www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(12): 209-213

www.thepharmajournal.com
Received: 14-09-2023
Accepted: 16-10-2023

Ganesh Prasad Nag
College of Horticulture and Research Station, Jagdalpur, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India

Deo Shankar
College of Agriculture, Raipur, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India

Bhagwat Kumar
College of Horticulture and Research Station, Jagdalpur, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India

Devendra Pratap Singh
Shaheed Gundadhur College of Agriculture and Research Station, Jagdalpur, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India

Anurag Kerketta
College of Horticulture and Research Station, Jagdalpur, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India

Bhupendra Kumar
College of Agriculture, Raipur, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India

Corresponding Author:
Ganesh Prasad Nag
College of Horticulture and Research Station, Jagdalpur, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India

Studies on major nutritional and anti-nutritional attributes of colocasia (*Colocasia esculenta* var. *antiquorum* L. Schott) selected germplasm of Chhattisgarh

Ganesh Prasad Nag, Deo Shankar, Bhagwat Kumar, Devendra Pratap Singh, Anurag Kerketta and Bhupendra Kumar

Abstract
A laboratory experiment was carried out with freshly harvested tuber samples of 24 selected promising germplasm lines in CRD with 3 replications evaluated during summer season at SGCARS, IGKV, Jagdalpur, Bastar, Chhattisgarh. The collected laboratory data was subjected to estimate the nutritional traits *viz.*, carbohydrates, starch, protein and anti- nutritional traits *viz.* calcium oxalate content (%), tennin (mg /100 g), phytate (mg /100 g). Among the quality parameters the highest nutritional value was registered in the genotypes *viz.* IC-639360, IC-639362, IGCOL-GB-18-1, IC-0623551, IC-0623550 whereas, lowest value of anti-nutritional factors was recorded in the genotype IC-639354 followed by IC-639360 *i.e.* found superior in quality. The analyzed anti-nutritional level of all genotype found no significant to health hazard.

Keywords: Colocasia, tuber, germplasms, nutritional and anti-nutritional

Introduction
Colocasia also known as 'Taro' is one of the ancient tuber crop and has been cultivated for more than 100 century ago in Tropical Asia (Lebot, 2009) [23] and it is being grown for long time by villagers in Bastar district of Chhattisgarh state. Taro serves as staple supply of nutritional diet for communities across the globe and it is the fourteenth mainly enthusiastic vegetable globally (Rao *et al.*, 2010) [29]. Worldwide taro covers an area of approximately 1.35 M ha in the midst of an annual production of 10.2 MT with 6.82 t ha^{-1} average productivity. An average yields reach 12.6 t ha^{-1} in Asia (FAOSTAT, 2019) [12]. Since consumers place such a high value on food's nutritional value, there is a considerable need for information on the nutritional contents of root crops (Huang, *et al.*, 2007) [15]. A tuber contains very high carbohydrates ranging from 73-80% (Soudy *et al.*, 2010) [31]. Taro contains two times more carbohydrate as compared to the potatoes and protein is more than yam, cassava and sweet potato. (FAO, 1999) [11]. Taro leaf also contains very good nutritional value and can be food source if it is processed in way that can reduce anti-nutritional components (Temesgen *et al.*, 2016) [33].

Anti-nutritional chemical substances found in plant tissues that prevent humans from absorbing nutrient elements. Their consequences can be direct or indirect, accompanied with mild repercussions to death. (Natesh, *et al.*, 2017) [25]. Taro contains anti-nutritional and toxic compounds; oxalates, phytates, trypsin and amylase inhibitors, tannins and cyanide. When these anti-nutritional substances are ingested, they may have negative health impacts mainly due to Fe and Zn absorption (Omoruyi and Dilworth, 2007) [26]. Taro has limited utilizations as a food material, due to oxalates content which causes irritation and swelling in mouth and throat (Kumoro *et al*., 2013) [20]. Recorded value in the literature is 367-710 mg/100 g (Iwuoha and Kalu, 1995) [16], Calcium oxalate content in taro corm contributed by the cultivated varieties, organic as well as inorganic fertilizers and environment conditions (Bradbury and Holloway, 1988). Phytate is the salt form of phytic acid and it may decrease the digestibility of proteins and minerals. (Krome *et al*., 2018) [19]. Anti-nutritional substances can be decreased using various processing unit operations such as cooking and blanching (Natesh, *et al*., 2017) [25]. Hence, it is prescribed to process taro for consumption (FAO, 1999) [11]. Keeping in view the major nutritional and anti-nutritional traits, present in Colocasia, we conducted experiments to assess and highlight these components in collected genotypes thereby it can be recommended in state for monetary as well as health benefits.

