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Chemical and Nutritional Composition of *Coleus tuberosus* (Ubi Kemili) Tubers from Malaysia: Preliminary Studies

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ABSTRACT

Coleus tuberosus is a tuber vegetable of the *Lamiceae* family, consisting of about 200 different species which include ornamental, medicinal plants and plants with edible tubers. This paper reports the chemical and nutritional composition of coleus potato. This study focused on the two parts of the tubers; peel and flesh. The flesh analyses resulted in 4.13% moisture, 5.73 g crude protein, 0.20 g fat, 85.67 g total carbohydrates, 4.27 g ash, minerals (potassium 1136.08 mg, calcium 16.06 mg, and magnesium 74.23 mg, iron 1.33 mg) and β-carotene 54.07 µg/100 g of dry weight. While the peel analyses resulted in 8.27% moisture, 8.73 g crude protein, 0.37 g fat, 68.60 g total carbohydrates, 14.03 g ash, minerals (potassium 3025.75, calcium 257.47 mg, and magnesium 70.03 mg, iron 49.76 mg/100 g dw) and β-carotene 661.87 µg/100 g dw. Amino acids and sugar contents were analyzed and indentified in both of flesh and peel of coleus potato. In general, coleus potato could be considered as one of the good sources of minerals especially (potassium, calcium, magnesium and iron) and β-carotene. To the best of our knowledge, this is the first study reporting the chemical composition of *C. tuberosus*. The data obtained will present the important indication of the potentially nutraceutical of coleus potato as one of the cheaper sources of nutrients.

Keywords: Coleus potato, chemical composition, nutraceutical, Malaysia
Abbreviations: ODS, ultrasphere octadecylsilyl; **UKF**, Ubi Kemili flesh; **UKP**, Ubi Kemili peel

INTRODUCTION

The world's population is expected to increase and as a consequence the demand on food also increases. Thus, the food production needs to be increased to support the population. World population increases from 6 billion at the start of this century to 7.9 to 19.9 billion by 2025. The majority of this increase will occur in less economical developed countries (Garza and Stover 2003). Over the last few decades, food insecurity and number of people suffering from malnutrition have increased. Throughout history humans have used some 3,000 plant species for food. The recent tendency has been to exploit fewer species and today, only around 20 species supply most of the world's food. Many beneficial plant species have been underused (Vietmeyer 1986). One of the ways to overcome these problems is by searching for the cheaper sources of nutrients. This can be obtained from plant materials especially underutilized crops like root and tuberous plants.

Tuberous plants are plants that have swollen region of an underground stem or root, usually modified for storing food. One of them is *Coleus tuberosus* which is also known as Chinese potato or coleus potato in English and Koorka in Hindi. In Malaysia, coleus potato is known as Ubi Kemili and belongs to *Labiatae* family, consisting of about 200 different species which include ornamental, medicinal plants and plants with edible tubers (Peter 2006; Palaniswami and Peter 2008). This plant is distributed in tropics, subtropics of Asia, Africa and the Pacific Islands. It is a small herbaceous plant, 15-30 cm high, prostrate or ascending, with a succulent stem. The leaves have an aromatic smell resembled mint. It has small pale violet flowers and small, dark brown tubers produced in clusters. Apart from that, it contains two types of bioactive compounds known as saponins (2-20%) and alkaloids (15-25%) which exhibits the medicinal properties of this plant (Palaniswami and Peter 2008). *C. tuberosus* is used as vegetable that have a special flavor and taste. In Malaysia, the tubers are used as replacement for potato in Malay curry or 'Gulai Lemak'. It is usually used in preparation of special dishes during wedding ceremony, especially in Johor, southern state of Malaysia.

Tuber crops make an important contribution to the diet of many impoverished people in tropical countries assuring their food security. This kind of crops usually neglected due to their negative image as poor people's food. It can be consumed as a cheap source of dietary energy either as a basic source or as a supplement to cereals (Palaniswami and Peter 2008).

