# DIVERSITY OF FRUIT MORPHOLOGY AND TASTE PARAMETERS OF NATURALLY AVAILABLE *SYZIGIUM CUMINI* TREES IN BATICALOA REGION OF SRI LANKA

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**ABSTRACT**

*Syzygium cumini (L.) Skeels (Madan or Jamun) is an evergreen multipurpose tree of family Myrtaceae and considered as an underutilized fruit crop in Sri Lanka. Though it is important in Ayurvedic medicine, no proper varietal development program has been carried out so far. Due to lack of availability of literature on morphological studies, its diversity in naturally available trees in the country has not been explored. This study has been focused on diversity of morphology, ripening and taste of S.cumini fruit in Baticaloa region of Sri Lanka. Fruits, including different ripening stages, were harvested from randomly selected trees from different sites in Batticloa. Fruits were visually observed and five fruit ripening stages were identified as Young (green), Premature (colour breaking), and Mature (Pink or Magenta), Pre-ripened, Ripened (dark purple). The tree reported the minimum average fruit length was 14.19 ±1.62mm, whereas the maximum was 24.85 ±1.22mm. The minimum and maximum average fruit widths reported were 10.38 ±0.94mm and 17.05±1.48mm respectively. The average fruit length to width ratio was varied from 0.99 ±0.01 to 1.64±0.18. These results were significantly different among the trees in the sample. The observed variation in length to width ratio of fruit disclosed that there was a shape-variation from globular to elongate. Average fruit pericarp (flesh) thickness was also significantly different among the trees with minimum of 19% and maximum of 50%. The minimum and maximum average flesh weight to seed weight ratios were 0.6 and 2.8 respectively. The results of the organoleptic evaluation, revealed that there was a significant difference in taste parameters among different trees. Further, a moderately positive correlation (r=0.52, p<0.001) was observed between bitterness and acidity. A weak negative correlation (r=0.42, p<0.1) was observed between pungency and overall acceptability of taste. The results of this study disclosed that there is a vast potential for varietal improvements under the existing morphological diversity and taste variation among available S cumni population.*

Key words: Diversity, Fruit morphology, Fruit taste, Syzigium cumini

## Introduction

*Syzygium cumini* (L.) Skeels (Madan) is commonly known as Jamun, which is a large evergreen multipurpose tree belonging to family Myrtaceae (Samba - Murthy and Subrahmanyam, 1989). It is native to Bangladesh, India, Pakisthan, Sri Lanka, Malaysia, the Philippines, and Indonesia. However, the tree could be found in many other regions in the world. Though the world production of *S. cumini* fruit is estimated at 13.5 million tonnes (Patil et al., 2012), it is considered as an underutilized fruit crop. The *Syzygium cumini* fruits are of good source of iron and are used as an effective medicine against diabetes, heart and liver trouble in Ayurveda and other folk medicines. Therefore, as a fruit crop it has a potential tremendous contribution to healthy life of the consumers. Further, wide variation of the tree in nature could potentially be support to reinforce the food security even in occurrence of global climate change scenario.

There is wide distribution of Madan tree throughout the country with high diversity in tree morphology, possibly genetic diversity, diversity in fruit morphology, quality and taste, diversity in phytochemicals and their properties. It also encompasses diversity in uses such as timber, landscaping and as a medicinal plant. The fruit is traditionally used for consumption and at present availability of the fruit is highly rare in the market. There is no improved variety of Madan available in Sri Lanka for commercial cultivation. For such kind of improvements it needs extensive understanding of fruit botany related to flower character, fruit quality and its level of variation in Sri Lanka.

Medicinal properties are highly valued by different researches who have worked on underutilised wild fruits. It is proven that *Syzygium cumini* is rich in chemical properties to fight against Diabetics (Kumar et al., 2008). Studies in India on *Syzygium cumini* showed that the seeds have been reported to be rich in flavonoids, a well-known antioxidant, which accounts for the scavenging of free radicals and protective effect on antioxidant enzymes (Ravi et al., 2004), and also found to have high total phenolics with significant antioxidant activity (Bajpai et al., 2005) and are fairly rich in protein and calcium. In Sri Lanka there are no studies have been conducted to evaluate anti-oxidant and other chemical properties of *Syzygium cumini* across the different climatic regions separately. It possibly varying subjected to different climatic and soil properties throughout the country. In Sri Lanka *S. cumini* trees mainly distributed in low elevated dry zone areas. Batticaloa region is one of the areas that *S. cumini* commonly available in nature. It provides a good background to have comprehensive study on morphological variation among *s. cumini* trees in the region. Fruit is the main part in the tree that gives more benefit to people and hence the scope of this study mainly concentrated on the fruit.

