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# PROXIMATE ANALYSIS AND MINERAL COMPOSITION OF POTENTIAL MINOR FRUITS OF WESTERN GHATS OF INDIA

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***Abstract***

*A study on fifteen minor fruits belonging to eleven families was undertaken. The fruits were harvested from different geographic locations of Western Ghats, viz., Uttar Kannada, Dharwad and Ooty. Ethnobotanically, various parts of these plants are utilized for treatment of wide array of health disorders such as jaundice, diabetes and dysentery. Fruits were screened for their proximate composition and mineral content. Further the relationship and variation between different attributes analyzed was investigated using two different statistical approaches such as principal component analysis and agglomerative hierarchical clustering. Phenological characters among the studied fruits varied greatly indicating that the fruits occur at different seasons of a year. In the present study, proximate and mineral composition analysis of the fruits indicated that these minor fruits are rich source of nutrients and minerals. Study indicated that fruits such as Carissa spinarum, Opuntia dillenii, Flacourtia indica, Syzygium caryophyllatum, Ixora coccinea, Buchanania cochinchinensis and Phoenix sylvestris contained adequate quantity of nutrients. PCA analysis revealed variability of 53.97% as contributed by the first two components. Cluster analysis classified the fruits into four major groups. Therefore, these underutilized fruits act as potential source of essential nutrients and minerals to the rural communities and can find application in the nutraceutical and food industries.*

***Key words**: agglomerative hierarchical clustering, minerals, proximate composition, principal component analysis, underutilized fruits.*

## INTRODUCTION

Fruits are essential part of human diet. They comprise good amount of antioxidants and essential nutrients such as polyphenols, flavonoids, minerals and vitamins (WHO, 2003). Inadequate consumption of fruits has resulted in several serious disorders. Regular intake of fruits and their products has shown lower incidence of cardiovascular diseases and cancer (Grivetti and Ogle, 2000; Anand et al., 2008; Hall et al., 2009). In addition, they have also been attributed to increase the immunity against various infections (Veer et al., 2000; Bernstein et al., 2002; Seeram, 2008). Minor fruits such as wild, unutilized and under utilized serve as alternative for food during food deficit and are considered as most valuable nutritional supplements for diet. It is pertinent to mention that a tropical country like India has more than 150 species of edible minor fruit species (Mazumdar, 2004; Mitra et al., 2008; Giampieri et al., 2012). In addition, these fruits act as source of income for rural communities. Small fruits are utilized and consumed more in rural areas in comparable to that of urban areas. Some of the small are rich source of nutrients and known to be beneficial for health. However, due to insufficient knowledge and increased urbanization, consumption and utilization of these fruits are declining and in most cases neglected. Previous reports suggests that these fruits comprise fair amount of essential nutrients and minerals which may not be found in cultivated fruits (Stadlmayr et al., 2013; Rahman and Rahman, 2014).

Minerals play a predominant role in maintaining good health (Maughan et al., 1999). Essential minerals help to fight diseases and promote good health. Many previous epidemiological reports suggest that lack of essential minerals in dietary intake can result in increased incidence of diseases (Key et al., 2004). Lack of essential minerals, *viz*., iron, zinc, sodium, copper and magnesium in the body cause some chronic diseases including cardiovascular disease, diabetes and hypertension (Steyn et al., 2004; Volpe, 2013). Moreover, human body cannot synthesize these minerals sufficiently and only they can be obtained externally through the diet (Nath and Gill, 1993; Milton, 2003).

Nowadays, chemometric tools finds application in easy determination and classification of geographic origin of food products based on the complex experimental data (Alonso-Salces et al., 2006; Woodcock et al., 2007). Previous reports indicate that principal component analysis (PCA) has been successfully employed to characterize various food products based on their antioxidant capacities, phenolic content and geographical origin (Rodríguez-Delgado et al., 2002; Wesolowski and Konieczynski, 2003). For instance, PCA was used to evaluate similarities and variations among 10 different Icelandic seaweeds depending on their phenolic content and antioxidant activity (Wang et al., 2009). In another study, PCA was used to categorize pomegranate juices depending on their antioxidant profiles and thus they could observe key determinants (Cam et al., 2009). PCA acts as powerful statistical tool that allows illustration of variations and similarities between multiple factors depending on multi-dimensional experimental data. More recently, Patras et al. (2011) evaluated the application of chemometric tools, *viz*., principal component analysis and cluster analysis to distinguish between fruits and vegetables depending on their antioxidant profiles, wherein different antioxidant groups were considered for the study.

