DEVELOPMENT OF BREAD FORTIFIED WITH FIBER FROM BY - PRODUCTS OF TEA (*Camellia sinensis*) PRODUCTION

BY

JUREEPUN SAEKWUNG

A special project submitted to
School of Biotechnology, Assumption University
In part fulfillment of the requirements of the Degree of Bachelor
of Science in Biotechnology
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Title: **Development of bread fortified with fiber from by-products of tea (Camellia sinensis) production**

Name: **Jureepun Saekwung**

Project Advisor: **A. Nootrudee Siriboon**

Academic year: **2011**

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(Ms. Nootrudee Siriboon)
Advisor

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Abstract

The fiber fortified bread was developed by tea (*Camellia sinensis*) by-products to create a new variety of bakery products. The study was conducted starting from a testing of standard formula by using bran bread formulation as the standard formula, to observe the overall characteristics of final product. Then performed just-about-right test to determine the attributes involve with the product that need to be adjusted. To improve the product taste, there are 3 attributes need to be adjusted including amount of sugar, butter, and tea powder. Those 3 attributes was varying into two levels each, and later performed the hedonic test throughout 2 different trials, one with tea leaves by-product and one with tea stems by-product, resulting in the most preferred formula in each trial (total of 8 formulas in each trial). As a result from the hedonic testing to find out only one most preferred formula for final product, the product using tea leaves by-product and tea stems by-product as the main ingredient got the hedonic score of 6.55±1.41 and 6.88±1.38 respectively. Therefore, the final product of fibre fortified bread is the one that made from tea stems by-product as the main ingredient. From 100 consumers used in the consumer acceptance test of the final product, 88% of them had accepted and intended to purchase this product if it has been launched in the market.

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Introduction

History of bread has gone a long way since late Stone Age, starting from campfires in Neolithic time, continuing through human settlement, villages, towns, and kingdom. The trade of baker is considered one of the oldest treads in the world. At the beginning bread was an accident when man dropped thick porridge glue over hot stones and made pancake. During Egypt time, slave made wine in noble houses, introduced yeast spores in air that fell into dough causing dough to ferment. After baking, leavened bread was first made in Egypt *(http://en.wikipedia.org/wiki/Chorleywood_bread_process)*

A major development in bread production was Chorleywood bread process in 1961. An intense mechanical work of the dough and reduction of fermentation time had increased bread production fast and provided better quality product. In addition lower protein flour could be turned into bread by high energy mixer. Thus, Chorleywood bread process has been used in large scale production of bread all over the world. *(http://en.wikipedia.org/wiki/Chorleywood_bread_process)*

Nowadays, most of people need to be rush according to a limited of time, everything turn to be hurry especially for urban life living. Therefore, the necessity to shorten the time for having breakfast or even to skip the meals in a day becomes more reasonably valid. But in truth, breakfast is the most important meal of the day because it provides body with energy needs to spend throughout the day. By this reason, many people figure this problem out by picking the quickest and easiest way in junk foods. It is known that junk foods usually contain high fat especially trans-fat and very high amount of sodium, those will harm health and give non nutritive value to body. Bread, a common form of food, can be eaten anytime should be one alternative way for people who always live in a rush to fulfill energy needs of the body.

To develop a new bakery product added up more fiber similar to whole wheat bread is a way to increase nutritive value to the product. Recently, a tea (*Camellia sinensis*) making product becomes very popular and quite famous in Thai consumers view. Wastes from tea process are selected as the main ingredients to conduct the product development testing is not just only increase nutritive value to the bread but also value adding to tea production. Besides, there are multiple health benefits of tea or even tea wastes that can provide great benefit to consumers. Nevertheless, use of wastes from tea process to making bakery product is kind of challenging development that might be one of the best choices for both Thai and international markets.

Aim

To develop a new variety of bakery products that added up with fiber from tea processed wastes.

Objectives

- To add up value to bread from using by-products from tea process
- To determine the best formula for making bread fortified with fiber from by-products from tea process
- To study consumer acceptance of the new bread

Literature Review

Tea making process

Figure1: Tea making process

The process of making tea (*Camellia sinensis*) starts from the hand picking process to produce high quality of tea, then withering the tea leaves in sunlight for about half an hour. After that, put the tea leaves in bamboo trays under the shade and allow the fermenting occurred. The tea leaves will later put in the bamboo roll shaking machine for kneading process and let it rotate slowly to keep the tea leaves fresh and soft. Next, keep the tea leaves in the roasting machine to make it soft and ready for rolling process. After the rolling of half-dry tea leaves, the tea leaves will wrap tightly in cloth to make the ball shape; and do the rolling process again for the cloth ball. Thereafter, repeat the roasting, kneading, wrapping, and rolling process for 30-40 times. Lastly, dry the tea leaves and pack it nicely.

For the tea materials used in this project (both tea stems and tea leaves) are the by-products of tea making process; the yellowish-like of tea leaves and too long of tea stems will recognize as 'the by-products of tea production process. These by-products are sorting out before the packing process of tea leaves. Therefore, the using of tea by-products would be the very good practice to value-added the developing products since there is a study claimed that more than 10% of tea production are 'tea by-products', which could not meet the standard and specifications of tea product.

✧ ***Bread***

Bread is a staple food prepared by cooking a dough of flour and water and others additional ingredients. Dough's are usually baked, but in some cuisines breads are steamed, fried, or baked on an uncoiled skillet. Dough may be leavened or unleavened. Salt, fat and leavening agents such as yeast and baking soda are common ingredients, although bread may contain other ingredients, such as milk, egg, sugar, spice, fruit (such as raisins), vegetables (such as onion), nuts (such as walnuts) or seeds (such as poppy). Referred to colloquially as the "staff of life", bread has been prepared for at least 30,000 years. The development of leavened bread can probably also be traced to prehistoric times. Sometimes, the word *bread* refers to a sweetened loaf cake, often containing appealing ingredients like dried fruit, chocolate chips, nuts or spices, e.g. pumpkin bread, banana bread or gingerbread. [*http://en.wikipedia.org/wiki/Bread*]

Fresh bread is prized for its taste, aroma, quality, appearance and texture. Retaining its freshness is important to keep it appetizing. Bread that has stiffened or dried past its prime is said to be stale. Modern bread is sometimes wrapped in paper or plastic film, or stored in a container such as a breadbox to reduce drying. Bread that is kept in warm, moist environments is prone to the growth of mold. Bread kept at low temperatures, in a refrigerator for example, will develop mold growth more slowly than bread kept at room temperature, but will turn stale quickly due to retrogradation. The

soft or the inner part of bread is known to bakers and other culinary professionals as the crumb, which is not to be confused with small bits of bread that often fall off, called crumbs. The outer hard portion of bread is called the crust. [*http://en.wikipedia.org/wiki /Bread*]

✧ ***Bread making***

Making yeast breads involves five basic steps: mixing, kneading, and fermenting the dough, then shaping and baking the bread. Flour is mixed with yeast, liquid ingredients; usually milk or water, and any additional ingredients such as salt, sugar, and shortening to form dough. After the dough becomes too thick to stir, it is kneaded by repeat the pressing step, folding and turning it to develop and stretch the gluten, which helps the bread rise during yeast fermentation. [*http://encarta.msn.com/encyclopedia_ 761562389_2/Bread.html*]

The kneaded dough is allowed to ferment until it rises to double its original size. It is to punched down and kneaded again briefly to break up large air pockets into smaller ones and to remix the dough slightly, enabling the yeast to come into contact with any pockets of un-metabolized sugars, and then allowed to rise again. Different types of bread dough may be allowed to rise several times, contributing to the texture and volume of the bread. Before the final rising, the dough is shaped into one of many traditional shapes, for example a loaf or a roll. After the final rising, the bread is baked. Cooking methods may contribute to the final characteristics of the bread. Heating the dough to temperatures above 60 ^{0}C (140 ^{0}F) kills the yeast while higher temperatures change the chemical structure of the dough. [*http://encarta.msn.com/encyclopedia_ 761562389_2/Bread.html*]

✧ ***Bread flour***

Bread flour is one type of wheat flour (*Triticum spp.*) is produced from hard wheat that has five nutrients: fat, minerals, moisture, starches and proteins. Fat and minerals each generally account for less than 1% of flour's content. The moisture content of flour is also relatively low-when packaged; it cannot exceed 15% under government standards. But its actual moisture content varies depending on climatic conditions and storage. In damp areas, flour absorbs moisture from atmosphere and the moisture content may exceed the standard limit. Starches comprise of 63% to 77% of flour. They are necessary for component absorption of moisture during baking. This process known as gelatinization, occur primarily at temperatures above 140^{0}F (60^{0}C). Starches also provide food for yeast during fermentation. Flour proteins are important because of

their gluten-forming potential. [Amendola and Rees, 2002]

Bread flour is high-protein flour, specially formulated for making yeast breads. The combination of extra protein, a tiny bit of malted barley to help the yeast, and vitamin C or Potassium bromate to help the formation of the gluten, helps the dough rise and retain gasses as it bakes, resulting in greater volume and better texture. Bread flour is called for in many bread and pizza crust recipes where you want the loftiness or chewiness that the extra gluten provides. It is especially useful as a component in rye, barley and other mixed-grain breads, where the added lift of the bread flour is necessary to boost the other grains. [*http://www.ochef.com/430.htm*].

✧ ***Sugar***

Sugar is an organic substance crystal that is readily dissolved in water and provides sweet taste. There are various types of sugar in bakery products such as granulated sugar, icing sugar (confectionary sugar), brown sugar; others i.e. corn sugar, milk sugar, malt sugar, invert sugar and honey. Sugar serve as yeast food that provide sweetness, flavor and energy, promote good crust color and good texture, and create tenderness and fineness of texture partly from weakening gluten structure. Besides, it helps retention moisture and prolonging shelf life, and assists creaming of fats and foaming of eggs.

✧ ***Salt***

Salt is one of basic ingredients in bread. Fine salt is preferred with bakery product .This salt contains 99.9% Sodium Chloride with trace of moisture and other salts of chloride and sulfate. The amount of salt added in bread is usually low from 1.0-1.3%. In artisan bread, the amount of salt is increased to 1.8-2.2% with 2% as norm. Main function of salt in bread is to providing taste and enhancing other flavor especially sweetness. Nevertheless, salt improves gluten structure by helping the binding of bonds in gluten network, and slow fermentation and enzyme activity; because salt is hygroscopic so it can draw water from surrounding environment.

✧ ***Yeast***

Louis Pasteur discovered yeast in 1859. This microorganism is found in nature and is responsible for fermentation in many beverages and bakery products. Yeast is a unicellular mold which is one type of leavening agent in bakery product. There are 2 main types of yeast in bakery products: fresh yeast or compressed yeast and dry yeast. Baker yeast is *Saccharomyces cerevisiae.* Yeast ferments nutrients in bread especially sugar as glucose, fructose, maltose and sucrose to energy. During the fermentation process, it produces ethanol, Carbon dioxide, and several metabolites. Yeast create bread crumb by the diffusion of Carbon dioxide into the dough until it becomes saturated and

evolves as gas creating air cells in the bread crumb and leavens the loaf and provide specific yeast odor to the products. Moreover, yeast use to increase nutritive value of the products especially with vitamin B.

✧ ***Butter***

Butter is one type of shortenings; shortenings refer to bakery ingredient capable of shortening gluten strands and tenderizing the product. Shortenings will be a group of solid fats, usually tasteless. Generally shortenings consist of nearly 100% fat. Shortening responsible to shorten or tenderize products and soften texture, lubricate gluten to prevent breakdown of gluten during mixing. It provides moistness, richness, and flavor to the products, and also increases the keeping quality as well.

Butter contains approximately 80% lipid. There are 2 major groups of butter including salted butter and unsalted butter. Salted butter contains 1-6% salt and unsalted none. Unsalted butter is more susceptible for spoilage than the salted butter but it is fresher and sweeter than the salted one. Butter is inferior to any shortening in its hardness and brittleness, but it is superior in flavor and melt in the mouth.

