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Reduction in oxalate, acridity, phenolic content and antioxidant activity of *Amorphophallus paeoniifolius* var. Gajendra upon cooking

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Abstract

The presence of oxalate and acridity has led to gross underutilization of *Amorphophallus paeoniifolius* (elephant foot yam- EFY), a salubrious tuber, consumed traditionally as a vegetable. Therefore, as a means to overcome oxalate and acridity problem, cooking in boiling water was studied. Boil-cooking of the EFY significantly decreased ($p < 0.01$) the oxalate content, both soluble and insoluble. Boiling for 10 min caused 35.39% reduction in soluble oxalates and 44.76% in total oxalates. However, further increasing boiling duration did not cause any significant change in oxalates. Similar trends were noticed in the cooking-mediated reduction in sensorial acridity score. Alternately, boiling also reduced ($p < 0.01$) phenolic content and antioxidant activity (DPPH) of EFY. Ten min boiling was found to be sufficient for reduction of oxalates to a reported safer level of 71 mg/ 100g. Therefore, proper cooking of the tuber can certainly enhance its consumption pattern without any possible deleterious effect (renal functioning and mineral bioavailability) on human population.

Introduction

Elephant foot yam (*Amorphophallus paeoniifolius* (Dennst.) Nicolson), an important but underutilized tuber of family Araceae (Aroids) is native to Asia. It is also called as King of Tuber Crops (Sengupta *et al*. 2008). The dry matter content in the tuber ranges from 17.50 to 24%, starch from 13.93 to 21.53%, sugar from 0.55 to 1.77%, protein from 0.84 to 2.60%, fat from 0.07 to 0.37% (Chattopadhyay *et al*. 2009). It is eaten in varied manners- boiled like potatoes and eaten with mustard, as curry, as pickle after boiling with tamarind leaves, as preserve after cooking in syrup. It can also be cooked with salt, chilly, tamarind and turmeric powder and is used as curry (Yesodharan and Sujana, 2007). In Assam (India), farmers consume a special dish made of EFY in the month of Bhadoh, which they perceive to be strength giving (Borah *et al*. 2008). Therapeutic uses of EFY include arsa (haemorrhoids), pliha (splenic disorders), gulma (tumor conditions), svasa (breathing disorders), kasa (cough) and asthila (prostate disorder) (Ayurveda Pharmacopeia of India, 2007). Various tuber extracts have been found to possess analgesic, cytotoxic activity, immune-modulatory activity, anthelmintic activity, anti-inflammatory, hepato-protective and anxiolytic activity (Shilpi *et al*. 2005; Angayarkanni *et al*. 2007; Tripathi *et al*. 2010; Ramalingam *et al*. 2010; De *et al*. 2010; Hurkadale *et al*. 2012; Saha *et al*. 2013). Recent work have shown that tuber extracts possess cytotoxic and apoptic activity against human colon carcinoma cell line HCT-15 (Ansil *et al*. 2014).

The major problem associated with the consumption of EFY is its acridity and/or oxalate content. These factors have averted the usage of elephant foot yam as a food crop. Acridity is experienced as irritative (itching-stinging-burning) sensation in the mouth and throat which may be followed by swelling. Its rubbing on external skin may also induce itching, thus pointing towards the intensity of irritation. The acridity is caused by needle like crystals of oxalate called raphides (Bradbury and Nixon, 1998; Lewu *et al*. 2010). Apart from acting as irritant, oxalate is considered to be anti-nutritional and toxic (Guil-Guerrero, 2014). Ingestion of higher amount of oxalate (2 g) can be fatal to humans (Libert and Franceschi, 1987). Oxalates can render minerals like iron, calcium, zinc, magnesium unavailable to body by chelating them. Therefore, consuming foods containing oxalate may cause deficiency of essential minerals in the body. The crystals of oxalates can also get deposited in kidney and cause renal stones, leading to renal failure. About 75% of kidney stones are composed of oxalates and consumption of foods containing oxalate increase urinary oxalate content to variable extent (Williams and Wandzilak, 1989;

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Holmes *et al*. 2001). Reducing oxalate in diet is necessary to prevent oxalate related maladies (Massey *et al*. 1993). For patients with kidney stone, dietary intake of oxalates should be restricted to 40–50 mg/ day (ADA, 2005).