Materials and Methods

Nutritional

Starch content

Colocasia flour was analyzed for determination of starch by the Anthron method (Hodge & Hofreiter, 1962) [14]. This process hydrolyzes a hot acidic medium to glucose and dehydrates it into hydroxymethyl furfural. Addition of anthrone to this compound forms green coloured product and value is estimated in percent.

Total sugars

Anthrone method was used to determine total sugar (Hodge and Hofreiter, 1962) [14] and estimated as follows:

$$\text{Amount of carbohydrate present in sample (\%)} = \frac{\text{mg of glucose}}{\text{Volume of test sample}} \text{ X } 100$$

Protein

The Kjeldhal technique was used to determine the protein content of colocasia flour (Latimer, 2016) [21]. The test portion must contain between 0.005-0.2 g of nitrogen, preferably more than 0.02 g, and should be weighed to the nearest 1 mg. The test sample was chosen based on the estimated nitrogen concentration. Thereafter organic matter were digested and followed by titration. Data were calculated and expressed results according to following formula:

$$W_{N1} \frac{(V_0 - V_1) \text{ X } C_1 \text{ X } M}{m}$$

Where,

W_{N1}= is the nitrogen content of the test sample, expressed in grams per kilogram;

V_0=is the volume of the sodium hydroxide solution required for the blank test, expressed in milliliters;

V_1=is the volume of the sodium hydroxide solution required for the determination, expressed in ml;

C_1= is the concentration of the sodium hydroxide solution used for the titrations, expressed in moles per litre;

M= is the molar mass, in grams per mole, of nitrogen (M = 14 g/mol);

m= is the mass of the test portion, expressed in grams.

Anti-Nutritional Factors

Oxalate

Abaza *et al*. (1968) [1] formulated a method for determining the oxalate content of raw taro and yam tubers. Oxalate content estimated by using formula:-

$$Oxalates\ (mg/100\ g) = \frac{\text{T X (Vmeq) X DF X } 10^5}{\text{(ME) X Wf}}$$

Where

T=titer value of KMNO4

Vmeq=Volume equivalent to 0.00225 anhydrous oxalic acid

DF = Dilution factor VTA (where V is the total volume of filtrate (250 ml)

and A is the aliquot used (50 ml)

ME= Molar equivalent of KMNO4 in oxalate

Phytate

Phytate content was determined by following the method updated (Vaintraub and Lapteva, 1988) [34] which was originally described by Latta and Eskin (1980) [22] to determine the phytate content. The following relation was used to determine the taro's phytate content:

$$\text{Phytate (mg/100 g)} = \frac{\text{(Absorbance of sample – Intercept) x 10}}{\text{(Slope x Density x Weight of Sample x 3)}}$$

Tannin

Burns (1971) [7] developed a method for determining the tannins contents of taro samples which can be find out using following formula:

$$\text{Tannin (mg/100 g)} = \frac{\text{[(Absorbance of sample} - \text{Absorbance of blank)} - \text{Intercept]}}{\text{(Slope x Density x Weight of Sample)}}$$

Results and Discussion

The observation recorded on five samples for 24 genotypes along with one standard check cv. White Guariya in three replications for nutritional and anti-nutritional components traits were evaluated on the basis of their mean performance. The data were first averaged of cormel basis chosen randomly for each genotype in each replication. The performances of 24 genotypes along with standard check are presented in table 1

Nutritional

Carbohydrates (%)

Carbohydrates were no significance differ among the 24 genotypes along with 1 White Guariya (S.C.) varied from 75 to 79.33 percent with an overall mean of 77.29 percent. The genotype IC-639360 (79.33%) was observed higher Carbohydrates percent while, minimum carbohydrates were noted in the genotype IC-639355 (75 percent) the observational evidence are in close conformity with the report of FAO (1990) [10], Vinning (2003) [35], Kirtikar and Basu (2005) [18] and Alcantara *et al*. (2013) [4].

