International Journal of Food Science and Nutrition
ISSN: 2455-4898; Impact Factor: RJIF 5.14
Received: 18-11-2019; Accepted: 19-12-2019
www.foodsciencejournal.com
Volume 5; Issue 1; January 2020; Page No. 91-95

Comparison of selected underutilized yam flours for their proximate and phytochemical composition

Dewni Gunasekara[1*], Ashani Bulathgama[2], Indira Wickramasinghe[3], Isuru Wijesekara[4]
[1-4] Department of Food Science and Technology, University of Sri Jayewardenepura, Nugegoda, Sri Lanka

Abstract
With the urbanization and changing food habits, most of these underutilized yams have lost their significance. However, the study of their nutritional value is insufficient. The overall objective of this study was to evaluate the nutritional composition, functional properties and phytochemical composition of four selected underutilized yam varieties in Sri Lanka; *"Dioscorea alata", "Amorphophallus campanulatus", "Canna indica" and "Dioscorea pentaphylla"*. The moisture content of "*Dioscorea alata*" was the highest (7.75 ± 0.09%) and the lowest was recorded in "*Canna indica*" (6.41 ± 0.04%). All five varieties were low in fat content and highest was recorded in "*Dioscorea alata*" (1.09 ± 0.01%). The crude protein content of "*Dioscorea alata*" and "*Amorphophallus campanulatus*" were 4.28 ± 0.13%, 5.70 ± 0.11% respectively. The highest ash content was recorded in "*Amorphophallus campanulatus*" (4.711 ± 0.36%). All five yam flour varieties were high in carbohydrate content and highest was recorded in "*Canna indica*" (85.28 ± 0.96 %). The observed fiber content in "*Dioscorea pentaphylla*" (5.20 ± 1.08 %) was much higher than the reported value of other yam flour varieties. K was the most predominat element found in each yam flour varieties. The highest K content was recorded in "*Amorphophallus campanulatus*". In antioxidant screening of "*Canna indica*", by using DPPH Radical scavenging activity, showed highest value compared to other varieties. The highest TPC of 42.50 ± 0.98 mg Gallic acid equivalent per g was recorded in "*Canna indica*" and the lowest was recorded as 6.47 ± 0.01 mg Gallic acid equivalent per g in "*Dioscorea pentaphylla*". Functional properties of the five varieties were illustrated by the water holding capacity and oil holding capacity. The highest oil holding capacity and the highest water holding capacity were recorded in "*Amorphophallus campanulatus*" (WHC-243.08 ± 2.56% & OHC-77.04 ± 2.95%).

Keywords: nutritional composition; physicochemical properties; antioxidant; TPC

1. Introduction
Sri Lanka has many underutilized yams with high nutritional potential. Most of their nutritional value has not been investigated yet [1]. Hence, this research attempt to investigate nutritional value of four selected underutilized yam varieties available in Sri Lanka; *Dioscorea alata*, *Amorphophallus campanulatus*, *Canna indica* and *Dioscorea pentaphylla* were used for the study.

Edible *Canna indica* can be divided into two main clusters: the green and red cultivar group [2]. Edible canna is herbaceous plant originated from South America, which its rhizome commonly used and its utilisation not optimise in Sri Lanka. There were the green and red cultivar groups mainly available is Sri Lanka. So this study was to identify the nutritional composition, physiochemical properties and antioxidant potential in each 2 cultivar groups. "*Dioscorea alata*" belongs to Dioscoreaceae family. D. atropurpurea and D. sativa are some synonyms. About 600 species of Dioscorea are consumed in various parts of the world [3]. *Dioscorea alata* have medicinal properties and can be used in Ayurvedic and Western medicine. Earlier, it was mainly grown in the garden. "*Amorphophallus campanulatus*" is a large aroid, which is found throughout Asia. The taxon is reported to occur in China, Bangladesh, India (including the Andaman Islands), Sri Lanka and Samoa. It has been cultivated for centuries in the Asian and Indopacific region and its natural distribution has been totally obscured because many specimens found in the wild are (probably) weedy escapees from cultivation [4]. "*Dioscorea pentaphylla*" is native to South-East Asia. It is not cultivated, grows naturally in the warmer, moist areas in Sri Lanka.