✧ ***Milk powder***

Milk powder is one type of dairy products apart from fresh liquid milk, cream, fermented milk, evaporated and condensed milk, and cheese. Milk contributes to texture, crust color, keeping quality, and nutritive value. Basically milk will perform the same way as fat. But since it contains some proteins, so it's might affect the gluten strength.

Milk powder contains about 5% or less moisture. It is often used because of its convenience and low cost. Dried whole milk made from evaporating almost all moisture from milk and obtaining milk powder. It provides low keeping quality because of high butterfat. In the other hand, non-fat milk solids is skim milk dried to powder, having better keeping quality due to less fat remaining in the milk.

✧ ***Tea powder***

Tea is the agricultural product of the leaves, leaf buds, and internodes of various cultivars and sub-varieties of the *Camellia sinensis* plant, processed and cured using various methods. Tea also refers to the aromatic beverage prepared from the cured leaves by combination with hot or boiling water, and is the common name for the *Camellia sinensis* plant itself. After water, tea is the most widely consumed beverage in the world. It has a cooling, slightly bitter, astringent flavor which many enjoy. There are at least six varieties of tea: white, yellow, green, oolong, black, and post-fermented teas of which the most commonly found on the market are white, green, oolong, and black.

Some varieties, such as traditional oolong tea and Pu-erh tea, a post-fermented tea, can be used medicinally. [*http://en.wikipedia.org/wiki/Tea*]

Tea waste is almost as rich in potent antioxidants, such as catechins, as the new and expensive green tea leaves used by the supplements industry, according to Iranian research to be published later this month in peer-reviewed journal Food Chemistry. The study carried out by the Ferdowsi University of Mashhad, investigated three extraction methods on different parts of the tea plant, and tea waste, and found surprisingly high levels of antioxidants across all of the extracts. Tea leaves that have already matured on the plant and the waste that is left after fermenting black tea, "are often considered as agricultural wastes", said Dr Reza Farhoosh, the author of the study. But they "could be used as potent natural anti-oxidative sources". European demand for tea extracts is currently surging, having reached 500 metric tonnes by 2003. With tea prices at around $1.5 per kg, the possibility of cheaper raw materials could shift the industry's cost base. Green tea and green tea extracts are currently produced from only the first two to four leaves of the tea plant *(Camellia sinensis)*. The other leaves are known as old tea leaves (OTL). Fermenting the green tea leaves produces black tea, and obviously produces black tea waste (BTW). The Iranian study reported high extraction yields of polyphenols from OTL and BTW, including Epigallocatechin gallate (EGCG), one of the most widely researched polyphenols in green tea. *[http://www.nutraingredients.com/Research /Tea-waste-rich-with-extractable-antioxidants]*

Three different extraction media were studied, using hot water, methanol or ethyl acetate. For both green tea and black tea waste, the most efficient of the three methods was hot water extraction, which delivered yields of 35 per cent for fresh green tea leaves and a close-running 30 per cent for BTW. Extracts from green tea are now well established as sources of polyphenols - containing a rich source of free radical scavenging catechins. Recent data suggests these compounds play a beneficial role in weight loss, cardiovascular and oral health, with some now emerging as particularly powerful. This has seen companies such as DSM, with its Teavigo boasting 95 per cent purity of Epigallocatechin gallate (EGCG), and Taiyo International, with its Sunphenon claiming more than 90 per cent purity, position themselves firmly in specific catechin markets. *[http://www.nutraingredients.com/Research/Tea-waste-rich-with-extractable -antioxidants]*

✧ ***Health benefits of tea***

- **Green Tea's Powerful Antioxidants**

Catechins are green tea's antioxidants which scavenge for free radicals that can damage DNA and contribute to cancer, atherosclerosis, and blood clots. Besides, grapes and berries, red wine, and dark chocolate also have potent antioxidants as well. During the minimal process of green tea, withering and steaming steps make green tea uniquely different from black tea and Oolong tea, because making of black tea and Oolong tea process require fermentation step. Therefore green tea remain the unique catechins especially epigallocatechin-3-gallate (EGCG) which are very concentrated. Anyhow, there's a question of how much green tea you need to drink to reap its health benefits. In fact, EGCG is not readily available to the body. (EGCG is not always fully used by the body). *[http://www.webmd.com/food-recipes/features/health-benefits-of-green- tea]*

- **Green Tea and Cancer**

Marji McCullough, ScD, RD, the American Cancer Society's strategic director of nutritional epidemiology, says human studies haven't yet proven what researchers like Chan have discovered in the lab: green tea's EGCG regulates and inhibits cancer growth and kills cells that are growing inappropriately. One of the challenges is epidemiologically finding populations that drink enough green tea in a long enough period of time," she says. "With cancer, it's always difficult to find the exposure time," or the point at which cancer cells begin to develop. It's still difficult not to be intrigued by a few human studies that have shown that drinking at least two cups of green tea daily inhibits cancer growth. One of the studies conducted in Japan that involved nearly 500 Japanese women with Stage I and Stage II breast cancer found that increasing of green tea consumption before and after surgery was associated with lower recurrence of the cancers. Many studies conducted in China have shown that the more green tea that participants drank can lower the risk of developing stomach cancer, esophageal cancer, prostate cancer, pancreatic cancer, and colorectal cancer. Lastly, a recent analysis of 22 studies that probed the correlation between high tea consumption and reduced risk for lung cancer concluded that by increasing your daily intake of green tea by two cups may reduce the risk of developing lung cancer by 18%. *[http://www.webmd.com/food-recipes/features/health-benefits-of-green-tea]*

- **Is Green Tea Good for Your Heart?**

There's a study that involved 500 Japanese men and women found that drinking at least four cups of green tea every day may be related to the reduced severity of coronary

heart disease among the male participants. A study conducted in Dutch, more than 3,000 men and women found that the more tea consumed, the less severe the clogging of the heart's blood vessels, especially in women. As in the suggestion of Goldberg, lifestyle and overall diet are critical to the outcomes of these studies. Anyway, green tea's antioxidants are dilators, because they improve the flexibility of blood vessels and make them less vulnerable to clogging. *[http://www.webmd.com/food-recipes/features/health-benefits-of-green-tea]*

- **Green Tea and Weight**

There are studies in Netherlands and one in Japan said that green tea and its extract have been shown to fight and lower the two risk factors for heart disease and diabetes including obesity and LDL or bad cholesterol. A Dutch study have shown that participants who drank caffeinated green tea lost more weight, but even those who typically drank the decaf variety saw a decrease in their waistlines and body weight. Researchers speculated that the caffeine helps with fat oxidation. In a study in Japan, 240 men and women were given varying amounts of green tea extract for three months. Those who got the highest amount lost fat and weight and had lower blood pressure and lower LDL or bad cholesterol. *[http://www.webmd.com/food-recipes/features/health-benefits-of-green-tea]*

- **Green Tea Straight Up**

Taking weight loss supplements that contain green tea extract probably won't hurt, unless you have liver problems. But the best way to get the most out of green tea is to drink it even if your main goal is losing weight. Diane McKay, PhD, a Tufts University scientist who studies antioxidants said that "Taken altogether, the evidence certainly suggests that incorporating at least a few cups of green tea every day will positively affect your health." *[http://www.webmd.com/food-recipes/features/health-benefits-of-green-tea]*

McCullough bears the same reminder: eat your fruits, vegetables, grains, seeds, and nuts. And go ahead; drink as much green tea as you want. Besides, she said "I don't think it can hurt to drink it. I'd focus on dietary sources rather than supplements because there are several compounds in green tea that might need to be consumed together. We just don't know yet." *[http://www.webmd.com/food-recipes/features/health-benefits-of-green-tea]*

Materials and Methods

Materials:

- Blender
- Flour sieves
- Scales
- Bread maker (Severin Bread Maker, SEV-3983)
- Digital balance

Raw materials:

- Bread flour (White Swan Brand, UFM)
- Yeast: Instant dry yeast (Fermipan Brand)
- Sugar (Mitphol Brand)
- Salt (Prungthip Brand)
- Milk powder (Dumex Brand)
- Butter: Unsalted butter (Allowrie Brand)
- Tap water
- Tea powder from
  - Tea leaves
  - Tea stems

  (Tea by-products from Choke Chumroen Tea Factory)

Methods

1. *Formulation*

1.1 Preliminary test

Bran bread formula was used as a standard formula to prepare bread using two bread makers (Severin Bread Maker, SEV-3983). Bran bread formula was used in the developing of bread fortified with tea by-products.

Table1: Bran bread formula

Ingredients	Amount (g)	Percentage on flour weight base
Bread flour	300	100
Sugar	21	7
Yeast	3	1
Salt	9	3
Butter	16	5.3
Milk powder	10	3.3
Water	200	66.7
Wheat bran	24	8

1.2 Preparation of tea by-products powder

Tea by-products from tea leaves and tea stems were ground and sifted and used instead of wheat bran in the bran bread formula (Table 1).

1.3 Developing formula

1.3.1 Using just-about-right test to determine the attributes involved with the product that need to be adjusted by 10 trained test panellists.

1.3.2 Adjusting formula according to the result obtained from (1.)

1.3.3 Performing 9-point hedonic scale preference test with the samples from (2) by 10 trained test panellists.

13.4 Selecting the most preferred formula between tea leaf powder and tea stem powder using 9-point hedonic scale preference test with the samples from (2) by 40 trained test panellists.

1.3 Testing consumer acceptance of the final product

Conduct consumer acceptance test of the final product obtained from (1.3.4) with 100 normal consumers

2. ***Sensory evaluation***

2.1 Just-about-right test on 5 attributes including softness, tea flavor, sweetness, saltiness, butter flavor, and moistness to determine the products attribute(s) need to be adjusted.

2.2 9-point hedonic score preference test was used in screening and selecting the most preferred formula. The test included 6 attributes that were softness, tea flavor, sweetness, saltiness, butter flavor, moistness, and overall acceptance.

2.3 Consumer acceptance test was conducted on a large scale of consumers to determine the following attributes - color, appearance, flavor, aroma, softness, and overall liking.

3. ***Statistical analysis***

3.1 Experimental design used in the experiment was Randomized Complete Block Design (RCBD) where treatment was bread formula and test panellists were columns.

3.2 Statistic analysis used Microsoft Excel Program to perform analysis of variance or ANOVA at $p<0.05$.

Experiment Plan

In the development of bread fortified with fibre from tea processed by-products, the experimentation plan consisted of 6 tasked covering a period of 7 months as followed:

1. Preparation and development of product (~2 weeks)

To select the high quality raw materials, in order to reach the premium quality of bread product.

2. First testing (~3 weeks)

To obviously observe the overall characteristics of bread, the bran bread formula is selected to use as the standard formula.

3. Development and Formulation (~7 weeks)

To develop the only one preferred formula toward 2 trials of experiment, (Select only 2 out of 16) including one from tea stems powder trial and another one for tea leaves powder trial. Those varying formulas are differences in amount of sugar, butter, and tea powder.

4. Second testing (~4 weeks)

To test product by using 40 panellists in order to identify out only one formula (the most preferred one) and have a high enough of potential to launching to the market. Besides, I have been observed all involved attributes and the overall liking of the final product by myself.

5. Check feedback; questionnaires (~4 weeks)

To observe the consumers' demographic, consumers behavior, consumer acceptance, and also purchasing intention of consumers toward the final product, the questionnaires is conducted to check the feedback from consumers (using 100 panellists). Nevertheless, it provided me some of comment and suggestion about the product, thus can use as the useful information for the further development.

6. Presentation of my product and results, including the project report (~10 weeks)

To collect all results and analyze them, then make it into project report and thus for the product presentation, it take about 10 weeks.

