International Food Research Journal 20(3): 1173-1179 (2013)
Journal homepage: *http://www.ifrj.upm.edu.my*

Composition of tree peony (*Paeonia suffruticosa*) and Chinese apple flower (*Malus* spp.) buds

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Article history

Received: 19 September 2012
Received in revised form: 15 December 2012
Accepted:17 December 2012

Keywords

Tree peony
apple flower
proximate composition
amino acids
fatty acids minerals
heavy metals

Abstract

Traditionally, in Chinese medicine, tree peony and apple flower buds are used to prepare herbal decoctions to cure various ailments. As both of these flowers are popular and used regularly, providing scientific evidence on their basic composition is a necessity. Hence, in the present study, we report the chemical composition of these two flower buds. Results revealed tree peony and apple flower buds to have high crude protein (15.73 and 26.30%), fibre (13.11 and 16.51%), and carbohydrate (57.84 and 40.63%) contents. Both the flowers had significant amounts of essential amino acids and unsaturated fatty acids. Essential minerals present in tree peony and apple flowers were potassium (1540.37 and 1125.60 mg/100 g), calcium (462.46 and 449.98 mg/100 g), magnesium (241.51 and 164.23 mg/100 g), sodium (12.75 and 20.06 mg/100 g), and phosphorus (420.00 and 590.00 mg/100 g), respectively. Heavy metals (cadmium, nickel, mercury, lead, and arsenic) were detected in trace amounts (< 0.50 mg/100 g) in both the flower buds. Results obtained indicate that both flowers could be exploited as an additional source of nutraceutical for the development of new functional foods.

Introduction

Tree peony (*Paeonia suffruticosa*; family Paeoniaceae, genus *Paeonia*, and section Moutan), is an ornamental plant possessing high therapeutic value. This plant has its origin in China and is widely distributed in Japan, USA, and Europe. Since time immemorial, the flowers of tree peony have been used to prepare traditional food such as casselores, cakes, herbal tea and drinks. Traditionally, Chinese used flowers and roots of tree peony for herbal medicine preparations as a remedy for women to cure irregular menstruation and dysmenorrhea (Wang *et al.*, 2005; Li *et al.*, 2009). Additionally, extracts of this flower have been used as an ingredient in skincare products to enhance skin flexibility, reduce pigment accumulation, and prevent fleck formation.

On the other hand, apple flowers (*Malus* spp. Family; Rosaceae) are widely cultivated in various provinces in China. Apple flowers have a bright color (white to pink) with a delicate floral flavor. It is commonly consumed by Chinese community as herbal tea decoction, and is known to have a fresh and sweet after-taste. Tea prepared from apple flower is considered to have a sweet and sour in taste with a tinge of sweet fragrance. A tea harmonized with other flower extracts such as rose and orange blossom are also desirable to obtain a soothing effect. Additionally, apple flower tea is also known to alleviate depression, regulate endocrine and to nourish the uterus, therefore is beneficial for women who suffer from menstrual pain (http://www.zhzyw.org/zycs/zyjc/101161632AGKF115CA672HA7.html; assessed on 3rd September 2012). In traditional Chinese medicine, apple flowers are considered to improve digestion, remove excess fat, revitalize blood, reduces stress, ease the nerve, and brighten the eyesight. Apple flower is considered to be good for skin-care and is believed to be useful to clear acne, lightens pigmentation, clear complexion, and diminish pimples, black heads, and other skin problems. The phenolics compounds present in the flower extracts are known to exhibit rich antioxidant activity (http://www.zhzyw.org/zycs/zyjc/101161632AGKF115CA672HA7.html; assessed 3rd September, 2012). In Malaysia, these two flowers are imported from China by local Chinese herb vendors. These flowers are consumed

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by Malaysian-Chinese community as herbal tea for their medicinal effects.

As flowers belonging to various species are known to encompass high nutraceutical value with rich antimicrobial properties (Voon *et al.*, 2012), it is a necessity to provide in-depth details on their chemical composition, especially where these can be used as a basic ingredient while developing novel food products or for where food bio-fortification is a necessity. In the present study, for the first time, we are reporting in detail the chemical composition of *P. suffruticosa* and *Malus* spp. flower buds.