The present study was undertaken to evaluate the proximate and mineral composition of fifteen potential under utilized fruits from Western Ghats of India. Further two statistical tools such as PCA and cluster analysis were employed to characterize and distinguish the fruits based on their nutrient composition.

## MATERIALS AND METHODS

### Study area and fruit collections

Fifteen minor fruits were collected from different location of Western Ghats, India, whose scientific names, vernacular names and the place of collection has been shown in Table 1. All the collected fruits were determinated and herbarium was deposited at the Department of Botany, Karnatak University, Dharwad, India.

### Proximate analysis and mineral composition

The fruits were washed cleanly, manually deseeded, chopped in to small pieces and oven dried at 45±5°C. Further the samples were pulverized into fine powder with the help of pestle and mortar. This was used for further analysis. Proximate composition of fruits was analyzed following methods of AOAC (2005). Briefly, nitrogen content was determined using the Kjeldahl method and protein content was calculated by multiplying nitrogen conversion factor (6.25). Moisture was determined by heating 5g of powdered sample in a hot air oven at 100±2°C until constant weight was obtained. Crude fat was determined by acid digestion which was further extracted with petroleum ether in a Soxhlet apparatus. Ash value was determined by incinerating the sample at 550±5°C for 5-6 h. Crude carbohydrate was calculated using the formula: 100 – (moisture – protein – fibre – fat – ash). Calorific value was calculated with Atwater conversion factor (4 for protein and carbohydrate and 9 for total fat). Minerals such as phosphorus (P), potassium (K), copper (Cu), iron (Fe), magnesium (Mg), zinc (Zn), calcium (Ca) and sodium (Na) of the fruits were determined following the methods of AOAC (2005) using atomic absorption spectrophotometer.

### Statistical analysis

Triplicate analysis was carried out and values are represented as mean of three assays on a dry weight basis. XLSTAT software (2014.5.03, Addinsoft, NY) was used for principal component analysis (PCA) and agglomerative hierarchical clustering (AHC).

## RESULTS AND DISCUSSIONS

The selected minor fruits used in the presented study are depicted in Figure 1 and the results of proximate composition and mineral content is represented in Table 2 and Table 3, respectively. Based on the calorific values, the fruits can be ranked in descending order as *P. dulce* > *B. cochinchinensis* > *S. caryophyllatum*

> *P. sylvestris* > *E. tectorius* > *S. pinnata* > *P. loureirii* > *F. indica* > *C. spinarum* > *I. coccinea* > *Z. oenopolia* > *S. anacardium* > *O. dillenii* > *S. jambos* > *A. cardiosperma*. The ash content of the fruits denotes the overall availability of minerals. The ash value varied from 3.36-0.24% from highest to lowest. Fats are essential as they are rich source of energy, further they help in absorption and transportation of fat-soluble vitamins especially A, D, and E. Generally, fruits comprise very low amount of fat (Lichtenstein and Van Horn, 1998). However, in the present study the fruits showed considerable variations in the fat content. *P. sylvestris*, *P. loureirii*, *B. cochinchinensis* and *E. tectorius* showed higher content of fat in comparable to rest of fruits. Among the minerals, iron is considered as an essential as it provides energy and supplies oxygen. Iron deficiency may lead to anaemia (Cook, 2005). Magnesium deficiency may lead to severe disorders such as diarrhoea, hypertension and cardiovascular diseases (Swaminathan, 2003). Nevertheless, it helps to tackle muscle cramping. Calcium accounts for most predominant element in the body and is essential in regulating muscle contractions and formation of bones (Soetan et al., 2010). Zinc is associated with cell growth and testosterone production, further it aids in metabolism of vitamins A and E. It is reported that its deficiency may cause several severe disorders including poor appetite and night blindness (Evans, 1986). In the present study, among the analyzed fruits, *P. sylvestris*, *P. loureirii*, *B. cochinchinensis* and *E. tectorius* exhibited a higher value of minerals when compared to other fruits.