Experimental Location

- E1 Room, E Building Assumption University (Hua Mak Campus)
- Assumption University (Hua Mak Campus)

Time Line

This project was conducted from March 29, 2011 to October 28, 2011.

Table 2: Project time line

Date / Tasks	29th March	12nd April	2nd May	20th July	18th August	28th October
Preparation and Development	←	→				
First Testing (Testing of Standard Formula)		←	→			
Development and Formulation			←	→		
Second Testing (Consumer Acceptance Test				←	→	
Project report and Presentation	←					→

Result and Discussion

1. Formulation

1.1 Testing of standard formula

Using of bran bread formulation (Table 1) as the standard formula to observe the overall characteristics of product. Tea by-product powders from tea leaves and tea stems were used instead of wheat bran in the bran bread formula. To control bread making process, three automatic bread makers were used by selecting the same the standard program, medium colour, and 0.5 kg-loaf size.

1.2 Preparation of tea waste powder

By-products from tea process used in the experiment were tea leaves and tea stems as shown in Figure 2. They were ground into powder in a blender and sifted with flour sieve to obtain tea leaves powder and tea stems powder, respectively. Dry leaves were thin and easy to crush while the dry stem was opposite.

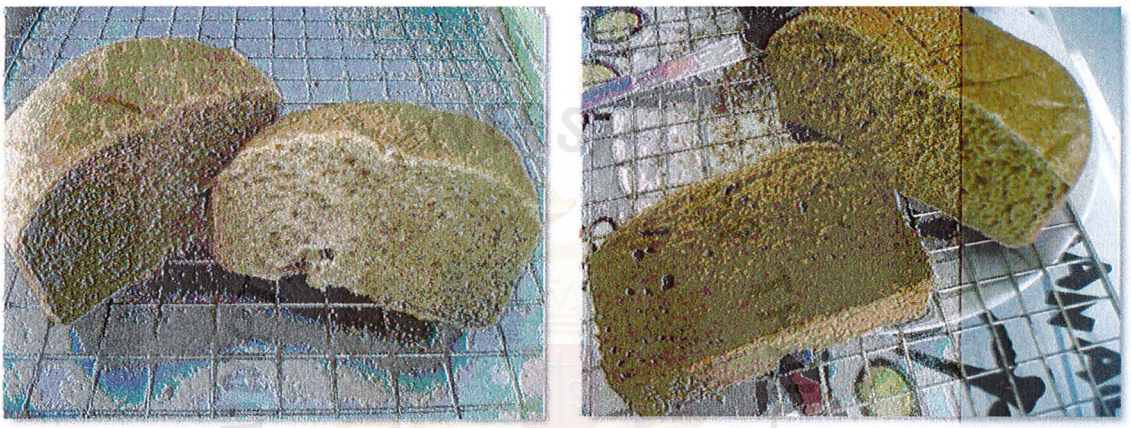
Figure2: By-products from tea process (Raw materials)

Upper left: Tea (leaves) processed by-product
Upper right: Tea leaves powder
Lower left: Tea (stems) processed by-product
Lower Right: Tea stems powder

From Figure 2, it was observed that tea leaves powder (upper right) was green and fine power while tea stems provided coarse powder and less green (lower right). It was expected that the difference in powder particles and color would affect overall bread structure, texture and color of the product.

1.3 Developing formula

Preparation of bread containing tea by-products showed that color of the bread was greatly influenced by color of the powder as showed in Figure 3. For crumb structure was controlled by the bread making machine, therefore the effect of tea by-product powder could not be observed visually. However, their effects might be determined by sensory or physical means.

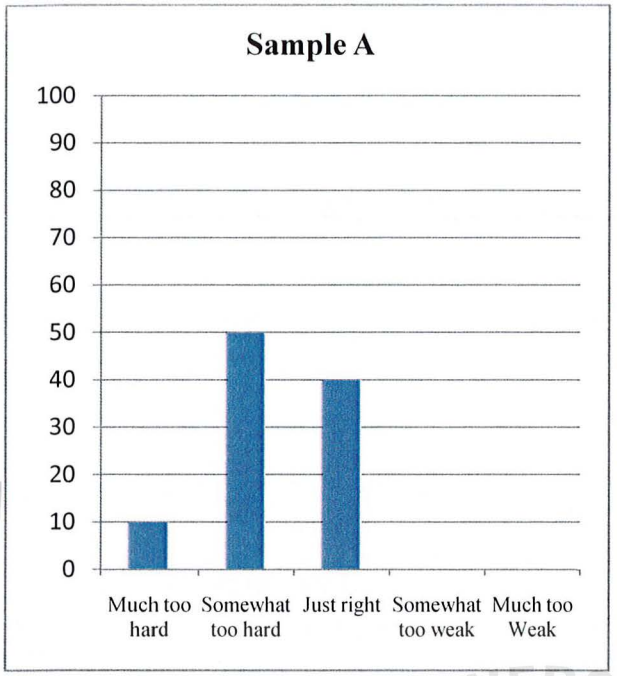


(a) Bread with tea leaves powder (b) Bread with tea stems powder

Figure 3: Effect of two different tea by-product powders in bread

1.3.1 Just-about-right Test

After observing the overall characteristics of bread, just-about-right test was used to determine the attributes in the product that needed to be improved. There were six attributes including softness, tea flavor, sweetness, saltiness, butter flavor, and moistness. Ten trained test panellists were asked to test the product and filled up the just-about-right questionnaire, Appendix A-1. Two samples were presented. They were sample A containing tea stems powder and sample B containing tea leaves powder. The results from JAR test were analyzed using Microsoft Excel program and demonstrated as the histogram charts for each attribute in Figure 4 to 9.



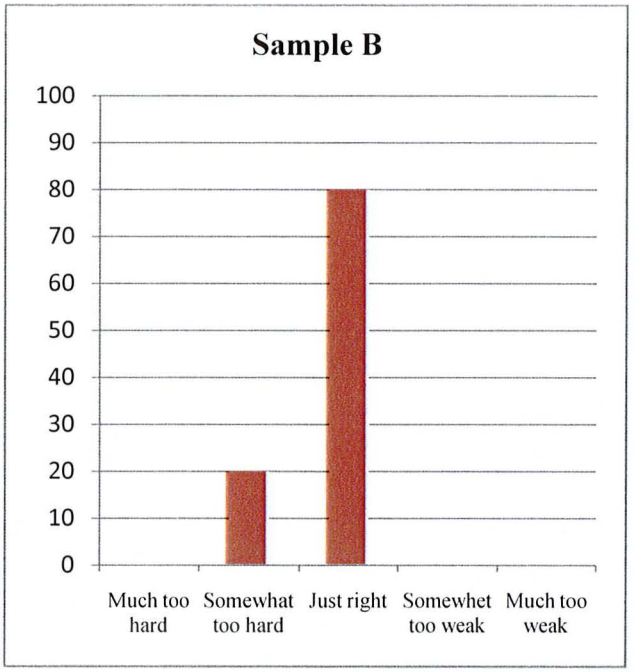
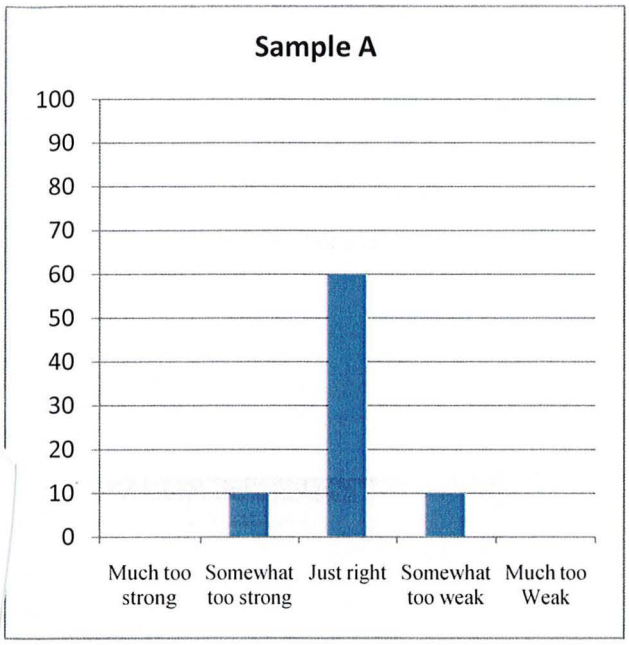


Figure 4: JAR test for 'softness' of bread fortified fibre with tea stems powder (Sample A) and tea leaves powder (Sample B)

From Figure 4, 60% of the test panellists thought that softness of sample A, contained tea stem powder, was somewhat too hard to much too hard while sample B, contained tea leaves powder, was just right by 80%, indicating that the softness might not need to be adjusted in bread containing tea leaves powder while bread containing tea stems powder might need to be adjusted. To adjust softness of bread crumb could be done by increasing water or shortening in the formula. However adjusting the amount of water could greatly affect structure of the product and difficult to do without affecting to overall structure of the bread, the adjustment of water in the formula might not be a good choice to do. On the other hand, adjusting shortening content might be possible. Nonetheless it should be done in less extent.



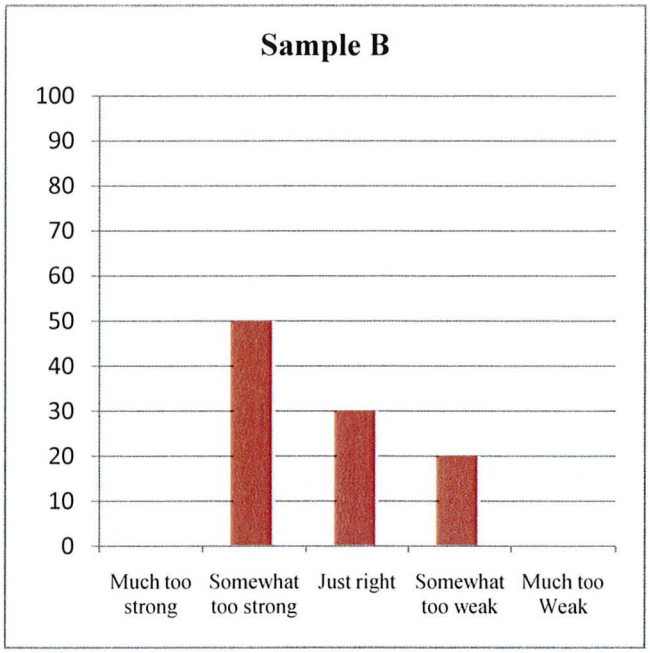
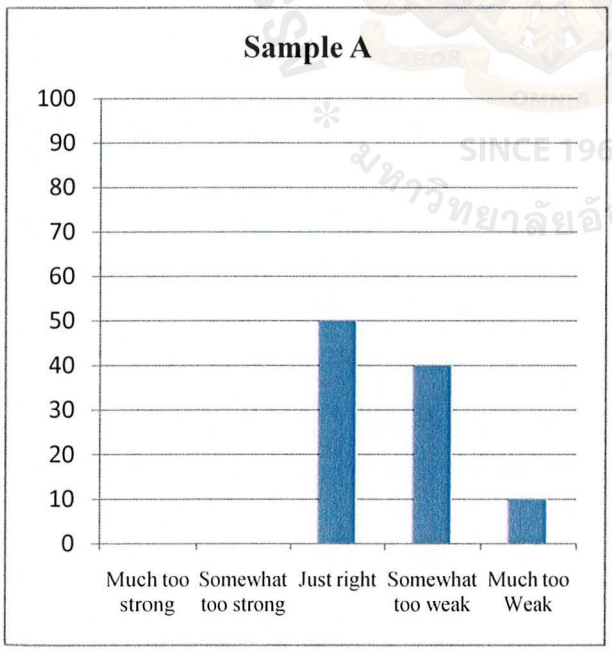


Figure 5: JAR test for 'tea flavor' of bread fortified fibre with tea stems powder (Sample A) and tea leaves powder (Sample B)

Figure 5 shows that sample A, tea stem, tea flavour was just right by 60% while sample B, tea leaves powder, was somewhat too strong by 50%. Since tea flavor is considered strong flavor, in the further study, tea flavor in the bread should be adjusted.



