

EFFECT OF KNEADING AND FERMENTATION TIME ON CHEMICAL QUALITY OF HERBAL TEA FROM MANGO PEEL

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ABSTRACT: This research aimed to develop herbal tea from agricultural by-product such as mango peel. The study was conducted using a 3x3 Factorial in completely randomized design. Two factors were investigated; the kneading time of mango peel at 10, 20 and 30 minutes and the fermentation time of mango peel at 15, 30 and 45 minutes. The result showed that total phenolic content and antioxidant activity of the unripe mango peel were 8.48 mg/g and 18.34%, respectively. And those contents were significantly higher than that ripen mango ($p \leq 0.05$). The kneading and fermentation time were affected on total phenolic content and antioxidant activity of the peel. Mango peel kneaded for 20 minutes had 20.83 – 28.50% antioxidant activity which significantly higher than that kneaded for 10 and 30 minutes ($p \leq 0.05$). And mango peel fermented for 15 minutes had 21.96 – 23.01 mg/g total phenolic compounds that significantly higher than fermentation time at 30 and 45 minutes ($p \leq 0.05$). Sensory evaluation showed that the score of color, flavor and taste of tea from mango peel kneaded and fermented for 10 and 15 minutes, respectively significantly higher than other kneading and fermentation times ($p \leq 0.05$).

Keywords: Mango, Herbal tea, Total phenolic compounds, Antioxidant activity

1. INTRODUCTION

Tea is an aromatic beverage prepared by pouring hot water over leaves of the *Camellia sinensis*. Tea is a popular beverage, consumed by people worldwide. It is rich in polysaccharides, caffeine, polyphenols and amino acids, as well as antioxidants, which are beneficial for human health [1]. Herbal teas also called tisanes are defined as water-based infusions prepared with herbal ingredients other than *Camellia sinensis*. Such teas are popular amongst health-conscious people as they are rich in minerals and antioxidants [2,3]. Tisanes are caffeine free and can be served hot or cold. Tisanes were drunk for both enjoyment and medicinal purposes. Plant phenolic, also called polyphenols, are a class of chemical compounds that consist of one or more hydroxyl groups (OH) bonded to one or more benzene rings. In recent years, quantifying the phenolic content and evaluating its contribution to the antioxidant capacity have become important [4]. Phenolic compounds are produced through the secondary metabolism of plants and are essential for their growth. This group of biologically active molecules has been extensively studied due to their multiple biological effects, such as anti-inflammatory, antimicrobial and antioxidant activity [5].

Mango (*Mangifera indica* L.) is one of the most popular and best known tropical fruits due to its production and consumer acceptance [6]. Mango is a highly prized fruit due to its attractive

color and flavor, delicious taste and high nutritional value [7,8]. Mango is normally used for direct consumption, as well as for the processing of dried fruit, fruit juice and etc [9]. During mango processing, the peel is one of the most important by-products, which constitutes about 15-20 g/100g of the fresh fruit weight [10]. In fact, mango peel has various nutrients, including dietary fiber, protein, fat, and phytochemicals like polyphenols, carotenoids, tocopherols and ascorbic acid etc. [11-14]. Bioactive compounds such as polyphenols, carotenoids and anthocyanins present in fruits and vegetables are receiving increased attention because of their potential antioxidant activity. Therefore, mango peel is a potential healthy food ingredient that could be used to improve the functional properties of food [9]. The application of mango peel powder has been reported in biscuits, bread and macaroni etc., and the products showed elevated polyphenol and dietary fiber contents, as well as improved antioxidant ability [15,16]. However, mango peel has not been applied in beverages. In this study, mango peel was imitated the process of making tea. Kneading and fermentation of the mango peel probably increase phenolic compounds and flavor. Thus, the objective of this research was to develop herbal tea from mango peel by investigated the optimization of kneading and fermentation times of the peel.

