International Food Research Journal 18(4): 1415-1420 (2011)

Evaluation of nutritional quality of torch ginger (*Etlingera elatior* Jack.) inflorescence

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Abstract: The inflorescence of torch ginger (*Etlingera elatior* Jack., Family Zingiberaceae) was analyzed to identify its nutritional and anti-nutritional contents. The inflorescence had significant amount of crude protein (12.6%), fat (18.2%) and fiber content (17.6%). Fatty acid profile was composed with high level of unsaturated fatty acids (palmitoleic acid 16.4%> linoleic acid 14.5% >Oleic acid 5.2%). The amino acid profiles revealed the presence of essential amino acids dominated by leucine and lysine (7.2 and 7.9 mg/100 mg protein, respectively). The inflorescence contained major minerals like: K (1589 mg/100 g), Ca (775 mg/100g), Mg (327 mg/100 g), P (286 mg/10 0g) and S (167 mg/100 g). The levels of antinutrients analyzed were 3496 and 2851 mg/100g for saponin and phytic acid, respectively. The heavy metals analyzed (Cd, As, Pb, Hg, Ni) were below detection limits. Results obtained confirm the usefulness of torch ginger inflorescence as a potential functional food and could be further explored in new food products and formulations.

Keywords: Torch ginger, proximate composition, fatty acid, amino acids, minerals, antinutrients

Introduction

Most of the food components including macro- and micro-nutrients play important role as a nutraceutical, and provides potential health benefits (Bernal *et al*., 2010). Dietary fiber, polyunsaturated fatty acids (PUFA), proteins, amino acids, minerals, vitamins and other bioactive compounds are considered as beneficial nutrient components (Andlauer and Fürst, 2002). Torch ginger (*Etlingera elatior*) is a popular plant in South-East Asia wherein their inflorescences are traditionally used for culinary and medicinal purposes. The inflorescence possesses a unique flavor and aroma and is used in preparing traditional dishes like: Ulam and Asam laksa in Malaysia (Chan *et al.*, 2007; Wijekoon *et al*., 2010). Traditionally, it is believed that daily intake of raw inflorescence can reduce diabetes and hypertension. Also, the inflorescence consumed along with bitter leaves (*Vernonia amygdalina*) is believed to relieve flatulence in postpartum women (Mai *et al*., 2009).

Reports available have shown torch ginger to exhibit rich antioxidant, anticancer and antimicrobial activities (Habsah *et al*., 2005; Chan *et al.*, 2007, 2008; Wijekoon *et al*., 2010; Lachumy *et al*., 2010). However, to our knowledge, no reports are available on the nutritional qualities of torch ginger inflorescence. Hence, the present study is an attempt to fill-in this existing gap by assessing the nutritional composition and antinutrients of torch ginger inflorescence. It is expected that the results generated might further pave way for successful incorporation and utilization of the inflorescence for development of new food products and formulations.

Materials and Methods

Plant material

The inflorescence of torch ginger plant was collected from a local wet market in Penang, Malaysia. The inflorescence used for analysis were fresh, unopened and of equal maturity with uniform colour (light pink) with no injuries or physical defects. Further, the inflorescences were surface cleaned and washed in running tap water to remove adhering debris. After this, samples were freeze dried for 48 h in a freeze dryer (Model 7754511, Labconco Corporation, Kansas City, Missouri) and were ground to fine powder (30 mesh size) using a commercial kitchen blender (Model BL 335, Kenwood, Selangor, Malaysia). The powdered samples were stored at 4°C until further analysis.

