

Total Phenolic Content and Antioxidant Capacity of Selected Canned Fruits

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Abstract

Fruits are high in polyphenols which are compounds associated with the protection against diseases such as diabetes and cancer. However, food processing including canning can lead to the loss of polyphenol in the fruits. Thus, the aim of this study was to evaluate the total phenolic content (TPC) and antioxidant capacity of canned fruits commercially available in the local supermarkets in Malaysia. The TPC was determined by using Folin-Ciocalteu method while the antioxidant capacity was evaluated by using 2,2-diphenyl-1-picrylhydrazyl radical (DPPH assay) and Ferric Reducing Antioxidant Power (FRAP assay). Five types of different canned fruits with the total of 21 samples including longan, lychee, rambutan, pineapple and orange were selected for the analysis. The samples were analyzed in two forms which were, the homogenized (fruits and syrup) and syrup samples. Canned pineapples have the highest TPC for both homogenized (95.16 ± 30.16 mg GAE/100 g) and syrup sample (108.62 ± 33.88 mg GAE/100 g). For antioxidant capacity, canned pineapple also had the highest value for the homogenized sample (41.79 ± 4.20 μ mol TE/100 g) while lychee was the highest (46.84 ± 12.81 μ mol TE/100 g) for syrup sample assessed by DPPH assay. For FRAP assay, lychee was highest in antioxidant capacity for both homogenized sample (40.61 ± 10.55 μ mol TE/100 g) and syrup sample (33.58 ± 7.56 μ mol TE/100 g). A positive and significant ($P < 0.001$) correlation was found between TPC and antioxidant capacity (DPPH and FRAP). In conclusion, canned pineapple and lychee were the highest sources of polyphenol as compared to other types of canned fruits. Further investigation is warranted to determine the specific polyphenol present in the canned fruits.

Keywords: canned fruits, antioxidant activity, total phenolic content, DPPH assay, FRAP assay

1. Introduction

Current research had focused on the potential benefits of polyphenol, the bioactive compounds naturally present in plant-based foods. The consumption of polyphenol-rich foods was associated with the prevention and protection against diabetes, cancer and cardiovascular diseases (Rothwell et al., 2015). Moreover, the phenolic compound can contribute to the sensorial attributes such as bitter and astringency of fruit products (Ferrer-Gallego et al., 2014). In addition, the presence of polyphenol content had significantly influenced the antioxidant activity of fruits (Ignat et al., 2011).

The phenolic compound was known to be a water-soluble compound. These characteristics cause the phenolic compound to leach out to the surrounding especially for fruits immersed in syrup or brine. Moreover, the phenolic compound had been reported to decrease in thermal processing (Rickman et al., 2007; Serrano et al., 2011). Thermal processing can also affect the content and the amount of phenolic compound absorbed in the body in a distinct way. It could also cause significant reduction in chemical composition of foods including phenolic compounds (Le Bourvellec et al., 2018) and antioxidant activities. Apart from the thermal processing, storage can lead to a reduction in the total phenolic content of food products (D'archivio et al., 2010; de Oliveira et al., 2012).

Industrial thermal processing also encompasses the process that can be found in household cooking. Apart from being used in traditional transformation processes, heat also had been used in processes such as canning, pasteurization and related technology (ultra-high temperature treatment), smoking and extrusion cooking (Van

Boekel et al., 2010). Depletion, increases or small changes in content and functional of polyphenol can be affected through food processes. Cooking of vegetable causes the breakage of cell wall component and subsequent release of molecules and causes the leaching of water-soluble polyphenol into the surrounding water or may destroy polyphenols by high temperature (Van Boekel et al., 2010). Recent data has proposed that nutrient content in canned fruits are comparable with the fresh counterparts with a lower price (Miller & Knudson, 2014). Nevertheless, information on the effect of canning on total phenolic content and antioxidant activities of commercially available canned products is very important to be investigated. Thus, the aim of the present studies was to determine the total phenolic content and antioxidant capacity of canned fruits including longan, lychee, rambutan, pineapple and orange.

2. Method

2.1 Sampling Procedures

Samples of the canned fruits were bought in two local supermarkets in Kuala Lumpur, Malaysia. The samples included in the study were 8 lychees, 5 longan, 3 pineapples, 4 rambutan and 1 orange. The difference in the number of samples was due to the availability of products in the supermarkets. All 21 samples of canned fruits from various brands in the form of fruits in heavy syrup were selected for the analysis. The canned fruits were analyzed in two forms: homogenized sample where the fruits were homogenized together with the syrup and the syrup only. Phenolic compounds are water-soluble and susceptible to leach out to the liquid during processing (Rickman et al., 2007). Previous study has reported that the analysis of canning syrup has caused an increase in the total phenolic value of the canned cherries samples (Chaovanalikit & Wrolstad, 2004). Thus, analyzing samples in two forms enabled the comparison to be made. The analyses were performed in triplicates for each sample and the results were reported in mean and standard deviation.