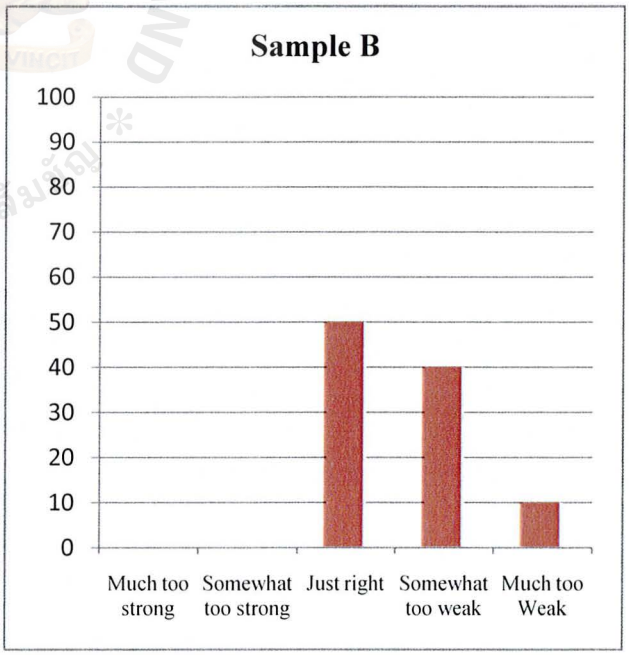


Figure 6: JAR test for 'sweetness' of bread fortified fibre with tea stems powder (Sample A) and tea leaves powder (Sample B)

Figure 6 demonstrated that sample A's and sample B's sweetness were rated as just right by 50% of the test panellists while another 50% rated that both samples contained too weak in sweetness. Thus, they might require adjustment in their sweetness's.

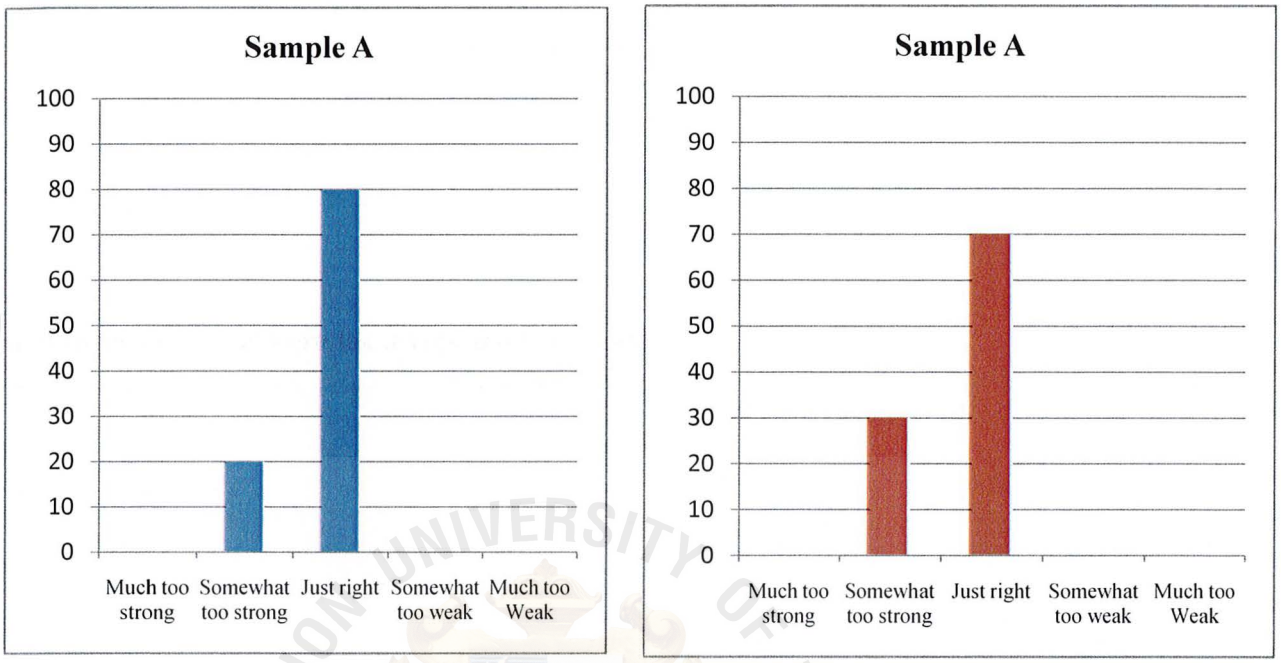


Figure 7: JAR test for 'saltiness' of bread fortified fibre with tea stem powder (Sample A) and tea leaf powder (sample B)

Figure 7 showed that sample A obtained just right by 80% of the test panellists in saltiness while sample B got 70% just right, indicated that the amount of salt for both samples did not require any adjustment.

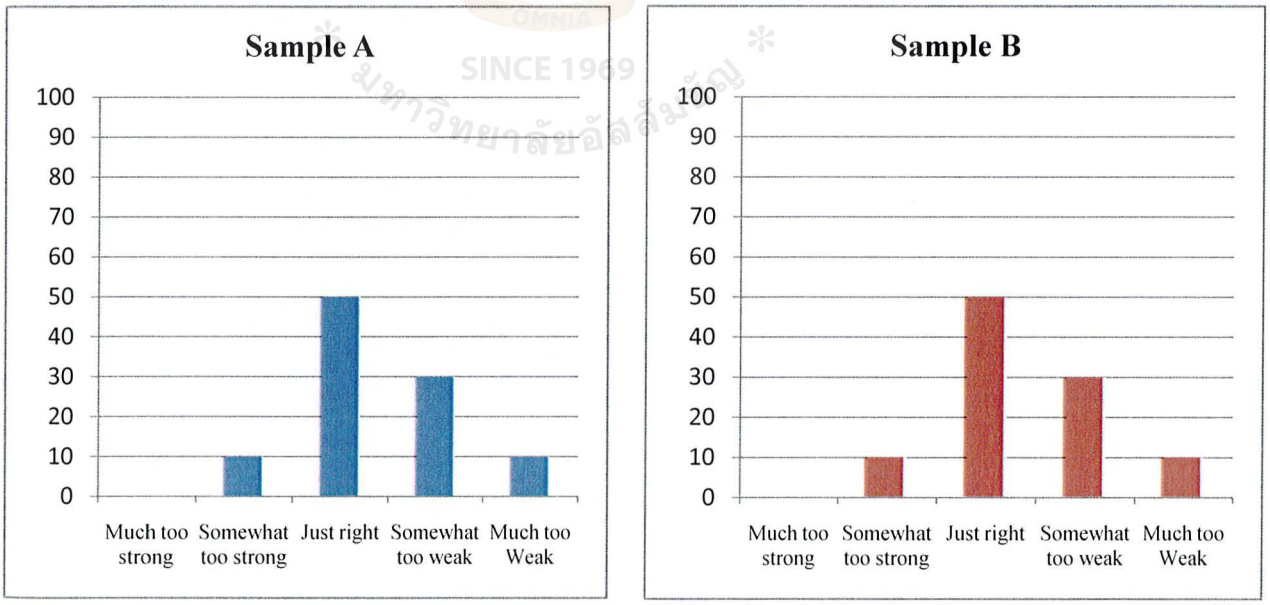


Figure 8: JAR test for 'butter flavor' of bread fortified fibre with tea stems powder (Sample A) and tea leaves powder (Sample B)

Figure 8 demonstrated that though both samples were rated by 50% of the test panellists just right in butter flavor, 40% of test panellists rated them to be somewhat too weak to too weak. This might show that butter flavor might require adjustment.

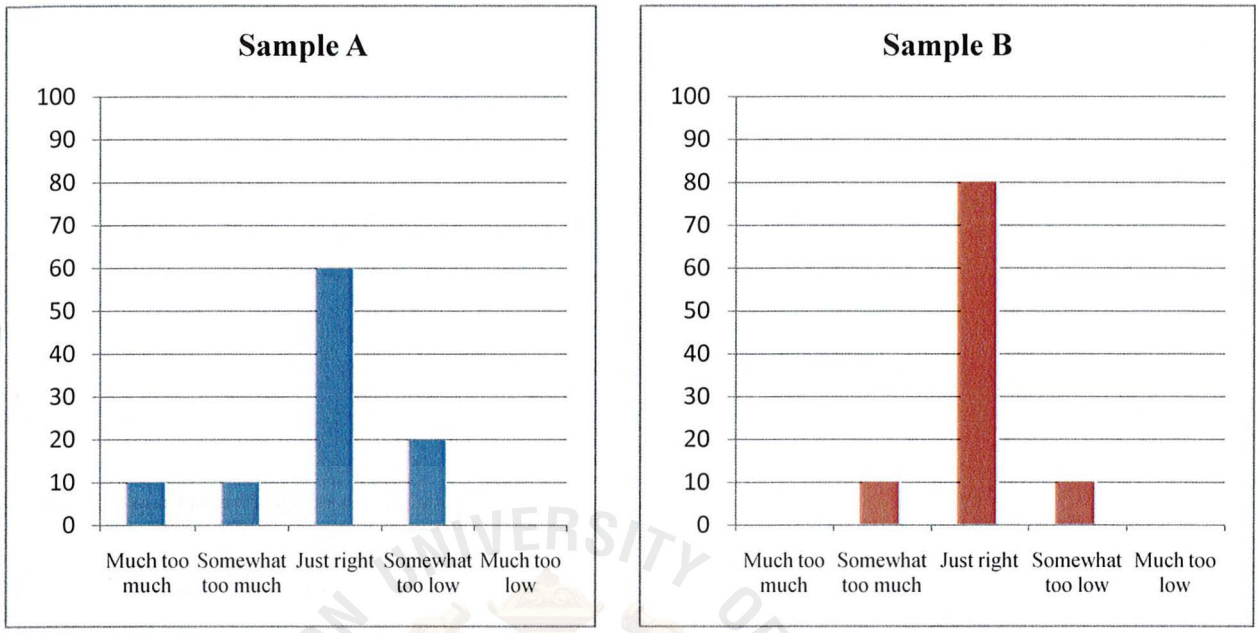


Figure 9: JAR test for 'moistness' of bread fortified fibre with tea stems powder (Sample A) and tea leaves powder (Sample B)

Figure 9 shows that sample A got 60% just right in moistness while sample B got 70% just right. The results showed that moistness did not need to be adjusted. However, moistness is related to softness of the product, which was rated as somewhat to soft. As mentioned earlier, adjusting the amount of water in the formula for bread is difficult and it would affect the structure formation of the bread, especially for gluten. Thus these attributes were not adjusted in the further study.

1.3.2 Adjusting formula

From figure 4 to 9, the results of JAR test indicated that three attributes needed to be adjusted. They were tea flavor (Figure 5), sweetness (Figure 6), and butter flavor (Figure 8). Table 3 and Table 4 showed the adjustment formulas for bread containing tea leaves powder and tea stems powder, respectively.

As mentioned earlier that tea flavor was a strong flavor and the result from JAR test indicated that this attribute was somewhat too strong. Therefore, the amount of tea power was adjusted from 8% fwb in the reference formula to 6.7% and 7.3% fwb

In the reference formula there is 7% sugar on a flour weight base (fwb). The result from JAR test, Figure 6, indicated that the amount of sugar should be increased. Therefore, the amount of sugar was varied to 7.3% and 8% fwb.

From butter flavor, the reference formula contains 5.3% butter on fwb while Figure 8 showed that 40% test panellists rated butter flavor as too weak to much too weak. Since butter is rich in flavour that gives to the product. Moreover butter or shortening can lubricate the gluten structure and provide softness and moistness to the product. However too much shortening can interfere with gluten network, the amount of shortening is usually low in the formula. In the adjusted formula, the amount of butter was increased to a lesser extent to 6% fwb.