Therefore, removal of acridity/ oxalate will benefit in better utilization of Araceae plants for food and feed purposes. Boiling as food processing operation could be effective in alleviating the oxalates. Osisiogu *et al*. (1974) found reduction in irritant effect of cocoyam after boiling for 15 min and complete disappearance after 1 h boiling. Wanasundera and Ravindran (1992) reported 40-50% loss of total oxalates in yam tubers (*Dioscorea alata* and *D. esculenta*) upon boiling. Iwuoha and Kalou (1995) also found boiling to cause significant reduction ($p < 0.05$) in oxalate content of Colocasia esculenta and Xanthosoma sagittifolium. Bhandari and Kawabatta (2006) processed 4 different cultivars of wild yam tubers of Nepal by boiling and reported reduction of 31-53%. Catherwood *et al*. (2007) reported 64-77% reduction in total oxalate level of 4 different cultivar of Japanese taro by boiling.

Until now there is lack of information regarding reduction in oxalate and/ or acridity parameter of *Amorphophallus paeoniifolius* due to boiling. Thus, the study was undertaken to assess the reduction in oxalate content and acridity upon boiling, a commonly resorted method of cooking.

Materials and Methods

Sample preparation

Fully mature elephant foot yam (var. Gajendra) tuber was procured from Navsari Agriculture University, Navsari, Gujarat during March. The tubers were washed thoroughly, peeled, diced into 2 cm cubes and were immediately dipped in 0.1% potassium metabisulphite solution for 5 min to prevent browning. The cubes were then blanched in boiling water (cubes: water- 1: 6) for 10 min and cooled. The blanched cubes were allowed to surface dry for 15 min and packed in nylon pouches (Hitkari Industries Ltd., Parwanoo) and stored in deep freezer (-20 ± 2°C) till further study.

Cooking treatment

The frozen EFY cubes were thawed overnight in a refrigerator (5 ± 1°C) and then cooked in excess boiling water (EFY: water- 1:6) for different time period i.e. 10, 20, 30 and 40 min. After boiling, EFY cubes and soak water was collected separately. EFY cubes were spread on blotting paper under air for cooling and then made into paste using mixer (Maxie food processor, Inalsa Appliances, India) and stored at -20°C till further analysis. The oxalate content (via hydrothermal degradation) as well as sensorial acridity was evaluated along with other characteristics viz. whiteness index, phenolic content and DPPH (2, 2 diphenyl-1-picryl hydrazyl) activity. The soak water was examined for the loss of yam solids.

Physico-chemical analysis

Oxalate content was extracted and determined as per Okombo and Liebman (2010), with minor modifications. For total oxalate, 10 g sample was weighed into a 250 ml Erlenmeyer flask with 50 ml of 2 M hydrochloric acid. The flask was covered with aluminium foil and placed into water bath (Laboratory Glassware Co., Ambala Cantt., India) at 75°C for 30 min with intermittent swirling (5 min interval). The flask was then allowed to cool and 50 ml of deionised water was added and swirled. The mixture was then filled in plastic centrifuge tubes and centrifuged for 10 min at 3000 rpm. The supernatant was then filtered into plastic vials and refrigerated prior to oxalate analysis. For soluble oxalate, extraction was carried with deionized water. The extracted samples were then analyzed for oxalate using the oxalate kit (Trinity Biotech Co., Wicklow, Ireland).

