THE STUDY OF THE EFFECTS OF TEMPERATURE AND SWEETNESS ON THE DRINKING QUALITY AND PREFERENCE OF GREEN TEA

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A special project submitted to the School of Biotechnology, Assumption University in part fulfillment of the requirement for the degree of Bachelor of Science in Biotechnology

2018

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THE STUDY OF THE EFFECTS OF TEMPERATURE AND SWEETNESS ON THE DRINKING QUALITY AND PREFERENCE OF GREEN TEA

ABSTRACT

Tea is one of the most popular and inexpensive beverage in the world. It is enjoyed by several types of people ranging throughout all age groups and all levels of society. Around three billion cups of tea are consumed daily worldwide. There have been many different views on the topic of brewing and processing tea procedures but not much has been done about how the temperature and sweetness affect the perception and preference of tea. The aim of this study was to experiment with green tea at three different temperatures: hot, cold, and room temperature (60°C, 23°C, and 5°C) and two types of sweetness (added 6% sugar and no sugar added) to study the effects of temperature and sweetness on the preference scores of consumers.

In this experiment a consumer test was performed on 120 consumers who had to taste 12 treatments over two sessions (6 samples per session) and score them on a 9 point hedonic scale, they were not informed of the aim of the experiment as to avoid bias. The results were then analyzed based on 7 of the following attributes: Overall liking, Color, Aroma, Sweetness, Bitterness, Flavors, and Astringency. It was found that all treatments were preferred almost equally except for the astringency which affects preference scores at different temperatures. And sweetness has shown to have no effect to preference and there is no significant interaction effect between temperature and sweetness.

KEY WORDS: Green tea / Preference / Temperature / Sweetness / Consumer testing

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INTRODUCTION

Tea is a drink which is enjoyed by all kinds of people for its aromatic qualities and the several health benefits it provides. Even if 50-60% of the production cost is in the labor, the tea production makes an important contribution to the economy of the manufacturing countries (Hicks, 2009). Green tea is a well-established Chinese tea that is produced from *Camellia sinensis* from the made from the leaves, buds, and stems of the plant through a special process of withering of the plant under heat and subjecting it to oxidation.

In Thailand, The Thai Royal Development Project was first implemented in the 1980s and was the first to identify tea as a potential source of income in the Northern Thailand Highlands where the cultivation of opium crops was becoming a major issue. Thailand itself did not have an ancient tea culture (compared to countries such as China, Japan, and Korea) up until the Royal Development Project's initiative. Although, tea was a common beverage in North Thailand only with the Shan due to some of the hill tribes originating from China. They collected tea leaves from wild growing tea trees and processed them according to their own traditions to different varieties of green tea and Pu Errh style teas (Highland Research and Development Institute, 2005). But now in Thailand, it is a huge booming market. Mostly cold drinks are preferred because of the hot climate and green tea, and mulberry tea were the main herbal teas consumed among Thai consumers for health benefits(Nookabkaew et al., 2006). Due to the large demand for tea, it is important to identify and understand the reasons for the most preferred temperatures and qualities of tea and whether the combination of temperatures and sweetness affect preference.

Several types of teas can be extracted from this *Camellia sinensis*; the end product depends on the different processing methods and level of oxidation and what is added to it. The grade of oxidation can range from 8 to 85% depending on the production style and variety. The reason that green tea has more health benefits attached to it than other teas is apparently due to its processing or lack thereof. Black tea is processed in a way that allows for 'fermentation' whereas green tea's processing

avoids the process or undergoes minimal oxidation. As a result, green tea retains concentrated amounts of antioxidants and poly-phenols, the substances that give green tea its many benefits (Murugesh & Subramanian, 2014).

Since there are several types of green teas in the market and various ways that it is consumed, it is important to find out at what temperature and sweetness do the consumers in Thailand prefer to consume their tea, whether they actually prefer it to be hot or cold versus sweet and not sweet. With the increasing consumption of Green tea and various preparation techniques influenced by quite a few cultures, no definite data has been established about the general temperature of serving. Most preparation methods use water that is heated between lowest being 142° F and highest being 189° F (should be lower than the boiling point of water) and a steeping time of 1 to 2 minutes (Lantano et al., 2015). However methods vary as everybody has a different viewpoint on tea, water temperature, and manufacturing methods. Not only do methods of preparation differ but the way that tea is drunk in different countries is also dissimilar.

Presently there is not a wealth of published information on how varying the serving temperature and sweetness will affect consumer preference of green tea and it is a major part of in the food industry is to understand a products characteristics and to know how consumer preference will be affected in order to be able to improve your product for the better.

The present aims to find that out that by experimenting with three different temperatures (60°C, 23°C, and 5°C) and two types of sweetness (added 6% sugar and no sugar added) in order to find out the most preferred combinations. This would be greatly beneficial to companies that will be developing their own green tea product as well as give rise to new more innovative green tea products.

