

Determination of metal, non-metal and heavy metal contents of some tropical fruits growing in Indonesia

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RESEARCH ARTICLE

Abstract

The importance of the current study was to determine the mineral and heavy metal contents of several tropical fruits provided from Indonesia. Mineral contents of some tropical fruits were determined by inductively coupled plasma-atomic emission spectrometry. As macro element, Ca contents of fruits were found between 167 mg/kg (Pir) and 1,051 mg/kg (Jambu). In addition, K contents of fruits ranged from 5,803 mg/kg (Manggis) to 17,659 mg/kg (Dragori). P contents ranged from 491 mg/kg (Sukun) to 3158 mg/kg (Dragori) ($P < 0.05$). As micro element, Fe content varied between 24.7 mg/kg (Pir) and 54.1 mg/kg (Dragori). In addition, while Mn contents of fruits change between 2.3 mg/kg (Sukun) and 33.2 mg/kg (Starfruit), Zn content varied from 2.9 mg/kg (Sukun) to 37.5 mg/kg (Dragori) ($P < 0.05$). As heavy metal, Cd, Cr, Mo and Ni contents of fruits were found at low levels.

Keywords: tropical fruits, minerals, heavy metal, ash, ICP-AES

1. Introduction

Heavy metal pollution is a serious problem in areas around metal smelters (Stihi *et al.*, 2011). The effect of environmental pollution on contamination of foods was a serious global public issue, and this issue is addressed widely (Ahmed *et al.*, 2000; Alergeria *et al.*, 1990; Moffat and Whittle, 1999). Fruits are sources of minerals, fibre and vitamins which provide nutrients for the human health (Aberoumand and Deokule, 2009). While tropical fruits are widely grown in Malaysia, India, Indonesia, Sri Lanka, China and Thailand, Indonesia has a rich diversity of tropical fruits including common, ornamental, wild fruits and highland fruits. A few of indigenous fruits are considered underutilised. Underutilised fruits are rich in minerals (Voon and Kueh, 1999). Some of the underutilised fruits are planted for local consumption and some of these fruits are grown under wild conditions (Khoo *et al.*, 2010; Subhadrabandhu, 2001), and started to gain popularity for consumption in tropical countries (Ikram *et al.*, 2009; Khoo *et al.*, 2010). Nowadays a variety of tropical fruits are essential components for different diets in Europe and

North America (Kondo *et al.*, 2005; Yuka *et al.*, 2003). Edem *et al.* (2011) investigated the proximate composition (66.67% moisture, 78.34% carbohydrate, 5.66% protein, 4.50% fibre, 9.83% fat, 2.12% ash and 420.42 kcal total energy value), ascorbic acid content (19.68%) and anti-nutrient composition (4.95 mg oxalate, 3.66% saponins, 0.17% cyanogenic glycoside, 0.02% phylate and 0.03% tannins) of *Chrysophyllum africanum* fruits.

The consumption of new exotic fruits has significantly increased (Corral-Aguayo *et al.*, 2008; Haruenkit *et al.*, 2007; Luximon-Ramma *et al.*, 2003). It was shown that durian possess high nutritional and bioactive properties (Haruenkit *et al.*, 2007; Poovarodom *et al.*, 2010).

The aim of the current study was to determine mineral and heavy metal contents of several tropical fruits provided from Indonesia.

2. Materials and methods

Materials

Ripened fruit samples (Manggis (*Garcinia mangostana* L.), Sukun (*Artocarpus altilis*), Srikaya (*Annona squamosa*), starfruit (*Averrhoa carambola*), Pir (*Pyrus sinkiangensis*), Dragori fruit (*Hylocereus undatus*), Guava-Jambu (*Psidium guajava* L.), Banana (*Musa balbisiana*), Salak (*Salacca zalacca*), Duku (*Lansium domesticum*)) were provided from Yogyakarta province of Indonesia in April 2013. They were transferred to the laboratory in cool bags. Fruits were washed with clear distilled water. They were kept at +4 °C till use.