Proximal composition

Freeze dried inflorescence samples were analyzed for chemical composition (protein, fat, fiber, ash and NFE) using the AOAC procedure (1990). The crude protein content was estimated by macroKjeldhal method (N x 6.25), while crude fat was determined by Soxhlet method by extracting with petroleum ether. The ash content was determined by incineration at 505 ± 5°C. All the analysis was performed in triplicates and expressed on dry weight basis. Nitrogen free extracts (NFE) was calculated by difference:

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NFE = 100 – [crude protein (%) + crude lipid (%) + crude fiber (%) + ash (%)]

While Gross energy (GE) was calculated as:

GE (kJ/100g) = (protein x 16.7) + (lipid x 37.7) + (carbohydrate x 16.7) (Bhat and Sridhar, 2008).

Fatty acid analysis

Fatty acid methyl esters (FAMEs) were analyzed according to the method outlined by Indarti *et al*. (2005). In brief, 20 mg of the sample was weighed into a clean screw-top glass bottle (10 ml capacity). For this, 4 ml of the freshly prepared mixture of methanol, Con. H_2SO_4 and chloroform (1.7:0.3:2.0 v/v/v) was added. Further, the bottles were tightly closed with Teflon caps and kept inside a heating block at 90°C for 90 min. On cooling, the mixtures were added with 1 ml of distilled water and thoroughly vortexed mixed for 1 min. On separation of the two phases, the lower phase was carefully transferred into another clean tube and dried over anhydrous Na_2SO_4 (to remove moisture for 24 h). From the dried fraction, 0.5 ml was transferred into a vial and added with internal standards (as 1 µl of capric acid, C6: 0) methyl ester which was pre-diluted in chloroform (1:499 v/v).

One micro-liter of this was injected into GC (Automatic system XL of Perkin Elemer) coupled with flame ionization detector (FID) and a fused silica capillary Omega wax 250 column (30 m x 0.25 mm ID, 0.25 µm film thickness; from Supelco, USA). The conditions maintained for the analysis included: initial oven temperature 50°C for 2 min. increased to 220°C at rate of 4°C/ min and held at 220°C for 35 min; injector temperature at 250°C; FID detector temperature at 260°C; Carrier gas-Helium controlled at 103.4 kPa; Hydrogen and compressed air for FID maintained at 275.6 kPa. Identification was based on the retention times of FAMEs with standard components of the methyl ester mixture run on the same conditions as samples.

Amino acid analysis

The method outlined by Bhat *et al*. (2008) and Huda *et al*. (2010) was used to determine amino acids profile in the samples, with slight modifications. In brief, a known weight of the sample (0.1 g each in triplicates) taken in sealed glass tubes were treated with 5 ml of 6 N HCl and incubated in an oven operating at 110°C for 24 h. The aliquots were then added with 0.4 ml of 50 mol/µml AABA (alpha amino buteric acid) as internal standards. Further, the mixture was made upto 100 ml with distilled water and filtered through Whatman filter paper (No.1) followed by filtering (Whatman syringe). The sulphur containing amino acids: methionine and cystine were analyzed separately after oxidizing with chilled performic acid and subsequent hydrolysis following to the aforementioned method for other amino acids. From the hydolysate 10 µl was injected to HPLC (Waters 2475, US) system and run for 50 min.

The essential amino acid (EAA) score was calculated with reference to FAO/WHO reference amino acids (see Table 4) following the equation given below,

$$\text{EAA score} = \frac{\text{mg of EAA in 100 mg test Protein}}{\text{mg EAA in 100 mg FAO/WHO reference pattern}} \times 100$$

Determination of mineral and heavy metals content by Inductively Coupled Plasma Optical Emission Spectrophotometer (ICP-OES)

The method described by Bhat *et al*. (2010) was employed to determine the mineral and heavy metal contents in the samples. Dried samples (1 g each in triplicates) were digested with 70% nitric acid and were allowed to cool prior to making upto 50 ml with deionized water. The diluents were then filtered through Whatman filter paper (No. 4) and used to inject to the ICP-OES. Minerals and heavy metals analysis was performed using Inductively Coupled Plasma Optical Emission Spectrophotometry (ICP-OES, OPTIMA 2100DV, Perkin Elmer, USA). Operating conditions applied with ICP-OES is presented in Table 1.

