Quality development of osmotic dehydrated Bilimbi (*Averrhoabilimbi Linn.*)

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SPECIAL PROJECT

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Title	:	**Quality development of osmotic dehydrated Bilimbi (*Averrhoabilimbi Linn.)***
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Abstract

This research was aimed to develop osmotic dehydrated Bilimbi *(Averrhoabilimbi* L) by using slow method. Two variations were studied as the amount of salt and concentration of syrup used in the process, based on JAR test. The amount of salt was varied as 70, 80 and 90 g/1000 g of ripen Bilimbi, while the concentrations of syrup variations were 30-40-40, 40-40-50 and 40-50-50 °Bx for 3 days osmotic dehydration at room temperature. The prototype product was produced by mixing ripen Bilimbi with salt 80 g/1 kg of fruit. The fruits were then transferred in to sugar syrup 40°Bx using the ration fruit to syrup as 1:2 for 24 h. After that the fruits were transferred to 40° Bx and 50° Bx sugar syrup for the second and third days, respectively. The Bilimbi fruits were taken from the syrup and rinsed with water for 1 min to get rid of excessive syrup from the surface. The fruits were finally air dried at 50°C. The product had the consumer acceptance as 91% with the price of 20-25 Baht (50%) and the consumers were will buy this product 88%. The prototype product had 13.1% moisture content, 4.1% salt content, 2.6% reducing sugar, 1.4% acidity and pH 4.35.

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Ms. Araya Chanthong

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Introduction

Fruits are important sources of digestible and indigestible minerals, carbohydrates and certain vitamins, particularly vitamins A and C. The moisture in most of the fruits is above 75% and fruits are prone to spoilage by molds and yeasts (Janisiewicz*et al.,* 1999). The essential amounts of vitamins, protein, minerals, dietary fiber and calories that provide the nutritional values are predictable and documented (Salunke*et al.*, 1991). Fruits and vegetables are produced during peak seasons but due to lack of preservation and storage facilities, the market become overstocked during such periods and get rotten prior to reach the final consumer.

Osmotic dehydration of fruits

In modern period, osmotic dehydration is an important intermediate step or pretreatment technology which got much attention in the field of preservation of fruit, such as reducing the consumption of energy and improved the food products quality. Much of work has been done on the kinetics of solute /exchange of water in and out of food tissues (Giraldo*et al.,* 2003), application of vacuum pulse during osmotic treatments and special effects on impregnation time (Mujica-Paz *etal.,* 2002).

Osmotic dehydration (OD) is the most popular method of pretreatment drying for food materials which caused the reduction of energy costs and better the quality of end products (Andres *et al.*, 2007; Ortega- Rivas, 2007). OD is frequently done by immersing the sample in concentrated solutions of salt or sugar. It is to apply in variety of fruits by decreasing the moisture contents up to 30% (Rastogi*etal.*, 2002; Beaudry*et al.*, 2004). The potential of chemical that existed between solution and sample of food which led to transfer mass fluxes, that is why water come out of the sample and solutes entered in to tissue. Since osmotic pressure was dynamic force for transfer of mass, OD was time consuming and slow process (Dhingra*et al.*, 2008; Pardo and Leiva, 2009). As a result, to change the formulation of food system and enabled for further processing (Torregianni and Bertolo, 2001).

Objectives

1. To develop the formula of osmotic dehydrated Bilimbi
2. Find the best formula of osmotic dehydrated Bilimbi

Literature review

1. Bilimbi

Averrhoabilimbi L., commonly known as bilimbi, belongs to the family of the Oxalidaceae. Nevertheless, Corrêa (1926) reported that it is native of India, from where it was brought to Brazil centuries ago. In Brazil, this tree is cultivated in the states of Rio de Janeiro, Amazonas, Pará and Santa Catarina, but the distribution of its fruits is limited. In these places, it is locally known as "bilimbi", "bilimbino", "biri-biri", "caramboleiraamarela" or "limão de caiena".

The tree and fruit are known by different names in different languages. They should not be confused with the carambola, which also share some of the same names despite being very different fruits. *Balimbing* in the Philippines actually refer to carambola and not bilimbi(Pushparaj and Natesan, 2004).

Bilimbi is a small tree up to 15 meters high. Fruits are fairly cylindrical with five broad rounded longitudinal lobes, and produced in cluster. During maturity stage, the maximum increase in fruits weight and dimensions, and their external green color changes into light yellow (Mathew *et al.*, 1993).

Agricultural Practice

Bilimbi fruits of an unidentified variety were harvested at two stages of maturity, subjectively determined by color development: yellowish-green fruits were considered ripe whereas those, which presented a light green hue, were considered half-ripe. The harvests took place during the periods of September to April (dry season) and May to August (rainy season), the average seasonal rainfall of which were the lowest (53.66 mm) and the highest (203.82 mm), respectively *(ESAL/FAEPE, 1990)*

1.2 Health Benefit

Bilimbi is medicinally used as a folk remedy for many symptoms. The fruit is used to reduce cough, phlegm, scurvy and purify blood. Squeeze bilimbi for its juice and drink. Mix the juice with boiled water and add some salt or sugar to lower its sour. Root is very useful to reduce thirsty and treat the apthousulcer. Clean the roots with water then bring them boil. Drink until get better. Leaves are used as a remedy for cough, phlegm, mumps and itch. Wash a handful of bilimbi leaves. Then pound them thoroughly with small boiled water. After that apply this mixture to your mumps twice a day (in the morning and evening)

Table 1: Nutritive value per 100 grams of raw bilimbi

Per 100 grams of edible pulp; edible pulp is 86% of fruit weight *(Coronel, Roberto E. 1983.)*

Proximate (g)	
Water	92.5–94.7
Energy (kcal)	27
Protein	0.61
Lipid (fat)	0.3
Carbohydrate	6.3
Fiber	0.6
Ash	0.3–0.4
Minerals (mg)	
Calcium	3.4–5
Iron	0.6–1.01
Phosphorus	11.1–13
Potassium	130
Sodium	4
Vitamins (mg)	
Ascorbic acid	35
Thiamine	0.010–0.02
Riboflavin	0.026–0.04
Niacin	0.02–0.302
Vitamin A	105 UI

1.3 Product made from Bilimbi

A bilimbi is generally regarded as too acidic for eating raw, but in Costa Rica, the green, uncooked fruits are prepared as a relish which is served with rice and beans or an accompaniment for fish and meat. Ripe fruits are frequently added to curries in the Far East. They yield 44.2% juice having a pH of 4.47, and the juice is popular for making cooling beverages. Mainly, the bilimbi is used in place of mango to make chutney, and it is much preserved. To reduce acidity, it may be first pricked and soaked in water overnight, or soaked in salted water for a shorter time; then it is boiled with much sugar to make a jam or an acid jelly. The latter, in Malaysia, is added to stewed fruits that are oversweet. Half-ripe fruits are salted, set out in the sun, and pickled in brine and can be thus kept for 3 months. A quicker pickle is made by putting the fruits and salt into boiling water. This product can be kept only 4-5 days. The flowers are sometimes preserved with sugar.

