Studies on flowering, fruiting and post-harvest characters of jamun (*Syzygium cuminii* Skeels) genotypes

काशी हिन्दू विश्वविद्यालय BANARAS HINDU UNIVERSITY

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Supervisor
Prof. Anil K. Singh

Submitted by
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CERTIFICATE

To,
The Registrar (Academic)
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Varanasi-221005,
U.P., India.

Through: Proper channel

Dear Sir,

I have great pleasure in forwarding the thesis entitled **"Studies on flowering, fruiting and post-harvest characters of jamun (*Syzygium cuminii* Skeels) genotypes"** submitted by **Mr. Neki Ram, I.D. No.: 17412HOR010, Enrolment No.: 397309** in partial fulfillment of the requirements for the award of the degree of **Master of Science (Agriculture)** in **Horticulture**, Department of Horticulture, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi.

This is to certify that the work has been carried out solely by **Mr. Neki Ram** under my guidance and data forming the basis of this thesis, to the best of my knowledge are genuine and original and no part of the work has been submitted for any other degree or distinction.

Thanking you.

Yours faithfully

Forwarded

(Anil K. Singh)
Supervisor

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by

Neki Ram

Thesis submitted in partial fulfilment of the requirements for the award of the degree of

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Date:

Place: Varanasi ***(Neki Ram)***

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LIST OF ABBREVIATIONS

%	per cent
@	at the rate of
°C	degree centigrade
CD	critical difference
cm	centimeter
et al.	et alibi (and others)
etc.	etcetera
Fig.	figure
g	gram
hrs	hours
ha	hectare
i.e.	that is
kg	kilogram
ml	mililitre
ppm	parts per million
m^2	square metre
no.	number
q	quintal
RBD	Randomized Block Design
RH	relative humidity
SEM ±	standard error of mean
viz.	(videlicet) Namely

CHAPTER-I

INTRODUCTION

Jamun (*Syzygium cuminii* Skeels) is an indigenous and important minor fruit crop of India which belongs to family Myrtaceae. The chromosome no. of jamun is (2n=40). It is also known with other common names like jambul, black plum, java plum, Indian blackberry, jamblang, jambu, jam and Neredupandu, etc. It is native to Indio-Malaya and is cultivated in tropical countries like's West Indies, South and East Africa and some subtropical countries Florida and Hawaii in the United States of America. The genus *Syzygium* comprises 1100 species and the native place range that extends from Africa to Madagascar through Southern East Asia and Pacific (Mahmoud II *et al*., 2001). In India jamun is grown in Indo-Gangetic plains, lower regions of Himalayas in north to Tamil Nadu in south. Some other species of jamun (*Syzygium cuminii* Skeel), Rose apple (*Syzygium jambos*), Malay rose apple (*Syzygium malaccensis*), Surinam cherry and water apple (*Syzygium javanicum*) are the most important fruits which are cultivated in India.

In India, major fruit growing states are Andhra Pradesh, Uttar Pradesh, Maharashtra, Gujarat, Tamil Nadu, Karnataka and Madhya Pradesh. The area under fruit cultivation is about 6405 thousand hectare with estimated production of 91443 thousand million tones according to Indian Horticulture Data Base Published by the NHB database (2016). Information regarding the area and production of jamun in India is not available because it is seldom plant in the orchard of the perennial fruit crops. However, it is distributed naturally throughout the tropical and subtropical regions of India. From these forests and from few orchards, where it has been planted as wind breaks, the fruits are collected and sold as fresh fruit for table purpose. The organized and systematic orchards are being established in different jamun growing areas (Prabhuraj, 2001).

Jamun trees can be grown on a wide variety of soils however, loamy and well-drained soils are best suitable for good yield and plant growth. These trees can be grown with soil pH range of (6.5 to 7.5). It is a fast growing plant and it is very tall and evergreen, so this is usually grown as wind breaker or shade purpose and avenue trees. It provides excellent firewood and charcoal to the rural population in India (Choudhary and

Mukhopadhyay, 2012) and it grows up to 25 m high with coarse, discoloured bark, grayish white young stems. The simple leaves are opposite, elliptic to broadly oblong, smooth, glossy, leathery and short pointed at tips. Its leaves contain essential oil (0.1%), which are used to make tea and are taken orally to treat diabetes in Brazil and have been reported to have anti-hyperglycemic effects. The leaves of jamun are used as fodder and also food for Tassar silkworms in India. The leaves and the bark have been reported as the most parts powerful of the tree. Woods are resistant to water stress and termite.

It is seasonal flowering crop plant which shows a wide range variation during flowering to know the per cent fruit set and fruit drop. The flowering starts during month of last week of March to first week of April and the fruit maturity 55 to 65 days after flowering. Its flowers are rich in nectar and used in the apiculture for their yield of high quality honey (Patel *et al.*, 2010). This fruit plant fruits are small to large, dark red purple, oval in shape, single seeded berry surrounded by flash pulp and the fruit skin. The maturity time of fruit depends upon the various external characters like emergence of waxy coating dots on the fruits surface and relative size of the fruit. When ripened fruits are started dropping; its implies the maturity of the particular variety is reached. The fruit samples for physio-chemical analysis were taken at optimum maturity. Ripened fruits are very juicy and fruit size is up to 3 cm long, shiny dark purplish red, with white to lavender flesh. The number of fruit per panicle is bearing 30 to 60 and average yield is 80 to 110 kg per plant. It is a good source of iron apart from being the source of minerals, vitamins carbohydrate, sugars and other photochemical (Singh *et al.,* 1967). Composition of jamun fruit is 25% edible portion water, 80.80% ash, 0.70% protein, 0.81% sugar, 12.70% fructose and glucose, 0.63% acidity, 0.88%. Jamun fruit contains some of the taxonomically informative molecules like malic acid, oxalic acid, gallic acid, ellagic acid, betulic acid, tannins and flavonoids.

Jamun is propagated in both methods such as by seed and vegetative method. Due to existence of polyembryony, it's come true parent through seed. Seed propagation result in late bearing, vegetative method propagation is preferred for improved type. The seeds have no dormancy, for that fresh seeds can be grown. Its flowering will be started in 5-8 year

after planting. In jamun, budding method is most successful. However, patch, shield and forket methods of budding give more than 70% success, if performed in the month of March.

It is an emerging fruit crop of the 21st century and the yields of fruit crop that could play an important role in meeting demand for nutritious natural fruit of high medicinal value. In recent years, those fruits are becoming popular among people due to its rich in medicinal importance particularly for its anti-diabetic, blood pressure and cancer properties are found. The demand for this fruit has been increasing both in urban and rural area. The plant has various medicinal uses in traditional systems of medicine. All plant parts of the jamun tree are used for various purposes to cure some diseases and health problems (Sagrawat *et al.,* 2006). One of the very common traditional uses of *Syzygium cuminii* is the powdered seed for control the blood sugar level in diabetic patients. The seeds are rich in calcium and proteins. The seeds contain an alkaloid jambosin and glycoside, which reduce the diastatic conversion of starch into sugars (Noomrio and Dahot, 1996). The entire plant is used for traditional medicinal motive and this has resulted in considerable chemical analysis of most of the plant's active compounds which attributes to the medicinal effects. It is healthy fruit with absolutely no trace of sucrose and therefore, the only fruit with minimum calories. The fruit pulp is used to make squash, sharbat, syrup, jams, jellies, juice, vinegar and wine.

Different plant parts in jamun are also reported for its antioxidant, anti-inflammatory, neuropsycho-pharmacological, anti-microbial, anti-bacterial, anti-HIV, anti-leishmanial, antifungal, nitric oxide scavenging, free radical scavenging, antifertility, anorexigenic and radio-protective activities (Sagrawat *et al*., 2006). Majority of the studies of jamun as anti-diabetic agent with its possible mechanism of action and delaying complications of diabetes such as cataract and neuropathy have been conducted but detailed studies on isolation of bioactive compounds and clinical trials followed by standardization are seriously required to know the full potential of plants and fruits. The fruits have been promising therapeutic value due to its various phyto-chemical constituents such as tannins, alkaloids, steroids flavonoids, terpenoids, fatty acids, phenols, minerals,

carbohydrates and vitamins. The other medicinal properties of fruits are including for dysentery, diarrhea, enlarged spleen and mouth disease. Various traditional medicine practitioners use the tree to cure diseases by using the powder, decoction, juice or paste of the different parts of plant (Ayyanar *et al*., 2012).

In jamun genotype it was found that heterozygosis to a greater extend on account of which there appears to be a large variation in the yield contributing characters, morphological and physic-chemical characters like-fruit weight, fruit length, fruit diameter, fruit colour, seed size, seed weight, fruit yield, pulp colour, TSS, acidity, phenol, ascorbic acid, antioxidant, pH and flavenoids.

The fruit are highly perishable in nature; the quality of fruits may deteriorate at very high speed if the favourable conditions and care should not be provided properly. The quality may be deteriorating due to genetic factors, environmental factors *viz*, temperature, humidity and gaseous imbalance or may be due to improper care and unfavorable conditions during pre and post-harvest stage. The lack of synchronized flowering is also an important factor which also affects fruit development process. In post-harvest quality are present the market quality, transport quality, edible quality and nutritional quality. Quality refers to a combination of characteristics, attributes and properties that provides the values to human and enjoyments (Sagrawat *et al*., 2006). Consumers consider better quality in relation to colour, flavour and nutrition. The produce quality is the final manifestation of inter-relation between the commodity and its surrounding environment. The physiological character and genetic characteristics are status of the commodity to examine the post-harvest study and quality of produce. The ultimate quality is the final manifestation of inter relation between the commodity and its surrounding environment.

Jamun is naturally spread cultivar and the enormous variability has been reported due to cross-pollination and predominance of seed propagation creating a lot of variation in their field population with respect to tree height, fruiting behavior, yield and quality attributes. This assessment of genetic variability is considered vital tool for formulating conservation strategies of these underutilized fruits (Singh *et al.,* 1967). Genetic variability

is considered vital tool for identification of superior accessions and conservation of this under-exploited fruit species. Phenotypic variability of plant organs such as leaves, flowers, fruits and seeds are most commonly used traits. Earlier studies on those fruit detected a lot of variation in respect of fruit shape, size, pulp colour, TSS, acidity, earliness, taste, flower initiation and fruit maturity.

Keeping all this in view, the present study entitled "**Studies on flowering, fruiting and post-harvest characters of jamun (*Syzygium cuminii* Skeels) genotypes**" is conducted to evaluate the quality attributes of fruits like, medicinal importance, morphological and physio-chemical characters (ascorbic acid, anthocyanin, pH, acidity, TSS and flavonoids), in Post-Harvest Lab Department of Horticulture under Institute of Agricultural Sciences, Banaras Hindu University, Varanasi (Uttar Pradesh) with following objectives.

1. To evaluate the genotypes of jamun for flowering and fruit characters.
2. To see the variation on various quality attributes in jamun genotypes.

CHAPTER-II

REVIEW OF LITERATURE

A study on jamun (*Syzygium cuminii* Skeels) genotypes grown under Banaras Hindu University, Varanasi was under taken to select the superior genotype. The diagnostic characteristics of tree fruit size, fruit weight, fruit width, seed weight, length, width and fruit colour etc, are important parameters for selecting the superior genotypes. Bajpai and Chaturvedi, (1990) reported that while selecting a cultivar of jamun the important parameters are oval or oblong shape of fruit, deep purple or bluish black colour, big size, more pulp, small stone, juiciness, earliness and sweetness. An experiment has been made to review the earlier work pertaining to the evaluation of *Syzygium cuminii* genotypes based on biochemical and morphological characteristics (Prabhuraj *et al.,* 2002, Prakash *et al.,* 2010, Ghojage *et al.,* 2011 and Singh and Singh, 2012). There are large numbers of morphological attribute which are suitable to study the genetic variability. The present study was therefore, undertaken with a view to determine the medicinal importance, biochemical and morphological properties of *Syzygium cuminii*. The citations have been presented in this chapter related to physio-chemical, morphological and medicinal properties can be described below.

2.1 Soil and climatic adoptability

Favourable soil and climatic condition are important factor for proper growth and development of trees. It also affects the fruit development and quality characteristics of genotypes; found growing in a particular soil and climatic conditions. These trees adopt a wide range of soils ranging from clay to sandy loam. Among the soil types loamy to deep well drained soils are most suitable for optimum growth and development (Irulappan and Anbu, 1994). Those trees are found growing under tropical and subtropical climates and from sea level to an altitude of 1800 m. Those trees require dry weather at the time of flowering and fruit setting. Early rains benefit ripening of fruit and proper development of fruit size, colour and taste (Singh, 1967 and Chundawat, 1990). Young plants are

susceptible to cold and drought conditions (Bose *et al*., 1990). It is also grown successfully in low to medium rainfall areas (600-700 mm) having vertisols soil (Subramaniyan *et al.*, 1989).

2.2 Variability in jamun genotypes

Ashraf (1987) observed that fruit shape in *Syzygium cuminii* varied from round to oblong and apex of fruits from flat to pointed one. He found more variability in physico-chemical characteristics of fruits offering possibility to select a variety suitable for fresh market and processing. Small seed size, maximum pulp content with good physio-chemical properties is considered ideal characteristics.

Singh *et al*. (1999) reported that different fruit like bael, jamun, mahua, lasora, wood apple, monkey jack and karonda were grown well region of eastern Uttar Pradesh. They observed the variability existing in their genotypes for selection of desirable genotypes. Also they determined the variability on physicochemical characteristics on fruits and recognized some desirable traits.

Kundu *et al*. (2001) investigated the 4 local types of *Syzygium cuminii* in West Bengal for their physicochemical characters and fruit yield. They found variation among selected 4 genotypes and that genotypes recorded JS-1 (with 1 oval-shaped large fruit) and JS-2 (cylindrical-shaped, medium-sized fruit) showed maximum characteristics for yield, fruit size and weight. Fruits of genotype JS-2 and JS-3 (pear-shaped, medium-sized fruits) showed high amounts of TSS, reducing sugar and total sugar.

Srimathi *et al*. (2001) conducted a study in *Syzygium cuminii* to determine the effect of fruit colour on the fruit, seed and seedling quality. They observed that maximum fruit length (2.1 cm), fruit breadth (1.3 cm), fresh weight (1.944 g), fruit dry weight (0.378 g), seed fresh weight (0.380 g), root length (8.1 cm), shoot length (21.2 cm), dry matter production (524 mg) and vigour index (2825) in blackish purple fruit. While the

maximum fruit volume (1.1 ml) and seed length (1.3 cm) were obtained in rosy fruit. The maximum seed moisture content (86.9%) was obtained in green fruit with rosy tinge.

Devi *et al*. (2002) evaluated the variability in physico-chemical characters of 18 jamun genotypes accessions from Goa. In this experiment a wide variation among its accessions was found. Single fruit weight ranged from 3.42 to 13.67 g, length from 3.31 to 5.26 cm, width from 5.21 to 9.82 cm, length/width ratio from 1.44 to 2.30 and pulp per cent from 58.57 to 84.55% were also noted. They were found a wide variation in physio-chemical characters also. TSS varied from 12.0 to 26.8^0 Brix, titratable acidity from 0.59 to 1.63%, total sugars found 6.87 to 25.31% and sugar/acid ratio from 15.39 to 27.92.

Prabhuraj *et al*. (2002) evaluated the nature and variability present in *Syzygium cuminii* seedling progenies for morphological characters of trees in the Belghum district of Karnataka. They found the more variability for the characters *viz*. plant width, leaf area, petiole length and leaf length to petiole length ratio.

Prabhuraj *et al*. (2003) found that existing natural variability among the selected 125 genotype of *Syzygium cuminii* were selected and to locate genotypes with better fruit qualities. They note down the physico-chemical parameters of the fruits and seeds such as fruit length and width, fruit weight, fruit volume, seed length and width, seed weight, seed volume, pulp weight, pulp%, pulp to seed ratio, TSS, acidity, phenol, pH and anthocyanin content. Among 125 plants they determined 9 desirable seedling trees which shown a wide variation with respect to the physico-chemical properties. Kannan and Thirumaran (2004) observed that mature fruit of jamun (*Syzygium cuminii*) had 75% pulp portion with pulp/seed ratio of 3.1:1. Revitalization of juice from fruits was 64.00% and the pomace content was 23.90%, whereas the preparation losses were 11.70%. Its fruits are contained 500 mg phenolic compounds and 196 mg anthocyanins per 100 ml fruit juice. The weight and length of fruits in grafted trees were additional than those of fruits from seedling trees. Biochemical composition of fruits from grafted trees restricted higher ascorbic acid, pectin, TSS and crude fiber than those of fruits from seedling.

Patel *et al*. (2005) conducted an experiment in Uttar Pradesh (Lucknow, Varanasi and adjoining areas) and Jharkhand (Ranchi and adjoining areas) to find out the existing natural variability among the *Syzygium cuminii* seedling plant. They found better genotypes with good fruit qualities and observations physico-chemical parameters of 32 genotypes. All the genotypes showed considerable more variability with respect to the physico-chemical character. The genotypes RNC-11 and RNC-26 were found promising and had higher fruit and pulp weight with sweet fruits. Maximum pulp content (97.71%) was recorded in genotype V-8 followed in genotype V-6 (95.84 %) and V-7 (93.81 %) in Varanasi area. They observed very low seed weight (0.12 g) in genotype V-8 followed by genotype V-6 (0.16 g) and V-7 (0.31 g).

Athani *et al*. (2006) evaluated of 55 genotypes of jamun was carried out for physio-chemical characters in Arabhavi and Maharashtra. They found wide variation among the strains in terms of economic characters. Strain ALG-58 emerged as a potential one for superior characters.

Singh *et al*. (2007) conducted a study in twenty-two jamun genotype to determine the variations in the morphological and physicochemical traits of jamun (*Syzygium cuminii*) genotypes. The study exposed that there was wide variation among the identified genotype. Weight of individual fruit ranged from 4.80 to 17.60 g, diameter from 1.66 to 3.04 cm, length from 2.22 to 4.51 cm, seed weight from 1.30 to 2.36 g and pulp content from 68.75 to 86.59%. The total soluble solids (TSS) with different genotype ranging from 12.2 to 18.4°Brix while the titrable acidity per cent ranged from 0.79 to 1.25%. They study was concluded that the cultivars CISH J-17, CISH J-14, CISH J-19 and CISH J-20 exerted potential accessions based on their physicochemical attribute.

Singh *et al*. (2009) recognized that the accession CISH J-37 was superior due to its large sized bunches with gorgeous deep purple colour, higher pulp to seed ratio (90-92) and TSS (16-17 ºBrix) was observed.

Sharma *et al.* (2009) studied on physico-chemical composition of fresh jamun and guava fruits. In their study it was found that the average jamun fruit weight and pulp weight were 5.42 and 69.2 g/kg fruit. The chemical compostion jamun fruits such as total soluble solids, total and reducing sugars were found to be 9.2%, 5.98%, 4.36% and 2.98%, while acidity, ascorbic acid, anthocyanins and total phenols were recorded to be 1.36%, 138 mg/100 g^{-1}, 2.08 and 218 mg/100 g^{-1} for jamun, respectively.

Prakash *et al*. (2010) evaluated jamun genotypes that showed the wide range of variability in the physico-chemical composition of fruit they found the Selection-1 was most promising for fruit weight, minimum seed weight, higher pulp per cent, TSS and total sugar.

Patel *et al*. (2010) observed that maximum fruit weight and pulp weight were determined in LS-27 and Krishna. The minimum seed weight and higher pulp:seed ratio was recorded in LS-27 followed by NA-7. The juice quantity was found maximum in LS-27 genotype. While the minimum pulp to juice ratio was record in LS-27 genotype followed by Gujarat Aonla-1 and LS-18. The maximum T.S.S. was found in hybrid-2 and LS-18, while the minimum titrable acidity was found in Krishna and NA-7. The ascorbic acid was recorded maximum in Gujarat Aonla-1 and Krishna. The finally results expressed that as compare to hybrids, LS-27 and Krishna varieties were observed superior for physico-chemical attribute.

Ghojage *et al*. (2011) conducted a study in Gokak taluk of Belgaum district in Karnataka and Sawantwadi in Sindhudurg district of Maharashtra, they determined the variability in selected genotype of jamun from seedling trees located observation on morphological and chemical attribute of the fruit are recorded. They selected thirty best genotype among selected genotype were taken for study. Among the physical characters the fruit weight was varied (13.45 g) in genotype KJS-4 and KJS-24 (5.27 g) was recorded for maximum fruit weight. They also found the longest fruit in genotype KJS-8 (4.49 cm) and shortest fruit was recorded in genotype of KJS-30 (2.70 cm). The genotype

KJS-4 and KJS-9 had the maximum pulp weight (11.47 g) and maximum pulp content (87.35%) was recorded respectively, while the genotype KJS-15 was found the minimum pulp content (60.23%) and pulp weight (3.56 g). The average pulp weight and pulp content were 8.35 g and 81.50%, respectively. The fruit with minimum seed weight was found in KJS-9 (1.34 g) genotype, while the maximum seed weight was determined in the genotype KJS-2 (2.08 g). The maximum pulp to seed ratio was recorded in genotype KJS-9 (6.91) and minimum pulp to seed ratio was recorded in KJS-24 (2.08) genotype. Among the chemical character the maximum TSS was record in the genotype KJS-3 (21.2%), while the minimum TSS was recorded in genotype KJS-29 (21.2%). The maximum anthocyanin was recorded in genotype KJS-18(1.393 ppm) while the minimum value was recorded in genotype KJS-1 (0.162 ppm).

Hareesh *et al*. (2012) conducted a study on variation of fruit, seed and seedling growth attributes among purple and white types in *Syzygium cuminii*. Seeds of white type showed delayed germination than purple type of seed. They also found that there were significant differences between purple and white types for fruit, seed, growth, germination and biomass of seedlings an also the poor performance of white type might be due to inherent character of off type.

Singh and Singh (2012) carried out a survey for studies on variability in *Syzygium cuminii* to identify the elite genotypes in Gujarat. They studied the flowering, fruiting and fruit quality attributes of 16 genotypes. They concluded that better performance of GJ-2, GJ-3 and GJ-8 were evaluated to be promising among all genotypes on the basis of overall performance.

Kumar *et al*. (2013) conducted a study on different genotypes of aonla to assess the variability in physico-chemical attribute of fruits. The observations was recored during experiment showed that genotype six and seven genotype are better than other, in physic-chemical properties of fruits. The maximum pulp per cent (88.25%), ascorbic acid content (679.25 mg/100 g^{-1}) and pulp to seed ratio (8.24) was observed in genotype

7. Whereas, the maximum TSS (12.18%), minimum acidity (1.80%) and maximum sugar (3.50%, 2.50% and 6.0% reducing, non-reducing and total sugar, respectively) was observed in genotype 6.

Manveen and Bal (2015) recorded a significant variation for the attribute like tree height, canopy volume in different genotypes of jamun (*Syzygium cuminii*). The maximum tree height was recorded in Selection-III and minimum in Selection-II. The maximum fruit weight (11.0 g) was recorded in Selection-I and minimum in Desi seedlings. Among extensive variability for fruit breadth (1.75 to 2.53 cm), fruit length (1.83 to 3.53 cm), pulp to stone ratio (2.41 in Desi seedlings) to maximum (3.18) in Selection-II was recorded. The maximum TSS to acid ratio, total sugar and reducing sugar to the tune of 50.8 were found in Selection I and minimum (26.2) in Selection III. Titratable acidity was recorded maximum (0.80%) in 'Desi', whereas it was record minimum (0.32%) in Selection-I. Selection-I registered the maximum TSS to acid ratio to the level of 50.82 followed by Selection-II having TSS to acid ratio of 44.93. Selection-III recorded the minimum TSS to acidity ratio 26.18 and the maximum total sugars content (21.08%) was in 'Desi' among all the genotype. The minimum total sugar content (11.06%) was examined in Selection-III. 'Desi' record the maximum reducing sugars content of 14.48% whereas Selection-III found the minimum reducing sugar content 7.61 per cent.

Devi *et al*. (2016) experimented to know the variability on flowering and physical attribute of jamun (*Syzygium cuminii* Skeels) genotypes. They found that genotype AJG-58 was showed early flowering in month of last week of February, maximum number of flowers (2983.25), number of panicles (94.00) and minimum duration (80.75). The genotypes AJG-20 observed maximum number of fruit (1644), fruit length (33.32 mm), number of fruit harvested (882) whereas maximum fruit width was observed in Konkan Bahadoli (21.62 mm). The maximum fruit weight and pulp weight was observed in AJG-85 (9.50 and 6.93, respectively). Seed length (17.93 mm), seed width (10.43 mm) and seed weight (2.40 g)was recorded maximum in Konkan Bahadoli

followed by AJG-20 (11.10 and 4.36, respectively). These two genotypes can be utilized for make jamun seed powder which is of high medicinal value for diabetic patients. These characters could be considered as important traits for breeding programme.

Agrwal *et al*. (2017) conducted a survey in Madhya Pradesh to observe elite jamun genotypes for morphological characteristics and chemical character of 16 genotypes. They found genotype JJ-5 was the better genotype among the 16 accessions for average fruit weight (55.40 g), fruit width (22.01 mm), fruit length (27.78 mm), seed weight (14.70 g) and pulp weight (31.60 g). The biochemical attribute also showed maximum variability among all the genotype of jamun. The maximum TSS was recorded in JJ-4 (21.25 °Brix) followed by JJ-3 (19.85 °Brix). Acidity was maximum (0.53%) in JJ-9 and ascorbic acid in JJ-15 (42.30 (mg/100 g^{-1}).

Kumari *et al*. (2018) conducted a study in which 14 commercial litchi cultivars grown under Indian condition were analysed for variations in total ascorbic acid, anthocyanins, flavonoids phenolics and antioxidant activity. The significant difference was obtained among the cultivars with respect to antioxidant activity and bioactive compounds. About 2.35-fold variation in ascorbic acid content, 1.88-fold variation in total phenolics content, 2.02-fold variation in total anthocyanins and 3.70-fold variation in total flavonoids were recorded among the different litchi cultivars. Hierarchical cluster analysis classified the cultivars into 6 groups based on antioxidant activity and bioactive compounds. Among the cultivars evaluated, Bombay, Dehra Rose, Large Red and Deshi were observed to be high in bioactive compounds and exhibited maximum antioxidant activity than other cultivars. These cultivare can be used in crop improvement programme to breed varieties rich in phytochemicals and develop functional food-based products to increase dietary intake of health promoting bioactive compounds.

Plathia *et al*. (2018) surveyed for evaluation of genetic diversity of jamun (*Syzygium cuminii*) of seedling growing areas of Jammu sub-tropical areas. The maximum fruit weight found in genotype SJJS-27 (11.40 g), while the minimum fruit

weight was recorded in SJJS-32 (8.40 g). The maximum fruit size was recorded in genotype SJJS-2 (629.62 mm), whereas minimum fruit size was noticed in genotype SJJS-21. The minimum fruit length was recorded in genotype JJ-1 (18.26 mm), while the minimum fruit length was recorded in genotype JJ-5 (27.78 mm). Fruit width varied from 22.71 mm (JJ-13) to 15.25 mm (JJ-1). The fruits genotype SJJS-36 had maximum pulp% and minimum seed per cent with 88.38% and 11.62%, while the minimum value of pulp per cent and maximum non-edible portation (seed) was recorded in SJJS- 21 with 82.15% and 17.85%, respectively.

2.3 Morphological parameter of fruit

Hedrick (1925) recorded that morphological parameters *viz*. tree shape, leaf size and its colour are the most important characters in fruit crops for selecting the superior genotypes. on apple considered that morphological parameter description should become and comprehensive. It was notice that qualitative characters were constant than quantitative in vegetative parts of plants.

Mishra and Bajpai (1984) evaluated that jamun is a cross pollinated crop and the pollination is by honey bees, house flies and wind. The maximum fruit setting (32.6 to 36.0%) that can be observed by hand pollination done one day after anthesis. Thereafter, a sharp decline is observed in fruit set.

Pareek *et al.,* (2007) studied on floral biology of ber and observed that the self and cross-incompatibility plant and long juvenile period the major hindrances for taking up the systematic hybridization programme in those crop. The duration of flowering in ber is prolonged and the time of blossoming largely depends on climatic conditions. Flowering, can, however be regulated to some extent by timing the pruning operation. The flower buds in ber are borne on both mature as well as current season's growth and the inflorescence is an axillary cyme. Most of the ber varieties are self-unfruitful and fruit poorly without cross pollination. Fruits drop immature if they are set without fertilization or due to embryo abortion at later stage of fruit development. Therefore, an attempt has

been made in this review to critically analyse the important aspects of ber flowering; flowering time, flowering duration, flowering habit, anthesis, dehiscence, stigma receptivity, pollen morphology, pollen viability, pollen germination, fruit set and fruit drop. The ber flowering literature provides a wealth of usable information for breeders.

Babu *et al.* (2011) experimented in the flower morphology of pomegranate and found that time taken for flower bud differentiation ranging from 19.9 to 23.5 days. The average weight of intermediate, hermaphrodite and male flower was observed to be 4.82, 2.62 and 1.71 g respectively. They also found hermaphrodite flowers are miraculous phenomenon heterostyle. The lengths of pistil hermaphrodite, intermediate and male flower were found to be 2.00, 1.55 and 0.65 cm, respectively.

Bajpai *et al.* (2012) observed that flowering in jamun were start in 3rd week of February and continued till in 2nd week of March under sub-tropical conditions. The tree canopy had 5-13 panicles/shoot, the number of buds panicle-1 ranged from 19 to 73 in different directions of canopy, the panicle size had direct related with number of flowering buds.

Devi *et al*. (2016) investigated on variability on flowering and physical characters of jamun genotypes (*Syzygium cumini* Skeels). They can be observing the physico-chemical and flowering characters of fruits were recorded on 6 genotypes. Significant difference was noticed in all genotypes for the characters studied. AJG-58 genotype showed early flowering (late February), maximum number of panicles (94.00) and number of flowers (2983.25).

2.3.1 Physiology of flowering

Misra and Bajpai (1975) observed that the inflorescence of *Syzygium cuminii* plant carried about 35-45 flowers and they are generally flower are born in axils of leaves on one season old branchlet and the floral buds assume a club like structure appearance.

