter are not significantly different.			
t Grouping	Mean	N	trt
A	6.6950	100	coco
A			
A	6.3750	100	lych
B	4.7150	100	straw

Fruitiness Aroma

Means with the same letter are not significantly different.			
t Grouping	Mean	N	trt
A	9.4800	100	straw
B	8.9400	100	lych
B			
B	8.4150	100	coco

Honey Aroma

Means with the same letter are not significantly different.			
t Grouping	Mean	N	trt
A	4.5700	100	coco
A			
A	4.2350	100	lych
B	1.6000	100	straw

Coconut/Lychee/Strawberry Aroma

Means with the same letter are not significantly different.			
t Grouping	Mean	N	trt
A	10.2850	100	straw
B	8.7250	100	lych
B			
B	8.5650	100	coco

Firmness

Means with the same letter are not significantly different.				
t Grouping		Mean	N	trt
	A	11.2700	100	straw
	A			
B	A	9.7850	100	lych
B				
B		8.6700	100	coco

Chewiness

Means with the same letter are not significantly different.			
t Grouping	Mean	N	trt
A	11.7150	100	straw
B	7.5350	100	lych
B			
B	7.3950	100	coco

Springiness

Means with the same letter are not significantly different.			
t Grouping	Mean	N	trt
A	10.4650	100	coco
A			
A	10.3300	100	lych
B	7.6650	100	straw

Sweetness

Means with the same letter are not significantly different.			
t Grouping	Mean	N	trt
A	10.9400	100	straw
B	8.8450	100	coco
B			
B	8.5850	100	lych

Sourness

Means with the same letter are not significantly different.			
t Grouping	Mean	N	trt
A	8.7900	100	straw
B	6.4900	100	lych
B			
B	6.4300	100	coco

Fruitiness Flavor

Means with the same letter are not significantly different.			
t Grouping	Mean	N	trt
A	8.7750	100	straw
B	6.4400	100	lych
B			
B	6.3800	100	coco

Tartness

Means with the same letter are not significantly different.			
t Grouping	Mean	N	trt
A	8.8600	100	straw
B	6.6200	100	coco
B			
B	6.5950	100	lych

Honey Flavor

Means with the same letter are not significantly different.			
t Grouping	Mean	N	trt
A	5.3450	100	coco
A			
A	5.2300	100	lych
B	1.4600	100	straw

Coconut/Lychee/Strawberry Aroma

Means with the same letter are not significantly different.			
t Grouping	**Mean**	**N**	**trt**
A	10.9250	100	straw
B	9.6950	100	lych
B			
B	9.3750	100	coco

Vinegar

Means with the same letter are not significantly different.			
t Grouping	**Mean**	**N**	**trt**
A	1.9650	100	coco
A			
A	1.8150	100	lych
B	1.1650	100	straw

Remarks:

Different letters denote significant difference between means ($P<0.05$)

Coco = coconut

Lych = lychee

Straw = strawberry

Trt = treatment