2. Osmotic dehydration

2.1History of osmotic dehydration

Pointing and coworkers in 1966 were pioneering the research on OD of foods (Pointing et al., 1966), and since after that a continuous stream of publication was appeared (Rastogi et al., 2002). By using of osmosis process 50% of original weight of fruit was reduced, after that it was subjected to freeze or vacuum dried. Monograph of apple was calculated the drying rate of osmotic dehydration provided by Farkas and Lazar (1969). Vial et al. (1991) and Heng (1990) studied the OD (kinetics) of papaya and kiwi in sucrose and glucose solutions.

The constancy of osmotically processed cherry studied by Torregianni et al. (1987), to analyze the sugar content, color, acidity, vitamin C, pH and organoleptic distinctiveness. The transfer of mass during OD of pineapple was reported by Beristain et al. (1990). Many research papers or review papers were published (Torregianni, 1993) dealing with a variety of parameters, such OD mechanism and modeling of solid gain and water loss (Rastogi et al., 2002).

2.2 Osmotic dehydration of fruits

In modern period, osmotic dehydration is an important intermediate step or pretreatment technology which got much attention in the field of preservation of fruit such as reducing the consumption of energy and improved the food products quality. Much of work has been done on the kinetics of solute /exchange of water in and out of food tissues (Giraldo et al., 2003), application of vacuum pulse during osmotic treatments and special effects on impregnation time (Mujica-Paz et al., 2002).

Osmotic dehydration (OD) was most popular method of pretreatment drying for food materials which caused the reduction of energy costs and better the quality of end products (Andres et al., 2007; Ortega- Rivas, 2007). OD was frequently done by immersing the sample in concentrated solutions of salt or sugar. It was to apply in variety of fruits by decreasing the moisture contents up to 30% (Rastogi et al., 2002; Beaudry et al., 2004). The potential of chemical that existed between solution and sample of food which led to transfer mass fluxes, that's why water come out of the sample and solutes entered in to tissue. Since osmotic pressure was dynamic force for transfer of mass, OD was time consuming and slow process (Dhingra et al., 2008; Pardo and Leiva, 2009). As a result, to change the formulation of food system and enabled for further processing (Torregianni and Bertolo, 2001).

In sucrose solution, the osmotic dehydration of mango subjected by temperature (30–50°C), immersion time (60–150 min) and concentration of solution (40–60% w/ w) was studied. The water loss was maximum and incorporation of solid was minimum to get the product similarity with non-processed fruit. Removal of water up to 25% with less than 6% solid uptake could be possible if condition was suitable by using sucrose 44% (w / w) solution, temperatures (38°C) and processing time up to 80 min (Azoabell and Francinaide, 2008).

Osmotic dehydration of Andes berry and tamarillo by using of three different osmotic agents: sucrose (70%), sucrose (70%)-glycerol (65%) 1:1 and ethanol. Water activity in fruits was lowered and promoted the constituents of flavor and moving of anthocyanins to somotic solution by using of this practice (Osorio et al., 2007). The loss of water and solid gain was caused by the application of osmotic treatments. The most helpful effect of osmotic dehydration was on lycopene, ascorbic acid and on the color quality. The result of osmotic pretreatment enhanced constancy of frozen product and extended shelf life (Olatidoye et al., 2010).

The pigments, flavor precursors and volatile compounds were transferred from fruit to osmotic solution. It was suggested that osmotic syrups can be effectively applied to natural additives in food and pharmaceutical industry (Morales et al., 2005). Mango slices were applied to osmotic dehydration in different hypertonic solutions of sucrose and glucose at three different temperatures (30, 50 and 60°C) to devoid of agitation (NgoranEssanBlaZita et al., 2009).

The mechanical response of mango was studied by using of 45 and 65°Brix as osmotic treatments which consisted of calcium lactate at different concentrations (0%, 1% and 2%), at the start of process, the vacuum pulse was applied. Dehydrated mango samples at 30°Brix were characterized as mechanical properties such as sugar and gain of calcium, loss of water and changes were done during treatments. Through compression test, mechanical properties were measured which effected by treatment conditions. At 2% concentration of osmotic solutions was influenced of calcium on mechanical properties by using 45°Brix of sucrose and vacuum pulse and promoted the calcium and solute gain. The samples become firmer, shorter and stiffer. Gain of calcium in the tissue particularly explained the mechanical changes but concentration and structural profile which developed in the tissue also promoted to the mechanical pattern (Torres et al., 2006).

The reduction of weight (WL %), loss of water (WR %) and solute (sugar) gain (SG %) were observed in osmotic dehydration of mango slices. The phenomena of mass transfer were affected by temperature and process time. Temperature and process time were different from the range of 40 to 120 minutes and 30 to 50°C respectively (Gabriela et al., 2004). Osmotic dehydration process was done to increase the final quality of product. This pretreatment was done on banana and tomato rings, which helped to study of kinetics of osmotic dehydration, color properties and organoleptic evaluations. The results showed that much reduction of weight when 100% sucrose used as osmotic agent in banana. The tomato showed the highest values when 30% NaCl and sucrose: salt (1: 1.5) were used. The osmotic dehydration of tomato showed the lower chroma (C*) and redness values (a*) during osmotic dehydration (Ali et al., 2010).

2.3 Mechanism of osmotic dehydration

Osmotic treatment was done on the basis of minimum dehydration for food. The base of osmotic treatment was osmosis, physical phenomena motivated by variation in solute concentration of two regions which separated or divided by semi-permeable membrane, causing the water movement from low solute to higher solute concentration region with the help of membrane. When water consists of cellular tissue was wrapped in solution of hypertonic which low in molecular substances such as salts and sugars. The movement of solutes from solution to material and it dependent on difference of concentration between food material and solution which gave up two simultaneous counter flows and water outflow from material to solution (Shi and Le Maguer, 2003).