Bajpai and Chaturvedi (1985) observed the flowering was start in jamun first week of March and continues up to last week of April.

Tarai *et al*. (2006) reported that the flowering of jamun was started in last week of March and continues up to end of April month which take 28 to 35 days duration of flowering.

Stephen (2012) stated that flowers are borne in the axils of leaves on branchlet in jamun. Flowering can be start in North Indian condition for the first week of March and continues up to end of April. The total flowering phase culminating in fruit set and ripening of fruit in finally was found 119 to 126 days with flower bud initiation 45-50 days. The growth and fruit development in *Syzygium cuminii* fruit can be divided into three phase first phase 15-55 days after fruit setting slow growth of fruit, second phase can be start from 52-60 days after fruit setting fast growth and third phase more than 60 days after fruit setting slow growth and low fruit weight. Fruits are called berries, shape of fruit oblong to ovoid oblong, dark purple colour with 1 or 2 white or green seeds. Rudimentary type of seeds is also found in jamun (Morton, 1987).

2.3.2 Fruit set

In *Syzygium cuminii* Fruit set was recorded after 30 days of full bloom (April-May). Harvesting stage of fruits at fully mature and physical characters *viz*. fruit length, fruit width, fruit volume, fruit weight, seed length, seed width, seed volume, seed weight and pulp weight.

Prakash and Singh (2007) found that the per cent fruit retention in *Syzygium cuminii* fruit ranging from 34.47 to 80.00%. The maximum fruit retention was noticed in Selection-10 followed by Selection-3. Similarly study was carried out the per cent fruit drop was maximum recorded in Selection-3 and the minimum in Selection-10.

Babu *et al.* (2011) experimented on pomegranate fruiting behavior and also found the fruit setting in pomegranate ranging from 16.66 to 31.57%.

Sharma and Sharma (2011) reported the impact of self and cross-pollinatinon fruit set in almond. They found the maximum fruit setting in Primorskij (32.37%) with minimum fruit setting in Makhdoom (17.96%). No fruit setting was observed in any genotypes by self-pollination and self-incompatible nature of all genotype. In cross pollination, fruit setting was recorded between 20.00 and 42.84% for different cross combinations.

2.3.3 Fruit drop

Prakash and Singh (2007) carried out a study on the mode of pollination and fruit drop pattern of jamun (*Syzygium cuminii*). Among different modes of pollination, they also found the maximum per cent fruit set was recorded in open pollination condition followed by hand pollination and the minimum per cent of fruit set was observed under the bagging condition. The per cent fruit retention ranging from 34.47 to 80.00%.

2.3.4 Fruit growth and development

Garande *et al.* (1998a) experimented to determine the changes in chemical composition during growth and development of black berry fruit. They observed the total soluble solids (TSS), total reducing sugars and moisture content was show a continuous increase as the fruits developed with a marked increase during ripening. Acidity and pH first decreased and then increased. There was a gradual decrease in tannins whereas pectins rose and then fell during the growth period. Fruit TSS-acid ratio and anthocyanin content followed an increasing trend with advancing maturity and markedly increased during ripening.

Garande *et al.* (1998b) conducted a study on jamun (*Syzygium cuminii*) fruit which sampled at 10 day intervals, from fruit set to until partial ripening of fruit. They observed

the physical changes (weight, length, diameter and volume of fruit) in jamun fruits show continuous increases during development, the increase the fruit volume was highly rapid than the increase in fruit weight, specific gravity was showed a continuous decrease from fruit set to maturity but always remained greater than 1 and the fruit took 63 days for absolute ripening from fruit set, the fruit colour distorted from dark green at fruit set to light reddish-purple at the partial ripening stage, mature *syzygium cuminii* fruit 75.67% was pulp per cent and the pulp to seed ratio was 3.11:1.

2.4 Physical parameters of fruit

Dhaware (1981) conducted a study in region of Marathwada for evaluateing a superior quality of fruit in jamun (*Syzygium cuminii*) and they were reported that selection PBN 4 (stone-less) is the best quality fruit was reported in first time.

Devi *et al*. (2002) surveyed during fruiting time of April-May 2001 in the forest areas and cultivated fields in Northern part of Goa to evaluated an elite genotypes. The ripe fruits from 18 selected genotype were analysed for physiochemical characters like weight of fruit, length of fruit, width of fruit, pulp content and seed content.

2.4.1 Weight of seed

Garande *et al*. (1998) conducted an experiment in jamun and revealed that the fruit consist of about 75.67% edible portion as pulp. The average weight of seed was 1.92 g and pulp to seed ratio was 3.11:1.

2.4.2 Weight of pulp

Jadhav (1989) experimented in Bhokar tahsil of Handed district and 50 genotypes of local mango were collected. He was observed the correlation between weight of friut, weight of seed, weight of pulp, pulp per cent edible: non-edible ratio, volume of fruit, size of fruit, shape index, acidity (%), TSS (°Brix), reducing sugar (%) and total sugar (%).

2.4.3 Size of fruit

Inamdar *et al*. (2002) reported that correlation coefficient and path analysis for yield contributing characters for use in the improvement of yield and fruit characters of jamun (*Syzygium cuminii*) thirty-four genotypes were collected and assessed. The highly positive significant correlation with weight of pulp (0.998), volume of fruit (0.993), weight of seed (0.952), length of fruit (0.897), size of fruit (0.896), length of seed (0.875) and breadth of seed (0.684). The negative significant correlation was observed in fruit weight with seed per cent (0.547), while the titratable acidity and total soluble solids were negative correlated with fruit weight. This study result was showed the direct and indirect effects that weight of pulp, weight of seed, breadth of fruit, volume of fruit, pulp to seed ratio had high positive direct effects on the fruit weight.

Karuna *et al*. (2004) conducted an experiment in which comparative evaluation of 4 type of variety of litchi fruits were studied, China and Kasba were observed a superior quality of fruit. Whereas they found maximum length of fruit in Purbi (3.89 cm), maximum pulp per cent in Kasba (13.892%) and maximum seed per cent (19.12%) in Deshi.

2.4.4 Size of stone

Islam *et al*. (1991) conducted a survey on 27 custard apple genotype were collected from 8 districts and the measured for qualitative and quantitative characters of fruit. Their variation was found in weight of fruit, size of fruit, edible portion and TSS, overall accessions CA022, CA001 and CA017 were found superior to others.

2.4.5 Pulp to seed ratio

Garande *et al*. (1998) conducted an experiment in *Syzygium cuminii* and also reported that the edible portion of fruit consists of about 75.67% pulp. The average seed weight was observed 1.92 g and pulp to seed ratio was 3.11:1.

2.4.6 Shape of fruit

Kologi *et al*. (1977) conducted an experiment on cashew nut and found strains numbered 5/16, 4/63 and 1/63 that were superior quality over other existing 13 strains from Madras region.

Mishra *et al*. (1984) observed the variability of flowering and physical characters of 6 jamun (*Syzygium cuminii* Skeels) genotypes. Genotype AJG-58 was observed early flowering (late February), the maximum number of panicles (94.00), number of flowers (2983.25) and minimum duration (80.75). Genotypes AJG-20 noticed the maximum number of fruit (1644), number of fruit harvested (882) and fruit length (33.32 mm) whereas maximum fruit width was found in Konkan Bahadoli (21.62 mm). The maximum fruit weight and pulp weight was noticed in AJG-85 (9.50 and 6.93 g). Seed length (17.93 mm) and seed width (10.43 mm) was found maximum in Konkan Bahadoli followed by AJG-20 (11.10 and 4.36, respectively). The maximum seed weight was found in AJG-20 (2.40 g) followed by AJG-85 (2.37 g).

Geetha *et al*. (1992) worked on jamun fruit observed the length of fruit, diameter of fruit, weight of fruit and volume of fruits.

Kumar *et al*. (1993) experimented the variability in existing genotypes in jamun for selection of desirable 8 genotypes. The variability's were observed in physical, chemical and morphological parameter of fruits. The mean of fruit weight ranging from 4.5 g to 14.0 g. Length of fruits range from 1.1 to 3.5 cm and diameter of fruit varies from 1.3 to 2.3 cm. The average seed weight range from 0.9 to 1.9 g. Length of seeds varied from 0.8 to 2.1 cm, and diameter of seed ranging 0.8 to 1.3 cm. The pulp content was varied from 71 to 91% and pulp to seed ratio was found in range from 2.5 to 10.3.

Garande *et al*. (1998) experimented in ripening stages in jamun fruit. He reported that the colour of fruit changed from dark green at fruit set to light reddish purple at partial ripening stages. The ripe jamun fruit had 75.67% edible portion.

Singh *et al*. (1999) surveyed on several fruit including jamun to observe the variability in existing genotype for selection of desirable character. They also found more variability on physicochemical characteristics on fruits and also identified superior genotypes.

Kundu *et al*. (2001) studied among the four (JS-1, JS-2, JS-3 and JS-4) locally available genotypes of jamun (*Syzygium cuminii*) in west Bengal, on fruit yield and physicochemical characters among all genotypes JS-1 (oval-shaped and large size of fruit) and JS-2 (are shape of cylindrical and sized of fruit medium) showed high characteristics for yield fruit weight and size. Fruit of JS-2 and JS-3 (are pear shaped and medium sized fruit) performed more amounts of total soluble solids (TSS), reducing sugar and total sugar.

Srimathi *et al*. (2001) carried out a comparative study in jamun (*Syzygium cuminii*) to examine the effect of fruit colour on the fruit, seed and seedling quality. The maximum length of fruit (2.1 cm), fruit breadth (1.3 cm), fruit dry weight (0.378 g), fresh weight (1.944 g), seed fresh weight (0.380 g), shoot length (21.2 cm), root length (8.1 cm), dry matter production (524 mg) and vigour index (2825) was observed in blackish purple fruit and the maximum fruit volume (1.1 ml) and seed length (1.3 cm) were observed in 4 rosy fruit, while the maximum seed moisture content (86.9%) was examine in green fruit with rosy tinge.

Devi *et al.* (2002) studied on variability in physico-chemical characters of 18 jamun accessions from Goa. The ranging of fruit weight from 3.42 to 13.67 g, length of fruit from 3.31 to 5.26 cm, girth of fruit from 5.21 to 9.82 cm, length to width ratio from 1.44 to 2.30 and pulp per cent was observed from 58.57 to 84.55%. They also observe a wide variation in chemical characters. TSS was varied from 12.0 to 26.8 ^{0}Brix, acidity from 0.59 to 1.63%, sugar to acid ratio from 15.39 to 27.92 and total sugars from 6.87 to 25.31%.

Patel *et al*. (2005) conducted a study on various genotypes of jamun. They concluded that genotype V-8 had maximum pulp content (97.71%) followed by V-6 (95.84%) and V-7 (93.81%). Accessions RNC-26 and RNC-11 were observed superior genotype with respect to weight of pulp and weight of fruit. The minimum seed weight was found in V-8 (0.12 g) followed by V-6 (0.16 g).

Prakash *et al.* (2010) reported that Selection-1 was very promising for fruit weight (14.55 g), having minimum seed weight (1.73 g), maximum pulp per cent (90.05%), maximum total soluble solid (21.23%) and total sugar (20.24%).

Shahnawaz and Sheikh (2011) determined fruit weight, length and width of two improved variety of jamun *i.e*. They found that V1 and V2 maximum fruit weight (9.55 g), fruit length (3.88 cm) and fruit width (2.98 cm) and V2 fruit weight (6.71 g), fruit length (2.73 cm) and fruit width (2.10 cm), respectively.

Ghojage *et al.* (2011) observed the physico-chemical variability on thirty selected *Syzygium cuminii* genotypes. The maximum fruit length was observed in KJS-8 (4.49 cm) genotype and it was recorded minimum in KJS-30 (2.70 cm). The maximum pulp weight (11.47 g) and pulp content (87.35%) were observed in genotype KJS-4 and KJS-9, respectively. The minimum pulp weight was recorded (3.56 g) in genotype KJS-15 with 60.23% pulp content. The minimum seed weight was noticed in genotype KJS-9 (1.34 g), whereas the maximum seed weight was determined in KJS-2 genotype (2.08 g). The pulp to seed ratio was varied from 2.08 to 6.91 in the genotypes KJS-9 and KJS-24, respectively.

Bakshi *et al.* (2013) carried out an investigation to evaluate the different mango genotypes on the level of physico-chemical characteristics under rained areas of Jammu. Out of all the fifteen mango genotypes, the maximum fruit weight was measured in Mallika (182.16 g) and the minimum fruit weight in Selection-4 (64.83 g). The maximum fruit length (10.52 cm) and fruit breadth (6.98 cm) was determined in Mallika, whereas it was minimum in Selection-1 (5.26 cm and 4.22 cm). The pulp weight (117.15 g) and

stone weight (35.60 g) was maximum in Mallika, while Dashehari variety showed maximum pulp to stone ratio (3.90), while the maximum pulp per cent was observed in Mallika (71.48%). The result was showed; Dashehari was rated best in terms of colour, flavour and taste over all the genotype.

El-Sissy (2013) observed the morphological and physio-chemical attributes of fifteen guava genotypes. The maximum fruit weight was observed in genotypes No. 10 (277.37 g) in 2011 and No. 2 (253.23 g) in 2012. The longest fruit was noticed in genotype No. 10 in both seasons. They showed all genotypes give similar results for fruit width except No. 22, which was showed the biggest one. The maximum firmness was recorded in genotype No. 14 in 2011 and genotype No. 2 in 2012. The minimum seeds per cent were the best character for fruit quality and associated with genotype No 2 (1.294 -1.121%).

Rahman *et al.* (2014) carried out a study on fruit characteristics, yield contributing characters and yield of 21 mango genotypes. A wide variation was recorded all the genotypes in respect of different characteristics 21 under the present study. The maximum weight of fruit (237.0 g) with fruit length and fruit diameter of 9.50 cm and 6.87 cm were noticed in the genotype MI-Jai 005, whereas the minimum fruit weight (95.33 g) with fruit length and fruit diameter of 2.2 cm and 2.7 cm were recorded in MI Jai 004 per cent edible portion were the maximum in MI Jai 001 (66.86%), while the minimum edible part in MI Jai 012 (38.59%).

Mahmoud and Peter (2014) observed the physical character of guava fruits and tree no. 99 was evaluation a superior one over all the genotypes in term of weight of fruit (300.5 g), diameter of fruit (7.36 cm), less number of seed per fruit, maximum pulp thickness (3.2 cm), maximum pulp weight (271.7 g), pulp to fruit weight ratio (88.7%) and higher peel weight (28.83 g).

Devi *et al.* (2016) conducted an experiment on ber and found that maximum length of fruit (33.32 mm) in genotype AJG-20, whereas the maximum fruit width was recorded

in Konkan Bahadoli (21.62 mm). Maximum fruit weight and pulp weight was recorded d in AJG-85 (9.50 and 6.93, respectively). Seed width (10.43 mm) and seed length (17.93 mm) was found maximum in Konkan Bahadoli followed by AJG-20 (11.10 and 4.36 mm). Maximum seed weight was noticed in AJG-20(2.40 g) followed by AJG-85 (2.37 g).

2.5 Chemical parameter of fruit

2.5.1 Total soluble solids

Garande *et al*. (1998) observed TSS, total sugar and reducing sugar in jamun and showed a continuous increase as the fruits developed with a marked increase during ripening. There was a gradual decreased in tannins whereas pectin rose and then fell down during the growth period. TSS to acidity ratio and anthocyanin content followed an increasing trend with advancing maturity and markedly increased during ripening.

2.5.2 Acidity per cent

Singh *et al*. (2004) observed the physico-chemical character analysis of aonla cultivar to examine the possibility of selecting variety for processing purpose. The variety NA-6 was repoted maximum TSS (11.12%), higher acidity (2.26%) in variety chakaiya, while the maximum ascorbic acid content was recorded (733.63 mg/100 g) in variety NA-7.

2.5.3 Total sugar

Miller G.L. (1959) recorded that significant amount of soluble protein was found 0.85 mg/ml, reducing sugar 1.05 mg/ml and total sugar 9.40 mg/ml in aqueous extract of jamun fruit pulp.

Khudriya and Roy (1985) experimented in *Syzygium cuminii* and recorded that the juice content 8.40 to 9.06% total sugar and reducing sugar content varied from 7.41 to 8.06 per cent.

2.5.4 Reducing sugar

Mazumbar and Majumdar (2003) recorded that reducing sugar content in fresh extraction to pulp of *Syzygium cuminii* fruit was 5.72%. While non reducing sugar content was 8.58% and total sugar was 14.31%. They determined that in fruit, both reducing and non-reducing sugar were present in more amount.

2.6 Physico-chemical characters

Verma and Ghosh (1979) collected the genotypes of citrus from the mainly citrus growing regions and noticed some economically desirable characters of fruit *viz*. acidity and fruit size.

Shinde (1984) studied the variability, path analysis, correlation and physico-chemical composition of 52 custard apple genotypes from Marathwada region. Out of 52 genotype D-7, D-8 and A-6 were recorded superior genotype.

Parida and Rao (1988) conducted a survey on collection of mango genotype in the different districts of Orissa during 1981 and 1982. On the basis of field performances, more than 500 varieties were collected. After systematic description and physicochemical analysis of selected varieties only 11 varieties were selected this possesses comparatively quality with reputed commercial varieties of country.

Chouhan and Dhaliwal (1993) study was carried out on variation in the TSS, acidity and sugars of fruits of open-pollinated seedlings of guava. The maximum and minimum values for all these characters showed transgressive segregation which is quite helpful in finding the suitable elite genotype as per requirement.

Kumar *et al*. (1993) studied on improvement of *Syzygium cuminii* by selection and recorded the variation in acidity and TSS. Total soluble solid of jamun fruits ranging from 8.7 to 11.5% and acidity varied from 2 to 2.5%.

Singh *et al*. (2004) conducted a study on the physico-chemical characters of aonla varieties and recorded that variety NA-10 had maximum fruit weight (44.84 g), maximum pulp per cent was reported in variety NA-6 (94.27%).

Bhardwaj and Yamdagni (2005) analyzed the ripe fruits of grafted as well as seedling type of *Syzygium cuminii* for physico-chemical and morphological characteristics. The grafted jamun fruit contained maximum total soluble solids, ascorbic acid, sugar, pectin, crude fiber and carotenoids and minimum total acidity and chlorophyll contents. The protein, tannin and anthocyanin contents were at par in both types of fruits.

Shukla *et al*. (2006) surveyed in collection of 7 genotypes of aonla from Uttar Pradesh. Physico-chemical analysis were showed that, maximum fruit weight was recorded in genotype AKS/CIAH/E032 (44.78 g), maximum fruit length (3.88 cm), fruit width (4.62 cm), pulp per cent (95.91%) and pulp weight (42.95 g) was also reported in genotype AKS/CIAH/E032.

Reynertson *et al.* (2005) and Bajpai *et al.* (2005) showed that anthocyanin contents are positively correlated with antioxidant activity and that purple fruit of jamun had good potential source of antioxidant.

Prakash *et al.* (2010) studied on genetic variability of some promising genotype of *Syzygium cuminii*. They also estimated wide range variability in the physico-chemical composition of the fruit of different genotypes. The Selection-1 was most promising genotype for maximum total soluble solid (21.23%) and total sugar (20.24%). Thus Selection-1 can be used for systematic and commercial growing of jamun.

Srivastava *et al.* (2010) observed the total soluble solids (TSS) content ranged from 14.3% (VJ-12) to 26.2% (VJ-14) in jamun. The total sugar content was minimum (9.94%) for VJ-12 and maximum (25.46%) for VJ-14. The total reducing sugar content was maximum observed in genotype (20.54%) for VJ-14 and minimum (8.14%) for VJ-12. The sugar to acid ratio varied from 13.42 (PJ-25) to 37.45 (VJ-5). Acidity value was maximum for VJ-20 (1.14%) and minimum for VJ-5 (0.37%). The TSS and acid ratio varied from 14.50 (PJ-25) to 43.78 (VJ-5). The ascorbic acid content range from 30.0 (VJ-10) to 45.3/100 g, pulp (PJ- 23).

Ghojage *et al.* (2011) recorded maximum TSS in genotype KJS-3 (21.2%) of jamun, whereas the minimum in KJS-29 (21.2%). The genotypes KJS-18 showed maximum total sugar (18.43%), while the minimum values were in KJS-1 (0.162 ppm) and KJS-22 (8.24%), respectively.

Singh and Singh (2012) observed that total soluble solid brix ranging from 9.60 to 12.30, total sugar 7.40 to 9.14% and vitamin C 3.0 to 43.0 mg/100 g in jamun genotypes. On the basis of overall performance GJ-2, GJ-3 and GJ-8 were determined to be promising among all the genotypes.

Ali *et al.* (2015) found compositional properties in different parts of *Syzygium cuminii* fruits. The estimates of moisture content, total soluble solids (TSS), total acidity in the pulp was record 86.24±1.45%, 9.11±0.45 ^{0}Brix, 52.48±1.34% DW and 5.66±0.04 %, respectively.

Ghosh *et al*. (2017) found that the physicochemical, sensory and mechanical properties for *Syzygium cuminii* fruit and seed for further use and storage. The maximum whole weight of fruit was recorded 8.99±1.89 g. Whereas the maximum seed weight was 1.64±0.21 g. In case of mechanical property of fruit can be penetrated up to 4.1 mm whereas, at the same load for seed it can penetrate up to 2.53 mm. Purple colour for pulp, juice and whole fruit was 9.7, -0.9 and -0.76, respectively. The maximum amount of phenol (203.76±9.84, 386.51±10.25), anthocyanin (195.58±6.15, 18.47±1.99) and tannin

(94.52±9.19, 388.99±7.34) present in both fruit and seed. In case of sensory properties mouth feel and colour was good for market sample.

Suradkar *et al*. (2017) examined the bioactive and physic-chemical compound of jamun (*Syzygium cuminii*) fruit. The physical character include fruit weight (18.32 g), length (3.10 cm), breadth (2.87 cm), specific gravity (1.07), volume (17.12 ml), pomace per cent (17.85%), stone per cent (28.45%) and juice recovery (53.70%) was repoted to be, respectively. The values for moisture (81.35%), protein (1.26%), fat (0.29%), ash (0.85%), crude fiber (1.05%) and carbohydrate (15.2%) content of jamun fruit was record to be, respectively. The chemical parameter like TSS (^{o}Brix), pH, titratable acidity%, reducing sugar (per cent), total sugar (per cent), and non-reducing sugar (per cent) was recorded to be 3.10 ^{o}Brix, 0.87%, 13.40%, 10.67% and 2.73%, respectively. The bioactive composition like ascorbic acid (21.48 mg/100 g^{-1}), anthocyanins (185.35 mg/100 g^{-1}), tannin (168.24 mg/100 g^{-1}), total phenols (2133.50 mg GAE/100 g^{-1}) and antioxidant activity (95.81%) of jamun genotype was recorded.

2.6.1 Antioxidant properties

Jyothi *et al*. (2007) studied anthocyanin pigments from jamun fruit peels were characterized and observed for their antioxidant activity.

Vasi and Austin (2009) studied that the antioxidant potential of *Syzygium cuminii* using various *in vitro* models. Ethanolic (50%) extract was showed maximum scavenging activity in all models. The finding justifies the therapeutic application of the plant in the indigenous system of medicine, augmenting its therapeutic value.

Swami *et al*. (2012) stated that jamun is a widely distributed forest tree in India and other tropical and subtropical regions of the world. The *Syzygium cuminii* fruits are rich in physio-chemicals character like glycoside jambolin, tannins, anthocyanins, terpenoids, gallic acid and various minerals. Those fruits possessed antineoplastic,

radioprotective and chemopreventive effects which are useful in the prevention and treatment of cancer.

Shrikanta *et al*. (2015) recorded the *Syzygium cuminii* seed (34.87 g dry weight), weight pulp (13.70 g) and skin of jamun (11.19 g dry weight) have more resveratrol content next to mulberry fruit (50.61 g dry weight). They also observed that the *Syzygium cuminii* seed extract exhibited the maximum polyphenol content (55.54 mg gallic acid equivalent g dry weight) and maximum antioxidant activity (IC50 value -0.40 mg ml^{-1}).

Koley *et al*. (2016) studied on the hydroethanolic extract of the seed, methanolic extracts of stem anthocyanin-rich fruit peel extract (Veigas et al., 2007) and the methanolic extract of the leaves of jamun (Kshirsagar and Upadhyay, 2009). They examined the free radical scavengers in the DPPH scavenging assay. (Bajpai *et al*., 2005) have also recorded that the hydromethanolic extract of the *Syzygium cuminii* seed was effective in scavenging (90.6%) free radicals as observed in the auto-oxidation of β - carotene and linoleic acid assay and was due to the presence of higher total phenolic content in the extract.

Koley *et al*. (2016) experimented on 12 commercial cultivars of chinese jujube and determined for their ascorbic acid, total phenolics content, total flavonoids content and antioxidant activity. The Results were showed that Indian jujube is a good source of total phenol and ascorbic acid varied from 19.54 to 99.49 mg/100 g^{-1} and 172 to 328.6 mg GAE/100 g^{-1}. Total antioxidant content varied from 7.41 to 13.93 and 8.01 to 15.13 lmol Trolox/g^{-1} in CUPRAC and FRAP respectively. Gola and Elaichi are good promising genotypes in terms of total flavonoids and phenolics content.

2.7 Medicinal uses

Basak, (2003) and Kusumoto *et al*. (1995) reported that methanol extract of jamun bark is inhibited the enzymatic activity of HIV-(Human Immuno Deficiency Virus type – I) protease by more than 70% Medicinally, the fruit is astringent, carminative, stomachic,

antiscorbutic and diuretic. jamun fruit contains polyphenols like, malvidin, delphinidin. These are essentially hydrolysable tannins and fruit also contains tannic acid derivatives such as corilagin, gallic acid, corilagin andellagic acid.

Mitra *et al*. (2008) stated that gallic acid in lime fruit besides exerting the effects of tannin derivatives is useful in treatment of anti-influenza A and B and polio 1 virus. This compound kills and cleanses *Escherichia coli* from the urinary tract.

Goyal *et al*. (2010) concluded that seed extract of jamun (*Syzygium cuminii*) involved precautionary and therapeutic behavior against chemical induces gastric carcinogenesis.

Baliga *et al*. (2011) recorded that the jamun fruits are successfully having the anticancer, radioprotective potential and chemopreventive due to its antioxidant properties.

Swami *et al*. (2012) stated that *Syzygium cuminii* is the most important medicinal plant in different traditional systems of medicine. It is most efficient treatment of diarrhea, diabetes mellitus, ulcers, inflammation and preclinical studies resulted to acquireing radioprotective, chemopreventive and antineoplastic properties. The plant is rich in anthocyanins, glucoside, ellagic acid, isoquercetin, kaemferol and myrecetin compound. The seeds are claimed to hold alkaloid, glycoside jambolin or antimellin and jambosine, which halts the diastatic renovation of starch into sugar.

2.8 Fruit quality

Jadon *et al*. (1999) found the correlation and regression studies in 31 genotypes of jamun and were reported positive and significant correlations between different fruit parameters (diameter, weight, length, volume and pulp weight) and the regression analysis was find out that fruit volume and pulp weight were more significantly

correlated with fruit weight, while pulp weight and seed weight were more correlated with fruit diameter.

Vanangamudi *et al*. (2000) recorded the prediction of seed storability in *Syzygium cuminii* through accelerated ageing test. Seed samples of those fruit drawn at 24hr intervals were tested for germination and seedling vigour in terms of root and shoot length, vigour index and dry weight and found reduction in germination below 50 per cent occurred earlier in fruit.

Tarai *et al*. (2005) carried out a fruit quality study in alluvial zone of West Bengal and found that the *Syzygium cuminii* fruit was show, moderate contents of total sugar, TSS and reducing sugar.

Ghosh *et al*. (2006) the study was conducted on the quality and storage behavior of some local types of *Syzygium cuminii* fruits. They observed the significant variation in physical parameters includes fruit length, fruit diameter and fruit weight and the ranging of variation in chemical characters are TSS (10.6-16.10 ^{0}Brix), reducing sugar (3.92-10.12%), total sugar (4.86-11.10%), non-reducing sugar (0.94-1.61%), ascorbic acids (1.28-7.63 mg/100 g^{-1}), acidity (0.86%). They reported that the fruits can be stored up to the 4th day with a considerable per cent of fruits retaining in edible condition.

Pathak and Chakraborty (2006) studied the physico-chemical characters of tropical underutilized fruits. They observed the variation in physical and chemical characters includes fruit weight (5.35 g), fruit length (2.88 cm), fruit diameter (1.65 cm), pulp weight (3.91 g), seed weight (1.42 g), pulp to seed ratio (2.75) and edible portion (73.08). Chemical characters are TSS (10.8 ^{0}Brix), TSS and acidity ratio (28.42), acidity (0.38%), total sugar (9.52%), reducing sugar (8.16%), non-reducing sugar (1.29%) and ascorbic acids (16.78 mg/100 g^{-1}).

Tarai *et al*. (2006) reported that the performance of jamun genotype in West Bengal. The physical and chemical character of fruit was recorded as fruit weight (4.4 g),

TSS (10.5 ^{0}Brix), acidity (0.38%), TSS and acidity ratio (27.63), total sugar (9.09%) and ascorbic acid (7.8 mg/100 g^{-1} of pulp).

Nawaz *et al*. (2010) studied various to mineral contents of *Syzygium cuminii* fruit products namely seed powder jam, pulp powder, squash and ready-to drink juice between the improved-V1 and indigenous-V2 varieties. They concluded that there was a significant difference between the products as well between the cultivars. However, variety V1 is comparatively better than variety V2 for containing minerals, sodium and potassium are found to be abundant in quantity particularly in fruit seed. It was also found that jamun fruit can be utilized in beverage or even baby foods for the supplementation of essential mineral elements to malnourished.

