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Effects of Different Processing Conditions on Physicochemical Properties, Bioactive Compounds and Sensory Acceptance of Betel Nut Tea

Unchalin Singkhum*

Department of Food Science and Technology, Faculty of Agricultural Technology, Rajamangala Technology University of Thanyaburi, Pathum Thani, 12130

* Corresponding author: anchalins_s@rmutt.ac.th

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Abstract

The effects of various roasting-rolling temperatures (40-50, 50-60, 70-80 °C), rolling times (10, 15, 20 minutes), and drying temperatures (60 and 80 °C) on water activity (aw), color values (L*, a*, b*), total phenolic content, antioxidant activity by DPPH, and ferric ion reducing antioxidant power (FRAP) in Betel nut tea were studied. The total phenolic content and antioxidant activity decreased when the roasting-rolling and drying temperatures increased ($p \leq 0.05$). As a result, the tea processing condition that produced the most bioactive compounds (roasting-rolling temperature of 50-60 °C, 15 minutes of rolling time, and drying temperature of 60 °C for 3 hours) was chosen to investigate the amount of water (60 and 80 milliliters) and water temperature (80, 90, and 100 °C) needed to make tea. The water and the water temperature did not affect the bioactive compounds ($p > 0.05$). Sensory evaluation with 50 panelists using a 9-point hedonic scale showed differences in preference scores in the taste ($p \leq 0.05$), but there was no significant difference in terms of color, odor, and overall liking for Betel nut tea ($p > 0.05$). Thus, the appropriate formula for Betel nut tea making was 5 grams of tea, 60-80 milliliters of water, and 80-90 °C water temperature.

Keywords: Betel nut, Betel nut tea, Herbal tea, Bioactive compound

Introduction

According to the Notification of the Ministry of Public Health (No. 280) B.E. 2547 (2004), certain therapeutic plants can be processed into herbal teas. Thai medicinal plants, such as mulberry leaf tea, fragrant pandan tea, bael tea, roselle tea, and safflower tea, are currently more popular to be processed into herbal teas. Because most herbal teas are caffeine-free, they are excellent for seniors and caffeine-allergic individuals.

The color, fragrance, and taste of tea are all influenced by the chemical content of the leaves. Polyphenols, which account for approximately 10-25 percent of the dry weight of all fresh tea leaves, are the compounds that influence tea flavor. These compounds have an astringent flavor. The majority of polyphenol chemicals are flavonoids, which have antioxidant characteristics (Agartvipart, 2015). People commonly consume tea from the Camellia Sinensis Plant Family, including polyphenol chemicals with natural antioxidant effects. Herbal tea is made from plants or fruits that contain polyphenols, which have antioxidant effects. Depending on the processing, the type and concentration of polyphenol compounds in tea will vary. Chemical processes and biochemistry in tea leaves, which produce different polyphenol chemicals, are affected by different processing methods. Therefore, herbal teas are suitable for health-conscious consumers (Yuan *et al*., 2011; Theppakorn, 2012).

The Betel Nut, also known as the Betel Palm, is a palm tree belonging to the Arecaceae family with the scientific name *Areca catechu* Linn. The fruit of the immature betel nut is dark green, whereas the adult betel nut is yellow-orange. Betel nuts are spherical or elliptical with an average diameter of 2-2.5 centimeters, betel nut bunches, and 10-15 fruits per bunch. The diuretic qualities of betel nut seed aid to relieve gastrointestinal pain, distension, dysentery, infected wounds, and parasites (Plansangkate and Promrak, 2008). The total phenolic content in betel nut rough extracts was 54.38 milligrams/milliliter, total tannin content was 87.74 milligrams/milliliter, and antioxidant activity was determined using the DPPH Radical technique with an IC50 value of 7.32 micrograms/milliliter (Sinsaior, 2012).

In accordance with the properties of bioactive substances in betel nuts; the researcher had an idea to use the betel nut and process it into herbal tea products by studying the physical properties, chemical properties, and bioactive substances in fresh betel nut flesh, developing a suitable tea making process and studying the appropriate conditions of tea making to get a nutritious betel tea rich in antioxidants with a unique taste and flavor, thereby increasing choices for consumers. It also makes the products more valuable. Moreover, it promotes the development of food products from plants, vegetables, and local herbs to be more widely acknowledged.

