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PHYTO-CHEMICAL AND NUTRITIONAL PROFILING OF TENDU FRUIT (*DIOSPYROS MELANOXYLON ROXB.*) AND EVALUATION OF ITS SHELF STABILITY

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ABSTRACT

Tendu fruit is one of the important forest fruit found in major part of India. Originally, plant is well known for its leaves as Bidipatta for making bidi in tribal areas of India. Since, the tendu fruit supposedly have very short shelf-life, therefore, the present study has been undertaken to evaluate the shelf stability as well as the nutritional and phytochemical potential of the fruit. The complete proximate analysis including the mineral and vitamin profiling of the pulp, skin and seeds were done. The fruit pulp was found to be especially rich in calcium, magnesium, sodium, potassium, phosphorous, thiamine, riboflavin, niacin and vitamin C, with potassium being as high as 305.52±8.94 mg/100 gm (wet basis). The fruit skin was found to have high amounts of crude fibre, potassium, calcium, phosphorous & magnesium, whereas for seeds, the values of protein, crude fibre and oil were 7.02±0.53 % 25.13±0.41 and 5.54±0.07 % respectively. The storage stability of the fresh fruit was found to be 5 days at 25°C and 65 % R.H. During storage, pH of fruit reduced drastically with an increase in acidity value from 0.12±0.00% to 2.09±0.01 %. The reading of Browning index (A_{420nm}) also gradually increased from 0.2257 to 0.4766. The DPPH scavenging activity, Hydrogen peroxide scavenging activity, Hydroxyl radical scavenging activity, and Reducing power assay of fruits were observed to be very high. Gallic acid and Tannic acid content in fruits was reported as 28.43% and 25.74 % respectively on dry basis.

Keywords: Tendu, Forest, Tribal, Vitamin, Mineral, Antioxidant activity and Phytochemical.

INTRODUCTION

Tendu/ Kendu (*Diospyros melanoxylon Roxb.*) belongs to family Ebenacea. The fruit is found in deciduous forest of India. An adult tree yields around 80-100 kg of fruits per year. Tendu plant is more popular among the people for its leaves than its fruits (Jamil *et al.*, 2020). The leaves of the plant are being used for wrapping bidis (country cigarette). The fruit has a great socio-cultural importance in Odisha, Jharkhand, Madhya Pradesh, Maharashtra and Karnataka especially among the tribal communities (Kadereshwar, 2015 & Gupta *et al.*, 2013). The tree is important for the tribal as they use the leaves of the tree for preparation of Bidis and generating livelihood. They also use to sell the fresh fruit for income generation and use dried fruit pulp for consumption in rainy season when shortage of the food/ food grains is being faced by them (Bahera 2009).

In India, the fruit appears in the month of March-April and harvesting/ collection is done by forest dwellers /tribals only as it comes under Minor Forest Produce category. The colour of the fruit is of light brown to yellow golden with short shelf life. The fruit is round, of small size and resemble with sapota in size and shape. However; the rind/ peel/skin of the fruit is comparatively harder than sapota. The fruit pulp is sweet in taste and have pleasant flavour (Pradhan, 2008). The fruit contains 3-5 seed embedded firmly in the pulp. The seeds are dark brown in color and

their seed coat is very hard. The inner part of the seeds is white in color.

The fruit get wasted due to lack of proper technology for value addition in forest area (Mohite *et al.*, 2018). The plant is traditionally used for its medicinal properties. The bark of tendu plant is astringent and its decoction is used in diarrhoea and dyspepsia. A dilute extract is used as an astringent lotion for the eyes (The Wealth of India, 1952). The present study has been aimed to evaluate the phytochemical, antioxidants and nutritional profiling of tendu fruits, and determination of shelf stability of fresh fruit at room temperature (28±2°C). This will help in reducing the wastage of this highly perishable fruit by developing low cost technologies for preparation of value-added products rich in nutrition and phytochemicals. The products developed may prove to be an extra source of income for tribals. The study also opens the door for exploiting the medicinal and nutraceutical potential of the whole fruit including pulp, skin and seeds.

MATERIALS AND METHODS

Sample preparation

The Tendu fruits were collected from local market of Ranchi, Jharkhand during the month of April to Mid-June. The freshly harvested fruits were cleaned, washed and stored at ambient conditions *i.e.* 25±1°C and 65±2

% relative humidity for further studies. The fruit pulp was removed manually with the help of stainless steel knife and spoon. The seeds and skin were separated from the pulp. The pulp, skin and seeds were stored separately under refrigerated conditions. All the chemicals and standards used were of analytical grade quality.