Previous work on coleus potato has focused on general proximate composition of fresh coleus tuber which contains 20.1-30% dry matter, 14.7-20.8% starch, 0.04-0.31% protein and 0.57-0.96% sugar. The tuber contains (per 100 g dry weight: carbohydrate 91%, protein 1.4%, fat 1%, ascorbic acid 4.8 µg, calcium 60.4 mg, iron 7.2 mg an energy 392 kcal (Rajmohan 2007). Sandhya and Vijayalakshmi (2001) investigated the antioxidant activity of total flavonoid extracted from coleus potato which showed higher antioxidant activities in experimental rats and animals. In other study, ursolic acid and oleanolic acid that presence in *C. tuberosus* may be partially responsible for the antioxidant and cancer chemopreventative agent of *C. tuerosus* (Nugraheni *et al*. 2011).

In this work we are reporting, for the first time, the chemical composition of *C. tuberosus*. The data obtained will present the important indication of the potentially nutraceutical of coleus potato as one of the cheaper sources of nutrients.

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Research Note

MATERIALS AND METHODS

Biological material

C. tuberosus purchased from the local market situated in Ayer Hitam, Johor, southern state of Malaysia at commercial maturity. Tuber samples were identified by the herbarium of the Institute of Bioscience, Universiti Putra Malaysia (UPM). All tuber samples were washed with tap water to remove the soil particle and dirt and air-dried. Dried tubers were divided into two parts: peel and flesh. Peel (±1 mm) of *C. tuberosus* obtained by peeling using a potato peeler. The flesh of each tuber was sliced into pieces and both the peel and sliced flesh were further dried at 50°C/2 days (Ventilated Memmert Oven, Memmert Gmbh + Co. KG, Germany) to a constant weight and stored at 4°C in an air-tight container prior to experiment.

Chemicals

All chemicals and reagents used were of analytical grade and obtained from Sigma Aldrich, Merck, Fisher Scientific and Pronadisa. The solvents used were of high-performance liquid chromatography (HPLC) grade. All of the sugars, amino acids, minerals and vitamins standards were bought from Sigma Aldrich.

Chemical analysis

The proximate composition (moisture, ash, crude fiber, crude protein "N × 6.25") of *C. tuberosus* peel and flesh was determined according to the methods described in AOAC (1997). Crude fat content was determined by adopting the method proposed by Pearson (1970). Carbohydrate content was calculated by difference as suggested by Pomeranz and Meloan (1987).

Calcium (Ca), potassium (K), magnesium (Mg), sodium (Na) and iron (Fe) were detected and quantified by Agilent 7500A ICP-MS (California, USA). Firstly, 0.5 g of the sample was digested in 5 mL of nitric acid or perchloric acid. Then, the sample was diluted to 40 mL with deionized water prior to detection (Cheng *et al*. 2008). Total phosphorus was quantified using a colorimetric method, phosphovanado-molybdate method (AOAC 1997).

β-Carotene was extracted according to the combination of methods suggested by Tee *et al*. (1996), Ismail and Cheah (2003) and Fikselová *et al*. (2008) with some modifications. Firstly, 10 g of sample was homogenized by using a Teflon homogenizer in the presence of 40 mL of 99.8% ethanol and 10 mL of 100% potassium hydroxide for about 5 min. Then, the homogenate obtained was saponified for about 30 min before cooled to room temperature. After that, it was transferred into separation funnel for extraction of the Vitamin A. 50 mL of *n*-hexane was added to the homogenate. The separation funnel was inverted and shaken vigorously for a few moments before the layers were allowed to separate. The aqueous layer was collected and re-extracted a few times using 50 mL of *n*-hexane each time. The upper layer was then pooled together and washed a few times until it was free from alkali. In order to make sure that it was free from alkali, 1% phenolphthalein solution was used as indicator. This reagent will turn from blue to pink color in the presence of alkali. After removing all the alkali, the solution was filtered through anhydrous sodium sulphate to remove water residue. Then, by using rotary evaporator at 45°C under reduced pressure, the hexane was removed. The extract obtained was then diluted to 10 mL with *n*-hexane and filtered through a 0.20 µm nylon membrane filter (Sigma-Aldrich, Kuala Lumpur, Malaysia). Further analysis was carried out by using reverse-phase HPLC. A Waters 600 HPLC equipped with Waters 410 Diode Array Detector and Waters 600 Controller pump was used. Separation and quantification were achieved on Ultrasphere octadecylsilyl (ODS) Hypersil C-18 column, (250 mm × 4.0 mm, 5 µm). The mobile phase was acetonitrile (85%): tetrahydrofuran (12.5%): deionized water (2.5%) and the flow rate was 0.3 mL/min.