It dependent on the nature of nonselective cell membrane, the own soluble constitutes of product such as sugars, organic acids and minerals also traveled to the product along with outward stream of water. That's why this movement may be quantitatively unimportant to major types of mass transfer; it may be much resemblance with nutritional and sensory attributes of final quality of the product (Raoult-Wack, 1994; Azoubel and Murr, 2002; Sunjka and Raghavan, 2004). Transfer of mass continued till equilibrium osmotic dehydration was achieved. It was recommended that through capillary flow and diffusion, removal of water took place whereas uptake of solute to the product and leaching of the soluble solids of the product were only took place through diffusion (Shi et al., 2009).

During osmotic treatment, food particles consisted of two phase behaviors in term of water and transfer of solutes. The dewatering of food material was well known to take place in high rate require more than few hours. After first several hours the rate of water loss slowly decreased in succeeding hours (6 hours) and finally flattens out. On the other way, solute impregnation into material was insignificant at the start of osmotic treatment, when dewatering rate was become lower then increased the solute rate into the material (Raoult-Wack, 1994). Early work on the osmotic treatment of food material was reported by Ponting et al. (1966), who explained the process as a moderate, non-thermal means of dehydration to generate good quality dehydrated fruit while decreased the original weight of the fruit to 50 % and preserved flavor and color.

On the basis of their pioneering work, osmotic treatment has attracted much attraction as practical processing method for fruits and vegetables. Although osmotic treatment has not much popular in the food of animal origin such as fish and meat.

It should be clarified that osmotic behaviors of plant and animal were entirely different in terms of compositions and structures. This review was based only for the osmotic treatment of fruits and vegetables. Collignan et al. (2001) provided the review of literature on osmotic treatment of meat and fish products.

Osmotic treatment has many advantages over conventional methods; much of them include its mechanical simplicity, processed flexibility, and decreased the cost of energy because without any change, water can be removed. This process was done at room temperature to avoid the degradation of color, texture and nutritional values of the food. In this process loss of volatile compounds and oxidative changes was lowered (Raoult-Wack, 1994; Marani et al., 2007).

Materials and Methods

1. Preliminary experiment for formulation development of dried Bilimbi

Preparation of osmotic dehydrated Bilimbi

Osmotic dehydrated Bilimbi was produced by slow osmotic dehydration method. Ripen bilimbi (1000 g) was mixed with 70 g of salt to reduce the sourness of fruit and then transferred to immerse in 30° Bx sugar syrup using the ratio of fruit to syrup as 1:2 for 24 h. After that the fruits were transferred to 40° Bx and 40° Bx sugar syrup for the second and third days, respectively. The Bilimbi fruits were taken from the syrup and rinsed with water for 1 min to get rid of excessive syrup from the surface. The fruits were finally air dried at 50°C until the constant weight obtained, cooled and then packed in the airtight container for further experiment.

Just About Right Test

The dried Bilimbi was sensory analyzed by using Just About Right test and 30 panelists.

2. Development of formula for dried Bilimbi production

According to the results from JAR in section 3.1, there were 4 attributes adjusted, which were color, sweetness, sourness and saltiness, resulting in the adjustment of the amount of salt and sugar used in osmotic dehydration process.

Variation of salt

The amount of salt used in the process had positively effect on saltiness and negatively effect on sourness attributes of the dried Bilimbi. JAR result showed that the amount of salt used in the preliminary step was lower than just right level; therefore, the amount of salt used was varied as 70, 80 and 90 g for 1000 g of ripen Bilimbi. Then, the fruits were transferred to immerse in 30° Bx sugar syrup using the ratio of fruit to syrup as 1:2 for 24 h. After that the fruits were transferred to 40° Bx and 40° Bx sugar syrup for the second and third days, respectively. The Bilimbi fruits were taken from the syrup and rinsed with water for 1 min to get rid of excessive syrup from the surface. The fruits were finally air dried at 50°C until the constant weight obtained, cooled and then packed in the airtight container for sensory evaluation using 9-point hedonic scale and 30 panelists.

Variation of sugar syrup concentration

The concentration of sugar syrup also influenced to the sweetness and color of the dried Bilimbi. JAR result showed that the sweetness of the finished product in the preliminary step was lower than just right level and based on the result from variation of salt, 1000 g of ripen Bilimbi were mixed with 80 g of salt. The fruits were transferred to immerse in sets of sugar syrup separately as Treatment A (30, 40 and 40°Bx), Treatment B (40, 40 and 50°Bx) and Treatment C (40, 50 and 50°Bx) for 3 day osmotic dehydration process, respectively, using the ratio of fruit to syrup as 1:2. The Bilimbi fruits were then taken from the syrup and rinsed with water for 1 min to get rid of excessive syrup from the surface. The fruits were finally air dried at 50°C until the constant weight obtained, cooled and then packed in the airtight container for sensory evaluation using 9-moint hedonic scale and 30 panelists.

3 Consumer acceptances

Production of osmotic dehydrated Bilimbi

According to the result obtained from section 3.2, the osmotic dehydrated Bilmbi was produced by mixing 1000 g of ripen Bilimbi with 80 g of salt to reduce sourness of fruits and then transferred to immerse in 40° Bx sugar syrup using the ratio of fruit to syrup as 1:2 for 24 h. After that the fruits were transferred to 40° Bx and 50° Bx sugar syrup for the second and third days, respectively. The Bilimbi fruits were taken from the syrup and rinsed with water for 1 min to get rid of excessive syrup from the surface. The fruits were finally air dried at 50°C until the constant weight obtained, cooled and then packed in the airtight container for further experiment.

Consumer acceptance test

The consumer acceptance was conducted in three public places of Bangkok. Two hundred consumers were voluntarily selected without compensation. They were asked to answer a questionnaire and scored the products based on their preferences.

4 Chemical analysis of osmotic dehydrated Bilimbi

Moisture Content

Moisture content is one of the most commonly measured properties of food materials. It is important to food scientists for a number of different reasons. One of them is to indicate the food quality. The texture, taste, appearance and stability of foods depend on the amount of water they contain. Despite having the same chemical formula (H_2O) the water molecules in a food may be present in a variety of different molecular environments depending on their interaction with the surrounding molecules. The water molecules in these different environments normally have different physiochemical properties which are bound water, absorbed water and free water. Foods are heterogeneous materials that contain different proportions of chemically bound, physically bound, capillary, trapped or bulk water. In addition, foods may contain water that is present in different physical states: gas, liquid or solid. The fact that water molecules can exist in a number of different molecular environments, with different physicochemical properties, can be problematic for the food analyst trying to accurately determine the moisture content of foods.