EFY paste was evaluated for sensory acridity by a panel of judges selected from the Division using a 5 point semi-structured acridity evaluation card. The panel members (Age group: 23-28 years; Sex: male) who were trained to judge the EFY acridity by applying the yam paste on the soft part (inside) of the forearm for 3-4 min for feeling the itchy sensation if any, were asked to make a "vertical mark" giving the relevant sample number along a 5-point semi-structured linear scale to indicate the intensity of acridity (0-no acridity, 4- extreme acridity) sensation (Kumar *et al*. 2013).

Hunter L*, a*, b* values of EFY paste were measured employing spectro-colorimeter, Colorflex® Model No. 45/0 (Hunter lab, Reston, USA) and converted to whiteness index (WI) from formula as shown;

$$WI = 100-\sqrt{(100-L^*)^2+a^{*2}+b^{*2}}.$$

Solid loss in soak/ cook water was determined by the gravimetric method as described in AOAC (2000).

Total phenolic content and antioxidant activity was evaluated in hydro-methanolic extract. 10 g of paste was weighed with 50 ml of 80% methanol and shaken for 1 h. It was then centrifuged at 4000

Table 1. Changes in oxalate, acridity and other physico-chemical parameters upon boiling of elephant foot yam

Boiling time (in min)	Soluble oxalate (mg/ 100g)	Total oxalate (mg/ 100g)	Acridity score	Whiteness index	Solids loss (%)	Total phenol (mg GAE/ g)	DPPH activity (µmol TE/ g)
10	8.38 ± 0.16^{b}	39.99 ± 0.76^{b}	0.16 ± 0.01^{b}	55.91 ± 0.43	0.67 ± 0.05^{a}	7.01 ± 0.10^{c}	6.46 ± 0.10^{c}
20	8.15 ± 0.07^{ab}	38.02 ± 0.26^{a}	0.12 ± 0.01^{a}	55.82 ± 0.45	1.27 ± 0.07^{b}	5.98 ± 0.12^{b}	5.43 ± 0.25^{bc}
30	7.89 ± 0.12^{ab}	37.66 ± 0.15^{a}	0.10 ± 0.01^{a}	55.16 ± 0.24	1.62 ± 0.06^{c}	4.74 ± 0.06^{a}	4.35 ± 0.42^{b}
40	7.66 ± 0.11^{a}	37.14 ± 0.27^{a}	0.10 ± 0.01^{a}	54.94 ± 0.87	1.95 ± 0.07^{d}	4.37 ± 0.10^{a}	2.74 ± 0.31^{a}
F value	6.81**	20.19**	11.05**	0.77	71.48**	149.82**	29.55**

Values are mean ± standard error; n= 4; means with different alphabetic superscript in different rows are significantly different as determined by Tukey"s test; ** $p < 0.01$, * $p < 0.05$

rpm for 30 min. The supernatant was collected and extraction was repeated. The supernatant was pooled and stored at -20°C till analysis. The total phenolic content was determined as per Cordenunsi *et al*. (2004). Standard curve was prepared using gallic acid. Based on absorbance, the total phenolic content of sample was calculated using standard curve equation, $y=0.0025x+0.0209$; $R^2=0.99$; where, y is absorbance and x is concentration of gallic acid (GA) and results were expressed as µg GA per g of sample. Antioxidant capacity based on DPPH (2, 2 diphenyl-1-picryl hydrazyl) radical was analyzed following the method given by Brand-Williams *et al*. (1995). Based on percent inhibition of absorbance of sample, trolox equivalent was determined using following standard curve equation: $y=531.51x-0.22$; $R^2=0.99$; where, y is the percent inhibition and x is the concentration of trolox (µmol). The results were expressed as µmol trolox equivalent (TE) per g sample.

Statistical analysis

The experiments were conducted in quadruplicates and data obtained were analyzed by one way analysis of variance using IBM SPSS Statistics version 20. Significant differences between means were determined using Tukey's test.

