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Comparison of total phenolic compound, antioxidant level and sensory evaluation among different forms of ginger juice

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Abstract

Excessive reactive oxygen species (ROS) is associated with inappropriate eating behaviors, physical inactivity, and stress. They are all causes of developing various non-communicable diseases indicating a public health problem in Thailand. Increasing antioxidant level is a reasonable approach to reduce ROS. Ginger (*Zingiber officinale Rosc*.) is a popular Thai traditional herbal medicine used in many Thai food recipes, especially beverages. The general objectives of this study aimed 1) to determine the level of total phenolic compound (TPC) and antioxidant levels in different forms of ginger juice; 2) to evaluate consumer acceptance of the appearance, aroma, taste and overall acceptability of different types of ginger juices with either sucrose (table sugar) or honey. Cold pressed with high pressure processed ginger juice (CPHPPGJ) had the highest TPC (193.72 ± 1.66 mg gallic acid/L) and antioxidant levels (12337.78 ± 561.72 µmoL Trolox/L) followed by cold pressed ginger juice (CPGJ), boiled ginger juice (BGJ) and hot water soaked ginger juice (HWSGJ). Regarding sensory evaluation, honey had the highest score of acceptability at 7.80 in HWSGJ, 7.47 in CPGJ and 7.15 in BGJ. Furthermore, honey added to all forms of ginger juice had a higher and more significant level of antioxidants than general formula. Thus, this beneficial information supported the practical product development and could serve as an alternative suggestion concerning ginger juice to those gaining the greatest benefits from consuming ginger.

Keywords: Cold pressed juice, high pressure processing, total phenolic compound, antioxidant, ginger juice

1. Introduction

The top three main causes of death in Thailand are non-communicable diseases (WHO, 2018). Cancer, cardiovascular disease, and cerebrovascular disease are associated with unhealthy eating patterns which present free radicals and reactive oxygen species (ROS) production (Hernández-Aguilera *et al.,* 2013; Pena-Oyarzun *et al.,* 2018; Wafula *et al.,* 2017). Free radicals are defined as unstable molecules composed of unpaired electrons in atomic orbits which are able to donate or receive electrons from other molecules by acting as oxidants (Cheeseman and Slater, 1993). It can occur in both enzymatic and nonenzymatic reactions that induce cell damage due to biologic systemic oxidation in carbohydrates, proteins, lipids, and nucleic acid (Young and Woodside, 2001), which are also related to increased oxidative stress (Wafula *et al.,* 2017). Oxidative stress significantly originates in various inflammatory diseases (arthritis and many types of vasculitis) (Gandhi *et al.,* 2017), ischemic diseases (heart and stroke) (Xuan *et al.,* 2018), and neurodegenerative diseases (Alzheimer's disease and Parkinson's disease) (Kim *et al.,* 2015; Wojtunik *et al.,* 2016). To prevent ROS production, antioxidants constitute interesting compounds that can donate electrons and neutralize free radicals by increasing the capacity of their function (Nimse and Pal, 2015; Zhang, *et al.,* 2016).