OBJECTIVE

- 1. To study the effect of temperature and sweetness on the drinking quality and preference of green tea.
- 2. To study whether the various combinations of Sweetness and Temperature affect each other significantly
- 3. To determine which combined characteristics are the least liked/preferred at each Temperature and Sweetness



LITERATURE REVIEW

1. Tea

Tea is a beverage that has been consumed for several centuries worldwide and thus has several variations of the preparation and consuming methods. Tea is usually made by steeping dried *Camellia sinensis* leaves in hot water and oxidizing them. The level of oxidation and flavorings or lack thereof will determine the kind of tea that will be produced.

1.1 Green tea, Oolong tea, and Scented teas

All tea is made from the same plant but what makes them different is their level of oxidation. Green tea is un-oxidized, black tea is fully oxidized while Oolong tea is in the middle (between 20% and 80% oxidation depending on the product). Scented teas are usually teas with different flavorings/additives added to it to make it more appealing or to give it extra flavor (mostly flowers but can also be spices and/or herbs). One of the most common scented tea is the jasmine tea which is light green tea and is scented with the aroma of the jasmine flower blossoms (Ahmed & Stepp, 2012). For products in the market, the grade of the tea leaves or the type of teas used also may depend on the manufacturers' preference/recipe.

1.2 Brewing tea

Brewing or steeping is the process of making a cup of tea. Since point of brewing is to bring out the best qualities of a given tea, the brewing must stop just as the tannins develop enough to give the tea a nice finish. If the water is too cool, no tannins shall be released, resulting in an unsatisfactory flavor. As water temperature increases so will the amount of tannin in the brew. That tannin can also dominate the flavor and the other elements will be missed. In some cases only a taste of bitterness remains (Xu et al., 2018).

The brewing technique plays a very important role in avoiding the tea developing an overcooked taste. The cup in which the tea is supposed to be served should also be warmed beforehand so that the tea does not immediately cool down. It is common practice for tea leaf to be left in the cup or pot and for hot water to be added as the tea is drunk until the flavor degrades (Mair & Hoh, 2009).

Green teas are especially better with a lower water temperature because when the tea is less oxidized, the lower brewing temperature will give a better flavor. Japanese green teas in particular are very raw and if boiling water is put on it, it will be cooked. The higher the temperature, the more the 'overcooked' feeling will be. Also the body, or viscosity, of a green tea results from dissolved particulate matter in the cup (such as miniscule hairs and leaf matter). If the water is too hot more acids will be released destroying this matter and reducing the body of the tea. This must be controlled even further when brewing scented teas as the aroma of the tea may degrade as well which can lead to variation in sensory features (Lantano et al., 2015).

1.3 Tea leaves processing methods

In the processing of green tea, plucked leaves are spread out in pans or bamboo trays to dry. The intent is to preserve the healthy and natural elements of the fresh leaves. The traditional method of processing green teas involves withering (not always depending on what end product is required), heating, rolling and drying. After picking, the fresh leaves are spread out on bamboo trays and exposed to sunlight or warm air for one to two hours. Once most of the water has evaporated from the leaves, they are quickly heated to prevent any oxidation. In modern mechanized processes, the leaves are warmed in metal pans to induce the evaporation of the leaves' moisture.

Flavored teas need another stage of processing once the leaves are sorted and graded. The black or green tea base is dried another time and flavoring, spice, or flowers are added. Some teas, such as most Jasmine teas, are flavored during the actual oxidation process. After the flavoring is added, the tea is cooled and packaged (Commins & Sampanvejsobha, 2008). Therefore the way the tea is processed and the type of the tea that are achieved in the end product contain various different properties depending on the processing methods. Depending on the content of antioxidants, phenolic compounds, and tannins, just to name a few, the perceived quality of the tea can be very drastic from person to person (Miyauchi et al., 2014).

1.4 Health benefits

Green tea has also long been thought to have several benefits to one's health. Some people that consume it regularly may have a lower risk of developing heart disease and certain types of cancer, it is also used to treat diabetes, "hardening of the arteries" (atherosclerosis), high cholesterol and skin allergies such as eczema; and to boost the immune system (Deka & Vita, 2011). A recent study showed that continuous consumption green tea would induce thermogenesis and facilitate fat oxidation, boosting the metabolic rate 4% without increasing the heart rate led to a reduction in body weight (Hursel et al., 2011). With several benefits and enlightening scientific studies, Green tea is especially popular now more than ever with both tea connoisseurs & normal people of the world.