Table 1. Botanical description of minor fruits collected and used in the present study

| Scientific name | Local name | Family name | Place of collection | Abbreviation |
|---|---|---|---|---|
| *Aporosa cardiosperma* (Gaertn) Merr. | Salle mara | Phyllanthaceae | Uttar Kannada | AC |
| *Buchanania cochinchinensis* (Lour.) M.R.Almeida | Nurukalu hannu | Anacardiaceae | Uttar Kannada | BC |
| *Carissa spinarum* L. | Kouli hannu | Apocynaceae | Uttar Kannada | CS |
| *Elaeocarpus tectorius* (Lour.) Poir | Bikki palzam | Elaeocarpaceae | Ooty | ET |
| *Flacourtia indica* (Burm.f.) Merr. | Karimullu hannu | Salicaceae | Uttar Kannada | FI |
| *Ixora coccinea* L. | Hole daswala | Rubiaceae | Uttar Kannada | IC |
| *Opuntia dillenii* (Ker Gawl.) Haw. | Papaskalli | Cactaceae | Dharwad | OD |
| *Phoenix loureiroi* var. *pedunculata* (Griff.) Govaerts | Tale karjura | Arecaceae | Dharwad | PL |
| *Phoenix sylvestris* (L.) Roxb. | Kadu karjura | Arecaceae | Dharwad | PS |
| *Pithecellobium dulce* (Roxb.) Benth. | Seeme hunase | Leguminosae | Dharwad | PD |
| *Semecarpus anacardium* Blanco | Gerr hannu | Anacardiaceae | Dharwad | SA |
| *Spondias pinnata* (L. f.) Kurz | Huli amate | Anacardiaceae | Uttar Kannada | SP |
| *Syzygium caryophyllatum* (L.) Alston | Kuntu nerle | Myrtaceae | Uttar Kannada | SC |
| *Syzygium jambos* (L.) Alston | Pannerale | Myrtaceae | Uttar Kannada | SJ |
| *Ziziphus oenopolia* (L.) Mill. | Pargi hannu | Rhamnaceae | Uttar Kannada | ZO |

PCA employed in the present study reduced the data dimensionally and represented the experimental data in a simpler way. Principal components (PC) 1 and 2 explained 54% of total variance of data. The biplot for PC1 vs PC2 is depicted in Figure 2. Figure 2a clearly indicates the scatterplot of distinction between different fruits. It is apparent from these biplots that fruits can be easily categorized depending on their nutrient contents. Figure 2b explains the location of minor fruits in the quadrants based on the factor loadings, *viz*., proximate composition and mineral components. The minor fruits such as *O. dillenii*, *S. anacardium* and *C. spinarum* contained a significant amount of fibre, potassium and sodium. Further *P. sylvestris*, *P. loureirii*, *B. cochinchinensis* and *E. tectorius* were found to contain fair amount of ash, fat, phosphorus, iron, zinc and magnesium; whereas, *P. dulce*, *S. caryophyllatum* and *S. pinnata* fruits were rich in carbohydrates, protein and calcium. Nevertheless, fruits such as *S. jambos*, *A. cardiosperma*, *F. indica*, *I. coccinea* and *Z. oenopolia* expressed high content of moisture. Copper was found in moderate quantity in all the fruits located in the lower bottom of the components.

AHC categorized the minor fruits into four major groups based on similarities. Dendrogram has been depicted in Figure 3 which clearly distinguishes minor fruits in to four main clusters and exhibited a significant correlation with the PCA analysis. The first cluster included *A. cardiosperma*, *S. jambos*, *Z. oenopolia* and *I. coccinea* which have been clustered orderly depending on their moisture content, whereas second cluster was represented by *O. dillenii*, *S. anacardium* and *C. spinarum* based on higher content of fibre, potassium and sodium, among these three *O. dillenii* showed slight higher content that's how it formed different sub cluster. Cluster 3 had 3 fruits wherein *S. pinnata* formed a single sub cluster, *S. caryophyllatum* and *F. indica* showed similar pattern. Finally, cluster 4 comprised 5 fruits, wherein the first sub cluster represented two fruits *P. sylvestris* and *P. loureirii*, which were almost similar in nutrient composition while the second subcluster had *E. tectorius*, *P. dulce* and *B. cochinchinensis*. Further *P. dulce* and *B. cochinchinensis* showed much more similarity. Fruits observed in cluster 4 exhibited higher content of ash, fat, phosphorus, iron, zinc and magnesium.