2. MATERIALS AND METHODS

2.1 Experimental Materials

In this research, unripe (immature) and ripe (mature) mangos were of Numdokmai variety and acquired from a local fresh market in Thailand. Harvesting index of unripe and ripe mango were 70–90 and 95–105 days after fruiting, respectively [17]. Unripe and ripe mangos were presented in Fig. 1. The fruits were first washed with tap water and then rinsed with distilled water before left to dry and peels removed.

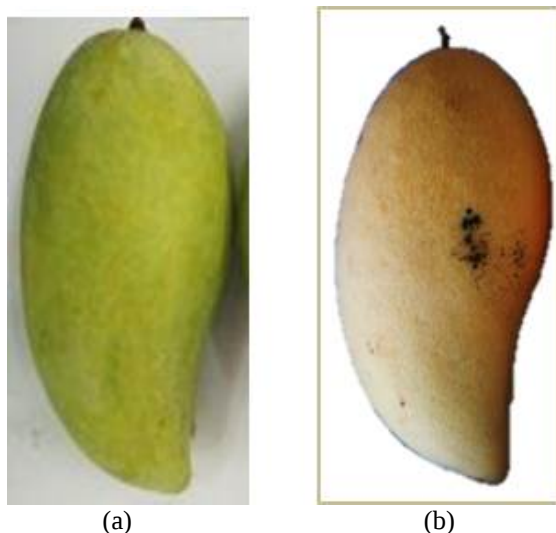


Fig. 1 Physical appearance of: (a) unripe and (b) ripe mango

2.2 Experimental Methodology

2.2.1 Mango peel drying process

The mango peels were cut into smaller pieces (1x3 cm) and kneaded by a kneader mixer (EMS-200LP, Japan) at a moderate speed for 10 minutes. The kneaded peels were transferred to stainless steel containers and covered with straining cloth to ferment for 10 minutes at room temperature. The fermented peels were then oven-dried at 60°C for 3 hours (BINDER GmbH, Germany). The dried unripe and ripe mango-peel tea products were retained in a concealed airtight container at room temperature.

2.2.2 Optimization of kneading and fermentation times

Prior to optimization, total phenolic content and antioxidant activity of unripe and ripe dried mango-peel tea products were characterized and compared. The tea product possessing higher total phenolic content and antioxidant activity was selected for subsequent experiment.

The kneading and fermentation durations of chosen dried mango peel tea product were optimized with regard to the chemical properties and sensory characteristics using a 3x3 factorial

design, giving rise to 9 experimental runs (i.e., nine dried mango peel tea products). The kneading time was varied between 10, 20 and 30 minutes; and the fermentation time between 15, 30 and 45 minutes. The chemical properties of interest were total phenolic content and antioxidant activity and the sensory characteristics included color, aroma, and taste.

2.2.3 Characterization of chemical properties

In this research, total phenolic content was determined using Folin-Ciocalteu method [18] with minor modifications. In the analysis, 0.3 milliliters of tea infusion was first mixed with 2.25 milliliters of 10% Folin-Ciocalteu reagent dissolved in distilled water, and with 2.25 milliliter of 6% sodium carbonate solution. The mixture was then incubated for 90 minutes at room temperature. The absorbance was measured at 725 nanometers using a spectrophotometer, and total phenolic content expressed as milligram/gram (mg/g).

Antioxidant activity was determined by (1,1-diphenyl-2-picrylhydrazyl) radical scavenging activity [19] with minor modifications, whereby 0.1 milliliter of tea infusion was added to 1.9 milliliter of 0.1 milliliter 1,1-diphenyl-2-picrylhydrazyl solution dissolved in ethanol, shaken and incubated in the dark for 30 minutes at room temperature. The absorbance was measured at 517 nanometers using the spectrophotometer. The 1,1-diphenyl-2-picrylhydrazyl scavenging activity was calculated by Eq. (1)

$$\text{Antioxidant activity (\%)} = \frac{A_{\text{control}} - A_{\text{sample}}}{A_{\text{control}}} \times 100 \quad (1)$$

where A_{control} and A_{sample} are the absorbance of reference and tea infusion sample, respectively.