Materials and Methods

Raw material preparation

The betel nuts were purchased in Si Mum Mueang market, Pathum Thani, Thailand. Betel nuts with a fire-colored peel and no insect punctures or rotting symptoms were chosen. The betel nuts needed to be cleaned and dried first. Next, remove only the betel nut peel, powder it, collect the sample in clean glass vials, and seal it for further physical and chemical analysis.

The process of making herbal tea from betel nut

Temperature for roasting and rolling and appropriate oven drying temperature for preparing herbal tea made from betel nut

The temperature for roasting and rolling, as well as the temperature for oven drying, were modified from the herbal tea production process (Khonsarn *et al*., 2018) as follows: roasting-rolling temperatures (40-50, 50-60, 70-80 °C), rolling time (10, 15, 20 minutes), and drying temperatures (60 and 80 °C), drying time 3 hours. The final moisture level of the betel nut flesh must be less than 8%. The dried betel nuts were then placed in bags and stored in desiccators for quality testing.

Appropriate conditions for making betel nut herbal tea

The appropriate amount of water and water temperature for making betel nut herbal tea were studied

In the second phase, betel nut tea was selected from the best formulae to determine the amount of water and appropriate water temperature for brewing betel nut tea. The researcher took 5 grams of betel nut tea, brewed it with hot water in the amount and temperature stated in the six formulas experiment, with the water amount (milliliter): temperature (°C) in tea brewing as follows: For 5 minutes, alternate 60:80, 80:80, 60:90, 80:90, 60:100, 80:100. Then, set the tea temperature to 65-70 (°C) for physical, chemical, and bioactive compound analysis, as well as sensory acceptance.

Physical properties and bioactive compound analysis

Color value; Color value analysis refers to the lightness (lightness: L*), redness (redness: L*), and yellowness (yellowness: L*) of betel nut tea by using a colorimeter (Hunter Lab Model Colourflex45/0, USA) to make three replicate measurements.

Water Activity (aw); Water activity (aw) in the betel nut tea recipe was measured using the water activity (aw) meter by Aqua Lab, Model CX2.

pH; The potential of pH was measured by a pH meter (Sartorius, PB-20, Germany).

Determination of bioactive compounds

Betel nut tea extract; Bioactive compounds of Betel nut tea extract were measured with modified methods from Pumtes *et al*. (2012) and Taokaenchan *et al*. (2018).

Bioactive compounds; Total phenolic content was determined by Folin-Ciocalteu's reagent method, modified methods from Namjooyan *et al*. (2010); Kubola and Siriamornpun (2008). Antioxidant activity by radical scavenging activity: This value was measured using the modified DPPH method from Mao *et al*. (2006) and Singh *et al.* (2002), and antioxidant activity was measured by ferric reducing antioxidant power (FRAP), Antioxidant activity was measured by ferric reducing antioxidant power (FRAP) modified from the methods of Benzie and Strain (1996); Kubola and Siriamornpun (2008).

Sensory evaluation of betel nut tea

The sensory evaluation of betel nut tea was examined by 50 taste panelists using a liking scale to measure preference, the 9–point hedonic scale, to select a condition of betel nut tea they liked the most. The test variables are color, odor, taste, and overall liking, with betel nut tea temperatures controlled at 65–70 °C. Three samples were tested, followed by a one-minute interval, then three more samples were tested.

Statistical analysis

Physical properties and bioactive compound data were analyzed using the Completely randomized design (CRD). Sensory evaluation was analyzed using the Random complete block design (RCBD). The obtained data with Analysis of variance (ANOVA) and difference of means between experimental groups compared with Duncan's new multiple range test at $p \leq 0.05$ was considered.

Results and Discussion

The study on the production process of herbal tea from betel nut

For betel nut tea production, the temperature and time for roasting, rolling, and oven drying were examined. Betel nut tea from all six formulae had significantly different aw value and color values of L*, a*, and b* ($p \leq 0.05$) but did not affect the pH value in betel nut tea ($p > 0.05$). The maximum aw value was 0.72 for betel nut tea roasted and rolled at 40-50 °C for 10 minutes and dried at 60 °C for 3 hours, and the lowest aw value was 0.72 for betel nut tea roasted and rolled at 50-80 °C for 10 minutes and dried at 70-80 °C for 3 hours.