2. Cultural perceptions

Different countries have different perceptions about the brewing, preparation methods and the presentation of green tea which in turn affect the outcome of consumers' preference. Usually countries with strong tea cultures prefer to drink it in their own traditional ways compared to countries that do not. For example, in Korea, green tea has traditionally been brewed unsweetened and even until now the current generation still prefers the same (Lee et al., 2010).

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2.1 Tea culture in China

In china, there are several cultural factors relating to green tea and due to the importance, the "culture of the Way of Tea", in Chinese society and culture, tea houses can be found in most Chinese neighborhoods and business districts (Fu et al., 2018). Which offer dozens of varieties of hot and cold tea with a variety of tea-friendly and/or tea-related snacks. Chinese traditional culture is also very deeply connected with their own Chinese tea as tea is often associated with literature, arts, and philosophy which affects the way the Chinese people perceive tea (Heiss & Heiss, 2007).

2.2 Tea culture in Japan

The strong cultural association the Japanese have with green tea has made it the most popular drink in traditional Japanese cuisine so much so that at restaurants, a cup of green tea is often served with meals. The best traditional Japanese restaurants take as much care in choosing the tea they serve as in preparing the food itself. Many Japanese are still taught the proper art of performing centuries-old tea ceremony as well. All tea ceremonies and rituals contain "an adoration of the beautiful among the sordid facts of everyday life", as well as refinement, an inner spiritual content, humility, restraint and simplicity "as all arts that partake the extraordinary, an artistic artificiality, abstractness, symbolism and formalism" to one degree or another (Ali et al., 2013). All in all it is a very respected and revered beverage which is usually served hot. Most of the vending machines also carry a wide selection of both hot and cold bottled teas.

2.3 Tea culture in Thailand

Although, Thailand does not have its own tea culture, green tea is also very popular in Thailand, producing many variations such as rose green tea, barley green tea, lemon green tea, etc. Thai medical communities in the past were more interested in herbs rather than tea for medicinal purposes. The ancient Thai people used materials such as lemon grass, ginger, and other Thai herbs rather than tea unlike China where it was considered a healing drink. Most of Thailand's tea culture has stemmed from early Chinese settlers. But at the present, Thai green tea is not to be confused with traditional Japanese or Chinese green tea as most of the tea today tends to be very heavily commercialized and the taste tends to be sweeter. People also prefer to drink flavored teas rather than plain green tea (Nookabkaew et al., 2006).

Additionally, cultures like Japan & China prefer and serve their tea at mostly high temperatures, if prepared traditionally, leading the global perception of the tea being 'best served' at those temperatures. But with the prevalence of industrially processed green tea like in Thailand, the perceived best temperature may be different than the perception of people experienced with the other tea cultures (Vittayaporn et al., 2010). Thai people also generally prefer to drink their tea cold (Lee et al., 2010).

3. Consumer preference

Consumer preference is subjective and depends on the consumer's interaction with the product and their own biases and experiences which will be a significant factor in affecting drinking quality. Drinking quality in this experiment does not refer to the cleanliness or consistency of the beverage; rather it refers to the enjoyment or fulfillment that the consumer receives after taking in the drink. The taste, flavor, appearance and even sound of the drink can make a multitude of different feelings occur. One of the most important factors that affect perception is the temperature of the beverage as it is served as it contributes to the overall liking but this also depends on the personal preference of each individual person (de Godoy et al., 2013).

Consumer preference may also change due to upcoming trends. Current consumer trends are approaching more of a clean and holistic approach rather than beverages that are packed with artificial flavors and additives. Consumers, especially in hotter and humid countries, tend to prefer colder drinks compared to their colder counterparts. Also there has been a global shift towards consumers buying beverages that are less processed and idea of 'fresh ingredients' used compared to previous years (de Godoy et al., 2013).



MATERIALS AND METHODS

This study aimed to measure the effect of serving temperature and sweetness on the tea perception. This was done by using consumer testing method. 100 different people were asked to taste green tea samples. The samples were varied to three different temperatures (5^{0} C, 23^{0} C, and 60^{0} C), two degrees of sweetness (added 6% sugar and no sugar added) and two commercial brands (Raming and Long Heng). Thus there were 12 treatments in total.

Treatment	Type of Tea	Sweetness	Temperature
Denotation:	(Type)	(LvSweet)	(Temp)
R.S.H	Raming	Sweet	Hot
R.S.C	Raming	Sweet	Cold
R.S.RT	Raming	Sweet	Room Temperature
R.NS.H	Raming	Not Sweet	Hot
R.NS.C	Raming	Not Sweet	Cold
R.NS.RT	Raming	Not Sweet	Room Temperature
L.S.H	Long Hong	Sweet	Hot
L.S.C	Long Hong	Sweet	Cold
L.S.RT	Long Hong	Sweet	Room Temperature
L.NS.H	Long Hong	Not Sweet	Hot
L.NS.C	Long Hong	Not Sweet	Cold
L.NS.RT	Long Hong	Not Sweet	Room Temperature

Table 1 Combinations of the type of tea, sweetness, and temperature

The method this experiment will the consumer testing method where 100 different people were asked to taste green tea at three different temperatures and sweetness's when served at the following temperatures: Cold $(5^{\circ}C)$ – after being chilled in a refrigerator, Room temperature $(25^{\circ}C)$ – bottles will be left at Room Temperature and lastly Hot $(60^{\circ}C)$ – boiled until temperature is reached and served immediately. Each sample was freshly brewed every time for each session to prevent other variables from interfering with consumer preference.