Pulp, Skin and Seed Ratio

The diameter of the fruit was measured with the help of slide callipers having least count of 0.01 cm (Mohite and Sharma, 2018). Then, the weight of the fruit was taken and fruit's pulp, seeds and skin were isolated. Also, the weight of each part was taken separately. The purpose of this study was to analyse the percent of fruit pulp that can be obtained from the whole fruit.

Color estimation

Colour of the fruit pulp and skin was measured manually with the help of Chroma meter (Chroma Meter CR-400, Minolta, Japan). The values of three coordinates- whiteness or brightness/darkness (L), redness/greenness (a) and Yellowness/blueness (b) were observed (Mohite *et al.*, 2020). These were used to calculate, hue, chroma and Browning Index using the method stated by Apkinar *et al.*, 2003.

Proximate Analysis

The proximate composition of the whole fruit including pulp, skin and seeds were determined according to established methods. The moisture content of the fruit was determined by hot air oven method (AOAC, 2012). The crude protein, crude fat and ash were determined by using standard protocols (Mohite *et al.*, 2018). The values were calculated and expressed in percentage (wb). Total carbohydrate was calculated as the percentage difference in sample mass to the sum of the other components. (IS: 1656(2007)).

Carbohydrate (% , wb) = 100 – [Moisture (%) + Crude protein (%) + Crude fat (%) + Ash (%)]

Crude Fibre

Crude fibre was estimated as per Indian Standard IS:10226 wherein the defatted sample was boiled for 30±1 min with standard concentration solution of sulphuric acid and washing the insoluble residue. The remaining residue was again boiled with standard concentration of sodium hydroxide for 30± 1 min. Then the residue was washed, weighted and determined the loss of mass on incineration (Jamil *et al.*, 2020).

Mineral Analysis

Mineral composition was determined according to AOAC method. Atomic Absorption spectrophotometer of (Varian make, Model no. AA280 FS) was used for the

analysis of minerals. NIST Traceable Minerals standards were used to draw curve. Iron and Zinc were estimated as per AOAC 999.11 at 248.3 & 213.9 nm respectively. Calcium, magnesium, manganese, sodium and potassium were analysed as per AOAC 975.03 and AOAC 985.35 respectively in fruit pulp and skin. As per the method, organic matrix was destroyed by dry ashing in muffle furnace, and obtained ash was dissolved in dilute acid. The values of calcium, magnesium, manganese, sodium and potassium were taken at 422.7 nm, 285.2 nm, 279.5 nm 589.0 nm and 766.5 nm respectively. The phosphorous was determined by UV- Vis spectrophotometer as per AOAC 965.17, where 2 gm of ash was treated with acid and a solution was prepared with 20 ml of molybdovanadate reagent and reading was taken at 400 nm in UV-Vis spectrophotometer after getting curved from NIST Traceable Phosphorous standard.

Vitamins Analysis

Vitamin C analysis was performed using 2,6-dichlorophenol indophenol dye method as per IS: 5838. Further, HPLC method (Water 486 tunable absorbance with UV- Vis detector, a reversed phase C-18 (25 x4.6 mm, 5 µm) HPLC column) was used to determine Vitamin B₁ (Thiamine), B₂ (Riboflavin) and B₃ (Nicotinamide). The mobile phase composition used was 70:30, 70 % buffer (Sodium salt of Hexane Sulphonic acid) and 30% methanol (HPLC grade). The pure standards of nicotinamide, riboflavin and thiamine were prepared by taking 50 mg standard with 70 % sodium salt of sulphonic acid and 30 % of methanol for each vitamin. Different concentrations of standard were prepared as per requirement by diluting the pure standard solution, and analysed using the same chromatographic conditions. Samples were prepared by weighing 15 gm of fruit pulp and add 40 ml of HPLC Water and 1 ml ammonia and volume was made up to 100 ml with buffer solution i.e. salt of hexane sulphonic acid, glacial acetic acid and deionized water /HPLC water. The samples and standards were run in HPLC and the concentration of the respective vitamins were calculated.