Starch (%)

Considerable variation was recorded for starch content among the genotypes ranging from 17.33% to 29.33% with a grand mean of 21.22% and the statistically higher starch content was observed in IC-639362 (29.33%) which was statistically on par with the genotype IC-639346 26.33% whereas, the significantly lowest starch content was recorded in IC-639352 (17.33%). The similar data is accounted by Onwueme (1994) [27].

Protein (%)

Protein among the 24 genotypes along with White Guariya (S.C.) varied from 1.65% to 5.37 percent with an overall mean of 3.56 percent. The data reveals that the genotype IGCOL-GB-18-1 was found significantly highest protein content which was at par with genotype IC-0623551 (4.93%) and IC-0623550 (4.70%) whereas, least significantly of protein content was recorded in genotype IC-639354 (1.65%). Our observation mirror to studied by Agoreyo *et al*. (2011) [2], Quach *et al*. (2013) [28] and Alcantara *et al*. (2013) [4].

Anti-nutritional

Food crops that are regularly consumed can also contain anti-nutritional elements such oxalates, phytic acid, cyanoglucosides, phenolics, protease inhibitors, and heavy metal. When these anti-nutritional substances are taken in foods, it may have negative health impacts by inhibiting protein digestion, Fe and Zn absorption as reported by Omoruyi and Dilworth (2007) [26]. However, according to FAO (1999) [11], processing methods like heating, soaking, and drying render the toxin ineffective.

Calcium oxalate content (%)

The results on calcium oxalate content revealed that the various genotypes differed significantly from one another.

The calcium oxalate content ranged from 0.17 to 0.61% with a grand mean of 0.38%. The genotype IC-639359 was recorded significantly highest calcium oxalate content (0.61%) while, significantly lowest calcium oxalate content was recorded in the genotype IC-639354 (0.17%). Similar finding was carried by Iwuoha and Kalu (1995) [16], Alcantara *et al*. (2013) [4] Kumoro *et al*. (2014) [20] and Akalu and Geleta (2017) [3] for raw taro corms. Currently, patients are advised to limit their intake of foods containing no more than 50–60 mg of oxalate day^{-1} (Massey *et al*., 2001) [24]. The raw taro corms analyzed in this study were less in contrast to the recommendations for patients with calcium oxalate kidney stones. Indigenous processing techniques, such as soaking as well as boiling before eating, may have a significant impact on consumer health by enhancing the availability of essential dietary minerals and reducing the risk of kidney stones. (Akalu and Geleta, 2017) [3].

Tennin (mg /100 g)

Tennin among the 24 genotypes along with 1 White Guariya (S.C.) varied from 4.55 to 6.27 with an overall mean of 5.57 mg/100 g. The significantly highest tennin content was observed in the genotype IC-0623549 (6.27 mg/100 g) which was statistically on par with the genotype IC-639347 (6.20 mg/100 g), IC-639352 (6.20 mg/100 g), IGCOL-MUNG-1 (6.17 mg/100 g) and IC-639358 (6.10 mg/100 g) respectively whereas, the significantly lowest tennin content was recorded in IC-639354 (4.55 mg/100 g).The similar data was interpretation by Alcantara *et al*. (2013) [4] and Akalu and Geleta (2017) [3].

Phytate (mg /100 g)

Phytate among the 24 genotypes along with 1 White Guariya (S.C.) varied from 27.66 to 38.33 with an overall mean of 33.15 mg/100 g. The significantly highest phytate content was recorded in IC-639355 (38.33mg/100 g) which was on par with the genotype IC-0623550 (36.97 mg/100 g) and IC-0623549 (36.35 mg/100 g) whereas, the significantly lowest phytate content was recorded in IC-639360 (27.66 mg/100 g). Relevant studies was carried out by Alcantara *et al*. (2013) [4] and Akalu and Geleta (2017) [3] in raw and processed taro products.