2.2 Sample Preparation

For sample in homogenized form, the fruits were homogenized with syrup and filtered using muslin cloth followed by filter papers (Whatman no. 1). For syrup samples, the fruits were separated from the syrup before analysis was carried out on the syrup only. Both homogenized and syrup samples were stored at 4 °C until the time of analysis. The samples were diluted 10 times with distilled water before each analysis.

2.2.1 Total Phenolic Content

Total phenolic content was determined according to the Folin-Ciocalteu method with gallic acid used as the polyphenolic reference standard. The method was modified from Singleton and Rossi (1965) and Fu et al., (2011). About 0.5 ml of diluted sample was added into 2.5 ml of Folin-Ciocalteu reagent in ration of 1:10. Following 4 minutes, 2 ml of saturated sodium carbonate (about 75 g/L) was added into the mixture. The absorbance was then measured at 760 nm by using UV/Vis spectrophotometer (Secomam, France) following incubation for 2 hours. The results were reported as mg Gallic Acid Equivalence/100 g.

2.2.2 DPPH Radical Scavenging Activity

The DPPH assay was based on modifications from Brand-Williams et al. (1995), and Lu et al. (2014). Briefly, about 3.9 ml of 0.06 mM DPPH freshly prepared solution in methanol was added into the 0.1 ml fruits sample and the mixture was vortexed. The sample was incubated in the dark for 30 minutes. Reading of absorbance was measured at wavelength 515 nm using the UV/Vis spectrophotometer (Secomam, France). Trolox (6-hydroxy-2,5,7,8-tetramethylchroman-2-carboxylic acid) was used as a standard and the results were reported in μmol Trolox Equivalence/100 g sample.

2.2.3 FRAP Assay

The FRAP assay was based on modifications from Benzie and Strain (1996), and Rufino et al. (2010). About 2.7 ml of FRAP assay was freshly prepared at 37 °C. About 270 μL of the solution was added to 90 ml of samples. The samples were incubated for 4 minutes and monitored up until 8 minutes at 37 °C. Trolox (6-hydroxy-2,5,7,8-tetramethylchroman-2-carboxylic acid) was used as a standard and the results were reported in μmol Trolox Equivalence/100 g sample.

2.3 Statistical Analysis

The analysis was conducted using IBM SPSS for Windows version 22 software. Data was analyzed using descriptive analysis and presented in mean and standard deviations. Analysis of Variance (ANOVA) was used to compare the total phenolic content, the antioxidant capacity of DPPH and FRAP in the samples and post hoc were used as the consequent analysis. Independent T-test was used to compare the total phenolic content and antioxidant capacity DPPH and FRAP between the two forms of samples. Pearson's correlation was used for

comparisons of total phenolic content and antioxidant capacity DPPH and FRAP. Significance was set at a P value less than 0.05.

3. Results and Discussion

3.1 Total Phenolic Content

Table 1 indicated the TPC of homogenized for canned pineapple fruits (95.16 mg GAE/100 g) was significantly higher ($P < 0.05$) than longan (47.69 mg GAE/100 g), lychee (51.80 mg GAE/100 g) and rambutan (27.53 mg GAE/100 g). TPC of homogenized rambutan sample (27.53 mg GAE/100 g) was significantly lower ($P < 0.001$) than pineapple fruit (95.16 mg GAE/100 g). With regards to syrup form sample, TPC of pineapple fruit (108.62 mg GAE/100 g) was also significantly higher ($P < 0.001$) than longan (56.75 mg GAE/100 g), lychee (60.07 mg GAE/100 g) and rambutan (39.52 mg GAE/100 g). As for syrup only sample, rambutan (39.52 mg GAE/100 g) was significantly lower ($P < 0.001$) than the pineapple (108.62 mg GAE/100 g).