Phytochemical Characterization

DPPH-Scavenging Activity Assay

The dried fruits were powdered in a laboratory mixer (Philips mixer, 0.5KWh motor). 2 g of powdered sample was taken in round bottom flask containing 30 ml of ethyl alcohol and refluxed on water bath for 1h. The resultant extract was cooled and filtered. The ethanolic extract of the fruit sample was also prepared using distilled water as solvent. The filtrate (1ml) was taken in a petri plate and dried in hot air oven at 55°C to know the amount of residual extract per ml (Paliwal and Sharma, 2020). The DPPH radical scavenging activity was measured according to the method described by Du *et al.*, (2013). The extract solution (0.1 mL) with variable concentrations (0.05–0.2 mg/mL) was added containing 2.9 mL of DPPH solution

(0.1 mM in ethanol). The mixture was incubated for 30 min at 37°C in dark. Then the absorbance was measured at 517 nm. Ascorbic acid was used as the standard for the assay.

Hydrogen Peroxide Scavenging Activity

The scavenging efficacy of the fruit extract against hydrogen peroxide was determined according to the method described by Li *et al.*, (2006). A solution of hydrogen peroxide (2 mmol/L) was prepared by using pH 7.4 phosphate buffer. The polysaccharides (0.05–0.2 mg/mL) solution was added to a hydrogen peroxide solution (0.6 mL). The phosphate buffer without hydrogen peroxide was taken as blank. Absorbance was measured at 230 nm and ascorbic acid was used as a standard.

Scavenging activity of hydroxyl radical

The hydroxyl radical scavenging activity was determined following the procedure as described by Xu *et al.*, (2009). The reaction mixture comprised of 0.3 mL of sodium salicylate (20 mM) and samples (0.05–0.2 mg/mL), 0.7 mL of H₂O₂ (6 mM), 1 mL of FeSO₄ (1.5 mM). Then, this mixture was incubated for 1 h at 37°C and absorbance was measured at 562 nm. For control, the sample was substituted with ascorbic acid.

Ferric Reducing Antioxidant Potential (FRAP)

The ferric reducing power assay was performed following the method of Du *et al.*, (2013). The reaction mixture was comprised of 1 mL samples (0.05–0.2 mg/mL), 2 mL phosphate buffer (0.2 M, pH 6.6) and 2 mL 1% (w/v) Potassium Ferricyanide. This mixture was incubated at 50°C for 20 min. After cooling instantly, 2 mL of Trichloroacetic acid (TCA, 10%, w/v) was added to complete the reaction. Then the reaction mixture was centrifuged at 2000 rpm for 10 min. The supernatant (2.5 mL) was mixed with 2.5 mL distilled water and 1 mL of 0.1% (w/v) ferric chloride, and kept for 10 min. The absorbance of the reaction mixture was read at 700 nm against a blank. Ascorbic acid was used as standard.

Gallic acid content (Total Polyphenol Content)

The gallic acid content in the dry powder of the fruit pulp was determined with HPLC run. The compound was extracted in fruit powder with 40 % ethanol. Further, the obtained extract was injected into C₁₈ SPHERISORB column, WATERS connected with PDA detector at 280 nm. Gallic acid was used as standard, where different concentrations (1, 5, 10, 20, 30, 40 µg/mL) were prepared for the calibration curve. The percent gallic acid in the sample was determined from the standard calibration curve of gallic acid. The mobile phase used was 0.01 M potassium dihydrogen phosphate-acetonitrile (85:15, v/v) and the pH was adjusted to 3.2±0.1. (Paulo *et al.*, 2017)

Tannic acid Content

Tannic acid in the fruit pulp is determined with HPLC. The tannic acid was extracted in fruit pulp powder by refluxing in 40 % ethanol. The extracted solution was injected in column (C₁₈ SPHERISORB column), WATERS connected with PDA detector at 280 nm. Tannic acid was used as standard, where different concentrations (10- 40 µg/ mL) were prepared for the calibration curve. The percent tannic acid in the sample was determined from the standard calibration curve of tannic acid. The mobile phase was water containing 0.1 % acetic acid: acetonitrile is 60:40 (Paulo *et al.*, 2017).

Total Flavanoid Content

Total Flavanoid content was determined in aqueous methanol extract of pulp powder by adding 2% aluminium chloride solution with extract (Mishra *et al.*, 2020). The absorbance was taken at 40 nm in spectrophotometer. Rutin was used as standard and the results were expressed as rutin equivalent (Sies *et al.*, 2005)

β-Carotene

Carotene estimation was done as per IS 5889 wherein the fruit pulp was extracted with petroleum ether and then separated and purified from non- carotene pigments. The absorbance readings were taken with UV- Vis Spectrophotometer at 440 nm with the standard curve obtained from β- Carotene standard.