Materials and Methods

Plant material

Flower buds of *P. suffruticosa* and *Malus* spp. were purchased from local Chinese herb store (Penang, Malaysia). The flower buds were dried in a freeze dryer (Model 7754511, Labconco Corporation, Kansas City, USA) and then ground to fine powder using a commercial kitchen blender. The powdered samples were stored at 4°C in an airtight container until further analysis.

Proximate analysis

Moisture content of the powdered samples was determined by using moisture analyzer (IR-30, Denver Instrument, Colorado, USA). Proximate analysis such as crude protein, crude fat, and crude fibre, and ash were determined based on the Official Method of Analysis (AOAC, 1990). Total crude carbohydrate was calculated by difference (Bhat and Sridhar, 2008):

$$\text{Total crude carbohydrate (\%)} = 100 - [\text{Moisture (\%)} + \text{crude protein(\%)} + \text{crude lipid (\%)} + \text{crude fiber (\%)} + \text{total ash (\%)}]$$

While, Gross energy was calculated using the following formula (Bhat and Sridhar, 2008):

$$\text{Gross energy (kJ/100 g)} = (\text{protein} \times 16.7) + (\text{fat} \times 37.7) + (\text{carbohydrate} \times 16.7)$$

Amino acid analysis

The method described by Bhat *et al.* (2008) and Huda *et al.* (2010) were used to determine amino acids composition in the samples. A known weight of the samples (~ 0.1 g each in triplicates) in sealed glass tubes was added with 5 ml of 6 N HCl and digested by incubating in an oven at 110°C for 24 h. After that, 0.4 ml of 50 µmol/ml alpha amino butyric acid (AABA) was added to the hydrolysate as internal standard. Next, the mixture was made up to 100 ml with distilled water and filtered through Whatman No. 1 filter paper and Whatman syringe filter. Sulphur containing amino acids such as methionine and cysteine were separately analyzed after oxidizing with chilled performic acid (2 ml) followed by subsequent hydrolysis with 6 N HCl based on the above mentioned method for other amino acids. All the samples were derivatized with AQC reagent and borate buffer prior to injecting to HPLC (Waters 2475, US) using eluent A (AccQ Taq TM concentrate, Waters) and eluent B (Acetonitrile 60 %, Sigma) with a flow rate of 1 ml/min. The HPLC system was coupled with a multi-fluorescence detector (excitation at 250 nm and emission at 395 nm), a 717 auto-sampler and a binary 1525 HPLC pump and bus satin model. A column size of 3.9 x 150 mm was used. Ten micro liter of the hydrolysate was injected into HPLC and run for 50 min. The resulting peaks were analyzed by 'Breeze software.' A calibration mixture was prepared using a commercial amino acid mixture (Standard H, Pierce Chemical, Rockford) and individual amino acid (Sigma). The amino acid score was determined using the 1985 FAO/WHO/UNU (FAO, 1991) suggested pattern of amino acid requirement for pre-school children, 2-5 years old (see Table 2) by following the formula below:

$$\text{Amino acid score} = \frac{\text{Amino acid content in food protein}}{\text{Amino acid content in the FAO/WHO/UNU reference pattern}} \times 100$$

Fatty acid analysis

Total lipids in the samples were extracted based on the direct fatty acid methyl esters (FAMEs) synthesis method described by Indarti *et al*. (2005), with slight modifications. About 100 mg of the samples was taken into a clean, 10 ml screw-top glass bottle. Next, 4 ml of the freshly prepared mixture of methanol, concentrated sulfuric acid and chloroform (1.7:0.3:2.0 v/v/v) was added. The bottles were vortexed for 30 seconds, bubbled with nitrogen gas and were tightly sealed with Teflon caps. Trans-esterification was pursued by marinating the bottles inside a heating block at 100°C for 30 min. After the reaction, bottles were cooled to ambient temperature in desiccators. Then, 1 ml of distilled water was added to the mixture, thoroughly mixed by vortexing for 1 min and allowed to stand for phase separation. Upon separation of the two phases, the lower phase was transferred into another clean, 10 ml bottle and dried over anhydrous sodium sulphate (Na_2SO_4). The samples were stored in a freezer at -20°C until GC analysis.