Table 2. Proximate composition of ripened minor fruits on dry weight basis*

| Scientific name | Moisture (%) | Ash (%) | Crude fat (%) | Crude Fibre (%) | Crude protein (%) | Crude carbohydrate (%) | Calorific value (Kcal/100g) |
|---|---|---|---|---|---|---|---|
| *Aporosa cardiosperma* (Gaertn) Merr. | 91.45 | 0.24 | 0.18 | 1.03 | 1.44 | 5.66 | 30.02 |
| *Buchanania cochinchinensis* (Lour.) M.R.Almeida | 63.01 | 1.45 | 0.43 | 2.59 | 1.69 | 30.83 | 133.9 |
| *Carissa spinarum* L. | 79.86 | 0.49 | 1.82 | 1.95 | 1.31 | 14.57 | 79.90 |
| *Elaeocarpus tectorius* (Lour.) Poir | 72.18 | 2.76 | 1.13 | 2.23 | 3.69 | 18.01 | 96.97 |
| *Flacourtia indica* (Burm. f.) Merr. | 74.12 | 2.09 | 0.21 | 2.96 | 2.42 | 18.20 | 84.37 |
| *Ixora coccinea* L. | 78.94 | 0.98 | 0.51 | 1.24 | 1.56 | 16.85 | 78.23 |
| *Opuntia dillenii* (Ker Gawl.) Haw. | 81.91 | 0.73 | 1.01 | 5.48 | 0.88 | 8.99 | 48.57 |
| *Phoenix loureiroi* var. *pedunculata* (Griff.) Govaerts | 73.89 | 2.53 | 0.63 | 3.27 | 2.44 | 17.24 | 84.39 |
| *Phoenix sylvestris* (L.) Roxb. | 70.44 | 2.08 | 0.57 | 3.52 | 2.18 | 21.21 | 98.69 |
| *Pithecellobium dulce* (Roxb.) Benth. | 60.54 | 3.36 | 0.51 | 1.83 | 2.53 | 31.23 | 139.6 |
| *Semecarpus anacardium* Blanco | 78.01 | 1.41 | 1.84 | 4.33 | 3.04 | 11.37 | 74.21 |
| *Spondias pinnata* (L. f.) Kurz | 74.01 | 2.06 | 0.71 | 1.29 | 2.13 | 19.89 | 94.47 |
| *Syzygium caryophyllatum* (L.) Alston | 66.76 | 1.08 | 0.93 | 3.73 | 3.22 | 24.09 | 119.3 |
| *Syzygium jambos* (L.) Alston | 87.71 | 0.76 | 0.22 | 1.76 | 0.84 | 8.71 | 40.18 |
| *Ziziphus oenopolia* (L.) Mill. | 78.45 | 0.77 | 0.11 | 2.23 | 1.81 | 16.72 | 74.30 |

*Values are represented as mean of three determinations

Table 3. Mineral composition of ripened minor fruits on dry weight basis (mg/100g)*

| Scientific name | P | K | Cu | Fe | Mg | Zn | Ca | Na |
|---|---|---|---|---|---|---|---|---|
| *Aporosa cardiosperma* (Gaertn) Merr. | 22.2 | 131.8 | 0.40 | 1.78 | 42.52 | 0.25 | 20.11 | 33.98 |
| *Buchanania cochinchinensis* (Lour.) M.R.Almeida | 53.3 | 229.2 | 0.21 | 4.49 | 61.89 | 0.88 | 61.54 | 21.22 |
| *Carissa spinarum* L. | 16.1 | 217.5 | 0.31 | 7.42 | 75.34 | 0.57 | 31.54 | 33.77 |
| *Elaeocarpus tectorius* (Lour.) Poir | 49.2 | 188.3 | 0.65 | 4.16 | 39.36 | 0.88 | 31.56 | 21.81 |
| *Flacourtia indica* (Burm. f.) Merr. | 11.1 | 142.8 | 0.04 | 1.11 | 18.91 | 0.33 | 51.12 | 44.12 |
| *Ixora coccinea* L. | 24.5 | 287.5 | 1.01 | 0.81 | 28.39 | 0.67 | 11.54 | 11.87 |
| *Opuntia dillenii* (Ker Gawl.) Haw. | 32.6 | 642.8 | 0.02 | 3.22 | 10.73 | 0.95 | 19.54 | 116.5 |
| *Phoenix loureiroi* var. *pedunculata* (Griff.) Govaerts | 28.4 | 288.3 | 0.41 | 9.81 | 59.63 | 0.78 | 22.43 | 51.65 |
| *Phoenix sylvestris* (L.) Roxb. | 32.5 | 131.1 | 0.32 | 9.91 | 58.89 | 0.71 | 24.43 | 43.41 |
| *Pithecellobium dulce* (Roxb.) Benth. | 49.1 | 212.3 | 0.66 | 4.76 | 95.87 | 0.61 | 44.98 | 12.45 |
| *Semecarpus anacardium* Blanco | 29.7 | 248.6 | 0.48 | 3.97 | 66.51 | 0.16 | 26.11 | 22.67 |
| *Spondias pinnata* (L. f.) Kurz | 23.5 | 165.2 | 0.73 | 2.25 | 31.37 | 0.62 | 66.41 | 21.09 |
| *Syzygium caryophyllatum* (L.) Alston | 14.1 | 42.14 | 0.12 | 1.04 | 19.83 | 0.15 | 44.41 | 21.31 |
| *Syzygium jambos* (L.) Alston | 20.2 | 66.91 | 0.91 | 1.22 | 4.934 | 0.12 | 28.99 | 80.92 |
| *Ziziphus oenopolia* (L.) Mill. | 18.3 | 128.5 | 0.51 | 4.73 | 19.04 | 0.65 | 29.01 | 12.76 |