On this ground we are looking for S. *cumini* for its morphological variation special concern on fruit morphological variation and variation in qualities of fruit in a selected region; Batticaloa of Sri Lanka.

## MATERIALS AND METHODS

**Location and tree selection**: Naturally growing *S. cumini* trees were randomly selected from Batticloa (7°43'58.5"N 81°41'18.8"E) region which belongs to low country dry zone area in Sri Lanka for this research. Geo-coordinates of selected trees were also recorded and name each tree separately as B series (B1, B2,.. etc.). Diameter at Breast Height (DBH) of selected trees is 20-30cm.

**Fruit ripening**: All fruits, including immature, different stages of ripening and fully ripen were harvested from available trees from different sites in Batticloa region. Harvested fruits of each tree were visually observed and classified into five distinct fruit maturity stages. Each maturity stages of each tree from all harvested regions were carefully observed for different colour developments separately.

**Fruit morphology**: Fruit size parameters (fruit length and fruit width) were measured in harvested S. cumini fruits. Photographs of fruits with scale in the side were taken using Nikon camera (Nikon DS7200) and images were analysed using Image software to get values of fruit length and width in millimetre (mm). Randomly selected 10 ripen fruits were taken from each tree for the analysis.

Cross section of ripen 10 fruits from each selected tree were prepared by cutting fruits with sharp laboratory knife and photographed them with scaled ruler by side of the cross section of fruit using dissecting microscope attaching a camera. Pericarp thicknesses in micro meter (μm) were measured by analysing photographs with ImageJ software.

Weight of fruits, seed and pericarp were measured using laboratory scale in gram (g).

**Fruit taste**: The organoleptic evaluations were obtained for the equally ripen samples collected from five different plantson the same day of harvesting. The organoleptic scoring was done by a panel of five members using a scorecard developed for the research study. Scorecard was prepared keeping in view of the taste quality characteristics of the Madan fruit. Descriptive terms were given to various quality attributes like pungency, acidity, bitterness and taste while tasting and some attributes after tasting and also overall acceptability.

Numerical scores were assigned to each attribute. A five-point scale was adopted to score each of the attributes, while the highest score (5) was assigned to most preferred characteristic and least (1) to the least desired characteristics (Ranganna, 1986). Data were analyzed using a non-parameter one-way test (Kruskal Wallis test) for each quality parameter. Pearson correlation was carried out among each quality parameter.