Shelf Stability Study of the Fruit

As soon as the fruits were collected, they were transported to the laboratory of Amity Institute of Food Technology, Uttar Pradesh on the same day. The fruits were kept at ambient conditions at 25 ±1°C & 65 ± 2 % R.H. The shelf-stability study of the fruit was conducted with several parameters such as acidity, pH, sugar, TSS, browning index, sensory evaluation and microbiological count for each day.

Sugar content and TSS

Sugar was quantified with the protocol IS: 6287, where Fehling's solution was used with methylene blue indicator. The total soluble solid was determined with hand refractometer and expressed in °Brix.

pH and Titratable acidity

The pH of pulp was estimated with pH Meter and standard solution of pH 4.0 & 7.0 as reference to calibrate the equipment. The titratable acidity was done as per IS: 2860 wherein 10mL water was added with 10 gm of sample and titrated against standard sodium hydroxide solution using phenolphthalein indicator.

Browning Index

The browning index was carried out wherein fruit pulp extracted using 20 ml of 65 % ethanol. The mixture was left at 27°C for 30 min and filtrate was used to take absorbance at 420 nm (Supapavanich *et al.*, 2011).

Sensory Evaluation

The sensory evaluation was done using a semi-skilled panel of 25 members. The sensory evaluation of fruits attributes viz. color and appearance, taste, flavour, texture and after taste/mouth feel and overall acceptability were done (Joshi, 2006). The panellists include both male and female members. A nine-point hedonic rating scale anchored by 'dislike extremely' to 'like extremely' was used.

Microbiological Analysis

Total plate count, Yeast and Mold count and Coliform count were done in the fruit pulp during storage period as per IS 5402, IS: 5403 & IS 5401 respectively (Mohite and Chandel, 2020).

Statistical Analysis

All the sample analysis was done in triplicates. The data was subjected statistically for analysis of variance (ANOVA) followed by Duncan's test, which was carried out at a significance level of 0.05 using SPSS using 16.0.

RESULTS AND DISCUSSION

Proximate composition	Pulp	Skin	Seeds
Moisture	70.33±2.02 ^a	30.87±1.63 ^b	10.01±0.58 ^c
Ash (g)	1.81±0.03 ^a	3.27±0.20 ^b	2.26±0.16 ^c
Protein (g)	0.57±0.05 ^a	1.93±0.08 ^b	7.02±0.53 ^c
Fat (g)	0.59±0.38 ^a	1.48±0.12 ^b	5.54±0.07 ^c
Crude Fibre (g)	6.59±0.05 ^a	35.39±1.60 ^b	25.13±0.41 ^c
Carbohydrate (g)	26.70 ±0.06	62.45 ±0.12	75.17 ±0.17

Mean values with different letter a,b,c on the different row differ significantly (Duncan's test, $p \leq 0.05$).

Table 1: Proximate composition of tendu fruit

Parameters (mg/ 100 g)	Mean ± S.D.
Iron (Fe)	0.66±0.03
Calcium	90.86±2.41
Magnesium	56.29±1.55
Sodium	87.11±1.49
Potassium	305.52±8.94
Manganese	1.26±0.02
Phosphorus	167.3±3.06
Zinc	0.67±0.05

Mean value in rows are significantly different ($p < 0.05$); S.D.; Standard deviation

Table 2a: Mineral composition of fruit pulp

Fruit pulp, skin and seeds ratio

The diameter of ripened fruits varies in the range of 2.79-3.81 cm, with most of the fruits having diameter in the range of 3.43-3.56 cm. The weight of each component of the fruit was measured and the result indicated that the pulp content of the fruit is 35.71 %, skin content as 33.93% and seeds content as 30.38%, whereas the whole fruit weight on average was 22.40 gm (Fig 1). This indicates a low pulp ratio from fruit, which means less edible portion. But, as the fruit is available at very low cost, so it can be used for development of products involving use of low-cost technologies. The combined seed and skin content of fruits have been reported as low as 10% in guava to as high as 70-75% in durian and jack fruit depending upon the type of fruit (Sagar *et al.*, 2018).

Color estimation

The average L*, a* and b* values for fresh fruit pulp were found to be 46.99±1.78, 6.78±1.20 and 28.02±2.99 respectively. The high b* value indicates that the fruit pulp is yellow in colour. The skin shows a higher value for a* indicating increase in browning on separation. The browning of skin may happen due to action of enzymes on components of skin resulting in enzymatic browning (Mohite *et al.*, 2018).