For the analysis, 3 µl of the dried fraction was transferred into a vial and were added with 1 µL of internal standard of caproic acid (C6: 0) methyl ester, which was previously diluted in chloroform (1:499

v/v). FAMEs were separated by injecting 1 µL of this solution into GC (Automatic system XL, Perkin Elmer, Norwalk, CT, USA) equipped with flame ionization detector (FID) and a fused silica capillary Omega wax 250 column (30 m x 0.25 mm internal diameter, 0.25 µm film thickness, Supelco, Bellefonte, Pennsylvania, USA). The conditions maintained for the system include: oven temperature started at 50°C for 2 min, increased at a rate of 4°C/ min to 220°C and held at 220°C for 35 min; injector temperature held at 250°C; FID detector temperature held at 260°C; Carrier gas (helium) maintained at 103.4 kPa; Hydrogen and compressed air for FID maintained at 275.6 kPa. Chromatographic data were recorded and integrated in a computer (Optiplex GX 110 of DELL, DELL Computers Corporation, Penang, Malaysia) by using Turbochrom NavigatorTM Software (Perkin Elmer, San Jose, California, USA). Identification of fatty acid was based on comparing the retention times of FAMEs with standard components FAME mixture No. 47885-U (Supelco) and menhaden oil which were run on the identical conditions as those maintained for the samples. Individual fatty acid content was calculated as percentage of total fatty acid detected. Determination was carried out in triplicate per sample.

Evaluation of minerals and heavy metal content

Mineral and heavy metal contents were determined based on AOAC (1990) acid digestion method using atomic absorption spectroscopy (Perkin Elmer, Beaconfiend, UK) equipped with deuterium hollow cathode lamp background correcting system. Phosphorus and boron content were determined colorimetrically by spectrophotometer (DR 2800, Hach, USA).

Statistical analysis

Results of the present study are represented as mean values ± standard deviation (S.D.) of triplicate measurements (n = 3), unless mentioned otherwise. The differences between mean values were determined by analysis of variance (one-way ANOVA) at a significance level of $p < 0.05$. The statistical analysis was performed using Statistical Package for Social Science, SPSS 14.0 (SPSS Inc., Wacker Drive, Chicago, USA).

Results and Discussion

Results on the proximate composition of tree peony and apple flower buds are depicted in Table 1. Tree peony and apple flower buds had high crude protein (15.73 and 26.30%), crude fibre (13.11 and 16.51%), and crude carbohydrates (57.84 and 40.63%). However, contents of crude fat (2.74 and 2.89%) and ash (4.89 and 6.68%) were found to be low. High content of protein is an indication that the flowers might have significant amount of amino acids. The protein content of the flowers was higher compared to egg (12.60%), wheat (8.55%), parboiled rice (7.70%), wild tribal pulses (12–20%) or common legumes such as peas and beans (17%), fruits (0.4-8.3%), and edible flowers (6.67-27.50%) (FAO, 1970; Livsmedelsverk, 1988; Richard *et al*., 1996; Arinathan *et al*., 2003; Sotelo *et al*., 2007; Butt and Batool, 2010; Madhumita and Naik, 2010; Hassan *et al*., 2011). This highlights the fact that these flowers or their extract can effectively be used for bio-fortification while developing novel low cost nutrition food and food supplements. Whereas, low level of crude fat can contribute to low calorie value of the flowers (when used as an additive), and this observation is in agreement with the general observation made on plants wherein they contribute to low energy values (Lintas, 1992).