The TPC of majority of the studied canned fruits were lower than their fresh counterpart as described by Fu et al. (2011) which also studied the TPC and antioxidant capacity of 62 canned fruits. TPC of pineapple fruit was reported to be higher than other fruits (Fu et al., 2011). The present findings seem to be consistent with previous research which found that pineapple contained high phenolic compound (Haripyaree et al., 2010). On the contrary, a study has reported that the total phenolic content of fresh pineapple cultivated in France had lower value than the current research (73.3 mg GAE/100 g) (Ellong et al., 2015). As for rambutan, most of the phenolic compound were found in the seed or peels (pericarp) rather than the fruits itself (Thitilertdech & Rakariyatham, 2011; Chunglok et al., 2014). Thus, this could be a possible explanation of the lowest TPC value reported for rambutan. Similar finding was reported for lychee, by which the total phenolic content was much higher in the seed and pericarp parts of the fruit (Chunglok et al., 2014). Previous study has reported a higher total phenolic content of fresh lychee (178 mg GAE/100 g) as compared to the canned lychee in the current study (Septembre-Malaterre et al., 2016). However, apart from processing, the differences are expected as the fruit was harvested in French Island, whereas most of the samples in the current study was produced in Thailand or China.

Table 1. Total phenolic content among canned fruits (homogenised and syrup sample)

Fruits	Total phenolic Content (mg GAE/100 g)*	
	Homogenized	Syrup only
Longan	47.69±8.46 ^a	56.75±6.15 ^a
Lychee	51.80±17.63 ^a	60.07±16.68 ^b
Rambutan	27.53±6.46 ^b	39.52±9.50 ^a
Pineapple	95.16±30.16 ^c	108.62±33.88 ^c
Orange	78.79±19.24 ^{ab}	85.25±18.76 ^{ab}

Note. * Data were reported as mean±standard deviation of six replicates. Different letter in the same column represent significant difference ($P < 0.05$) using One Way ANOVA.

3.2 Antioxidant Capacity Determined by DPPH and FRAP Assay

The results for antioxidant capacity of DPPH assay and FRAP assay for both homogenized and syrup samples were compared in Table 2. As for antioxidant capacity of DPPH assay, pineapple fruits (41.79 $\mu\text{mol TE}/100\text{ g}$) was significantly higher ($P < 0.05$) than rambutan (39.35 $\mu\text{mol TE}/100\text{ g}$). As for rambutan fruits (39.35 $\mu\text{mol TE}/100\text{ g}$), the antioxidant capacity was significantly lower ($P < 0.05$) than longan (41.67 $\mu\text{mol TE}/100\text{ g}$) and lychee (39.76 $\mu\text{mol TE}/100\text{ g}$).

Phenolic compounds that were found in pineapple were reported as myricetin, gallic acid, sinapic acid, caffeic acid, p-hydroxybenzoic acid, p-hydroxybenzoic aldehydes, acid, salicylic acid and trans-cinnamic acid (Yapo et al., 2011). Consequently, the diversity of polyphenol compounds present in the pineapples could partially explained the high value of antioxidant capacity assessed by DPPH of the fruit. The low DPPH value for lychee samples in the current study was supported by a previous study that reported a low free radical scavenging activity of the fresh lychee (Septembre-Malaterre et al., 2016).

In the syrup sample, lychee (46.84 $\mu\text{mol TE}/100\text{ g}$) was significantly higher ($P < 0.05$) compared to longan (43.62 $\mu\text{mol TE}/100\text{ g}$), rambutan (41.01 $\mu\text{mol TE}/100\text{ g}$), pineapple (44.15 $\mu\text{mol TE}/100\text{ g}$) and orange (46.04 $\mu\text{mol TE}/100\text{ g}$). Besides, rambutan fruits (41.01 $\mu\text{mol TE}/100\text{ g}$) was significantly lower ($P < 0.05$) compared to

longan (43.62 $\mu\text{mol TE}/100\text{ g}$), lychee (46.84 $\mu\text{mol TE}/100\text{ g}$) and pineapple (44.15 $\mu\text{mol TE}/100\text{ g}$). Majority of the samples studied have shown to possess a higher antioxidant activity in syrup compared to the homogenized counterparts except orange. One of the possible explanation is the leaching out of significant amount of antioxidant into the liquid used in the canning process as reported in a study on canned berries (Skrovankova et al., 2015).

FRAP is also considered one of the methods that are frequently used for determination of antioxidant capacity in many types of food. This assay measures the ability of antioxidant in food to reduce the ferric ion into ferrous ion as stated by Guo et al. (2003). As for homogenized sample, the highest antioxidant capacity of FRAP came from lychee fruits (40.61 $\mu\text{mol TE}/100\text{ g}$). The antioxidant capacity FRAP of the lychee fruits were significantly higher ($P < 0.05$) as compared to pineapple fruits (23.57 $\mu\text{mol TE}/100\text{ g}$). The FRAP in orange fruit (22.89 $\mu\text{mol TE}/100\text{ g}$) were significantly lowest than other samples such as longan (30.23 $\mu\text{mol TE}/100\text{ g}$), lychee (40.61 $\mu\text{mol TE}/100\text{ g}$), rambutan (22.10 $\mu\text{mol TE}/100\text{ g}$) and pineapple (23.57 $\mu\text{mol TE}/100\text{ g}$).