Table 3: Adjusted formula in trial 1 using tea leaves powder

Formula / Ingredients	1	2	3	4	5	6	7	8
Bread Flour	100	100	100	100	100	100	100	100
Sugar	7.3	7.3	8	8	7.3	7.3	8	8
Yeast	1	1	1	1	1	1	1	1
Salt	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7
Butter	5.3	5.3	5.3	5.3	6	6	6	6
Milk Powder	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3
Water	66.7	66.7	66.7	66.7	66.7	66.7	66.7	66.7
Tea Leaves Powder	6.7	7.3	6.7	7.3	6.7	7.3	6.7	7.3

Table 4: Adjusted formula in trial 2 using tea stems powder

Formula / Ingredients	9	10	11	12	13	14	15	16
Bread Flour	100	100	100	100	100	100	100	100
Sugar	7.3	7.3	8	8	7.3	7.3	8	8
Yeast	1	1	1	1	1	1	1	1
Salt	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7
Butter	5.3	5.3	5.3	5.3	6	6	6	6
Milk Powder	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3
Water	66.7	66.7	66.7	66.7	66.7	66.7	66.7	66.7
Tea Stems Powder	6.7	7.3	6.7	7.3	6.7	7.3	6.7	7.3

16 breads were prepared using automatic bread makers and tested with 10 test panellists using 9-point hedonic scale preference test for 7 attributes, Appendix B-1. The results were analyzed and shown in Table 5 and 6 for bread contained tea leaves powder and tea stems powder, respectively.

Table 5: Hedonic score testing for screening the most preferred formula of the product using tea leaves by-product as the main ingredient.

Sample	Attributes (Mean score ± SD)						
	Softness	**Tea flavor**	**Sweetness**	**Saltiness**	**Butter flavor**	**Moistness**	**Overall acceptance**
Formula 1	6.70±1.16	6.20±1.75	7.00±1.05	7.20±0.79	6.00±1.25	7.10±1.45	6.70±0.82^{ab}
Formula 2	6.80±1.03	5.80±1.40	7.20±0.92	7.40±0.97	6.40±0.97	6.90±1.10	6.50±0.97^{b}
Formula 3	7.30±0.82	6.50±1.51	7.40±1.07	7.30±1.25	6.60±1.65	7.50±0.85	7.50±0.85^{b}
Formula 4	7.20±0.79	6.10±1.91	7.00±0.94	7.20±1.14	6.60±1.71	7.30±1.06	7.10±1.29^{b}
Formula 5	7.10±0.99	6.30±1.49	6.70±1.64	6.70±0.95	6.10±1.45	6.50±0.97	6.50±0.71^{a}
Formula 6	7.10±0.88	6.00±1.76	6.80±1.69	6.80±1.23	6.20±1.23	6.80±0.92	6.90±0.99^{ab}
Formula 7	7.40±1.51	6.80±1.62	6.80±1.81	6.90±1.37	6.40±1.51	6.80±1.40	7.30±1.49^{b}
Formula 8	7.40±1.35	6.90±1.29	6.60±1.51	7.00±1.33	6.40±1.26	6.90±1.37	7.30±0.95^{b}

Statistical analysis showed that there were no significant differences in preference scores for all attributes. Formula that gave the highest preference score in overall acceptance was selected for further study, which was formula 3. In addition, formula 3 also received the highest scores in sweetness, butter flavor, and moistness. It was ranged from moderately like (7) to like very much (8) from 9-point hedonic scale.

Table 6: Hedonic score testing for screening the most preferred formula of the product using tea stems by-product as the main ingredient.

Sample	Characteristics (Mean score ± SD)						
	Softness	**Tea flavor**	**Sweetness**	**Saltiness**	**Butter flavor**	**Moistness**	**Overall acceptance**
Formula 9	6.80±0.92	6.50±1.08	7.00±1.15	6.80±0.92	6.40±0.97	6.90±0.74	6.90±0.88
Formula 10	7.20±0.63	7.20±0.63	7.20±1.23	6.90±0.88	6.70±0.67	6.90±0.57	7.10±0.74
Formula 11	7.40±0.97	7.30±0.82	7.10±0.99	6.70±1.06	7.10±0.99	7.10±0.88	7.10±0.88
Formula 12	7.30±0.82	6.80±1.03	7.00±1.05	7.10±0.88	6.90±0.99	7.50±1.18	7.40±0.70
Formula 13	6.40±1.17	6.90±0.99	6.60±1.17	7.10±1.10	6.60±0.84	6.60±1.17	6.40±0.88
Formula 14	6.70±1.16	7.20±1.03	6.70±0.95	7.30±0.82	6.70±0.82	6.80±0.79	7.00±0.82
Formula 15	7.10±1.37	7.60±1.17	7.40±0.70	7.40±0.84	7.20±0.63	7.20±0.79	7.30±0.82
Formula 16	7.30±1.16	7.30±1.06	7.30±1.16	7.40±0.70	7.10±1.10	7.00±0.94	7.60±1.26

For tea stems, there was no significant difference in all attributes. Formula 16 obtained the highest score in overall acceptance of 7.60. It was chosen for further study.

1.3.4 Selecting the most preferred formula

Bread sample contained by-product from tea leaves, Formula 3, and bread sample contained by-product from tea stems, Formula 16 were tested on 40 test panellists with a 9-point hedonic scale preference test. The test panellists were asked to rate both samples on 6 attributes and the results from statistic analysis shown in Table 7. There was no significant difference on the preference scores in all attributes from both samples. However the overall acceptance score of Formula 16, contained tea stems powder, obtained 6.88 higher than those from Formula 3, 6.55. Therefore Formula 16 was selected from running in consumer acceptance test in the next study.

Table 7: The average data from hedonic score testing to find the most preferred formula for finish product

Sample	Characteristics (Mean score ± SD)					
	Softness	Tea flavor	Sweetness	Saltiness	Moistness	Overall
Formula **3**	7.13±1.32	6.48±1.60	6.33±1.75	6.53±1.40	6.35±1.56	6.55±1.41
Formula **16**	7.02±1.33	6.40±1.95	6.38±1.86	6.45±1.65	6.30±1.71	6.88±1.38

2. *Consumer acceptance test*

Lastly, the final product acceptance test was performed by using 100 consumers. The questionnaire consists of demographic part, consumer behavior part, product acceptance part, and purchasing intention part. (Appendix C-1). All processed data of the consumer acceptance test were shown in Appendix C-2 and also presented as pie charts.

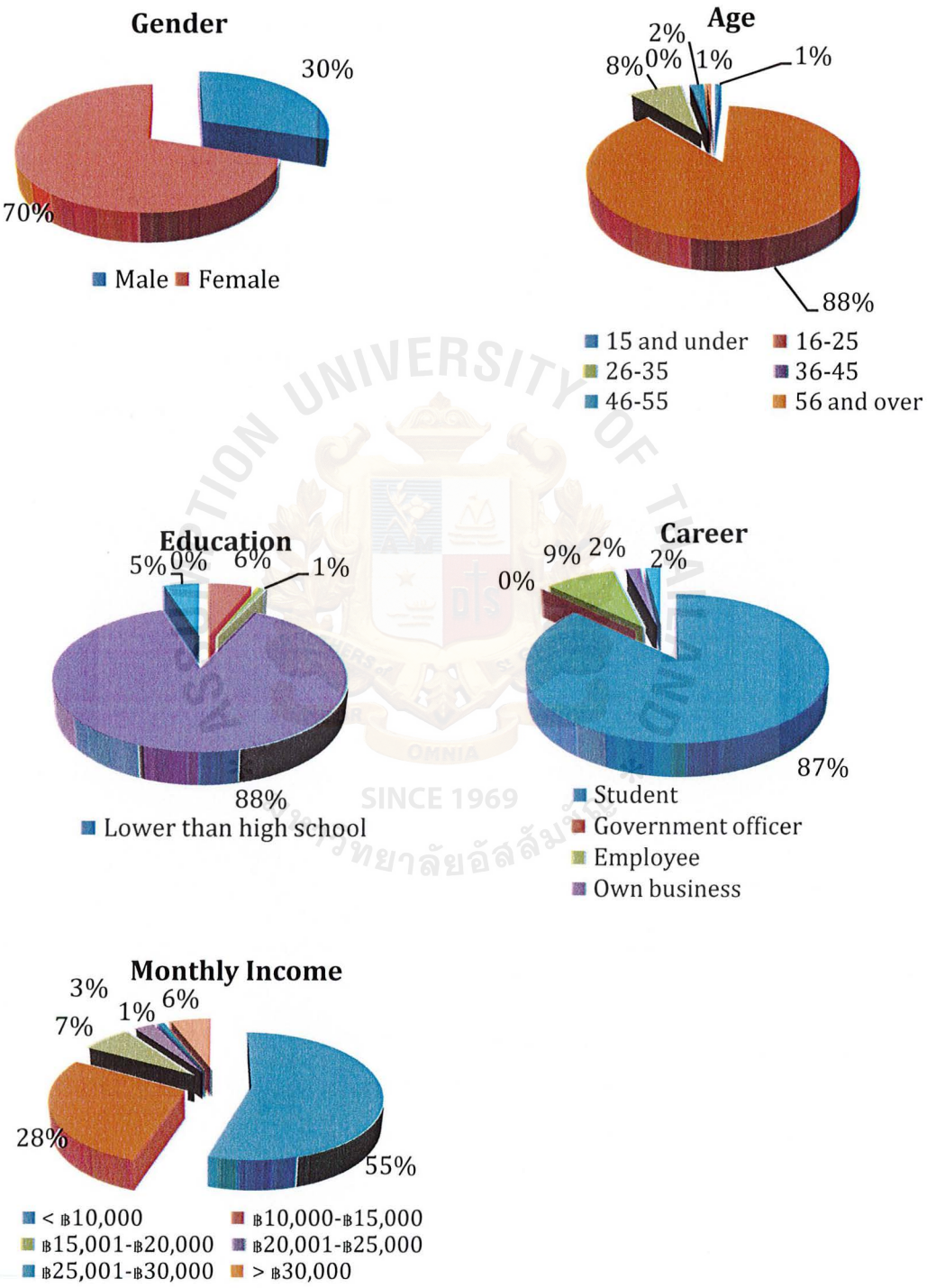


Figure 10: Consumers' demographic results

From Figure 10 showed the results of demographic part of the consumers. There

was 30% male and 70% female from 100 consumers with the most age range of 16-25. Their monthly incomes were not that high as they were mostly students, thus it seemed to affect the acceptable price of product itself. The consumers were asked to identify their favorite bakery brands, the desire product price, and size of final product to indicate out the overall relationship of consumer acceptance toward the final product.