Table 1. Operating conditions used in ICP-OES

Parameter	Specifications
Rising time	30 seconds
Rinsing pump speed	2.5 ml/min
Transfer time	30 seconds
Stabilization time	30 seconds
Transfer pump speed	2.0 ml/min
Power	1500 W
Normal speed of pump	2 ml/min
Plasma gas flow rate	15 l/min
Shear gas flow rate	25 l/min
Auxiliary flow rate	0.2 l/min
Nebulization flow rate	0.8 l/min

Determination of antinutritional compounds

Phytic acid content was analyzed following the method described by Vaintraub and Lapteva (1988) with slight modifications. Whereas, the method described by Baccou *et al*. (1977) was adapted for determining saponin levels.

Statistical analysis

All the data obtained are reported on dry weight basis and represent the mean of triplicates ± standard deviations (n = 3 ± s.d.) .

Results and Discussion

The results on proximal composition of torch ginger inflorescence is depicted in Table 2. The total moisture content was 89.9% (fresh weight),

Table 2. Proximate composition of torch ginger inflorescence (n= 3 ± S.D.) (on dry weight basis)

Composition (%)	Amount (g/ 100g)
Crude protein	12.6 ± 0.5
Crude lipid	18.2 ± 1.0
Crude fiber	17.6 ± 2.0
Ash	15.5 ± 0.3
Nitrogen free extracts (NFE)	36.3 ± 2.6
Energy value (kJ/ 100 g)	1322.3 ± 36.2

while the crude protein, lipid and fiber content in the samples were 12.6, 18.2 and 17.6% (dry weight), respectively. The presence of high protein (Table 2) and amino acids (Table 4) indicate torch gingers inflorescence to be a good source of protein. The presence of high ash (15.5%, Table 2) indicates the level of essential or non-essential mineral elements in the sample (Bhat and Sridhar, 2008). Presence of ample amounts of dietary fiber in the inflorescence might be advantageous as they are known to reduce serum cholesterol level, reduce risk of coronary heart disease and lower the risks from hypertension and constipation (Ishida *et al*., 2000).

Fatty acid composition

Fatty acid profile of the inflorescence is shown in Table 3. The fatty acid profiles revealed: Saturated fatty acids (SFA) content (57.8%) to be higher than that of unsaturated fatty acids (USFA) (42.2%). Out of the total unsaturated fatty acids, 22.4% was monounsaturated fatty acids (MUFA) and 19.8% was polyunsaturated fatty acids (PUFA). Myristic acid (C14:0) (47.6%) accounted for nearly 82.4% of the total SFA. The contribution to SFA was found to be increased in the order of: stearic acid (C18:0) < palmitic acid (C16:0) < myristic acid (C14:0). The major MUFA was represented by palmitioleic acid (16.4%) and oleic acid (5.2%). Among the PUFA, the dominant fatty acid present was linoleic acid (14.5%). Seafoods and beef form an excellent source of palmitoleic acid but such foods are not acceptable to population relying on vegetarian based diets. Additionally, plant oils from coconut, palm, soybean and canola are rich sources of myristic and linoleic acid, respectively. On this basis, torch ginger inflorescence could be considered as a satisfactory source for myristic, palmitoleic acid and omega fatty acids such as linoleic acid (Table 3).

Earlier, Parthasarathy *et al*. (2008) have reported fatty acid composition of ginger rhizome (Zingiberaceae family), wherein unsaturated fatty acids (oleic acid, 22.9% and linoleic acid, 23.2%) were present in high amounts. Additionally, Gur *et al*. (2006) have reported the PUFA content of turmeric rhizome (Zingiberaceae family) wherein, unsaturated fatty acids like: palmitoleic, linoleic and oleic acids were found in high amounts. These results are on par with our present study as torch ginger also belongs to the Zingiberaceae family. Presence of PUFA in the diet is essential for human health as these fatty acids act as functional foods by affecting various physiological processes and provide protection against cardio-vascular diseases, hypertension, inflammation and autoimmune disorders (Benatti *et al*., 2004).