2.9 Correlation coefficient

Inamdar *et al*. (2002) studied on correlation and regression study between different phenotypic characters of fruits from the selected thirty four jamun (*Syzygium cuminii*) genotypes that resulted highly significant positive correlation with fruit volume (0.993 cc), pulp weight (0.998 g), seed volume (0.918 cc), seed weight (0.952 g), fruit size (0.896 cm), seed length (0.875 cm), fruit length (0.897 cm), pulp thickness (0.842 kg/cm^2) and seed breadth (0.684 cm). Seed per cent had highly significant but negative correlation was found with fruit weight. They found that main emphasis in selection should be given for maximum pulp thickness, pulp weight, fruit volume, fruit size and pulp:seed ratio.

Srivastava *et al*. (2012) conducted a correlation study for physic-chemical properties in *Syzygium cuminii* fruit and revealed that for superior quality genotypes, major emphasisin selection should be given for maximum pulp weight, fruit size, fruit volume, pulp to seed ratio and higher TSS along with less size of seed.

Podder and Majumder (2017) carried out a study of correlations between different fruit attribute like, (fruit weight length, volume, diameter and pulp weight),

observed them to be positive and significant correlation in thirty-one genotypes of jamun (*Syzygium cuminii*) from the Shahdol and Jabalpur region of Madhya Pradesh. The regression psychoanalysis performed the volume of fruit and weight of pulp was most positively significant correlated with fruit weight while pulp weight and seed weight were good correlated with diameter of fruit.

CHAPTER-III

MATERIALS AND METHODS

The experiment entitled "**Studies on flowering, fruiting and post-harvest characters of jamun (*Syzygium cuminii* Skeels) genotypes**" was carried out in Banaras Hindu University, Varanasi during the year 2018. The details of experimental materials and methods adopted during the course of investigation are described below.

3.1 Experiment site

The experimental site lies approximately in the center of North-Genetic alluvial plain, on the left bank of river Ganga at a distance of about 10 km away from Varanasi Railway Station in the South-East direction. Geographically, Varanasi city is situated in 25°10' North latitude, 83°03' East longitudes. The altitude of location is 123.23 meters above the mean sea level. The district has a geographical area of 1578 sq./km which forms 0.64 per cent of the total geographical area of Uttar Pradesh state.

3.2 Plan of work

The experiment was carried out on the plant of jamun at Horticulturist Unit, Banaras Hindu University, Varanasi during March 2018 to June 2018, whereas postharvest study was carried out in the Research Laboratory of Horticulture Department, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh, India.

3.3 Meteorological conditions

The climate of Varanasi is humid subtropical with large variation between summer and winter temperature. Fog is common in winter and summer is accompanied by hot dry winds. The normal period of set of monsoon in this region is the third week of June and it lasts up to end of September. The average annual rainfall is about 1110 mm

and annual PET is about 1552. The temperature beings to rise from the middle of February and reaches its maximum end of May. The coolest time observed in a year is the first half of January. During the experiment, the maximum temperature was ranged up to 36-41^0 C and minimum temperature was about 11-13.8^{0}C**.**

Table 3.1 Weekly meteorological data during the period of experimentation 2018.

Week No.	Month & Date	Rainfall (mm)	Temperature ^{0}C		R.H. per cent		Wind speed km/hr	Sunshine hours	Evaporation (mm)
			Max.	Min.	Mor.	Even.			
1	March 05-11	0.0	30.4	13.8	82	36	2.4	7.9	3.9
2	12-18	0.0	33.1	15.7	72	28	2.2	8.5	4.5
3	19-25	0.0	34.1	15.6	73	27	1.8	8.8	4.8
4	26-01	0.0	35.4	16.8	69	24	3.7	9.0	6.6
5	April 02-08	9.4	33.8	20.0	70	42	3.2	7.9	6.4
6	09-15	0.0	34.8	20.2	72	35	2.6	8.8	5.8
7	16-22	0.0	39.0	21.9	55	25	2.2	9.6	7.9
8	23-29	0.0	36.6	20.8	57	31	3.7	9.8	8.2
9	30-06	15.4	34.3	21.9	78	49	5.4	8.8	6.6
10	May 07-13	0.0	36.9	24.0	69	62	3.3	10.1	8.0
11	14-20	0.0	35.2	25.1	73	43	4.4	8.6	7.2
12	21-27	0.0	41.0	27.1	72	29	3.0	9.7	8.2
13	28-03	0.0	36.1	26.3	69	50	4.9	8.4	7.0
14	June 04-10	0.0	36.1	27.5	71	52	3.6	8.2	7.4
15	11-17	2.4	41.0	27.3	60	36	6.9	7.1	9.1
16	18-24	0.0	40.4	28.3	63	36	3.6	9.1	8.8
17	25-01	33.3	33.9	26.7	80	61	4.1	4.0	6.1

The relative humidity was maximum in the month of March (82%) while the lowest relative humidity was observed during the month of April (55%). The weekly data on various weather parameters, prevailing during the experiment was recorded from Meteorological Observatory of Department of Agronomy, Banaras Hindu University, Varanasi.

3.4 Experimental material

An old plant of 30-35 years of uniform growth and vigour of 47 genotype of jamun (*Syzygium cuminii*) were selected for study about 'Studies on flowering, fruiting and postharvest characters of jamun (*Syzygium cuminii* Skeels) genotypes' at Banaras Hindu University, Varanasi, Uttar Pradesh, India.

3.5 Methods

Floral characters were recorded at the time of flowering. Mature fruits were collected for recording fruit characters, morphological, physical and chemical characters.

3.6 Location of selected genotype in experiment

Genotypes situation

Jamun genotypes were assigned as Genotype no. (JG) from 1 to 55 in Horticulture Unit, Banaras Hindu University, Varanasi.

3.7 Treatment Details

Table 3.2: Details of different genotypes.

Sr. No.	Genotypes	Notation
1.	Jamun Genotype-1	JG-1
2.	Jamun Genotype-2	JG-2
3.	Jamun Genotype-5	JG-5
4.	Jamun Genotype-6	JG-6
5.	Jamun Genotype-8	JG-8
6.	Jamun Genotype-9	JG-9

7.	Jamun Genotype-10	JG-10
8.	Jamun Genotype-11	JG-11
9.	Jamun Genotype-12	JG-12
10.	Jamun Genotype-13	JG-13
11.	Jamun Genotype-14	JG-14
12.	Jamun Genotype-15	JG-15
13.	Jamun Genotype-16	JG-16
14.	Jamun Genotype-17	JG-17
15.	Jamun Genotype-18	JG-18
16.	Jamun Genotype-19	JG-19
17.	Jamun Genotype-20	JG-20
18.	Jamun Genotype-21	JG-21
19.	Jamun Genotype-22	JG-22
20.	Jamun Genotype-23	JG-23
21.	Jamun Genotype-24	JG-24
22.	Jamun Genotype-25	JG-25
23.	Jamun Genotype-26	JG-26
24.	Jamun Genotype-27	JG-27
25.	Jamun Genotype-28	JG-28
26.	Jamun Genotype-29	JG-29
27.	Jamun Genotype-30	JG-30
28.	Jamun Genotype-31	JG-31
29.	Jamun Genotype-32	JG-32
30.	Jamun Genotype-33	JG-33
31.	Jamun Genotype-34	JG-34
32.	Jamun Genotype-35	JG-35
33.	Jamun Genotype-36	JG-36
34.	Jamun Genotype-37	JG-37
35.	Jamun Genotype-39	JG-39
36.	Jamun Genotype-40	JG-40
37.	Jamun Genotype-41	JG-41
38.	Jamun Genotype-42	JG-42
39.	Jamun Genotype-44	JG-44
40.	Jamun Genotype-46	JG-46
41.	Jamun Genotype-49	JG-49
42.	Jamun Genotype-50	JG-50
43.	Jamun Genotype-51	JG-51
44.	Jamun Genotype-52	JG-52
45.	Jamun Genotype-53	JG-53
46.	Jamun Genotype-54	JG-54
47.	Jamun Genotype-55	JG-55

3.8 Observations

Observations on various morphological, physical and quality characteristics were recorded as per the methods given under different characters below.

3.8.1 The general informations

The most common method of propagation of jamun is from seeds of local types. Those trees are rarely planted in the form of an orchard. Trees are generally planted on the bunds, side of the river and as wind break. In jamun flowering was started from month of March to April. Fruits are ripe in May to June. The fruits were harvested when they attained a colour of deep purple or black. Fruits were plucked gently by hand.

3.8.2 Procedure followed for selection of trees and collection of fruit samples

The selected jamun locations were visited to collect required information as per the proforma. The jamun trees were observed carefully for fruiting *i.e*. total number of fruits along with desirable fruit characters like big sized, attractive and glossy skin colour of fruits. The fruit samples were packed in polythene bags and brought to laboratory for further study.

3.9.1 Morphological features of jamun

3.9.1.1 Flower bud emergence

The observation in accordance to the flower bud emergence was taken by making the bud primordia of smallest size, which was visible to eye in the leaf axial.

3.9.1.2 Flowering duration

The period between emergence of first and last flower was considered as duration of flowering. Tagged plants in two directions to record duration of flowering and the observations were recorded daily in relation to date of initiation of flowering. The

opening of 70 to 80% flower was indicative of full bloom stage of the tree. Flowering started from the month of March to April and duration of flowering was 25 to 35 days.

3.9.1.3 Fruit set

After flower emergence after 25 to 30 days fruit setting may be started in jamun. The different mode of pollination *viz*, bagging, hand pollination and open pollination condition were allowed to find out the mode of pollination for fruit setting.

3.9.1.4 Duration of fruit maturity

The period between emergences of first fruit to maturity was considered as duration of fruit maturity. Fruit matured about 50 to 60 days after fruiting.

3.10 Physico-chemical properties of jamun

Fully matured fruits were harvested and physical parameters *viz*, average fruit length, fruit weight, fruit diameter, seed length, seed weight, seed diameter, pulp content, pulp:seed ratio, fruit:seed ratio and chemical properties *viz*, total soluble solid (TSS), acidity, pH, anthocyanin content, ascorbic acid content, TSS:acidity ratio, total phenol content, total flavonoid content and total antioxidant capacity were determined.

3.10.1 Physical characteristics

3.10.1.1 Fruit length (mm)

The length of the fruit was measured from the tip of the fruit to other end using digital vernier caliper and it was expressed in mili meters.

3.10.1.2 Fruit width (mm)

The fruit width was taken at the middle of the fruit across the fruit length using digital vernier caliper and it was expressed in milli meters.

3.10.1.3 Fruit weight

Eighty fruits per plant were selected randomly and used for estimation of fruit weight. These fruits were weighed with the help of a measuring balance and mean weight per fruit was computed and expressed in gram.

3.10.1.4 Seed size

The size of seed (both length and breadth) was measured with the help of vernier callipers by taking polar diameter and transfer diameter of seed. Total length and breadth of twenty seeds were measured separately in centimeters and the average was worked out by dividing the total respective length and breadth of twenty seeds and expressed in cm.

3.10.1.5 Seed weight

Eighty seeds were selected randomly and used for estimation of weight. These seeds were weighed with the help of a measuring balance and mean weight per seed was computed and expressed in gram (g).

3.10.1.6 Pulp weight

Initial weight of the randomly selected fruits was recorded with top pan electronic balance. Seeds were removed manually and the extracted pulp was weighed.

Pulp weight = weight of the fruit (g) – weight of the seed (g)

3.10.1.7 Pulp per cent (%)

Pulp per centage was calculated after recording the pulp and fresh weight of fruits.

Pulp per cent = weight of pulp/weight of fruit × 100

3.10.1.8 Seed/pulp ratio

Seed pulp ratio computed on the basis of pulp per cent and seed per cent in fruits.

Pulp to seed ratio = weight of pulp/ weight of seed

3.10.1.9 Fruit/seed ratio

Fruit and seed ratio calculated on the basis of fruit per cent and seed per cent in fruit.

3.10.2 Chemical properties

3.10.2.1 Total soluble solids (TSS)

A drop of juice from composite pulp sample was taken on the prism of the hand refract meter and per centage of total soluble solids was determined by observing it against the light.

3.10.2.2 Acidity

5 ml juice was mixed with 19.5 ml distilled water and then two to three drops of phenolphthalein indicater was added. Then titrated against 0.1N NaOH. The appearance of light pink colour marked the end point.

$$\text{Per cent titrable acidity} = \frac{\text{Titrate value} \times \text{Dye factor} \times \text{Volume made up} \times 100}{\text{Volume of the sample taken} \times \text{Weight of sample taken} \times 1000}$$

3.10.2.3 Estimation of pH

pH of fruits were measured using digital pH meter. Standard buffer solutions of pH 4.0, 7.0 and 10.0 were used to calibrate the instrument. The sample was prepared by adding 2.5 times distilled water to the macerated tissue in a beaker.

3.10.2.4 Estimation of total phenol content

Polyphenols content were determined calorimetrically. 100 mm sample was taken (mili-micro) and then 2.9 ml distilled water was added 0.5 ml FCA (folin) solution. After 3 minute, 20 per cent $NaCo_3$ (2ml) was added and then after one hours readings were recorded in spectrophotometer at 760nm.

3.10.2.5 Estimation of anthocyanins

Sample of 0.05 g crushed pulp was blended with 5ml of ethanolic-HCl, transferred to a 50ml centrifugal tube and made up to volume. The sample was stored overnight in refrigerator at 4ºC. All the readings were recorded in spectrophotometer at 535nm.

$$\text{Total anthocyanin} = \frac{\text{O.D} \times \text{Dilution} \times \text{Total volume made up} \times 100}{\text{Weight of sample} \times e}$$

Where 'e'-(Absorbance of solution containing 0.1 mg/ml anthocyanin)

3.10.2.6 Antioxidant content

The antioxidant activity in those fruits was estimated by CUPRAC method (Cupric reducing antioxidant capacity). Cupric reducing antioxidant capacity of *Syzygium cuminii* fruit was carried out by Apak method. In this method, 1 ml distilled water was taken. Then 1.0 ml each sample of neo-cuproine solution, copper chloride solution ($CuCl_2$), ammonium acetate buffer solution and 100 µl of sample extract (80% ethanol) were added. Then mixture was stand 30 minute. Then reading was note at 450 nm against a reagent blank. The result was measured as trolox equivalent (µmol TE g^{-1}).

3.10.2.7 Ascorbic acid content

Ascorbic acid content measured in the fruit pulp by 2, 6-dichlorophenol indophenols dye method. 0.025 g^{-1} of fruit pulp was taken and then fruit pulp was crushed by mortar and pustule with diluted 50 ml with 3% metaphosphoric acid solution (MPA).

Finally volume was made up to 10 ml and sample was taken. Then the sample was centrifuged and the supernatants were titrated with dye till a purple colour end point. The titrate value was note and the results were showed in mg /100 g fruit weight.

$$\text{Ascorbic acid} = \frac{\text{Titrate value} \times \text{Dye factor} \times \text{Volume made up} \times 100}{\text{Weight of sample taken} \times \text{Volume of the sample taken}}$$

3.10.2.8 Flavonoid content

In Jamun, fruit total flavonoids was measured by Zhishen *et al*. (1999) method. An aliquot of 1.0 ml jamun extract in ethanol was added than 4.0 ml of distilled water, 0.3 ml of 5% sodium nitrite ($NaNO_2$) the mixture was stand for 5 minutes after 0.3 ml of 10% aluminium chloride solution was added. The mixture was allowed to stand for 6 min, than 2.0 ml of 1 N NaOH was added to it and finally volume was made to 10.0 ml with distilled water. The reading was noticed at 510 nm in spectrophotometer. The finally result was expressed in catechin equivalent (mg CE 100 g^{-1}).

3.11 Statistical analysis of the data

The data was analyzed by using Randomized Block design by taking four replication within the plant and data were recorded for randomly selected 20 fruits from each replications and subjected to the following statistical analysis:

3.11.1 Analysis of variance for the design of experiment.

3.11.2 Variability parameters.

3.11.3 Heritability (Broad sense)

3.11.4 Correlation coefficient analysis.

3.11.1 Analysis of variance for the design of experiment.

Table 3.3: Analysis of variance

Sources of variation	d.f.	S.S	M.S.S	Variance ratio/ F- value (cal)
Replication	r -1	SSr	SSr / (r -1) = MSr	MSg/MSe
Treatments (Genotypes)	t-1	SSg	SSt / (g -1) = MSg	
Error	(r -1) (g -1)	SSe	SSe / (r -1) (g -1) = MSe	
Total	rg -1	SSt		

Where,

r = Number of replications

g = Number of genotypes/ treatments

SSr = Sum of Squares due to replication

SSg = Sum of Squares due to genotypes / treatments

SSe = Sum of Squares due to error

SSt = Total Sum Squares

MSr = Mean sum of squares due to replication

MSg = Mean sum of squares due to genotypes / treatments

MSe = Error mean sum of squares

Test of significance

If the variance ratio (or) F – calculated value $\frac{MSg}{EMS}$ or treatment / genotypes was greater than the F- table value at 5% level of significance, the variance between treatments was considered to be significant. It the F- calculated value is less than F–

tabulated value, the difference between treatments was considered to be non–significant (Fisher and Yates, 1943).

3.11.2 Variability parameters

Variability consisting of coefficient of variation (C.V.), standard deviation was determined for variability per cent and difference with individual type, individual strains (Panse and Sukhatme 1967).

The determined 'F' value was compare with the tabulated 'F' value. If the 'F' test value was significant, after that critical difference (C.D.) and standard error were calculated below;

SE(m)± = $\sqrt{(Me/r)}$

SE(d)± = $\sqrt{(2Me/r)}$

C.D. (5%) = SE (d) × $t_{0.05}$ error d.f.

3.11.2.1 Phenotypic and genotypic coefficient of variation (CV)

Phenotypic and genotypic coefficient of variation was calculated by the method suggested by Burton and Devane (1953):

$$\text{Phenotypic coefficient of variation (PCV)} = \frac{\text{Phenotypic standard deviation}}{\text{General mean}} \times 100$$

$$= \frac{\sigma_P}{\overline{X}} \text{ x } 100$$

$$\text{Genotypic coefficient of variation (GCV)} = \frac{\text{Genotypic standard deviation}}{\text{General mean}} \times 100$$

$$= \frac{\sigma_g}{\bar{X}} \text{ x } 100$$

3.11.3 Heritability (Broad Sense)

Heritability is the proportion of genetic variance to the phenotypic variance an expressed in percentage. It was calculated by the formula given by Allard (1960) which is given below:

$$H = \frac{\sigma_g^2}{\sigma_p^2}$$

Where,

H = Heritability in broad sense

$\sigma 2g$ = Genotypic variance = $\frac{MST - MSE}{r}$

$\sigma 2p$ = Phenotypic variance= $\sigma 2g + \sigma 2e$

where,

MST = Total mean sum of squares

MSE = Error mean sum of squares

3.11.4 Correlation coefficient analysis

Phenotypic and genotypic correlations were determining the statistical analysis in variance value in which whole variability had been dividing into genotype, replication and error.

The simple phenotypic correlation coefficients among pairs of characters were calculated according to the formula suggested by Searle (1961).

$$r_{(X1X2)} = \frac{\text{Cov}\,(X_1X_2)}{\sqrt{V(X_1)\cdot V(X_2)}}$$

Where,

X_1 = Character 1

X_2 = Character 2

$r_{(X1X2)}$ = Correlation between characters X_1 and X_2

Cov_{X1X2} = Covariance between X_1 and X_2

$V_{(X1)}$ = Variance of X_1

$V_{(X2)}$ = Variance of X_2

In the estimation of phenotypic correlation coefficients, phenotypic covariance and variance are considered for calculation.

The statistical significance of correlation coefficients was tested against table "r" values at (n-2) d.f (degree of freedom), where n refers to pair of observation. (statistical table by Fisher and Yates, 1963) at 5% levels of significance.

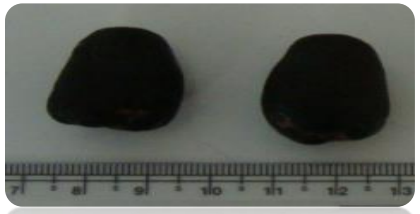
JG-5

JG-16

JG-20

JG-21

JG-27



JG-30

JG-36

JG-40

JG-41

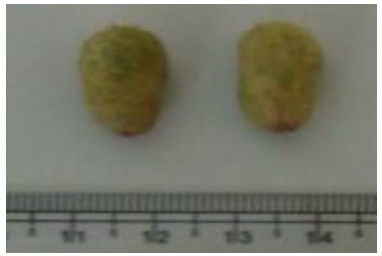
JG-42

JG-44

JG-54

Plate 3.1: Fruit of jamun collection

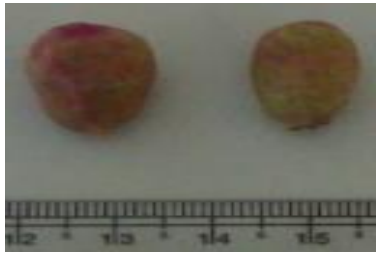
JG-5



JG-16

JG-20

JG-24

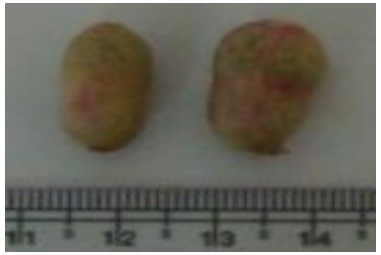


JG-27

JG-30

JG-36

JG-40



JG-41

JG-42

JG-44

JG-54

Plate 4.2: Seed of jamun collection

CHAPTER-IV

EXPERIMENTAL FINDINGS

Evaluation of local superior elite types of jamun (*Syzygium cuminii* Skeels) was undertaken in Banaras Hindu University, Varanasi during March 2018 to June 2018. About 47 genotypes of jamun were selected and examined in laboratory for their fruit characters. The data obtained on the physio-chemical characters and phenotypic variability correlation coefficient of jamun fruit and other aspects of jamun genotypes were analysed statistically. The results are presented with two different approaches.

1) Variability studies of various fruit characters.
2) Correlation studies.

4.1. Variability studies of various fruit characters of jamun fruit

The analysis of variability revealed significant variance owing to type for most of the characters under study. The estimation of range, mean, coefficient of variation and standard deviation are presented in Table 4.1. The various characters of 47 genotypes were described below which show a broad spectrum of variability.

4.1.1 Physical characters

4.1.1.1 Duration of flowering (days)

The data on duration of flowering are presented in Table 4.1 and exhibited in Figure 4.1 for which the results showed significant differences among the genotypes. Maximum duration of flowering (34.50 days) was recorded in genotype JG-21, which was statistically at par with JG-27 (34.50 days) followed by JG-23 (34.25 days), JG-33 (34.25 days) and JG-5 (34.00 days). Whereas, JG-21 was significant to JG-6 (31.00 days), JG-11 (31.00 days) and all other genotype. However, minimum duration of flowering was recorded in the genotype JG-41 (25.00 days) followed by JG-51 (26.75 days), JG-36 (27.00 days), JG-17 (27.00 days) and JG-1 (27.25 days).

4.1.1.2 Duration of fruit maturity (days)

The mean duration of fruit maturity (50.28 days). Significant variability was noticed in duration of fruit maturity and it ranged from 44.50 to 56.25 days. Genotype JG-51 recorded maximum duration of fruit maturity (56.25 days), which was statistically at par with JG-16 (56.00 days) followed by JG-34 (55.25 days), JG-17 (55.00 days) and JG-9 (55.00 days). Whereas, JG-51 was significant to JG-15 (52.00 days) and all other genotype of jamun. While the minimum duration of fruit maturity (44.50 days) was recorded with genotype JG-22 followed by JG-28 (45.25 days), JG-52 (45.75 days), JG-10 (46.00 days) and JG-54 (46.50 days).

4.1.1.3 Fruit weight (g)

The data presented in Table 4.l indicated the difference among the type with regarding to fruit weight. The average weight of fruit is 5.06 g. The variability in fruit weight was more and ranged from 3.31 to 11.67 g. Out of 47 genotypes JG-55 (11.68 g) recorded maximum weight of fruit, which was significant to all other genotypes of jamun. While, minimum fruit weight was recorded with JG-15 (3.31 g) followed by JG-20 (3.37 g), JG-23 (3.40 g), JG-14 (3.60 g) and JG-12 (3.62 g).

4.1.1.4 Fruit length (mm)

The average length of fruit was (23.05 mm). The variability in fruit length was more and it's ranged from 18.50 to 32.11 mm. Genotype JG-55 recorded maximum fruit length (32.11 mm), which was significant to all remaining genotypes of jamun. The minimum fruit length was recorded in JG-26 (18.50 mm) followed length was recorded in JG-26 (18.50 mm) followed by JG-15 (18.93 mm), JG-14 (19.76 mm), JG-33 (20.69 mm) and JG-28 (20.75 mm).

4.1.1.5 Fruit diameter (mm)

The variations in fruit diameter were presented in Table 4.1 ranged from 15.02 to 23.85 mm. The average fruit diameter was 17.60 mm out of 47 genotypes. Maximum

fruit diameter was recorded in genotype JG-16 (23.85 mm) which was the statistically at par with JG-55 (23.23 mm). Whereas, JG-16 was significant to JG-46 (22.19 mm), JG-21 (21.15 mm), JG-39 (20.69 mm) and all remaining genotypes of jamun. While the minimum fruit diameter was recorded in genotype JG-6 (15.02 mm) followed by JG-15 (15.12 mm), JG-14 (15.32 mm), JG-34 (15.50 mm) and JG-44 (15.60 mm).

4.1.1.6 Seed weight (g)

The mean seed weight was 1.35 g. The average seed weight ranged from 0.62 to 1.79 g. Out of 47 types, maximum seed weight was recorded in genotype JG-37 (1.79 g), which was significant to all remaining genotypes of jamun. While, the minimum seed weight was recorded in genotype JG-6 (0.62 g) followed by JG-14 (0.65 g), JG-15 (0.68 g), JG-44 (1.20 g) and JG-28 (1.21 g).

4.1.1.7 Seed length (mm)

The variations in seed length were presented in Table 4.2 of different types ranged from 14.01 to 20.07 mm. The average seed length was 17.55 mm out of 47 types, the maximum length seed was recorded in genotype JG-55 (20.07 mm) which was the statistically at par with JG-54 (19.87 mm). Whereas, JG-55 was significant to JG-51 (19.27 mm), JG-52 (19.12 mm), JG-26 (19.03 mm) and all remaining genotypes of jamun. Whereas, minimum seed length was recorded in genotype JG-15 (14.01 mm) followed by JG-14 (15.44 mm), JG-30 (15.68 mm), JG-5 (15.97 mm) and JG-6 (16.21 mm).

Table 4.1: Physical characters of fruits of jamun genotypes.

Jamun Genotype	Duration of flowering (days)	Duration of fruit maturity (days)	Fruit weight (g)	Fruit length (mm)	Fruit diameter (mm)
JG-1	27.25	50.00	6.57	25.73	20.17
JG-2	32.25	49.00	5.94	24.80	19.14
JG-5	34.00	53.00	3.80	22.24	15.81

JG-6	31.00	48.50	3.78	23.11	15.02
JG-8	28.00	51.25	5.14	21.41	16.64
JG-9	32.25	55.00	4.00	22.70	16.26
JG-10	32.50	46.00	5.58	23.11	17.92
JG-11	31.00	53.25	4.58	21.92	17.30
JG-12	33.00	50.50	3.62	21.93	15.67
JG-13	32.75	47.50	6.18	24.50	18.77
JG-14	34.00	50.25	3.60	19.76	15.32
JG-15	28.25	52.00	3.31	18.93	15.12
JG-16	33.00	56.00	4.86	23.85	23.85
JG-17	27.00	55.00	5.19	22.62	17.88
JG-18	29.00	53.50	5.70	23.65	17.92
JG-19	28.25	48.75	6.42	25.34	18.92
JG-20	32.00	49.25	3.37	21.10	15.28
JG-21	34.50	47.75	7.63	25.87	21.15
JG-22	28.00	44.50	5.91	24.22	19.10
JG-23	34.25	50.00	3.40	21.95	15.03
JG-24	32.00	52.75	5.18	22.65	17.08
JG-25	33.50	54.50	4.65	21.88	17.58
JG-26	32.00	52.75	3.80	18.50	16.02
JG-27	34.50	48.00	4.84	23.42	18.58
JG-28	31.00	45.25	4.38	20.75	15.70
JG-29	27.25	47.00	4.77	22.15	17.16
JG-30	28.00	48.25	4.30	22.55	16.05
JG-31	33.25	46.75	3.75	22.06	17.20
JG-32	32.50	48.75	4.56	22.10	16.12

JG-33	34.25	51.00	4.13	20.69	15.88
JG-34	33.00	55.25	3.97	23.33	15.50
JG-35	32.00	50.75	4.16	22.24	16.23
JG-36	27.00	51.00	4.29	21.96	16.69
JG-37	33.25	48.00	4.16	23.27	16.65
JG-39	32.00	49.50	6.90	27.39	20.69
JG-40	27.50	49.50	4.35	22.90	17.54
JG-41	25.00	54.00	4.69	23.04	16.91
JG-42	33.50	49.00	4.31	23.46	16.72
JG-44	31.50	48.00	3.75	22.36	15.60
JG-46	33.50	49.00	4.40	22.19	22.19
JG-49	31.50	54.00	3.95	21.24	16.49
JG-50	27.25	51.25	7.09	21.55	16.36
JG-51	26.75	56.25	6.43	26.22	19.89
JG-52	29.50	45.75	6.32	26.08	19.69
JG-53	29.00	48.50	6.97	25.27	19.41
JG-54	29.50	46.50	7.52	23.67	17.82
JG-55	34.00	50.75	11.68	32.11	23.23
Mean	**30.98**	**50.28**	**5.06**	**23.06**	**17.60**
C.D. 5%	3.12	4.11	0.40	0.81	0.64

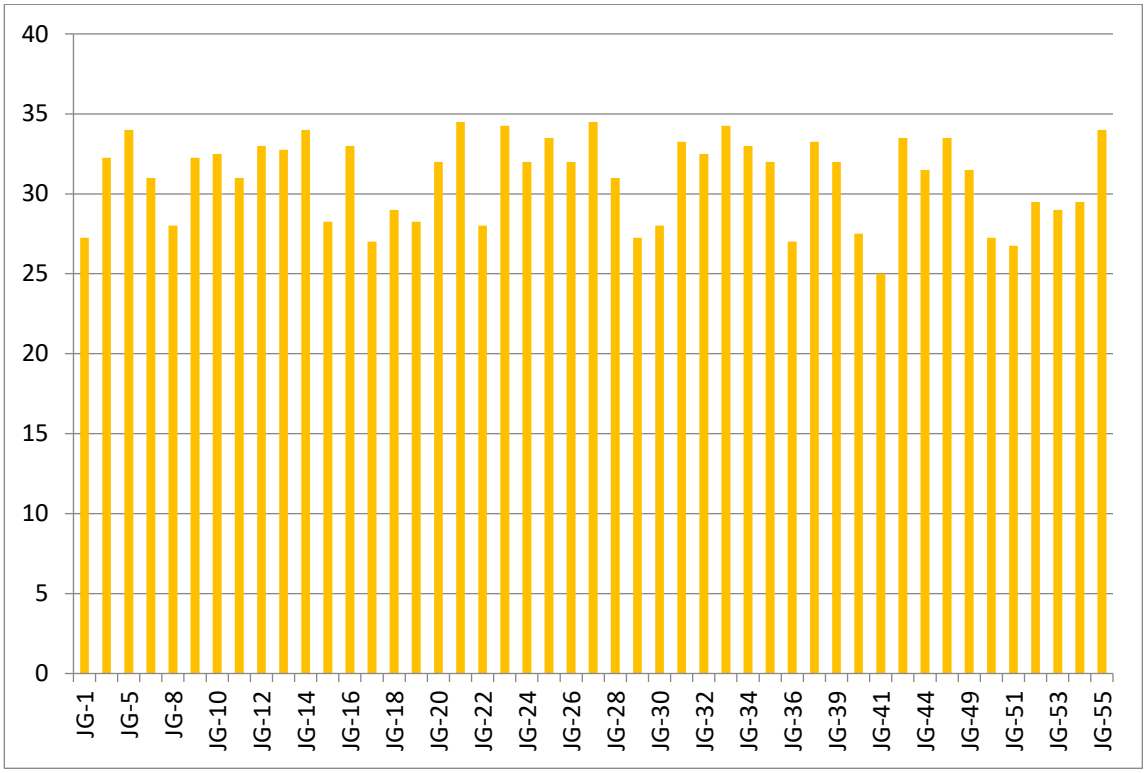


Figure 4.1: Duration of flowering in different jamun genotypes.