Among the bioactive phytochemicals, polyphenols have been extensively studied as the most abundant antioxidants provided by the human diet [5]. Hence this study was conducted to analyse the antioxidant capacity and total phenolic content in each yam flour varieties. Initially for the raw yams methanol extract, the determination of total phenolic content and antioxidant capacity determination by DPPH radical scavenging assay method were done.Functional properties are the fundamental physicochemical properties that reflect the complex interaction between the composition, structure, molecular conformation and physico-chemical properties of food components together with the nature of environment in which these are associated and measured [6]. Functional characteristics are required to evaluate and possibly help to predict how new proteins, fat, fibre and carbohydrates may behave in specific systems as well as demonstrate whether or not such protein can be used to stimulate or replace conventional protein [7]. Specific objective of this study involved the collection of data on the water holding capacity and oil holding capacity of five underutilized yam flour varieties.

2.1 Materials and methods
2.1. Sample Collection
Fully mature, undamaged raw yams were selected and collected from Agricultural Research Station, Department of Agriculture, Thelijjawila, Sri Lanka. Random sampling

method was used in collecting yam samples. Collected samples were immediately transported carefully to the laboratory of the Department of Food Science and Technology, University of Sri Jayewardenepura, Sri Lanka. At the laboratory, the samples were stored in refrigerated condition (Temperature 4°C to 0°C) until taken to analysis & sample preparations (Maximum duration was one week).

2.2. Preparation of Flour Samples

Yams stored in refrigerator were taken out and washed, hand peeled, and trimmed to remove defective parts. Then the tubers were cut into thin pieces and dried in an air convention oven at 60 °C for 24 h. The dried pieces were powdered using a laboratory scale grinder and sifted through a 300 µm sieve. The flour samples were sealed and packed in separate airtight containers for further analysis.

2.3. Determination of Flour Properties

Microscopic view of each granules were examined under (10x40) microscopic image projection (Scanner and camera - Magnus-7M0215 & light microscope - MC30 made in Australia). Also L*, a*, b* colour values of each flour was measured by using a chromameter (Lovibond® LC100). Colour values were taken as triplicates on different areas of the thallus and the spreaded powder.

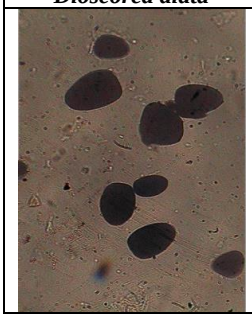
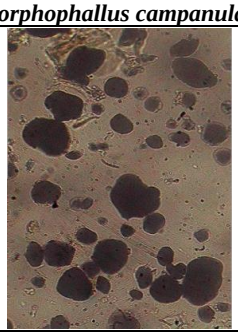
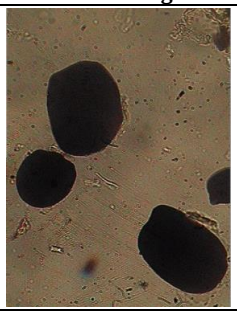
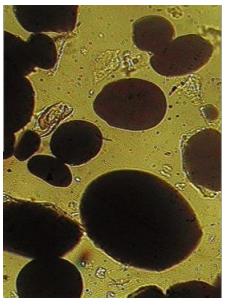
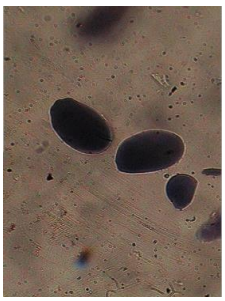
The proximate analysis was carried out to determine the moisture content (AOAC 925.10), crude protein content (AOAC 990.03), total fat content (AOAC 922.06), carbohydrate content [8], and total ash content (AOAC 925.25) of the flour samples. The fiber content was calculated by the difference of the entire proximate parameters. (Fiber content = 100 – (moisture% + ash% + protein% + fat% + carbohydrate %)). The results were expressed in dry weight (DW) basis and all measurements were performed in triplicates. The determination of mineral (Potassium, Calcium, Iron, Zinc, Magnesium, Copper) content was carried out according to AOAC 975.03 method from dry ashing followed by atomic absorption spectroscopy method.

The total antioxidant capacity was determined using DPPH [1, 1-diphenyl-2-picrylhydrazyl] radical-scavenging activity, the procedure followed the method described by [9]. The total phenolic content of the yam flour samples were measured using Folin-Ciocalteu reagent assay according to the method described by [10] with some modifications. For the antioxidant capacity and total phenolic content determination of each five yam flour varieties, methanol extract was used according to [9].