Ginger (*Zingiber officinale Rosc.*) is a famous of Thai traditional herbal medicine exhibiting high polyphenol antioxidants (Sharif and Bennett, 2016). The bioactive compounds of fresh ginger like gingerols, shogaols, paradols, and zingeronehave have been shown antioxidant activity in various modules. Pharmacological effects related to active compounds inside ginger have been reported in various studies. The hexahydrocurcumin, 1-dehydro-6-gingerdione, 6-dehydroshogaol and 6-shogaol showed the anti-inflammatory effect by inhibiting nitric oxide synthase (iNOS) and cyclooxygenase-2 (COX-2) (Li *et al.,* 2012; Sharif and Bennett, 2016). Gingerol and zingerone are mainly active compounds creating antioxidant and gastroprotective effects by reducing free radical scavenging, reducing abdominal discomfort including nausea, vomiting, and bloating (Haniadka *et al.,* 2013). Moreover, ginger has been popularly used in Thai cultural home remedies for so many decades and diet recipes, especially beverages. Thermal processing procedures such as boiling or soaking in hot water can be detrimental to bioactive compounds (Huang, 2017; Hulle and Rao, 2016; Jayachandran *et al.,* 2015). The popular household method for ginger juice preparation in Thailand are hot water-soaked ginger juice (HWSGJ), boiled ginger juice (BGJ) and cold pressed ginger juice (CPGJ). On the other hand, an updated food product innovative for industry level is applied cold pressed with high pressure processing (CPHPPGJ) to maintain nutritive value and kills microorganism (Zuluaga *et al.,* 2016) without using heat (Huang, 2017; Hulle and Rao, 2016; Jayachandran *et al.,* 2015).

Some consumer groups are unable to drink original ginger juice due to its spicy taste and pungent smell. To mix ginger juice with sugar is an alternative way to approach the antioxidant and nutraceutical effects. Related studies mostly reported about the antioxidant potencies of fresh ginger, dried ginger, and aged ginger that reported about 6-shogaol level in ginger increased based on timing and temperature of preparation. (Du *et al.,* 2018; Jung *et al.,* 2018; Kimura *et al.,* 2016; Li *et al.,* 2016). However, few studies have investigated the phenolic compounds and antioxidant levels in the different forms of ginger juice especially HWSGJ, BGJ, CPGJ, and

CPHPPGJ or evaluating sensory reactions of mixtures using different sweeteners such as sucrose and honey. Thus, this study aimed to determine the total phenolic compounds (TPC), antioxidant levels, and sensory evaluation of consumers among different forms of ginger juice with different sweetness mixtures.

2. Materials and Methods

2.1 Ginger juice preparation

Raw aged ginger harvesting on 10-12 months was randomly selected from three local markets in Bangkok: Huai-Kwang market, Minburi market, Ratchawat market. Then the ginger was cleaned, peeled, and smashed before separating in three forms of beverages: CPGJ, HWSGJ and BGJ which were the most popular household preparation method as shown in figure 1. CPGJ was produced using a bladeless cold pressed machine while CPHPPGJ; was the innovative food industrial method which produced using a bladeless cold pressed machine and high-pressure processing (HPP) machine (Hiperbaric 135, USA). On the other hand, HWSGJ was produced from aged ginger (100 g) soaked in 1 liter of hot water (80°C) and filtered through Whatmann No.1 after 15 min. BGJ was produced by boiling aged ginger (100 g) in 1 liter of hot water at 100°C for 10 min then filtering through Whatmann No.1 and adding boiled water until 1-liter volume. Additionally, in term of sucrose added formula, 100 g of sucrose was added and 100 mL of honey was added into honey added formula.