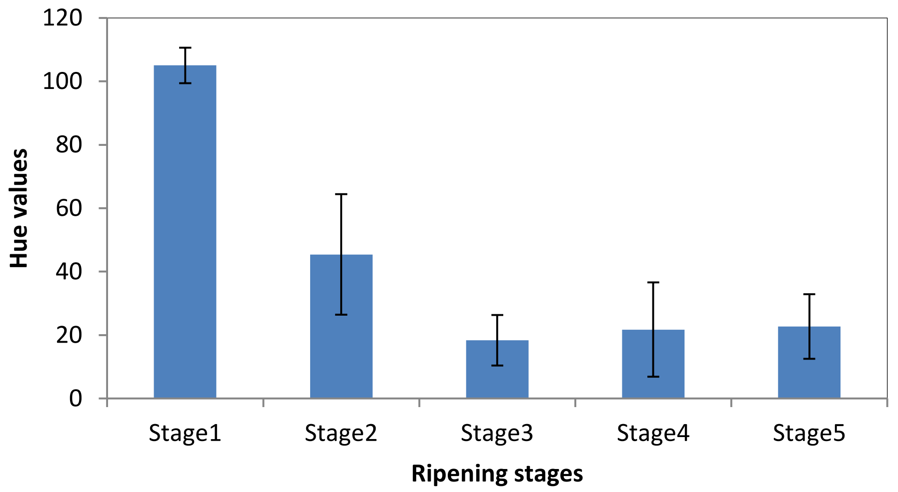
## RESULTS AND DISSCUSSION

Fruit ripening stages were classified as stage 1, Stage 2, Stage 3, Stage 4 and Stage 5. Patel, (2014) also explained five stages of ripening of *Syzigium cumini* fruit. These five stages can be named as Young, Premature, Mature, Preripened, Ripened. Stage 1 is green for all trees. Stage 5 for every tree is dark black purple. Stage 2, stage 3 and stage 4 showed colour variations among different trees. Stage 2 (Premature stage) is colour breaking phase which starts changing from green to pink. Part of fruit become pink and in some trees showed pink and green in one fruit which can identified separately. Some fruits showed no clear line in between pink and green, mostly its dull pink. In stage 3 (Mature) whole fruit colour become pink or magenta. In Stage 4 (Preripened ) whole fruit is dark purple or blood red.

Values of hue angle were also showed variation among different ripening stages (Fig 1). Stage 1 showed less variation among all trees however, stage 5 showed extreme variation of hue angle among all trees. Stage 2, Stage 3 and Stage 4 also showed high deviation among the trees.

The fruit colour is known to serve as an index for determining the ripening stage and optimal harvest time for fruits. Mostly several processes take place as fruit ripening and become edible, and then senesce. During ripening process of *S. cumini* fruit, chlorophyll content reduces drastically (Patel et al., 2014). This is usually due to chlorophyll degradation as with senescence of other horticultural crops (Dissanayake et al., 2008; Dissanayake et al., 2012). Likewise, the amount of carotenoids also significantly reduced from young stage during ripening (Patel et al., 2014). Consequently, with the decrease in the amount of chlorophylls and carotenoids, the amount of anthocyanins increased which leads to black purple in ripen stage and make purple stain in the mouth while eating. Further, according to Kumar and Verma (2011) purple colour of the fruit is due to presence of one or two cyanidindiglycosides. However, as there are not uniform colour variation among stage 2, stag 3 and Stage 4, chlorophyll degradation process could be vary among trees.

**Figure 1. Hue values of five ripening stages of *S. cumini* fruits. Vertical bars represent average values with standard deviation.**

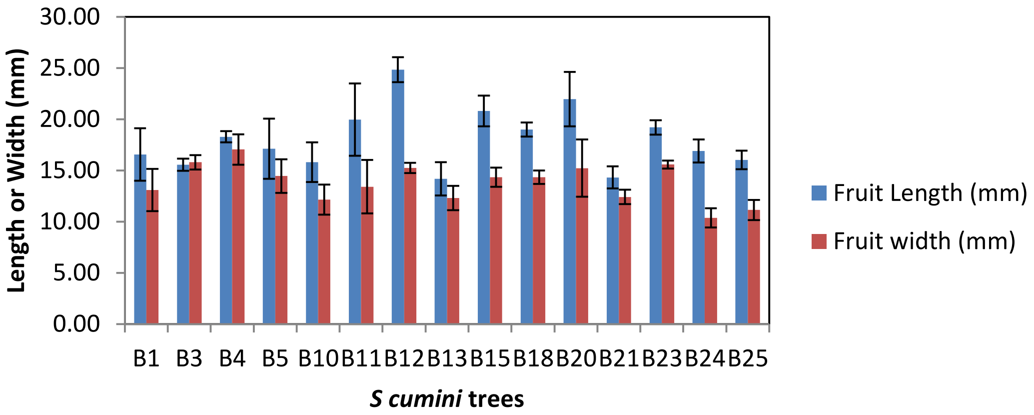



**Fruit length, width and length/width ratio**
The reported minimum average fruit length was 14.19 ±1.62 mm (B13)while the maximum was 24.85 ±1.22 mm (B12) about 10mm variation. The grand mean of fruit length of all trees was 17.18± 3.16 mm. Only 27% of the sampled trees contain ripen fruits length more than 20mm length. Meanwhile, there were 13% of trees contained fruit less than 15mm length. Rest of the 60% of trees contained fruit in between 15mm and 20mm of average length (Fig. 2).