Herbal teas are of high quality and standard, according to the Notification of the Ministry of Public Health. (No. 280) B.E. 2547 (2004). Specifically, the moisture content must not exceed 10 percent by weight, pathogenic microorganisms must not be present, and toxic compounds from microorganisms, pesticides, or other hazardous substances must not be present in proportions that may be harmful to customers. The water activity (aw) of the betel nut teas in all six recipes was 0.62-0.72, which was the value within the herbal tea product standard that required moisture content of less than 10% by weight because there was enough water content for microbes such as bacteria, yeast, or fungi to grow and destroy the food, it was designated as a risky food group if the water activity was greater than 0.85. Food will have a longer shelf life if the aw value is lower than the amount of water activity that the microorganisms can live in (Khonsarn *et al.*, 2018).

Color analysis of betel nut tea products revealed that all six formulations had significantly different betel nut teas ($p \leq 0.05$). The lightness, redness, and yellowness qualities of roasted-rolled and dried foods tend to increase as the temperature rises. Unsuitable drying circumstances cause product quality loss, such as taste, color, nutrition, and rehydration capability, making drying difficult to control (Maskan, 2000).

Analysis of total phenolic content: Antioxidant activity as measured by DPPH radical scavenging activity; DPPH and Ferric reducing/antioxidant power; and FRAP techniques for all six betel nut tea formulations (Table 1). The total phenolic content and antioxidant activity were found to be substantially different ($p \leq 0.05$). When the overall phenol concentration of a roasted-rolled product is affected by increasing the temperature and drying time, antioxidant activity diminishes.

Table 1 Physical properties and bioactive compounds of betel nut tea

Formulas	Physical properties					Bioactive compounds		
	L*	a*	b*	aw	pH	TPC (mgGAE/g)	DPPH (% inhibition)	FRAP (mg TE/g)
1	13.72[f]	45.64[d]	20.04[e]	0.72[a]	5.72	54.46[bc]	7.20[a]	2.58[a]
2	14.74[d]	46.32[c]	21.86[c]	0.72[a]	5.74	57.32[a]	7.43[a]	1.92[b]
3	14.04[e]	46.65[a]	24.24[a]	0.69[a]	5.74	58.48[a]	5.54[ab]	1.76[ab]
4	15.22[c]	43.91[e]	20.51[d]	0.65[b]	5.72	57.30[a]	5.07[ab]	1.61[ab]
5	15.52[b]	42.53[f]	22.62[b]	0.62[b]	5.74	53.88[c]	4.30[b]	1.13[b]
6	16.52[a]	46.46[a]	20.03[e]	0.63[b]	5.77	56.86[ab]	4.18[b]	1.06[b]

[a-f] Values with different letters in the same column are significantly different (p≤0.05), TPC: Total phenolic content

Formulas 1-6 = Temperature, time for roasting and rolling and drying; 1= 40-50 °C 10 min and drying 60 °C 3 h, 2= 40-50 °C 20 min and drying 80 °C 3 h, 3= 50-60 °C 15 min and drying 60 °C 3 h, 4=50-60 °C 15 min and drying 80 °C 3 h, 5=70-80 °C 10 min and drying 60 °C 3 h, 6= 70-80 °C 10 min and drying 80 °C 3 h

The total phenolic content and antioxidant activity of betel nut tea with roasting and rolling temperatures of 40-50 °C for 10 minutes and drying temperatures of 60 °C for 3 hours were found to be the highest by FRAP and DPPH, with 54.46 milligrams of gallic acid equivalents/gram, 2.58 milligrams of Trolox equivalents/gram, and 7.20% inhibition. The lowest total phenolic content and antioxidant activity are obtained by roasting and rolling at 70-80 °C for 10 minutes and drying at 80 °C for 3 hours. As a result, roasting-rolling and drying at high temperatures for an extended period reduce the beneficial components in betel nut tea.

The following crucial processes in the tea production process, such as withering, are included. The process of withering causes the water in the tea leaves to evaporate, causing the tea leaves to wither and the permeability of various substances inside and outside the cell to increase. Polyphenol oxidase catalyzes oxidation and polymerization, which chemically reacts with polyphenols to produce new components that change the betel nut tea's color, aroma, and flavor. The following crucial processes in the tea production process, such as withering, are included.