Mean performance and range of nutritional and anti-nutritional attributing traits observed in the population of colocasia in present investigation are discussed here. Significant differences were recorded for almost all the traits except carbohydrates percent suggesting existence of sufficient variation in the population for carrying out various analysis based on mean performance of the genotypes IC-639360 was observed higher carbohydrates percent. Starch showed significant difference among all the genotypes evaluated. Maximum starch content was observed in IC-639362 (29.33%) but result obtained from the present investigation revealed lowest starch content was recorded in IC-639352. The data regarding protein content revealed that, significant differences exist among the genotypes studied. The highest protein content was found significantly in the genotype IGCOL-GB-18-1 while, noted least in protein content was recorded in genotype IC-639354.The genotype IC-639359 was recorded higher calcium oxalate content and the genotype IC-639354 in minimum hence, the genotype recorded with minimum may be involved in breeding programme. The traits tennin content observed with significant differences among genotypes tested for traits. The highest tennin content was recorded in the genotype IC-0623549 and lowest tennin content was recorded in IC-639354. Hence, they may be utilized in future. The significant differences were also observed in phytate content showing substantial variation among genotypes studied. The highest phytate content was observed in IC-639355 and minimum in genotype IC-639360. The conclusion obtained from the finding of present experimentation and their practical utilities in improving colocasia for nutritional and anti-nutritional attributes are discussed below.

A broad range of variability was recorded for the traits nutritional *viz.* carbohydrates, starch and protein, and anti-nutritional *viz.* calcium oxalate, tennin and phytate content which indicated that, sufficient variability was created in the material which can be utilized in future colocasia improvement programme. These results are in close proximity with the findings of following investigators *viz.* Ashokan *et al*. (1980) [5], Sundersan and Nambisen (1982) [32], Chand *et al*. (1987) [8], Iwuoha I and Kalu A (1994) [17], Habashy and Radwan (1997) [13], Bhandari and Kawabata (2004) [6], Omoruyi and Dilworth (2007) [26] Devi *et al*., 2013 [9], Akalu and Geleta (2017) [3] and Rashmi *et al*. (2018) [30] in taro.

Table 1: Quality parameters (Major nutritional and anti-nutritional) of corms and cormels of colocasia Germplasms

Accession Number	Quality parameters					
	Nutritional			Anti-nutritional		
	Carbohydrates (%)	Starch (%)	Protein (%)	Calcium oxalate (%)	Tennin (mg/100 g)	Phytate (mg/100 g)
IC-639346	76.43	26.33	3.63	0.23	5.80	29.33
IC-639347	77.00	20.33	4.20	0.28	6.20	30.00
IC-639348	75.67	21.33	4.35	0.32	5.87	31.33
IC-639349	77.00	20.00	4.13	0.34	5.77	32.80
IC-639350	78.33	20.00	3.65	0.20	4.80	34.53
IC-639351	76.33	22.33	4.23	0.36	4.70	35.75
IC-0623547	78.67	18.33	1.73	0.43	5.53	34.67
IC-0623551	78.00	18.67	4.93	0.38	5.80	35.76
IC-0623550	77.67	20.67	4.70	0.41	5.90	36.97
IC-0623549	76.33	18.67	3.97	0.39	6.27	36.35
IC-639352	76.67	17.33	2.57	0.38	6.20	36.11
IC-639353	77.33	18.33	3.70	0.40	6.17	32.33
IC-639354	78.55	25.00	1.65	0.17	4.55	33.33
IC-639355	75.00	18.33	1.80	0.41	5.30	38.33
IC-639356	77.00	22.00	5.37	0.38	5.07	30.93
IC-639357	77.33	21.67	3.85	0.43	5.63	33.33
IC-639358	78.00	23.00	4.78	0.44	6.10	31.37
IC-639359	76.13	20.67	3.74	0.61	5.77	30.62
IC-639360	79.33	20.00	1.72	0.29	6.17	27.66

White Gauriya (SC)	77.77	22.67	4.03	0.43	5.60	31.15
IC-639361	78.23	19.67	4.23	0.45	4.87	33.33
IC-639362	77.50	29.33	3.60	0.52	6.03	34.00
IC-639363	76.00	23.00	1.83	0.42	4.70	33.00
IC-639364	78.67	21.67	3.07	0.46	4.87	32.67
C.D.	NS	3.31	0.73	0.06	0.79	3.68
SE(m)	0.89	1.16	0.26	0.02	0.28	1.29
SE(d)	1.25	1.64	0.36	0.03	0.39	1.83
CV	1.98	9.46	12.39	9.70	8.56	6.74

Conclusions

The corms and cormels of colocasia from the data, reveals that it contains an appreciable amount of carbohydrates, starch and protein, and low level of anti-nutritional *viz.* calcium oxalate, tennin and phytate whose value can be reduced by cooking. The genotype IC-639360, IC-639362, IGCOL-GB-18-1, IC-0623551, IC-0623550whereas, the lowest value of anti-nutritional factors were found in the genotype IC-639354 and IC-639360 and registered as superior in quality amongst all the genotypes. These genotypes may be exploited for future breeding programme.