The samples were prepared using Raming and Long Heng tea bags and were prepared 15 - 30 minutes before were served. They were prepared using a boiling plate and glassware and the temperature was measured with a thermometer periodically. The samples were served in a plain white plastic sipping cup with no aroma and each participant was presented with six different sample of each variation at the same time with a glass of water. Participants were then instructed to cleanse their palate with the water before moving on to rating the liking of the next sample. To keep the hot and cold temperature for each sample consistent, the time from brewing until serving the samples was kept to a minimum of 10 minutes in order to avoid "bad samples". Although the participants were answering their questions in the same room with multiple people testing at a time, they were not allowed to speak to each other about the samples until they were finished rating the samples individually in order to avoid bias.

A 9-point hedonic scale was employed to measure the consumer preference which was collected as a form of a questionnaire at the end of tasting. The attributes used were overall linking, color aroma, sweetness, bitterness, flavor and astringent

For the analysis, the SAS software was used to conduct an Analysis of Variance (ANOVA) test with the three way Factorial Randomized Complete Block Design (RCBD) in order to find out which of the attributes was significantly affected by each variation of each factor (p<0.05). Duncan's Multiple Range test (DMRT) was also performed as a post hoc test to measure specific differences between pairs of means to see which factors were affecting. Demographic information was also collected through the form of questionnaires at Assumption University Hua Mak campus.

RESULT AND DISCUSSION

In this experiment, the participants' preference scores were analyzed using an ANOVA test using a three way RCBD factorial design in order to see whether each variable (Type of tea, level of sweetness, and temperature) or their combination had a significant effect on consumer preference of the tea.

Table 1 below shows the p-value of seven attributes which are Overall Liking, Color, Aroma, Sweetness, Bitterness, Flavor, and Astringency. The results show that the three ways combination between the type of tea (denoted by "Type"), level of sweetness (denoted by: LvSweet), temperature (denoted by: "Temp") had no significant effect on the Overall liking. But further analysis indicated that the consumers liking scores for Aroma were affected by the combination of, all three of the variables, the type of tea, level of sweetness, and the temperature. The Astringency scores were also significantly affected by the type of tea and the combination between the type of tea and the level of sweetness (p<0.05).

	Overall Liking	Color	Aroma	Sweetness	Bitterness	Flavor	Astringency
Туре	0.0627	0.1346	0.5486	0.8464	0.9708	0.6979	0.0079
LvSweet	0.6712	0.4531	0.6308	0.7526	0.3181	0.3675	0.9441
Type*LvSweet	0.7362	0.6606	EP0.108	0.0583	0.3394	0.893	0.0123
Temp	0.0016	0.6532	0.6447	0.5673	0.8135	0.4336	0.1065
Type*Temp	0.0025	0.852	0.5067	0.7526	0.321	0.7281	0.1467
LvSweet*Temp	0.617	0.7666	0.1654	0.3537	0.7675	0.6631	0.6013
Type*LvSweet*T emp	0.5983	0.986	0.0480	0.1894	0.7848	0.1865	0.7784
Block	<.0001	0.1206	0.4168	0.0003	0.005	0.0211	0.2963
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Table 2 Table showing the attributes that were significantly affected by change in treatments (p<0.05)

Regarding the overall liking, the means were varied in treatments and in consumers scores; all of them have different overall liking scores and the consumers clearly seem to prefer either Hot or Cold tea as can be seen from the mean scores (refer to *Appendix A*). The three way interaction between type of tea, temperature, and level of sweetness did not lead to any significance for the overall liking.

Temperature itself and the combination of the type of tea and temperature clearly significantly affects the overall liking scores at 0.0016 and 0.0025 at (p<0.05) while the type of tea by itself does not affect it. The overall liking scores were affected was when Raming was served at Room temperature with no sweetness which showed that consumers preferred drinking either Hot or Cold drinks but not at room temperature where the mean scores overall liking drops (refer to *Appendix B*).