The results from the consumer identification of their favorite bakery brands, the desire product price, and size of final product were shown as following;

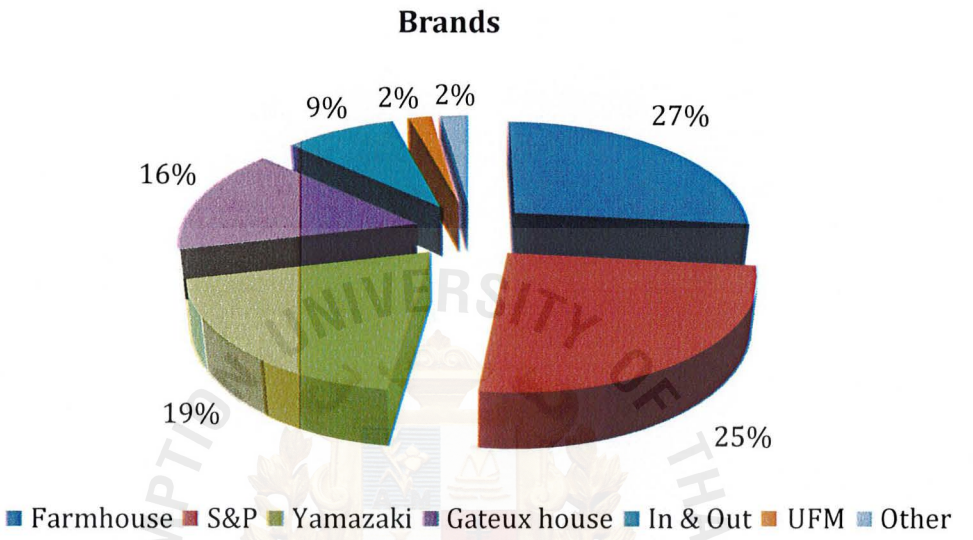


Figure 11: Consumers' favorite brands pie chart

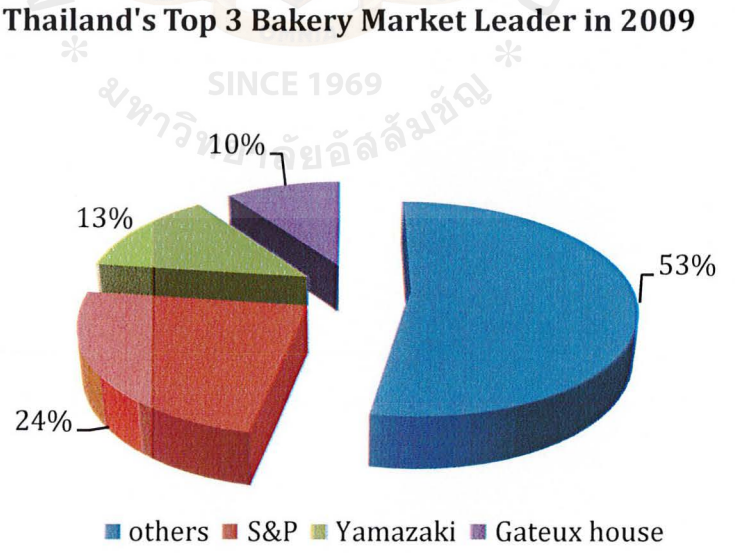


Figure 12: Thailand's top 3 bakery market leader in 2009 pie chart

(Resource: ThanNews No. 2235 of 15 Jul - 18 Jul 2549)

Figure 11 showed the preferable of bakery brand from consumers' liking scores,

and Figure 12 Thailand's top 3 bakery market leaders in 2009 which was quite agreeably in the same trend with the consumers' liking results. S&P, Yamazaki, and Gateaux house brand were the top level brands of most consumers in Thailand. Anyhow, in Figure 10 it was seen that the most preferable brand was "Farm house". There were many reasons why 'Farm house' was selected to be the first rank. "Farm house" is the old Thai local brand that many people are familiar with. This brand could be found in many convenience stores such as 7-11 and Family Mart. In addition, there are various kinds of bakery product under the name of 'Farm house'. In the same way, you can see the actual statistic recorded from "Thailand's top 3 bakery market leader in 2009", those top level bakery brands still earn high range of market share in Thailand until now. That's why most of consumers are familiar with it resulting in good brand awareness and thus become the high performance brands of Thai market.

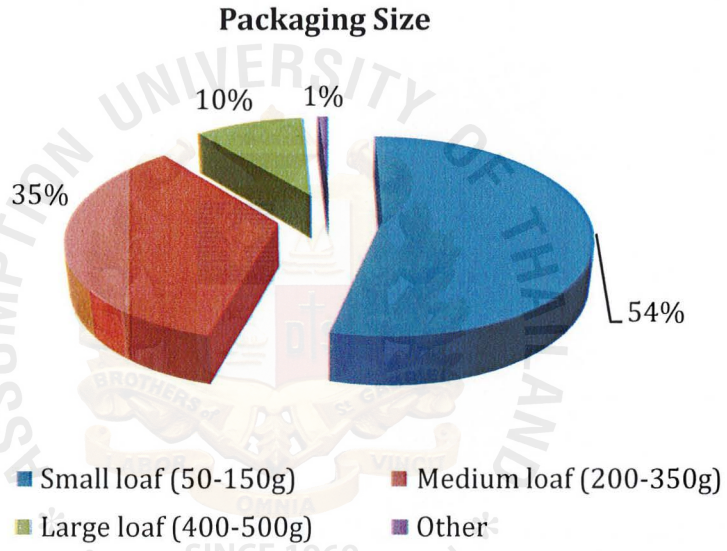


Figure 13: Preferable size of bread pie chart

From Figure 13, the consumer preferred size of bread was the medium loaf one – 200-350 g. Due to most consumers in the testing group were students, so they normally prefer 'one time consuming' with the easy-to-go packaging size that would be more convenient for them.

Table 8: Cost calculation of ingredient usage of product

Ingredients list	Amount (g)	Percentage	Price/Packing	Packaging size (g)	Cost
Bread Flour	300	100	36.00	1,000	10.8
Sugar	24	8	23.50	1,000	0.56
Yeast	3	1	145.00	500	0.87
Salt	7	2.33	6.00	500	0.08
Butter	18	6	63.00	150	7.56
Milk Powder	10	3.33	102.00	600	1.70
Water	200	66.67	0.00	0	0
Tea powder	22	7.33	5.00	100	1.10
Total raw material cost / batch (approximately 560 g)					22.67
Total raw material cost / loaf (approximately 560 g)					22.67
Total raw material cost / pack (250 g)					10.12
Production cost / pack (250 g)					3.03
Promotion cost / pack (250 g)					3.03
Raw material cost + production cost + promotion cost					16.18
Benefit / pack (250 g) for 25 Baht					54.51
Benefit /pack (250 g) for 30 Baht					85.41

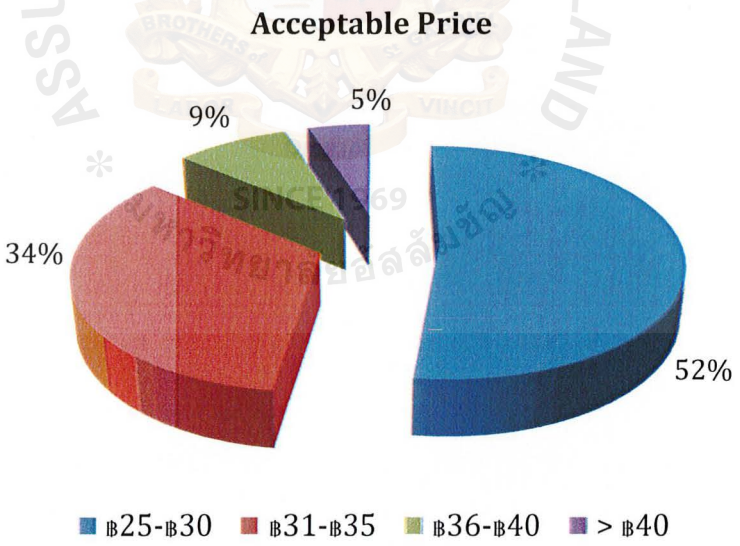


Figure 14: Product acceptable price range pie chart

Figure 13 showed the acceptable product price range of ฿25-฿30. This was agreed with the results from consumers' career and their monthly income that most consumers were students with monthly income less than ฿ 10,000.-, indicated the acceptable price range was not in the relatively high.

Table 9: The average preference score from 9-point hedonic score testing in final product acceptance test

Characteristics of final product (Mean score ± SD)					
Color	Appearance	Flavor	Aroma	Softness	Overall
6.45±1.23	6.62±1.16	6.68±1.32	6.80±1.33	6.82±1.34	6.82±1.23

As in the table shown above, the final product got the average overall liking score of 6.82±1.23 from the 9-point hedonic score testing meaning that most of consumers liked the bread fortified with fibre from tea processed by-products from slightly like (6) to moderately like (7). In the same way, the average scores of other characteristics including color, appearance, flavor, aroma, and softness were not significantly differences ($p<0.05$), fell in the same range of overall acceptance.

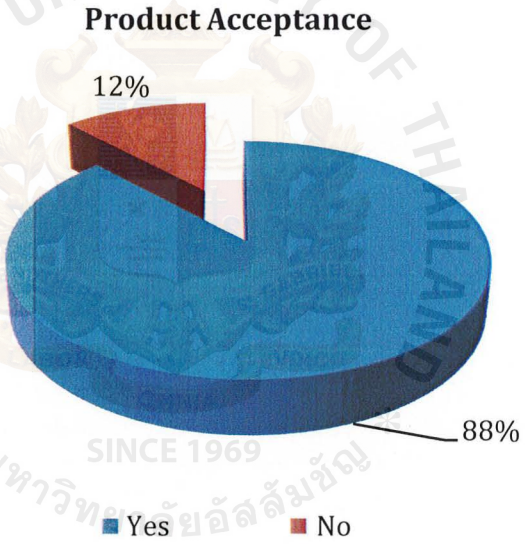


Figure 15: Final product acceptance pie chart

As a summary, Figure 15 showed that consumers' acceptance of final product had obtained 88%, indicated its potential place in the market.

Conclusion

Bread fortified with fiber from tea processed by-products was produced from the by-products in the tea making processes. It was developed from the original recipe of bran bread and gradually adjusted the amount of ingredients, especially the replacing of green tea powder instead of bran until the acceptance of finished product could meet the certain standard actually. The final product formula was demonstrated in Table 10 where tea by-products powder made from tea stem was selected as source of tea in the tea bread.

Table 10: Formula for finished product developed base on the consumer preference test

Ingredients	Amount (g)
Bread flour	100
Sugar	8
Yeast	1
Salt	2.7
Butter	6
Milk powder	3.3
Water	66.7
Tea stems by-product powder	7.3

Recommendations

1) To improve the color of the final product, bread fortified with fiber from tea processed by-product. The limitation of tea stems processed by-product is its pale green color. There should be some study on an improvement of bread color by addition of green tea or synthetic food colorant.
2) To improve uniformity of the loaf, it should be some study of making sandwich bread in a Pullman bread pan.
3) To verify the improved chemical quality of the tea bread, fiber content should be determined.
4) To verify the improved nutritive value of the fortified fiber in tea bread, the fiber content should be determined.

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Appendix A:
Developing Formula

Appendix A-1

Test No. _____

Just About Right Test

Product: Bread Fortified with Fiber from Tea Processed By-products

Name: _____

Instruction:

1. Please rinse your mouth with water before starting. You may rinse again at anytime during the test you need to.
2. Please taste the sample in the order presented, from left to right.
3. Please mark X and O to rate whether the level of a sensory attribute of the sample is "too high", "just right", or "too low".

Sample A (X) Used of tea stems by-product

Sample B (O) Used of tea leaves by-product

1. Softness

Much too hard	Somewhat too hard	Just right	Somewhat too soft	Much toosoft

2. Tea flavor

Much too strong	Somewhat too strong	Just right	Somewhat too weak	Much too weak

3. Sweetness

Much too strong	Somewhat too strong	Just right	Somewhat too weak	Much too weak

4. Saltiness

Much too strong	Somewhat too strong	Just right	Somewhat too weak	Much too weak

5. Butter Flavor

Much too strong	Somewhat too strong	Just right	Somewhat too weak	Much too weak

6. Moistness

Much too much	Somewhat too much	Just right	Somewhat too less	Much too less

Appendix A-2

Frequency of consumer behavior on just about right test for developing and adjusting the formula of product

Sample A: Use of tea stems by-product as the main ingredient.