Acknowledgments

We would like to thanks for Dr H. C. Nanda, Dean, SGCARS, Jagdalpur, Bastar, C.G. the guidance in divergence studies in colocasia germplasms.

Competing interest

The authors declare that there is no any competing interest exists.

Authors' contributions

Deo Shankar and D. P. Singh: Designed the experiments and trials for study.

G. P. Nag: Conducted the designed experiments and recorded observation data and wrote manuscript.

Bhagwat Kumar, Anurag Kerketta and Bhupendra Kumar: Check thoroughly and drafted final manuscript after proof reading by Deo Shankar.

References

1. Abaza RH, Blake JT, Fisher EJ. Oxalate Determination: Analytical Problems Encountered with Certain Plant Species, J Associ. Offi. Analy. Chemists. 1968;51(5):963-967.
2. Agoreyo B, Akpiroroh O, Orukpe OA, Osaweren OR, Owabor CN. The Effects of Various Drying Methods on the Nutritional Composition of *Musa paradisiaca*, *Dioscorea rotundata* and *Colocasia esculenta*. Asian J. Bioche. 2011;6(6):458-464. 10.3923/ajb.2011.458.464.
3. Akalu ZK, Geleta SH. Anti-nutritional Levels of Tubers of *Colocasia esculenta*, L. Schott (Taro) and *Dioscorea alata* (Yam) Cultivated in Ethiopia. Journal of Nutrition and Food Sciences. 2017;7(2):585
4. Alcantara RM, Hurtada WA, Dizon EI. The Nutritional Value and Phytochemical Components of Taro [*Colocasia esculenta* (L.) Schott] Powder and its Selected Processed Foods. J Nutr. Food Sci. 2013;3(3):207.
5. Ashokan PK, Hussain MA, Poti NN. Quality attributes in Colocasia. Agrie. Res. J. Kerala. 1980;18(1):102-103
6. Bhandari M, Kawabata J. Assessment of antinutritional factors and bioavailability of calcium and Zinc in wild yam. Food Chem. 2004;85(2):281-287
7. Burns RE. Method for Estimation of Tannin in Grain Sorghum. Agronomy J. 1971;63(3):511-512.
8. Chand B, Jaiawal RC, Gautam NC. Genetic variability and correlation studies in Colocasia (*Colocasia esculenta* L.). Haryana J. Hort. Sci. 1987;16(1-2):134-39.
9. Devi HS, Singh V, Duwey RK, Chauhan VBS. Assessment of genetic diversity in taro (*Colocasia esculenta* L.). In: National conference on: Tuber crops (other than potato) for sustainable agriculture and livelihood security in climate change scenario AAU, Jorhat on April. 2013;29:53-54.
10. FAO. Carbohydrates in Human Nutrition. Agriculture and Consumer Protection. WHO, Rome, Italy; c1990.
11. FAO. Taro cultivation in Asia and the Pacific, Food and Agriculture Organization of the United Nations (FAO), Rome, Italy; c1999.
12. FAOSTAT. FAO org. Retrieved 6 December 2019.
13. Habashy HN, Radwan HM. Chemical, physical and technological studies on *Egyptian taro*. Annals of Agricultural Science Cairo. 1997;42:169-185.
14. Hodge JE, Hofreiter BT. Determination of reducing sugars and carbohydrates. In: Whistler, R.L. and Wolfrom, M.L., Eds., Methods in Carbohydrate Chemistry, Academic Press, New York; c1962. p. 380-394.
15. Huang KH, Ravindran VLiX, Ravindran G, Bryden WL. Apparent ileal digestibility of amino acids in feed ingredients determined with broilers and layers. J. Sci. Food Agric. 2007;87(1):47-53.
16. Iwuoha CI, Kalu FA. Calcium oxalate and physicochemical properties of cocoyam: *Colocasia esculenta* and *Xanthosoma sagittifolium* tuber flours as affected by processing, Food Chem. 1995;54(1):61-66.
17. Iwuoha I, Kalu A. Calcium oxalate and physic-chemical properties of cocoyam (*Colocasia esculenta* and *Xanthosoma sagittifolium*) tuber flours as affected by processing. Food Chem. 1994;54(1):61-66.
18. Kirtikar KR, Basu BD. Indian Medicinal Plants. Dehradun: International Book Distributors. 2005;4:2615.
19. Krome C, Jauncey K, Lohaus G, Focken U. Phytate analysis and phytase application in *Jatropha curcas* kernel meal for use in aquaculture feeds, AACL Bioflux, 2018, 11(3).
20. Kumoro AC, Putri RDA, Budiyati CS, Retnowati DS, Ratnawati. Kinetics of Calcium Oxalate Reduction in Taro (*Colocasia esculenta*) Corm Chips during Treatments Using Baking Soda Solution International Conference and Workshop on Chemical Engineering UNPAR 2013, ICCE UNPAR, 2013 Procedia Chemistry. 2014;9:102-112
21. Latimer GW. Official Methods of Analysis of AOAC International; AOAC International: Gaithersburg, MD, USA; c2016.
22. Latta M, Eskin M. Simple and rapid colorimetric method for Phytate determination. J Agr. Food Chem. 1980;28(6):1313-1315.
23. Lebot V. Tropical Root and Tuber Crops: Cassava, Sweet Potato, Yam and Aroids. CABI, Wallngford, UK; c2009. p. 413-416.