Proximate analysis of Tendu fruit pulp, skin and seeds

The proximate composition of tendu is represented in the

Parameters (mg/ 100 g)	Mean ± S.D.
Iron (Fe)	6.79±0.34
Calcium	470.37±1.67
Phosphorous	38.08±1.17
Potassium	1012.3±2.96
Magnesium	67.49±1.21

Mean value in rows are significantly different ($p < 0.05$); S.D.; Standard deviation

Table 2b: Mineral composition of skin

Days	1 st Day	2 nd Day	3 rd Day	4 th Day	5 th Day
pH	5.94 ±0.06	4.56±0.06	4.21±0.03	4.00±0.03	3.95±0.03
Acidity (as % citric acid)	0.12±0.00	0.52 ±0.00	0.96 ±0.01	1.66±0.04	2.09±0.01
Sugar g/ 100g	10.47 ±0.04	11.17±0.03	10.01±0.04	7.07±0.05	6.86±0.04
Browning index (A _{420nm})	0.2257	0.2824	0.3147	0.3846	0.4766
Total Plate count (cfu/ 10 g)	No growth < 10 cfu/10 gm	No growth < 10 cfu/10 gm	3.32 log cfu/ g	3.60 log cfu/ g	3.73 log cfu/ g
Y& M Count (cfu/ 10g)	No growth < 10 cfu/10 gm	No growth < 10 cfu/10 gm	2.81 log cfu/ g	2.89 log cfu/ g	2.95 log cfu/ g
Coliform count	No growth	No growth	No growth	No growth	No growth
Taste	Very good	Very good	Good	Good	Not so good

Table 4: Shelf-life analysis of Tendu fruit

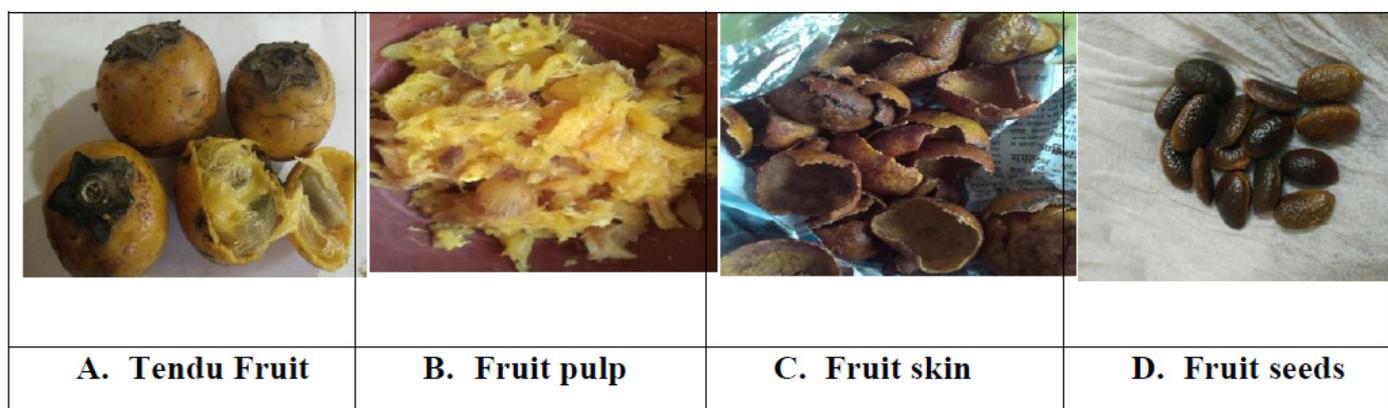


Fig.1 A. Freshly collected Tendu Fruit B. Fresh fruit pulp C. Freshly peeled skin D. Freshly pitted seeds