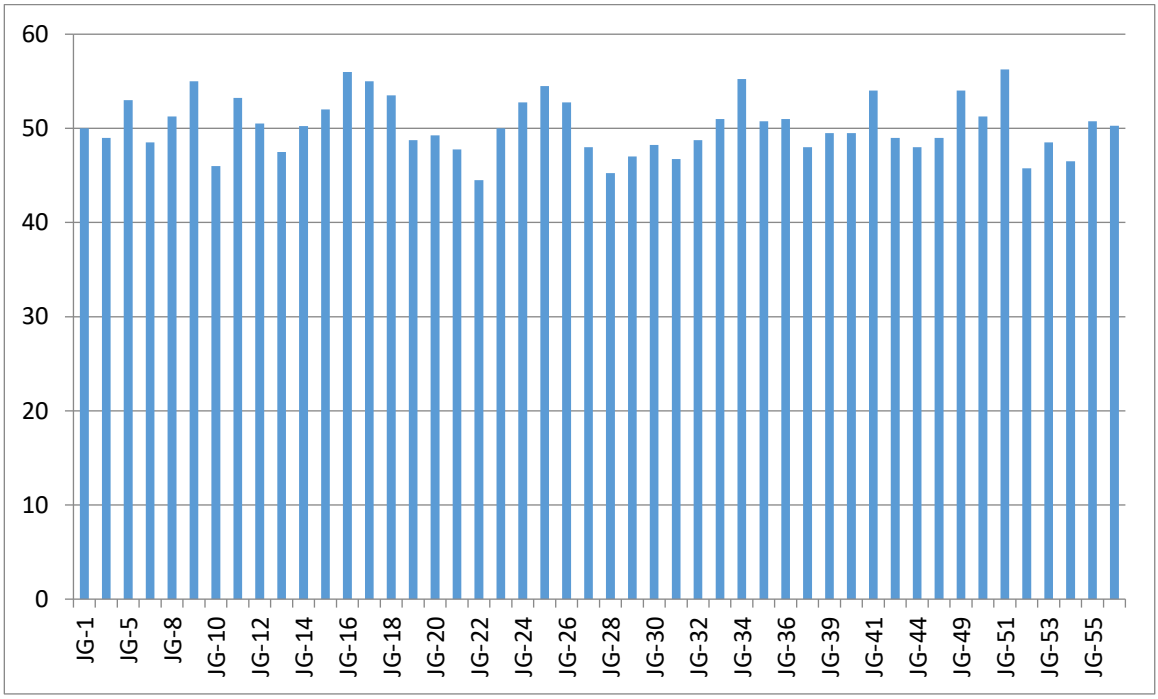


Figure 4.2: Days of fruit maturity in different jamun genotypes.

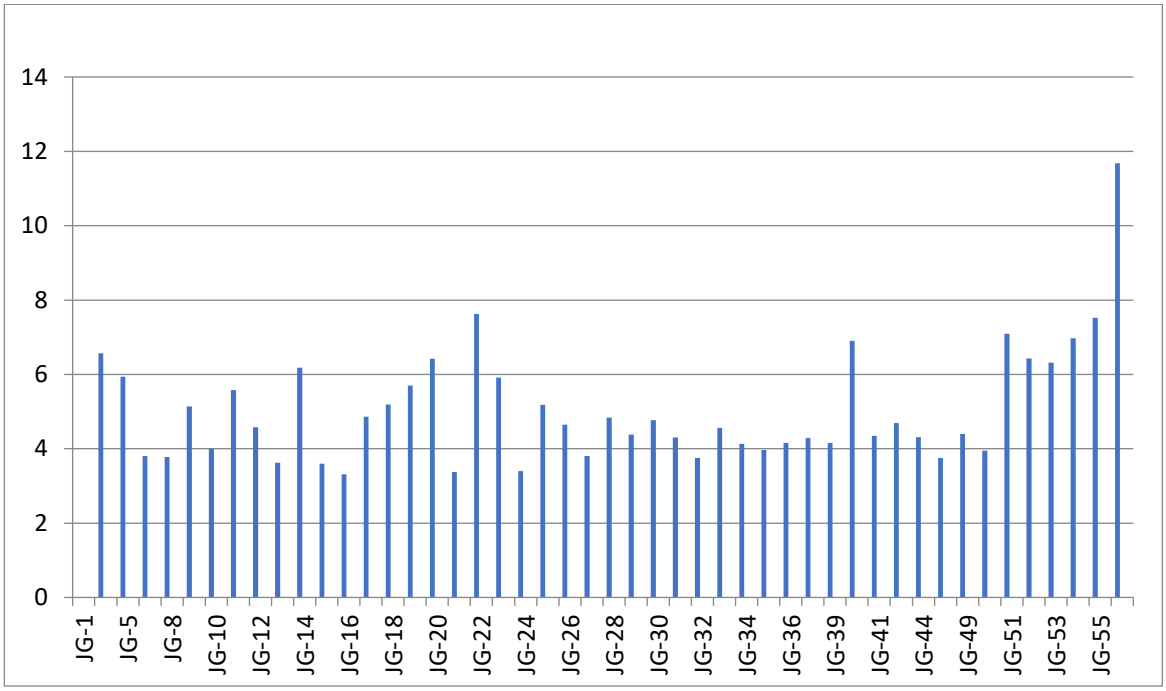


Figure 4.3: Fruit weight in different jamun genotypes.

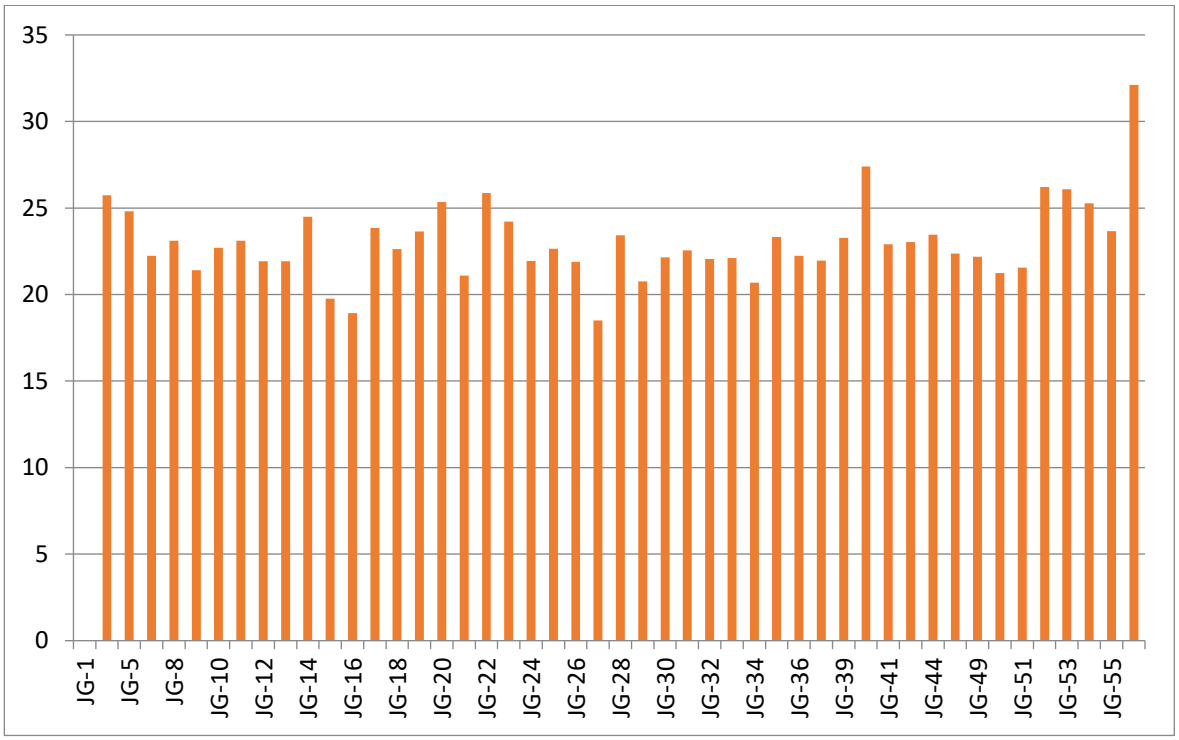


Figure 4.4: Fruit length in different jamun genotypes.

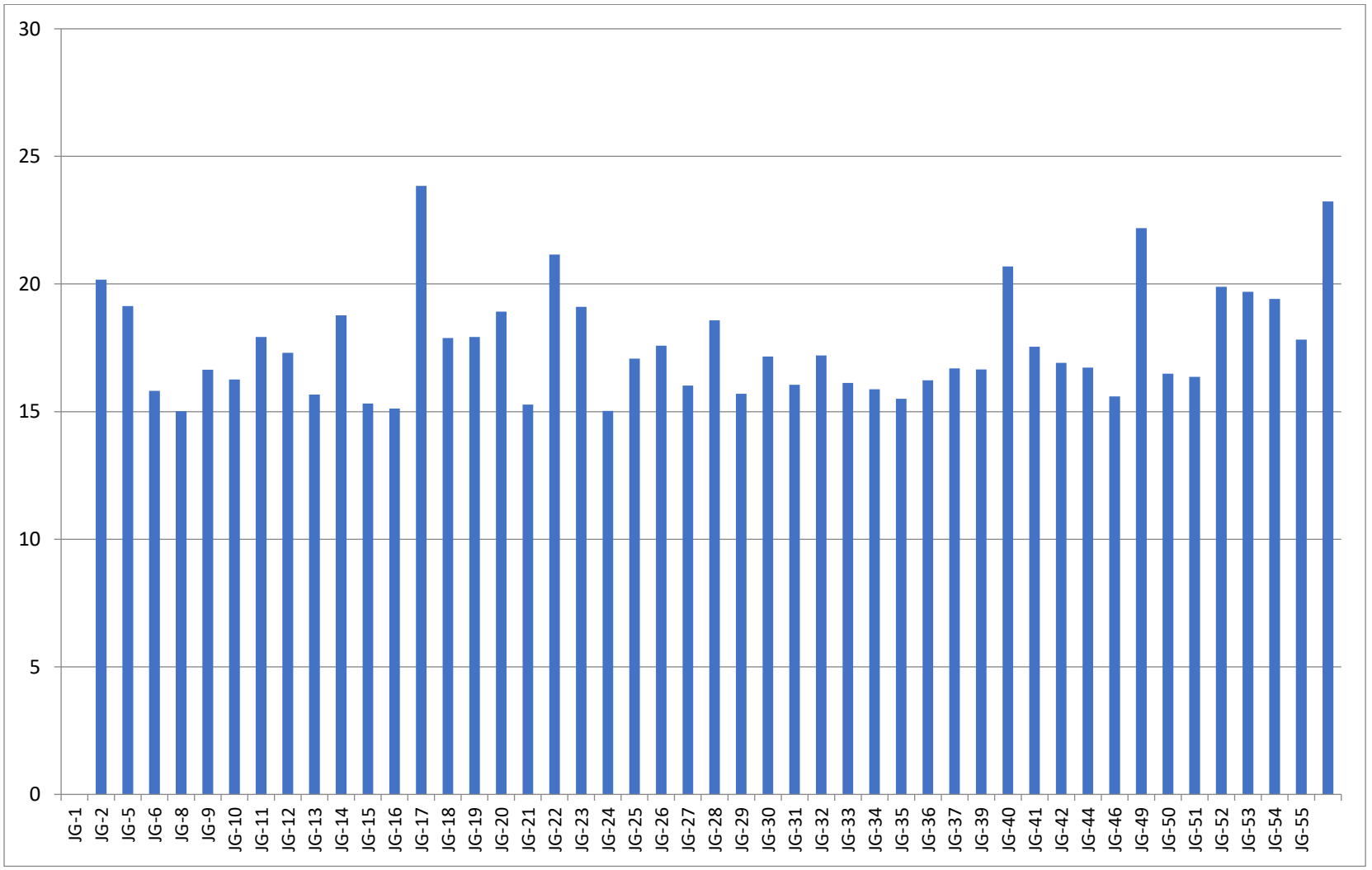


Figure 4.5: Fruit diameter in different jamun genotypes.

4.1.1.8 Seed diameter (mm)

The data presented in Table 4.2 indicated that the difference among the genotypes with regarding average diameter of seed was 10.70 mm. The maximum seed diameter was recorded in genotype JG-50 (12.06 mm) which was the statistically at par with JG-9 (11.96 mm) followed by JG-42 (11.78 mm), JG-24 (11.74 mm) and JG-18 (11.71 mm) mm). Whereas, JG-50 was statistically significant to JG-39 (11.46 mm), JG-26 (11.36 mm) and all remaining genotype of jamun. While the minimum seed diameter in genotype JG-6 (7.40 mm) followed by JG-15 (8.47 mm), JG-2 (9.12 mm), JG-55 (9.16 mm) and JG-13 (9.95 mm).

4.1.1.9 Pulp percentage

Significant difference was observed among various jamun genotypes with respect to pulp percentage and it ranged from 80.22 to 85.55 % (Table 4.2). The maximum pulp percentage (85.55%) was observed in genotype JG-20 which was statistically at par with JG-32 (85.17%) followed by JG-10 (84.87%), JG-30 (84.83%) and JG-14 (84.72%). Whereas, JG-20 was significant to JG-1 (81.93%), JG-2 (81.81%) and all remaining genotypes of jamun. The minimum pulp percentage (80.22%) was recorded in genotype JG-12 followed by JG-27 (80.72%), JG-55 (81.47%), JG-8 (81.60%) and JG-44 (81.69%).

Table 4.2: Physical characters of fruits of jamun genotypes.

Jamun Genotype	Seed weight (g)	Seed length(mm)	Seed diameter(mm)	Pulp (%)
JG-1	1.27	18.57	10.62	81.93
JG-2	1.23	16.31	9.12	81.81
JG-5	1.39	15.97	10.28	83.78
JG-6	0.62	16.21	7.40	82.13
JG-8	1.48	18.24	11.36	81.60
JG-9	1.55	18.53	11.96	83.23
JG-10	1.53	18.26	10.51	84.87

JG-11	1.39	16.68	11.02	83.72
JG-12	1.41	16.85	11.21	80.22
JG-13	1.33	17.26	9.95	82.30
JG-14	0.65	15.44	9.61	84.72
JG-15	0.68	14.01	8.47	84.67
JG-16	1.38	18.66	11.25	82.97
JG-17	1.33	16.96	10.67	83.01
JG-18	1.38	17.20	11.71	83.72
JG-19	1.39	17.28	10.98	83.51
JG-20	1.26	17.55	11.12	85.55
JG-21	1.30	18.14	11.02	83.51
JG-22	1.31	16.31	11.17	81.71
JG-23	1.25	17.74	10.80	82.99
JG-24	1.33	16.38	11.74	84.52
JG-25	1.32	18.58	10.88	83.55
JG-26	1.39	19.03	11.36	83.40
JG-27	1.58	17.64	11.21	80.72
JG-28	1.21	16.57	10.85	83.34
JG-29	1.58	17.73	10.19	82.04
JG-30	1.30	15.68	10.53	84.83
JG-31	1.57	18.39	10.93	82.68
JG-32	1.36	17.56	11.07	85.17
JG-33	1.44	18.34	11.19	82.83
JG-34	1.30	17.55	10.39	82.20
JG-35	1.65	17.02	10.53	82.08

JG-36	1.58	17.16	10.99	83.92
JG-37	1.79	16.32	10.69	82.34
JG-39	1.58	18.72	11.46	82.36
JG-40	1.35	16.69	10.73	84.63
JG-41	1.54	17.40	10.66	83.04
JG-42	1.47	18.17	11.78	84.09
JG-44	1.20	17.25	10.31	81.69
JG-46	1.27	18.95	10.76	83.80
JG-49	1.26	17.06	10.61	83.73
JG-50	1.36	18.51	12.06	82.93
JG-51	1.45	19.27	10.85	82.30
JG-52	1.48	19.12	10.90	83.48
JG-53	1.31	17.89	10.27	82.93
JG-54	1.46	19.87	10.50	83.67
JG-55	1.42	20.07	9.16	81.47
Mean	**1.35**	**17.55**	**10.70**	**83.10**
C.D. 5%	0.12	0.74	0.60	3.58

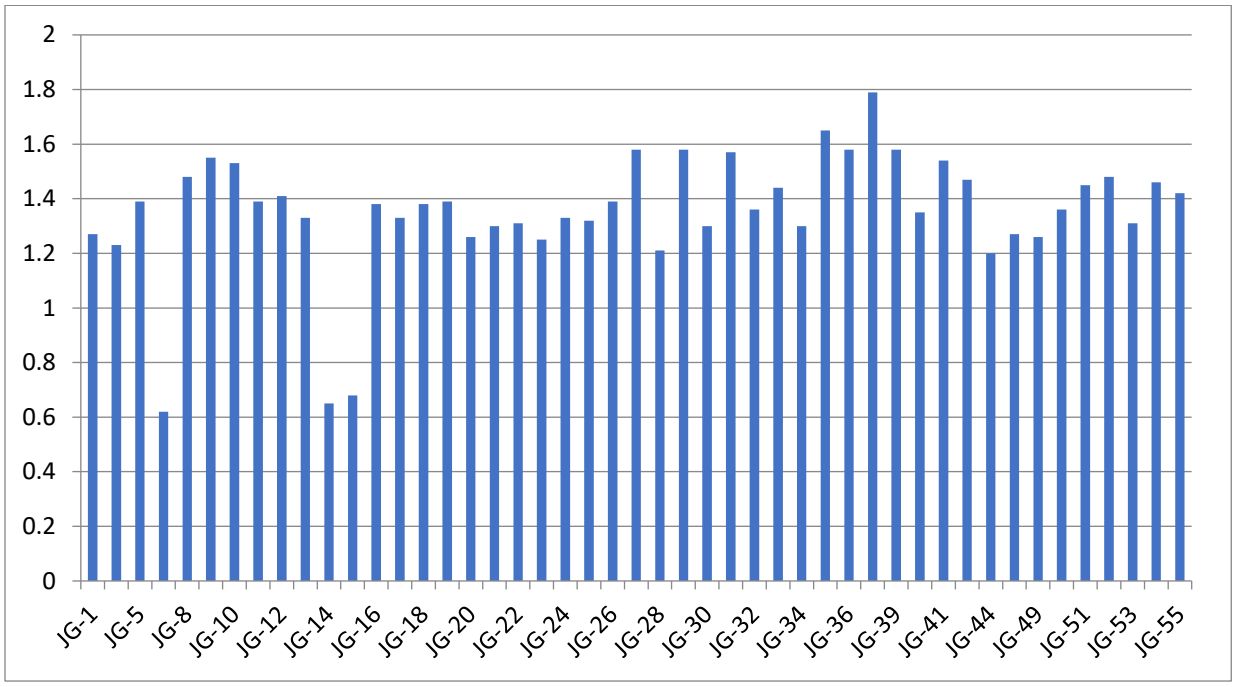


Figure 4.6: Seed weight in different jamun genotypes.

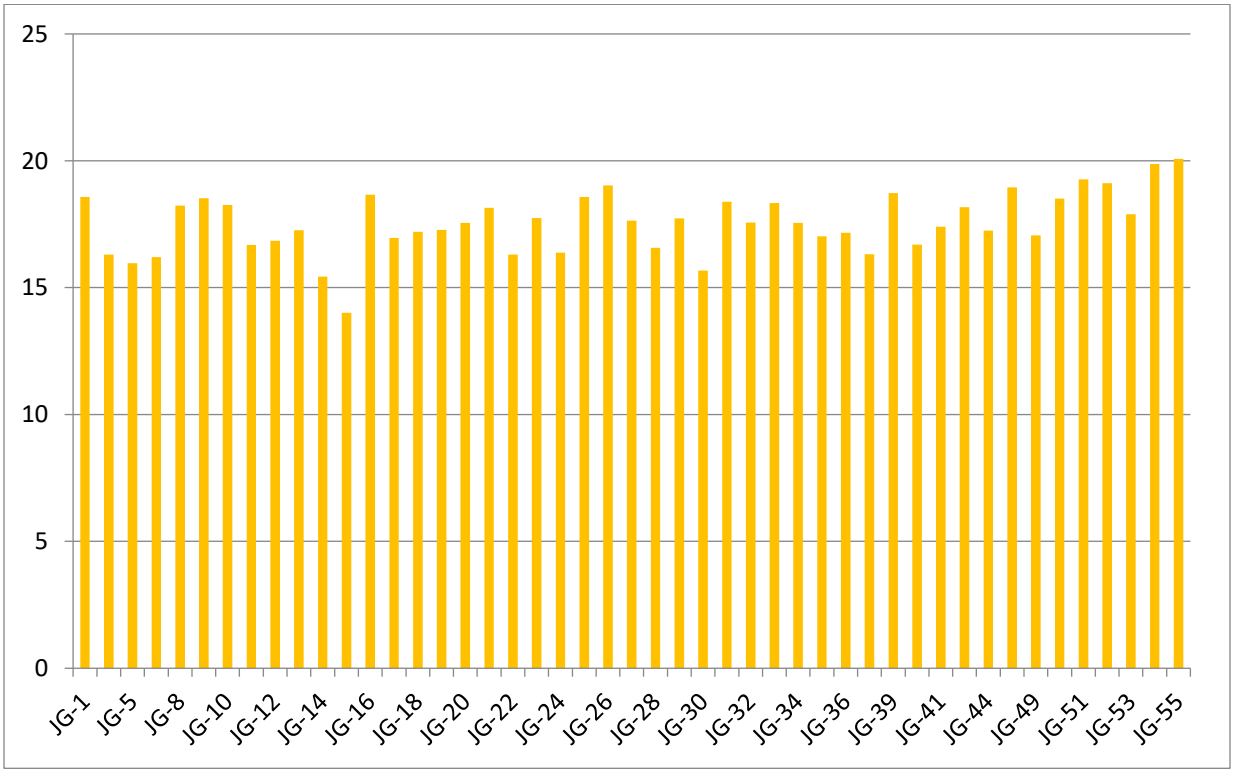


Figure 4.7: Seed length in different jamun genotypes.

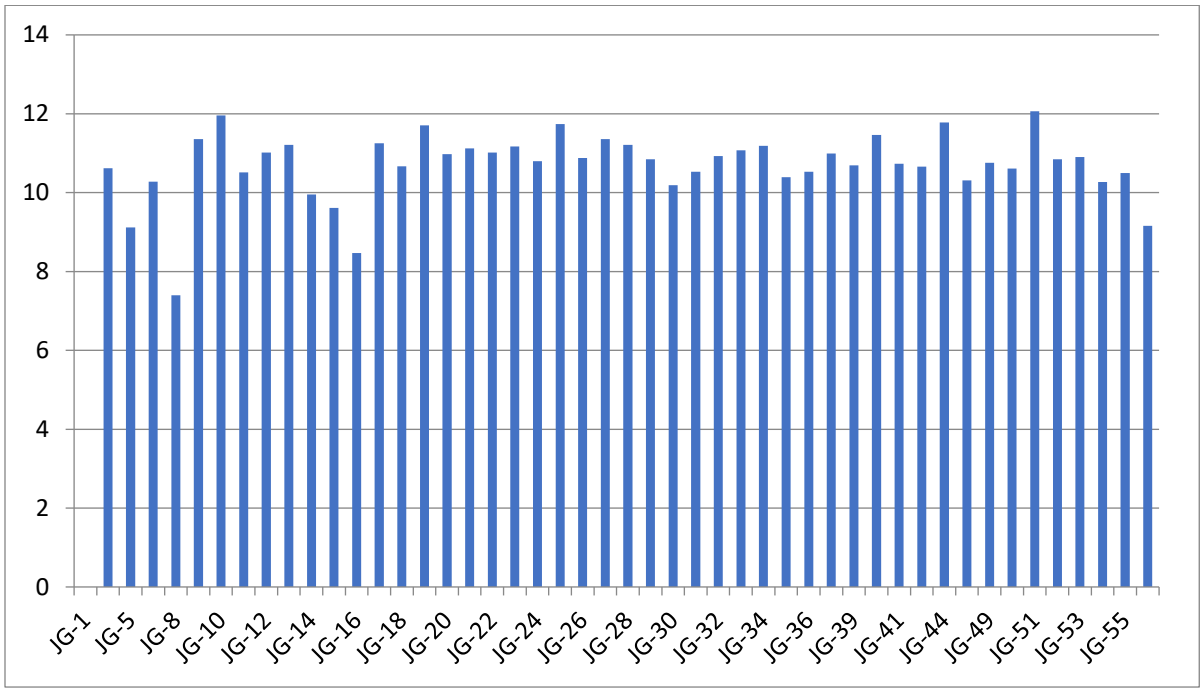


Figure 4.8: Seed diameter in different jamun genotypes.

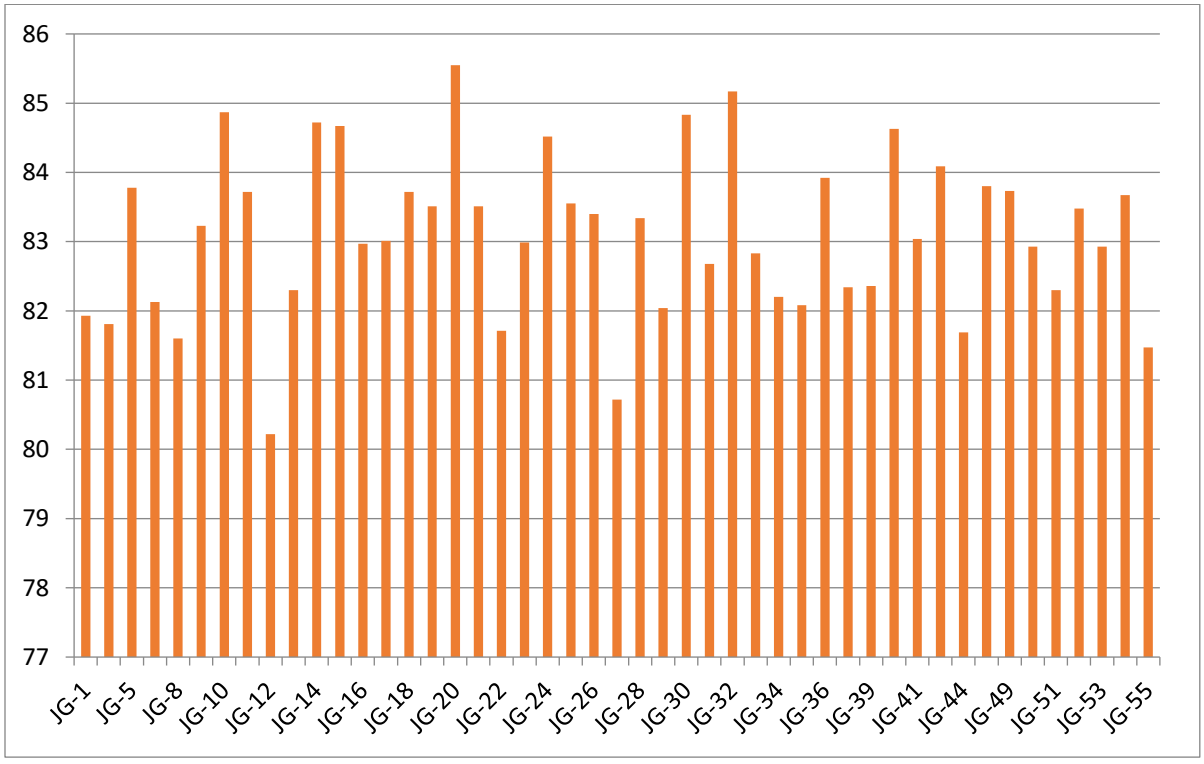


Figure 4.9: Pulp per cent in different jamun genotypes.