Table 1. Proximate composition of freeze dried tree peony and apple flower buds (n = 3 ± SD)

Composition	Tree Peony	Apple flower
Moisture (%)	5.68 ± 0.33^{a}	7.00 ± 0.81^{a}
Crude protein (%)	15.73 ± 0.05^{a}	26.30 ± 0.19^{b}
Crude fibre (%)	13.11 ± 1.58^{a}	16.51 ± 1.44^{a}
Crude fat (%)	2.74 ± 0.05^{a}	2.89 ± 0.10^{a}
Total ash (%)	4.89 ± 0.03^{a}	6.68 ± 0.05^{b}
Total crude carbohydrate (%)	57.84 ± 1.69^{a}	40.63 ± 1.70^{b}
Gross energy (KJ/100 g)	1332.03 ± 29.63^{a}	1226.63 ± 26.88^{b}

Mean values in same row followed by same letters are not significantly different from each other ($p > 0.05$) based on the one-way ANOVA

Amino acids profile of both the flower buds used in this study is shown in Table 2. Tree peony and apple flower contained high proportion of non-essential amino acids (67.35% and 62.37% in total amino acid). Tree peony contained high amount of aspartic acid (16.40%) and glutamic acid (17.28%) while limited amount of methionine (0.23%) and cysteine (0.55%) were detected. For apple flower, level of aspartic acid and glutamic acid (18.71% and 11.24%) was high compared to the rest of the amino acids which were found to be moderate. The amino acid contents of apple flowers were higher than those of tree peony, which might be due to high contents of protein.

Essential amino acids (histidine, isoleucine, leucine, phenylalanine, theonine, and valine) of both of the flowers were high when compared to FAO/ WHO/UNU (FAO, 1991) pattern. Their amino acid

scores ranged between 100.90-155.79 and 102.57-292.43, respectively. However, lysine (in tree peony and apple flower) and sulfur-containing amino acids (methionine + cysteine) (in tree peony) had a lower value compared to the suggested pattern and had a score of 85.20, 89.42, and 31.51, respectively. Thus, apple flower was better in term of protein quality.

Table 2. Amino acid composition and amino acid score of protein in tree peony and apple flower buds (n = 3 ± SD)

Amino acid	FAO/WHO /UNU pattern	Percentage in total amino acid (%)		Amino acid score	
		Tree peony	Apple flower	Tree peony	Apple flower
Essential amino acid					
Histidine	1.9	$2.45 \pm 0.60_a$	$2.48 \pm 0.10_a$	128.88	130.52
Isoleucine	2.8	$4.36 \pm 0.14_a$	$4.07 \pm 0.07_b$	155.79	145.33
Leucine	6.6	$6.66 \pm 0.07_a$	$6.77 \pm 0.12_a$	100.90	102.57
Lysine	5.8	$4.94 \pm 0.12_a$	$5.19 \pm 0.17_a$	85.20	89.42
Methionine	-	$0.23 \pm 0.02_a$	$6.01 \pm 0.33_b$	-	-
Phenylalanine	-	$4.29 \pm 0.16_a$	$4.23 \pm 0.09_a$	-	-
Threonine	3.4	$4.38 \pm 0.09_a$	$4.18 \pm 0.36_a$	128.73	122.94
Valine	3.5	$5.35 \pm 0.10_a$	$4.69 \pm 0.08_b$	152.89	134.10
Non-essential amino acid					
Alanine	-	$6.02 \pm 0.14_a$	$5.16 \pm 0.08_b$	-	-
Arginine	-	$6.56 \pm 0.28_a$	$6.40 \pm 0.07_a$	-	-
Aspartic acid	-	$16.40 \pm 0.59_a$	$18.71 \pm 0.37_b$	-	-
Cysteine	-	$0.55 \pm 0.09_a$	$1.30 \pm 0.11_b$	-	-
Glutamic acid	-	$17.28 \pm 0.16_a$	$11.24 \pm 0.17_b$	-	-
Glycine	-	$4.38 \pm 0.05_a$	$4.20 \pm 0.02_b$	-	-
Proline	-	$7.82 \pm 2.01_a$	$7.32 \pm 0.22_a$	-	-
Serine	-	$4.91 \pm 0.52_a$	$5.14 \pm 0.04_a$	-	-
Tyrosine	-	$3.43 \pm 0.06_a$	$2.90 \pm 0.05_b$	-	-
SAA[a]	2.5	$0.79 \pm 0.11_a$	$7.31 \pm 0.44_b$	31.51	292.43
AAA[b]	6.3	$7.72 \pm 0.19_a$	$7.14 \pm 0.08_b$	122.54	113.28