2.2.4 Sensory evaluation of mango peel tea

The sensory evaluation of dried mango peel tea infusions was carried out using a 9-point hedonic scale, where 1 denotes extremely unfavorable and 9 extremely favorable. The dried mango peel tea (3 grams) was brewed in 200 milliliters hot water (80-90°C) for 5 minutes. Then, 20 milliliter of the tea infusions was transferred to tea cups for sensory test where a group of 30 untrained panelists evaluated the tea solution samples on color, aroma, taste, and overall acceptance, based on 9-point hedonic scale.

2.2.5 Statistical analysis

All experiments were carried out in triplicate and the results expressed as mean. Analysis of variance (ANOVA) was used to analyze the data and Duncan's multiple range test to compare means. Statistical significance was based on the 5% significance level ($p \leq 0.05$).

3. RESULTS AND DISCUSSION

3.1 Chemical Qualities of Tea from Unripe and Ripe Mango Peel

Figure 2 (a)-(d) respectively illustrate the physical appearance of unripe and ripe dried mango peel tea products and their respective tea infusions. By comparison, unripe mango peel tea possessed a darker color and stronger scent than ripe mango peel tea.

Chlorophyll and carotenoid of mango peel tea were shown in Table 1. Total phenolic content and antioxidant activity of tea from unripe mango peel were 8.48 mg/g and 18.34%, respectively (Table 2). And those contents were significantly higher than that ripe mango ($p \leq 0.05$). The total phenolic content and antioxidant activity of mango peel var. *Raspuri* and *Badami* have been reported. The total polyphenols content in 80% acetone extract of raw mango peels ranged from 90 to 110 mg/g peel, whereas it ranged from 55 to 100 mg/g in ripe peels depending on the variety [20]. In the present study, the phenolic content and antioxidant activity were lower than those reported previously; a possible reason could be that the peel was diluted into ready to drink solution before the measurements. However, in this present study also found that total phenolic content and antioxidant activity of the solution from unripe peel higher than product from ripe peel. Thus, the unripe mango peel was selected for the next experiment.

Table 1 Chlorophyll and carotenoid of tea from unripe and ripe mango peel.

Tea product	Chlorophyll (mg/g)	Carotenoid (mg/g) ^{ns}
Unripe mango	3.33 ^a	12.24
Ripe mango	0.12 ^b	12.80

Mean of the same column with different superscripts indicating significant differences ($p \leq 0.05$).

ns mean not significant

Table 2 Total phenolic content and antioxidant activity of tea from unripe and ripe mango peel.

Tea product	Total phenolic content (mg/g)	Antioxidant activity (%)
Unripe mango	8.48 ^a	18.34 ^a
Ripe mango	5.85 ^b	11.00 ^b

Mean of the same column with different superscripts indicating significant differences ($p \leq 0.05$).



Fig. 2 Physical appearance of: (a) unripe and (b) ripe dried mango peel tea products, (c) unripe and (d) ripe mango peel tea infusions

3.2 Optimization of kneading and Fermentation Times

Kneading and fermentation probably did not affect chlorophyll of mango peel tea (Table 3). Although, chlorophyll of processed mango peel was lower than unprocessed, this might be due to chlorophyll damaged while drying in high temperature. The central Mg atom is replaced by hydrogen ions. This affects the energy levels within the molecule, causing its absorbance spectrum to alter. Thus processed mango peel changed color, becoming a paler, insipid yellowy green. Carotenoid trended to increase after the process (Table 3).

In Table 4, total phenolic of unripe mango peel tea were positively correlated with the fermentation time, and the antioxidant activity initially rose with increase in the kneading time and declined beyond 20 minutes. Specifically, the moderate kneading time (20 minutes), for all fermentation durations (15, 30 and 45 minutes), achieved significantly higher antioxidant activity (20.83–28.50%), compared with short (10 minutes; 16.65–19.20%) and long (30 minutes; 15.93–18.70%) kneading time ($p \leq 0.05$). Meanwhile, the short fermentation time (15 minutes) yielded significantly higher total phenolic compounds (21.96–22.62 mg/g), vis-à-vis moderate (30 minutes; 17.34–20.01 mg/g) and long (45 minutes; 17.35–19.78 mg/g) fermentation times ($p \leq 0.05$). Generally, total phenolic contents of herbal teas were between 0.08–28.97 g/100g dry weight, averaging 4.52 g/100g dry weight [21].