Results and Discussion

Effect of boiling on oxalate content (soluble and total) of EFY

The soluble oxalate (water soluble) exists in plants as crystals of sodium, potassium and ammonium salts (Holloway *et al*. 1989). Oxalic acid chelates the metal ions and exists as crystals of water insoluble salt of calcium, iron or magnesium (Noonan and Savage, 1999). Apart from acting as an irritant, oxalates have their own repercussions on human body, the major effects being deposition of calcium oxalate crystals in the kidneys (renal stones) and reduction in bioavailability of minerals. The total oxalate content in various species of Dioscorea varied from 67-104 mg /100g while soluble oxalate content varied from 37-85 mg/ 100g (Bhandari and Kawabatta, 2004). The soluble oxalate content in various varieties of EFY have been found to vary from 2.91 to 18.50 mg/ 100g (Chhattopadhyay *et al*. 2009). Boiling is one of the best means employed by humans for making foods more palatable and less toxic. A significant destructive effect of boiling upon oxalate level was observed. The soluble oxalate level declined from 12.97 mg/ 100g (0 min boiling) to 7.66 mg/ 100g (40 min boiling) i.e. by 40.9%, whilst the total oxalate content (soluble and insoluble together) decreased from 72.39 mg/ 100g (0 min boiling) to 37.14 mg/ 100g (40 min boiling) i.e. by 48.7%. Table 1 further shows that both oxalates declined increasingly with increasing boiling duration, but the greatest reduction occurred during initial 10 min of boiling; the oxalate content in yam cooked for longer duration (20, 30 and 40 min) did not differ significantly from that obtained after 10 min boiling. Boiling has been reported to be effective in reducing the oxalates in various root crops i.e. colocasia, wild yam, Japanese taro and trifoliate yam tuber (Iwuoha and Kalu, 1995; Bhandari and Kawabatta, 2006; Catherwood *et al*. 2007; Abiodun *et al*. 2014). Shimi and Haron (2014) suggested optimal cooking for reducing the oxalate content. Thermal degradation/ decomposition at higher temperature and leaching of oxalates in cook water) might have caused the reduction (Sefa-Dedeh and Agyir-Sackey, 2004; Judprasong *et al*. 2006). Leaching of oxalate is facilitated by skin softening during boiling.

Effect of boiling on acridity of EFY

Acridity is an unpleasant phytochemical quality found in plants of Araceae (Aroid) family. The corms and leaves of most cultivars of the edible aroids are acrid i.e. if eaten raw, they may cause soreness and swelling of the lips, mouth and throat. Acrid sensation is perceived as a severe itching, stinging or burning sensation in the mouth and throat, followed by swelling. There might be less severe irritation or itching of external skin, on hands and arms. Calcium oxalate crystals are thought to be causing itching sensation. When in sufficient quantity, calcium oxalate crystals cause mechanical abrasion of the mucous membranes and causes irritation and burning sensation in the mouth and throat. Acridity i.e. itchiness felt upon consumption of EFY was determined by hand sensing technique as carried out by Paull *et al*. (1999) . The sensory acridity scores varied from 2.12 (0 min boiling) to 0.10 (40 min boiling) (Table 1). The EFY not subjected to boiling was perceived to be definitely acrid by the judges as the application of paste on the forearm caused a definite itching sensation. Cooking by boiling for 10 min or more significantly ($p < 0.01$) decreased the acridity, although the decrease was slight and non-significant in the yam cooked beyond 10 min. The EFY was perceived to be only minutely acrid after cooking in boiling water.