Drying method is a mass transfer process consisting of the removal of water moisture or moisture from another solvent, by evaporation from a solid, semi-solid or liquid. When water in food is evaporated to dryness, it leaves a residue. All of the materials forming this residue are grouped together under the term total solids.

$$\% \text{ Moisture content} = \frac{\text{Weight loss}}{\text{Weight of sample}} \times 100\%$$

Salt Content

Salt is a kind of compound that produced from neutralization of acid, when it is reacted the ion will be exchanged and causes the acid to be neutralized. Which mean that it is ionic compound that compose of cation and anion such as chloride, acetate, fluoride and sulfate.

There are many kind of salt. The first one is basic salt, this kind of salt will produce hydroxide ions when it is dissolved in water. Second one is acid salt, this kind of salt will produce hydronium ion in water. The third one is neutral salt. This kind of salt are not acid or basic but it contain anionic center and cationic center which could be called "zwitterions".

Evaluation of salt concentration (sodium chloride) present in foodstuffs is very important mainly for the reason of preservation and taste of the food products. Total chloride in the food is usually determined and can be presented as sodium chloride content.

$$\% \text{ Salt content} = \frac{T \times N \times 0.05845 \times 100}{V}$$

Reducing Sugars

The Lane-Eynon method is an example of a titration method of determining the concentration of reducing sugars in a sample. A burette is used to add the carbohydrate solution being analyzed to a flask containing a known amount of boiling copper sulfate solution and a methylene blue indicator. The reducing sugars in the carbohydrate solution react with the copper sulfate present in the flask. Once all the copper sulfate in solution has reacted, any further addition of reducing sugars causes the indicator to change from blue to white. The volume of sugar solution required to reach the end point is recorded. The reaction is not stoichiometric, which means that it is necessary to prepare a calibration curve by carrying out the experiment with a series of standard solutions of known carbohydrate concentration

Acidity

Acidity in food can be expressed in these ways:

- Total titratable acidity (TTA) is reported as the predominant acid contained in the sample.
- Volatile acidity (VA) is the acid that vaporized out of the sample at room temperature or high temperature.
- Fixed acidity (FA) is the acid that remains in the sample after evaporating of the volatile acid away from the sample.
- pH is defined as log of number of a solution contained 1-gram equivalent of hydrogen ion.

5. Statistical analysis

A randomized block design with 3 replications was used in this experiment. The mean comparison was performed by using Duncant's Multiple Range Test at 95% confidential level.

Result and Discussion

1. Preliminary test

Osmotic dehydrated Bilimbi was produced by using slow osmotic dehydration method. Ripen bilimbi (1000 g) was mixed with 70 g of salt to reduce the sourness of fruit and then transferred to immerse in 30° Bx sugar syrup for 24 h. After that the fruits were transferred to 40° Bx and 40° Bx sugar syrup for the second and third days, respectively. The Bilimbi fruits were taken from the syrup and rinsed with water for 1 min to get rid of excessive syrup from the surface. The fruits were finally air dried at 50°C until the constant weight obtained, cooled and then packed in the airtight container for Just About Right Test using 30 panelists. Four attributes, as color, texture, sweetness, sourness and saltiness, were evaluated. The result was shown in Table 2.

Table 2: Sensory evaluation of osmotic dehydrated Bilimbi by using Just About Right test (n=30)

Attribute	Much too week	Little too week	Just right	Little too strong	Much too strong
Color	10.0	16.7	40.0	26.7	6.7
Texture	0.0	6.7	76.7	10.0	6.7
Sweetness	6.7	33.3	40.0	20.0	0.0
Sourness	6.7	10.0	46.7	26.7	10.0
Saltiness	10.0	30.0	50.0	10.0	0.0

It was noticed that all attributes except texture received the percentage of just right $\leq$ 50%, resulting in the adjustment of the amount of salt and sugar used in osmotic dehydration process.

2. Development of formula for dried Bilimbi production

Variation of salt

The amount of salt used in the process had positively effect on saltiness and negatively effect on sourness attributes of the dried Bilimbi. The amount of salt used was varied as 70, 80 and 90 g for 1000 g of ripen Bilimbi. Then, the fruits were transferred to immerse in 30° Bx sugar syrup for 24 h. After that the fruits were transferred to 40° Bx and 40° Bx sugar syrup for the second and third days, respectively. The Bilimbi fruits were taken from the syrup and rinsed with water for 1 min to get rid of excessive syrup from the surface. The fruits were finally air dried at 50°C until the constant weight obtained, cooled and then packed in the airtight container for sensory evaluation using 9-point hedonic scale and 30 panelists. The result was shown in Table 3.

Table 3: Preference scores of osmotic dehydrated Bilimbi produced by using different amounts of salt (n=30)

Attributes	Amount of salt (g)		
	70	**80**	**90**
Overall	6.1^{a*}	6.6^{a}	6.1^{a}
Color	5.9^{b}	5.9^{b}	6.3^{a}
Texture	6.0^{a}	6.1^{a}	6.2^{a}
Flavor	6.2^{ab}	6.6^{a}	5.9^{b}
Sweetness	6.1^{ab}	6.5^{a}	5.9^{b}
Sourness	5.9^{ab}	6.2^{a}	5.8^{b}

* Same letters mean no significant difference at 95% confidential level.

It was observed that there were significantly ($p<0.05$) different in all attributes except texture and overall preference. Dried Bilimbi produced by using 80 g salt obtained the highest scores in flavor, sweetness and sourness as 6.6, 6.5 and 6.2, respectively, followed by that of 70 g. This indicated that increasing the amount of salt enhanced the preference scores of flavor, sweetness and sourness. This might be caused that salt can boost sweet taste perception (Gray, 2011). Gray N. 2011. Study suggests why salt can boost sweet taste perception. www.foodnavigator.com. Access date: 18 March 2014 Moreover, the sodium ion from salt reacts with the malic and citric acids present in fruit to form neutral sodium salts. Acids normally have a tart or sour taste but when they are converted into neutral compounds they lose this sourness, and so the fruit tastes sweeter.

On the other hand, too much salt (90 g) gave the lowest preference scores of flavour, sweetness and sourness due to too high salty taste, although it provided the highest score of colour as 6.3. Therefore, 80 g of salt was chosen for the further experiment.

Variation of sugar syrup concentration

The concentration of sugar syrup also influenced to the sweetness and color of the dried Bilimbi. Ripen Bilimbi (1000 g) were mixed with 80 g of salt. The fruits were transferred to immerse in sets of sugar syrup separately as Treatment A (30, 40 and 40°Bx), Treatment B (40, 40 and 50°Bx) and Treatment C (40, 50 and 50°Bx) for 3 day osmotic dehydration process, respectively. The Bilimbi fruits were then taken from the syrup and rinsed with water for 1 min to get rid of excessive syrup from the surface. The fruits were finally air dried at 50°C. The sensory evaluation result was shown in Table 4.