Thiamine was extracted from the sample with diluted sulphuric acid in an autoclave and oxidized with cyanogen's bromide to thiochrome, which is extracted with isobutanol. The fluorescence of thiochrome was determined by HPLC on a 5 µm HyPurity Aquastar C-18 column (150 mm × 4.6 mm) with fluorimetric detection, as described by Vuilleumier *et al*. (1988). Riboflavin was extracted from the sample in an autoclave with diluted sulphuric acid. The extract was diluted in methanol and any precipitate was removed by centrifugation. The riboflavin content was determined by HPLC on a 5 µm HyPurity Aquastar (150 mm × 4.6 mm) column (C-18) with fluorimetric detection, according to Schüep and Steiner (1988).

Ascorbic acid was determined by using method proposed by Singh *et al*. (2007). A 10 g of sample was homogenized by using a Teflon homogenizer at the maximum speed in the presence of 100 mL of 1% *m*-phosphoric acid. Then, the homogenate was brought to 250 mL volume by adding 1% *m*-phosphoric acid prior to filtration with Whatman filter paper. About one milliliter of filtrate was added to 1.0 mL of 5% dithiothreitol before the volume was made up to 10 mL with 1% *m*-phosphoric acid. All of the standards and sample solution were filtered by using 0.20 µm nylon membrane filter before injection. Samples of 10 µL were injected on a reversed phase C-18 column (150 × 4.60 mm, 5 mm) and detected by using Shimadzu SPD-10AV, UV-Visible detectors set at 261 nm. The mobile phase consisted of acetonitrile: 0.05 M KH_2PO_4 (pH 5.9) in the ratio of 75: 25 with a flow rate of 1.5 mL/min. Ascorbic acid was quantified by comparison of areas to those of authentic standards, including the reference standard. The ascorbic acid value was expressed as mg/100 g.

Amino acid determination was carried out after acid hydrolysis with 10 mL of 6 M HCl at 110°C overnight under nitrogen atmosphere. After that, the hydrolyzate was cooled and dried in vacuum desiccators at 45°C. Then, it was redissolved in citrate buffer (pH 2.2). All of the standards and samples were injected directly to the automatic amino acid analyzer (LC 5001) from Germany (Cheng *et al*. 2008). The detection and quantification of amino acid in the sample was achieved by comparing the retention times of the peaks with the standards. Amino acid was reported as gram of amino acid per 100 mg of protein.

Monosaccharides and disaccharides in samples were analyzed by using the AOAC method (984.17) (1997). All samples and standard were prepared in 1% (w/v) solution and filtered through 0.45 µm membrane filter (Milipore). The detection of monosaccharide and disaccharide was performed on high performance liquid chromatography (HPLC) by Waters 600 equipped with Waters 410 Differential Refractometer and Waters 600 Controller pump. Separation and quantification were achieved on SUPELCOSIL™ LC-NH_2 column (2.5 mm × 4.6 mm, 5 µm). The mobile phase was acetonitrile: water (78: 22, v/v) and the flow rate was 1.0 mL/min. The concentration of sugar in the sample was calculated by comparison with peak area of the standard curve of the respective sugar.