The physicochemical properties; water holding capacity and oil holding capacity of each yam flours were measured in triplicates by the modified methods described by [11] and [12] respectively.

3. Results and Discussion

Table 1: The granule morphology of "*Dioscorea alata", "Amorphophallus campanulatus", "Canna indica*" and "*Dioscorea pentaphylla*" flour varieties

Dioscorea alata	***Amorphophallus campanulatus***	***Canna indica*-green**	***Canna indica* -red**	***Dioscorea pentaphylla***
				

There are various environmental factors affecting the granule morphology has been observed. The granules in the storage root were larger than in the fibrous root. According to the microscopic view obtained from microscopic image projection, all the five varieties of yam flour samples have oval shape granules (figure 01). The growth temperature is also a main factor to affect the granule size and shape. Mainly round, oval and truncated shapes of the granules were in native yams [14].

Table 2: Colour values of "*Dioscorea alata", "Amorphophallus campanulatus", "Canna indica"*, and *"Dioscorea pentaphylla"* flour varieties

Flour Variety	L*	a*	b*
Dioscorea alata	66.97 ± 3.01^{a}	5.07 ± 1.34^{a}	5.93 ± 1.67^{c}
Amorphophallus campanulatus	53.63 ± 0.85^{c}	6.07 ± 1.96^{a}	15.70 ± 1.18^{ab}
Dioscorea pentaphylla	52.00 ± 0.67^{c}	4.50 ± 1.08^{a}	10.80 ± 3.76^{bc}
Canna indica – green	61.27 ± 1.10^{b}	6.47 ± 0.81^{a}	22.03 ± 3.72^{a}
Canna indica – red	65.20 ± 0.17^{ab}	8.27 ± 2.02^{a}	19.37 ± 1.74^{a}

Values are means of at least triplicate determinations while errors are computed as standard errors. a,b,c,d,values in the same raw with different superscript indicates significant differences ($P < 0.05$)

Table 2 above represents the average chromameter colour valurs for each yam flour varieties. Flour color often affects the color of the finished product and is therefore one of many flour specifications required by end-users. Lightness of flour samples were higher due to L* values of all flours were above 50. According to the analysis of variance of a*

values, p value is higher than 0.05. So there was no significance difference of a* value in each five variety of flour samples. Also b*values are higher than a* values of each five flour samples, proved that yellow colour was more prominent when compared to red colour.

Table 3: proximate composition of *"Dioscorea alata", "Amorphophallus campanulatus", "Canna indica"* and *"Dioscorea pentaphylla"* flour varieties

Parameters	*Canna indica* -green	*Canna indica* - red	*Dioscorea pentaphylla*	*Amorphophallus campanulatus*	*Dioscorea alata*
Moisture %	6.62 ± 0.10^{bc}	6.41 ± 0.04^{c}	6.49 ± 0.28^{c}	7.00 ± 0.05^{b}	7.75 ± 0.09^{a}
Protein %	4.00 ± 0.09^{b}	3.97 ± 0.11^{b}	4.20 ± 0.19^{b}	5.70 ± 0.11^{a}	4.28 ± 0.13^{b}
Fat %	0.84 ± 0.02^{b}	0.85 ± 0.03^{b}	0.36 ± 0.02^{d}	0.56 ± 0.04^{c}	1.09 ± 0.01^{a}
Ash %	2.52 ± 0.18^{c}	1.68 ± 0.05^{d}	3.34 ± 0.14^{b}	4.711 ± 0.36^{a}	2.97 ± 0.18^{bc}
Carbohydrate%	84.23 ± 0.80^{a}	85.28 ± 0.96^{a}	80.41 ± 0.99^{bc}	79.27 ± 0.90^{c}	82.01 ± 0.04^{b}
Fiber%	1.80 ± 0.83^{b}	1.81 ± 0.95^{b}	5.20 ± 1.08^{a}	2.75 ± 1.16^{ab}	1.90 ± 0.29^{b}
K	134.4 ± 40.0^{b}	118.1 ± 29.5^{b}	191.6 ± 63.1^{b}	1262.0 ± 222^{a}	1102.3 ± 86.2^{a}
Mg	35.73 ± 3.73^{ab}	44.30 ± 7.37^{a}	19.76 ± 0.98^{bc}	45.08 ± 13.54^{a}	10.67 ± 0.44^{c}
Ca	2.46 ± 0.56^{ab}	0.98 ± 0.13bc	1.39 ± 0.46^{bc}	3.61 ± 1.405^{a}	0.13 ± 0.11^{c}
Zn	0.61 ± 0.10^{bc}	1.66 ± 0.14^{a}	0.44 ± 0.02^{c}	1.19 ± 0.40^{ab}	0.50 ± 0.37^{c}
Cu	0.14 ± 0.03^{a}	0.14 ± 0.04^{a}	0.08 ± 0.02^{a}	0.07 ± 0.02^{a}	0.09 ± 0.08^{a}
Fe	0.67 ± 0.06^{a}	0.51 ± 0.14^{ab}	0.39 ± 0.05^{bc}	0.51 ± 0.11^{ab}	0.14 ± 0.08^{c}

a,b,c,d, values in the same raw with different superscript indicates significant differences ($P < 0.05$)

The moisture content of "*Dioscorea alata*" was the highest (7.75 ± 0.09%) and the lowest was recorded in "*Canna indica* -red" (6.41 ± 0.04%). The moisture contents of all flour varieties were within the acceptable limit of not more than 10% for long term storage of flour (14). The moisture content of "*Dioscorea alata*" (*D. alata L.*) obtained in this experiment (7.75 ± 0.09%) was less than the recorded moisture content of the same species in previous studies (9.97 ± 0.15%) [15]

All four varieties were low in fat content and the highest was recorded in "*Dioscorea alata*" (1.09 ± 0.01%) whereas the lowest was recorded in "*Dioscorea pentaphylla*" (0.36 ± 0.02%). According to ANOVA tukey pairwise comparison test all yam flour varieties except "*Canna indica*-green" & "*Canna indica*-red" showed significant differences between one another at 0.05 significance level. The observed average value for fat content of "*Dioscorea alata*" flour was 1.09 ± 0.01%. This value was similar to the value reported 1.53±0. 31% in [16]. The fat content of *Amorphophallus campanulatus* obtained in this experiment (0.56 ± 0.04%) was less than the recorded fat content of the same species in previous studies (1.414 ± 0.79 %) [17].

The crude protein content of "*Dioscorea alata*", "*Dioscorea pentaphylla*"and "*Canna indica*-green" were 4.28 ± 0.13%, 4.20 ± 0.19 % and 4.00 ± 0.09% respectively. The highest protein content was recorded in "*Amorphophallus campanulatus*" (5.70 ± 0.11%), but this value was less than the protein content recorded by [18]. According to the One Way ANOVA Tukey pairwise comparison test, all "*Amorphophallus campanulatus*" pairs showed significant differences between another yam flour varieties at 0.05 significance level. The protein content of "*Dioscorea alata*" obtained in this experiment (4.28 ± 0.13%) was less than the recorded protein content of the same species in previous study [19]. Protein is essential in the human diet for growth. Protein content of the D. alata varieties ranged between 4.3% for TDa 01/00002 and 8.7% for TDa 85/00250 with a mean of 6.0% [19].

Ash content represents all the inorganic minerals consist within the sample. The decreasing order of ash content were found to be "*Amorphophallus campanulatus*" >"*Dioscorea pentaphylla*" >"*Dioscorea alata*" >"*Canna indica* - green" >"*Canna indica* -red". The highest ash content was recorded in "*Amorphophallus campanulatus*" (4.711 ± 0.36%) and the lowest was recorded in "*Canna indica* -red" (1.68 ± 0.05%). The ash content was recorded in "*Amorphophallus campanulatus*" (4.711 ± 0.36%) was similar to the recorded ash content of the same variety in previous studies (4.83 ± 0.54%) [19]. The ash content of *Canna indica* L. was recorded as 2.85 ± 0.07% in (14). Ash content is a reflection of mineral status, even though contamination can indicate a high concentration in a sample. Value range of ash content of "*Dioscorea alata*" was recorded between 2.9 and 4.1% with a mean of 3.5% [19] was higher than the recorded ash content (2.97 ± 0.18%) in this study.

All five yam flour varieties were high in carbohydrate content and highest was recorded in "*Canna indica* -red" (85.28 ± 0.96 %) whereas the lowest was recorded in "*Amorphophallus campanulatus*" (79.27 ± 0.90%). According to ANOVA tukey pairwise comparison test, yam flour varieties of "*Canna indica* - green" & "*Canna indica* - red" have not shown a significant differences between them at 0.05 significance level. The observed average value for carbohydrate content of "*Dioscorea alata*" flour was 82.01 ± 0.04 %. This value was similar to the value reported 83.61 ± 1.20% in previous studies [15]. The Carbohydrate content of "*Amorphophallus campanulatus*" obtained in this experiment (79.27 ± 0.90%) was higher than the recorded carbohydrate content of the same species in previous studies (70.75%) [15].

The observed fiber content in "*Dioscorea pentaphylla*" (5.20 ± 1.08 %) was much higher than the reported value of other yam flour varieties. The observed average value for fiber content of "*Dioscorea alata*" flour was 1.90 ± 0.29%. This value was higher to the value reported 1.62 ± 0.39% in previous studies [15]. The fiber content of "*Amorphophallus campanulatus*" obtained in this experiment (2.75 ± 1.16%) was less than the recorded fiber content of the same species in previous studies (14.32%) [18].

The most significant macro-elements present in the yam flour varieties were K, Na, Mg and Ca. K was the most predominat element found in each yam flour varieties. The highest K content was recorded in "*Amorphophallus campanulatus*" range between 1040 and 1484 (mg per 100 g of dried flour sample). So it can be concluded that, K content of "*Amorphophallus campanulatus*" was varied to

some extent. The K content was recorded in "*Amorphophallus campanulatus*" was similar to the recorded K content of the same variety in previous studies (1208 ± 5.66) (17). Magnesium is known to be an important mineral for cardiovascular function and its external administration could prevent its intracellular depletion. Magnesium content in the five yams ranged between 19.76 ± 0.98 for "*Dioscorea pentaphylla*" and 45.08 ± 13.54 for "*Amorphophallus campanulatus*" differing significantly between each two varieties at 0.05 significance level. The highest Fe content was recorded in "*Canna indica* – green" and the lowest was recorded in "*Dioscorea alata*". Cu content of each five varieties do not have a significantly different between others at 0.05 significance level. The highest Cu content was recorded in both "*Canna indica* – green" and "*Canna indica* -red" and the lowest was recorded in "*Amorphophallus campanulatus*", 0.14 ± 0.03, 0.14 ± 0.04 and 0.07 ± 0.02 respectively. The quantitative ranges for the various nutrient components in yams may vary due to season, location and analytical methods, however, basic information on chemical and mineral content is of great interest particularly for varieties traditionally used in some communities.

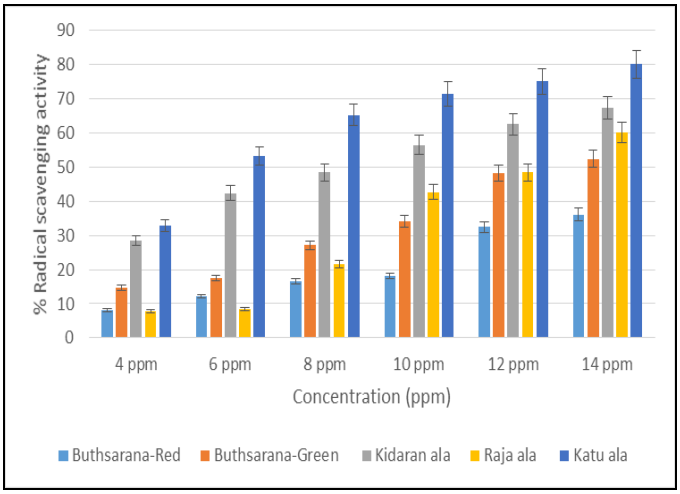


Fig 1: % Radical scavenging activity Vs Concentration of yam flour sample

Yams contain some amounts of other useful antioxidants such as vitamin C and carotenoids which exerts useful physiological effects. The antioxidant activity is system dependent. Moreover, it depends on the method adopted as well as on the oxidation processes [21]. In antioxidant screening of "*Canna indica* -red", by using DPPH Radical scavenging activity, showed highest value in methanolic extract. "*Dioscorea pentaphylla*" samples showed the lowest radical scavenging activity. Methanalic extract showed decrease of absorbance with the increment of concentration of the sample.

Table 4: Total phenolic content of "*Dioscorea alata", "Amorphophallus campanulatus", "Canna indica*" and *"Dioscorea pentaphylla"* expressed in mg GAE/g

Total phenolic content (mg GAE/g)				
Dioscorea alata	***Amorphophallus campanulatus***	***Dioscorea pentaphylla***	***Canna indica-green***	***Canna indica -red***
13.47 ± 0.76^{d}	30.77 ± 0.97^{b}	6.47 ± 0.01^{e}	42.50 ± 0.98^{a}	16.86 ± 0.76^{c}

Mean ± SD (n=3) Different superscripts (a, b, c, d, e) in the same row are significantly different at $p < 0.05$.

The above table 4 indicates the values obtained of TPC for each five yam flour varieties. There was a significant difference among the Total Phenolic Content of different yam flour varieties at 0.05 significance level. The ascending order of TPC was recorded as "*Dioscorea pentaphylla", "Dioscorea alata", "Canna indica -red", "Amorphophallus campanulatus", "Canna indica - green"* when considering the five species. The highest TPC of 42.50 ± 0.98 mg Gallic acid equivalent per g was recorded in "*Canna indica* -green" and the lowest was recorded as 6.47 ± 0.01 mg Gallic acid equivalent per g in "*Dioscorea pentaphylla*".

Table 5: WHC and OHC of "*Dioscorea alata", "Amorphophallus campanulatus", "Canna indica"* and *"Dioscorea pentaphylla"* flour varieties.

Parameters	***"Canna indica - green"***	***" Canna indica-green"***	***"Dioscorea pentaphylla"***	***"Amorphophallus campanulatus"***	***"Dioscorea alata"***
WHC	181.41 ± 2.80^{b}	179.99 ± 3.45^{b}	102.28 ± 2.66^{d}	243.08 ± 2.56^{a}	115.47 ± 1.97^{c}
OHC	69.97 ± 0.54^{b}	70.89 ± 3.58^{ab}	54.12 ± 2.33^{c}	77.04 ± 2.95^{a}	64.73 ± 1.11^{b}

a,b,c,d, values in the same row with different superscript indicates significant differences ($P < 0.05$)

The water holding capacities of the yam flour varieties are shown in the Table 5, the highest water holding capacity were recorded in "*Amorphophallus campanulatus*" and the lowest was recorded in "*Dioscorea pentaphylla*". There was a significant difference between the each varieties of yam flour samples except "*Canna indica* green & red" according to Tukey pairwise comparison test at 0.05 significance level. The oil holding capacity (OHC) of flour is equally important as it improves the mouth feel and retains the flavor [22]. The decreasing order of oil holding capacity were found to be

"*Amorphophallus campanulatus*" >"*Canna indica* -red" >*"Canna indica* - green" >*"Dioscorea alata" >"Dioscorea pentaphylla*". The oil binding capacity was less in "*Dioscorea pentaphylla*" when compared to other varieties. Also the oil binding capacity was lower than the water binding capacity in every samples. It might be due to the hydrophilic properties of each flour samples were higher. There was a significant difference between some yam flour samples according to Tukey pairwise comparison test at 0.05 significance level.

4. Conclusion

The proximate composition, functional properties and phytochemical composition of five selected underutilized yam flour varieties in Sri Lanka were similar to those reported values of most of those yams grown in many parts of the world. Yam flour is a good source of carbohydrates, protein, and minerals. In addition, it has good functional characteristics and can improve the nutritional quality of value-added products.

5. References

1. Rangani GDDM, Bandara BES, Hettiarachchi IC, Sivashankar P. A Study on Consumption Pattern & Awareness of Underutilized Fruits Among Urbanites Within Maharagama Ds Division. J Appl Microbiol. 2015; 119(3):859. {\textendash}867.
2. Sari N, Purnomo, Daryono BS, Suryadiantina, Setyowati M. Variation and intraspecies classification of edible canna (Canna indica L.) based on morphological characters. AIP Conf Proc. 2016; 1744.
3. Agbor-Egbe T, Treche S. Evaluation of the Chemical Composition of Cameroonian Yam Germplasm Evaluation of the Chemical Composition of Cameroonian Yam Germplasm. 1995; (September 1995).
4. Hetterscheid WLA, Ittenbach S. Everything you always wanted to know about Amorphophallus, but were afraid to stick your nose into!!!!! Aroideana. 1996; 19:7-131.
5. Scalbert AG, Williamson. Dietary intake and bioavailability of polyphenols. Journal of Nutrition. 2000; 123:20735-855.
6. Siddiq M, Nasir M, Ravi R, Dolan KD, Butt MS. Effect of defatted maize germ addition on the functional and textural properties of wheat flour. Int. J. Food Prop. 2009; 12:860-870.
7. Mattil KF. the functional requirement of protein in foods. J. Am. Oil Chem. Soc. 1971; 48:477
8. Dubois M, Gilles KA, Hamilton JK, Rebers PA, Smith F. <Dubois1956.pdf>. 1956; 350–6.
9. Hsu CL. *et al*. "Chemical composition, physical properties, and antioxidant activities of yam flours as affected by different drying methods," Food Chemistry. 2003; 83(1):85–92. Doi: 10.1016/S0308-8146(03)00053-0.
10. Li Y. *et al*. "Total phenolic, flavonoid content, and antioxidant activity of flour, noodles, and steamed bread made from different colored wheat grains by three milling methods," Crop Journal. Crop Science Society of China and Institute of Crop Science, CAAS. 2015; 3(4):328–334. Doi: 10.1016/j.cj.2015.04.004.
11. Mesías M, Morales F. Effect of Different Flours on the Formation of Hydroxymethylfurfural, Furfural, and Dicarbonyl Compounds in Heated Glucose/Flour Systems. Foods [Internet]. 2017; 6(2):14. Available from: http://www.mdpi.com/2304-8158/6/2/14
12. Chandra S, Samsher. Assessment of functional properties of different flours. African J Agric Res [Internet]. 2013; 8(38):4849–52. Available from: http://www.academicjournals.org/AJAR
13. Otegbayo B, Oguniyan D, Akinwumi O. Physicochemical and functional characterization of yam starch for potential industrial applications. Starch/ Staerke. 2014; 66(3-4):235–50.
14. David O, Arthur E, Kwadwo SO, Badu E, Sakyi P. Proximate Composition and Some Functional Properties of Soft Wheat Flour. Int J Innov Res Sci Eng Technol. 2015; 4(2):753–8.
15. Obadina AO, Babatunde BO, Olotu I. Changes in nutritional composition, functional, and sensory properties of yam flour as a result of presoaking. Food Sci Nutr. 2014; 2(6):676–81.
16. Senanayake SA. Characterization of starches from underutilized tubers and yams and development of modified starches from sweet potatos (Ipomea batatas (L) Lam), 2014, (L).
17. Basu S, Das M, Sen A, Choudhury UR, Datta G. Analysis of complete nutritional profile and identification of bioactive components present in Alocasia indica tuber cultivated in Howrah District of West Bengal, India. Asian Pac J Trop Med. 2014; 7(S1):S527–33.
18. Srivastava S, Verma D, Srivastava A, Dixit B, Corm RB. Phytochemical and Nutritional Evaluation of Amorphophallus campanulatus Nutrition & Food Phytochemical and Nutritional Evaluation of Amorphophallus campanulatus (Roxb.) Blume Corm, 2014, (July).
19. Baah FD, Maziya-dixon B, Robert A, Oduro I. Nutritional and biochemical composition of D. alata (Dioscorea spp.) tubers, 2009, (April).
20. Okonwu K, Ariaga C. Nutritional Evaluation of Various Parts of Canna indica L. Annu Res Rev Biol [Internet]. 2016; 11(4):1–5. Available from: http://www.sciencedomain.org/abstract/17617
21. Yaich H. *et al*. 'Effect of extraction procedures on structural, thermal and antioxidant properties of ulvan from Ulva lactuca collected in Monastir coast', International Journal of Biological Macromolecules. Elsevier B.V. doi:10.1016/j.ijbiomac.2017.07.141.
22. Islam MZ, Taneya MLJ, Syduzzaman M, Hoque MM. Physicochemical and Functional Properties of Brown Rice (Oryza sativa) and Wheat (Triticum aestivum) Flour and Quality of Composite Biscuit Made. 2012; 10(November):20–8.