It was obvious that processed mango peel had phenolic content and antioxidant activity

significantly higher than mango peel without any process ($p \leq 0.05$). The results in this study were consistent with the previous study [22]. They found that Japanese-style-green-tea-process-young (JGTP-Y) coffee leaves and black-tea-process-mature (BTP-M) coffee leaves exhibited antioxidant and anti-inflammatory activities that reflected both the phenolic concentration and specific composition. Tea fermentation is usually referred as the atmospheric oxidation of catechins (flavanols) catalyzed by the tea leaf endogenous enzymes, which produces polyphenol pigments [23].

Table 3 Chlorophyll and carotenoid of unripe mango peel teas.

Kneading & Fermentation (minutes)	Chlorophyll (mg/g) ^{ns}	Carotenoid (mg/g)
10 & 15	0.09	16.22 ^{bc}
10 & 30	0.08	15.90 ^{cd}
10 & 45	0.11	14.35 ^{de}
20 & 15	0.10	19.44 ^a
20 & 30	0.09	18.94 ^a
20 & 45	0.09	17.56 ^{ab}
30 & 15	0.05	16.26 ^{bc}
30 & 30	0.12	13.25 ^e
30 & 45	0.08	15.14 ^d

Mean of the same column with different superscripts indicating significantly differences ($p \leq 0.05$).

ns mean not significant

Table 4 The total phenolic content and antioxidant activity of unripe mango peel teas.

Kneading & Fermentation (minutes)	Phenolic (mg/g)	Antioxidant activity (%)
10 & 15	21.96 ^a	19.20 ^b
10 & 30	18.13 ^c	17.30 ^b
10 & 45	17.35 ^c	16.65 ^c
20 & 15	22.21 ^a	28.50 ^a
20 & 30	20.01 ^b	25.80 ^a
20 & 45	19.78 ^c	20.83 ^a
30 & 15	22.62 ^a	18.43 ^b
30 & 30	17.34 ^c	15.93 ^c
30 & 45	18.25 ^c	18.70 ^b

Mean of the same column with different superscripts indicating significantly differences ($p \leq 0.05$).

The process of mango peel tea in this study was modified from oolong tea processing since it used short oxidation period. The kneading action of mango peel probably caused some of the sap, essential oils, and juices inside the skin to ooze

out, which further enhances the taste of the tea. And in the fermentation process probably induced the phytochemical compounds and enzymes in mango peel broken down, and its antioxidants are released or transformed. Oxidation is highly important in the formation of many taste and aroma compounds, which give a tea has specific color, strength, and briskness.

The correlation between the total phenolic content and antioxidant property of mango peel teas were calculated as shown in Fig. 3. There was no significant correlations detected between the total phenolic compounds and antioxidant activity ($r^2 = 0.31$). Many studies indicated that total phenolic compounds were highly positively correlated with antioxidant activity [24-26]. However, the result in this study was difference from other studies; the possible reasons could be that this result was based on the determination and statistical analysis of a small number of samples. Meanwhile, the correlation between the carotenoid content and antioxidant property of mango peel teas showed the strongly relation ($r^2 = 0.87$). Carotenoids also have antioxidant properties. The antioxidant activity of these compounds can shift into a pro-oxidant effect, depending on such factors as oxygen tension or carotenoid concentration. Mixtures of carotenoids alone or in association with others antioxidants can increase their activity against lipid peroxidation [27].