Table 4: Preference scores of osmotic dehydrated Bilimbi produced by using different concentration of sugar syrup (n=30)

Attributes	Treatment		
	(30, 40 and 40°Bx)	(40, 40 and 50°Bx)	(40, 50 and 50°Bx)
Overall	6.4^{ab*}	6.8^{a}	6.4^{b}
Color	6.1^{b}	6.1^{b}	6.4^{a}
Texture	6.3^{b}	6.5^{a}	6.5^{a}
Flavor	6.5^{b}	6.8^{a}	6.4^{b}
Sweetness	6.3^{b}	6.7^{a}	6.0^{b}
Sourness	6.0^{a}	6.1^{a}	6.1^{a}

* Same letters mean no significant difference at 95% confidential level.

It was recognized that all attributes except sourness were significantly ($p<0.05$) difference. Treatment B obtained the highest scores as 6.8, 6.5, 6.8 and 6.7 for overall, texture, flavor and sweetness, respectively, whereas Treatment C had the highest score for color as 6.4. This probably caused by high sugar concentration (40, 50 and 50°C) used, compared to other treatments, resulting in low brown color development during drying process. Moreover, there was no significant difference between treatments B and C in texture attribute. Therefore, Treatment B was chosen for consumer acceptance test.

3. Consumer acceptance

One hundred consumers were voluntary participated in the consumer acceptance test. Consumer demographic is shown in Figure 1. Consumers participated in this test were 32% male and 68% female.

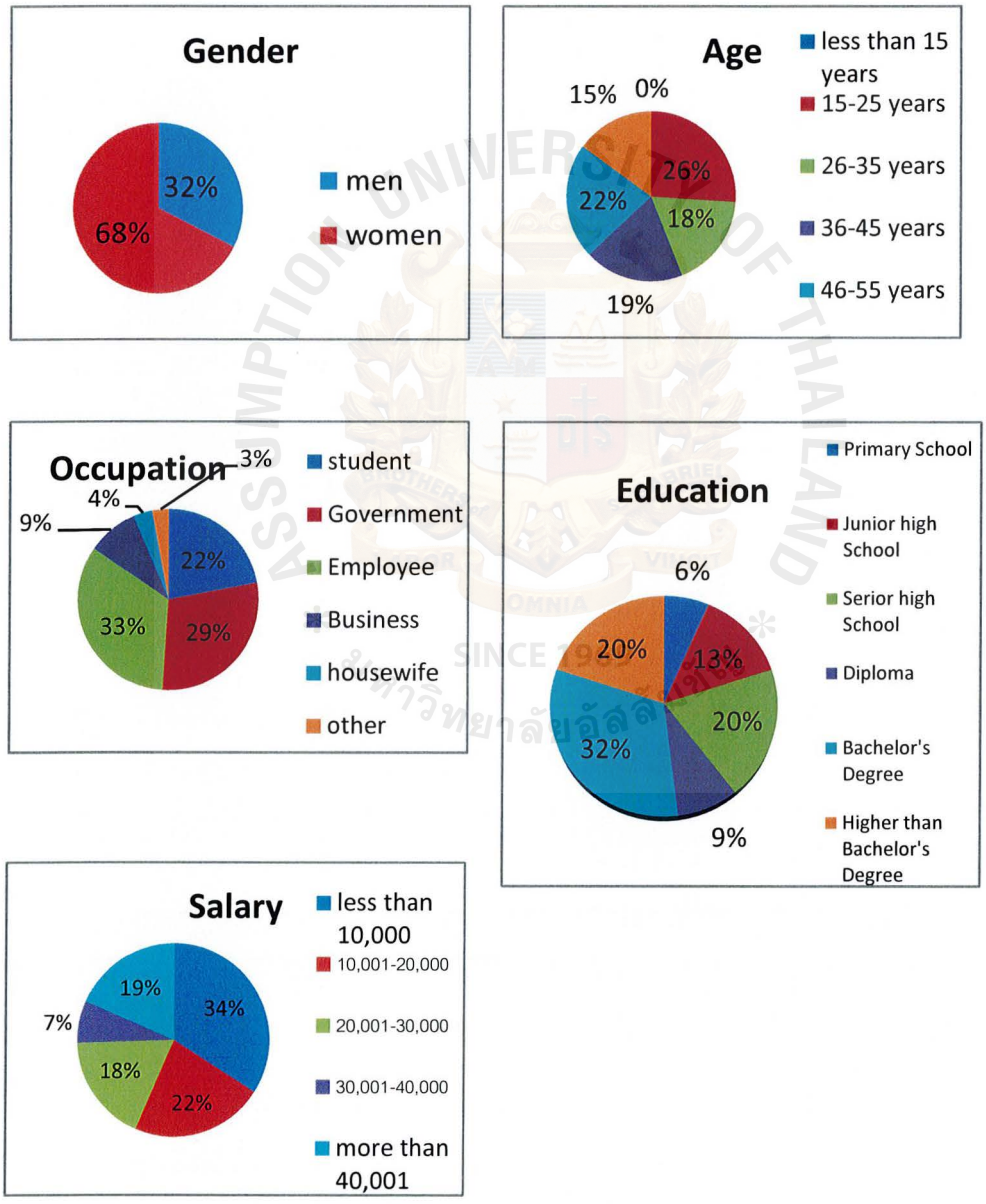

Figure 1: Consumer demographic (n=200)

The majority of the consumers had the age from 15-25 years old, 28%, followed by 26-35 years old (18%) belonging to working class found in Business Officer. The remaining were 19% from 36-45 years old, 22% from 46-55 years old belonging to working class found in Government Office, and 15% of more than 55 years old. The majority of the consumers had the bachelor's degree at 32% follow by higher than bachelor's degree and senior high school at 20%. The top two of occupations of consumer were employee and government 33% and 29%. Their salaries are less than 10,000 baht.