Statistical analysis

All analyses were conducted in triplicate. Significant differences between means of experiments were determined by the least significant difference. A significance level of 0.05 was chosen (Sokal and Rohlf 1987).

RESULTS

Proximate composition and energy content

Proximate composition of pell and flesh samples is given in **Table 1**. Water content for Ubi Kemili flesh (UKF) is 4.13% while for Ubi Kemili peel (UKP) it is 8.27%. The protein content found in the peel part was 8.73 g/100 g of dw while the flesh part contained only 5.73 g of protein /100 g dw. The protein content in the peel and flesh of the Ubi Kemili tubers showed the significantly differences between the two parts as stated in **Table 1**. The crude fat content in peel 0.37 g/100 g dw while the flesh part contained 0.20 g/100 g dw. The fat content also showed significant variation between peel part and flesh part. Ash content in peel of Ubi Kemili was found to be significantly higher as compared to the flesh part with 14.03 g/100 g dw. The average energy values of UKP and UKF were 1159, 1448 Kj or (276, 345 kcal)/100 g dw, respectively.

Table 1 Proximate composition and energy content for 100 g dry weight (dw) of flesh and peel of Coleus tuberosus[a,b]

Sample	Moisture content %	g/100 g dw				Energy/100 g dw	
		Protein[c]	Fat	Ash	Crude fiber	kJ	kcal
Ubi Kemili flesh	4.13 ± 0.06 b	5.73 ± 0.06 b	0.20 ± 0.00 b	4.27 ± 0.15 b	0.60 ± 0.00 b	1448 a	345 a
Ubi Kemili peel	8.27 ± 0.12 a	8.73 ± 0.12 a	0.37 ± 0.06 a	14.03 ± 0.06 a	12.13 ± 0.06 a	1159 b	276 b

[a] Average, standard deviation of triplicate samples
[b] In columns, averages followed by different letters are significantly different ($p \leq 0.05$)
[c] Calculated as (N×6.25) according to AOAC (1997)

Table 2 Mineral content for 100 g dry weight (dw) of flesh and peel parts of Coleus tuberosus[a,b].

Minerals	Ubi Kemili flesh mg/100 g	Ubi Kemili peel mg/100g	DRIs [c] for adults (mg/day)	Value in 100 g consumed Ubi Kemili / DRIs × 100	
				flesh	peel
Major					
Potassium	1136.08 ± 0.00 b	3025.75 ± 0.00 a	4700	24.17	64.38
Phosphorus	0.32 ± 0.00 a	0.01 ± 0.00 b	700	0.05	0.001
Calcium	16.06 ± 0.00 b	257.47 ± 0.00 a	1000	1.60	25.75
Sodium	12.33 ± 0.00 b	15.02 ± 0.00 a	1500	0.82	1.00
Magnesium	74.23 ± 0.00 a	70.03 ± 0.00 b	Men: 400	18.55	17.51
			Women: 310	32.94	22.59
Trace					
Iron	1.33 ± 0.00 b	49.76 ± 0.00 a	Men: 8	16.63	622
			Women: 18	7.39	276

[a] Average, standard deviation of triplicate samples
[b] In columns, averages followed by different letters are significantly different ($p \leq 0.05$)
[c] DRIs = Dietary Recommended Intakes for Adults [34]

Sugar composition

The UKP and UKF contained fructose (0.1, 0.2 g/100 g dw) respectively, glucose (3.5, 0.8 g/100 g dw), sucrose (0.1, 0.1 g/100 g dw) and maltose (0.1, 0.1 g/100 g dw). Sugar content was significantly different and varied among different parts of Ubi Kemili.

Vitamins

For β-carotene content in peel (661.87 µg/100 g) is extremely higher than in the content in flesh part (54.07 µg/100 g). Vitamin C was found to be 3.10 mg/100 g in both of parts. Thiamine (Vitamin B1) and riboflavin (Vitamin B2) were almost undetectable by our analytical method.