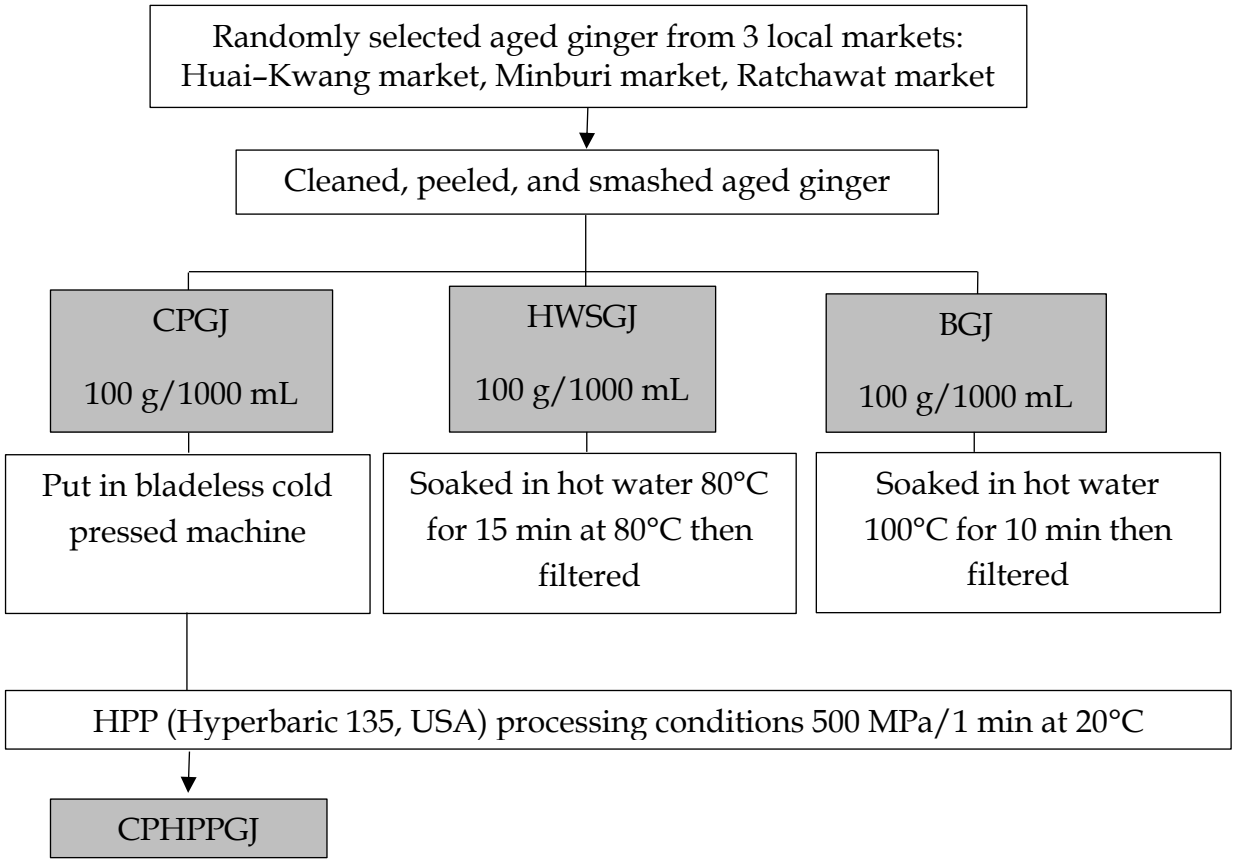

Figure 1 Ginger juice preparation

2.2 Total phenolic compound

Total phenolic compound (TPC) was determined using the Folin-Ciocalteu's method following Amarowicz (Amarowicz *et al.*, 2004). Briefly, 25 µL of CPGJ, CPHPPGJ, HWSGJ and BGJ were mixed with 50 µL of Folin-Ciocalteu's reagent (Sigma-Aldrich, Singapore) in a black, opaque microplate for 5 min then 200 µL of 7.5% sodium carbonate (Merck, Germany) was added for 2 h at room temperature. The sample was measured at 725 nm using spectrophotometer (Synergy HT, Bio-Tex Instruments, Vermont, USA) and expressed as mg gallic acid.

2.3 Antioxidant level

Antioxidant level was determined by Oxygen Radical Antioxidant Capacity (ORAC) using modified Ou's method (Ou *et al.*, 2001). 25 µL of CPGJ, CPHPPGJ, HWSGJ and BGJ were mixed with 150 µL of fluorescein reagent (Sigma-Aldrich, Sigapore) in an incubator at 37°C for 15 min then 25 µL of 153 mM of 2,2'-Azobis (2-amidinopropane) dihydrochloride (AAPH) reagent (Sigma-Aldrich, Singapore) was added. The sample was measured at 528 nm and 485 nm after 90 min reaction using a spectrophotometer (Synergy HT, Bio-Tex Instruments, Vermont, USA) and expressed as µmoL trollox equivalent.