1. Softness

	Frequency	Percent	Valid Percent	Cumulative Percent
Much too hard	1	10.0	10.0	10.0
Somewhat too hard	5	50.0	50.0	60.0
Just right	4	40.0	40.0	100.0
Total	10	100.0	100.0	

2. Tea Flavor

	Frequency	Percent	Valid Percent	Cumulative Percent
Much too strong	1	10.0	10.0	10.0
Somewhat too strong	2	20.0	20.0	30.0
Just right	6	60.0	60.0	90.0
Somewhat too weak	1	10.0	10.0	100.0
Total	10	100.0	100.0	

3. Sweetness

	Frequency	Percent	Valid Percent	Cumulative Percent
Just right	5	50.0	50.0	50.0
Somewhat too weak	4	40.0	40.0	90.0
Much too weak	1	10.0	10.0	100.0
Total	10	100.0	100.0	

4. Saltiness

	Frequency	Percent	Valid Percent	Cumulative Percent
Somewhat too strong	2	20.0	20.0	20.0
Just right	8	80.0	80.0	100.0
Total	10	100.0	100.0	

5. Butter flavor

	Frequency	Percent	Valid Percent	Cumulative Percent
Somewhat too strong	1	10.0	10.0	10.0
Just right	5	50.0	50.0	60.0
Somewhat too weak	3	30.0	30.0	90.0
Much too weak	1	10.0	10.0	100.0
Total	10	100.0	100.0	

6. Moistness

	Frequency	Percent	Valid Percent	Cumulative Percent
Somewhat too much	2	20.0	20.0	20.0
Just right	6	60.0	60.0	80.0
Somewhat too less	1	10.0	10.0	90.0
Much too less	1	10.0	10.0	100.0
Total	10	100.0	100.0	

Sample B: Use of tea leaves by-product as the main ingredient.

1. Softness

	Frequency	Percent	Valid Percent	Cumulative Percent
Somewhat too hard	2	20.0	20.0	20.0
Just right	8	80.0	80.0	100.0
Total	10	100.0	100.0	

2. Tea Flavor

	Frequency	Percent	Valid Percent	Cumulative Percent
Somewhat too strong	5	50.0	50.0	50.0
Just right	3	30.0	30.0	80.0
Somewhat too weak	2	20.0	20.0	100.0
Total	10	100.0	100.0	

3. Sweetness

	Frequency	Percent	Valid Percent	Cumulative Percent
Just right	5	50.0	50.0	50.0
Somewhat too weak	4	40.0	40.0	90.0
Much too weak	1	10.0	10.0	100.0
Total	10	100.0	100.0	

4. Saltiness

	Frequency	Percent	Valid Percent	Cumulative Percent
Somewhat too strong	3	30.0	30.0	30.0
Just right	7	70.0	70.0	100.0
Total	10	100.0	100.0	

5. Butter flavor

	Frequency	Percent	Valid Percent	Cumulative Percent
Somewhat too strong	1	10.0	10.0	10.0
Just right	5	50.0	50.0	60.0
Somewhat too weak	3	30.0	30.0	90.0
Much too weak	1	10.0	10.0	100.0
Total	10	100.0	100.0	

6. Moistness

	Frequency	Percent	Valid Percent	Cumulative Percent
Somewhat too much	1	10.0	10.0	10.0
Just right	8	80.0	80.0	90.0
Much too less	1	10.0	10.0	100.0
Total	10	100.0	100.0	

Appendix B:
Product Development

Appendix B-1

Test No. _____

Hedonic Test

Product: Bread Fortified with Fiber from Tea Processed By-products

Name: _____

Instruction:

1. Please rinse your mouth with water before starting. You may rinse again at anytime during the test you need to.
2. Please taste the sample in the order presented, from left to right.
3. Please rate the sample from most preferred to least preferred using the following numbers (9-point hedonic scale).

1 = Dislike extremely	4 = Dislike slightly	7 = Like moderately
2 = Dislike very much	5 = Neither like nor dislike	8 = Like very much
3 = Dislike moderately	6 = Like slightly	9 = Like extremely

Hedonic Rating

Attributes	Sample no.							
	1	2	3	4	5	6	7	8
Softness								
Tea Flavor								
Sweetness								
Saltiness								
Butter Flavor								
Moistness								
Overall								

Appendix B-2

Hedonic score testing for screening the most preferred formula of the product using tea leaves powder as the main ingredient.

nple	Attributes (Mean score ± SD)						
	Softness	Tea Flavor	Sweetness	Saltiness	Butter Flavor	Moistness	Overall
ıula 1	6.70±1.16	6.20±1.75	7.00±1.05	7.20±0.79	6.00±1.25	7.10±1.45	6.70±0.82^{ab}
ıula 2	6.80±1.03	5.80±1.40	7.20±0.92	7.40±0.97	6.40±0.97	6.90±1.10	6.50±0.97^{b}
`la 3	7.30±0.82	6.50±1.51	7.40±1.07	7.30±1.25	6.60±1.65	7.50±0.85	7.50±0.85^{b}
ıa 4	7.20±0.79	6.10±1.91	7.00±0.94	7.20±1.14	6.60±1.71	7.30±1.06	7.10±1.29^{b}
la 5	7.10±0.99	6.30±1.49	6.70±1.64	6.70±0.95	6.10±1.45	6.50±0.97	6.50±0.71^{a}
ıla 6	7.10±0.88	6.00±1.76	6.80±1.69	6.80±1.23	6.20±1.23	6.80±0.92	6.90±0.99^{ab}
ula 7	7.40±1.51	6.80±1.62	6.80±1.81	6.90±1.37	6.40±1.51	6.80±1.40	7.30±1.49^{b}
ula 8	7.40±1.35	6.90±1.29	6.60±1.51	7.00±1.33	6.40±1.26	6.90±1.37	7.30±0.95^{b}

Appendix B-3

Hedonic score testing for screening the most preferred formula of the product using tea stems powder as the main ingredient.

ımple	Characteristics (Mean score ± SD)						
	Softness	Tea Flavor	Sweetness	Saltiness	Butter Flavor	Moistness	Overall
mula 9	6.80±0.92	6.50±1.08	7.00±1.15	6.80±0.92	6.40±0.97	6.90±0.74	6.90±0.88
nula 10	7.20±0.63	7.20±0.63	7.20±1.23	6.90±0.88	6.70±0.67	6.90±0.57	7.10±0.74
mula 11	7.40±0.97	7.40±0.97	7.10±0.99	6.70±1.06	7.10±0.99	7.10±0.88	7.10±0.88
mula 12	7.30±0.82	7.30±0.82	7.10±0.99	7.10±0.88	6.90±0.99	7.50±1.18	7.40±0.70
mula 13	6.40±1.17	6.90±0.99	6.60±1.17	7.10±1.10	6.60±0.84	6.60±1.17	6.40±0.97
mula 14	6.70±1.56	7.20±1.03	6.70±0.95	7.30±0.82	6.70±0.82	6.80±0.79	7.00±0.82
nula 15	7.10±1.37	7.60±1.17	7.40±0.70	7.40±0.84	7.20±0.63	7.20±0.79	7.30±0.82
nula 16	7.30±1.16	7.60±1.06	7.30±1.16	7.40±0.70	7.10±1.10	7.00±0.94	7.60±1.26

Appendix B-4

Screening test analysis on all attributes

1) Softness

- ***Tea Stems***

ANOVA

SOV	SS	df	MS	Fcal	Ftab	
Trt	8.75	7	1.25	1.64	2.17	**n.s**
Panel	31.20	9	3.47	4.55	2.04	
Err	48.00	63	0.76			
Total	87.95	79				

Duncan's multiple range test sqrt(MES/r)

Sy 0.276

	p						
	2	3	4	5	6	7	8
r	2.827	2.974	3.071	3.141	3.196	3.239	3.275
Rp	0.78	0.82	0.85	0.87	0.88	0.89	0.90

- ***Tea Leaves***

ANOVA

SOV	SS	df	MS	Fcal	Ftab	
Trt	4.75	7	0.68	0.60	2.17	**n.s**
Panel	14.25	9	1.58	1.39	2.04	
Err	71.75	63	1.14			
Total	90.75	79				

Duncan's multiple range test sqrt(MES/r)

Sy 0.337

	p						
	2	3	4	5	6	7	8
r	2.827	2.974	3.071	3.141	3.196	3.239	3.275
Rp	0.95	1.00	1.04	1.06	1.08	1.09	1.11

2) Tea Flavor

- ***Tea Stems***

ANOVA

SOV	SS	df	MS	Fcal	Ftab	
Trt	8.40	7	1.20	1.23	2.17	**n.s**
Panel	9.45	9	1.05	1.08	2.04	
Err	61.35	63	0.97			
Total	79.20	79				

Duncan's multiple range test sqrt(MES/r)

Sy 0.312

	p						
	2	3	4	5	6	7	8
r	2.827	2.974	3.071	3.141	3.196	3.239	3.275
Rp	0.88	0.93	0.96	0.98	1.00	1.01	1.02

- ***Tea Leaves***

ANOVA

SOV	SS	df	MS	Fcal	Ftab	
Trt	10.35	7	1.48	0.67	2.17	**n.s**
Panel	45.55	9	5.06	2.28	2.04	*
Err	139.65	63	2.22			
Total	195.55	79				

Duncan's multiple range test sqrt(MES/r)

Sy 0.471

	p					
	2	3	4	5	6	7
r	2.827	2.974	3.071	3.141	3.196	3.239

3) Sweetness

- ***Tea Stems***

ANOVA

SOV	SS	df	MS	Fcal	Ftab	
Trt	5.387	7	0.770	0.738	2.166	**n.s**
Panel	15.762	9	1.751	1.678	2.036	
Err	65.738	63	1.043			
Total	86.887	79				

- ***Tea Leaves***

ANOVA

SOV	SS	df	MS	Fcal	Ftab	
Trt	4.988	7	0.713	0.782	2.166	**n.s**
Panel	78.313	9	8.701	9.552	2.036	
Err	57.387	63	0.911			
Total	140.688	79				

4) Saltiness

- ***Tea Stems***

ANOVA

SOV	SS	df	MS	Fcal	Ftab	
Trt	5.09	7	0.73	1.10	2.17	**n.s**
Panel	17.51	9	1.95	2.93	2.04	
Err	41.79	63	0.66			
Total	64.39	79				

Duncan's multiple range test sqrt(MES/r)

Sy 0.258

	p						
	2	3	4	5	6	7	8
r	2.827	2.974	3.071	3.141	3.196	3.239	3.275
Rp	0.73	0.77	0.79	0.81	0.82	0.83	0.84

- ***Tea Leaves***

ANOVA

SOV	SS	df	MS	Fcal	Ftab	
Trt	4.39	7	0.63	0.62	2.17	**n.s**
Panel	31.06	9	3.45	3.44	2.04	
Err	63.24	63	1.00			
Total	98.69	79				

Duncan's multiple range test sqrt(MES/r)

Sy 0.317

	p						
	2	3	4	5	6	7	8
r	2.827	2.974	3.071	3.141	3.196	3.239	3.275
Rp	0.90	0.94	0.97	1.00	1.01	1.03	1.04

5) Butter Flavor

- ***Tea Stems***

ANOVA

SOV	SS	df	MS	Fcal	Ftab	
Trt	5.59	7	0.80	1.25	2.17	**n.s**
Panel	17.01	9	1.89	2.96	2.04	
Err	40.29	63	0.64			
Total	62.89	79				

Duncan's multiple range test sqrt(MES/r)

Sy 0.253

	p						
	2	3	4	5	6	7	8
r	2.827	2.974	3.071	3.141	3.196	3.239	3.275
Rp	0.71	0.75	0.78	0.79	0.81	0.82	0.83

- ***Tea Leaves***

ANOVA

SOV	SS	df	MS	Fcal	Ftab	
Trt	3.39	7	0.48	0.26	2.17	**n.s**
Panel	21.01	9	2.33	1.23	2.04	
Err	119.49	63	1.90			
Total	143.89	79				

Duncan's multiple range test sqrt(MES/r)

Sy 0.436

	p						
	2	3	4	5	6	7	8
r	2.827	2.974	3.071	3.141	3.196	3.239	3.275
Rp	1.23	1.30	1.34	1.37	1.39	1.41	1.43