Minerals

Flesh and peel samples were analyzed for mineral content. **Table 2** indicates a high concentration of potassium (3025.75 mg/100 g) in the peel as compared to the flesh (1136.08 mg/100 g). It was followed by the calcium in the peel (257.47 mg/100 g) and flesh (16.06 mg/100 g), magnesium in the flesh (74.23 mg/100 g) and peel (70.03 mg/100 g), iron in the peel (49;76 mg/100 g) and flesh (1.33 mg/100 g), sodium in the peel part (15.02 mg/100 g) and flesh part (12.33 mg/100 g), and phosphorus in flesh (0.32 mg/100 g) and in peel (0.01 mg/100 g). Results showed that a wide variation was observed in the quantitative composition of mineral in Ubi Kemili from different parts, peel and flesh.

Amino acids

Amino acids were determined and quantified by HPLC and the amino acid chromatogram of both part were shown in **Fig. 1** and **Fig. 2**. Sixteen amino acids were detected in Ubi Kemili including the essential and non-essential amino acids. From **Table 3**, it can be seen that asparagine, arginine and threonine contents for both parts of Ubi Kemili were not significantly different.

Table 3 Amino acid content of flesh and peel parts of *Coleus tuberosus* [a,b].

Amino acid	Ubi Kemili flesh (mg/g of protein)	Ubi Kemili peel (mg/g of protein)
Isoleucine	0.63 ± 0.03 a	0.67 ± 0.00 a
Leucine	0.26 ± 0.00 b	0.39 ± 0.01 a
Lysine	0.63 ± 0.00 b	0.75 ± 0.00 a
Methionine	0.26 ± 0.03 b	0.40 ± 0.01 a
Total sulfur-containing amino acids	1.78	2.21
Tyrosine	0,16 ± 0.01 b	0.19 ± 0.02 a
Phenylalanine	0.37 ± 0.00 b	0.44 ± 0.00 a
Total aromatic amino acids	0.53	0.63
Threonine	0.36 ± 0.02 a	0.34 ± 0.00 a
Valine	0.37 ± 0.00 a	0.44 ± 0.00 a
Total essential amino acids	0.73	0.78
Histidine	0.11 ± 0.00 b	0.15 ± 0.00 a
Arginine	0.27 ± 0.00 a	0.27 ± 0.01 a
Aspartagine	0.63 ± 0.03 a	0.67 ± 0.00 a
Glutamic acid	0.63 ± 0.00 b	0.75 ± 0.00 a
Serine	0.26 ± 0.00 b	0.39 ± 0.01 a
Proline	0.25 ± 0.01 b	0.39 ± 0.01 a
Glysine	0.26 ± 0.03 b	0.40 ± 0.01 a
Alanine	0.27 ± 0.00 b	0.40 ± 0.00 a
Total non-essential amino acids	2.68	3.42

[a] Average, standard deviation of triplicate samples
[b] In columns, averages followed by different letters are significantly different ($p \leq 0.05$)

DISCUSSION

C. tuberosus is tolerant of high temperatures and rain-fall and prefers well-drained, loose or sandy soil and direct sunlight. It produces less well in the shade or in dense soil. In dry conditions, it may fail to produce tubers. The tubers are harvested about four to five months after planting, after the plants have flowered and the aerial parts have died back (Kay 1987). Different moisture contents in the peel and flesh of Ubi Kemili tubers might be influenced by several factors like the age of tuber, types of soil used to cultivate the tubers, soil moisture and climate. Food and Nutrition Board (2005) stated that the Recommended Dietary Allowance of good-quality protein is 0.80 g/kg body weight/day, and the Acceptable Macronutrient Distribution Range for protein is 10-35% of energy for adults. Animal products and plant are the best protein sources for human. Root-tubers like potato and sweet potato play a crucial role as a major non-cereal source of dietary protein worldwide (Davies 1996). It also includes other root-tubers like the Ubi Kemili. Based on the results obtained, peel part has higher protein content compared to the flesh part. This might be due to the different distribution of nitrogen within the tubers which is not homogenous (Woolfe and Poats 1987), being highest in the peel and decreasing in the cortex and rising again towards the pith. Protein nitrogen content was similar in