Figure 1: Preference of Overall Liking based on the interaction between Type of Tea (Raming and Long Heng) and Temperature $(5^{\circ}C, 23^{\circ}C, and 60^{\circ}C)$

A study 2017 in Taiwan with a similar demographic distribution of age, sex, and education level conducted by Shu & Mega, the samples they used were hot loose

leaf Japanese green tea, Matcha powder that was served hot as well, alongside with Japanese Green tea bags. The tea bags were steeped in regular PET bottle water at room temperature, then they moved the tea bag 10 times with an up-and down motion during infusion and then they waited until the color become light green for approximately 5 minutes (Shu & Mega, 2017). The Taiwanese consumers were not affected by the temperature and stated their preference was based off the taste of the tea only which contrasts with the interaction result of this experiment.

There is also another study where green tea preference was measured in consumers in the United States, Korea and Thailand where temperature was also not a major contributing factor to affecting preference. The participants were presented with six samples of different types of hot green tea instead of a variety of samples. The study also stated that Thai people prefer to drink their tea cold and they preferred tea samples with fruity flavors and no green flavor. This is most likely because the Thai market is very small for green tea and most of it is mass produced and often has very little green flavor.

Although there have been a lot of studies done on how temperature and type of tea affect the preference of tea as stand-alone factors, there is a lack of evidence tying them together and whether or not they affect one another and due to lack of access to a wide variety of green tea in the market and the lack of familiarity, the liking score of consumers in Thailand would most likely vary depending on each specific consumer segment and the individual tea drinking culture that they are familiar with unlike other cultures that already have a very strong tea culture like China, Japan, and Korea (Lee et al., 2010). As for the 3 way interaction effect in liking scores of Aroma, the type of tea, temperature, and level of sweetness was significant at 0.0480 at (p<0.05). The preference scores for Aroma for Raming served at room temperature were the lowest out of all of the treatments and combinations.

Consumers do not prefer Raming at Room Temperature regardless of level of sweetness and this can be seen reflected in the mean score of the overall liking of the tea, which is in line with the study mentioned previously where Thai people seem to care more about the temperature of the tea and were alright with consuming hot tea as well as the people that have answered the questionnaire only prefer to drink tea either hot or cold as well.



Figure 2: Preference of Aroma based on the interaction between Type of Tea and Temperature

The Astringency was affected by the type of tea itself and the combination of the type of tea and the level of sweetness among tea samples' Astringency attribute, Long Heng at Not Sweet served at hot temperatures was observed to have the highest mean score meaning it was most preferred. Regarding Astringency, the Astringency is significantly varied in treatments. Long Heng at Not Sweet and Raming at Not Sweet are significantly different in liking scores but Long Heng at Sweet and Raming at Sweet are not significantly different. From the results, when the treatment does not involve any level of sweetness, it causes the preference of the astringency to be vary, which is understandable as most people prefer their tea to be sweeter than completely astringent.



Figure 3: Preference of Astringency based on the interaction between Type of Tea and level of Sweetness

This is most likely due to Astringency is perceived as "dry, rough feeling in the mouth and contraction of the tongue tissue" and it usually involves the formation of

aggregated precipitates between tannins or polyphenols and proteins in the saliva. These Tannins impact the taste of tea positively and when the effects are too strong then the level of sugar helps to mask it (Lawless T. & Hildegarde, 1999) This is also illustrated when Raming is Not Sweet, where the preference scores are lower. The consumers preferred the astringency of Long Heng Not Sweet over the astringency in Raming regardless of sweetness level.

Additionally in another study it was found that White teas that were brewed and served at high temperatures had high a greater antioxidant capacity and phenols content and such conditions were preferred by sensory panels compared to the mild infusions that were served (Perez-Burillo et al., 2018). And green teas carry more antioxidants due to the way that it is processed than white teas under as well as under same brewing conditions leading to a change in overall drinking quality which may explain why the consumers preferred to drink tea at higher temperature and levels of sweetness's as the change in physical properties directly affect the overall perception of the tea.

Questionnaire Results

Question	Total No. of responses	Percentage (%)
Do you like drinking tea?	VINCIT	
Yes	OMNIA 86 🔆	71.7
No	34	28.3
What form of tea do you like?	CE1909 39200	
Bottled	າລຍລລ38	31.7
Tea bag	29	24.2
Powdered	7	5.8
Drink kiosks	40	33.3
Others	6	5
What type of tea do you usually drink?		
Green tea	73	60.8
Black tea	20	16.7
White tea	0	0
Traditiona	al 7	5.8
Other	20	16.7