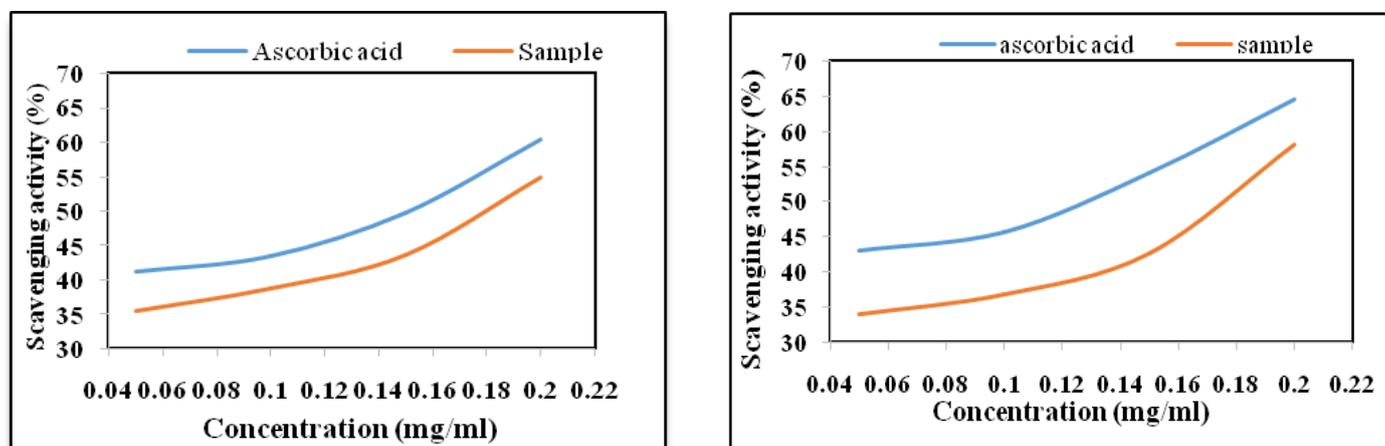


Fig. 2. DPPH scavenging activity (a) and Hydrogen peroxide scavenging activity (b) of fruit extract

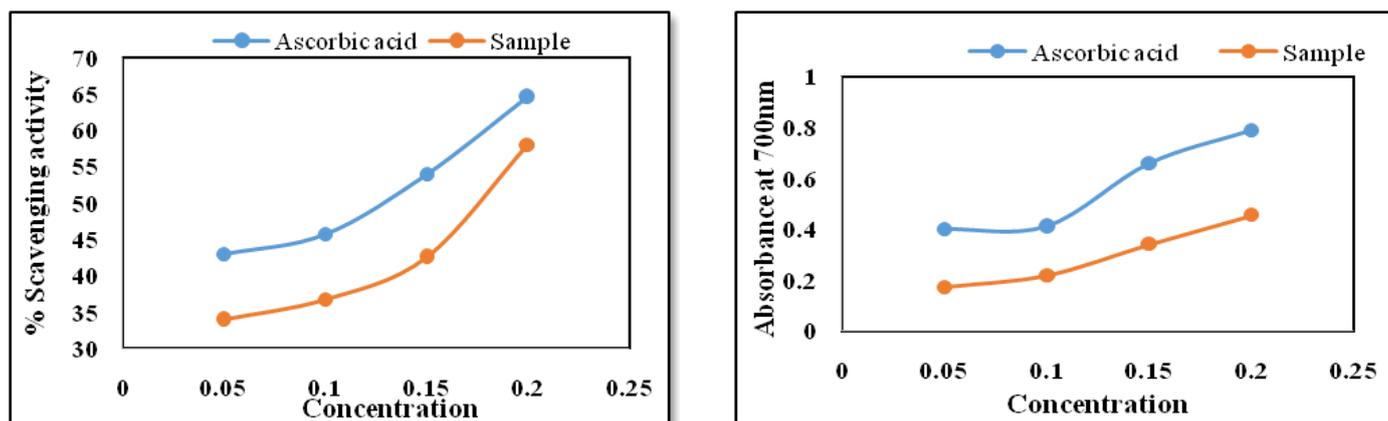


Fig. 3. Hydroxyl radical scavenging activity (a) and Reducing power assay (b) of fruit extract