Effect of boiling on loss of solids in cook water

Solids loss in cooking water is an important parameter affecting the viability of boiling in water as cooking method. It reflects the hydrothermal degradation occurring in food on cooking and thereby serves as an indicator of lethality of boiling as cooking process. The loss of solids during cooking even during steeping, is a normal phenomenon which can lead to decreased nutritional and economic value of the food, but also can help in effacing anti-nutritional elements present in the food system. The boiling time appeared to have a significant direct effect on the solids loss occurring in cook water (Table 1). The solids loss ranged from 0.67 to 1.95%. The significant increase ($p < 0.01$) in losses with cooking time is invariably a result of softening arising from the rise in temperature and cooking duration (Chiang and Luo, 2007). Vegetable softening during cooking occurs due to loss in turgor and changes occurring in cell wall matrix polysaccharides which causes loss of water and cellular solutes (Lewicki, 1998; Gliszczynska-Swigło *et al*. 2006; Xu *et al*. 2014). Boiling has also been known to cause skin rupture of the tuber (Albihn and Savage, 2001). The thermal softening behavior of cassava has been well illustrated by Sajeev *et al*. (2008) and Sajeev *et al*. (2010).

Effect of boiling on whiteness value of EFY

The whiteness value of EFY paste obtained after cooking in boiling water for different periods are presented in Table 1. Cooking in boiling water did not alter the whiteness value of the EFY paste significantly (Table 1), although a very minute decline (non-significant) in whiteness was observed with increasing cooking time. Thus there was no perceivable browning (enzymatic and non-enzymatic) during the plain-water boiling process. Polyphenol oxidases, the main causatives of enzymatic browning are heat labile in nature and are destroyed at 80°C (Vamos-Vigyazo, 1981).

Effect of boiling on phenolic content and antioxidant activity of EFY

The total phenolic content (in terms of gallic acid) as determined by the Folin-Ciocalteau Reagent assay, declined from 7.01 mg/ g (10 min boiling) to 4.37 mg/ g (40 min boiling) and, at the same time DPPH scavenging activity (in terms of trolox) dropped from 6.46 µmol /g (10 min boiling) to 2.74 µmol /g (40 min boiling). The total phenolic content in wild yam tubers ranged from 13 to 166 mg/ 100g (Bhandari and Kawabata, 2004). Both the phenolics and DPPH activity showed a high degree of correlation ($r= 0.93$). Referral to Table 1 indicates that an increased boiling time caused a significant decrease ($p < 0.01$) in both the anti-oxidative capacity determining parameters. This, in turn, points toward the loss of phytochemicals (antioxidants) during the cooking process. Leaching of phenolic antioxidant constituents in cook water upon boil-cooking, has been reported to be the main factor causing reduction in anti-oxidative parameters (Xu and Chang, 2008). Further, boiling itself is high thermal lethality process. The breakdown of phenolics during boiling treatments may also have contributed toward the declining trend in the total phenolic content and DPPH activity (Scalzo *et al*. 2007). The other possibilities favouring the reduction of antioxidants as a result of cooking of the yam could be chemical transformation, decomposition of phenolics, protein-polyphenol interaction under thermal conditions (Makris and Rossiter, 2001; Murakami *et al*. 2004; Perla *et al*. 2012) etc. Various workers have experimented upon numerous vegetables to discover cooking, boiling in particular, to be negatively impacting the anti-oxidative nature.

Conclusion

Boiling, a commonly utilized cooking process was examined for its effect on oxalate and acridity problem found in *Amorphophallus paeoniifolius.*

Boiling caused an appreciable reduction in oxalate content (both soluble and total) as well as sensorial acridity score. Simultaneously, reduction in total phenolic content as well as DPPH activity and increment in solids loss in cook water was also noticed. Boiling elephant foot yam for ten minutes was found to be sufficient in reducing the oxalates way below the reported safer level of 71 mg/ 100g (Kumoro *et al*. 2014).

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References

Abiodun, O. A. and Akinoso, R. 2014. Effect of delayed harvesting and pre-treatment methods on anti-nutrients content of trifoliate yam flour. Food Chemistry 146: 515-520.

Albihn, P. B. E. and Savage, G. P. 2001. The effect of cooking on the location and concentration of oxalate in three cultivars of New Zealand-grown oca (*Oxalis tuberosa* Mol). Journal of the Science of Food and Agriculture 81: 1027-1033.

American Dietetics Association (ADA). 2005. Urolithiasis/urinary stones. In ADA Nutrition Care, Manual no. 275. Chicago: American Dietetics Association.