Mean values in same row followed by same letters are not significantly different from each other ($p > 0.05$) based on the one-way ANOVA

[a] SAA: Sulfur-containing amino acid (methionine + cysteine)

[b] AAA: Aromatic amino acid (phenylalanine + tyrosine)

The flowers or their extracts would be inadequate as a sole source of dietary protein due to the limiting amino acids lysine and methionine + cysteine. However, a combination of these flowers with cereals, legumes or meat and their products can complement each other and can fulfill the necessary amino acids requirements. The presence of rich amount of amino acids can support the use of these flowers as a base of nutraceutical, as most of the amino acids obtained from different food sources have been reported to act as antioxidant, antimicrobial, anti-inflammatory, and immune stimulating agents (Bernal *et al*., 2011; Nimalaratne *et al*., 2011).

In Table 3, results obtained for the fatty acid profiles of tree peony and apple flower buds are highlighted. In total, 18 fatty acid components were detected in tree peony and apple flowers. Among these 8 components were saturated fatty acids, while the remaining was unsaturated fatty acid. Saturated fatty acids accounted for higher proportion of the total fats in tree peony and apple flower buds (62.71% and 50.94%, respectively). Apple flower had significantly higher ratio of unsaturated fatty acids to saturated fatty acids as compared to tree peony flower buds. High level of caprylic acid (36.18%), palmitic acid (17.02%), linoleic acid (14.37%), gamma-linolenic (6.71%), and alpha-linolenic acid (5.66%) were detected in tree peony, whereas in apple flower buds, high level of caprylic acid (14.47%), myristic acid (10.10%), palmitic acid (20.01%), oleic acid (11.04%), linoleic acid (17.06%), and alpha-linolenic acid (11.59%) were detected. Among the saturated fatty acids, caprylic acid was the most abundant component in tree peony while palmitic acid was the most abundant in apple flower, both accounted for 57.69 % and 39.28% of the total saturated fatty acids, respectively.

Table 3. Fatty acid composition of tree peony and apple flower buds (n = 3 ± SD)

Fatty acid	Shorthand designation	% total fatty acid detected by peak area	
		Tree peony	Apple flower
Saturated fatty acid			
Caprylic acid	C8:0	$36.18 \pm 2.56_a$	$14.47 \pm 0.66_b$
Lauric acid	C12:0	$0.19 \pm 0.04_a$	$0.31 \pm 0.19_a$
Tridycelic acid	C13:0	$0.30 \pm 0.01_a$	$0.44 \pm 0.02_b$
Myristic acid	C14:0	$4.11 \pm 0.31_a$	$10.10 \pm 1.04_b$
Pentadecylic acid	C15:0	$0.19 \pm 0.04_a$	$0.22 \pm 0.16_a$
Palmitic acid	C16:0	$17.02 \pm 1.39_a$	$20.01 \pm 1.20_b$
Stearic acid	C18:0	$4.00 \pm 0.30_a$	$3.72 \pm 1.05_a$
Arachidic acid	C20:0	$0.88 \pm 0.18_a$	$1.66 \pm 0.15_b$
Unsaturated fatty acid			
Myristoleic acid	C14:1	0.27 ± 0.15	ND
Cis-10-pentadecenoic acid	C15:1	$0.07 \pm 0.01_a$	$0.32 \pm 0.24_a$
Palmitoleic acid	C16:1n7	$4.14 \pm 0.35_a$	$1.83 \pm 0.99_b$
Hexadecatrienoic acid	C16:3n4	2.63 ± 0.10	ND
Oleic acid	C18:1n9	$3.61 \pm 1.67_a$	$11.04 \pm 0.37_b$
Vaccenic acid	C18:1n7	$1.45 \pm 0.42_a$	$2.82 \pm 0.18_b$
Linoleic acid	C18:2n6	$14.37 \pm 2.58_a$	$17.06 \pm 1.79_a$
Gamma-linolenic acid	C18:3n6	6.71 ± 1.57	ND
Isomer of linolenic acid	C18:3n4	ND	1.28 ± 1.13
Alpha-linolenic acid	C18:3n3	$5.66 \pm 0.92_a$	$11.59 \pm 1.42_b$
Dihomo-gamma-linolenic acid	C20:3n6	ND	0.96 ± 0.04
Eicosatetraenoic acid	C20:4n3	1.10 ± 0.13	ND
Eicosapentaenoic acid	C20:5n3	ND	0.78 ± 0.05
Cetoleic acid	C22:1n11	ND	1.37 ± 0.52
Sum of saturated fatty acids		$62.71 \pm 4.38_a$	$50.94 \pm 2.66_b$
Sum of unsaturated fatty acids		$37.29 \pm 4.38_a$	$49.06 \pm 2.66_b$
TUFA/TSFA[x]		$0.60 \pm 0.11_a$	$0.97 \pm 0.11_b$