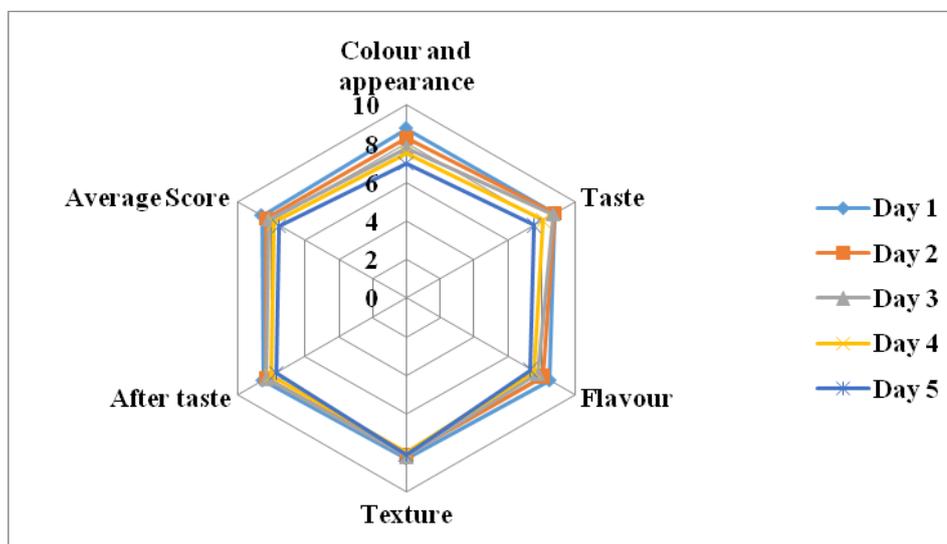


Fig.4: Sensory Analysis fruit on per day interval

Table 1. The moisture content in the fruit pulp is found to be higher, whereas, the protein, ash and fat content value were found to be less in comparison to the values reported by Hmar *et al.*, (2017). Although, the carbohydrate content value was to be almost same. This may be attributed to difference in harvest locations. The physical and chemical characteristics of fruits and vegetables have been reported to be influenced by several factors including varietal differences, soil types, weather conditions and time of harvest as well as post-harvest handling (de Souza *et al.*, 2012). In comparison to pulp, the fruit skin and seeds were found to contain higher amount of protein, fat and ash with a significant decrease in moisture values. L*, a* and b* values of different components (pulp, skin and seed) of tendu fruits were found to be related positively with ash and fat content, but, negatively with protein content.

Crude Fibre Content

Crude fibre includes a mixture of various carbohydrate polymers present in plants (such as cellulose, resistant starch, pectin, gums, inulin and hemicelluloses) that may be associated with lignin and other non-carbohydrate components (such as saponins and waxes). The tendu fruit pulp, skin and seeds with reported crude fibre content of $6.59 \pm 0.05\%$, $35.39 \pm 1.60\%$ & $25.13 \pm 0.41\%$ respectively, are a rich source of crude fibre. Dietary fibre is known to have many health benefits and 25–30 g/day of daily fibre intake is recommended for an individual (Singh *et al.*, 2016).

Mineral Composition of the fruit pulp and skin

The mineral composition of the tendu fruit pulp is given in Table 2a. As reflected from Table 2, the tendu fruit pulp is found to be an excellent source of macrominerals like potassium, phosphorous, calcium, sodium and magnesium. These minerals are essential for various body functions and help in preventing many diseases. Apart from these, the manganese, zinc and iron were found to be 1.26 mg/100gm, 0.67 mg/100gm and 0.66 mg/100 gm

respectively. The Potassium content of 305.52 mg/100gm in the tendu fruit pulp is comparable to the Kiwi fruit which is reported to have 312 mg/100 gm potassium and is considered as one of the richest sources of potassium (Lynley, 2013). Similarly, the magnesium content is comparable with the spinach, calcium with rhubarb and phosphorus with beans and lentils (Gopalan *et al.*, 1989). Martinez-Ballesta *et al.*, (2010) reported an iron content ranging from 0.1 to 3 mg/100 g in various fruits and vegetables.

The potassium and calcium content in the tendu fruit skin was found to be 1012 mg/100gm and 470.37 mg/100gm respectively. Besides this, presence of a fair amount of phosphorous, magnesium and iron in skin was indicated with a value of 38.08 mg/100gm, 67.49 mg/100 gm & 6.79 mg/100gm respectively. Since fruit peel has significantly high concentrations of different minerals, it can be utilized for the production of nutraceuticals. Also, it can be used for the purpose of animal feed. Szefer and Grembecka (2006) reported the presence of manganese (ranging between 0.01 and 0.67 mg/100 g) and zinc (ranging between 0.02 and 0.6 mg/100 g) in different fruits and vegetables.