Table 3. Fatty acid profiles of the oil of torch ginger inflorescence (n= 3 ± S.D.) (on dry weight basis)

Fatty acid	Formula	Amount (percent in oil)
Saturated fatty acids		
Myristic acid	C14:0	47.6 ± 5.2
Palmitic acid	C16:0	9.0 ± 1.2
Stearic acid	C18:0	1.2 ± 0.1
Unsaturated fatty acids		
Palmitoleic acid	C16:1n7	16.4 ± 2.1
hexadecadienoic acid	C16:2n4	1.1 ± 0.0
hexadecatrienoic acid	C16:3n4	0.1 ± 0.0
Hexadecatetraenoic acid	C16:4n3	0.4 ± 0.0
Oleic acid	C18:1n9	5.2 ± 0.3
Cis-vaccenic acid	C18:2n7	0.8 ± 0.1
Linoleic acid	C18:2n6	14.5 ± 1.9
Octadecatrienic acid	C18:3n4	1.1 ± 0.0
α-parinaric acid	C18:4n3	3.2 ± 0.2
cis-11-Eicosenoic acid/ Gondoic acid	C20:1n9	0.1 ± 0
Eicosatetraenoic acid	C20:4n3	0.2 ± 0
Cetoleic acid	C22:1n11	0.7 ± 0.1
Docosapentaenoic acid/ Cupanodoic acid	C22:5n3	0.4 ± 0.1
Sum of saturated fatty acids	-	57.8
Sum of unsaturated fatty acids	-	42.2
Ratios		
TUFA/ TSFA [a]	-	0.73
TPUFA/ TMUFA [b]	-	0.88
C14:0 + C15:0 + (C16:0 ÷ C18:0)	-	55.1
C18:1÷C18:2	-	0.34
ω-6÷ω-3	-	0.23

[a] ratio of total unsaturated/ total saturated fatty acids; [b] ratio of polyunsaturated fatty acid/ total monounsaturated fatty acids; Data represent means ± SD of three determinants

Amino acid profiles

Table 4 shows the amino acids profile of the torch ginger inflorescence. Till date, there are no contemporary data available on the amino acid composition of the proteins of *E. elatior* plant (rhizome, leaves or inflorescence). Generally, amino acid profile is an indication of the nutrition value of the protein component (Bodwell *et al*., 1980). Results on amino acids indicated essential (EAA) and non-essential amino acids to constitute 47.1% and 52.9%, respectively of the total protein. Among the non-essential amino acids, glutamic acid (10.1 mg/100 mg Protein) and aspartic acid (9.4 mg/100 mg Protein) were present in high levels. Whereas, among the EAA: lysine, leucine, valine, threonine, isoleucine, phenylalanine were present in ample amounts. However, methionine was found to be the limiting EAA in the sample (0.8 mg/100 mg of Protein). Some of the amino acids derived from different food sources have proven their potential as antioxidants, antimicrobial, anti-inflammatory and immune stimulating agents (Bhat *et al*., 2008; Bernal *et al*., 2010). Hence, the presence of these in torch ginger provides a more nutraceutical touch.