4.1.1.10 TSS to acidity ratio

The data pertaining to TSS: acidity was depited from Table 4.3. There was considerable variation in TSS to acidity ratio from 8.43 to 23.13%, with coefficient of variation 5.92%. Out of 47 genotypes, the minimum value of TSS to acidity ratio genotype was recorded in JG-16 (8.43%) genotype followed by JG-34 (8.65%), JG-41 (8.85%) and JG-10 (9.18%). While the maximum TSS to acidity ratio was recorded in JG-25 (23.13%) which was statistically at par with genotype JG-53 (22.45%). Whereas, JG-25 genotype was significant to JG-15 (22.28%), JG-14 (21.38%) and JG-12 (19.75%).

4.1.1.11 Pulp to seed ratio

The data on pulp to seed ratio are presented in Table 4.3 and exhibited in Figure 4.10. The results showed significant differences among the genotypes. The maximum pulp to seed ratio was recorded in the JG-55 (9.35%) genotype which was statistically significant to all other genotypes. The minimum pulp to seed ratio was noticed in the JG-21 (1.35%) genotype followed by JG-50 (1.46%), JG-10 (1.53%), JG-31 (1.57%) and JG-27 (1.59%).

4.1.1.12 Fruit to seed ratio

It is obvious from Table 4.3 and exhibited in Figure 4.11. That fruit to seed ratio varied from 1.73 to 10.10 per cent. The results showed significant differences among the genotypes. The maximum fruit to seed ratio was recorded in the JG-55 (10.10%) genotype which was significant to all remaining genotypes of jamun. The minimum fruit to seed ratio was observed in the genotype JG-44 (1.73%) followed by JG-52 (1.98%), JG-11 (2.06%), JG-32 (2.07%) and JG-25 (2.22%).

4.1.2 Chemical characters

4.1.2.1 TSS °Brix

The data on TSS presented in Table 4.4. The TSS varied from 9.05 to 23.90 °Brix. Where, the mean value was 14.18 °Brix. The maximum TSS (23.90 °Brix) was observed in genotypes JG-25 which was statistically at par with JG-53 (23.03 °Brix), JG-15 (22.80 °Brix),

however, it was statistically significant to JG-14 (22.20 °Brix), JG-12 (20.25 °Brix) and all remaining genotypes of jamun.

Table 4.3: TSS to acidity, pulp to seed and fruit to seed ratio of jamun genotypes.

Jamun Genotype	TSS: acidity ratio	Pulp: seed ratio	Fruit: seed ratio
JG-1	13.85	2.06	3.81
JG-2	14.23	3.26	3.88
JG-5	9.78	2.94	3.32
JG-6	12.23	1.66	4.33
JG-8	14.20	2.78	2.69
JG-9	15.20	2.61	2.99
JG-10	9.18	1.53	4.57
JG-11	14.34	4.22	2.06
JG-12	19.75	2.18	3.42
JG-13	14.25	3.93	3.44
JG-14	21.38	3.25	6.16
JG-15	22.28	2.34	5.53
JG-16	8.43	2.26	2.84
JG-17	11.83	1.70	4.79
JG-18	10.65	2.01	3.46
JG-19	11.88	3.36	3.05
JG-20	12.17	1.84	2.94
JG-21	8.90	1.35	2.81
JG-22	12.50	3.90	4.38
JG-23	15.03	2.24	2.55
JG-24	11.45	2.46	5.09
JG-25	23.13	1.99	2.22
JG-26	14.58	2.95	5.64
JG-27	14.25	1.59	2.74
JG-28	9.98	2.50	2.39

JG-29	12.45	2.17	4.31
JG-30	14.10	4.59	3.38
JG-31	12.68	1.57	2.68
JG-32	13.50	2.50	2.07
JG-33	12.05	3.34	2.98
JG-34	8.65	2.04	2.83
JG-35	12.78	3.65	3.47
JG-36	13.53	4.49	3.66
JG-37	12.48	2.58	2.65
JG-39	10.43	3.87	6.47
JG-40	13.13	3.83	3.26
JG-41	8.85	3.66	2.65
JG-42	12.15	3.42	5.20
JG-44	17.88	4.43	1.73
JG-46	11.35	3.16	3.09
JG-49	16.23	2.00	2.54
JG-50	13.60	1.46	6.30
JG-51	13.35	2.57	4.79
JG-52	14.90	1.94	1.98
JG-53	22.45	2.07	5.10
JG-54	13.13	2.29	2.64
JG-55	12.35	9.35	10.10
Mean	**13.56**	**2.85**	**3.72**
C.D. 5%	1.12	0.38	0.32

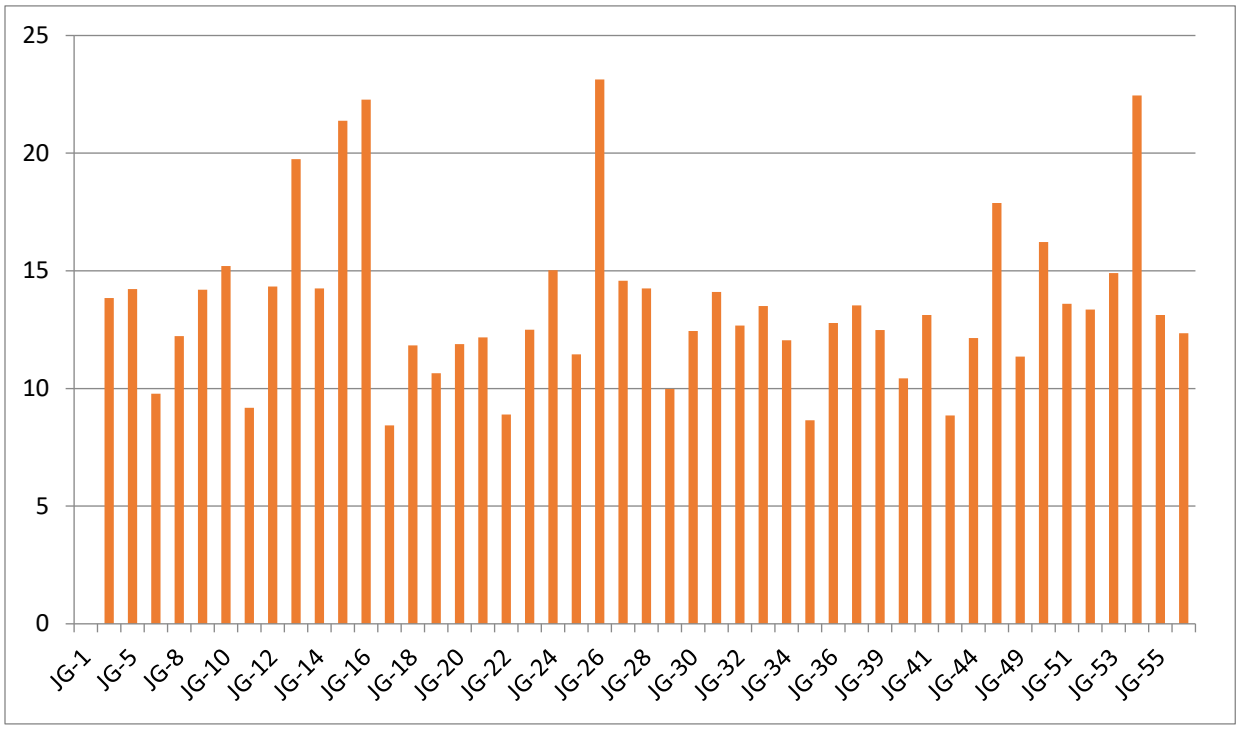


Figure 4.10: TSS to acidity ratio in different jamun genotypes.

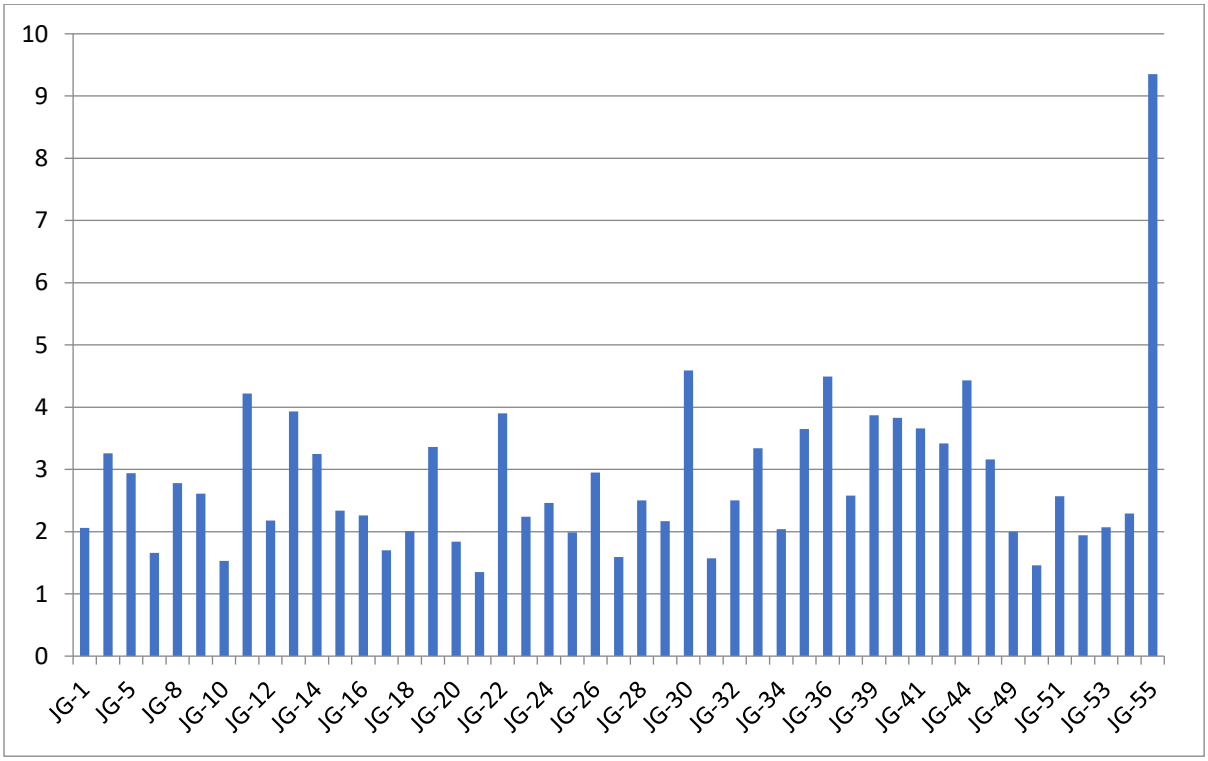


Figure 4.11: Pulp to seed ratio in different jamun genotypes.

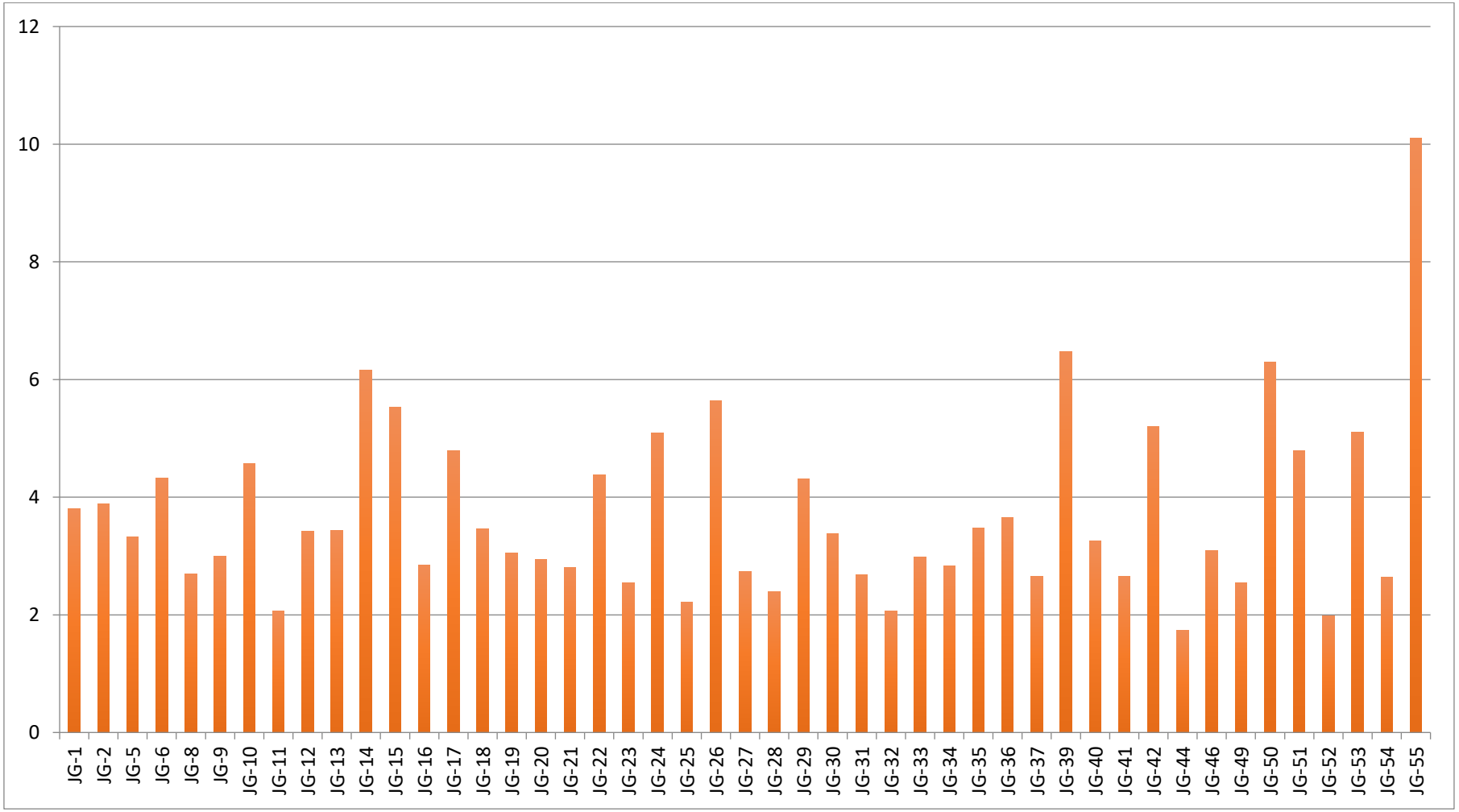


Figure 4.12: Fruit to seed ratio of different jamun genotypes.

The minimum TSS was noted in genotype JG-34 (9.05 °Brix) followed by JG-16 (9.25 °Brix), JG-21 (9.28 °Brix) JG-41 (9.70 °Brix) and JG-10 (10.00 °Brix).

4.1.2.2 Anthocyanin content (mg 100 g^{-1})

Significant difference was observed in all jamun genotype with respect to anthocyanin % content which was ranged from 14.14 to 93.04 mg 100 g^{-1}. The maximum anthocyanin content (93.04 mg 100 g^{-1}) was recorded in JG-29, which was statistically significant to all remaining genotypes of jamun. Whereas, minimum anthocyanin content (14.14 mg 100 g^{-1}) was recorded in JG-2 followed by JG-55 (25.14 mg 100 g^{-1}), JG-6 (31.23 mg 100 g^{-1}), JG-5 (41.65 mg 100 g^{-1}) and JG-28 (43.95 mg 100 g^{-1}).

4.1.2.3 Ascorbic acid (mg 100 g^{-1})

The data presented in Table 4.4 indicated the difference among the genotypes with regards to ascorbic acid content. The average ascorbic acid content was 85.40 mg 100 g^{-1}. The variability in ascorbic acid was higher and it ranged from 33.00 to 132.31 mg 100 g^{-1}. Genotypes JG-23 recorded maximum ascorbic acid content (132.31 mg 100 g^{-1}), which was statistically at par with JG-18 (131.84 mg 100 g^{-1}), JG-40 (126.35 mg 100 g^{-1}), JG-19 (123.86 mg 100 g^{-1}). Whereas, JG-23 was significant to JG-46 (103.60 mg 100 g^{-1}) and all remaining genotypes. However, the minimum ascorbic acid content (33.00 mg 100 g^{-1}) was recorded in genotype JG-30 followed by JG-20 (44.45 mg 100 g^{-1}), JG-26 (47.31 mg 100 g^{-1}), JG-27 (49.96 mg 100 g^{-1}) and JG-11 (56.22 mg 100 g^{-1}).

4.1.2.4 Acidity (%)

The data presented in Table 4.5 indicated the difference among the genotypes with respect to acidity. The average acidity was observed to be 0.79 % and was ranged from 0.45 to 1.09 %. The maximum acidity (1.09%) was found in genotype JG-21, which was statistically at par with JG-40 (1.06%), JG-1(1.06%), JG-2 (1.06%) and JG-44 (1.06%). Whereas, JG-21 was significant to JG-14 (0.86%), JG-33 (0.86%) and other genotypes of jamun. While the minimum acidity (0.45%) was found in genotype JG-18 followed by JG-17 (0.48 %), JG-11 (0.56%), JG-34 (0.58%) and JG-37 (0.58%).

Table 4.4: Quality characters of fruits of jamun genotypes.

Jamun Genotype	TSS	Anthocyanin Content	Ascorbic acid
JG-1	14.50	60.08	65.36
JG-2	14.68	14.14	97.12
JG-5	10.53	41.65	85.48
JG-6	12.85	31.23	64.89
JG-8	14.70	61.88	85.37
JG-9	15.75	69.28	109.14
JG-10	10.00	62.10	82.33
JG-11	13.28	59.39	56.22
JG-12	20.25	80.77	85.55
JG-13	15.01	68.85	76.39
JG-14	22.20	50.11	76.31
JG-15	22.80	70.94	91.77
JG-16	9.25	70.27	108.80
JG-17	12.45	78.20	112.50
JG-18	11.15	49.31	131.84
JG-19	12.70	59.57	123.86
JG-20	12.76	79.92	44.45
JG-21	9.28	71.76	102.83
JG-22	13.18	51.89	61.68
JG-23	15.65	62.37	132.31
JG-24	12.10	61.23	62.23
JG-25	23.90	78.54	115.08
JG-26	15.08	70.20	47.31
JG-27	14.90	75.64	49.96
JG-28	10.43	43.95	60.94

JG-29	13.08	93.04	79.59
JG-30	14.85	50.89	33.00
JG-31	13.43	62.32	85.73
JG-32	14.25	83.46	97.65
JG-33	12.80	77.03	97.38
JG-34	9.05	63.14	76.73
JG-35	14.95	59.24	78.78
JG-36	14.03	71.15	61.52
JG-37	12.83	74.21	109.09
JG-39	11.08	77.40	71.05
JG-40	13.75	69.09	126.35
JG-41	9.70	69.47	88.69
JG-42	12.59	52.63	66.26
JG-44	18.73	79.41	102.50
JG-46	11.80	68.10	103.60
JG-49	16.93	80.63	121.32
JG-50	14.10	65.12	64.43
JG-51	14.05	62.63	62.19
JG-52	15.43	51.55	120.91
JG-53	23.03	86.49	63.63
JG-54	13.78	76.41	88.55
JG-55	13.03	25.14	84.80
Mean	**14.18**	**64.29**	**85.40**
C.D. 5%	1.14	4.48	24.34

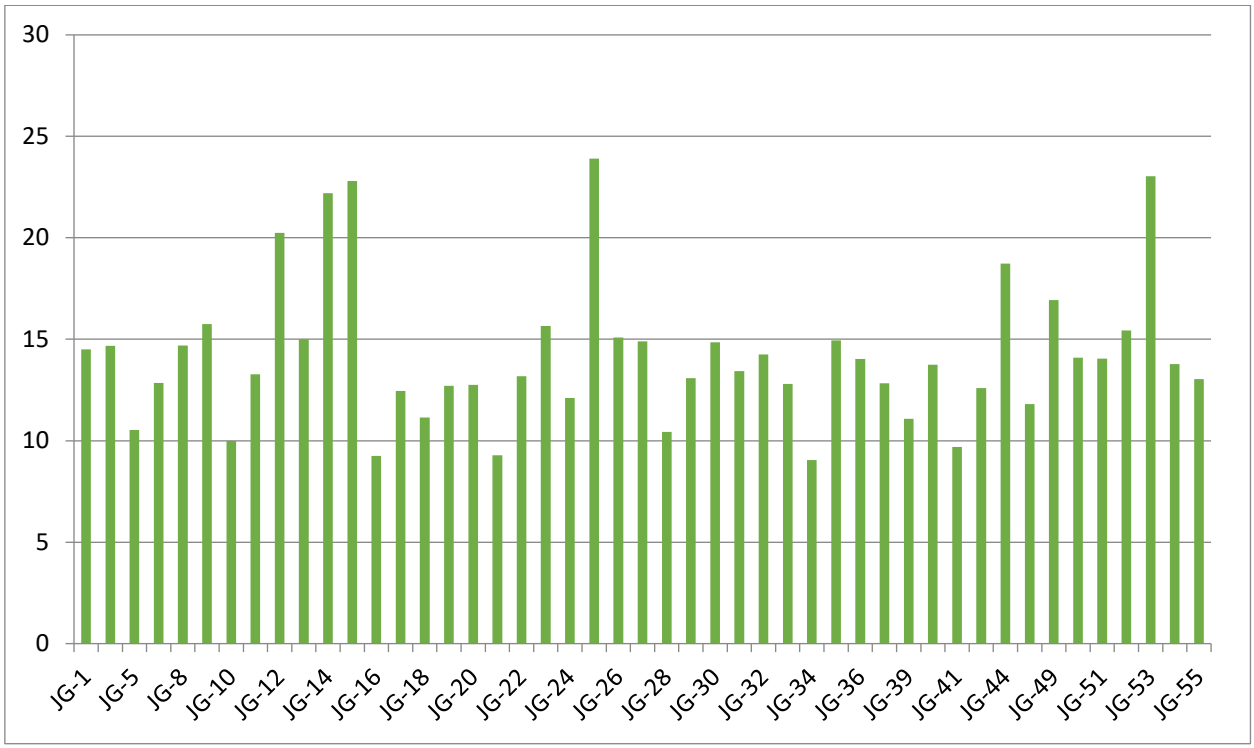


Figure 4.13: TSS content of different jamun genotypes.

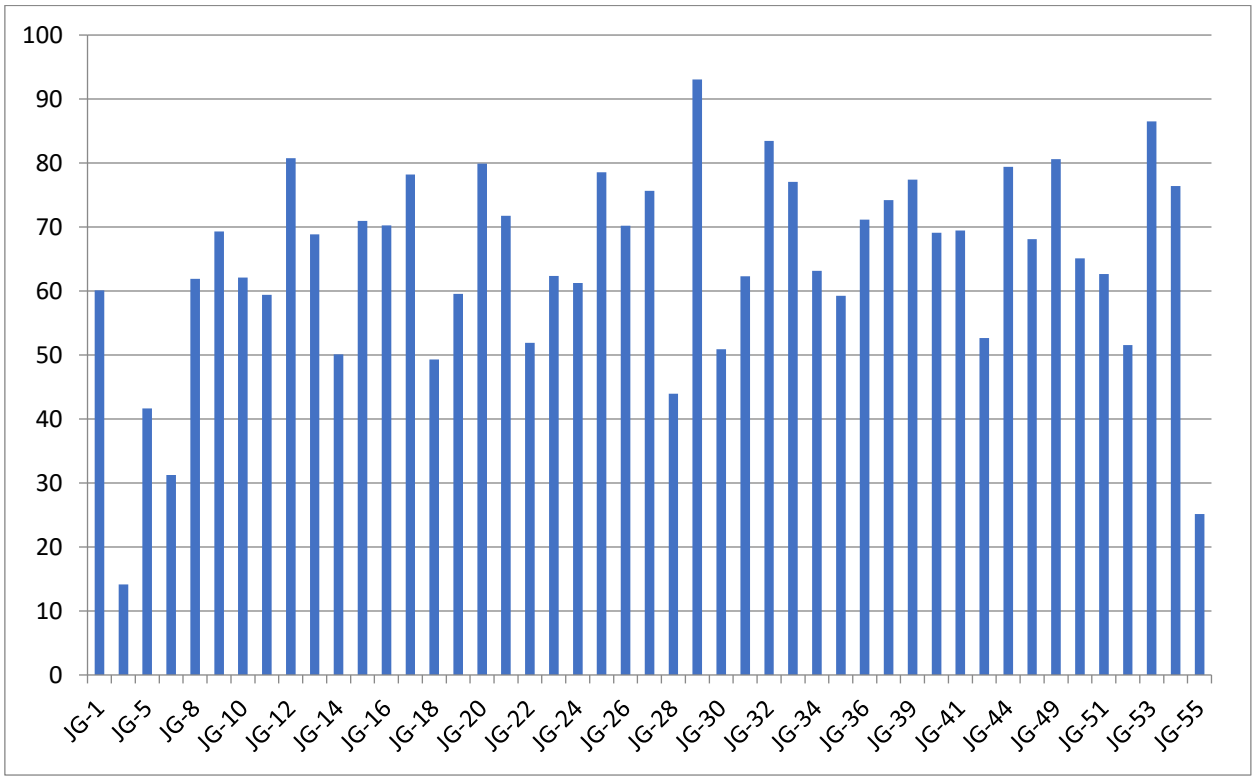


Figure 4.14: Anthocyanin content of different jamun genotypes.

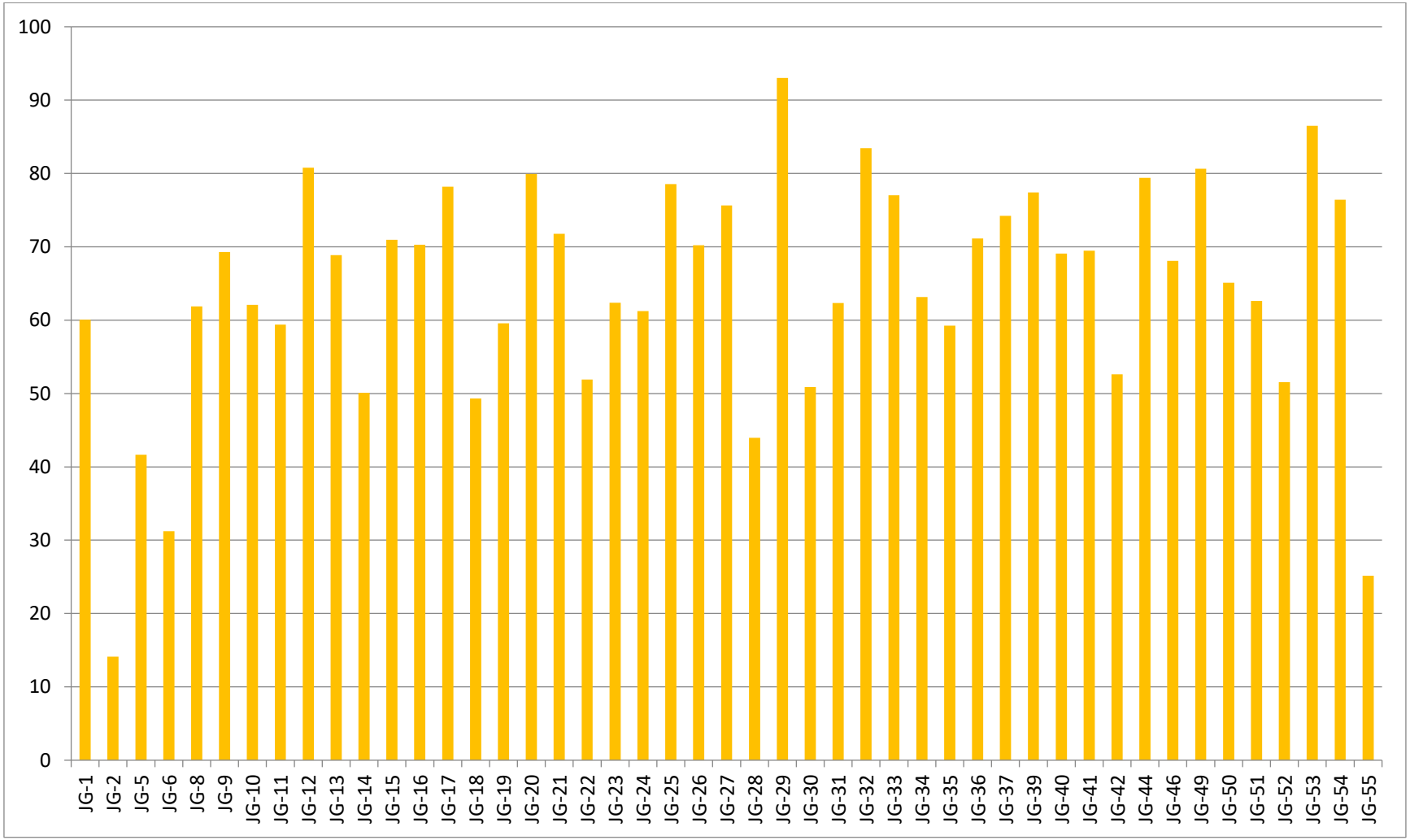


Figure 4.15: Ascorbic acid of different jamun genotypes.

4.1.2.5 pH

Significant difference was observed among jamun genotypes with respect to pH and it was ranged from 2.39 to 3.73 was determined. The maximum pH (3.73) was recorded genotype in JG-55, which was statistically at par with JG-6 (3.69), JG-14 (3.67), JG-50 (3.66) and JG-29 (3.67). Whereas, JG-55 was significant to JG-12 (3.46), JG-51 (3.45) and all other genotypes of jamun. While, minimum pH content (2.39) was recorded in genotype JG-21 followed by JG-22 (2.61), JG-13 (2.69), JG-37 (2.70) and JG-24 (2.71).

4.1.2.6 Phenol content (mg 100 g^{-1})

It is obvious from the Table 4.5 and Figure 4.19 that the phenol content varied from 43.58 to 273.44 mg 100 g^{-1}. The results were showed significant differences among the genotypes. Maximum phenol content (273.44 mg 100 g^{-1}) was observed in the genotype JG-12, which was statistically significant to all other genotypes. The minimum phenol content (43.58 mg 100 g^{-1}) was recorded in the genotype JG-10 followed by JG-41 (55.74 mg 100 g^{-1}), JG-34 (59.33 mg 100 g^{-1}), JG-51 (59.33 mg 100 g^{-1}) and JG-39 (59.50 mg 100 g^{-1}).