These results showed that fruit length in the region relatively shorter when compared to previously recorded data in India and Indonesia which showed some fruits with 35mm length and 50mm respectively (Bijauliya *et al.*, 2017; Ayyanar and Subash-Babu, 2012). However, this disclosed that variation of fruit length of selected sample trees are very high giving insight of having high potential to have fruits with more long length in the area.

**Fruit width**
The minimum average fruit width reported was 10.38 ±0.94mm while the maximum average was 17.05±1.48mm about 6.67mm variation (Fig 2).The grand mean of fruit width of all trees was 13.20±2.07mm. About 33% of sampled trees contained ripen fruits width more than 25mm. Meanwhile, there were 13% of trees contained fruit around 10mm width. Rest of the 54% of trees contained fruit in between 15mm and 10mm of average width.

**Figure 2.Fruit length (mm) and width (mm) of *S cumini* trees in Batticaloa. Vertical bars represent average values with standard deviation.**



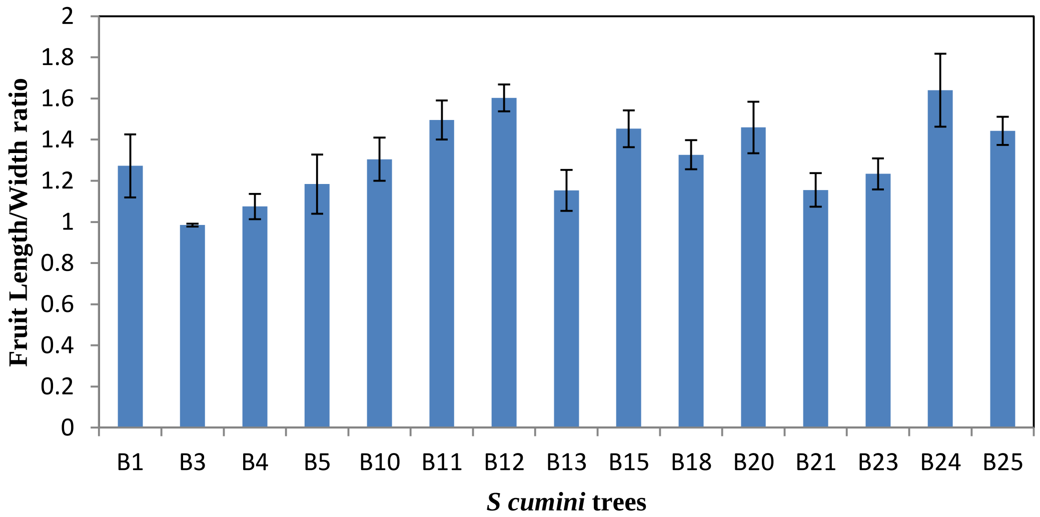

**Fruit Length/width ratio**

The minimum average fruit length/width ratio was 0.99 ±0.01 (B3) while the maximum value of 1.64±0.18 (B24) with about 0.65 variation (Fig 3). Average fruit length/width ratio of all trees was 1.31±0.19. Only about 20% ofsampled trees having more or less than 1.5 ratio.

Variation of this ratio among trees indicated that the fruit shape is from globular to elongate. Especially if the ratio is around 1 fruits are globular in shape. Normal description of fruit shape of *S. cumini* is ovoid-oblong or elliptical (Mutua *et. al.* 2009). However, in present study it showed that significantly different fruit shapes were reported such as globular or Spheriod according to IPGRI, Rome (1995) and then ovoid-oblong.

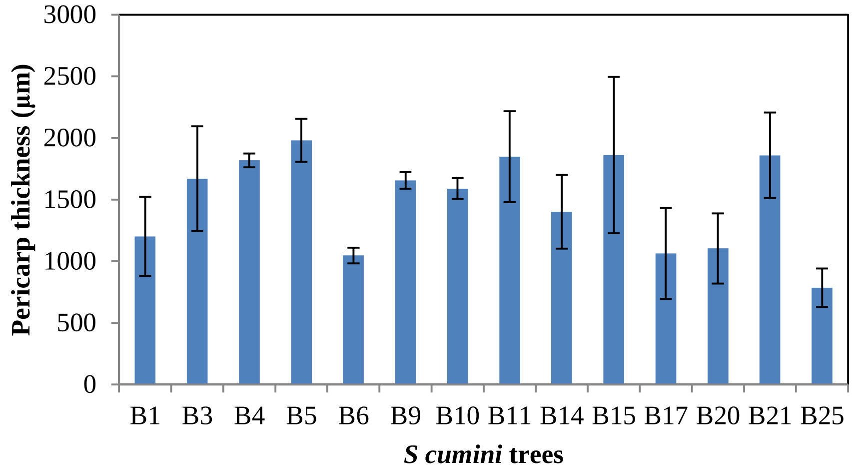
Figure 3. Fruit Length/width ratio of *S cumini* trees in Batticaloa. Vertical bars represent average values with standard deviation