*Values are represented as mean of three determinations

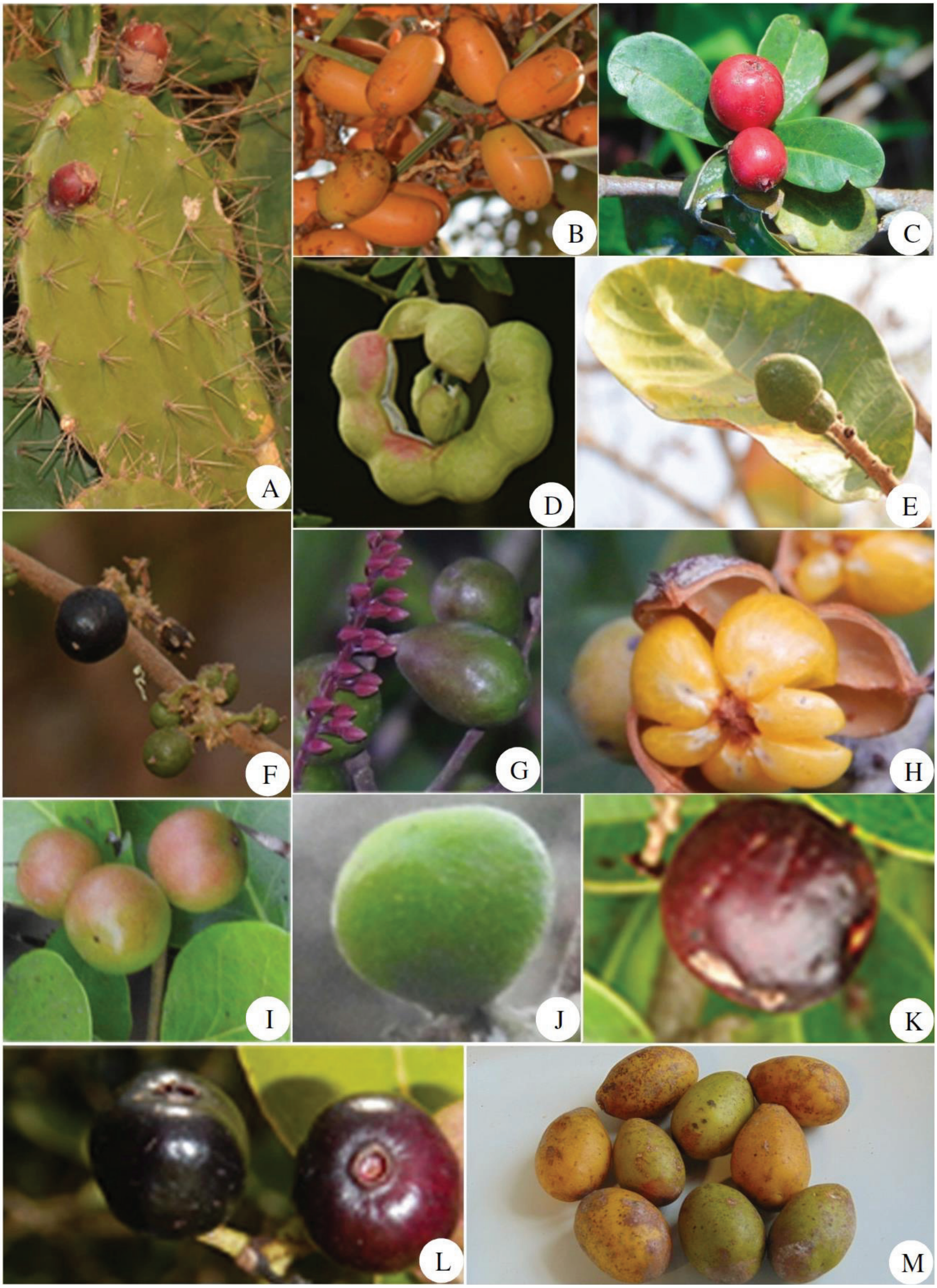


Figure 1. Minor fruits used in the present study for proximate and mineral analysis: (A) *Opuntia dillenii*; (B) *Phoenix loureirii* var. *pedunculata*; (C) *Ixora coccinea*; (D) *Pithecellobium dulce*; (E) *Semecarpus anacardium*; (F) *Ziziphus oenopolia*; (G) *Elaeocarpus tectorius*; (H) *Aporosa cardiosperma*; (I) *Carissa spinarum*; (J) *Buchanania cochinchinensis*; (K) *Flacourtia indica*; (L) *Syzygium caryophyllatum*; (M) *Spondias pinnata*

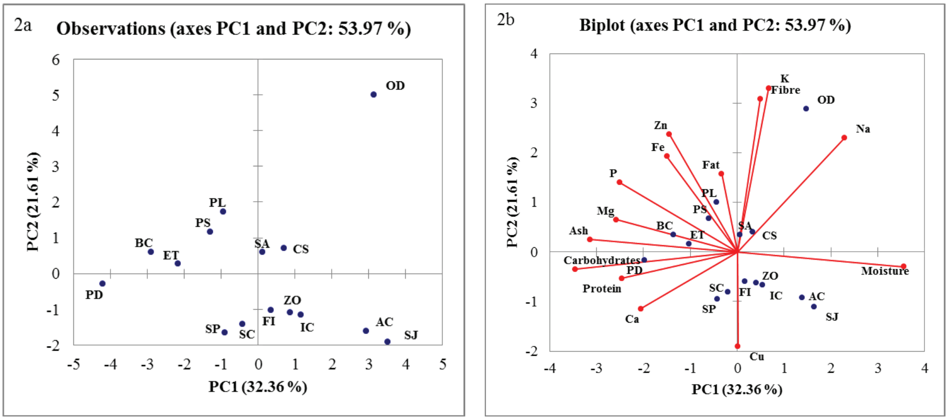


Figure 2. PC1 vs PC2 biplots indicating variability among types of fruits: 2a: biplot showing distinction between minor fruits; 2b: biplot highlighting fruits with different variables, *viz*., proximate composition and mineral content