Mineral composition

Table 5 depicts the results of the analyzed minerals

Table 4. Amino acid profile of proteins in torch ginger inflorescence (n=3 ± S.D.) (on dry weight basis)

Amino acid	Amount of amino acid (mg/100 mg Protein)	FAO/WHO pattern [a]	Essential amino acid score
Essential amino acids			
Histidine	2.3 ± 0.1	1.9	121.05
Isoleucine	4.2 ± 0.3	2.8	150
Leucine	7.2 ± 0.5	6.6	109.1
Lysine	7.9 ± 0.7	5.8	136.2
Methionine	0.8 ± 0.1	-	-
Phenylalanine	4.1 ± 0.3	-	-
Threonine	4.4 ± 0.3	3.4	129.4
Valine	5.0 ± 0.3	3.5	142.8
Non-essential amino acids			
Alanine	5.1 ± 0.3	-	-
Arginine	6.2 ± 0.4		
Aspartic acid	9.4 ± 1.1	-	-
Cysteine	4.7 ± 0.1	2.5[b]	220.0
Glutamic acid	10.1 ± 0.8	-	-
Glycine	4.2 ± 0.2	-	-
Proline	3.0 ± 0.6	-	-
Serine	4.8 ± 0.3	-	-
Tyrosine	2.5 ± 0.2	6.3[c]	104.7

[a] FAO/WHO (1991); [b] Methionine + cystine; [c] Tyrosine + phenylalanine

Table 5. Mineral composition of the torch ginger inflorescence (n= 3 ± S.D.) (on dry weight basis)

Element	Amount mg/100g (dry weight)
Calcium	775.3 ± 14.3
Copper	0.6 ± 0
Iron	2.4 ± 0
Magnesium	327.1 ± 6.2
Manganese	8.3 ± 0.8
Zinc	2.8 ± 0.1
Sodium	4.5 ± 0.3
Potassium	1589.0 ± 5.2
Sulfur	167.0 ± 3.9
Phosphorus	286.0 ± 5.7
Boron	2.6 ± 0.1
Fluorine	1.4 ± 0
Selenium	<0.1
Cobalt	<0.1
Chromium	<0.1
Molybdenum	<0.1
Na: K ratio	0.003
Ca: P ratio	2.7

in the inflorescence of torch ginger. Accordingly, the inflorescences were rich in essential minerals like K (1588 mg/100 g), Ca (775 mg/10 g), Mg (327 mg /100 g), S (166.6 mg/100 g) and Na (4.5 mg/100 g). Minerals such as: Fe, F, Zn, Se, Cu, Mn, Cr, Mo, and Co, considered as trace elements in human nutrition was also present in low amounts (<10 mg/100 g). Boron, an ultra-trace element was also present in the inflorescence (2.6 10 mg/100 g). Our results on minerals are on par with the earlier report on medicinal plant species (Bhat *et al*., 2010) wherein Mg, K, and Ca were found to be pre-dominant. Belitz *et al.* (2009) have reported that the dietary intake of essential minerals should be >50 mg/day. The essential minerals: Ca, K, Mg and P are important in extracellular and intracellular body functions and as components in building blocks of structural components in human body. Also, the presence of high levels of potassium in diets is considered to be beneficial for those suffering from hypertension and excessive excretion of potassium through the body fluids. Minerals like iron and selenium, even if present in threshold levels can act as antioxidants and are involved in strengthening the immune system. Whereas, magnesium and zinc are known to prevent cardiomyopathy, muscle degeneration, growth retardation, dermatitis, gonadal atrophy, impaired spermatogenesis, congenital malformations and bleeding disorders (Bhat and Sridhar, 2008; Bhat *et al*., 2010). The presence of these minerals in the torch ginger inflorescence provides base for using them in food applications.

Antinutrients and heavy metals

Results on the antinutrients (saponin and phytc acid) and heavy metal contents of torch ginger inflorescence is shown in Table 6. Saponin and phytic acid content of the inflorescence was found to be 3496 and 2851 mg/100 g (dry weight), respectively. This study serves as the first report on occurrence of phytic acid in torch ginger plants inflorescence. Earlier in one of the reports on phytochemical analysis, the presence of saponin in the *E. elatior* inflorescence has been reported, but qualitatively (Lachumy *et al*., 2010). Under the physiological pH 6-7, phytic acids are highly charged as eight out of the twelve hydroxyl groups possesses negative charge. This state renders phytic acid to bind most of the divalent cations. Hence, bioavailability of minerals such as magnesium, calcium, zinc and iron in the intestine tends to decrease (Bohn *et al.*, 2008). Additionally, phytic acid may also act as metal binder or chelating agent. When saponin is present in the diet, their hemolytic action renders the aglycon moiety to bind with steroids (particularly cholesterol) and form insoluble complexes, affecting the membrane permeability of the intestine mucosal cell, leading to shortage in nutrient absorption (Francis *et al*., 2002).