Vitamin Composition of the fruit pulp and skin

The fruit pulp and skin were analysed for the vitamin content. The results obtained in fruit pulp for vitamin B₁, B₃ & B₃ were 0.34mg/100gm, 2.79 mg/100gm, 1.16 mg/100gm respectively. Besides this, fruit pulp also contained Vitamin C and beta-Carotene at a level of 20.38 mg/100gm and 336.33 mg/100 gm respectively. The values for vitamin C was found to be higher, but beta-carotene showed less value in comparison to the values reported for tendu fruit by Hmar *et al.*, 2017, which may be due to difference in soil and weather conditions from where the fruits were grown and harvested. The values of vitamin B₁, B₃ and B₃ in fruit skin were 0.30 mg/100g, 2.09 mg/100g, and 1.16 mg/100gm respectively.

Phytochemical analysis of fruit pulp

The polyphenolic content in terms of tannic acid and Gallic acid in fruit pulp powder was found to be 25.75mg/100 gm (wb) and 28.43 mg/100gm(wb) respectively. Folin-Ciocalteu reagent colorimetric method is a widely used method for the estimation of Total Phenolic Content (Paliwal *et al.*, 2018). The benefits of using this method is the low cost and simplicity, but it cannot be used for the determination of individual ingredients and does not represent the true antioxidant activity of foods owing to the possible interactions between these components and the food matrix. Therefore, the antioxidant activity was evaluated using the parameters such as DPPH

Scavenging activity, Hydrogen peroxide scavenging activity, Hydroxyl radical scavenging activity, Reducing power assay in aqueous and ethanol extract of fruit pulp. DPPH antioxidant activity ranged between 2.6 and 5.5 mM TE/g for different fruits, while it ranged from 2.1 to 4.7 mM TE/g for different vegetables. For fruits pulp, the highest DPPH scavenging activity was observed for black carrot, while the lowest was observed for orange carrot. (Gopalan, 1989). Fig 2 and Fig 3 showed that the antioxidant activity of tendu fruit, although lower than control, but still showed high values indicating that the fruit has a high antioxidant potential. The fruit can serve as an excellent source of phytochemicals as a part of regular diet. The total flavanoid content was found to be 1.12 µg/mL, RE, which is comparable to the value reported by Sailakshmi, et al., 2018 for ripened fruit pulp.

Shelf stability study of the fruit

The shelf stability of the fruit was studied and found to be 5 days. The fruits were stored at room temperature at 25 ±1°C at 65±2 RH in an open basket (Table 4). During the storage pH value decreased from 5.94 to 3.95, and acidity increased from 0.12% to 2.09% from day one to day five. The increase in acidity may be due to acid formation, degradation of polysaccharides and oxidation of reducing sugars or break down of pectin into pectinic acid naturally available in fruit pulp (Damiani et al, 2012). In the same manner the sugar content of the fruit were observed to be 10.47 % on first day and 6.86 % on 5th Day. Titrable acidity increased gradually and is similar to that in sea Buckthorn and Russian Orange (Ohkawa, 2009). The increase in the titrable acidity corresponds to a decrease in sugar content, TSS and in pH. The browning index was found to be increasing during the storage studies from 0.2257, to 0.4766. The browning of the fruit pulp is due to polyphenol oxidase (PPO) enzymes which oxidises phenolic compounds naturally present in the fruit (Kasim et al, 2015). During storage of fruit, initially for two days no TPC (Total Plate Count) and YMC (Yeast and Mould Count) were observed. However, on 3rd day onwards TPC and YMC were found to be 3.32 log cfu/ g and 2.81 log cfu/g respectively, and on 5th day the number increased to 3.73 log cfu/ g and 2.95 log cfu/ g for TPC and YMC. Although no coliform count was reported during the storage of fruits. The score of organoleptic evaluation of the fresh fruit during storage period of 5 days are presented in the Fig 4. The overall acceptability of the fresh fruit on day one is observed to be 8.58 which decreases to 7.56 on 5th Day. Major changes were observed in color and appearance which may have happened due to browning reaction, which darkens the color of pulp with each passing day.

CONCLUSION

The outcome of the study revealed that the fruit pulp is of high nutritional value and can be a cheap source of sugar,

essential mineral such calcium, magnesium, potassium and phosphorous along with Vitamin C, B₁, B₂, B₃ and β-carotene. The skin of the fruit is a good source of crude fibre, magnesium, potassium, phosphorous, calcium and can be used as a low-cost source for extraction of phytochemicals, or can be utilized for animal feed or manure preparation. Further, phytochemical analysis of tendu fruit indicates that its pulp is an excellent source of bioactive compounds which have many health and medicinal benefits, the seed of the fruit is rich in crude fibre and protein which can be locally used by tribal people for many purposes. The shelf stability of the fruit was found to be 5 days only.

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