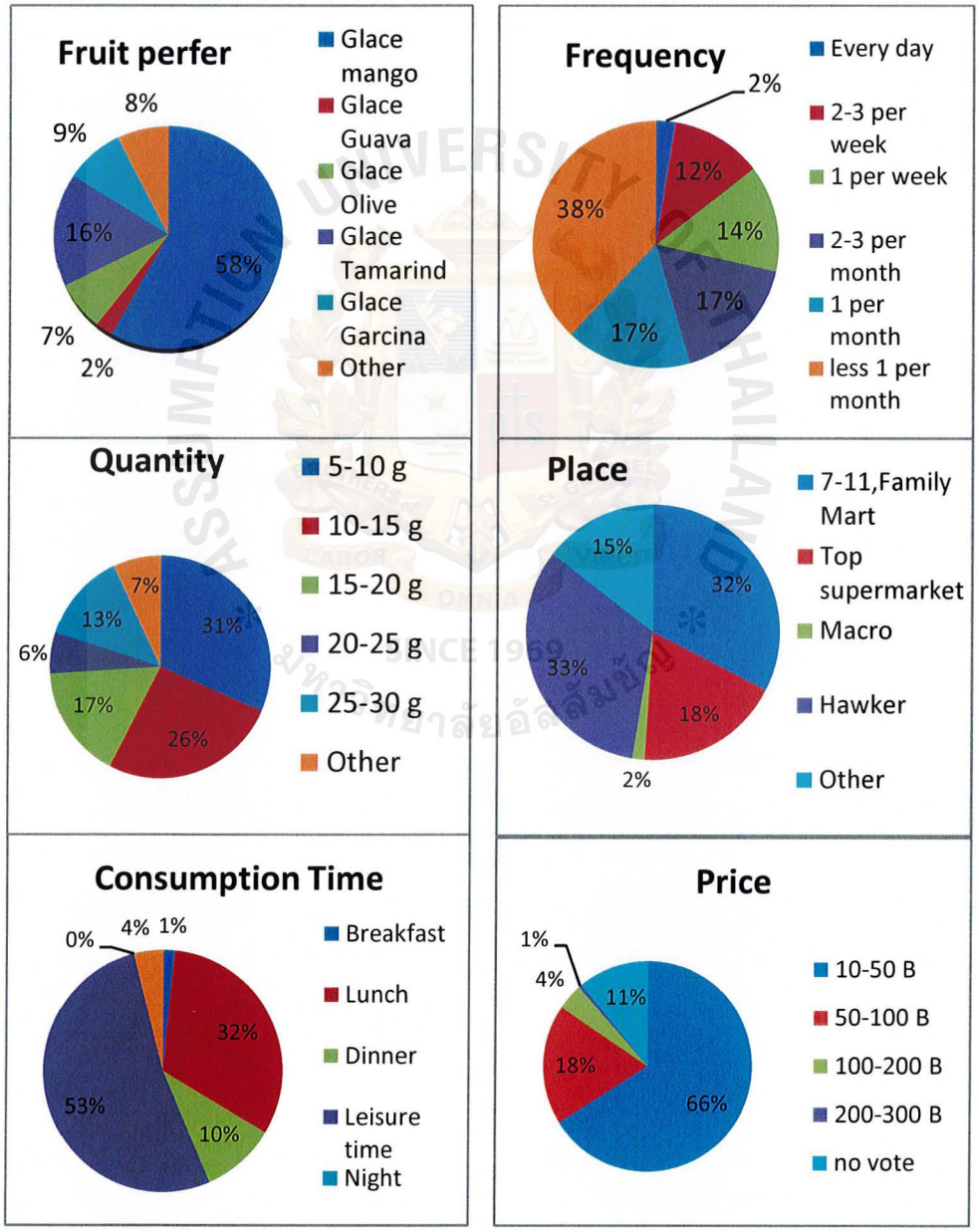

Figure 2: Consumption behavior of consumers (n = 200)

Glace fruit consumption behavior was also investigated and the result was shown in Figure 2.

The most consumer's behavior consume on fruit glace is mango. The frequency of consume glace fruit on less than 1 time per month and also 1-3 times per month. The quantity of glace fruit that consumer prefer per time about 5-10g. Their mostly like to buy at hawker and 7-11 at 33%. They also like to consume on leisure time at 53%. The prefer price around 10-50 baht.

For consumer preference of the product, it was noticed that 91% of consumers accepted the osmotic dehydrated Bilimbi, with the price of 20-25 Baht (50%). Moreover, 88% of consumers decided to buy this product (Figure 3).