Determination of mineral and ash contents

The sampling and sample pre-treatment were carried out. Samples were selected randomly from 100 kg of fruits. They were dried at 70 °C in oven, and then ground, and sieved in 10 mesh diameter. Later, about 0.5 g of dried and ground samples were digested by using 5 ml of 65% HNO₃ and 2 ml of 35% H₂O₂ in a closed microwave system (Cem-MARS Xpress, Matthews, NC, USA). The volumes of the digested samples were completed to 20 ml with ultra-deionised water, and mineral contents were determined by inductively coupled plasma atomic-emission spectrometry (ICP-AES; Varian-Vista, Belrose, Australia). Measurements of mineral concentrations were checked using the certified values of related minerals in the reference samples received from the National Institute of Standards and Technology (NIST, Gaithersburg, MD, USA) (Skujins, 1998). Crude ash values of fruit samples were determined according to the Association of Official Analytical Chemists (AOAC, 2000).

Working conditions of ICP-AES

In this study, ICP-AES was used. Its radio frequency power changes between 0.7 and 1.5 kW (1.2-1.3 kW for axial). In addition, plasma gas flow rate (Ar) ranged from 10.5 to 15 l/min. Auxiliary gas flow rate (Ar) is 1.5 l/min. Viewing height is between 5 and 12 mm. Copy and reading time change between 1 and 5 s (max. 60 s).

Statistical analyses

Results of the research were analysed for statistical significance by analysis of variance (Püskülcü and İkiz, 1989).

3. Results and discussion

The mineral content of tropical fruits is given in Table 1. Calcium contents of fruits were found between 167 mg/kg (Pir) and 1,051 mg/kg (Jambu). In addition, potassium contents of fruits ranged from 5,803 mg/kg (Manggis) to 17,659 mg/kg (Dragori). While magnesium content of samples changed between 669 mg/kg (Sukun) and 2,854 mg/kg (Dragori), phosphor contents ranged from 491 mg/kg (Sukun) to 3,158 mg/kg (Dragori). S contents of fruits were found between 305 mg/kg (Sukun) and 1,687 mg/kg (Dragori). K, Mg, P and S contents of Dragori fruit were found on the highest level comparing with other fruits, followed by Duku, Guava-Jambu, Starfruit, Srikaya, and Manggis.

Metal and non-metal contents of fruits are shown in Table 2. B contents of fruits changed between 5.4 mg/kg (Duku) and 29.5 mg/kg (Pir). While Cu content of fruits changed from 1.2 mg/kg (Sukun) to 6.9 mg/kg (Pir), iron

Table 1. Macro element concentrations (mg/kg; dry matter) in tropical fruits (data are presented as means ± standard deviation, n=3 replicates).¹

Samples	Ca	K	Mg	P	S
Manggis	710±17 ^a	5,803±600 ^b	1,173±120 ^{bc}	642±49 ^{bc}	624±9 ^c
Sukun	478±39 ^b	9,497±620 ^b	669±41 ^c	491±60 ^{bc}	305±23 ^c
Srikaya	326±16 ^b	8,562±156 ^{cd}	1,230±72 ^b	1,531±86 ^{ab}	555±28 ^c
Starfruit	326±17 ^b	13,424±149 ^{cd}	1,310±93 ^b	1,033±93 ^b	1,057±51 ^a
Pir	167±13 ^c	10,596±234 ^b	934±31 ^{bc}	734±51 ^b	341±20 ^c
Dragori	437±33 ^b	17,659±534 ^b	2,854±12 ^a	3,158±93 ^a	1,687±93 ^a
Jambu	1,051±125 ^a	11,550±451 ^{bc}	1,383±100 ^b	1,407±27 ^b	1,087±59 ^a
Banana	254±19 ^b	11,261±796 ^a	1,491±106 ^b	778±108 ^b	434±35 ^c
Salak	359±25 ^b	11,312±722 ^a	976±12 ^{bc}	1,057±120 ^b	481±19 ^c
Duku	936±20 ^a	14,480±371 ^c	1,620±45 ^{ab}	2,595±92 ^a	807±57 ^c
Minimum	167	5,803	669	491	305
Maximum	1,051	17,659	2,854	3,158	1,687
Mean	504	11,415	1,364	1,343	738

¹ Means in the same column with the same letters are not significantly different ($P < 0.05$).

Table 2. Heavy metal and micro element concentrations (mg/kg; dry matter) (data are presented as means \pm standard deviation, n=3 replicates).