Table 6. Antinutrients and heavy metal contents in torch ginger inflorescence (n= 3 ± SD) (on dry weight basis)

Element/compound	Amount
Saponin (mg/ 100 d.w)	3496 ± 83
Phytic acid (mg/ 100 d.w)	2851 ± 85
Cadmium (ppm)	<0.1
Arsenic (ppm)	<0.01
Lead (ppm)	<0.1
Mercury (ppm)	<0.01
Nickel (ppm)	<0.1

Long time presence of heavy metals in any food (even at threshold levels) can lead to bio-accumulation leading to serious ailments. However, the presence of heavy metals in any plant or their produce is highly influenced by the surrounding environmental conditions of the plants habitat (Schilcher *et al.*, 1987; Bhat *et al.*, 2010). In this study, all the analyzed heavy metals (Ni, Cd, As, Pb, Hg) were found to be at a lower concentration and were below the detection limits, thus making it safer for consumption. Lower heavy metal content may reflect low or no application of agrochemicals, unpolluted soil with heavy metals or selective absorption of metals.

Conclusion

Results of our present study provides a strong base on the nutritional value of torch ginger inflorescence with the presence of high amounts of dietary fiber, unsaturated fatty acids, essential amino acids and essential minerals with lower levels of heavy metal contaminants. With the availability of adequate data on the therapeutic value, the inflorescence has wide scope to be utilized in food bio-fortification, and also as a source of nutraceutical for the development of new functional foods.

Acknowledgement

One of the authors (M. M. Jeevani Osadee Wijekoon) acknowledges Universiti Sains Malaysia for the postgraduate fellowship awarded.

References

AOAC (1990). Official Methods of Analysis (15th ed.) Washington, DC: Association of Analytical Chemists.

Andlauer, W. and Fürst, P. 2002. Nutraceuticals: a piece of history, present status and outlook. Food Research International 35: 171-176.

Baccou, J., Lambert, F. and Samvaire, Y. 1977. Spectrophotometric method for the determination of total steroidal sapogenin. Analyst 102: 458-465.

Belitz, H. D., Grosch, W. and Schieberle, P. 2009. Food Chemistry, New York, Springer, pp. 1-1070.

Benatti, P., Peluso, G., Nicolai, R. and Calvani, M. 2004. Polyunsaturated fatty acids: biochemical, nutritional and epigenetic properties. Journal of American College of Nutrition 23: 281-302.

Bernal, J., Mendiola, J. A., Ibáñez, E. and Cifuentes, A. 2010. Advanced analysis of nutraceuticals. Journal of Pharmaceutical and Biomedical Analysis (in press, corrected proof).

Bhat, R., Kiran, K., Arun, A. and Karim, A. 2010. Determination of mineral composition and heavy metal content of some nutraceutically valued plant products. Food Analytical Methods 3: 181-187.

Bhat, R. and Sridhar, K. R. 2008. Nutritional quality evaluation of electron beam-irradiated lotus (*Nelumbo nucifera*) seeds. Food Chemistry 107, 174-184.

Bhat, R., Sridhar, K. R., Young, C. C., Bhagwath, A.A. and Ganesh, S. 2008. Composition and functional properties of raw and electron beam-irradiated *Mucuna pruriens* seeds. International Journal of Food Science and Technology 43: 1338-1351.