Table 3 Table showing consumer preferences about tea consumption

Question	Total No. of	$\mathbf{D}_{anaanta}(0/\mathbf{)}$
	responses	Percentage (%)
How often do you drink tea?		
Everyday	22	18.3
3-4 times/week	53	44.2
1-2 times/week	30	25
2-3 times/month	12	10
Other	3	2.5
When do you usually drink tea?		
Morning	43	35.8
Afternoon	20	16.7
Late afternoon	33	27.5
Evening	1	0.8
Before bed	12	10
Other	11	9.2
What is the price of the tea you buy?		
(including bottled)	RCIN	
10-30 baht	63	52.5
31 – 50 baht	43	35.8
51 – 70 baht	12	10
Over 70 baht	2	1.7
Other	0	0
What brand of tea do you buy?		T
Twinning	2	1.7
Oishi 💦 📩 📩	44	36.7
Nestle	n s 23	19.2
Lipton	34	28.3
Fitne	2 BRIEL	2 1.7
Other	15	12.5
How do you usually drink your tea?		
Hot 💥 🛛 🕅	NIA 74	61.7
Cold Cold	E106044 20	36.7
Room temperature	0 1200	0
Other Other	12282	1.7
What do you usually drink with tea?		
With meals	0	0
With snacks (ex, biscuits,	10	15.0
cakes, scones etc)	17	13.0
By itself	69	57.5
Other	32	26.7

Question	Total No. of responses	Percentage (%)	
Why do you drink tea?			
Taste	43	35.8	
Aroma	14	11.7	
Relaxing	33	27.5	
Social activity with friends	10	8.3	
Tradition	13	10.9	
For the health benefits	7	5.8	

Demographic information

Table 4 Table showcasing the demographic information of the consumers that participated in this study

• • •	VFRSIN	
	No. of responses	Percentage (%)
Gender		
Male	53	44.2
Female	-67	55.8
Age		
Under 17		3.3
18-24 years old		64.2
25-34 years old		16.7
35-44 years old	15 IS	
45-54 years old	351 GADINEL	
55-64 years old		0.8
	LABOR	
Education level 🛛 🕺	OMNIA 😽	
High school	SINCE 1959	4.2
Vocational school	775. 3 - 32	2.5
Associate degree	ี้ "ยาลยอลเร็	0
Bachelor's degree	95	79.2
Master's degree	14	11.7
Professional degree	0	0
Doctorate degree	3	2.5
T 1		
JOD	10	40.0
A student	49	40.8
Employed	33 15	27.5
Out of work	15	12.5
A nomemaker	5	4.2
Millitary Detine 1	U 18	0
Ketirea	18	15

	No. of responses	Percentage (%)
Education level		
High school	5	4.2
Vocational school	3	2.5
Associate degree	0	0
Bachelor's degree	95	79.2
Master's degree	14	11.7
Professional degree	0	0
Doctorate degree	3	2.5
Income per month		
Less than 5,000	5	4.2
5,000 - 10,000	26	21.7
10,000 - 20,000	45	37.5
20,000 - 30,000	21	17.5
More than 30,000	23	19.2

The participated consumers were mostly Bachelor's degree students in Assumption University Hua Mak campus, Thailand (79%), age between 18-24 years old. The percentage of genders for both females and males were almost equal. More than half them drink tea (72%) and drink in the bottled form. The type of bottled tea that consumers typically drink was green tea (61%) and the frequency of drinking tea were 3-4 days per week in the morning and late afternoon. The price that consumers would pay to purchase a bottled tea was 10-30 baht (52%). The choice of brands vary from Oishi (42%), to Lipton (32%), to Nestle (22%) and so on. 61% of consumers usually drink tea by itself without any snacks or foods that served in cold temperature (61%).

There were several reasons why consumers drink tea, 38% of consumers drink tea because of taste of tea, 29% was for relaxing, 12 % was for aroma of tea. The number of tea drinking has constantly increasing in recent years as the new ranges of flavors availability in the markets and the general growing of health consciousness. Lastly, most of the consumers preferred to drink their tea at either at hot (61.7%) or cold (44%) or others (2%) and not at room temperature (0%) and which is shown by the results of this research where the samples had the least liking scores when they were served at room temperature.

CONCLUSION

This experiment was performed in order to study the effects of temperature and sweetness on the drinking quality and preference of green tea through consumer testing and through testing, it can now be concluded that Sweetness had no interaction effect to green tea and its preference scores but Temperature and the interaction between type of tea has a significant effect on the Overall Liking Scores of Raming Tea and the Astringency of Long Heng, The preference of Aroma was affected by the interaction of all three variables. And lastly, there is no interaction effect between Temperature and Sweetness for both types of tea. The results are most likely due to the change in the properties of the tea itself due to different steeping methods and the Thai's lack of familiarity with green tea itself due to the lack of variety as the tea in Thailand is mass produced and is very sweet. This research is important for future product development for green tea and its products.