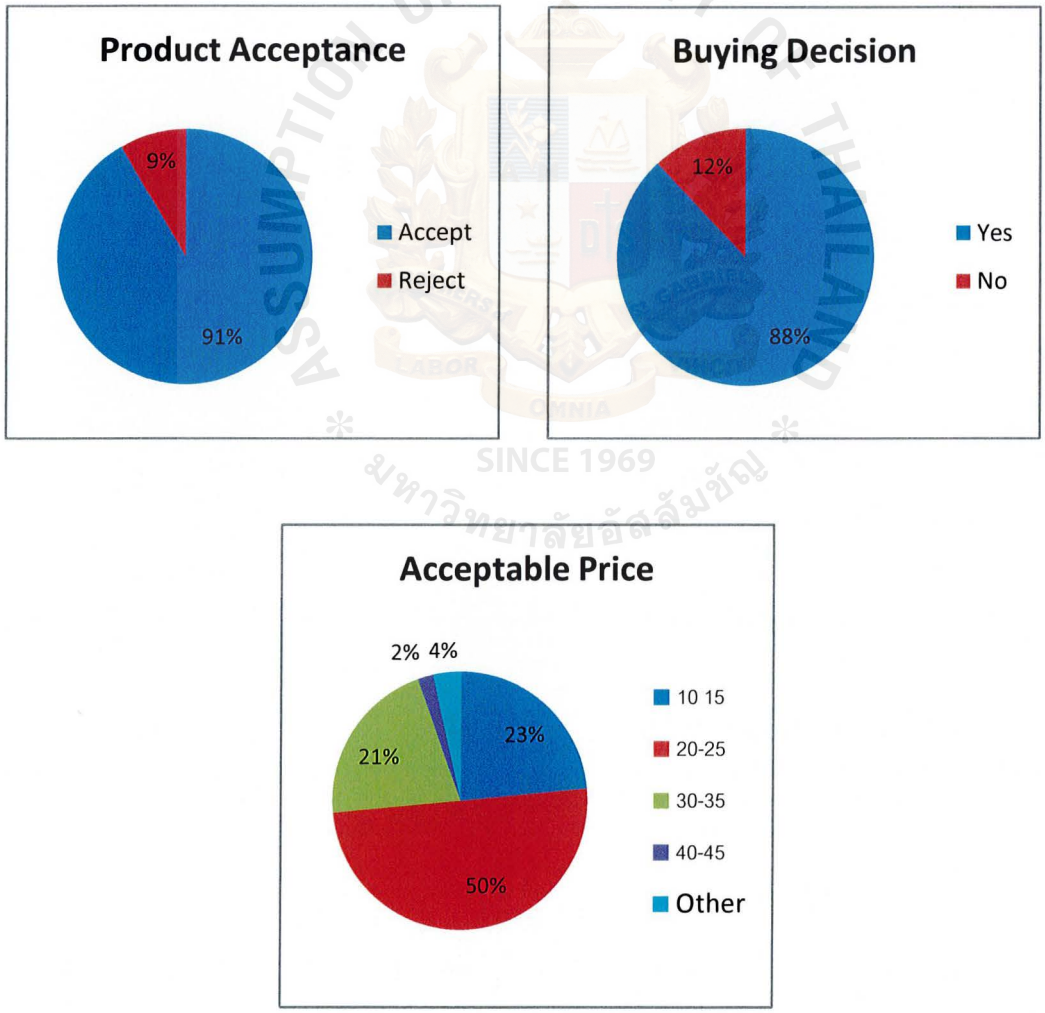

Figure 3: Consumer acceptance (n=200)

In addition, this product received the preference score of 6.7, indicating that consumers moderately like this product (Table 5).

Table 5: Overall liking score of prototype product

Liking score	Frequency	%
1	1	0.5
2	2	1
3	3	3.5
4	1	0.5
5	32	16
6	27	13.5
7	80	40
8	40	20
9	14	7

4. Some chemical properties of osmotic dehydrated Bilimbi

Some chemical properties of osmotic dehydrated Bilimbi were also investigated and the results were shown in Table 6. The prototype product had 13.1% moisture content, 4.1% salt content, 2.6% reducing sugar, 1.4% acidity and pH 4.35.

Table 6: Some chemical properties of osmotic dehydrated Bilimbi

Composition	Value
Moisture content (%)	13.1
Salt content (%)	4.1
Reducing sugar (%)	2.6
Acidity (%)	1.4
pH	4.3

Conclusion

To produce osmotic dehydrated bilimbi, ripen Bilimbi fruits *(Averrhoabilimbi* L) were mixed with salt 80 g/1 kg of fruit. The fruits were then transferred in to sugar syrup 40°Bx using the ration fruit to syrup as 1:2 for 24 h. After that the fruits were transferred to 40° Bx and 50° Bx sugar syrup for the second and third days, respectively. The Bilimbi fruits were taken from the syrup and rinsed with water for 1 min to get rid of excessive syrup from the surface. The fruits were finally air dried at 50°C. The product had the consumer acceptance as 91% with the price of 20-25 Baht (50%) and the consumers were will buy this product 88%. The prototype product had 13.1% moisture content, 4.1% salt content, 2.6% reducing sugar, 1.4% acidity and pH 4.35.

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Appendix A: Questionnaires

Just About Right Test

Name: _____

Please indicate (✓) your opinion about the following characteristics of dried Bilimbi.

Attribute	Much too week	Little too week	Just right	Little too strong	Much too strong
Color					
Texture					
Sweetness					
Sourness					
Saltiness					

Comment:

_____

_____

9-point Hedonic scale

Panel # ..... **Date:**
.....

Instruction: Please rate each attribute of dehydrated Bilimbi using 9-point Hedonic scale as follow

9	**Like Extremely**	4	**Dislike Slightly**
8	**Like Very Much**	3	**Dislike Moderately**
7	**Like Moderately**	2	**Dislike Very Much**
6	**Like Slightly**	1	**Dislike Extremely**
5	**Neither like nor dislike**		

Attribute	172	439	985
Over All			
Color			
Texture			
Flavor			
Sweetness			
Sourness			

Comment:.....
.....
.....

Consumers' Acceptance Survey

แบบสอบถามการยอมรับของผู้บริโภค

ผลิตภัณฑ์ : **ตะลิงปิงแช่อิ่มอบแห้ง**

แบบสอบถามชุดนี้เป็นส่วนหนึ่งของวิชาปัญหาพิเศษFT 4190 หลักสูตรปริญญาตรีคณะเทคโนโลยีชีวภาพมหาวิทยาลัยอัสสัมชัญ

ส่วนที่ 1 ข้อมูลทั่วไปของผู้บริโภค

โปรดทำเครื่องหมาย✔หน้าข้อความที่ท่านเห็นว่าตรงกับคำตอบของท่านเพียงคำตอบเดียว

1. เพศ: _____ชาย _____หญิง
2. อายุ: _____น้อยกว่า 15 ปี _____15 – 25 ปี _____ 26 – 35 ปี
   _____36 – 45 ปี _____ 46 – 55 ปี _____ มากกว่า 55 ปี
3. สถานภาพสมรส: _____โสด_____สมรส_____หย่าร้าง/หม้าย
4. ระดับการศึกษา:
   _____ประถมศึกษา_____มัธยมศึกษาตอนต้น/ปวช
   _____มัธยมศึกษาตอนปลาย/ปวส _____อนุปริญญา
   _____ปริญญาตรี _____สูงกว่าปริญญาตรี
5. อาชีพ:
   _____นักเรียนนักศึกษา _____ข้าราชการ/รัฐวิสาหกิจ
   _____ลูกจ้างทั่วไป/พนักงานบริษัท _____ค้าขาย/ธุรกิจส่วนตัว
   _____พ่อบ้านแม่บ้าน _____อื่นๆ(_____)
6. รายได้เฉลี่ยต่อเดือน
   _____ต่ำกว่า 10,000 บาท _____10,001 – 20,000 บาท
   _____20,001 – 30,000 บาท _____ 30,001 – 40,000 บาท
   _____มากกว่า 40,001 บาทขึ้นไป

ส่วนที่ 2 ข้อมูลพื้นฐานการบริโภคผลไม้แช่อิ่ม

โปรดทำเครื่องหมาย✓หน้าข้อความที่ท่านเห็นว่าตรงกับคำตอบของท่านเพียงคำตอบเดียว

7. ผลไม้แช่อิ่มชนิดใดที่ท่านนิยมทาน

☐ มะม่วงแช่อิ่ม ☐ฝรั่งแช่อิ่ม ☐มะกอกแช่อิ่ม

☐มะขามแช่อิ่ม ☐มะดันแช่อิ่ม ☐อื่นโปรดระบุ .....