4.1.2.7 Antioxidant content (µmol TE g^{-1})

The data represented in Table 4.5 indicates the difference among the genotypes with respect to antioxidant content and the mean was 4.82 µmol TE g^{-1}. Maximum antioxidant content (7.33 µmol TE g^{-1}) was recorded by genotype JG-23, which was statistically at par with JG-55 (7.26 µmol TE g^{-1}) followed by JG-21 (7.17 µmol TE g^{-1}), JG-22 (7.07 µmol TE g^{-1}) and JG-39 (6.82 µmol TE g^{-1}). Whereas, JG-23 was significant to JG-31 (6.69 µmol TE g^{-1}) and JG-44 (6.63 µmol TE g^{-1}). However, minimum antioxidant content (1.87 µmol TE g^{-1}) was recorded by genotype JG-41 followed by JG-18 (2.11 µmol TE g^{-1}), JG-34 (2.33 µmol TE g^{-1}), JG-13 (2.64 µmol TE g^{-1}) and JG-51 (2.78 µmol TE g^{-1}).

4.1.2.8 Flavonoid content (mg CE 100 g^{-1})

The variation in flavonoid content were presented in Table 4.5 and ranged from 16.89 to 193.90 mg CE 100 g^{-1}. The average flavonoid content was 51.41 mg CE 100 g^{-1}. From 47

genotypes, maximum flavonoid content (193.90 mg CE 100 g^{-1}) was recorded by genotype JG-32, which was statistically significant to all remaining genotypes of jamun.

Table 4.5: Quality characters of fruits of jamun genotypes.

Jamun Genotype	Acidity	pH	Phenol content	Antioxidant content	Flavonoid content
JG-1	1.06	2.80	94.59	4.81	49.00
JG-2	1.06	2.74	64.49	5.84	68.16
JG-5	0.64	3.24	93.71	2.95	27.56
JG-6	0.74	3.69	198.36	6.51	28.18
JG-8	0.96	2.77	123.38	5.43	39.64
JG-9	0.83	3.28	132.30	6.60	30.78
JG-10	0.58	3.56	43.58	6.34	50.40
JG-11	0.56	2.86	150.50	5.69	43.31
JG-12	0.96	3.46	273.44	6.86	158.38
JG-13	0.75	2.69	67.29	2.64	91.18
JG-14	0.86	3.67	129.06	3.12	28.00
JG-15	0.83	3.59	139.04	6.78	78.05
JG-16	0.64	3.06	98.53	3.96	60.29
JG-17	0.48	2.77	92.84	5.64	28.09
JG-18	0.45	2.80	106.14	2.11	48.74
JG-19	0.96	2.82	94.15	3.10	81.46
JG-20	0.83	3.50	195.65	3.64	53.81
JG-21	1.09	2.39	89.08	7.17	23.89
JG-22	0.70	2.61	59.50	7.07	28.88
JG-23	0.99	3.26	68.08	7.33	37.36
JG-24	0.64	2.71	87.94	2.81	41.83
JG-25	1.09	3.27	135.63	6.20	152.51
JG-26	0.90	3.43	129.76	3.25	21.09

JG-27	0.83	3.25	122.76	6.14	45.41
JG-28	0.67	3.54	92.05	3.07	27.30
JG-29	0.67	3.65	59.68	3.79	29.49
JG-30	0.83	2.87	155.93	3.02	45.41
JG-31	0.96	2.95	163.98	6.45	31.59
JG-32	0.80	2.74	267.66	6.69	193.90
JG-33	0.86	3.38	193.20	6.38	43.93
JG-34	0.58	3.50	59.33	2.33	18.90
JG-35	0.80	2.83	96.69	3.06	65.98
JG-36	0.64	3.37	196.00	3.87	56.96
JG-37	0.58	2.70	235.11	3.03	58.71
JG-39	0.64	2.80	59.50	6.82	16.89
JG-40	1.06	3.10	61.69	5.35	27.21
JG-41	0.80	3.10	55.74	1.87	24.50
JG-42	0.85	3.29	166.60	5.63	57.64
JG-44	1.06	3.53	163.36	6.63	95.46
JG-46	0.96	2.79	198.80	4.64	41.04
JG-49	0.64	3.26	100.45	6.05	42.53
JG-50	0.90	3.66	123.38	3.00	28.44
JG-51	0.64	3.45	59.33	2.78	27.21
JG-52	0.90	2.82	62.65	3.00	23.63
JG-53	0.80	3.43	91.18	3.91	75.43
JG-54	0.80	3.00	138.34	5.78	23.01
JG-55	0.51	3.73	64.75	7.26	45.15
Mean	**0.79**	**3.14**	**120.32**	**4.82**	**51.41**
C.D. 5%	0.22	0.27	13.61	0.56	11.47

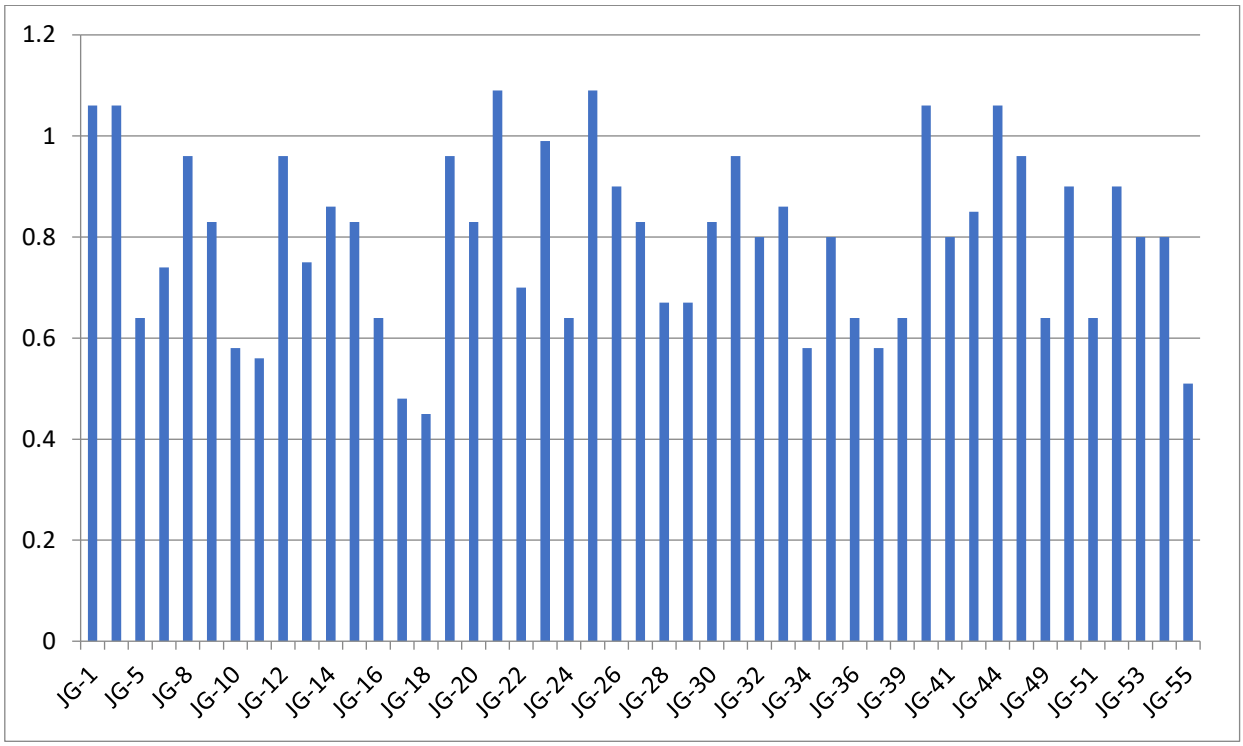


Figure 4.16: Titrable acidity content of different jamun genotypes.

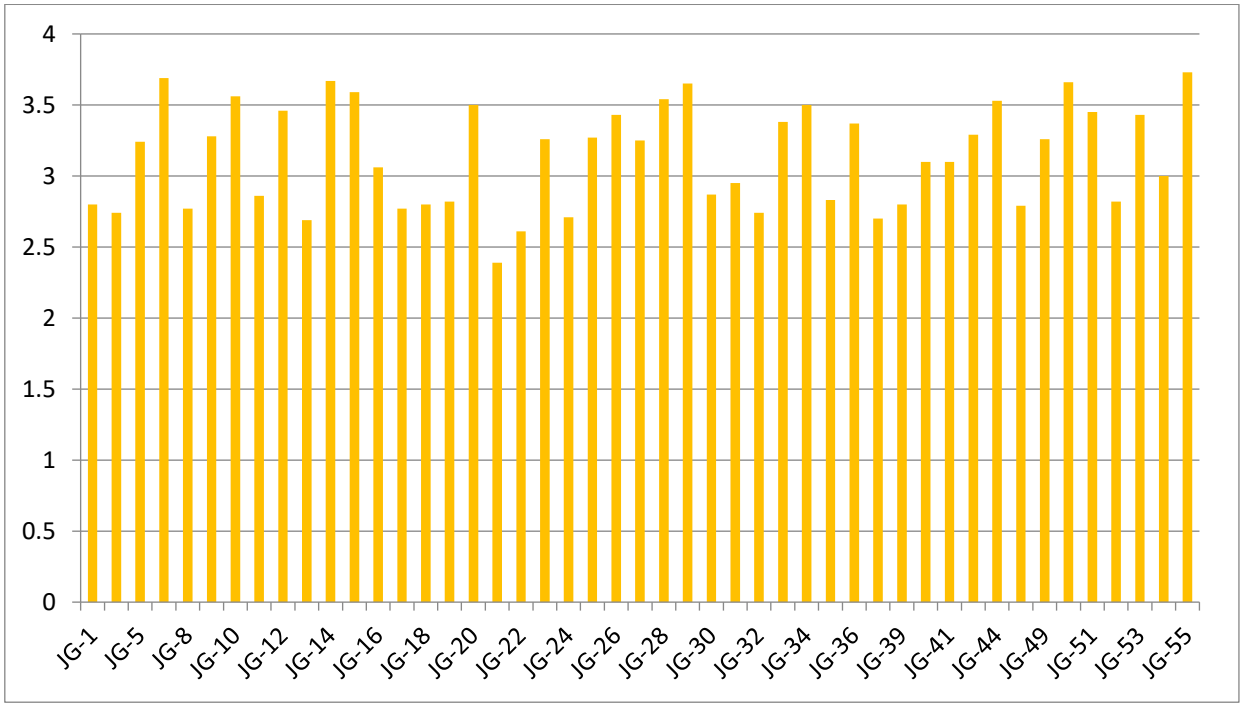


Figure 4.17: pH content of different jamun genotypes.

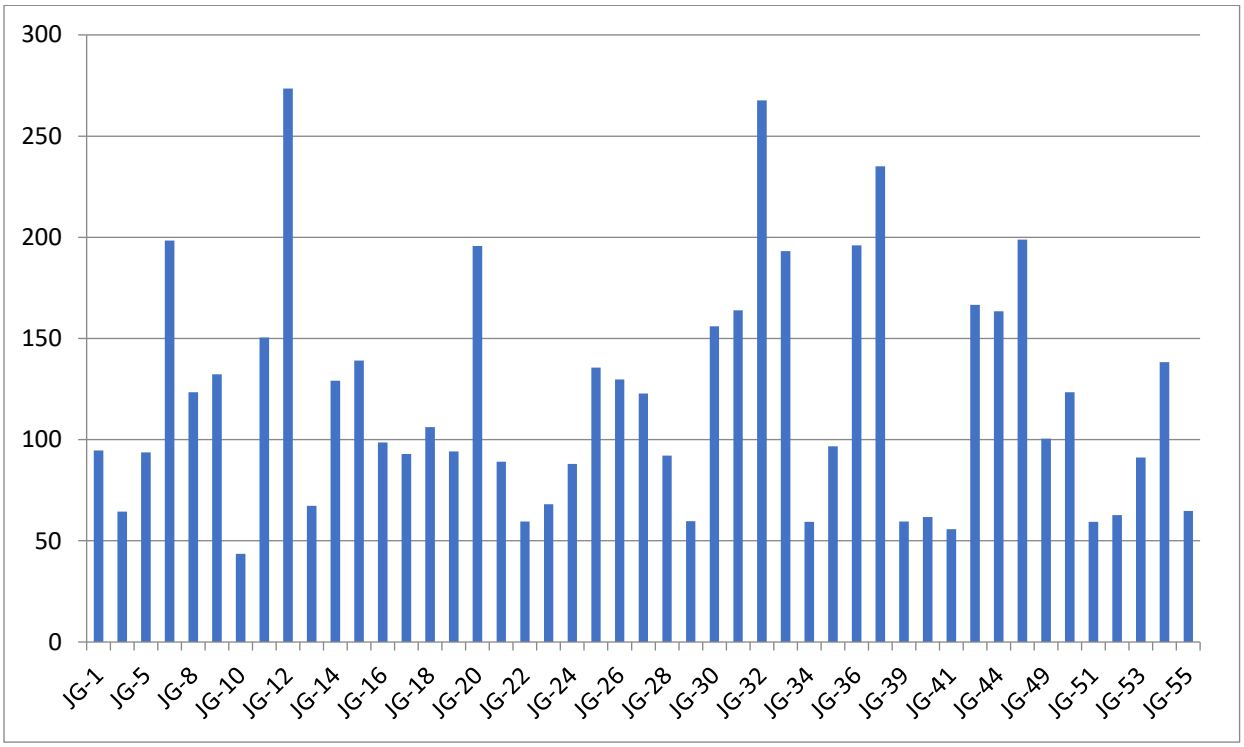


Figure 4.18: Phenol content of different jamun genotypes.

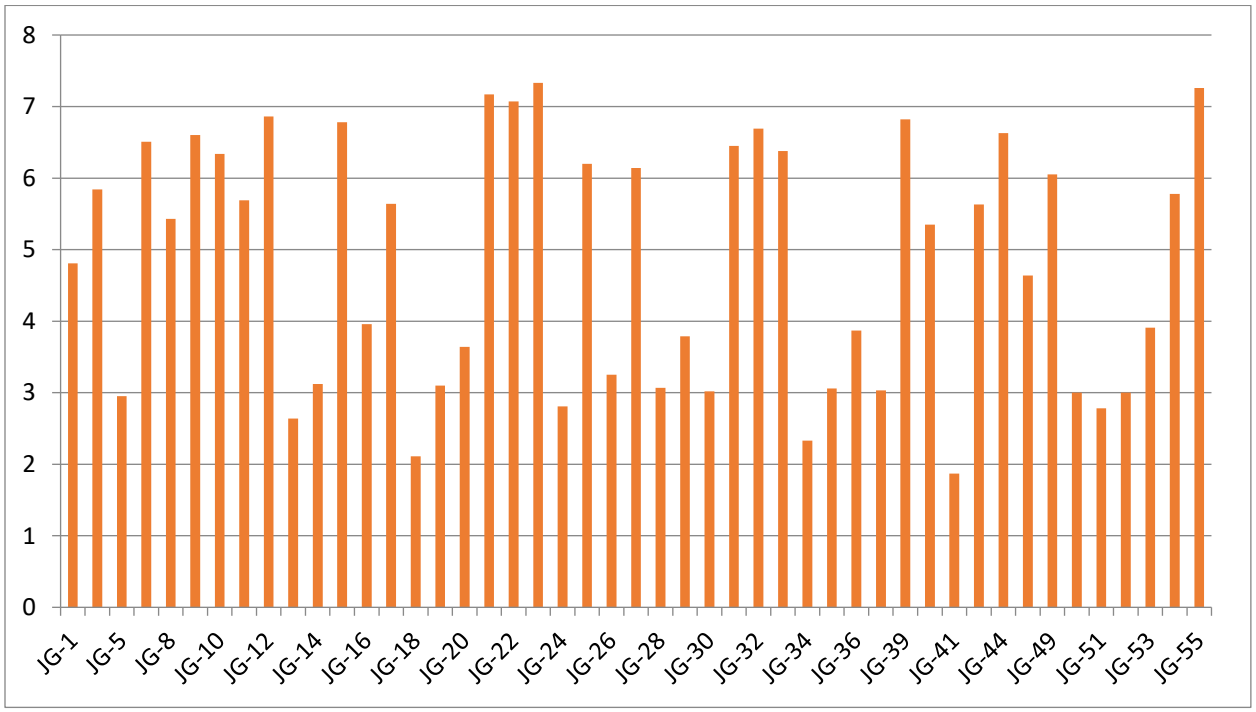


Figure 4.19: Antioxidant content of different jamun genotypes.

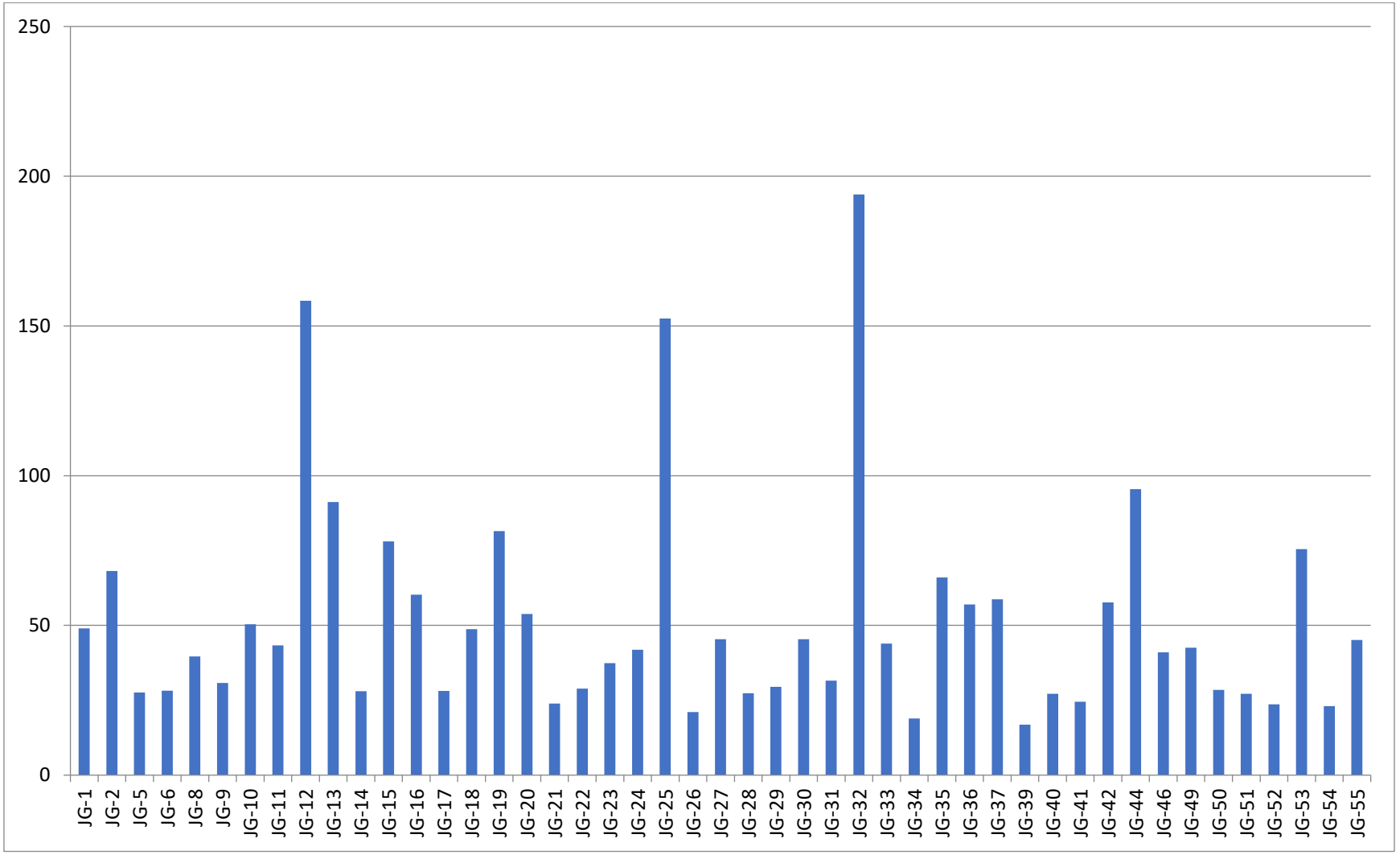


Figure 4.20: Flavonoid content of different jamun genotypes.

and JG-13 (91.18 mg CE 100 g^{-1}). While, minimum flavonoid (16.89 mg CE 100 g^{-1}) was recorded in by genotype JG-39 followed by JG-34 (18.90 mg CE 100 g^{-1}), JG-26 (21.09 mg CE 100 g^{-1}), JG-54 (23.01 mg CE 100 g^{-1}) and JG-52 (23.63 mg CE 100 g^{-1}).

4.2 Variability and heritability

The data pertaining to variability and heritability, the range of variability was maximum in case of phenol content (43.57-273.43) followed by ascorbic acid (33.00-132.31), pulp per cent (80.22-85.55), anthocyanin content (14.14-93.03) and flavonoids (16.81-193.90). While the minimum variability was recorded in acidity (0.44-1.08) followed by seed weight (0.61-1.78), pulp:seed ratio (1.34-9.34), pH (2.39-3.72) and fruit:seed ratio (1.72-10.10).

Significant variation was observed in all the characters studied. The maximum coefficient of variation was observed in flavonoid (PCV = 72.60, GCV =70.82) followed by phenol (PCV = 48.26, GCV = 46.57), pulp:seed ratio (PCV = 46.98, GCV = 45.98), fruit:seed ratio (PCV = 41.79, GCV = 41.33) and antioxidant (PCV= 36.42, GCV= 35.46). While the minimum coefficient of variation was found in pulp per cent (PCV= 3.01, GCV= 0.61) followed by fruit maturity (PCV= 7.83, GCV= 5.21), seed length (PCV= 7.31, GCV= 6.66), seed diameter (PCV= 8.73, GCV= 7.75) and duration of flowering (PCV= 10.61, GCV= 7.78).

However, heritability was observed in all jamun genotypes. Maximum heritability was found in case of fruit:seed ratio (0.97) followed by phenol (0.97), flavonoids (0.95), anthocyanin (0.96) and antioxidant (0.95). Whereas, minimum heritability was found in pulp per cent (-0.04) followed by duration of fruit maturity (0.44), acidity (0.48), duration of flowering (0.53) and ascorbic acid (0.64).

4.3 Correlation coefficient

4.3.1 Seed length (mm)

It was found that seed length showed positive significant correlation coefficient with fruit weight, fruit length, fruit diameter and seed diameter. While the negative correlation coefficient was found in TSS, TSS: acidity, phenol and flavonoids.

4.3.2 Seed diameter (mm)

Seed diameter had exhibited positive significant correlation with anthocyanin, seed length and seed weight. While the non-significant correlation was estimated in TSS, pH, TSS: acidity and fruit:seed ratio.

4.3.3 Pulp (per cent)

The correlation studies in pulp per cent had shown that there were highly significant positive correction between anthocyanin, ascorbic acid, pH, phenol and flavonoids. While negative correlation in TSS, antioxidant, fruit weight, fruit length, seed weight and pulp:seed ratio.

4.3.4 Pulp to seed ratio

Among the following pulp to seed ratio data represented the highly positive correlation between fruit weight, fruit length, fruit diameter and flavonoid. The non-significant correlation was observed between anthocyanin, seed diameter, pulp per cent and phenol.

4.3.5 Fruit to seed ratio

A positive and highly significant observation was noticed in between fruit to seed ratio and fruit weight, fruit length, fruit diameter and fruit to seed ratio. While, the negative correlation was observed between anthocyanin, ascorbic acid, acidity and phenol.

4.3.6 Fruit maturity (days)

Fruit maturity was positively and significantly correlated with seed length, seed diameter and fruit to seed ratio. While the non-significant correlation was observed between acidity, antioxidant, fruit weight, fruit length and fruit diameter.

4.3.7 Duration of flowering (days)

The correlation was observed between duration of flowering with phenol, antioxidant, flavonoid, fruit diameter and fruit to seed ratio were positively and highly significant. The non-significant correlation between fruit length, fruit weight, seed weight, pulp % and fruit to seed ratio.

Table 4.6: Phenotypic correlation coefficient different physical and chemical characters of jamun genotypes.

Character	Anthocynin Content		TSS		Ascorbic Acid		Acidity		pH		Phenols Content	
Anthocynin content	1.0000		0.2131	**	0.0777		0.0768		0.0158		0.2474	***
TSS	0.2131	**	1.0000		0.0227		0.3124	***	0.2553	***	0.2270	**
Ascorbic acid	0.0777		0.0227		1.0000		0.1290		-0.1871	*	-0.0734	
Acidity	0.0768		0.3124	***	0.1290		1.0000		-0.0840		0.1290	
pH	0.0158		0.2553	***	-0.1871	*	-0.0840		1.0000		0.0617	
Phenols content	0.2474	***	0.2270	**	-0.0734		0.1290		0.0617		1.0000	
Antioxident content	0.0730		0.2037	**	0.1700	*	0.1989	**	0.0218		0.1920	**
Flavnoid content	0.2583	***	0.4617	***	0.1405		0.1920	**	-0.0285		0.4978	***
TSS: acidity ratio	0.2106	**	0.9932	***	0.0162		0.3067	***	0.2521	***	0.2437	***
Duration of fruit maturity	0.0677		0.0251		0.0784		-0.1790	*	0.0754		-0.0418	
Duration of flowering	-0.0753		-0.0038		0.0973		0.0660		0.0356		0.2058	**
Fruit weight	-0.2300	**	-0.1643	*	-0.0086		-0.1082		-0.1434	*	-0.4143	***
Fruit length	-0.2946	***	-0.2527	***	0.0613		-0.1415		-0.2009	**	-0.3895	***
Fruit diameter	-0.1025		-0.2532	***	0.1234		-0.0388		-0.3229	***	-0.3525	***
Seed weight	0.2643	***	-0.3446	***	0.0455		-0.1332		-0.2672	***	-0.0645	
Seed length	0.1563	*	-0.1975	**	0.0612		0.0733		0.0343		-0.1213	
Seed diameter	0.3564	***	-0.2152	**	0.0170		0.0232		-0.2541	***	0.0586	
Pulp %	0.0465		-0.0228		0.0197		0.0225		0.0088		0.0398	
Pulp: seed ratio	-0.3472	***	-0.0243		-0.0991		-0.1137		0.0493		-0.0818	
Fruit: seed ratio	-0.2832	***	0.0708		-0.2687	***	-0.2077	**	0.3126	***	-0.2423	***

Table 4.7: Phenotypic correlation coefficient different physical and chemical characters of jamun genotypes.

Character	Duration of fruit maturity		Fruit Weight		Fruit Length		Fruit Diameter		Seed Weight		Seed Length		Seed Diameter		Pulp %		Pulp: seed Ratio		Fruit: seed ratio	
Anthocynin content	-		-	*	-	***	-		0.264	**	0.156	*	0.3564	**	0.0465		-	***	-0.2832	*
TSS	-		-	*	-	***	-	**	-	**	-	**	-0.2152	**	-0.0228		-		0.0708	
Ascorbic acid	0.0973		-		0.0613		0.123		0.045		0.061		0.0170		0.0197		-		-0.2687	*
Acidity	0.0660		-		-		-		-		0.073		0.0232		0.0225		-		-0.2077	*
pH	0.0356		-	*	-	**	-	**	-	**	0.034		-0.2541	**	0.0088		0.049		0.3126	*
Phenols content	0.2058	*	-	*	-	***	-	**	-		-		0.0586		0.0398		-		-0.2423	*
Antioxidant content	0.2611	*	0.0717		0.0995		0.074		-		0.122		-0.1212		-0.1118		0.069		0.0528	
Flavnoid content	0.1418		-		-		-		-		-		-0.0049		0.0075		0.000		-0.2102	*
TSS: acidity ratio	-		-	*	-	***	-	**	-	**	-	**	-0.2076	**	-0.0178		-		0.0632	
Duration of fruit maturity	-0.0061		-0.1150		-0.0912		-0.0099		-0.0391		0.0106		0.0803		-0.0039		-0.0193		0.0494	
Duration of flowering	1.0000		-		-		0.030		-		0.087		0.0233		-0.1195		0.016		-0.0309	
Fruit weight	-		1.0000		0.8081	***	0.691	**	0.197	**	0.490	**	-0.0155		-0.1061		0.382	***	0.5044	*
Fruit length	-		0.8081	*	1.0000		0.709	**	0.256	**	0.406	**	-0.0849		-0.1365		0.413	***	0.3448	*
Fruit diameter	0.0305		0.6918	*	0.7091	***	1.000		0.221	**	0.473	**	0.0683		-0.0805		0.244	***	0.2443	*
Seed weight	-		0.1975	*	0.2568	***	0.221	**	1.000		0.452	**	0.5716	**	-0.0569		0.081		-0.1674	*
Seed length	0.0879		0.4902	*	0.4062	***	0.473	**	0.452	**	1.000		0.3482	**	-0.0968		0.056		0.0969	
Seed diameter	0.0233		-		-		0.068		0.571	**	0.348	**	1.0000		0.0554		-	*	-0.2068	*
Pulp %	-		-		-		-		-		-		0.0554		1.0000		-		-0.0461	
Pulp: seed ratio	0.0161		0.3828	*	0.4132	***	0.244	**	0.081		0.056		-0.1773	*	-0.0616		1.000		0.4321	*
Fruit: seed ratio	-		0.5044	*	0.3448	***	0.244	**	-	*	0.096		-0.2068	**	-0.0461		0.432	***	1.0000	

4.3.8 Anthocyanin content

A positively and highly significant correlation was observed between anthocyanin and TSS, phenol, flavonoid and TSS to acidity ratio. However, the negative correlation was observed between fruit weight, fruit length, pulp to seed ratio and fruit to seed ratio.

4.3.9 TSS content

The correlation studies between TSS and anthocyanin, acidity, pH, phenol and flavonoid were high and positively significant. While, there were non-significant correlation between fruit weight, fruit length, fruit diameter, seed diameter and seed weight.