The process of withering causes the water in the tea leaves to evaporate, causing the tea leaves to wither and the permeability of various substances inside and outside the cell to increase and the roasted-rolled method is to press down on the tea leaves and crush them to break the cells. When cells are destroyed, various substances leak out of the cells and coat various areas of the tea leaves. while polyphenol oxidase catalyzes oxidation and polymerization, which chemically reacts with polyphenols to produce new components that change the tea's color, aroma, and flavor. Different colors are produced when the various substances that flow out of the cell are subjected to heat during drying. Fermentation is a continuous process that begins with withering and rolling and ends with the deactivation of polyphenol oxidase by steaming or burning. Polyphenol oxidase catalyzes the oxidation reaction that causes polyphenol to oxidize and polymerize in this process. It forms a complex compound of polyphenols with bigger molecules, which results in variations in the tea's scent, color, and flavor, depending on the chemical composition of the tea and the manufacturing process. Drying is the process of lowering the moisture content of tea leaves to less than 5 percent in order to extend the shelf life of the tea (Chuamchamp *et al*., 2020). As a result, the color of betel nut tea products is affected by roasting–rolling temperature and time, total phenolic concentration in raw materials, and drying temperature. The obtained products would have a darker hue if the drying temperature was exceedingly high, as opposed to the low temperature in roasted-rolled and dried.

The high temperature of the drying process affects antioxidants, and total phenolic content has decreased. Molecules of total phenolic content vaporize and decay into a carboxylic acid carboxaldehyde, which evaporates with the vapor (Jackman and Smith, 1996). Furthermore, high temperatures cause antioxidants to be degraded. As a result, applying high temperatures in food processing alters the antioxidant activity of the food (Pokorn and Schmidt, 2001). Seewaeng and Siriamornpun (2019) explored how drying temperatures (60, 70, and 80 °C) affected phytochemical components and antioxidant activity in *Bambusa beecheyana*. Total phenolic compounds, total flavonoids, antioxidant activity as measured by DPPH radical scavenging activity, and antioxidant activity in *Bambusa beecheyana* all decreased as the dried temperature increased.

To explore the water quantity and acceptable temperature of betel nut tea making, the researcher chose the tea making process of the betel nut in formulations 3, which involves roasting–rolling at 50–60 °C for 15 minutes and dryer at 60 °C for 3 hours, based on the consideration of bioactive chemicals. Six formulas were used to specify the conditions for brewing tea (water (milliliters): temperature (°C)) for making tea. This experiment used 60:80, 80:80, 60:90, 80:90, 60:100, 80:100, 60:100, 80:100, and 5 grams of betel nut tea. The total phenolic content, antioxidant activity by DHHP, and FRAP techniques were not affected by the water content or water temperature in tea brewing ($p>0.05$) (Table 2).

The greatest total phenolic content was 18.668 milligrams of gallic acid equivalents/gram when tea was made with 60 milliliters of water at 100 °C. Phenolic compounds tended to increase as the water temperature for tea manufacturing increased. Furthermore, betel nut tea brewed with 60 milliliters of water at 80 °C was found to have antioxidant activity of 2.451% inhibition by using the DHHP method and 0.753 milligrams of Trolox equivalents/gram by using the FRAP method. So, the temperature of the tea water rises, the antioxidant activity tends to decrease.

The heating process causes bioactive substances to degrade or change their structure, resulting in cellular integrity loss or oxidative breakdown, which is catalyzed by O_2, enzymes, and light. The disruption of cell structure can occur during processing procedures such as blanching, drying, and crushing, as well as other pre-processing processes that affect the antioxidant potential of fruits and vegetables, such as rolling and fermentation. The total phenolic components in jack fruit tea rise after fermentation (Davey *et al.*, 2000). The rolling and fermentation processes apply mechanical strain to the plant cell walls, which encase the phenolic chemicals, and diseased cell walls are more easily damaged. When the plant cells are cooked with hot water, the phenolic compounds dissolve more easily (Nicoli *et al*., 1997).