Consumers also typically drink green tea in morning and late afternoon. The reasons of purchasing tea were varying. Cold bottled tea was the highest vote for form of tea that consumers would purchase as in Thailand the weather is humid and hot and bottled tea is convenient to carry around. However, taste, aroma, flavor, and presentation of the products (package) have an impact of buying decision of tea as well. In conclusion, further research should focus on the temperature of serving tea more than altering its sweetness and type, as both of those attributes are dependent on the consumers subjective taste and that in Thailand people prefer their tea either cold or warm and not at Room Temperature.

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APPENDIX

	Overall						
Sample	Liking	Color ^{ns}	Aroma ^{ns}	Sweetness ^{ns}	Bitterness ^{ns}	Flavor ^{ns}	Astringency
R.S.H	5.7±1.2 ^a	5.9±1.4	6.0 ± 1.36	6.0±1.5	5.8±1.47	6.1±1.5	5.6±1.78 ^{abc}
R.S.C	5.6±1.5 ^a	6.0±1.5	6.0±1.38	6.0±1.5	6.1±1.48	5.9±1.3	5.6±1.7 ^{abc}
R.S.RT	5.2±1.4 ^a	5.9±1.6	6.0±1.37	5.9±1.6	5.9±1.44	6.0±1.4	5.4±1.69 ^{bc}
R.NS.H	5.7±1.4 ^b	6.0±1.6	6.0±1.42	5.8±1.6	5.9±1.52	5.9±1.5	5.4±1.7 ^{bc}
R.NS.C	5.7±1.2 ^a	5.9±1.5	6.0±1.34	5.9±1.4	6.0±1.53	6.0±1.3	5.3±1.57°
R.NS.RT	5.2±1.5 ^a	5.9±1.4	6.1±1.5	5.7±1.4	5.9±1.48	5.8±1.4	5.2±1.58 ^c
L.S.H	5.8±1.2 ^b	6.0 ±1.51	6.2±1.5	5.6±1.6	5.8±1.40	6.0±1.5	5.8±1.77 ^{abc}
L.S.C	5.6±1.4 ^a	6.08±1.5	5.9±1.4	6.0±1.5	5.8±1.45	6.1±1.4	5.4±1.67 ^{bc}
L.S.RT	5.6±1.3 ^a	5.88±1.5	6.0 ±1.4	5.9±1.4	5.9±1.34	5.7±1.4	5.7±1.7 ^{abc}
L.NS.H	5.6±1.4 ^a	6.13±1.4	5.9±1.4	6.1±1.6°	6.0±1.37	5.9±1.5	6.0±1.58 ^a
L.NS.C	5.6±1.4ª	6.08±1.3	6.1±1.5	5.9±1.5	5.9±1.43	5.8±1.4	5.5±1.57 ^{bc}
L.NS.RT	5.7±1.3 ^a	6.03±1.4	6.0±1.4	5.9±1.5	6.1±1.50	5.9±1.5	5.8±1.7 ^{ab}

Appendix A: Mean and Standard Deviation of 7 attributes of sample tea

Note: Different letter in a column shows the samples were significantly different (p < 0.05). NS = non significant

Treatment	Sample	Overall Liking	Score	Astringency	Score
Α	R.S.H	А	5.73±1.20	ABC	5.63±1.78
В	R.S.C	А	5.61±1.37	ABC	5.57±1.70
С	R.S.RT	В	5.23±1.37		5.41±1.69
D	R.NS.H	А	5.73±1.37		5.43±1.71
Е	R.NS.C	A	5.74±1.23	С	5.28±1.57
F	R.NS.RT	BUNIL	5.20±1.47	C	5.23±1.58
G	L.S.H	A	5.76±1.19	ABC	5.57±1.77
Н	L.S.C	A	5.64±1.35	BC E	5.38±1.67
I	L.S.RT	A	5.58±1.34	ABC E	5.71±1.72
J	L.NS.H	ABROTHERS	5.63±1.40	AZ	5.98±1.58
K	L.NS.C	A	5.63±1.39	BC O	5.48±1.57
L	L.NS.RT	ASI SINC	5.74±1.29 E 1969	AB *	5.83±1.66
		้าทยาล	้ยอัลละ		and the second

Appendix B: Duncan test to show the significant attributes (Note: Different letters indicate significant difference) (p<0.05)

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Appendix C: Table showing how Overall Liking is significantly affected with the interaction with Temperature and the interaction between the Type of Tea and the Temperature of Tea itself (p<0.05)

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Туре	1	5.03	5.03	3.47	0.06
LvSweet	1	0.26	0.26	0.18	0.67
Type*LvSweet	1	0.16	0.16	0.11	0.74
Temp	2	18.81	9.41	6.49	0.00
Туре*Тетр	2	17.47	8.74	6.03	0.00
LvSweet*Temp	2	1.40	0.70	0.48	0.62
Type*LvSweet*Temp	2	1.49	0.74	0.51	0.60
Block	119	637.49	5.36	3.70	<.0001