Mean values in same row followed by same letters are not significantly different from each other ($p > 0.05$) based on the one-way ANOVA

ND= not detected

[x]Ratio of total unsaturated fatty acids to total saturated fatty acids

Despite dietary issues and guidelines provided regarding the onset of coronary artery diseases associated with excessive intake of saturated fats, still most of these saturated fats are a pre-requisite factor. Saturated fatty acids such as myristic acid and palmitic acid form an integral part of cell membrane structure in human body and helps in maintaining optimal function of the kidneys (Monserrat *et al*., 2000). Besides, medium chain fatty acids such as caprylic acid are reported to exhibit anti-viral, anti-

bacterial, anti-fungal and anti-protozoal activities and helps in boosting the immune system (Chomchalow, 2011). Additionally caprylic acid and capric acid are known to improve immune system, stimulate energy expenditure and oxidation of fat and helps in lowering the body weight (Supriya *et al*., 2012). In this study, unsaturated fatty acids such as myristoleic acid, hexadecatrienoic acid, gamma-linolenic acid, and eicosatetraenoic acid were detected only in tree peony flower buds, whereas isomer of linolenic acid (C18:3n4), dihomo-gamma-linolenic acid, eicosapentaenoic acid and cetoleic acid were detected only in apple flower. Among the unsaturated fatty acids, the dominant components present in both the flowers were the polyunsaturated linoleic acid, which is an essential component of cell membrane in human. However, no significant difference were recorded between the amount of linoleic acid in tree peony (38.54% of total unsaturated fatty acids) and in apple flower (34.77% of total unsaturated fatty acids). The polyunsaturated fatty acids (PUFA's) such as alpha-linolenic acid (omega-3) and gamma-linolenic acid (omega-6) are highly essential as they are able to impart protection against various diseases such as hypertension, heart diseases, inflammation and auto-immune disorders (Benatti *et al*., 2004). The monounsaturated fatty acid (MUFA's) such as oleic acid can lower total cholesterol level as well as raise levels of high-density lipoproteins. MUFA's can also slow down the progression of heart disease, reduce blood pressure and help in increasing the production of antioxidants (Win, 2005; Terés *et al*., 2008).