2.4 Sensory evaluation

Nine different ginger juices with different sweeteners (sucrose and honey) were prepared in the Food Laboratory of the Department of Nutrition, Faculty of Public Health, Mahidol University. Fifty panelists were included in our study by simple random sampling from faculty staff, and 3rd and 4th year students. Inclusion criteria were selected by age 20 to 60 years, no food allergy history related to ginger or honey, no taste defect and interest to join our study. Exclusion criteria were related to having gallstone in gallbladder or any illness like cold, sore throat or runny nose, anti-coagulant drug use, and those absent on the day of evaluation. The samples were given to panelists using a 9-point hedonic scale evaluation form for different parameters such as appearance, color, aroma, taste, and acceptability (Cox *et al.* 1999; Klemmer, 1968). Acceptance index were calculated followed this formula (BertagnolliI *et al.*, 2014):

$$\text{Acceptance index} = (\text{Average score in each parameter} / 9)*100$$

2.5 Statistical analysis

SPSS, Version 18.0 was used for statistical analysis. TPC and antioxidant capacity were express as means ± SD. One-way ANOVA was used to compare TPC antioxidant capacity and total acceptability among 9-different types of ginger juice. The result of sensory evaluation was expressed as percentage in several parameters such as appearance, color, aroma, taste, and acceptability. Statistically significant was determined at $P<0.05$.

3. Results and Discussion

3.1 Total phenolic compound and antioxidant level

As shown in Table 1, different methods of ginger juice preparation showed different TPC and antioxidant levels. CPHPPGJ had the highest TPC (193.72 ± 1.66 mg gallic acid/L) and antioxidant levels (12337.78 ± 561.72 µmoL Trolox/L) followed by CPGJ, BGJ and HWSGJ when compared with the original formula. High pressure processing (HPP) could be the product development process able to increase the antioxidant level because this process kills all microorganism or bacteria growth as the cold pasteurization technique (Marszatek *et al.*, 2015; Patras *et al.*, 2009).

Regarding sweetener added, honey in all types of ginger juice could increase the TPC and antioxidant capacity because of their antioxidant properties (Al-Mamary *et al.*, 2002). Honey also exhibited the high antioxidant from related phenolic compounds and flavonoids which increased both TPC and antioxidant capacity significantly in all different types of ginger juice formula (Erejuwa *et al.*, 2012; Fauzi *et al.*, 2014). In term of high antioxidant in sugar added formula, it may be related to the limitation of spectrophotometry by using Folin's ciocauteu method and ORAC method that detected the phenolic compound by color, when sugar added was more brown color than others that will be the color interfere during this method. Another reason on phenolic compound and antioxidant level may related to the concentration among 4 difference preparation methods. CPGJ and CPHPP contained more TPC and antioxidant level than other formula because of high concentration preparation method while HWSGJ and BGJ seem like a traditional household dilution method even start from the equal amount of ginger (100 g).

Table 1 Total phenolic compound and antioxidant activity in 4 different types of ginger juice

Type of ginger juice	Ginger juice formula	TPC (mg gallic acid/L)	Antioxidant level (ORAC) (µmoL Trolox equivalent/L)
HWSGJ	Original (no added sugar)	12.01 ± 0.91^{i}	960.67 ± 48.07^{e}
	Sucrose added	40.81 ± 0.55^{g}	2125.52 ± 153.26^{d}
	Honey added	49.29 ± 0.73^{f}	2176.86 ± 155.88^{d}
BGJ	Original (no added sugar)	28.22 ± 0.20^{h}	2279.54 ± 462.58^{d}
	Sucrose added	54.32 ± 1.07^{e}	2490.25 ± 42.99^{d}
	Honey added	97.86 ± 0.73^{c}	3375.34 ± 74.16^{c}
CPGJ	Original (no added sugar)	91.68 ± 3.76^{d}	7265.19 ± 69.24^{b}
	Sucrose added	105.00 ± 3.76^{b}	7845.79 ± 318.61^{a}
	Honey added	149.28 ± 5.62^{a}	7950.95 ± 465.28^{a}
CPHPPGJ	Original (no added sugar)	193.72 ± 1.6^{j}	12337.78 ± 561.72^{k}