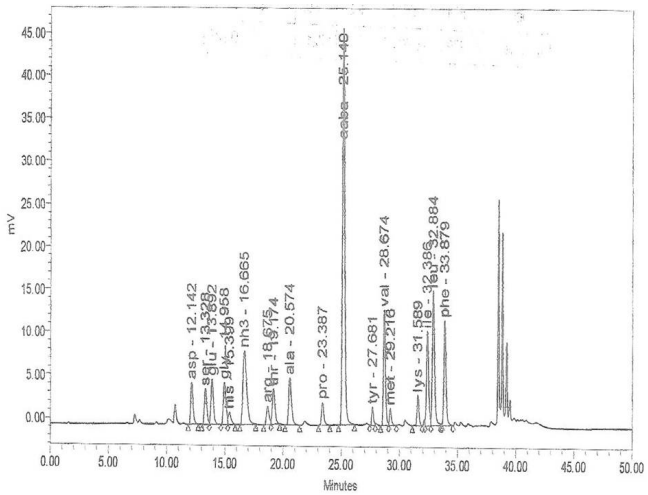

Fig. 1 Amino acid profile of skin part of *Coleus tuberosus*. (From left: asparagine, serine, glutamate, glycine, histidine, arginine, threonine, alanine, proline, tyrosine, valine, methionine, lysine, isoleucine, leucine, phenylalanine)

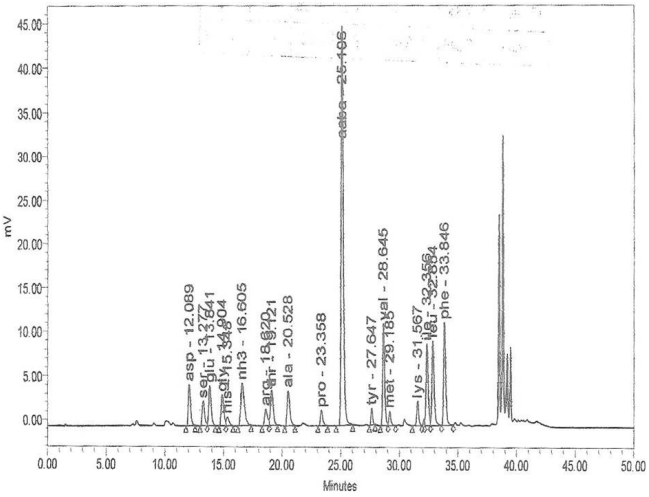

Fig. 2 Amino acid profile of flesh part of *Coleus tuberosus*. (From left: asparagine, serine, glutamate, glycine, histidine, arginine, threonine, alanine, proline, tyrosine, valine, methionine, lysine, isoleucine, leucine, phenylalanine)