Samples	B	Cd	Cr	Cu	Fe	Mn	Mo	Ni	Zn
Manggis	8.6 \pm 0.6	0.110 \pm 0.015	0.452 \pm 0.008	3.5 \pm 0.5	26.0 \pm 1.0	8.9 \pm 1.4	0.182 \pm 0.012	0.425 \pm 0.003	8.9 \pm 1.6
Sukun	5.7 \pm 0.6	0.051 \pm 0.008	0.497 \pm 0.099	1.2 \pm 0.1	29.2 \pm 0.3	2.3 \pm 0.1	0.426 \pm 0.003	0.484 \pm 0.084	2.9 \pm 0.2
Srikaya	7.3 \pm 0.3	0.066 \pm 0.017	0.446 \pm 0.019	2.5 \pm 0.5	26.4 \pm 0.6	3.5 \pm 0.1	0.178 \pm 0.014	0.555 \pm 0.067	4.2 \pm 0.2
Starfruit	6.6 \pm 0.1	0.139 \pm 0.010	0.503 \pm 0.005	6.4 \pm 0.5	39.8 \pm 0.2	33.2 \pm 2.8	0.370 \pm 0.008	2.083 \pm 0.148	27.2 \pm 0.6
Pir	29.5 \pm 1.3	0.052 \pm 0.019	0.415 \pm 0.005	6.9 \pm 0.2	24.7 \pm 0.8	3.8 \pm 0.1	0.242 \pm 0.019	0.774 \pm 0.012	4.4 \pm 0.1
Dragori	8.2 \pm 0.0	0.124 \pm 0.019	0.640 \pm 0.022	5.7 \pm 0.6	54.1 \pm 0.9	28.7 \pm 1.3	0.499 \pm 0.026	2.749 \pm 0.099	37.5 \pm 2.2
Jambu	8.7 \pm 0.8	0.066 \pm 0.009	0.678 \pm 0.093	6.3 \pm 0.2	46.1 \pm 2.6	16.8 \pm 1.1	0.170 \pm 0.013	1.006 \pm 0.121	13.0 \pm 0.0
Banana	7.6 \pm 0.0	0.085 \pm 0.004	0.514 \pm 0.044	4.9 \pm 0.7	35.3 \pm 2.7	3.3 \pm 0.2	0.534 \pm 0.114	0.469 \pm 0.062	9.9 \pm 1.2
Salak	6.3 \pm 0.3	0.089 \pm 0.003	0.502 \pm 0.034	6.3 \pm 0.1	30.8 \pm 0.3	3.6 \pm 0.2	0.178 \pm 0.025	1.391 \pm 0.006	11.9 \pm 0.3
Duku	5.4 \pm 0.2	0.081 \pm 0.004	0.516 \pm 0.025	5.8 \pm 0.2	49.8 \pm 1.8	12.2 \pm 0.7	0.282 \pm 0.039	0.725 \pm 0.028	18.1 \pm 0.4
Minimum	5.4	0.051	0.415	1.2	24.7	2.3	0.170	0.425	2.9
Maximum	29.5	0.139	0.678	6.9	54.1	33.2	0.534	2.749	37.5
Mean	9.4	0.086	0.516	5.0	36.2	11.6	0.306	1.066	13.8

content varied between 24.7 mg/kg (Pir) and 54.1 mg/kg (Dragori) ($P < 0.05$). In addition, while Mn contents of fruits changed from 2.3 mg/kg (Sukun) to 33.2 mg/kg (Starfruit), zinc content varied from 2.9 mg/kg (Sukun) to 37.5 mg/kg (Dragori). Cd, Cr, Mo, and Ni contents of fruits were found at the lowest levels. The highest B and Cu contents were found in Pir fruit. In addition, while the highest Fe and Zn contents were determined in Dragori fruit, the highest Mn contents was determined in Starfruit (33.2 mg/kg) ($P < 0.05$). The ash contents of fruits ranged from 1.6% to 11.1% (Table 3). The highest ash was found in Pir fruit (11.2%), followed by Dragori (6.0%), starfruit (5.5%), banana (4.9%), duku (4.5%), and Guava-Jambu (3.2%) ($P < 0.05$).

Table 3. Ash contents (%) of fruits (mean \pm standard deviation).