**Figure 3. Fruit Length/width ratio of *S. cumini* trees in Batticaloa. Vertical bars represent average values with standard deviation.**



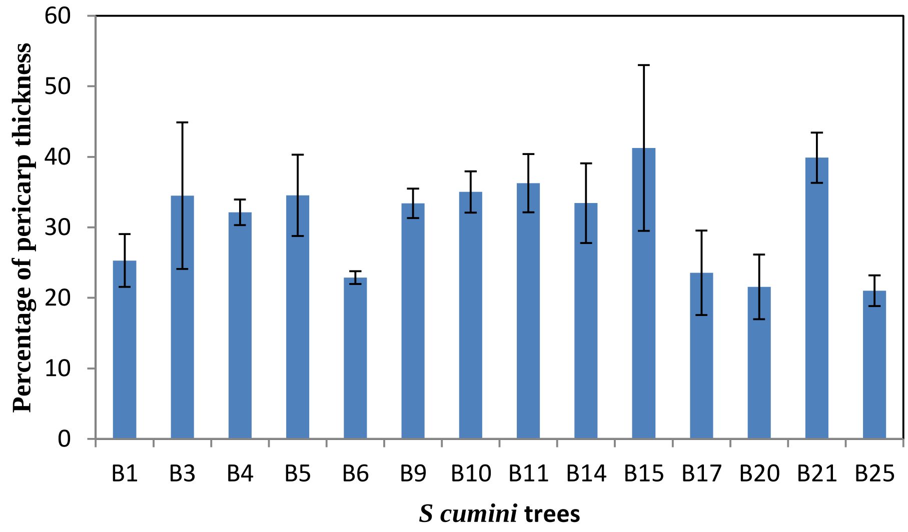
**Pericarp thickness**

**Figure 4. Pericarp (flesh) thickness (µm) of *S cumini* fruits from different trees in Batticaloa. Vertical bars represent average values with standard deviation.**




Average fruit pericarp thickness was varied from 785.29±156.04µm (B25) to 981.53±174.61µm (B5) (Fig 4). Variation of fruit pericarp thickness was around 1196.24µm. Average fruit pericarp thickness of all trees was 1491.67±168.99µm. Only 28% of the selected plantshave more or less than 1000µm of pericarp thickness. In average, pericarp thicknesses of recorded fruits are very thin and consumable potion is very less compared to seed size. Due to the variation in pericarp thickness there might be more potential to find trees with fruits having big pericarp.

**Figure 5.Percentage of pericarp (flesh) thickness (µm) of *S. cumini* fruits from different trees in Batticaloa. Vertical bars represent average values with standard deviation.**




Proportion of pericarp occupied in cross section of fruit is presented in Figure 5. It indicated high variation percentage of pericarp thickness among *S. cumini* trees in the area. Some fruits contained more than 50% of pericarp. Average portion of pericarp occupied in fruit in selected trees is 30%.

**Fruit weight**

Flesh weight of fruit also varied among the selected trees. These findings indicated that flesh weight of Madan fruits are bit higher than seed weight except four trees. Though the average flesh weight to seed weight ratio is 1.4, ratio varies from 0.6 (B25) to 2.8 (B15). Here also tree to tree variation is high. This gives provision to select best plants with more flesh weight in the region.

Plants with high ratio give good source for juice and wine production. However, in some cases medicinal drinks are prepared by grinding seed. In this situation high seed weight is beneficial for such commercial purpose.