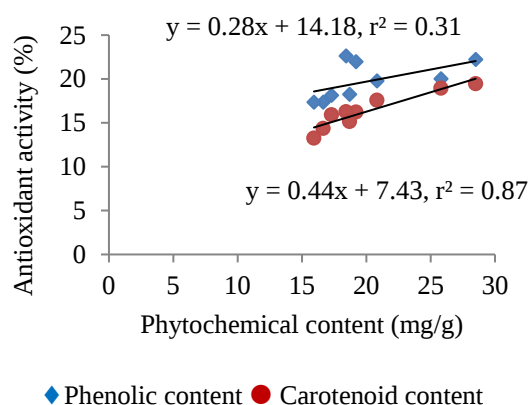


Fig. 3 The regression and correlation between the total phenolic compounds, carotenoid content and antioxidant activity of the mango peel tea product.

Color of mango peel tea and the infusions were shown in Fig. 4. Color of infusions of mango peel kneaded for 10 minutes and fermented for 10 and 30 minutes were slightly darker than other treatments. The aroma and taste of infusions were green and a bit astringent. The hedonic test on parameters such as color, flavor, taste and overall acceptance of mango peel tea infusion were presented in Table 3. Sensory evaluation showed that the score of color, flavor and taste of tea from

mango peel kneaded and fermented for 10 and 15 minutes, respectively significantly higher than other kneading and fermentation times ($p \leq 0.05$).

Table 5 Sensory attributes evaluation such as color, flavor, taste and overall acceptance of mango peel tea infusion.

Kneading & Fermentation (minutes)	Sensory evaluation			
	Color	Flavor	Taste	Overall acceptance
10 & 15	6.70 ^a	6.73 ^a	6.67 ^a	6.67 ^a
10 & 30	5.70 ^b	5.97 ^b	5.90 ^b	6.00 ^b
10 & 45	5.77 ^b	5.97 ^b	5.77 ^b	5.87 ^b
20 & 15	6.00 ^b	5.70 ^b	5.70 ^b	5.97 ^b
20 & 30	6.10 ^b	5.67 ^b	5.73 ^b	5.90 ^b
20 & 45	5.93 ^b	5.77 ^b	5.93 ^b	5.90 ^b
30 & 15	6.03 ^b	5.73 ^b	5.90 ^b	5.90 ^b
30 & 30	5.87 ^b	5.90 ^b	5.90 ^b	5.93 ^b
30 & 45	6.10 ^b	5.90 ^b	5.67 ^b	5.87 ^b

Mean of the same column with different superscripts indicating significant differences ($p \leq 0.05$).

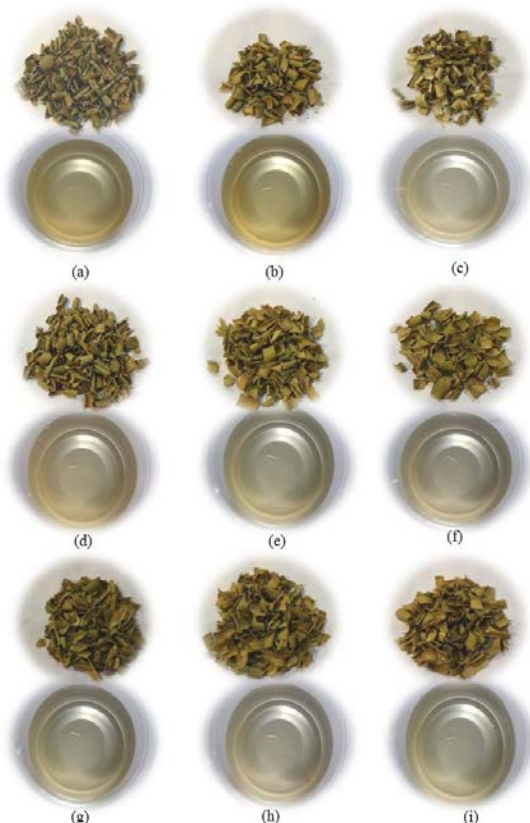


Fig. 4 Physical appearance of mango peel tea and color of mango peel tea infusions that kneaded and fermented at different time: (a) 10 and 15, (b) 10 and 30, (c) 10 and 45, (d) 20 and 15, (e) 20 and 30, (f) 20 and 45, (g) 30 and 15, (h) 30 and 30 and (i) 30 and 45 minutes, respectively.