Samples	Ash ¹
Manggis	1.6 \pm 0.4 ^c
Sukun	2.9 \pm 0.8 ^c
Srikaya	2.3 \pm 0.7 ^c
Starfruit	5.5 \pm 0.9 ^{bc}
Pir	11.1 \pm 1.3 ^a
Dragori	6.0 \pm 0.9 ^{bc}
Jambu	3.2 \pm 0.5 ^c
Banana	4.9 \pm 0.7 ^{bc}
Salak	3.1 \pm 0.3 ^c
Duku	4.5 \pm 0.8 ^{bc}
Minimum	1.6
Maximum	11.1
Mean	4.5

¹ Means with the same letter are not significantly different ($P < 0.05$).

Payal *et al.* (2012) reported that starfruit (*A. carambola*) contained 15.5-20.0 mg/100 g P, 7.0 mg/100 g Ca, 0.4 mg/100g Fe, and 0.4 g/100 g ash. Pineapple juice contained 0.538 mg/100 ml Zn, 0.060 mg/100 ml As, 0.748 mg/100 ml Fe, 12.004 mg/100 ml Mg, 0.898 mg/100 ml Na, 9.250 mg/100 ml P, 128.076 mg/100 ml K, and 0.890 mg/100 ml Al (Sairi *et al.*, 2004). The results showed that the pineapple (*Ananas comosus* L.) fruit contained 0.20% ash, 37.34 mg/100 g fresh weight (fw) Ca, 92.75 mg/100 g fw Mg, 4.24 mg/100 g fw Na, 0.23 mg/100 g fw Cu, 3.12 mg/100 g fw Fe, 5.70 mg/100 g fw Mn, and 0.32 mg/100 g fw Zn (Othman, 2011). Haruenkit *et al.* (2007) reported that durian and snake fruits contained 2.1 and 1.9 mg/100 g fw, 201.2 and 191.2 mg/100 g fw K, 11.23 and 7.16 mg/100 g fw Mg, 18.32 and 6.11 mg/100 g fw Ca, 991 and 301.7 mg/100 g fw Fe, 145.2 and 249.9 mg/100 g fw Mn, 32.3 and 35.1 mg/100 g fw Zn and 24.1 and 8.4 mg/100 g fw Cu. Durian kuning (*Durio graveolens*) and Durian nyekkek (*Durio kutejensis*) contained 1.0% and 1.6% ash, 43 and 25 mg/100 g P, 529 and 362 mg/100 g K, 10 and 19 mg/100 g Ca, 27 and 19 mg/100 g Mg, 0.6 and 0.7 mg/100 g Fe, 4 and 5 mg/100 g Mn, 7.0 and 3.2 mg/100 g Cu and 5.9 and 7.3 mg/100 g Zn, respectively. Apples, guava and pineapple contained 0.3, 0.7 and 0.4% ash, 16, 15 and 6 mg/100 g P, 1.2, 1.2 and 1.4 mg/100 g Fe (Voon and Kueh, 1999). The pineapples contained 33.2 mg/kg Mn, a level higher than the values (0.02-0.39 mg/100g fw) reported for fruits by Ellen *et al.* (1990), value 85.70 mg/100 g dry weight) reported for fruits (Othman, 2011) and values (0.08-0.2 mg/100 g fw) reported for Galician fruits by Romero-Rodriguez *et al.* (1994). The iron level (mean 36.2 mg/kg) was higher than the iron level (0.07-0.37 mg/100 g fw) reported by Hunt *et al.* (1991) and the level (0.3-0.6 mg/100 g fw) reported by Romero-Rodriguez *et al.* (1994) for Galician fruits. There were significant differences in mineral contents of fruit species ($P < 0.05$). Harmanescu *et*

al. (2005) reported that orange, grapefruit, apricot, peach, pear and orange juice known as popular fruits contained between 42 and 82 mg/l Na, 8 and 1,440 mg/l K and 4 and 48 mg/l Mg. The same variation was observed for our results. In comparison with literature, it may be different values for almost all element parameters. Differences among the values of fruit element contents can be probably due to growing, climatic, environmental conditions, locations and analytical conditions. The important of current study is to determine mineral and heavy metal contents of several tropical fruits provided from Indonesia.

4. Conclusions

The highest levels of K, Mg, P, and S contents of fruits were found in Dragori that is followed by Duku, Guava-Jambu, starfruit, Srikaya, and Manggis. Similar fruits can be used as supplement for good personal health. The ash contents of fruits ranged from 1.6 to 11.1%. Due to high ash contents, these fruits contain high comparable quantities of basic macro and micro elements.

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