**Table1. Fruit weight (g), seed weight (g), pericarp (flesh) weight (g) and flesh weight: seed weight ratio of *S. cumini* fruits from different trees in Batticaloa.**

| Tree | Single fruit Weight(g)±SD | Single Seed Weight (g) | Flesh Weight (g) | Flesh wt: seed wt ratio |
|---|---|---|---|---|
| B1 | 2.568(±0.16) | 0.886(±0.24) | 1.682(±0.24) | 1.9 |
| B5 | 3.216(±0.59) | 1.106(±0.22) | 2.11(±0.09) | 1.9 |
| B10 | 1.302(±0.40) | 0.698(±0.22) | 0.604(±0.12) | 0.9 |
| B11 | 2.292(±0.43) | 0.848(±0.37) | 1.444(±0.44) | 1.7 |
| B13 | 1.234(±0.32) | 0.722(±0.22) | 0.512(±0.11) | 0.7 |
| B15 | 2.258(±0.44) | 0.602(±0.27) | 1.656(±0.36) | 2.8 |
| B18 | 1.952(±0.33) | 0.694(±0.19) | 1.258(±0.18) | 1.8 |
| B20 | 2.292(±0.29) | 1.012(±0.16) | 1.28(±0.06) | 1.3 |
| B21 | 1.09(±0.10) | 0.562(±0.20) | 0.528(±0.14) | 1.0 |
| B23 | 1.818(±0.20) | 1.096(±0.22) | 0.722(±0.05) | 0.7 |
| B25 | 1.292(±0.40) | 0.816(±0.23) | 0.476(±0.04) | 0.6 |

**Organoleptic qualities**

The results of the study revealed that there was a significant difference among the different plants in some quality parameters evaluated by the taster panel. According to the results, pungency of fruits taste (Mean rank=2.69 p=0.028) and tasty (Mean rank= 3.34 p=0.050) were significantly different among the plants.

The pungencyof the plant number B15 scored significantly lower ranks compared to that of the other plants (p=0.028) (Fig.6). Tasty of the bothplants B15 and B5 scored higher ranks than that of the other plants (p=0.050) (Fig. 6). The plant number B15 and B5 clearly showed that when pungency of the fruit taste lowered consequently increases the tasty of the Madan fruit. In addition, B11 (Fig. 6) clearly showed that when increment of pungency and bitterness consequently decreases the tasty of fruit.

Among the tested plants B15 has the overall highest acceptability. This would results due to the lowest level of pungency, bitterness, acidity, astringency and also recorded highest level of tasty compared with other plants. Further, B11 recorded lowest acceptability since it has high bitterness, pungency, acidity and astringency causing lowest taste. There is significant (p=0.0001 a positive correlation (0.687)) between taste and acceptability. However, only negative correlation recorded between pungency and taste.

It is evident that after few minutes of organoleptic evaluation taste and astringency not vary significantly among plants. However, there is a significant (p= 0.032 and p=0.003) strong positive correlation (0.420 and 0.557) between after few minutes astringency with pungency and initial astringency respectively (Fig. 7).

**Figure 6: Mean rank given for the pungency, bitterness, taste and acceptability of *S.cumini* fruits of selected trees.**

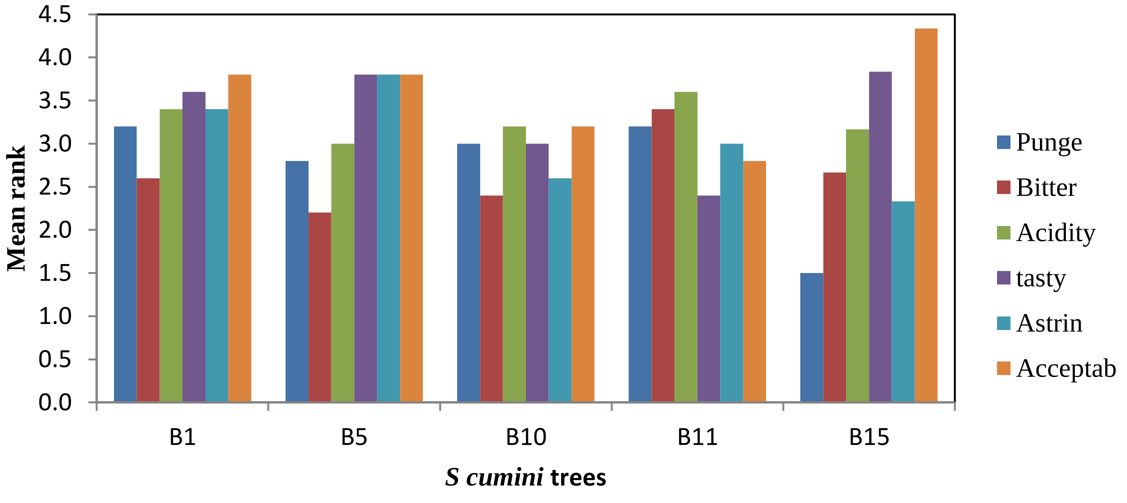
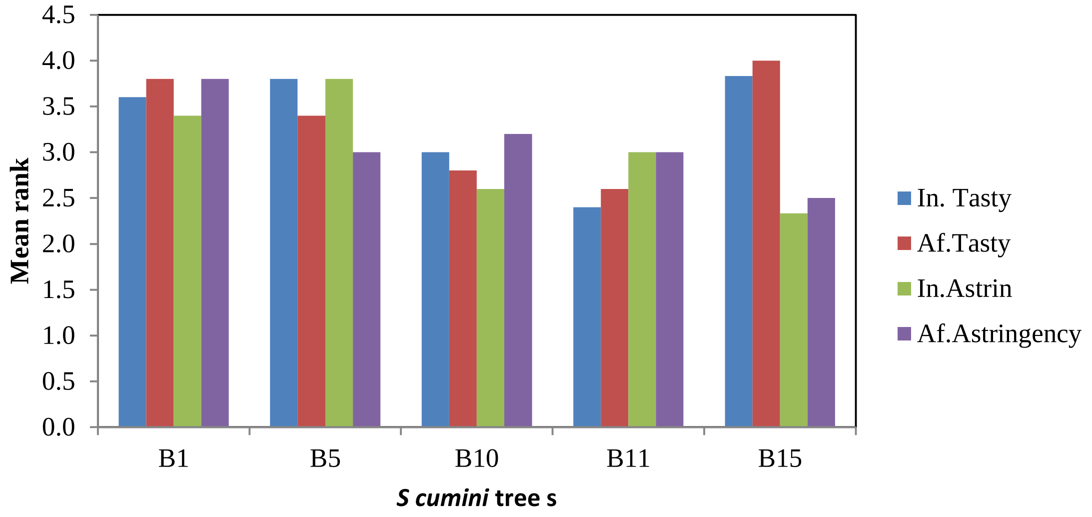


**Figure 7: Mean rank given to the Initial (In.) and After (Af.) taste and astringency of *S.cumini* fruits of selected trees.**




Ripe madan fruit is usually eaten in fresh form. Fully ripen fruits are juicy, almost odourless, with a pleasant, slightly bitter, astringent taste (Orwa *et al*, 2009). The fruit is usually astringent, sometimes unpalatable. The flavour varies from acid to fairly sweet. Fruit has a combination of sweet, mildly sour and astringent flavour and tends to colour the tongue purple which is similar to the other early findings (Ayyanar and Subash-Babu, 2012). Glucose and fructose are contributed for the tasty in ripe fruit with no trace of sucrose. More than 50% Maleic acid and small quantity of oxalic acid has been reported. Tannins mainly gallic acid is responsible for the astringency of the fruit. (Kumar andVerma 2011). Accordingly due to the variation of amount of chemical constituents presence in ripe fruits of different *S. cumini* plants may result variation of organoleptic qualities.

**CONCLUSION**

The sample of *S. cumini* trees used to study the fruit morphological variation in the Batticaloa region of Sri Lanka showed that there were high tree to tree variations in fruit size. This observation indicated that there are many cultivars available in the region with favourable fruit size. Accordingly theses phenotypic variations as a consequences of genetic variations indicated that there must be a significant potential for future cultivar development (Govindaraj *et al*., 2015). This shape variation was more intense when the fruit shape was considered that indicated a changed from globule to ovule. Pericarp (flesh) thickness also showed clear tree to tree variation. Nevertheless, organoleptic qualities also showed high variation among trees. Those observed variations indicated a huge potential for further improvement of *S. cumini* trees in the region for enhancing its commercial value. This study gives clear background for future investigation of about fruit quality studies for development or investigate of promising cultivars for possible commercial use or for medicinal purpose.

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