4.3.10 Ascorbic acid

Positive correlation was observed with antioxidant, fruit length, fruit diameter, seed weight and seed length, while the negative correlation was noticed in between pH, phenols, fruit to seed ratio and pulp to seed ratio.

4.3.11 Acidity

Acidity showed positive significant correlation with TSS, ascorbic acid, antioxidant and flavonoid. While, the negative correlation was observed in pH, fruit maturity, fruit to seed ratio.

4.3.12 pH

Present study reported highly significant relation in between pH with TSS, TSS to titrable acidity and fruit to seed ratio. The non-significant with ascorbic acid followed by fruit weight, fruit length and fruit diameter.

4.3.13 Phenol content

The negative correlation was recorded with fruit diameter, fruit length, fruit weight and fruit to seed ratio. While the positive correlation was observed in anthocyanin, TSS, antioxidant and flavonoid.

4.3.14 Antioxidant content

Antioxidant was positively and significantly correlated with TSS, ascorbic acid, acidity, phenol and flavonoid. While, the non-significant correlation was observed between fruit maturity, seed weight, seed diameter and pulp per cent.

4.3.15 Flavonoid content

Highly positively correlation was found with anthocyanin, TSS, acidity and phenol. The negative correlation was observed with pH, fruit maturity, fruit weight, fruit length and fruit diameter.

4.3.16 TSS to acidity ratio

The correlation was observed between TSS to acidity ratio with TSS, anthocyanin, acidity, pH, phenol, antioxidant and flavonoid were positively and highly significant. While the non-significant correlation between fruit length, fruit weight, fruit diameter, seed length, seed diameter and pulp to seed ratio.

CHAPTER-V

DISCUSSION

Jamun (*Syzygium cuminii* Skeels) is a tropical and sub-tropical fruit of high commercial and nutritive value are found. These fruits tree are largely grown on avenues and along with roadsides. It is naturally wide spread fruit plant and the more variability have been found due to, its highly cross pollinated crop. The present study investigation was undertaken to study variability and correlation studies among different genotype of jamun. The finding thus obtained in previous chapters is discussed with the supports of proper reasoning and available literature. In this chapters discussed under following different character like, floral biology, fruit character and variability in physicochemical characters of different genotypes.

5.1 Morphological feature of jamun tree

Syzygium cuminii genotypes are large evergreen and multipurpose, height of tree up to twenty meter and produce flowering from March to April month. Most of the genotypes are spreading in nature, but some are erect. The shape of leaves is oblong-elliptic to obovate. The similar finding of morphological feature of jamun tree was carried out by Bose *et al*. (1998).

5.1.1 Flower biology

Flower bud emergence was marked by the bud primordial of smallest size, visible to eye in leaf axil in the form of panicle. Flower bud early emergence in genotype JG-55 (9 February) followed by JG-10 (15 February), JG-11 (16 February) and JG-39 (16 February). Late in the case of JG-52 (15 March) during 2018. The variation in 47 genotypes of *syzygium cuminii* may be due to the genetic makeup of the plants and environmental conditions. These findings are similar with the observation made by Misra and Bajpai, (1984), Bajpai *et al*. (2012) and Devi *et al*. (2016) in jamun fruit.

5.1.2 Initiation of flower

The flowering in jamun can be start early in genotype JG-55 (10 March) followed by JG-54 (15 March), JG-11 (15 March) and JG-30 (15 March), while late flowering can be start in genotype JG-52 (14 April) followed by JG-54 (14 April) and JG-2 (28 March). The variation in flowering initiation due to plant genetic makeup. Similar observation was on flowering initiation was also observed by Bajpai *et al*. (2012) and Devi *et al*. (2016) in jamun fruit.

5.1.3 Duration of flowering

The maximum duration of flowering was recorded in genotype JG-21 (34.50 days) followed by JG-27 (34.50 days), JG-23 (34.24 days) and JG-33 (34.25 days). The minimum duration of flowering was observed in JG-41 (25.00 days) followed by JG-51 (26.75 days), JG-36 (27.00 days) and JG-17 (27.00 days). This difference in flowering duration due to variation in initiation of flower bud, initiation of flower, end of bloom and genetic makeup. The duration of flowering observation was recorded for 43 dayss in *Syzygium cuminii* by Misra and Bajpai (1984), Bajpai *et al*. (2012) and Devi *et al*. (2016).

5.1.4 Duration of fruit maturity

The minimum duration of fruit maturity was observed in JG-22 (44.50 days) followed by JG-28 (45.15 days), JG-52 (45.75 days) and JG-10 (46 days). The maximum duration of fruit maturity was recorded in genotype JG-51 (56.25 days) followed by JG-16 (56.00 days), JG-34 (55.15 days) and JG-17 (55.00 days). The variation in duration of fruit maturity due to genetic makeup of plant and environmental condition. The similar study was observed Devi *et al*. (2016) and Bajpai *et al*. (2012) in jamun fruit.

5.3 Variability in physical character of jamun genotype

The study was carried out in different jamun genotype for their physical character under the present investigation. The highest fruit weight was recorded in genotype JG-55 (11.68 g) followed by JG-21 (7.63 g), JG-54 (7.52 g), JG-50 (7.09 g) and JG-53 (6.97 g).

The lowest fruit weight was found in the genotype JG-15 (3.31 g) followed by JG-20 (3.37 g), JG-23 (3.40 g), JG-14 (3.60 g) and JG-12 (3.62 g). The variation in all genotype due to genetic makeup and environmental condition. Similar findings were observed by Devi *et al*. (2002) in fruit weight of *Syzygium cuminii* ranged from 3.42 to 13.67 g, Patel *et al*. (2005) in jamun, Singh *et al*. (2007) observed that in jamun fruit weight ranged from 4.80 to 17.60 g, while Sharma *et al*. (2009) and Prakash *et al*. (2010) observed that the most promising fruit weight (14.55 g) for jamun Srivastava *et al*. (2011) determined physico-chemical characteristics of jamun fruit of 25 genotypes.

A wide variation in fruit length was also observed in 47 evaluated in jamun genotype. The maximum fruit length was recorded in the genotype JG-55 (32.11 mm) followed by JG-39 (27.39 mm), JG-53 (25.27 mm), JG-51 (26.22 mm) and JG-52 (26.08 mm), while the minimum fruit length was observed in JG-26 (18.50 mm) followed by JG-15 (18.93 mm), JG-14 (19.76 mm), JG-33 (20.69 mm) and JG-28 (20.75 mm). This variation in genotypes is due to genetic makeup of plant. Similar findings were observed by Devi *et al*. (2002), Singh *et al*. (2012), Sharma *et al*. (2009) and Ghojage *et al*. (2011), who found that highest fruit length was evaluated in KJS-8 (4.49 cm) while lowest was recorded in KJS-30 (2.70 cm).

Fruit diameter was also varied from 15.02 to 23.85 mm. The results were showed significant variation in all genotype. The maximum fruit diameter was absorbed in the genotype JG-16 (23.85 mm) followed by JG-55 (23.23 mm), JG-46 (22.19 mm), JG-21 (21.15 mm) and JG-39 (20.69 mm). While the lowest diameter of fruit was recorded in JG-6 (15.02 mm) followed by JG-15 (15.12 mm), JG-14 (15.32 mm), JG-34 (15.50 mm) and JG-44 (15.60 mm). The variation in genotypes due to genetic makeup of plant. The similar result was found by Srivastava *et al.* (2011) who evaluated that fruit width was maximum in PJ-24 (2.07 cm) and the minimum was observed PJ-25 (1.26 cm) in *Syzygium cuminii*, Manveen and Bal (2015) was observed fruit width ranging from 1.75 to 2.53 cm in jamun fruit.

A wide variation was seen in seed weight and size of jamun genotype. The minimum seed weight was noticed in genotype JG-6 (0.62 g) followed by JG-14 (0.65 g),

JG-15 (0.68 g), JG-44 (1.20 g) and JG-28 (1.21 g). Whereas, the maximum seed weight was recorded in JG-37 (1.79 g) followed by JG-35 (1.65 g), JG-27 (1.58 g), JG-39 (1.58 g) and JG-29 (1.58 g). However, the maximum seed length was noticed in genotype JG-55 (20.07 mm) followed by JG-54 (19.87 mm), JG-51 (19.27 mm), JG-52 (19.12 mm) and JG-26 (19.03 mm). While the minimum seed length was observed in JG-15 (14.01 mm) followed by JG-14 (15.44 mm), JG-30 (15.68 mm), JG-5 (15.97 mm) and JG-6 (16.21 mm). The highest seed diameter was evaluated in JG-50 (12.06 mm) followed by JG-9 (11.96 mm), JG-42 (11.78 mm), JG-24 (11.74 mm) and JG-18 (11.71 mm). The minimum seed diameter was observed in genotype JG-6 (7.40 mm) followed by JG-15 (8.47 mm), JG-2 (9.12 mm), JG-55 (9.16 mm) and JG-13 (9.95 mm). The variation in seed length, weight and width due to plant genetic makeup and environmental condition. The similar finding was observed by Patel *et al.* (2005), Singh *et al.* (2007), Inamdar *et al.* (2002), Singh *et al.* (2007) and Prakash *et al.* (2010) in jamun fruit.

The ranging of fruit to seed ratio was 10.10 to 1.73 per cent. The maximum fruit to seed ratio was noticed from JG-55 (10.10%) followed by JG-39 (6.47%), JG-50 (6.30%), JG-14 (6.16%) and JG-26 (5.64%), while the minimum fruit to seed ratio was carried out by JG-44 (1.73%) followed by JG-52 (1.98%), JG-11 (2.06%), JG-32 (2.07%) and JG-25 (2.22%).

Pulp to seed ratio in jamun varied from 1.35 to 9.35. The highest pulp to seed ratio was found in genotype JG-55 (9.35) followed by JG-30 (4.59), JG-36 (4.49), JG-44 (4.43) and JG-11 (4.22). The minimum pulp to seed ratio was noticed in JG-21 (1.35) followed by JG-50 (1.46), JG-10 (1.53), JG-31 (1.57) and JG-27 (1.59). Variation in pulp to seed ratio owed to plant genetic makeup. Maximum pulp to seed ratio is a desirable character for table purpose of fruits (Singh and Singh, 2012). Srivastava *et al*. (2012) revealed that pulp per cent of a fruit was more significant and positively correlated with fruit volume and pulp/seed ratio while the non-significant correlated with seed per cent. Seed pre-cent showed highest significant non-significant correlation with pulp to seed ratio and fruit volume.

Pulp content was varied from 80.22 to 85.55% in all jamun genotype. Among the genotypes, the minimum pulp per cent was recorded in JG-12 (80.22%) followed by JG-27 (80.72%), JG-55 (81.47%), JG-8 (81.60%) and JG-44 (81.69%). The maximum pulp per cent was noticed in JG-20 (85.55%) followed by JG-32 (85.17%), JG-10 (84.87%), JG-30 (84.83%) and JG-14 (84.72%). Most of the genotypes produced high pulp per cent. It is due to more fruit weight and less seed weight. This clearly showed that, during selection of genotype based on fruit, the breeder should give emphasis on fruit pulp content which should be more than fruit weight. The variation in pulp content due to plant genetic makeup and environmental condition. The similar study was carried out by Devi *et al*. (2002), Sharma *et al*. (2009) and Prakesh *et al*. (2010).

5.5 Variability in chemical parameter of jamun fruit genotype

A wide range of variability was noticed in different *Syzygium cuminii* genotypes for TSS content. It is ranging 9.05 to 23.90 °Brix. The highest TSS value was recorded in genotype JG-25 (23.90 °Brix) followed by JG-53 (23.02 °Brix), JG-15 (22.80 °Brix), JG-14 (22.20 °Brix) and JG-12 (20.25 °Brix). The lowest TSS content was evaluated in JG-34 (9.05 °Brix) followed by JG-16 (9.25 °Brix), JG-21 (9.28 °Brix) JG-41 (9.70 °Brix) and JG-10 (10.00 °Brix). The variation in TSS content owed by plant genetic makeup. The same result was observed by Roy *et al.* (2013) and Devi *et al*. (2002) in fruit jamun.

Variation was also determined in acidity content of the fruit which ranging from 0.45 to 1.09 per cent. The highest acidity content was recorded in JG-21 (1.09%) followed by JG-40 (1.06%), JG-1 (1.06%), JG-2 (1.06%) and JG-44 (1.06%). The lowest acidity content was found in JG-18 (0.45%) followed by JG-17 (0.48%), JG-11 (0.56%), JG-34 (0.58%) and JG-37 (0.57%). The variation in acidity content owed by plant genetic makeup. In many fruit crops it was observed that if total soluble solids (TSS) were increased than acidity will decrease. Similar finding was carried out by Srivastava *et al.* (2011).

The maximum anthocyanin was recorded in genotype JG-29 (93.04 mg 100 g^{-1}) followed by JG-53 (86.49 mg 100 g^{-1}), JG-32 (83.46 mg 100 g^{-1}), JG-12 (80.77 mg 100 g^{-1})

and JG-49 (80.63 mg 100 g^{-1}). The minimum anthocyanin content was carried out in JG-2 (14.14 mg 100 g^{-1}) followed by JG-55 (25.14 mg 100 g^{-1}), JG-6 (31.23 mg 100 g^{-1}), JG-5 (41.65 mg 100 g^{-1}) and JG-28 (43.95 mg 100 g^{-1}). The variation in anthocyanin content due to plant genetic makeup and environmental condition. The similar study was observed by Devi *et al*. (2002), Chandrasekhar and Raghavarao (2014) and Jampani *et al*. (2014) in fruit jamun.

The range of variation in ascorbic acid 33.00 to 132.31 mg 100 g^{-1}. The maximum ascorbic acid was observed in JG-23 (132.31 mg 100 g^{-1}) followed by JG-18 (131.84 mg 100 g^{-1}), JG-40 (126.35 mg 100 g^{-1}), JG-19 (123.86 mg 100 g^{-1}) and JG-46 (103.60 mg 100 g^{-1}). While the lowest ascorbic acid was recorded in JG-30 (33.00 mg 100 g^{-1}) followed by JG-20 (44.45 mg 100 g^{-1}), JG-26 (47.31 mg 100 g^{-1}), JG-27 (49.96 mg 100 g^{-1}) and JG-11 (56.22 mg 100 g^{-1}). The variation in anthocyanin content was due to plant genetic makeup and environmental conditions. The similar study of variation in ascorbic acid content has been reported among *Syzygium cuminii* from Uttar Pradesh and Jharkhand by Patel *et al*. (2005) in fruit jamun.

The maximum phenol was recorded in genotype JG-12 (273.44 mg 100 g^{-1}) followed by JG-32 (267.66 mg 100 g^{-1}), JG-37 (235.11 mg 100 g^{-1}), JG-46 (198.80 mg 100 g^{-1}) and JG-6 (198.36 mg 100 g^{-1}). The minimum phenol content was recorded in the genotype JG-10 (43.58 mg 100 g^{-1}) followed by JG-41 (55.74 mg 100 g^{-1}), JG-34 (59.33 mg 100 g^{-1}), JG-51 (59.33 mg 100 g^{-1}) and JG-39 (59.50 mg 100 g^{-1}). Similar study was observed by Shahnawaz *et al*. (2011) in *syzygium cuminii* and Souza *et al*. (2014) in fruit jamun.

A wide range of variability was noticed in different *Syzygium cuminii* genotypes for pH, content. It is ranging 2.39 to 3.73. The highest pH value was recorded in genotype JG-55 (3.73) followed by JG-6 (3.69), JG-14 (3.67), JG-50 (3.66) and JG-29 (3.65). The lowest pH content was evaluated in JG-21 (2.39) followed by JG-22 (2.61), JG-13 (2.69), JG-37 (2.70) and JG-24 (2.71). The variation in all genotype was due to plant genetic makeup. The same result was observed by Roy *et al.* (2013) and Devi *et al*. (2002) in fruit jamun.

The antioxidant was also ranging from 1.87 to 7.33. The results were showed significant variation in all genotype. The maximum antioxidant was determined in the genotype JG-23 (7.33 µmol TE g^{-1}) followed by JG-55 (7.26 µmol TE g^{-1}), JG-21 (7.17 µmol TE g^{-1}), JG-22 (7.07 µmol TE g^{-1}) and JG-39 (6.82 µmol TE g^{-1}). While the lowest antioxidant was found in JG-41 (1.87 µmol TE g^{-1}) followed by JG-18 (2.11 µmol TE g^{-1}), JG-34 (2.33 µmol TE g^{-1}), JG-13 (2.64 µmol TE g^{-1}) and JG-51 (2.78 µmol TE g^{-1}). The variation in genotypes was due to genetic makeup of plant. The similar finding was carried out by Shahnawaz *et al*. (2009) in *Syzygium cuminii* and Souza *et al*. (2014) in brazilian blackberry, red raspberry, strawberry, blueberry and sweet cherry fruits.

The flavonoid was also varied from 16.89 to 193.90 mg CE 100 g^{-1}. The maximum flavonoid was recorded in the genotype JG-32 (193.90 mg CE 100 g^{-1}) followed by JG-12 (158.38 mg CE 100 g^{-1}), JG-25 (152.51 mg CE 100 g^{-1}), JG-44 (95.46 mg CE 100 g^{-1}) and JG-13 (91.18 mg CE 100 g^{-1}). While the lowest flavonoid was recorded in JG-39 (16.89 mg CE 100 g^{-1}) followed by JG-34 (18.90 mg CE 100 g^{-1}), JG-26 (21.09 mg CE 100 g^{-1}), JG-54 (23.01 mg CE 100 g^{-1}) and JG-52 (23.63 mg CE 100 g^{-1}). The variation in all genotype was due to plant genetic makeup. The finding was similar with the findings of Shahnawaz *et al*. (2009) in *syzygium cuminii* and Souza *et al*. (2014) in brazilian blackberry, red raspberry, strawberry, blueberry and sweet cherry fruits. In any breeding programme variability along with die population is a requirement for genetic improvement. High variability found in different characters of present study is a suggestion that the effective enhancement could be made in this fruit crop.

5.6 Correlation study of jamun genotype

In any breeding programme study of correlation among different morphological, chemical and physical attributes provide a plan of association that could be successfully utilized for selection of desirable characters. In present study specific relationship between different fruit characters of various types was worked out.

5.6.1 Seed length

In present study the length of seed which showed positive significant correlation coefficient with fruit weight, fruit length, fruit diameter and seed diameter. While the negative correlation coefficient was found in TSS, TSS: acidity, phenol and flavonoid. The variation in seed length was due to plant genetic makeup and environmental condition. Similar study of correlation was also carried out by Inamdar (2002) in jamun, Jadhav (1989), Jondhaie (1989) in mango fruit, Naikwade *et al.* (1989) in markingnut, Munde *et al.* (2001) in charoli.

5.6.2 Seed diameter

Diameter of seed had exhibited positive significant correlation with anthocyanin, seed length and seed weight. While the non-significant correlation was estimated in TSS, pH, TSS: acidity and fruit: seed ratio. The variation in diameter of seed was due to plant genetic makeup. Similar studies in correlation were also reported by Inamdar (2002) in jamun, Jadhav (1989), Jondhaie (1989) in mango, Naikwade *et al.* (1989) in markingnut, Munde *et al.* (2001) in charoli.

5.6.3 Pulp per cent

The correlation studies in pulp per-cent had shown that there was highly significant positive correction between anthocyanin, ascorbic acid, pH, phenol and flavonoids. While negative correlation in TSS, antioxidant, fruit weight, fruit length, seed weight and pulp toseed ratio. The variation in pulp per cent due to plant genetic makeup and environmental condition. Similar result was observed by Munde *et al.* (2001) in charoli, Inamdar (2002) in jamun.

5.6.4 Pulp to seed ratio

Among the following pulp to seed ratio, data are represented the highly positive correlation between fruit weight, fruit length, fruit diameter and flavonoid. The non-significant correlation was observed between anthocyanin, seed diameter, pulp% and

phenol. Variation in pulp to seed ratio owed by plant genetic makeup and environmental condition. Similar study of correlation was carried out by Inamdar (2002) in jamun, Jadhav (1989), Jondhaie (1989) in mango.

5.6.5 Fruit to seed ratio

A positive and highly significant was observed between fruit to seed ratio and fruit weight, fruit length, fruit diameter and fruit to seed ratio. While the negative correlation was observed between anthocyanin, ascorbic acid, acidity and phenol. Same type of results were observed by various research workers in *Syzygium cuminii* by Jadhav (1989) in jamun, Jondhaie (1989) in mango, Inamdar (2002) in jamun, Naikwade *et al.* (1989) in markingnut and Munde *et al.* (2002) in charoli.

5.6.7 Fruit maturity

Fruit maturity was positively and significantly correlated with seed length, seed diameter and fruit to seed ratio. While non-significant correlation was observed between acidity, antioxidant, fruit weight, fruit length and fruit diameter. Similar types of correlation were also reported by Inamdar (2002) in jamun, Jadhav (1989) in jamun, Jondhaie (1989) in mango, Naikwade *et al.* (1989) in markingnut, Munde *et al.* (2001) in charoli.

5.6.8 Duration of flowering initation

The correlation was observed between duration of flowering with phenol, antioxidant, flavonoid, fruit diameter and fruit to seed ratio were positively and highly significant. The non-significant correlation between fruit length, fruit weight, seed weight, pulp % and fruit to seed ratio. The variation in flowering duration due to plant genetic makeup and environmental condition. Similarly results of correlation coefficient were also observed by Inamdar *et al*. (2002) in jamun, Jadhav (1989) in jamun and Jondhaie (1989) in mango.

5.6.9 Anthocyanin content

A positive and highly significant correlation was observed between anthocyanin and TSS, phenol, flavonoid and TSS to acidity ratio. The negative correlation was observed between fruit weight, fruit length, pulp to seed ratio and fruit to seed ratio. The variation in anthocyanin content was due to plant genetic makeup and environmental condition. Same result was observed by Jondhaie (1989) in mango and Inamdar *et al*. (2002) in jamun.

5.6.10 TSS content

The correlation studies in Jamun between TSS and anthocyanin, acidity, pH, phenol and flavonoid were highly and positively significant. While the non-significant correlation was seen between fruit weight, fruit length, fruit diameter, seed diameter and seed weight. Variations in TSS were due to plant genetic makeup. In the same way correlation studies were also reported by Inamdar *et al*. (2002) in jamun, Jadhav (1989) in jamun and Jondhaie (1989) in mango.

5.6.11 Ascorbic acid

Positive correlation was observed with antioxidant, fruit length, fruit diameter, seed weight and seed length; while the negative correlation between pH, phenols, fruit to seed ratio and pulp to seed ratio was observed in jamun genotype. Variations in TSS were due to plant genetic makeup and environmental factor. Similar results were studied by Inamdar (2002) in jamun, Jadhav (1989), Jondhaie (1989) in mango, Naikwade *et al.* (1989) in markingnut and Munde *et al.* (2001) in charoli.

5.6.12 Acidity

The acidity which showed positive significant correlation coefficient with TSS, ascorbic acid, antioxidant and flavonoid. While the negative correlation coefficient was observed in pH, fruit maturity, fruit to seed ratio. Variations in acidity was due to plant genetic makeup. Result was similar with the studies of Inamdar (2002) in jamun, Jadhav

(1989), Jondhaie (1989) in mango, Naikwade *et al.* (1989) in markingnut and Munde *et al.* (2001) in charoli.

5.6.13 pH

Present study which shows highly significant with TSS, TSS to titrable acidity and fruit to seed ratio. The non-significant effect with ascorbic acid followed by fruit weight, fruit length and fruit diameter was observed. Variations in pH was due to plant genetic makeup and environmental factor. Result was similar with the studies of Inamdar (2002) in jamun, Jadhav (1989), Jondhaie (1989) in mango, Naikwade *et al.* (1989) in markingnut and Munde *et al.* (2001) in charoli.

5.6.14 Phenol content

The negative correlation was recorded with fruit diameter, fruit length, fruit weight and fruit to seed ratio. While the positive correlation was observed with anthocyanin, TSS, antioxidant and flavonoid. Variations in phenol content was due to plant genetic makeup. Similar result was found by Inamdar (2002) in jamun, Jadhav (1989) in jamun, Jondhaie (1989) in mango, Naikwade *et al.* (1989) in markingnut and Munde *et al.* (2001) in charoli.

5.6.15 Antioxidant content

Antioxidant was positively and significantly correlated with TSS, ascorbic acid, acidity, phenol and flavonoid. While non-significant correlation was observed between fruit maturity, seed weight, seed diameter and pulp per-cent. Inamdar (2002) in jamun, Jadhav (1989) in jamun, Jondhaie (1989) in mango, Naikwade *et al.* (1989) in markingnut and Munde *et al.* (2001) in charoli found the same result.

5.6.16 Flavonoid content

Highly positively correlation was found with anthocyanin, TSS, acidity and phenol while negative correlation was observed with pH, fruit maturity, fruit weight, fruit length and fruit diameter. Variations in flavonoid content was due to plant genetic makeup and environmental factor. Which found similar with the result of Inamdar (2002) in jamun,

Jadhav (1989) in jamun, Jondhaie (1989) in mango, Naikwade *et al.* (1989) in markingnut and Munde *et al.* (2001) in charoli.

5.6.17 TSS to acidity ratio

The correlation was observed between TSS to acidity ratio with TSS, anthocyanin, acidity, PH, phenol, antioxidant and flavonoid were found positive and highly significant. While the non-significant correlation between fruit length, fruit weight, fruit diameter, seed length, seed diameter and pulp to seed ratio. Similar result was found by Inamdar (2002) in jamun, Jadhav (1989) in jamun, Jondhaie (1989), Kokadwar in mango, Naikwade *et al.* (1989) in markingnut and Munde *et al.* (2001) in charoli.

CHAPTER-VI

SUMMARY AND CONCLUSION

The present investigation entitled "**Studies on flowering, fruiting and post-harvest characters of jamun (*Syzygium cuminii* Skeels) genotypes**" was carried out during March 2018 with 47 genotypes were evaluated for variability studies in at jamun Institute of Agricultural Sciences, Banaras Hindu University, Varanasi. The main objective of this study was to determine the morphological and chemical characters of *Syzygium cuminii* collections maintained in BHU main campus for identifying the superior genotypes. Mature fruit samples were recorded for quality attributes. The experimental results obtained are summarized below.

6.1 Variability in jamun genotypes

1. The genotype JG-21 (34.50 days) attained maximum duration of flowering, while JG-41 (25.00 days) was recorded minimum duration of flowering.
2. The number of days taken from fruit set to maturity varied from 44.50 to 56.25 days. The minimum days from fruit set to fruit maturity (44.50 days) was observed in JG-22 and maximum days (56.25 days) observed in JG-51 (56.25 days).
3. The fruit weight of the collections varied from 11.67 to 3.30 g. The fruit weight in *Syzygium cuminii* genotype was maximum recorded in JG-55 (11.67 g) and minimum was observed in genotype JG-15 (3.30 g).
4. The fruit length of the collections ranging from 18.50 to 32.11 mm. The minimum fruit length in jamun was recoreded in genotype JG-26 (18.50 mm), while the maximum fruit length was evaluated in JG-55 (32.11 mm).
5. The maximum fruit diameter was found in genotype JG-16 (23.85 mm) and minimum fruit diameter was recorded in genotype JG-6 (15.02 mm). The fruit diameter of the collection ranging from 15.02 to 23.85 mm.
6. The seed weight of different genotype was recorded and varied from 0.62 to 1.79 g. Genotype JG-37 (1.79 g) recorded the highest seed weight and JG-6 (0.62 g) were recorded the lowest seed weight in jamun genotype.

7. Seed length in different genotypes of jamun was ranging from 14.01 to 20.07 mm. The minimum seed length was recorded in JG-15 (14.01 mm) genotype. While the maximum seed length was observed in genotype JG-55 (20.07 mm).
8. The highest seed diameter was observed in JG-50 (12.06 mm) and the lowest seed diameter was recorded in JG-6 (7.40 mm). A varied range of seed diameter was observed *i.e*. 7.40 to 12.06 mm.
9. The TSS to acidity ratio in different genotype was ranging from 8.43 to 23.13 per cent. The maximum TSS to acidity ratio was observed in JG-25 (23.13%) genotype. While the minimum TSS to acidity ratio was found in JG-16 (8.43%).
10. The maximum pulp to seed ratio was observed in JG-55 (9.35%) and minimum pulp to seed ratio was found in JG-21 (1.35%). The range of pulp to seed ratio was found 1.35 to 9.35 per cent.
11. The ratio of fruit to seed was maximum found in genotype JG-55 (10.10 per cent). While the minimum fruit to seed ratio was observed in JG-44 (1.73%).
12. Anthocyanin content of the fruit varied from 14.14 mg 100 g^{-1} to 93.04 mg 100 g^{-1}. minimum anthocyanin content of 14.14 mg 100 g^{-1} was recorded in JG-2 whereas the maximum anthocyanin content of 93.04 mg 100 g^{-1} in JG-29.
13. TSS of the fruits ranging from 9.05 ^{0}Brix to 23.90 ^{0}Brix. The minimum TSS of 9.05 ^{0}Brix was recorded in JG-34 and the maximum TSS content of 23.90 ^{0}Brix recorded in JG-25.
14. Among *Syzygium cuminii* genotype, ascorbic acid content ranged from 33.00 to 132.31 mg 100 g^{-1}. The maximum ascorbic acid content was absorbed in genotype JG-23 (132.31 mg 100 g^{-1}). While the lowest ascorbic acid content in JG-30 (33.00 mg 100 g^{-1}).
15. Acidity content of the jamun fruit varied from 0.45 to 1.09 per cent. JG-18 recorded the minimum acidity content of 0.45 per cent whereas JG-21 recorded the maximum acidity content of 1.09 per cent.
16. pH of the fruit varied from 2.39 to 3.73. The lowest pH of 2.39 was observed in JG-21 and the highest pH of 3.73 was found in JG-55.