4. CONCLUSION

Total phenolic content and antioxidant activity of tea from unripe mango peel were significantly higher than that ripe mango ($p \leq 0.05$). Kneading time had effect on antioxidant activity of the tea product, while, fermentation time had effect on total phenolic content of the tea. The result showed that mango peel kneaded for 20 minutes had antioxidant activity significantly higher than kneading time at 10 and 30 minutes ($p \leq 0.05$). And mango peel fermented for 15 minutes had total phenolic compounds significantly higher than fermentation time at 30 and 45 minutes ($p \leq 0.05$). Sensory evaluation showed that the score of color, flavor taste and overall acceptance of the infusion from mango peel tea kneaded and fermented for 10 and 15 minutes, respectively significantly higher than other kneading and fermentation times ($p \leq 0.05$).

5. ACKNOWLEDGMENTS

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6. REFERENCES

- [1] Das, S., Oliveira, L.M., Silva, E., Liu, Y. and Ma, L.Q. Fluoride concentrations in traditional and herbal teas: Health risk assessment, *Environmental Pollution*, Vol. 231, 2017, 779-784.
- [2] Fu, Y., Yanga, J., Cunningham, A.B., Towns, A.M., Zhanga, Y., Hua-ying Yang, H., Li, J. and Yanga, X. A billion cups: The diversity, traditional uses, safety issues and potential of Chinese herbal teas, *Journal of Ethnopharmacology*, Vol. 222, 2018, 217-228.
- [3] Atoui, A.K., Mansouri, A., Boskou, G. and Kefalas, P., 2005. Tea and herbal infusions: their antioxidant activity and phenolic profile. *Food Chemistry*, Vol 89, 2005, 27-36.
- [4] Cai, Y.Z., Xing, J., Sun, M., Zhan, Z.Q. and Corke, H. Phenolic antioxidants (hydrolyzable tannins, flavonols, and anthocyanins) identified by LC-ESI-MS and MALDI-QIT-TOFMS from *Rosa chinensis* flowers. *Journal of Agricultural and Food Chemistry*, Vol. 53, Issue 26, 2005, 9940-9948.
- [5] Rafiee, Z., Barzegar, M., Ali, M. and Maherani, B., Nanoliposomal carriers for improvement the bioavailability of high valued phenolic compounds of pistachio green hull extract, *Food Chemistry*, Vol. 220, 2017,