Appendix: Table showing how Aroma is significantly affected with the interaction between the Type of Tea, Level of Sweetness, and Temperature

	Of A	01110			
Source	DF	Type III SS	Mean Square	F Value	Pr > F
Туре	1	0.7067291	0.7067291	0.36	0.5486
LvSweet	1	0.4536269	0.4536269	0.23	0.6308
Type*LvSweet	1	5.0799278	5.0799278	2.59	0.108
Temp	2	1.7243134	0.8621567	0.44	0.6447
Type*Temp	2	2.6707049	1.3353525	0.68	0.5067
LvSweet*Temp	2	7.0753501	3.537675	1.8	0.1654
Type*LvSweet*Te mp	2	11.9064042	5.9532021	3.03	0.05
Block	119	239.161673	2.009762	1.02	0.4168

3

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Туре	1	19.5946611	19.5946611	7.07	0.0079
LvSweet	1	0.0136145	0.0136145	0	0.9441
Type*LvSweet	1	17.4132298	17.4132298	6.28	0.0123
Temp	2	12.4338928	6.2169464	2.24	0.1065
Type*Temp	2	10.651133	5.3255665	1.92	0.1467
LvSweet*Temp	2	2.8199103	1.4099551	0.51	0.6013
Type*LvSweet*Temp	2	1.3887748	0.6943874	0.25	0.7784
Block	119	352.5155686	2.9623157	1.07	0.2963

Appendix: Table showing how Astringency is significantly affected with the Type of Tea and the interaction between the Type of Tea and the Level of Sweetness

Appendix: Duncan's Multiple range test for Astringency (p<0.05)

Attribute (P-value)	Overall Liking	Color	Aroma SINCE196	Sweetness
Sweetness	0.6142	0.8482	0.1196	0.1138
Temperature	<000.1	0.9599	0.3316	0.7302
Interaction	0.856	0.9206	0.0484	0.9353

Attribute (P-value)	Bitterness	Flavor	Astringency
Sweetness	0.969	0.5432	0.072
Temperature	0.39	0.6059	0.4315
Interaction	0.6152	0.6371	0.9094

Temperature	Mean	Grouping
Hot	5.7417	А
Cold	5.6625	А
RT	5.2301	В

Appendix H: Questionnaire used to gather information regarding consumer preferences

Name

No.

Questionnaire

Tea is a commonly found beverage throughout Asia and other parts of the world. This study aims to measure the consumer's opinions and thoughts as to help this project succeed. This questionnaire is part of a senior project in association with the Faculty of Biotechnology in Assumption University.

1. Do you like drinking tea?

 \Box Yes \Box No

- 2. What form of tea do you like?
 - □ Bottled
 - □ Tea bag
 - Powdered
 - Drink kiosks
 - □ Other

- 3. What type of tea do you usually drink?
 - \Box Green tea
 - \Box Black tea
 - \Box White tea
 - □ Traditional
 - □ Other
- 4. How often do you drink tea?
 - □ Everyday
 - \Box 3-4 times/week
 - □ 1-2 times/week
 - □ 2-3 times/month
 - □ Other

□Before bed

- 5. When do you usually drink tea?
 - □ Morning
 - □ Afternoon
 - □ Late afternoon
 - □ Evening
- 6. What is the price of the tea you buy? (including bottled)
 - \Box 10 30 baht
 - \Box 31 50 baht
 - \Box 51 70 baht
 - □ Over 70 baht
 - □ Other

- 7. What brand of tea do you buy?
 - Twinning
 - Oishi
 - □ Nestle
 - □ Lipton
 - □ Fitne
 - Other
- 8. How do you usually drink your tea
 - Hot

- Cold
- Room temperature Other
- 9. What do you usually drink with tea?
 - \Box With meals
 - □ With snacks (Ex, biscuits, cakes, scones etc)
 - □ By itself
 - \Box Other
- 10. Why do you drink tea?
 - Taste
 - Aroma
 - Relaxing
 - Social activity with friends
 - Tradition
 - For the health benefits
 - Other

Demographic

- 1. Sex
 - \Box Male \Box Female

2. Age

- □ Under 18
- □ 18-24 years old
- □ 25-34 years old
- □ 35-44 years old
- □ 45-54 years old
- □ 55-64 years old
- □ **Over** 60

3. Job

- □ A student
- □ Self-employed
- □ Out of work
- □ A homemaker
- □ Military
- \Box Retired
- \Box Unable to work

4. Education level

- \Box High school
- \Box Vocational school
- \Box Associate degree
- □ Bachelor's degree

- □ Master's degree
- □ Professional degree
- \Box Doctorate degree
- 5. Income per month
 - \Box Less than 5,000
 - □ 5,000 10,000
 - □ 10,000 20,000
 - □ 20,000 30,000
 - \Box More than 30,000