6) Moistness

- ***Tea Stems***

ANOVA

SOV	SS	df	MS	Fcal	Ftab	
Trt	5.20	7	0.74	1.24	2.17	**n.s**
Panel	21.00	9	2.33	3.89	2.04	
Err	37.80	63	0.60			
Total	64.00	79				

Duncan's multiple range test sqrt(MES/r)

Sy 0.245

	p						
	2	3	4	5	6	7	8
r	2.827	2.974	3.071	3.141	3.196	3.239	3.275
Rp	0.69	0.73	0.75	0.77	0.78	0.79	0.80

- ***Tea Leaves***

ANOVA

SOV	SS	df	MS	Fcal	Ftab	
Trt	6.95	7	0.99	0.75	2.17	**n.s**
Panel	13.45	9	1.49	1.13	2.04	
Err	83.55	63	1.33			
Total	103.95	79				

Duncan's multiple range test sqrt(MES/r)

Sy 0.364

	p						
	2	3	4	5	6	7	8
r	2.827	2.974	3.071	3.141	3.196	3.239	3.275
Rp	1.03	1.08	1.12	1.14	1.16	1.18	1.19

7) Overall

- ***Tea Stems***

ANOVA

SOV	SS	df	MS	Fcal	Ftab	
Trt	9.92	7	1.42	2.61	2.17	*
Panel	22.45	9	2.49	4.60	2.04	
Err	34.17	63	0.54			
Total	66.55	79				

Duncan's multiple range test sqrt(MES/r)

Sy 0.233

	p						
	2	3	4	5	6	7	8
r	2.827	2.974	3.071	3.141	3.196	3.239	3.275
Rp	0.66	0.69	0.72	0.73	0.74	0.75	0.76

- ***Tea Leaves***

ANOVA

SOV	SS	df	MS	Fcal	Ftab	
Trt	10.35	7	1.48	1.51	2.17	**n.s.**
Panel	15.95	9	1.77	1.81	2.04	
Err	61.65	63	0.98			
Total	87.95	79				

Duncan's multiple range test sqrt(MES/r)

Sy 0.313

	p						
	2	3	4	5	6	7	8
r	2.827	2.974	3.071	3.141	3.196	3.239	3.275
Rp	0.88	0.93	0.96	0.98	1.00	1.01	1.02

Appendix B-5

Test No. _____

Hedonic Test

Product: Bread Fortified with Fiber from Tea Processed By-products

Name: _____

Instruction:

1. Please rinse your mouth with water before starting. You may rinse again at anytime during the test you need to.
2. Please taste the sample in the order presented, from left to right.
3. Please rate the sample from most preferred to least preferred using the following numbers (9-point hedonic scale).

2 = Dislike extremely (ไม่ชอบมากที่สุด)	4 = Dislike slightly (ไม่ชอบเล็กน้อย)	7 = Like moderately (ชอบปานกลาง)
3 = Dislike very much (ไม่ชอบมาก)	5 = Neither like nor dislike (เฉยๆ)	8 = Like very much (ชอบมาก)
3 = Dislike moderately (ไม่ชอบปานกลาง)	6 = Like slightly (ชอบเล็กน้อย)	9 = Like extremely (ชอบมากที่สุด)

Hedonic Rating	**Sample A**	**Sample B**
1.) Softness (ความนุ่ม)	_____	_____
2.) Tea Flavor (รสชา)	_____	_____
3.) Sweetness (ความหวาน)	_____	_____
4.) Saltiness (ความเค็ม)	_____	_____
5.) Moistness (ความชื้น)	_____	_____
6.) Overall (ภาพรวมของผลิตภัณฑ์)	_____	_____

Appendix C:
Consumer Acceptance

Appendix C-1

Questionnaires: Consumer behavior and preferences on "Bread fortified with fiber from tea processed by-products

Instruction: Please make ☐ in the box that you think it follow on your thinking and attitude

Part 1: Demographic

1. Gender ☐ Male ☐ Female

2. Age ☐ 15 and under ☐ 16-25 ☐ 26-35
   ☐ 36-45 ☐ 46-55 ☐ 56 and over

3. Highest Education ☐ Lower than high school ☐ High school
   ☐ Diploma ☐ Bachelor's Degree
   ☐ Higher bachelor's degree

4. Career ☐ Student ☐ Government Officer
   ☐ Employee ☐ Own business
   ☐ Other _____ *(Please specify)*

5. Monthly Income ☐ Less than ฿10,000 ☐ ฿10,000 – ฿15,000
   ☐ ฿15,001 – ฿20,000 ☐ ฿20,001 – ฿25,000
   ☐ ฿25,001 – ฿30,000 ☐ More than ฿30,000

Part2: Consumers behavior and product acceptance

6. Do you usually consume bread?
   ☐ Yes ☐ No

7. Do you recall any brands of bread you have consumed?
   ☐ Yes ☐ No

8. What brands of bread do you familiar the most? (Choose three brands)
   ☐ Farmhouse ☐ S&P ☐ Yamazaki
   ☐ Gateux House ☐ In & Out ☐ UFM
   ☐ Other _____ *(Please specify)*

9. Please identify your 2 most preferred flavor you usually eat (Choose two flavors)

☐ Original ☐ Whole wheat/ Whole meal

☐ Black sesame ☐ Butter

☐ Other _____ *(Please specify)*

10. You usually eat bread as ;

☐ Main course

☐ Snack (any time you are hungry)

☐ Other _____ *(Please specify)*

11. How much size of bread do you usually buy at one time?

☐ Small loaf (50-150g) ☐ Medium loaf (200-350 g)

☐ Large loaf (400-500g) ☐ Other _____ *(Please specify)*

12. Where do you usually buy bread?

☐ 7-11 ☐ Family Mart ☐ Grocery stores

☐ Tops Supermarket ☐ Tesco Lotus ☐ Villa market

☐ Big C ☐ Robi nson ☐ The Mall

☐ Central ☐ Home Fresh Mart ☐ Other

13. Please try this bread fortified with fiber from tea processed wastes and rate the product in the table provoded.

Instruction:

a) Please rinse your mouth with water before starting. You may rinse again anytime during the test.

b) Please taste the sample and rate the sample in each attribute from most preferred to least preferred by ticking in these following table:

ttribute	Dislike extremely	Dislike Very much	Dislike Moderately	Dislike slightly	Neither like nor dislike	Like slightly	Like moderately	Like Very much	Like extremely
ılor									
ıpearance									
ıvor									
oma									
ftness									
′erall									

Part3: Purchase intention

14. What is your most acceptable price of this product? (200 g per pack)

☐ 25-30 Baht ☐ 31-35 Baht

☐ 36-40 Baht ☐ >40 Baht

15. If this product is launched to the market, are you willing to buy this product?

Why?

☐ Yes ☐ No

_____

_____

_____

16. Suggestion

_____

_____

_____

Appendix C-2

Frequency of consumer acceptance on final product

1. Gender

	Frequency	Percent	Valid percent	Cumulative Percent
Male	30	30.0	30.0	30.0
Female	70	70.0	70.0	100.0
Total	100	100.0	100.0	

2. Age

	Frequency	Percent	Valid Percent	Cumulative Percent
15 and under	1	1.0	1.0	1.0
16-25	88	88.0	88.0	89.0
26-35	8	8.0	8.0	97.0
36-45	0	0	0	97.0
46-55	2	2.0	2.0	99.0
56 and over	1	1.0	1.0	100.0
Total	100	100.0	100.0	

3. Education

	Frequency	Percent	Valid Percent	Cumulative Percent
Lower than high school	0	0	0	0
High school	6	6.0	6.0	6.0
Diploma	1	1.0	1.0	7.0
Bachelor's Degree	88	88.0	88.0	95.0
Higher than bachelor's degree	5	5.0	5.0	100.0
Total	100	100.0	100.0	

4. Career

	Frequency	Percent	Valid Percent	Cumulative Percent
Student	87	87.0	87.0	87.0
Government officer	0	0	0	87.0
Employee	9	9.0	9.0	96.0
Own business	2	2.0	2.0	98.0
Other	2	2.0	2.0	100.0
Total	100	100.0	100.0	

5. Monthly Income

	Frequency	Percent	Valid Percent	Cumulative Percent
< ฿10,000	55	55.0	55.0	55.0
฿10,000-฿15,000	28	28.0	28.0	83.0
฿15,001-฿20,000	7	7.0	7.0	90.0
฿20,001-฿25,000	3	3.0	3.0	93.0
฿25,001-฿30,000	1	1.0	1.0	94.0
> ฿30,000	6	6.0	6.0	100.0
Total	100	100.0	100.0	

6. Do they usually consume bread?

	Frequency	Percent	Valid Percent	Cumulative Percent
Yes	83	83.0	83.0	83.0
No	17	17.0	17.0	100.0
Total	100	100.0	100.0	

7. Can they recall the brand?

	Frequency	Percent	Valid Percent	Cumulative Percent
Yes	89	89.0	89.0	89.0
No	11	11.0	11.0	100.0
Total	100	100.0	100.0	

8. Brands

	Frequency	Percent	Valid Percent	Cumulative Percent
Farmhouse	80	26.67	26.67	26.67
S&P	76	25.33	25.33	52.0
Yamazaki	58	19.33	19.33	71.33
Gateux house	46	15.33	15.33	86.66
In & Out	27	9.0	9.0	95.66
UFM	6	2.0	2.0	97.66
Other	7	2.33	2.33	100.0
Total	100	100.0	100.0	

9. Flavor

	Frequency	Percent	Valid Percent	Cumulative Percent
Original	77	38.5	38.5	38.5
Whole wheat	64	32.0	32.0	70.5
Black sesame	12	6.0	6.0	76.5
Butter	43	21.5	21.5	98.0
Other	4	2.0	2.0	100.0
Total	200	100.0	100.0	

10. They usually consume bread as;

	Frequency	Percent	Valid Percent	Cumulative Percent
Main course	75	75.0	75.0	75.0
Snack	19	19.0	19.0	94.0
Other	6	6.0	6.0	100.0
Total	100	100.0	100.0	

11. Size of bread

	Frequency	Percent	Valid Percent	Cumulative Percent
Small loaf (50-150g)	54	54.0	54.0	54.0
Medium loaf (200-350g)	35	35.0	35.0	89.0
Large loaf (400-500g)	10	10.0	10.0	99.0
Other	1	1.0	1.0	100.0
Total	100	100.0	100.0	

12. Where do they usually buy bread?

	Frequency	Percent	Valid Percent	Cumulative Percent
7-11	27	27.0	27.0	27.0
Family mart	8	8.0	8.0	35.0
Grocery stores	1	1.0	1.0	36.0
Tops supermarket	5	5.0	5.0	41.0
Tesco Lotus	7	7.0	7.0	48.0
Villa market	7	7.0	7.0	55.0
Big C	5	5.0	5.0	60.0
Robinson	0	0	0	60.0
The Mall	15	15.0	15.0	75.0
Central	13	13.0	13.0	88.0
Home fresh mart	10	10.0	10.0	98.0
Other	2	2.0	2.0	100.0
Total	100	100.0	100.0	

13. Preferences score

Characteristics of final product (Mean score ± SD)					
Color	Appearance	Flavor	Aroma	Softness	Overall
6.45±1.23	6.62±1.16	6.68±1.32	6.80±1.33	6.82±1.34	6.82±1.23

14. Acceptable price

	Frequency	Percent	Valid Percent	Cumulative Percent
฿25-฿30	52	52.0	52.0	52.0
฿31-฿35	34	34.0	34.0	86.0
฿36-฿40	9	9.0	9.0	95.0
> ฿40	5	5.0	5.0	100.0
Total	100	100.0	100.0	

15. Product Acceptance

	Frequency	Percent	Valid Percent	Cumulative Percent
Yes	88	88.0	88.0	88.0
No	12	12.0	12.0	100.0
Total	100	100.0	100.0	