- 115–122.
- [6] Ribeiro, S.M.R., Barbosa, L.C.A., Queiroz, J.H., Knödler, M. and Schieber, A. Phenolic compounds and antioxidant capacity of Brazilian mango (*Mangifera indica* L.) varieties, *Food Chemistry*, Vol. 110, Issue 3, 2008, 620-626.
- [7] Mitra, S.K. and Baldwin, E.A. Mango. In: *Postharvest Physiology and Storage of Tropical and Subtropical Fruits*. Mitra, S.K. (Ed.), CAB International, Wallingford, Oxon, 1997, pp. 85-122.
- [8] Lalel, H.J.D., Singh, Z. and Tan, S.C. Glycosidically-bound aroma volatile compounds in the skin and pulp of 'Kensington Pride' mango fruit at different stages of maturity, *Postharvest Biology and Technology*. Vol. 29, 2003, 205-218.
- [9] Chen, Y., Zhao, L., He, T., Ou, Z., Hu, Z. and Wang, K., Effects of mango peel powder on starch digestion and quality characteristics of bread, *International Journal of Biological Macromolecules*. Vol 140, 2019, 647-652.
- [10] Ajila, C.M., Jaganmohan, Rao, L. and Prasada Rao, U.J.S., Characterization of bioactive compounds from raw and ripe *Mangifera indica* L. peel extracts, *Food and Chemical Toxicology*, Vol. 48 Issue 12, 2010, 3406-3411.
- [11] Ajila, C.M., Bhat, S.G. and Prasada Rao, U.J.S., Valuable components of raw and ripe peels from two Indian mango varieties, *Food Chemistry*, Vol. 102 Issue 4, 2007, 1006–1011.
- [12] Hockeng, K., Prasad, K.N., Ismail, A. and Mohdesa, N., Carotenoids from *Mangifera pajang* and their antioxidant capacity, *Molecules*, Vol. 15 Issue 10, 2010, 6699–6712.
- [13] Marina, Z. and Noriham, A., Quantification of total phenolic compound and in vitro antioxidant potential of fruit peel extracts, *International Food Research Journal*, Vol. 21, 2014, 1925–1929.
- [14] Dhital, S., Bhattarai, R.R., Gorham, J. and Gidley, M.J., Intactness of cell wall structure controls the in vitro digestion of starch in legumes, *Food and Function*, Vol. 7 Issue 3, 2016, 1367–1379.
- [15] Ajila, C.M., Leelavathi, K. and Prasada Rao, U.J.S., Improvement of dietary fiber content and antioxidant properties in soft dough biscuits with the incorporation of mango peel powder, *Journal of Cereal Science*, Vol. 48 Issue 2, 2008, 319–326.
- [16] Ajila, C.M., Aalami, M., Leelavathi, K. and Prasada Rao, U.J.S., Mango peel powder: a potential source of antioxidant and dietary fiber in macaroni preparations, *Innovative Food Science and Emerging Technologies*, Vol. 11 Issue 1, 2010, 219–224.
- [17] Maturity index, [online] <http://elearning.yru.ac.th/pluginfile.php>. July 3, 2019.
- [18] Bakar, M.F.A., Mohamed, M., Rahmat, A., and Fry, J. Phytochemicals and antioxidant activity of different parts of bambangan (*Mangifera pajang*) and tarap (*Artocarpus odoratissimus*). *Food Chemistry*, Vol 113, 2009, 479-483.
- [19] Brand-Williams, W., Cuvelier, M.E. and Berset, C. Use of free radical method to evaluate antioxidant activity. *LWT–Food Science and Technology*, Vol.28, Issue 1, 1995, 25-30.
- [20] Ajila, C.M., Naidu, K.A., Bhat, S.G. and Prasada Rao, U.J.S. Bioactive compounds and antioxidant potential of mango peel extract. *Food Chemistry*, Vol, 105, 2007, 982-988.
- [21] Atoui, A.K., Mansouri, A., Boskou, G., Kefalas, P. Tea and herbal infusions: their antioxidant activity and phenolic profile. *Food Chemistry*, Vol. 89, Issue 1, 2005, 27-36.
- [22] Chen, X.M., Ma, Z. and Kitts, D.D. Effects of processing method and age of leaves on phytochemical profiles and bioactivity of coffee leaves. *Food Chemistry*, Vol. 249, 2018, 143–153.
- [23] Feng, Z., Li, Y., Li, M., Wang, Y., Zhang, L., Wan, X. and Yang, X., Tea aroma formation from six model manufacturing processes. *Food Chemistry*, Vol 285, 2019, 347–354.
- [24] Jin, L., Li, X.B., Tian, D.Q., Fang, X.P., Yu, Y.M., Zhu, H.Q., Ge, Y.Y., Ma, G.Y., Wang, W.Y., Xiao, W.F. and Li, M. Antioxidant properties and color parameters of herbal teas in China. *Industrial Crops and Products*, Vol 87, 2016, 198-209.
- [25] Chan, E.W.C., Lim, Y.Y., Chong, K.L., Tan, J.B.L., Wong, S.K. Antioxidant properties of tropical and temperate herbal teas. *Journal of Food Composition and Analysis*, Vol. 23, Issue 2, 2010, 185-189.
- [26] Deetae, P., Parichanon, P., Trakunleewatthana, P., Chanseetis, C., Lertsiri, S. Antioxidant and anti-glycation properties of Thai herbal teas in comparison with conventional teas. *Food Chemistry*, Vol. 133, Issue 3, 2012, 953-959.
- [27] Zakynthinos, G., and Varzakas, T. Carotenoids: from Plants to Food Industry. *Current Research in Nutrition and Food Science*, Vol. 4 (Special Issue 1), 2016, 38-51.