The heating procedure influences the bioactive chemicals, which is in line with the findings of Nayak *et al*. (2011), who looked at the effects of temperature and duration (0-60 minutes) at 100 °C on the DPPH radical scavenging activity and ABTS+ of Purple Potato. The DPPH radical scavenging activity dropped when the duration was prolonged, but the ABTS+ radical scavenging activity rose in the first 5 minutes. As time passed, the DPPH radical scavenging activity decreased. Next, Jirarattanarangsri and Budprom (2017) investigated the effects of several methods on total phenolic content, anthocyanin content, and antioxidant activity by setting the temperature at 50 °C and 60 °C for 24 hours and dry roasting at 175 °C and 250 °C for 5 minutes. The researchers discovered that drying and roasting did not affect total phenolic chemicals. When the temperature process was increased, the antioxidant activity measured by the DPPH technique was reduced significantly ($p \leq 0.05$). Furthermore, Singkhum (2021) investigated the effects of the manufacturing process on the physical, chemical, and biological constituents in Karanda tea. The study found that the amount of water used to make tea (80 and 90 milliliters) and the temperature of the water (70 and 90 milliliters) did not affect bioactive compound. When the temperature of the water used to make tea is raised, bioactive compound tend to rise.

The sensory evaluation of the amount of water and water temperature in all six formulas for making betel nut tea found that the water and temperature did not significantly affect the color, odor, and overall liking of betel nut tea ($p>0.05$). Nevertheless, the satisfaction value point of taste was a significant difference ($p \leq 0.05$) (Table 2).

Table 2 Bioactive compound and hedonic score of sensory evaluation of betel nut tea brewing

water:water temperature	Bioactive compound			Score of sensory evaluation			
	FRAP (mgTE/g)	DPPH (%inhibition)	TPC (mgGAE/g)	Color	Odor	Taste	Overall liking
60 ml:80 °C	0.842	2.615	18.335	7.16	6.54	6.88^{b}	7.32
80 ml:80 °C	0.799	2.558	18.496	7.40	6.80	6.92^{b}	7.18
60 ml:90 °C	0.759	2.504	18.434	7.20	6.76	7.04^{ab}	7.24
80 ml:90 °C	0.757	2.480	18.564	7.06	6.98	7.16^{ab}	7.14
60 ml:100 °C	0.753	2.451	18.668	7.28	6.84	7.22^{ab}	7.20
80 ml:100 °C	0.721	2.317	18.620	7.14	6.88	7.38^{a}	7.14

Note: $^{a, b, c}$ Values with different letters in the same column are significantly different ($p \leq 0.05$), TPC: Total phenolic content

The tea made with 5 grams of betel nut tea, 80 milliliters of water, and 100 °C received the highest average score for flavor. However, there were no differences in taste between preparing tea with 60 milliliters of water and a water temperature of 90 °C and 60 milliliters of water and a water temperature of 100 °C, respectively. The taste of betel nut tea will change as the amount of water and the temperature of the water rises. The taste satisfaction of the panelists was affected significantly by increasing water and temperature. The amount of water and the temperature of the water used to make betel nut tea, o

On the other hand, did not affect the overall liking. As a result, making betel tea requires 60-80 milliliters of water and a water temperature of 80-100 °C.

Making good quality tea is both a science and an art. The critical factor for the quality of tea's quality is the quality and quantity of tea leaves. When tea leaves are immersed in hot water, they gradually loosen. Still, adding many tea leaves will make it difficult to relax, which affects the flavor of tea and is not the standard of that type of tea. Once the tea leaves become entirely loosened, they should contain 90% of the tea waste. The water temperature for making tea depends on the type of tea. Tea-making equipment should be made of baked clay because it can retain heat. The long or short duration of making tea can determine whether the tea has a mild or intense taste.

Conclusions

Betel nut with temperatures and time for roasting and rolling at 50-60 °C for 15 minutes and drying temperature at 60 °C for 3 hours was an acceptable tea production method of betel nut tea with high bioactive components, according to the study of the tea production process. The bioactive chemicals are affected by the roasting and rolling temperatures, as well as the drying temperature. Customers choose to create a tea with 5 grams of betel nut tea and 60-80 milliliters of water at 80-100 °C of water temperature to obtain bioactive substances that are useful to consumers in the appearance of color, flavor, and taste. Another strategy to improve the nutritional content of beverage products and promote food products made from plants, vegetables, and local herbs is to design a beverage that mimics herbal tea made from local herbs.

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