24. Massey LK, Palmer RG, Horner HT. Oxalate content of soybean seeds (*Glycine max*: Leguminosae), Soya foods and other edible legumes. J Agr. Food Chem. 2001;49(9):4262-4266.
25. Natesh HN, Abbey L, Asiedu SK. An overview of nutritional and anti nutritional factors in green leafy vegetables. Horticult. Int. J. 2017;1(2):58-65.
26. Omoruyi FO, Dilworth L. Anti-nutritional factors, zinc, iron and calcium in some Caribbean tuber crops and the effect of boiling or roasting. J Nutr. Food Sci. 2007;37(1):8-15.
27. Onwueme IC, Winston BC. Tropical root and tuber crops: production, perspectives and future prospects. FAO Plant production and protection paper, 126. FAO, Rome; c1994.
28. Quach ML, Melton LD, Harris PJ, Burdon JN, Smith BG. Cell wall compositions of raw and cooked corms of taro (*Colocasia esculenta*). J Sci. Food and Agri. 2003;81(3):311-318.
29. Rao RV, Matthews P, Eyzaguirre PB, Hunter D. The global diversity of *C. esculenta*: ethnobotany and conservation. Biodiversity International, Rome; c2010.
30. Rashmi DR, Raghu N, Gopenath TS, Palanisamy P, Bakthavatchalam P, Karthikeyan M, *et al*. Taro (*Colocasia esculenta*): An overview. Journal of Medicinal Plants Studies. 2018;6(4):156-61.
31. Soudy ID, Delatour P, Grancher D. Effects of traditional soaking on the nutritional profile of taro flour (Colocasia esculenta L. Schott) produced in Chad. Revue de Medecine Veterinaire. 2010 Jan 1;1:37-42.
32. Sundersan S, Nambisen B. Calcium oxalate content of edible aroids and its effect on acridity. Abstract International Food Conference, Bangalore; c1982.
33. Temesgen M, Retta N, Tesfaye E. Effect of pre-curding on nutritional and anti-nutritional composition of taro (*Colocasia esculenta* L.). Int. J Food Sci. Nut. 2016;1(1):5-11.
34. Vaintraub IA, Lapteva NA. Colorimetric determination of phytate in unpurified extracts of seeds and the products of their processing. Analytical biochemistry. 1988 Nov 15;175(1):227-230.
35. Vinning G. Select markets for taro, sweet potato and yam In: Rural Industries Report for Research and Development Corporation. RIRDC Publication No. 03/052, Kingston Act; c2003.