17. Phenol content was found to be maximum in JG-12 (273.43 mg 100 g^{-1}) among Jamun genotypes, whereas the minimum phenol content was recorded in JG-10 (43.57 mg 100 g^{-1}) genotype.
18. The antioxidant content of the collections varied from 1.87 to 7.33 μmol TE g^{-1}. The maximum antioxidant content was recorded in JG-23 (7.33 μmol TE g^{-1}) and minimum was observed in genotype JG-41 (1.87 μmol TE g^{-1}).
19. The maximum flavonoid content was found jamun genotype JG-32 (193.90 mg 100 g^{-1}) and minimum flavonoid content was recorded in genotype JG-39 (16.89 mg 100 g^{-1}). The flavonoid content of the collection ranging from 193.90 to 16.89 mg 100 g^{-1}.
20. In the genetic study, maximum range was observed in flavonoids content. Both the PCV and GCV were highest (PCV= 72.60 and GCV= 70.82), while the minimum GCV and PCV was found in antioxidant content (PCV= 36.42 and GCV= 35.47). The maximum heritability was found in phenol and fruit to seed ratio h^2 (97.8 %) and minimum heritability was observed for pulp per cent (-0.042). High genetic advance was observed for phenol (116.25), while minimum genetic advance was found in pulp per cent (-0.215).

6.2 Correlation coefficient

1. Length of seed in jamun which showed positive significant correlation coefficient with fruit weight and fruit length. While the negative correlation coefficient was recorded in TSS and TSS: acidity ratio.
2. Diameter of seed had exhibited positive significant correlation with anthocyanin and seed length while the non-significant correlation was found in TSS and pH.
3. The correlation studies in pulp per cent had shown that there was highly significant positive correction between anthocyanin and ascorbic acid. While negative correlation in TSS and antioxidant.
4. Among the pulp to seed ratio data are represented the highly positive correlation between fruit weight and fruit length. The non-significant correlation was observed between anthocyanin and seed diameter.

5. A positive and highly significant value was observed between fruit to seed ratio and fruit weight. While the negative correlation was observed between anthocyanin and ascorbic acid.
6. Fruit maturity was positively and significant correlated with seed length, seed diameter. While non-significant correlation was observed between acidity and antioxidant.
7. The correlation was observed between duration of flowering with phenol and antioxidant was positively and highly significant. The non-significant correlation between fruit length and fruit weight.
8. A positive and highly significant correlation was observed between anthocyanin TSS and phenol. The negative correlation existed between fruit weight and fruit length in jamun.
9. The correlation between TSS and anthocyanin, acidity were highly and positively significant. While the non-significant correlation between fruit weight and fruit length.
10. Positive correlation was observed with antioxidant, fruit length and fruit diameter. While the negative correlation was found between pH and phenols.
11. The acidity which showed positively significant correlation coefficient with TSS and ascorbic acid. While the negative correlation coefficient was observed in pH and fruit maturity
12. The study showed highly significant value with TSS, TSS to titrable acidity ratio in jamun while the nonsignificant value was found with ascorbic acid followed by fruit weight.
13. The negative correlation was recorded with fruit diameter, fruit length. While the positive correlation was observed with anthocyanin and TSS.
14. Antioxidant properly was found positively and significant correlated with TSS and ascorbic acid. While nonsignificant correlation was observed between fruit maturity and seed weight.
15. Highly positive correlation was found with anthocyanin, TSS, acidity and phenol and negative correlation was observed with pH, fruit maturity, fruit weight, fruit length and fruit diameter.

16. The correlation was observed between TSS to acidity ratio with TSS and anthocyanin was positively and highly significant. While the non-significant correlation between fruit length and fruit weight.

6.3 Conclusion

Jamun is a minor fruit but, having a lot of medicinal and pharmaceutical properties. From this experiment it may be concluded that flowering period of jamun genotypes continued from March to May and flower bud attained maturity after 24 to 35 days of flowering. Wide range of variability was observed for physico-chemical composition of fruits among different genotypes. On the basis of the characters studied genotype JG-55 and JG-23 were found to be superior among all the genotypes.

REFERENCES

Afify, A.M.R., Fayed, S.A., Shalaby, E.A. and El-Shemy, H.A. 2011. *Syzygium cuminii* active principles exhibit potential anticancer and antioxidant activities. *African Journal of Pharmacy and Pharmacology*, **5**: 948-956.

Agrawal, V., Rangare, N.R. and Nair, R. 2017. Variability studies in different accessions of jamun (*Syzygium cuminii* Skeels) from Madhya Pradesh. *International Journal of Chemical Studies*, **5**(3): 07-11.

Akar, R. and Aydin, C. 2005. Some physical properties of jamun fruit varieties. *Journal of Food Engineering*, **66**: 387-393.

Ali, S., Masud, T., Abbasi, K.S., Ali, A. and Hussain, A. 2013. Some compositional and biochemical attributes of jamun fruit (*Syzygium cuminii*) from Potowar region of Pakistan. *Research in Pharmacy*, **3**(5): 01-09.

Ali, T.M., Abbasi, K.S., Ali, A. and Hussain, A. 2015. Some compositional and biochemical attributes of jamun fruit (*Syzygium cuminii*) from Potowar region of Pakistan. *Research in Pharmacy*, **3**(5): 224-229.

Ashraf, S.M. 1987. Studies on postharvest technology of jamun (*Syzgium cumunii* Skeels) fruit. Ph.D. Thesis, Narendra Deva University of Agriculture and Technology, Faizabad. (U.P.).

Athani, S.I., Prabhuraj, H.S., Swamy, G.S.K., Patil, P.B., Sabarad, A.I., Gasti, V.D., Duragannavar, M.P. and Dasaraddi, S.V. 2006. Variability studies in physical parameters and pulp characters of jamun in fruits. In: Abstracts, National Seminar on Appropriate Technology for Sustainable Horticulture; Annamalai University, Tamil Nadu, 31p.

Ayyanar, M. and Babu, P.S. 2012. *Syzygium cuminii* (L.) Skeels: A review of its phytochemical constituents and traditional uses. *Asian Pacific Journal of Tropical Biomedicine*, **2**: 240-246.

Babu, K.D., Chandra, R., Sharma, J. and Jadhav, V.T. 2011. Flower biology of pomegranate cultivar Ganesh under Solapur conditions of Maharashtra-A preliminary study. *Acta Horticulturae*, **890**: 221-26.

Bajpai, A., Singh, A.K. and Ravishankar, H. 2012. Reproductive phenology, flower biology and pollination in jamun (*Syzygium cuminii* L.). *Indian Journal of Horticulture*, **69**(3): 416-419.

Bajpai, M., Pande, A., Tewari S.K. and Prakash, D. 2005. Phenolic contents and antioxidant activity of some food and medicinal plants. *International Journal of Food Science Nutrition*, **56**: 287-291.

Bajpai, P.N. and Chaturvedi, O.P. 1985. Fruits of India: Tropical and Subtropical. Naya Prokash Publishers, Calcutta. 586 p.

Bakshi, P., Kumar, R., Jasrotia, A. and Sharma, A. 2013. Variability in physico-chemical and sensory attributes of mango genotypes under rainfed conditions of Shivalik Foothills of Himalayas. *Asian Journal of Horticulture*, **8**(1): 39-42.

Baliga, M.S., Bhat, H.P., Baliga, B.R.V., Wilson, R. and Palatty, P.L. 2011. Phytochemistry, traditional uses and pharmacology of *Eugenia jambolana* Lam. (black plum): A review. *Food Research International*, **44**: 1776-1789.

Banerjee, A., Dasgupta, N. and De, B. 2005. *In vitro* study of antioxidant activity of *Syzygium cuminii* fruit. *Food Chemistry*, **90**: 727-733.

Banerjee, J. and Narendhirakannan, R.T. 2011. Phytochemical analysis, antibacterial, *in vitro* antioxidant and cytotoxic activities of ethanolic extract of *Syzygium cuminii* (L.) seed extract. *International Journal of Pharmaceutical Sciences Research*, **2**: 1799-1806.

Barua, U. and Shanna, R.K. 2004. Correlation and path analysis studies in apple. *Indian Journal of Horticulture*, **61**(1): 18-23.

Basak, S.L. 2003. Nutritional and medicinal values of plant foods. Naya Udyog, Kolkata. 260p.

Benherlal, P.S. and Arumughan, C. 2007. Chemical composition and *in vitro* antioxidant studies on *Syzygium cuminii* fruit. *Journal of Science of Food and Agriculture*, **87**: 2560-2569.

Bhardwaj, R. and Yamdagni, R. 2005. Physico-chemical characteristics of jamun (*Syzygium cuminii* Skeels). *Haryana Journal of Horticultural Sciences*, **34**(2): 54-59.

Bhatia, I.S. and Bajaj, K.L. 1975. Chemical constituents of the seeds and bark of *Syzygium cuminii*. *Planta Medicinals*, **28**: 347-352.

Bhuyan, M.A.J. and Kobra, K. 2007. Fruit characteristics of some uncommon mango varieties grown under Joydebpur condition. *Bangladesh Journal of Agriculture Research*, **32**(3): 493-500.

Bunyard, E.A. 1927. Flower of apple as an aid in identifying varieties. *Journal of Royal Horticulture Society*, **38**: 234-237.

Chandrasekhar, J. and Raghavarao, K.S.M.S. 2014. Separation and concentration of anthocyanins from jamun: *Chemical Engineering Communications. An Integrated Process. Publisher: Taylor and Francis.* CFTRI, Mysore, India, **202**(10): 1368-1379.

Chaudhary, B. and Mukhopadhyay, K. 2012. *Syzygium cuminii* Skeels: A potential source of nutraceuticals. *International Journal of Pharmaceutical Biological and Chemical Sciences*, **2**: 46-53.

Chouhan, P.S. and Dhaliwal, G.S. 1993. Studies on variation in the total soluble solids, acidity and sugars of fruit of open pollinated seedlings of guava. *Haryana Journal of Horticultural Sciences*, **22**(1): 13-16.

Chundawat, B.S. 1990. Arid fruit culture. Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi.

Daware, S.G., Chakrawar, V.R. and Borkar, S.T. 1985. Variability and correlation studies in jamun. *The Punjab Horticultural Journal*, **25**(1-4): 89-93.

de Souza, V.R., Pereira, P.A.P., da Silva, T.L.T., de Oliveira Lima, L.C., Pio, R. and Queiroz, F. 2014. Determination of the bioactive compounds, antioxidant activity and chemical composition of brazilian blackberry, red raspberry, strawberry, blueberry and sweet cherry fruits. *Food Chemistry*, **156**: 362-368.

Devi, C.A., Swamy, G.S.K. and Naik, N. 2016. Studies on flowering and fruit characters of jamun genotypes (*Syzygium cuminii* Skeels). *Biosciences Biotechnology Research Asia*, **13**(4): 2085-2088.

Devi, P.S., Thangam, M., Desai, A.R. and Adsule, P.G. 2002. Studies on variability in physico-chemical characters of different jamun (*Syzygium cuminii* Skeels) accessions from Goa. *Indian Journal of Horticulture*, **59**: 153-56.

Dhaware, 1981. Survey for selection of superior jamun and ber strains in Marathwada region. M.Sc. (Agri.) Thesis, MAU, Parbhani.

Dhillon, B.S. and Gill, B.S.2013. Effect of climate on vegetative, flowering and fruiting behaviour of hard pear (*Pyrus pyrifolia*) under Amritsar conditions. *Asian Journal of Horticulture*, **8**(1): 88-92.

El-Sisy, 2013. Evaluation of some genotypes of guava trees grown under alexandria governorate condition vegetative growth, flowering and fruit quality. *World Applied Sciences Journal*, **28**(4): 583-595.

Escribano-Bailon, M.T., Santos-Buelga, C., Alonso, G.L. and Salinas, M.R. 2002. Anthocyanin composition of the fruit of *Coriaria myrtifolia* L. *Phytochemical Analysis*, **13**: 354-357.

Faria, A.F., Marques, M.C. and Mercadante, A.Z. 2011. Identification of bioactive compounds from jamun (*Syzygium cuminii*) and antioxidant capacity evaluation in different pH conditions. *Food Chemistry*, **126**: 1571-1578.

Ganesh, T. 1990. Fruiting patterns among canopy trees and fruit use by vertebrates in a wet evergreen forest of Western Ghats, India. Ph.D. Dissertation, Pondicherry University, Pondicherry, India. p143-149.

Garanade, V.K., Joshi, G.D., Magdum, M.B. and Waskar, D.P. 1998b. Studies on physical changes during growth and development of jamun (*Syzygium cuminii* Skeels) fruit. *Agricultural Science Digest*, **18:** 206-208.

Garande, V.K., Joshi, G.D. and Wasker, D.P. 1998a. Studies of changes in chemical composition during growth and development of jamun (*Syzygium cuminii* Skeels) fruit. *Orissa Journal of Horticulture*, **26**(1): 76-78.

Garande. V.K. and Joshi. G.D. 1997. Changes in chemical composition during growth and development of jamun (*Syzygium cuminii* Skeels) fruits. *South Indian Journal of Horticulture*, **45**: 156-157.

Garnayak, D.K., Pradhan, R.C., Naik, S.N. and Bhatnagar, N. 2008. Moisture dependent physical properties of jatropha seed (*Jatropha curcas* L.*). Indian Crops Production,* **27**: 123-129.

Geetha, C.K., Babylatha, A.K., Mathew, K.L. and George, S.T. 1992. Fruit development in jamun (*Syzygium cuminii* Skeels). *South Indian Horticulture*, **40**(6): 350-351.

Ghojage, A.H., Swamy, G.S.K., Kanamadi, V.C., Jagdeesh, R.C., Kumar, P., Patil, C.P. and Reddy, B.S. 2011. Studies on variability among best selected genotypes of jamun (*Syzygium cuminii* Skeels). *Acta Horticulturae*, **890**: 255-260.

Ghosh, P., Pradhan, R.C., Mishra, S., Patel, A.S. and Kar, A. 2017. Physico-chemical and nutritional characterization of jamun (*Syzygium cuminii*). *Current Research in Nutrition and Food Science Journal*, **5**(1): 25- 35.

Ghosh, S. 1960. The content of folie acid and its conjugates in some common Indian fruits. *Science and Culture*, **26**: 287-289.

Ghosh, S.N., Mitra, S.K., Banik, B.C., Hasan, M.A., Sarkar, S.K., Dhua, R.S., Kabir, J. and Hore, J.K. 2006. Proceedings of national symposium on production, utilization and export of underutilized fruits with commercial potentialities. Bibhan Chandra Krishi Viswa Vidyalaya, West Bengal, pp. 266-270.

Gowri, S.S. and Vasantha, K. 2010. Phytochemical screening and antibacterial activity of *Syzygium cuminii* (Myrtaceae) leaves extracts. *International Journal of Pharm Tech Research*, **2**: 1569-157.

Goyal, P.K., Verma, P., Sharma, P., Parmar, J. and Agarwal, A. 2010. Evaluation of anti-cancer and anti-oxidative potential of *Syzygium cuminii* against benzopyrene induced gastric carcinogenesis in mice. *Asian Pacific Journal of Cancer Prevention*, **11**: 753-758.

Grotewold, E. 2006. The genetics and biochemistry of floral pigments. *Annual Review of Plant Biology*, **57**: 761-780.

Hanamura, T., Hagiwara, T. and Kawagishi, H. 2005. Structural and functional characterization of polyphenols isolated from acerola fruit. *Journal of Bioscience, Biotechnology and Biochemistry*, **69**: 280-286.

Hareesh, T.S., Sathish, B.N., Tambat, B. and Vasudeva, R. 2012. Variation for fruit, seed and seedling growth attributes among purple and white types in *Syzygium cuminii*. An important

tropical wild edible fruit species of the Indian sub-continent. *International Journal of Forest Usufructs Management*, **13**(2): 26-32.

Hasan, S.M.R., Hossain, M.M., Akter, R., Jamila, M., Mazumder, M.E.H. and Rahman, M.E.H. 2009. DPPH free radical scavenging activity of some Bangladeshi medicinal plants. *Journal of Medicinal Plant Research*, **3**: 875-879.

Hedrick U.P. 1925. Systematic Pomology. Macmillan Company of New York.

Inamdar, S., Swamy, G.S.K., Patil, P.B. and Athani, S.I. 2002. Correlation and path analysis studies in jamun (*Syzygium cuminii* Skeels) for fruit characters. *Journal of Maharashtra Agricultural Universities*, **27**(2): 212-213.

Irulappan and Anbu, S. 1994. Trees and Tree Fanning. Edited by Thampan, P.K., Peekay Tree Crops Development Foundation Cochin, Kerala, pp. 219-223.

Islam, M.A. and Hoque, M.A. 1991.Variabilities of custard apple fruits in Bangladesh. *Bangladesh Journal of Agriculture Research*, **16**(l): 84-86.

Ivan, A.R. 2006. Medicinal plant of world: chemical constituents, traditional uses and modern medicinal uses, Human Press Totowa, New Jersey, pp 283-289.

Jadahv, A.S. 1989. Survey for selection of superior type of local mango (*Mangifera indica* L.) in Bhokar taluka of Nanded district, M.Sc. (Agri.) Thesis, MAU, Parbhani.

Jadon, U.S., Nema, B.K., Sharma, H.L., Pandey, S.K. and Srivastava, S.R. 1999. Correlation and regression analysis in jamun (*Syzygium cuminii* Skeels). *Journal of Tropical Forest*, **15**(1): 71-75.

Jagetia, G.C. and Baliga, M.S. 2004. The evaluation of nitric oxide scavenging activity of certain Indian medicinal plants *in vitro* a preliminary study. *Journal of Medicinal Food*, **7**: 343-348.

Jain, M.C. and Seshadri, T.R. 1975. Anthocyanins of *Eugenia jambolana* fruits. *Indian Journal of Chemistry*, **3**: 20-23.

Jaiswal, S.G., Patel, M. and Naik, S.N. 2015. Physico-chemical properties of *Syzygium cuminii* Skeels, jam and comparative antioxidant study with other fruit jams. *Indian Journal of Natural Products Resource*, **6**(1): 9-15.

Jampani, C., Naik, A. and Raghavarao K.S.M.S. 2014. Purification of anthocyanins from jamun (*Syzygium cuminii* L.) employing adsorption. *Separation and Purification Technology*, **125**: 170-178.

Jondhale, P.G. 1989. Survey of selection of superior of superior types of mango (*Mangifera indica* L.) in Kandhar Taluka of Nanded district. M.Sc. (Agri.) Thesis, MAU, Parbhani.

Jyothi, M., Mandayam, S., Narayana, P., Laxmanb, M. and Neelwarnea, B. 2007. Chemical nature, stability and bioefficacies of anthocyanins from fruit peel of *Syzygium cuminii* Skeels. *Food Chemistry*, **105**: 619-27.

Kanma, K., Abhay, M. and Singh, J. 2004. Physico-chemicaI characteristics of some litchi cultivars of Bihar. *Progress Horticulture*, **36**(l): 22-25.

Kapoor, S. and Ranote, P.S. 2015. Antioxidant potentials and quality of blended pear jamun (*Syzygium cuminii*) juice. *International Research Journal of Biological Science*, **4**(4): 30-37.

Keskar, B.G., Karale, A.R., Dhawale, B.C. and Chaudhary, K.G. 1989. Improvement of jamun by selection. *Maharashtra Journal of Horticulture*, **4**: 117-20.

Keskar, B.G., Karale, A.R., Dhawale, B.C. and Chaudhary, K.G. 2010. Improvement of jamun (*Syzygium cuminii* Skeels). *Maharashtra Journal of Horticulture*, **4**: 117-20.

Kheaw, N., Chaisuksant, R. and Suntornwat, O. 2009. Antioxidant capacity of flesh and seed from *Syzygium cuminii* fruits. *Acta Horticulturae*, **837**: 73-77.

Khuridiya, D.S. and Roy, S.K. 1985. Processing of jamun (*Syzygium cuminii*) fruits into ready to serve beverage. *Journal of Education Science and Technology*, **22**(1): 217-220.

Koley, T.K., Kalyan, B. and Asrey, R. 2011. Neutraceutical properties of jamun and its products. *Indian Food Industry*, **30**(3): 43-46.

Koley, T.K., Kaur, C., Nagal, S., Walia, S. and Jaggi, S. 2016. Antioxidant activity and phenolic content in genotypes of indian jujube (*Zizyphus mauritiana* Lamk.). *Arabian Journal of Chemistry*, **9**: 1044-1052.

Kologi, S.D., Sulikere, G.S. and Nagraj, A.P. 1977. Chrompet-Madras selection of cashewnut is promising. *Current Research*, **12**: 201-202.

Kshirsagar, R. and Upadhyay, S. 2009. Free radical scavenging activity screening of medicinal plants from Tripura. *Natural Product Radiance*, **8**: 117-122.

Kumar, A., Ilavarasan, R., Jayachandran, T., Deecaraman, M., Aravindhan, P., Padmanabhan, N. and Krishan, M.R.V. 2008. Anti-diabetic activity of *Syzygium cuminii* and its isolated compound against streptozotocin induced diabetic rats. *Journal of Medicinal Plant Research*, **2**: 246-249.

Kumar, R., Syamal, M.M., Dwivedi, S.V. and Anand, R.K. 2013. Studies on variability in physico-chemical properties of aonla (*Emblica officinalis*) genotypes. *Asian Journal of Horticulture*, **8**: 706-708.

Kumar, S., Singh, I.S. and Ashraf, S.M. 1993**.** Improvement of jamun (*Syzygium cuminii* Skeels) through selection. *Haryana Journal of Horticulture Science*, **22**(1): 17-21.

Kundu, S. Ghosh, D.K. and Maiti, S.C. 2001. Evaluation of some local types of jamun (*Syzygium cuminii* Skeels) of West Bengal. *Enviroment Eco*cology, **19**: 872-74.

Kusumoto, I.T., Makabayashi, T., Kida, H., Miyashiro, H., Hattori, M., Namba, I. and Shimotohno, K. 1995. Screening of various plant extracts used in ayurvedic medicine for inhibiting effects on human immune deficiency virus type 1 (HIV) protease. *Phytotherapy Research*, **9**(3): 180-184.

Lane, J.H. and Eynon, J. 1923. Determination of reducing and total sugars by Fehling's solution with methylene blue as indicator. *Journal of Chemical Society*, **42**: 32-37.

Leelavinothan, P. and Saravanan, G. 2006. Effects of *Syzygium cuminii* bark on blood glucose, plasma insulin and C-peptide in streptozotocin induced diabetic rats. *International Journal of Endocrinology and Metabolism*, **4**: 96-105.

Lewis, Y.S., Dwarakanath, C.T. and Johar, D.S. 1956. Acids and sugars in *Eugenia jambolana. Journal of Science and Industrial Research*, **15C**: 280-281.

Lichtenthaler, R., Rodrigues, R.B., Maia, J.G., Papagiannopoulos, M., Fabricius, H. and Marx, F. 2005**.** Total oxidant scavenging capacities of *Euterpeoleracea* Mart. (Acai) fruits. *International Journal of Food science and Nutrition*, **56**: 53-64.

Loganayaki, N. and Manian, S. 2010. *In vitro* antioxidant properties of indigenous underutilized fruits. *Food Science Biotechnology*, **19**: 725-734.

Mahmoud, H.H. and Peter, T.S. 2014. Physical screening in fruits of guava (*Psidium guajava* L.). *Journal of Emerging Trends in Engineering and Applied Sciences*, **5**(2): 135-144.

Mahmoud, II, Marzouk, M.S., Moharram, F.A., El-Gindi, M.R. and Hassan, A.M. 2001. Acylated flavonol glycosides from *Eugenia jambolana* leaves. *Phytochemistry*, **58**: 1239-1244.

Manveen, K. and Bal, J.S. 2015. An evaluation of jamun (*Syzygium cuminii*) germplasm for conservation of elite ones. *Hort Flora Research Spectrum*, **4**(4): 342-346.

Mazumdar, B.C. and Majumder, K. 2003. Method on physico-chemical analysis of fruit, university college of agricultural Calcutta university, **8**(8): 108-109.

Miller, G.L. 1959. Use of dinitrosalioylic acid reagent for the determination of reducing sugar. *Analytical Chemistry*, **31**: 426-428.

Mishra, R.S. and Bajpai P.N. 1984. Studies on pollination, fruit set and fruit development in jamun (*Syzygium cuminii* Skeel). *Progressive Horticulture*, **16**(1-2): 1-5.

Misra, R.S. and Bajpai, P.N. 1975. Studies on floral biology of jamun (*Syzygium cuminii* Skeels). *Indian Journal of Horticulture*, **32**(2): 15-24.

Modi, D.C., Patel, J.K., Shah, B.N. and Nayak, B.S. 2010. Anti-inflammatory activity of seeds of *Syzygium cuminii*. *Journal of Pharmacy Education Research*, **1**: 68-70.

Morton, J. 1987. Jamun (*Syzygium cuminii* Skeels), fruits of warm climates. Miami, USA: Purdue University, pp 375-378.

Munde, V.M. 2001. Survey for selection of superior charoli (*Buchanania lanzan*) types in Aurangabad and Beed district of Marathwada region. M.Sc. (Agri.) Thesis, MAU, Parbhani.

Naikwade, M.M., Shinde, G.S. and Patil, V.K. 1989. Selection of promising types of markingnut in Marathwada region. *Journal of Maharashtra Agriculture Universities*, **14**(1): 118-119.

Nawaz, M.S., Sheik. S.A., Nizamani, S.N., Bhanger, M.I. and Afridi, I. 2010. Determination of mineral elements in jamun fruit (*Eugenia jambolana*) products. *Pakistan Journal of Food Science*, **20**(1-4): 1-7.

Noomrio, M.H. and Dahot M.U. 1996. Nutritive value of *Eugenia jumbos* fruit. *Journal of Islamic Academy Science*, **9**: 9-12.

Panse and Sukhatme, P.V. 1989. Statistical methods for agricultural workers. *Indian Council of Agricultural Research*, New Delhi, pp. 205-214.

Pareek, S., Mukherjee, S. and Paliwal, R. 2007. Floral biology of ber-A review. *Agricultural Research Communications Centre India*, **28**(4): 277.

Parida, G.N. and Rao, D.P. 1988. Classification and selection of some elite mangoes in Orissa. *Acta Horticulturae*, **231**: 89-92.

Patel, D.A., Patel, H.C., Sarvaiya, S.N. and Masu, M.M. 2010. Studies on physicochemical status of different genotypes and hybrids of Aonla. *Asian Journal of Horticulture*, **4**(2): 461-463.

Patel, V.B., Pandey, S.N., Singh, S.K. and Das, B. 2005. Variability in jamun (*Syzygium cuminii* Skeels) accessions from Uttar Pradesh and Jharkhand. *Indian Journal of Horticulture*, **62**: 244-247.

Pathak, P.K. and Chakraborty, I. 2006. Studies on physic-chemical characters of some potential underutilized tropical fruits. Proceedings of national symposium on production, utilization and export of underutilized fruits with commercial potentialities, Bibhan Chandra Krishi Viswavidyalaya, Kalyani, Nadia, West Bengal, **8**(8): 271-274.

Plathia, M., Wali, V.K., Bakshi, P. and Sharma, N. 2018. Studies on variability of seedling origin jamun (*Syzygium cuminii* Skeels) germplasm growing in subtropical region of Jammu, India. *International Journal of Current Microbiology and Applied Sci*ences, **7**(2): 3363-3368.

Prabhuraj, H.S. 2001. Evaluation of jamun seedling progenies and standardization of softwood grafting. M.Sc. (Hort.) Thesis, University of Agricultural Sciences, Dharwad (India).

Prabhuraj, H.S., Athani, S.I., Patil, B.R., Swamy, G.S.K. and Patil, P.B. 2003. Description of promising jamun (*Syzygium cuminii* Skeels) strains. *My Fores*t, **39**: 39-42.

Prabhuraj, S., Swamy, G.S.K., Athani, S.I., Patil, B.R., Hulamani, N.C. and Patil, P.B. 2002. Variability in morphological characteristics of jamun (*Syzygium cuminii* Skeels) trees. *My Forest*, **38**(2): 187-190.

Prakash, J. and Singh, S.P. 2007. Mode of pollination, fruit set and fruit drop in jamun (*Syzygium cuminii* Skeels). *Environment and Ecology*, **25**(4): 1151-1154.

Prakash, J., Maurya, A.N. and Singh, S.P. 2010. Studies on variability in fruit characters of jamun. *Indian Journal of Horticulture*, **67**(2): 63.

Prince, P.S., Menon, V.P. and Pari, L. 1998. Hypoglycaemic activity of *Syzygium cuminii* seeds: effect on lipid peroxidation in alloxandiabeticrats. *Journal of Ethanopharmacology*, **61**(1): 1-7.

Priya Devi, S., Thangam, M., Desai, A.R. and Adsule, P.G. 2002. Studies on variability in physico-chemical characters of different jamun (*Syzygium cuminii*) accessions from Goa. *Indian Journal of Horticulture*, **59**(2): 153- 156.

Rahman, S.M.L., Bhuyan, M.H.M.B., Mustakim, A.A.M.M., Sarker, J.C. and Ahmed, R.N. 2014. Fruit characteristics, yield contributing characters and yield of twenty one mango genotypes under north eastern hilly region of Bangladesh. *International Journal of Experimental Agriculture*, **4**(2): 1-4.

Rakesh, L. and Shivanna. H. 2015. Variation in important traits of jamun (*Syzygium cuminii* Skeels). *Karnataka Journal of Agricultural Sciences*, **28**(1): 120-122.

Ram, K., Syamal, M.M., Dwivedi, S.V. and Anand, R.K. 2013. Studies on variability in physico-chemical properties of aonla (*Emblica officinalis* Gaertn) genotypes. *Asian Journal of Horticulture*, **8**(2): 706-708.

Reynertson, K.A., Basile, M.J. and Kennelly, E.J. 2005. Antioxidant potential of seven Myrtaceous fruits. *Ethnobotanical Research Application*, **3**: 25-35.

Roy, G., Malla, S. and Chakravarty, S. 2013. Integrated processing of jamun (*Syzygium cuminii* Skeels) fruit for value addition and assessment of its impact on health and nutrition. *Clin Diagn Lab Immunol*, **21**: 65-69.

Roy, S.K., Pal, R.K. and Ramanjaneya, K.H. 1999. Jamun potential fruit for processing. *Indian Journal of Horticulture*, **44**(2): 9-10.

Ruan, Z.P., