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Evaluation of physicochemical properties in different cultivars of Taro [*Colocasia esculenta* (L.) Schott]: A comparative study

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Abstract
Taro (*Colocasia esculenta* L. Schott) is a member of the *Araceae* family and is an important source of carbohydrate and is used as a staple in some tropical and subtropical areas of the world. Although taro is rich in digestible carbohydrates, micronutrients and is quite affordable, it remains largely underutilized. In this work, the physical attributes as well as biochemical components of taro such as L-ascorbic acid, phenol content, dry matter, moisture, starch, titratable acidity, total sugar and reducing sugar are studied to compare the variation among seven different cultivars grown in the Indian subcontinent. The result of the study revealed that the cultivar TTR-17-10 showed better qualitative attributes on post harvest analysis. It had higher total soluble solids (5.333 ^{0}Brix), starch (35.713%), reducing sugar (3.357%) and total sugar (5.947%) as compared to other cultivars that were studied. However, when it comes to antioxidant content such as L-ascorbic acid cultivar TTR-12-8 (114.117 mg/100gm) showed a significantly better performance as compared to other cultivars studied.

Keywords: Colocasia, esculenta, sugars, starch, taro, titratable acidity, total phenols, TSS

Introduction

Taro (*Colocasia esculenta* (L.) Schott) also called as *Colocasia* or *Eddoe* or *Arvi* is a tropical tuber crop belongs to the monocotyledonous family *Araceae* of the older *Arales* whose members are known as aroids (Henry, 2001 and Van Wyk, 2005) [9, 24]. Taro is known to have originated from the tropical region between India and Indonesia (Matthews, 2004) [15] and has been grown in the South Pacific for hundreds of years (FAO, 1992) [5]. It is grown throughout the tropics and sub-tropics and is also known as “Potato of the Tropics”.

Taro serves as staple source of diet for people around the world and it is the fourteenth most consumed vegetable worldwide (Rao *et al.*, 2010) [20]. Globally taro is cultivated in an area of around 1.9 million ha with an annual production of 10 m t and average yield of 53 t ha^{-1}. Most of the world production of taro is in Africa, followed by Asia and Oceania. Nigeria is the largest producer of taro in the world with an annual production of 2.8 million metric tons which accounts for 27% of the world’s total production. China, Japan, Thailand and Philippines are the major producers of taro in Asia; while in Oceania, production is dominated by Papua New Guinea, Fiji, Solomon Islands, Samoa and Tonga (FAO, 2019) [7].

Nutritional value is the main concern when a crop is being considered as a food source. A great emphasis is placed on the nutritional value of food by consumers, as a result of which need exists for information on the nutritional contents of root crops (Huang *et al*., 2007) [11]. Malnutrition and food shortage among the poor rural population is highly evident. Cultivation of crops like colocasia will not only increase food production, but also provide balanced nutrition to the deprived sections of the nation. As a consequence, popularizing taro cultivation and identifying suitable cultivars for nutritional value is important. However, taro remains a largely underutilized crop in our country and cultivated only in small pockets having very limited industrial uses. The main reason is due to the fact that the crop has high moisture content and respiration rate and there are almost no standard postharvest management techniques which leads the crop to deteriorate rapidly during storage due to mechanical injury sustained during postharvest handling. So, in order to reduce the post harvest losses, expand its range of usage and consequently benefit from its hidden economic potential, the present study was conducted with aims to increase its demand in the market by evaluating some of the promising cultivars grown under West Bengal condition in India.

Materials and Methods

Experimental site

The present investigation was conducted in the humid tropical region of India in the Department of Post Harvest Technology of Horticultural Crops, faculty of Horticulture, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia District, West Bengal, India during the period from 2019- 2020. The materials used, experimental details, and techniques employed in the investigation are furnished as follows:

Methods

7 different cultivars of taro TTR-17-9, TTR-17-10, TTR-17-11, Muktakeshi, TTR-12-1, TTR-12-8, and TTR-12-8, were acquired from the All India Coordinated Research Projects (AICRP) on tuber crops, Mondouri farm, West Bengal, were studied under this experiment with 3 replications each. The design of the experiment implemented was Completely Randomized Design (CRD) adopted from the statistical procedure of Gomez and Gomez (1984) [8].

Moisture content and dry-matter content in a sample was recorded by oven drying 10g of sample at 60 ^{0}C, till a constant weight was obtained (Rangana, 2000) [19].

Total soluble solids (TSS) were determined by using a Hand refractometer. The reading was expressed as ^{0}Brix (A.O.A.C., 1985) [1].

Titratable acidity and ascorbic acid was determined by titrating the sample extracted in distilled water against 0.1N NaOH and 2, 6 dichloro-indophenol dye titration method (Ranganna, 2000) [19] respectively.

Total sugar and reducing sugar level was estimated by the copper reduction method, using Fehling's solution and methylene blue indicator (Ranganna, 2000) [19].

Total phenols were estimated according to the procedure given by Swain and Hillis (1959) [23] and Walter and Purcell (1979) [25]. Reagents used are sodium carbonate (20%), folin-ciocalteau reagent, and ethyl alcohol (95%). A standard curve was drawn using gallic acid as standard. Different concentrations of gallic acid were prepared and optical density was read at 750 nm wavelength. The concentration of samples was calculated based on the standard curve.

Amount of starch present in the samples was determined as per Rangana (2000) [19]. After the sugar present in the sample has been leached out starch is hydrolyzed using acid and estimated as invert sugar.

Starch (%) = % Reducing sugar × 0.9

Results and Discussion

Physical attributes

Several physical attributes of different taro cultivars are summarized in Table 1. Cormel girth in different cultivars studied was significantly different from one another. Among the taro cultivars studied, TTR-17-10 (208.553mm) recorded highest average cormel girth followed by TTR-17-11 (203.043mm) and TTR-17-9 (187.153mm) recorded lowest average cormel girth.

Table 1: Physical attributes of taro cultivars

Cultivar	Flesh colour	Cormel girth (mm)	Length (cm)	Specific gravity (Kg m^{-3})	No. of cormels (per plant)	Weight of cormels per plant (in kg)	Yield (t/ha)
TTR-17-9	White	187.153	6.067	0.503	87.333	1.633	8.29
TTR-17-10	White	208.553	5.633	0.770	67.667	1.683	6.44
TTR-17-11	White	203.043	6.967	1.180	115.333	1.883	10.47
MUKTAKESHI	White	196.903	8.400	0.763	116.000	0.683	11.27
TTR-12-1	White	194.417	8.500	0.880	39.667	0.833	10.25
TTR-12-3	White	197.117	5.333	0.953	43.000	0.533	3.48
TTR-12-8	White	190.217	4.500	1.050	42.000	0.883	6.64
MEAN		196.771	6.485	0.871	73.000	1.161	8.123
S.Em ±		0.933	0.268	0.016	3.568	0.037	0.209
C.D at 5%		2.856	0.819	0.050	8.466	0.112	0.639

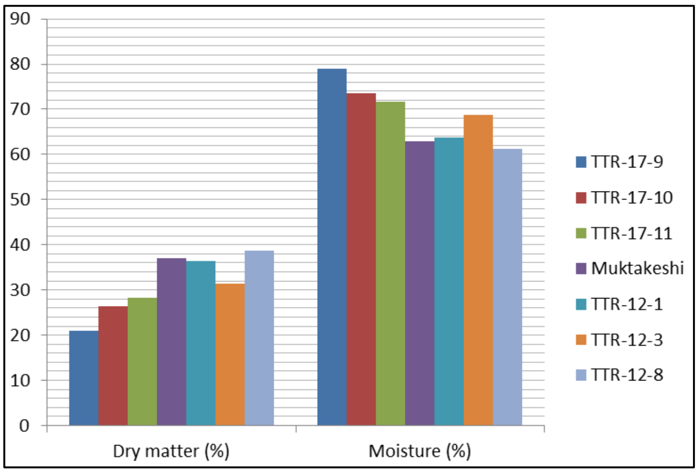

Fig 1: Comparison of Dry matter and Moisture content between different Taro cultivars

The average length of the cormels also varied significantly from one cultivar to another. TTR-12-1 had the average cormel length of 8.500 cm which was the highest among all cultivars followed by muktakeshi which had 8.400 cm and TTR-17-11 with 6.967 cm cormel length. The lowest average cormel length was recorded in cultivar TTR-12-8.

Significant variation in specific gravity was also recorded among different taro cultivars. Highest specific gravity was recorded in cultivar TTR-17-11 (1.180 Kg m^{-3}) followed by TTR-12-8 (1.050 Kg m^{-3}) and TTR-12-3 (0.953 Kg m^{-3}) and the lowest specific gravity was recorded in TTR-17-9 with only 0.503 Kg m^{-3}. According to Hollyer *et al.*, (2000) [10], the specific gravity of raw taro corms varies in a narrow range of 0.94 – 0.98 Kg m^{-3}, and more mature corms have higher value. According to this study the variation in specific gravity may be mainly due to inherited traits determined by the genetic makeup of a cultivar.

The number of cormels obtained varied significantly and a maximum average number of cormels was observed in the variety Muktakeshi (116) followed by TTR-17-11 (115.333) while the least number of cormels was observed in TTR-12-1 (39.667) as seen in Table 1. Miyasaka *et al.*, (2001) also reported that inadequate rainfall during the time of greatest water need resulted in lower yield and percentage corm dry matter in taro.

Weight of cormels per plant also varied significantly. Highest weight was recorded in TTR-17-11 followed by TTR-17-10 and TTR-17-9 i.e., 1.883 kg, 1.683 kg and 1.633 kg respectively. Lowest weight per plant was recorded in TTR-12-3 (0.533 kg) followed by TTR-12-1 (0.833 kg) which was found to be significantly at par with TTR-12-8 (0.883 kg). Similar results were found by Angami *et al.*, (2015) [3] in which he stated that variation in weight of cormels may be due to accumulated storage of foods, the moisture content in the corm, etc, and thus have a direct bearing on crop yield. Yield also varied significantly in different cultivars. Maximum yield in Muktakeshi (11.27 t ha^{-1}) and lowest (3.48 t ha^{-1}) in TTR-12-3 was recorded (Table 1). This may be due to differences in planting date and temperature changes during the growth of taro as stated by Lu *et al.*, (2001) [14].

Dry matter and moisture content

Dry matter content is an important determining factor for both processing and selling in fresh markets. Corms with higher dry matter content tend to be more susceptible to bruising and disintegrate more rapidly. There was a significant variation recorded in the dry matter content among various taro cultivars in the present study. TTR-12-8 recorded maximum dry matter content of 38.73%, followed by Muktakeshi (37%) and TTR-12-1 (36.33%). The lowest dry matter content was observed in TTR-17-9 *i.e.*, 21% as shown in Table 2; Figure 1. The table also summarizes the moisture content of taro cultivars which was found to be significantly varied. As dry matter content was observed the least in TTR-17-9, this variety recorded the highest moisture content of 79% followed by TTR-17-10 (73.53%) and TTR-17-11 (71.73%). Cultivar TTR-12-8 had the lowest moisture percentage (61.26%). According to Huang *et al.*, (2007) [11], moisture content of taro varies with variety, growth condition and harvest time and in general the moisture content of taro ranges from 60- 83%. Angami *et al.*, (2015) [3] also summarized in his findings that at harvest, dry matter content ranged from 27.50% to17.17% and moisture content ranged from 82.83% to 72.50% in different cultivars that he studied.

Titratable acidity

Titratable acidity among the cultivars was found to be insignificant as most of the cultivars were statistically at par with each other. The highest acidity was found in TTR-17-11 (0.231%) followed by TTR-17-10 (0.157%) which had the same amount of titratable acidity as TTR-12-3 and TTR-12-8. The lowest reading however was recorded by TTR-12-1 (0.073%) which was statistically at par with TTR-17-9 (0.084%) (Table 2; Figure 2). Nevertheless, a study conducted by Panja *et al.*, (2017) [18] observed that the titratable acidity in elephant foot yam (similar tuber crop) varied from 0.144% to 0.226% in different cultivars, hence, indicating that the titratable acidity of tuber crops and corms are comparatively low as compared to other crops such as fruits and vegetables.

Table 2: Dry matter (%), Moisture (%), Titratable acidity (%) and TSS (^{0}Brix) of taro

Cultivars	Dry matter (%)	Moisture (%)	Titratable acidity (%)	TSS (^{0}Brix)
TTR-17-9	21.000	79.000	0.084	3.600
TTR-17-10	26.467	73.533	0.157	5.333
TTR-17-11	28.267	71.733	0.231	1.867
Muktakeshi	37.000	63.000	0.126	2.600
TTR-12-1	36.333	63.667	0.073	3.267
TTR-12-3	31.333	68.667	0.157	2.867
TTR-12-8	38.733	61.267	0.157	3.667
Mean	31.304	68.695	0.140	3.314
S.Em±	1.393	1.393	0.056	0.282
CD at 5%	4.266	4.266	N/A	0.863

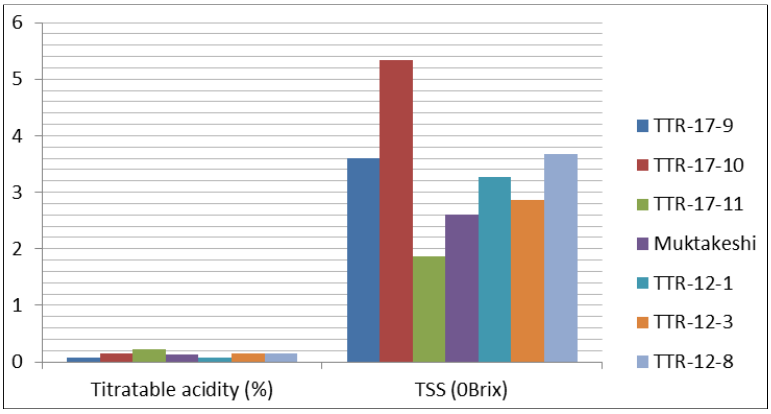

Fig 2: Comparison of Titratable acidity and TSS content in different taro cultivars

Total soluble solids (TSS)

Kamiloglu, (2011) [12] stated that TSS is a major quality parameter, which is correlated with the texture and composition. Significant variation in TSS content of different cultivars of taro was observed (Table 2; Figure 2). Cultivar TTR-17-10 recorded a maximum TSS content of 5.333 ^{0}Brix followed by TTR-12-8 (3.667 ^{0}Brix) which was statistically at par with TTR-17-9 (3.6 ^{0}Brix) as summarized in Table 2. The least amount of TSS was recorded by cultivar TTR-17-11 (1.867 ^{0}Brix). Kandil *et al.*, (2011) [13] explained that TSS in tuber crops is a function of the amount of pectin and the density of the finished products much of which is the ability to take up nutrients and convert sucrose to carbohydrate in tubers. Angami *et al.*, (2015) [3] in his research on several varieties of taro corms reported a TSS range of 1.60 ^{0}Brix to 5.85 ^{0}Brix.

Starch

According to Njintang *et al.*, (2007) [17] starch is the most important component (73- 80%) of taro. In the present study, starch percentage in taro cultivars ranged from 35.713% to 12.453% as seen in Table 3; figure 4. The highest of which was found in TTR-17-10 (35.713%), followed by TTR-17-9 (20.837%) which was statistically at par with TTR-12-1 (20%). However, cultivar Muktakeshi showed a significantly lower starch content of 12.433% as compared to other cultivars. Surajit and Tarafdar (2015) [22] also recorded similar variations in starch content (13.71% to 18.36%). A study conducted by Shellikeri *et al.*, (2019) [21] in his study also reported that the starch content varied from 13.57% to 24.13%.

Ascorbic acid

Ascorbic acid is an important phytochemical in plants which is necessary for the growth, development and repair of all body tissues. Many functions in our body such as formation of collagen, absorption of iron, proper functioning of immune system, etc., require vitamin-C. Ascorbic acid was also found to be present in taro corms showing various degrees of significant variation among the cultivars. The highest amount of ascorbic acid was recorded in the cultivar TTR-12-8 with 114.117 mg/100gm of ascorbic acid followed by TTR-12- which contains 105.767 mg/100gm of ascorbic acid. Among the cultivars TTR-17-10 had the lowest ascorbic acid content of 42.863 mg/100gm (Table 3; Figure 4). FAO (1999) [6] also states that vitamin C (ascorbic acid) and vitamin B complex (niacin, riboflavin and thiamin) which are important constituents of human diet, are present in appreciable quantity in corms and leaves of taro.

Sugars

Sucrose is the most important sugar found in taro, but fructose, maltose, glucose and raffinose are also present. Sugar content is also an important factor accounting for their usability in processing. Table 3; Figure 3 also represents the comparison of total sugar and reducing sugar content in various taro cultivars. Both total sugar and reducing sugar showed significant variation. The highest total sugar was found in TTR-17-10 (5.947%) followed by TTR-17-9 (4.440%) and TTR-17-11 (3.787%). The lowest 2.173% was found in TTR-12-3. Reducing sugar was recorded highest in the cultivar TTR-17-10 (3.357%) followed by TTR-12-1 (2.377%). Lowest reducing sugar was recorded in TTR-12-3 (1.310%). Angami *et al.*,(2015) [3] also reported a similar finding in his work where he tested several different cultivars of taro in the North eastern region of India and found that the total sugars ranged from 5.58% in cultivar Nainital and lowest was found in BCC-1A with only 1.60% of total sugar content.

Table 3: Starch (%), Ascorbic acid (mg/100gm), Total sugar (%), Reducing sugar (%) and Phenol (mg GAE/ 100gm) of taro

Cultivars	Starch (%)	Ascorbic acid (mg/100gm)	Total Sugar (%)	Reducing sugar (%)	Phenol (mg GAE/ 100gm)
TTR-17-9	20.837	51.213	4.440	1.920	250.470
TTR-17-10	35.713	42.863	5.947	3.357	140.730
TTR-17-11	15.043	56.78	3.787	1.647	129.300
Muktakeshi	12.453	52.327	3.030	2.230	111.930
TTR-12-1	20.000	105.767	2.673	2.377	128.70
TTR-12-3	16.480	94.633	2.173	1.310	59.270
TTR-12-8	13.120	114.117	3.420	1.450	76.800
Mean	19.092	73.957	3.638	2.041	128.170
S.Em±	0.883	5.491	0.083	0.115	1.800
CD at 5%	2.704	16.815	0.254	0.351	5.511

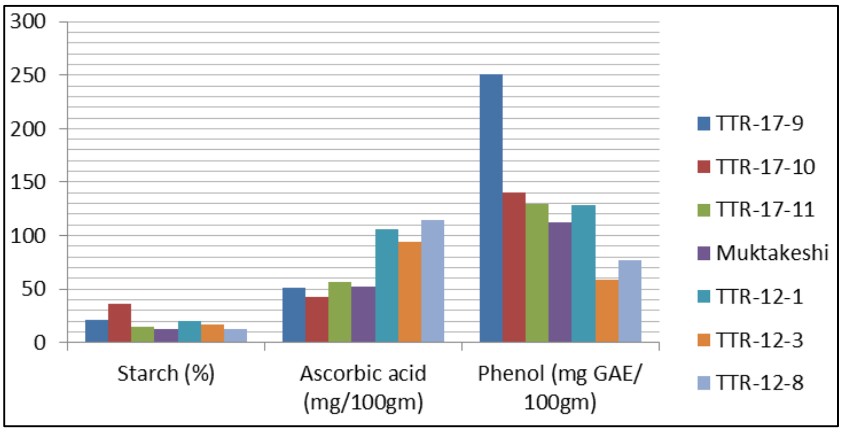

Fig 3: Comparison of Starch, Ascorbic acid and Phenols in different taro cultivars

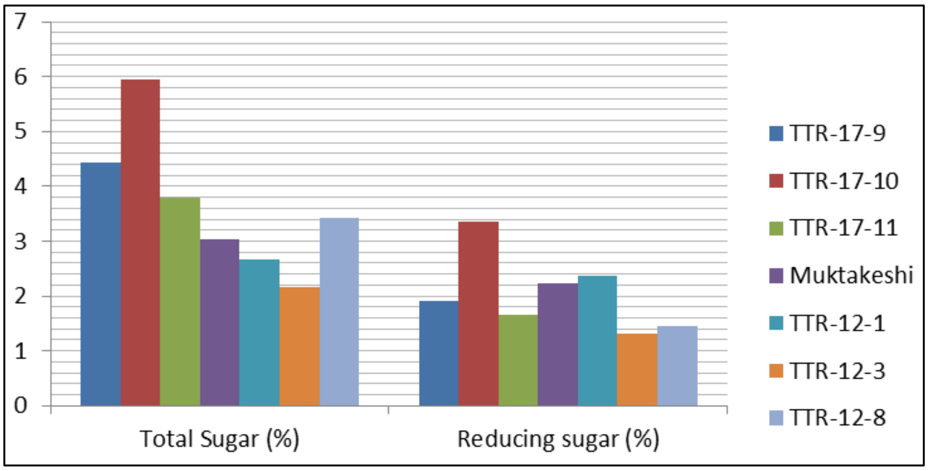

Fig 4: Comparison of Total sugar and Reducing sugar content in different taro cultivars

Total phenol

According to Dai and Mumper (2010) [4] phenolic compounds have potent antioxidant properties and expressed marked effects in the prevention of numerous oxidative stress associated diseases such as cancer. In this experiment phenol content was measured in mg galleic acid equivalent per 100gm. The cultivars showed wide significant variation among each other and the highest total phenol content was observed in TTR-17-9 (250.470 mg GAE/100gm) followed by TTR-17-10 (140.730 mg GAE/100gm), TTR-17-11 (129.30 mg GAE100gm), TTR-12-1 (128.70 mg GAE/100gm), Muktakeshi (111.930 mg GAE/100 gm) and TTR-12-8 (76.80 mg GAE/100gm). Lowest phenol content was observed in TTR-12-3 (59.270 mg GAE/100gm) as shown in Table 3: Figure 4. The findings in this research are in partial agreement with Alcantara *et al.*, (2013) [2] who found similar variations in phenolic content of raw taro corms ranging from 34 mg/100gm to 78 mg/100gm. Similarly, Njintang *et al.*, (2007) [17] observed total phenol content of taro corms varied from one variety to another in different countries.

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