Bodwell, C. E., Satterlee, L. D. and Hacker, L. R. 1980. Protein digestibility of the same protein preparation by human and rat assays and by invitro enzymetic digestion methods. American Journal of Clinical Nutrition 33: 677-686.

Bohn, L., Meyer, A. S. and Rasmussen, S. K. 2008. Phytate: impact on environment and human nutrition. A challenge for molecular breeding. Journal Zhejiang University Science 9: 165-191.

Chan, E. W. C., Lim, Y. Y. and Omar, M. 2007. Antioxidant and antibacterial activity of leaves of *Etlingera* species (Zingiberaceae) in Peninsular Malaysia. Food Chemistry 104: 1586-1593.

Chan, E. W. C., Lim, Y. Y., Wong, L. F., Lianto, F. S., Wong, S. K., Lim, K. K., Joe, C. E. and Lim, T.Y. 2008. Antioxidant and tyrosinase inhibition properties of leaves and rhizomes of ginger species. Food Chemistry 109: 477-483.

Francis, G., Kerem, Z., Makkar, H. P. S. and Becker, K. 2002. The biological action of saponins in animal systems: areview. British Journal of Nutrition 88: 587-605.

Gur, S., Turgut-Balik, D. and Gur, N. 2006. Antimicrobial activities and some fatty acids of turmeric, ginger root and linseed used in the treatment of infectious diseases. World Journal of Agricultural Science 2: 439-442.

Habsah, M., Ali, A. M., Lajis, N. H., Sukari, M. A., Yap, Y. H., Kikuzaki, H. and Nakatani, N. 2005. Antitumour-promoting and cytotoxic constituents of *Etlingera elatior*. Malaysian Journal of Medical Science 12: 6-12.

Huda, N., Dewi, R. S. and Ahmad, R. 2010. Proximate, color and amino acid profile of indonesian traditional smoked catfish. Journal of Fisheries and Aquatic Science 5: 106-112.

Indarti, E., Majid, M. I. A., Hashim, R. and Chong, A. 2005. Direct FAME synthesis for rapid total lipid analysis from fish oil and cod liver oil. Journal of Food Composition and Analysis 18: 161-170.

Ishida, H., Suzuno, H., Sugiyama, N., Innami, S., Tadokoro, T. and Maekawa, A. 2000. Nutritive evaluation on chemical components of leaves, stalks and stems of sweet potatoes (*Ipomoea batatas poir*). Food Chemistry 68: 359-367.

Lachumy, S. J. T., Sasidharan, S., Sumathy, V. and Zuraini, Z. 2010. Pharmacological activity, phytochemical analysis and toxicity of methanol extract of *Etlingera elatior* (torch ginger) flowers. Asian Pacific Journal of Tropical Medicine 3: 769-774.

Mai, C. W., Wong, S. Y., Tan, E. L., Balijepalli, M. K. and Pichika, M. R. 2009. Antiproliferative and apoptotic studies of the standardised extracts of *Etlingera elatior* on human colorectal carcinoma cells. Malaysian Journal of Chemistry 11: 136-142

Parthasarathy, V. A., Chempakam, B. and Zachariah, T. J. 2008. Chemistry of spices. Wallingford, UK; Cambridge, MA, CABI Pub.

Schilcher, H., Peters, H. and Wank, H. 1987. Pestiszide and schmermretalle in Arzneipmanzen and Arzneiplanzen Zubereitungen. Pharma-zeutische Industrie 49: 202-211.

Vaintraub, I. A. and Lapteva, N. A. 1988. Colorimetric determination of phytate in unpurified extract of seeds and product of their processing. Analytical Biochemistry 175: 227-230.

Wijekoon, M. M. J. O., Bhat, R. and Karim, A. A. 2010. Effect of extraction solvents on the phenolic compounds

and antioxidant activities of bunga kantan (*Etlingera elatior* Jack.) inflorescence. Journal Food Composition Analysis (in Press, Accepted Manuscript).