cortical, medullary and pith region as reported by Desborough and Weiser (1974). Variations in protein contents in tubers were influenced by the variety difference, climate, location, growing season and also the cultivation process. Vigue (1973) reported that lower temperatures stimulated the increased in total nitrogen percentage of tubers. Results reported by Salunkhe and Kadam (1998) on the fat content of potatoes flesh was approximately 0.1% while Noman *et al*. (2007) reported that lipid content in the flesh of potato and sweet potato was 0.04% and 0.26%, respectively. Therefore, it could be said that the fat content in the flesh of Ubi Kemili is slightly higher than in potato but slightly lower than in sweet potato. However, there is no report on the fat content of the peel of either potato or sweet potato that we could compare with the peel of Ubi Kemili. As tubers are very low in lipids, we could not expect the high sources of lipid soluble vitamins from them. Palaniswami and Peter (2008) reported that most of the root crops contain only negligible amounts of lipid soluble vitamin (beta carotene) except the yellow variety of sweet potato which contains a high amount of beta carotene. Ash content in peel parts of Ubi Kemili was found to be significantly higher as compared to the flesh part with 14.03% amount of ash. The significant differences of the ash content between the peel and flesh of coleus potato might be due to the exposure of the peel parts with the soil that contain high number of organic matter. Carbohydrate content was calculated based on the difference of other constituents – moisture, protein, fat and ash content – from a total of 100%. Carbohydrate in plant foods can be classified as digestible and non-digestible. Digestible carbohydrate includes monosaccharides, disaccharides, oligosaccharides and starch, whereas the nondigestible carbohydrate could be categorized as dietary fiber. Tuber crops contain non-starch polysaccharides which include celluloses, hemicelluloses, pectins and other associated structural proteins and lignins. All of them can be referred as dietary fiber (Palaniswami and Peter 2008). Issues on dietary fiber gained a lot of interest in recent years. Some researchers suggested that increased the consumption of dietary fiber can contributed to a reduction in diseases such as colon cancer, diabetes and other diseases. Fiber acts as a molecular sieve which trapped all carcinogenic materials from recirculated into our body. It also absorbs water, thus producing soft and bulky stools. Apart from that, it has been also reported that fiber polysaccharides affect the absorption of lipids, as they can be strong inhibitors of the pancreatic lipase that participates in the lipid metabolism (Dunaif and Schneeman 1981). On the other hand, dietary fiber contributes to decrease the levels of total cholesterol and low-density lipoproteins in plasma, which is associated to a greater dilution and excretion of bile acids (Gallaher 1992). In contrast to the proposed health benefits, the excessive consumption of dietary fiber may lead to adverse effects such as flatulence, bloating and abdominal discomfort (Bouhnik *et al*. 1999). This has been attributed to the excessive gas production when high doses of fiber are consumed.

The sugar content (fructose and glucose) of peel and flesh parts of coleus potato was higher than those reported by Finotti *et al*. (2006) in potato. Sucrose and maltose amounts in both parts were the lowest (0.10 g/100 g) and it is similar to those reported by Rodriguez-Saona and Wrolstad (1997) in potato.

The beta carotene content in coleus potato is lower than sweet potato reported by USDA (2005). Vitamin C was found to be 3.10 mg/100 g, which is almost 6 times lower than potato and 9 times lower than sweet potato reported by Noman *et al*. (2007).

The mineral content in coleus potato except for sodium and phosphorus, was high compared to the common tubers like potato and sweet potato reported by Noman *et al*. (2007). In general, Ubi Kemili could be considered as one of the good sources of calcium, potassium, magnesium and iron.

Ubi Kemili is rich in amino acids as compared to the other types of tuber like potato (Yang *et al*. 2011) and sweet potato (Yeoh and Truong 1996; USDA 2005).

CONCLUSION

This is the first paper to report the complete analysis of *C. tuberosus* (Ubi Kemili) tubers. Ubi Kemili tubers were interesting tubers in term of their chemical and nutritional composition. Results of this study indicated that the peel of Ubi Kemili has a significantly high level of β-carotene, potassium, magnesium, iron and calcium and amino acids like asparagine, glutamic acid, leucine, valine, and glycine. Moreover, the high crude fiber content in the peel part also can be utilized in order to overcome constipation and increase digestion. Besides, the flesh part also rich in carbohydrates that can supply enough energy for our body. Therefore, it can be hypothesized that Ubi Kemili can be exploited in order to produce new functional foods due to the high nutritional value that it has. All these results and its potential nutraceutical quality could participate in the development of Ubi Kemili as a commercial crop of economical utility. But certain molecules such as antimicrobial molecules and cancer chemoprevention triterpenoids (i.e., oleanolic acid and ursolic acid) of both peel and flesh of *C. tuberosus* still have to be studied.

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