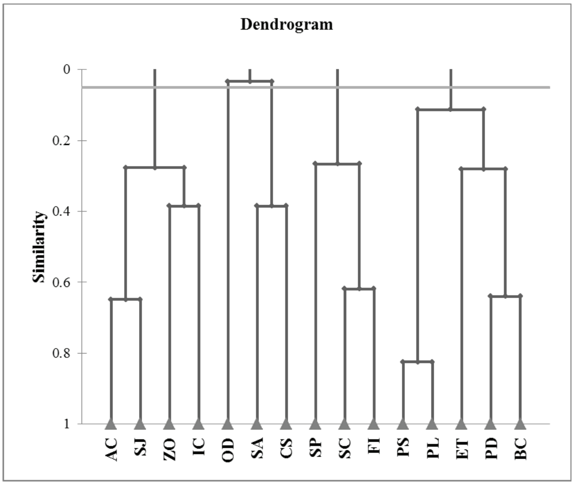


Figure 3. Dendrogram depicting agglomerative hierarchical clustering of minor fruits

## CONCLUSIONS

Considerable variations were observed between fruits in terms of nutrient composition. The study thus provided deeper insights on the nutrient composition of the fifteen types of fruits. Moreover, the present study endorses the potential use of these fruits in the near future by food and nutraceutical industries through commercialization by domestication. Further, utilizing these bioresources which are available in plenty during the glut season, can offer local employment and can improve the economy of rural communities.

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