Note: Value expressed as means ± SD. The different superscripts significantly differed at $P<0.05$
HWSGJ defined as hot water-soaked ginger juice, BGJ defined as boiled ginger juice, CPGJ defined as cold-pressed ginger juice, CPHPPGJ defined as cold-pressed with high pressure processing ginger juice

3.2 Sensory evaluation

The sensory evaluation using different parameters such as appearance, color, aroma, taste, and total acceptability are shown in Table 2 compared with the original formula, CPGJ had the highest percentage of total acceptability (76.56%) followed by HWSGJ (40.89%) and BGJ (16.33%) while BGJ has the highest percentage of total acceptability (75.11%) followed by CPGJ (72.44%) and HWSGJ (69.67%) in sugar added formula comparison. Moreover, HWSGJ has the highest percentage of total acceptability (86.67%) followed by CPGJ (83%) and BGJ (79.44%) in honey added formula comparison.

In terms of product development, the acceptance index should be more than 70% (Nantapatavee, 2011). Honey added-CPGJ had the highest aroma acceptance (70.89%) and total acceptability (83%), useful information for ginger juice product development while original CPGJ, sugar-added CPGJ, Honey-added HWSGJ, sugar-added BGJ and honey-added BGJ showed an acceptance index particularly in total acceptability 76.56, 72.44, 86.67, 75.11 and 79.44%, respectively. The average total acceptability score of honey-added formula significantly exhibited the highest score of 7.80 in HWSGJ, 7.47 in CPGJ and 7.15 in BGJ when compared with sugar-added formula and original formula among all different types of ginger juice using a 9-point hedonic scale.

Table 2 Acceptance index in different parameters of different types of ginger juice

Type of ginger juice	Ginger juice formula	Acceptance index (%)				
		Appearance	Color	Aroma	Taste	Total acceptability
HWSGJ	Original (no added sugar)	61.11	59.11	50.89	36.67	40.89
	Sucrose added	69.33	66.00	57.56	61.11	69.67
	Honey added	53.11	53.11	62.22	57.56	86.67
BGJ	Original (no added sugar)	63.33	62.89	51.78	29.78	16.33
	Sucrose added	60.00	58.67	55.33	56.67	75.11
	Honey added	63.11	61.33	65.11	57.56	79.44
CPGJ	Original (no added sugar)	51.33	52.67	58.00	36.67	76.56
	Sucrose added	55.56	55.33	50.44	55.33	72.44
	Honey added	59.56	64.67	70.89	65.56	83.00

Note: Value expressed as percentage. HWSGJ defined as hot water-soaked ginger juice, BGJ defined as boiled ginger juice, CPGJ defined as cold-pressed ginger juice.

The limitation of this study, it was that the serving temperature could have affected the sensory test, requiring clinical study support in the future. However, the benefit of this study could be the information support to apply in product development and further research in clinical among human subjects and shelf life testing.

4. Conclusion

Cold-pressed with HPP was the developed innovative product which could maintain the highest antioxidant levels in both TPC and antioxidant capacity in ginger juice due to using the cold-pasteurization method. Honey-added CPGJ exhibited the highest total acceptability score, useful information for product development. Moreover, natural sugar (sucrose) and honey-added can improve the acceptable of ginger juice but require more further clinical research on human in difference sweetener added ginger juice and shelf-life testing. However, it could constitute an alternative for product development with higher antioxidant levels due to antioxidant properties and appropriate portion size to be recommended for healthy product development.

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