Angayarkanni, J., Ramkumar, K. M., Poornima, T. and Priyadarshini, U. 2007. Cytotoxic activity of *Amorphophallus paeoniifolius* tuber extracts in vitro. American- Eurasian Journal of Agriculture and Environment Science 2: 395-398.

Ansil, P. N., Wills, P. J., Varun, R. and Latha, M. S. 2014. Cytotoxic and apoptotic activities of *Amorphophallus campanulatus* (Roxb.) Bl. tuber extracts against human colon carcinoma cell line HCT-15. Saudi Journal of Biological Sciences 21: 524-531.

AOAC. 2000. Official methods of analysis 17th ed. Washington DC: Association of Official Analysis Chemists (AOAC).

Ayurvedic Pharmacopoeia of India. 2007. The Ayurvedic Pharmacopoeia of India, Part- I Volume-III, Ministry of Health and Family Welfare, Government of India. New Delhi: Department of AYUSH

Bhandari, M. R. and Kawabata, J. 2006. Cooking effects on oxalate, phytate, trypsin and a-amylase inhibitors of wild yam tubers of Nepal. Journal of Food Composition and Analysis 19: 524–530.

Borah, P., Saikia, J. and Narzary, B. D. 2008. Status of elephant foot yam cultivation in Assam. In Palaniswami, M.S., Anil, S. R., Sajeev, M. S., Unnikrishnan, M., Singh, P. P. and Choudhary, B. C. (Eds). National Seminar on *Amorphophallus*: innovative technologies, abstract book, status papers and extended summary, p. 55-57. Patna: Indian Society for Root Crops.

Bradbury, J. H. and Nixon, R. W. 1998. The acridity of raphides from edible aroids. Journal of the Science of Food and Agriculture 76: 608-616.

Brand Williams, W., Cuvelier, M. and Berset, C. 1995. Use of free radical method to evaluate antioxidant activity. Lebensm Wiss and Technology 28: 25-30.

Catherwood, D. J., Savage, G. P., Mason, S. M., Scheffer, J. J. C. and Douglas, J. A. 2007. Oxalate content of cormels of Japanese taro (*Colocasia esculenta* (L.) Schott) and the effect of cooking. Journal of Food Composition and Analysis 20: 147-151.

Chattopadhyay, A., Saha, P., Pal, S., Bhattacharya, A. and Sen, H. 2009. Quantitative and qualitative aspects of elephant foot yam. International Journal of Vegetable Science 16: 73-84.

Chiang, P. and Luo, Y. 2007. Effects of pressurized cooking on the relationship between the chemical compositions and texture changes of lotus root (*Nelumbo nucifera* Gaertn.). Food Chemistry 105: 480-484.

Cordenunsi, B. R., Menezes, E. W. D., Genovese, M. I., Colli, C. L., Souza, A. G. A. D. and Lajolo, F. M. 2004. Chemical composition and glycemic index of Brazilian pine seeds. Journal of Agricultural and Food Chemistry 52: 3412- 3416.

De, S., Dey, Y. N. and Ghosh, A. K. 2010. Anti-inflammatory activity of methanolic extract of Amorphophallus paeoniifolius and its possible mechanism. International Journal of Pharma and Biosciences 1: 1-8.

Gliszczyn´ska-Swigło, A., Ciska, E., Pawlak-Leman´ska, K., Chmielewski, J., Borkowski, T. and Tyrakowska, B. 2006. Changes in the content of health-promoting compounds and antioxidant activity of broccoli after domestic processing. Food Additives and Contaminants 23: 1088–1098.

Guil-Guerrero, J. L. 2014. The safety of wild edible plants: Fuller discussion may be needed. Journal of Food Composition and Analysis 35: 18-20.

Holloway, W. D., Argall, M. E., Jealous, W. T., Lee, J. A. and Bradbury, J. H. 1989. Organic acids and calcium oxalic acid in tropical root crops. Journal of Agricultural and Food Chemistry 37: 337-341.