Table 4 depicts the results obtained for minerals and heavy metals detected in the flower buds of tree peony and apple flower. Tree peony and apple flower were rich in essential minerals such as potassium (1540.37 and 1125.60 mg/100 g), calcium (462.46 and 449.98 mg/100 g), magnesium (241.51 and 164.23 mg/100 g), sodium (12.75 and 20.06 mg/100 g), and phosphorus (420.00 and 590.00 mg/100 g). The trace elements (selenium, chromium, copper, iron, manganese, zinc, aluminium, and boron) were present in low quantity (< 15 mg/100 g). Among the analyzed minerals, the content of potassium was found to be highest in both the flowers, indicating potassium to be main constituent. Between tree peony and apple flower, tree peony had significantly higher content of potassium and magnesium, while apple flower had significantly higher content of sodium, phosphorus, copper, iron, and manganese. The appreciable amount of essential minerals indicates that the flowers are able to meet the daily dietary requirements of essential minerals, which is >50 mg/day (Belitz *et al.*, 2009). Potassium, calcium, magnesium, and phosphorus form an integral part of the building blocks of structural components in humans and are vital for intracellular and extracellular functions of the body. The presence of the high amounts of potassium in the flower buds might be beneficial against hypertension and excessive excretion of potassium through the body fluid. Besides, minerals like magnesium and zinc have functions in preventing various diseases such as dermatitis, muscle degeneration, cardiomyopathy, congenital malformations, growth retardation, gonadal atrophy, impaired spermatogenesis, and bleeding disorders. Trace elements such as iron and selenium, though were present in threshold levels, can also act as potential antioxidants and strengthen the immune system (Bhat and Sridhar, 2008; Bhat *et al*., 2010). Results of the present study are comparable to the previous report on medicinal plants (Bhat *et al.* ,2010) wherein potassium, calcium, and magnesium were found to be in appreciable amounts.

In the present study, in both the flowers, all the analyzed heavy metals (cadmium, nickel, mercury, lead, and arsenic) were found in trace concentrations (< 0.50 mg/100 g) which were under recommended limits for heavy metals in herbal drug (Blagojević *et al.*, 2009). Thus, these flowers or their preparations can be considered safe for human consumption and feasible to be used in food and pharmaceutical applications. Low concentration of heavy metals in the flowers might be attributed to the growing environments such as unpolluted soil from heavy metals or where minimum agrochemicals have been used.

Table 4. Minerals and heavy metal contents of tree peony and apple flower buds (n = 3 ± SD)

Element	Amount (mg/100g)	
	Tree peony	Apple flower
Mineral		
Potassium	$1540.37 \pm 0.66_a$	$1125.60 \pm 5.93_b$
Calcium	$462.46 \pm 0.16_a$	$449.98 \pm 9.46_a$
Magnesium	$241.51 \pm 0.57_a$	$164.23 \pm 5.43_b$
Sodium	$12.75 \pm 0.08_a$	$20.06 \pm 1.06_b$
Phosphorus	$420.00 \pm 3.41_a$	$590.00 \pm 18.67_b$
Selenium	< 0.25	< 0.25
Chromium	< 0.25	< 0.25
Copper	$1.73 \pm 0.06_a$	$2.99 \pm 0.17_b$
Iron	$5.01 \pm 0.08_a$	$10.37 \pm 0.30_b$
Manganese	$2.29 \pm 0.10_a$	$5.12 \pm 0.07_b$
Zinc	$4.09 \pm 0.11_a$	$4.56 \pm 0.40_a$
Aluminium	$1.86 \pm 0.04_a$	$2.35 \pm 0.18_a$
Boron	< 0.10	< 0.10
Heavy metal		
Cadmium	< 0.05	< 0.05
Nickel	< 0.50	< 0.50
Mercury	< 0.05	< 0.05
Lead	<0.50	<0.50
Arsenic	< 0.05	< 0.05

Mean values in same row followed by same letters are not significantly different from each other (p>0.05) based on the one-way ANOVA

Conclusions

The presence of significant amount of crude fibre, carbohydrate, proteins, essential amino acids, fatty acids and essential minerals provides a strong base to use tree peony and apple flower buds. Accordingly, the flowers can find wide applications and be a potential source of ingredient for food and pharmaceutical applications.

Acknowledgements

First author thanks Institute of Postgraduate Studies, Universiti Sains Malaysia for the fellowship provided. Individual research funds provided as RU grants (No. 1001/PTEKIND/814139, USM) for the corresponding author is also gratefully acknowledged.

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