8. ความถี่ในการบริโภคผลไม้แช่อิ่มของท่าน

☐ ทุกวัน ☐ 2 – 3 ครั้งต่อสัปดาห์ ☐ 1 ครั้งต่อสัปดาห์

☐ 2 – 3 ครั้งต่อเดือน ☐ 1 ครั้งต่อเดือน ☐น้อยกว่า 1 ครั้งต่อเดือน

9. ปริมาณผลไม้แช่อิ่มที่ท่านรับประทานต่อครั้ง

☐ 5-10 กรัม ☐10-15 กรัม ☐15-20 กรัม

☐20-25 กรัม ☐25-30 กรัม ☐อื่นโปรดระบุ

10. สถานที่ที่ท่านซื้อผลไม้แช่อิ่ม

☐ร้านสะดวกซื้อ (7-11, Family Mart) ☐ซูเปอร์มาร์เก็ต (Tops Supermarket, อื่นๆ)

☐ไฮเปอร์มาร์ (Macro) ☐ร้านรถเข็นข้างทาง

☐อื่นๆโปรดระบุ .....

11. จำนวนเงินที่ท่านใช้จ่ายในการซื้อผลไม้แช่อิ่มโดยเฉลี่ย .....

12. เวลาที่ท่านรับประทานผลไม้แช่อิ่ม

☐เช้า ☐กลางวัน ☐เย็น

☐เวลาว่าง ☐กลางคืน ☐อื่นๆ

ส่วนที่ 3 ข้อมูลพฤติกรรมของผู้บริโภคต่อตะลิงปิงแช่อิ่มอมแห้ง

14. กรุณาประเมินความชอบต่อผลิตภัณฑ์ตามเกณฑ์ต่อไปนี้

9 – ชอบมากที่สุด 8 – ชอบมาก 7 – ชอบปานกลาง

6 – ชอบเล็กน้อย 5 – เฉยๆ 4 – ไม่ชอบเล็กน้อย

3 – ไม่ชอบปานกลาง 2 – ไม่ชอบมาก 1 – ไม่ชอบมากที่สุด

คะแนน : .....

15. ท่านยอมรับผลิตภัณฑ์นี้หรือไม่

☐ยอมรับ ☐ไม่ยอมรับ

16. ท่านจะซื้อผลิตภัณฑ์นี้หรือไม่ถ้ามีการขายในท้องตลาดด้วยราคาที่เหมาะสม

☐ซื้อ ☐ไม่ซื้อเพราะ .....

17. ราคาที่เหมาะสมกับผลิตภัณฑ์30กรัม

☐ 10 – 15 บาท ☐ 20 – 25 บาท ☐ 30 – 35 บาท

☐40 – 45 บาท ☐อื่นๆโปรดระบุ .....

ขอขอบพระคุณในความร่วมมือมาณที่นี้

Appendix I: Statistical Analysis

Consumer acceptance survey

Part I Demographic of consumers

Sex	
Female	135
Male	65

Age	
< 15 year	0
15 – 25 year	52
26 – 35 year	36
36 – 45 year	38
46 – 55 year	44
> 55 year	30

Marriage status	
Divorced	13
Married	63
Single	124

Education	
Primary School	13
Junior high School	27
Senior high School	39
Diploma	17
Bachelor's Degree	64
Higher than Bachelor's Degree	40

Career	
Student	44
Employee	67
Domestic housewife	7
Governmental officer	58
Business	18
Others	6

Average income per month	
<10,000฿	68
10,001 - 20,000฿	45
20,001 - 30,000฿	36
30,001 - 40,000฿	12
>40,001฿	37

Part II Consumers' buying behavior

Bread brand	
Glace mango	116
Glace Guava	5
Glace Olive	14
Glace Tamarind	33
Glace Garcina	17
Other	15

Frequency of consumption	
Every day	5
2-3 per week	24
1 per week	28
2-3 per month	34
1 per month	33
less 1 per month	76

Consumption quantity per time	
5-10 g	63
10-15 g	52
15-20 g	33
20-25 g	12
Other	14

Buying place	
7-11,Family Mart	65
Top supermarket	37
Macro	3
Hawker	66
Other	29

Consumption time	
Breakfast	3
Lunch	64
Dinner	20
Leisure time	105
Night	0
Other	8

Part III Consumers' buying intension

Consumer acceptance of the product	
Accept	183
Reject	17

Consumer willingness to buy the product	
Yes	176
No	24

Price of 10 slices or 250 gram	
10 15	47
20-25	100
30-35	42
40-45	4
Other	7

Appendix II

ANOVA TABLE

Frist Time

1. Color

Level of Trial	N	Mean	StdDev
		----------CO----------	
1	2	5.90000000	0.56568542
2	2	5.90000000	0.56568542
3	2	6.25000000	0.63639610

2. Flavor

Level of Trial	N	Mean	StdDev
		----------FL----------	
1	2	6.20000000	0.70710678
2	2	6.60000000	0.56568542
3	2	5.85000000	0.35355339

3. Overall

Level of		----------OV----------	
Trial	N	Mean	StdDev
1	2	6.10000000	0.70710678
2	2	6.55000000	0.77781746
3	2	6.10000000	0.14142136

4. Sourness

Level of		----------SO----------	
Trial	N	Mean	StdDev
1	2	5.90000000	0.42426407
2	2	6.20000000	0.28284271
3	2	5.80000000	0.28284271

5. Sweetness

Level of		----------SW----------	
Trial	N	Mean	StdDev
1	2	6.05000000	0.35355339
2	2	6.50000000	0.42426407
3	2	5.90000000	0.56568542

6. Texture

Level of		----------TE----------	
Trial	N	Mean	StdDev
1	2	6.00000000	0.42426407
2	2	6.10000000	0.56568542
3	2	6.20000000	0.28284271

Second Time

1. Color

Level of Trial	N	CO Mean	CO StdDev
1	2	6.05000000	0.07071068
2	2	6.10000000	0.28284271
3	2	6.35000000	0.21213203

2. Flavor

Level of Trial	N	FL Mean	FL StdDev
1	2	6.45000000	0.07071068
2	2	6.80000000	0.00000000
3	2	6.35000000	0.35355339

3. Overall

Level of Trial	N	OV Mean	OV StdDev
1	2	6.40000000	0.00000000
2	2	6.80000000	0.42426407
3	2	6.35000000	0.49497475

4. Sourness

Level of Trial	N	SO Mean	SO StdDev
1	2	5.95000000	0.21213203
2	2	6.05000000	0.07071068
3	2	6.05000000	0.63639610

5. Sweetness

Level of Trial	N	SW Mean	SW StdDev
1	2	6.25000000	0.21213203
2	2	6.65000000	0.07071068
3	2	6.00000000	0.56568542

6. Texture

Level of Trial	N	TE Mean	TE StdDev
1	2	6.25000000	0.07071068
2	2	6.45000000	0.21213203
3	2	6.50000000	0.42426407