Holmes, R. P., Goodman, H. O. and Assimos, D. G. 2001. Contribution of dietary oxalate to urinary oxalate excretion. Kidney International 59: 270-276.

Hurkadale, P. J., Shelar, P. A. Palled, S. G., Mandavar, Y. D. and Khedkar, A. S. 2012. Hepatoprotective activity of *Amorphophallus paeoniifolius* tubers against paracetamol induced liver damage in rats. Asian Pacific Journal of Tropical Biomedicine 2: S238-S242.

Iwuoha, C. I. and Kalu, F. A. 1995. Calcium oxalate and physico-chemical properties of cocoyam (*Colocasia esculenta* and *Xanthosoma sagittifolium*) tuber flours as affected by processing. Food Chemistry 54: 61-66.

Judprasong, K., Charonkiatkul, Sungpuag, P., Vasanchitt, K. and Nakjamanong, Y. 2006. Total and soluble oxalate content in Thai vegetables, cereal grains and legume seeds and their changes after cooking. Journal of Food Composition and Analysis 19: 340-347.

Kumar, A., Patel, A. A., Singh, R. B., and Desai, K. 2014. Alkali pre-soaking effects on acridity, colour parameters and oxalate content of elephant foot yam. Journal of Root Crops 39: 88-95.

Kumoro, A. C., Budiyati, C. S. and Retnowati, D. S. 2014. Calcium oxalate reduction during soaking of giant taro (*Alocasia macrorrhiza* (L.) Schott) corm chips in sodium bicarbonate solution. International Food Research Journal 21: 1583-1588.

Lewicki, P. P. (1998). Effect of pre-drying treatment, drying and rehydration on plant tissue properties: A review. International Journal of Food Properties 1: 1-22.

Lewu, M. N., Adebola, P. O. and Afolayan, A. J. 2010. Effect of cooking on the mineral contents and anti-nutritional factors in seven accessions of *Colocasia esculenta* (L.) Schott growing in South Africa. Journal of Food Composition and Analysis 23: 389–393.

Libert, B. and Franceschi, V. R. 1987. Oxalate in crop plants. Journal of Agricultural and Food Chemistry 35: 926–937.

Makris, D. P. and Rossiter, J. T. 2001. Domestic processing of onion bulbs *(Allium cepa)* and asparagus spears *(Asparagus officinalis)*: effect on flavonol content and antioxidant status. Journal of Agricultural and Food Chemistry 49: 3216–3222.

Massey, L. K., Roman-Smith, H. and Sutton, R. A. L. 1993. Effect of dietary oxalate and calcium on urinary oxalate and risk of formation of calcium oxalate kidney stones. Journal of American Dietetic Association 93: 901–906.

Murakami, M., Yamaguchi, T., Takamura, H. and Matoba, T. 2000. Effects of thermal treatment on radical-scavenging activity of single and mixed polyphenolic compounds. Journal of Food Science 69: FCT7–FCT10.

Noonan, S. C. and Savage, G. P. 1999. Oxalate content of foods and its effect on humans. Asia Pacific Journal of Clinical Nutrition 8: 64–74.

Okombo, J. A. and Liebman, M. 2010. Oxalate content of selected breads and crackers. Journal of Food Composition and Analysis 23: 118–121.

Osisiogu, I. U. W., Uzo, J. O. and Ugochukwu, E. N. 1974.The irritant effect of cocoyams. Planta-Media 26(2): 669.

Paull, R., Tang, C., Gross, K. and Uruu, G. 1999. The nature of the acridity factor. Postharvest Biology and Technology 16: 71–78.

Perla, V., Holm, D. G. and Jayanty, S. S. 2012. Effects of cooking methods on polyphenols, pigments and antioxidant activity in potato tubers. LWT - Food Science and Technology 45: 161–171.