In a syrup sample, the highest average of antioxidant capacity belongs to lychee which is 33.58 $\mu\text{mol TE}/100\text{ g}$. The antioxidant capacity of lychee fruits was significantly higher ($P < 0.05$) than the pineapple (28.59 $\mu\text{mol TE}/100\text{ g}$). Other than that, the lowest average of antioxidant capacity found in orange (24.31 $\mu\text{mol TE}/100\text{ g}$). The antioxidant capacity of FRAP for orange was significantly higher ($P < 0.05$) as compare to the one in longan (25.58 $\mu\text{mol TE}/100\text{ g}$), lychee (33.58 $\mu\text{mol TE}/100\text{ g}$), rambutan (25.52 $\mu\text{mol TE}/100\text{ g}$) and pineapple (28.59 $\mu\text{mol TE}/100\text{ g}$). Storage can contribute to a reduction in antioxidant activities of the canned products (Ahmed et al., 2012). The differences in results obtained from DPPH and FRAP assay can partly be explained by the mechanism of action of both assays. In DPPH assay, the tested compounds with overlap spectra with DPPH mixture can interfered the absorption, thus affect the reading (Pisoschi & Negulescu, 2011). Results obtained from FRAP assay can be influenced by time scale of analysis, where some polyphenols have short reaction time while others required longer time to react and to be detected (Prior et al., 2005).

Table 2. Antioxidant capacity of selected canned fruits

Fruits	DPPH Assay ($\mu\text{mol TE}/100\text{ g}$)*		FRAP Assay ($\mu\text{mol TE}/100\text{ g}$)*	
	Homogenized	Syrup only	Homogenized	Syrup only
Longan	41.67 \pm 3.62 ^a	43.62 \pm 6.52 ^a	30.23 \pm 9.19 ^a	25.58 \pm 4.43 ^a
Lychee	39.76 \pm 3.26 ^a	46.84 \pm 12.81 ^b	40.61 \pm 10.55 ^a	33.58 \pm 7.56 ^{ab}
Rambutan	39.35 \pm 3.12 ^b	41.01 \pm 2.67 ^c	22.10 \pm 4.03 ^c	25.52 \pm 5.58 ^a
Pineapple	41.79 \pm 4.20 ^a	44.15 \pm 4.87 ^a	23.57 \pm 2.58 ^{ad}	28.59 \pm 3.88 ^c
Orange	38.96 \pm 3.58 ^{ab}	46.04 \pm 0.86 ^a	22.89 \pm 2.58 ^a	24.31 \pm 9.75 ^d

Note. * Data were stated as mean \pm standard deviations of six replicates. Different letter at the same column represent significant different at ($P < 0.05$) based on One Way ANOVA.

3.2 Association between Total Phenolic Content and Antioxidant Capacity

Table 3 showed a positive and significant correlation ($P < 0.01$) between total phenolic content and antioxidant capacity of DPPH assay and FRAP assay in the studied samples. In comparison of homogenized sample, there was a significant and positive correlation that can be seen between the total polyphenol content and antioxidant capacity of DPPH ($R^2 = 0.764$) and FRAP ($R^2 = 0.812$). Similarly, a positive and significant correlation was found between the total polyphenol content and antioxidant capacity of DPPH ($R^2 = 0.702$) and FRAP ($R^2 = 0.664$) for the syrup samples. The findings of the current study are consistent with previous study in citrus fruits cultivated in Bangladesh (Rahman et al., 2016). The presence of phenolic compounds in fruits can partly contribute to the antioxidant activities of the fruits (Septembre-Malaterre et al., 2016).

Table 3. Correlation between total phenolic content and antioxidant capacity of DPPH assay and FRAP assay

Parameter	Pearson's rho	
	Homogenized	Syrup
Radical Scavenging Activity DPPH	0.764**	0.702**
Ferric Reducing Antioxidant Power FRAP	0.812**	0.664**

Note. ** Correlations are significant at $P < 0.01$ according to Pearson correlation.

4. Conclusions

In conclusion, there were significant differences in TPC within homogenized and syrup only sample of canned fruits. Although not significantly different, the trend in results showed a higher TPC and antioxidant capacity from DPPH assay and FRAP assay in syrup only samples as compared to homogenized samples. Highest TPC was for pineapple fruit for both homogenized and syrup samples. In the future, analysis of more various types of canned fruits should be carried out to give a clearer picture of the contents of total polyphenols and antioxidant capacity of fruits that are available in Malaysia.

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