Ramalingam, R., Bindu K. H., Madhavi, B. B., Nath, A. R. and Banji, D. 2010. Phytochemical and anthelmintic evaluation of corm of *Amorphophallus campanulatus.* International Journal of Pharma and Biosciences 1: 1-9.

Saha, A., Bose, S. and Banerjee, S. 2013. Anti-anxiety activity of *Amorphophallus paeoniifolius* tuber in mice. Journal of Pharmacy Research 6: 748-752.

Sajeev, M. S., Sreekumar, J., Moorthy, S. N., Suja, G. and Shanavas, S., 2008. Texture analysis of raw and cooked tubers of short-duration lines of cassava by multivariate and fractional conversion techniques. Journal of Science of Food and Agriculture 88: 569-580.

Sajeev, M. S., Sreekumar, J., Unnikrishnan, M., Moorthy, S. N. and Shanavas, S. 2010. Kinetics of thermal softening of cassava tubers and rheological modeling of the starch. Journal of Food Science and Technology 47: 507-518.

Scalzo, R. L., Genna, A., Branca, F., Chedin, M. and Chassaigne, H. 2007. Anthocyanin composition of cauliflower (*Brassica oleracea* L. var. *botrytis*) and cabbage (*B. oleracea* L. var. *capitata*) and its stability in relation to thermal treatments. Food Chemistry 107: 136-144.

Sefa-Dedeh, S. and Agyir-Sackey, E. K. 2004. Chemical composition and the effect of processing on oxalate content of cocoyam *Xanthosoma sagittifolium* and *Colocasia esculenta* cormels. Food Chemistry 85: 479–487.

Sengupta, S., Chowdhary, B. M., Singh, B. N. and Ray R. N. 2008. Status of elephant foot yam cultivation in Jharkhand. In Palaniswami, M. S., Anil, S. R., Sajeev, M. S., Unnikrishnan, M., Singh, P. P. and Choudhary, B. C. (Eds). National Seminar on *Amorphophallus*: innovative technologies, abstract book, status papers and extended summary, p. 30-34. Patna: Indian Society for Root Crops.

Shilpi, J. A., Ray, P. K., Sarder, M. M. and Uddin, S. J. 2005. Analgesic activity of Amorphophallus campanulatus. Fitoterapia 76: 367-369.

Shimi, G. and Haron, H. 2014. The effects of cooking on oxalate content in Malaysian soy-based dishes: Comparisons with raw soy product. International Food Research Journal 21(5): 2019-2024.

Tripathi, A. S., Chitra, V., Sheikh, N. W., Mohale, D. S. and Dewani, A. P. 2011. Immunomodulatory activity of the methanol extract of *Amorphophallus campanulatus* (Araceae) tuber. Tropical Journal of Pharmaceutical Research 9: 451-454.

Vamos-Vigyazo, L. 1981. Polyphenol oxidase and peroxidase in fruits and vegetables. Critical Reviews in Food Science and Nutrition 15: 49–127.

Wanasundera, J. P. D. and Ravindran, G. 1992. Effects of cooking on the nutrient and anti-nutrient content of yam tubers (*Dioscorea alata* and *Dioscorea esculenta*). Food Chemistry 45: 247-250.

Williams, H. E. and Wandzilak, T.R. 1989. Oxalate synthesis, transport and the hyperoxaluric syndromes.

Journal of Urology 141: 742–747.
Xu, B. and Chang, S. K. C. 2008. Effect of soaking, boiling, and steaming on total phenolic content and antioxidant activities of cool season food legumes. Food Chemistry 110: 1-13.
Xu, F., Zheng, Y., Yang, Z., Cao, S., Shao, X. and Wang, H. 2014. Domestic cooking methods affect the nutritional quality of red cabbage. Food Chemistry 161: 162-167.
Yesodharan, K. and Sujana, K. A. 2000. Wild edible plants traditionally used by the tribes in the Parambikulam Wildlife Sanctuary, Kerala, India. Natural Product Radiance 6: 74-80.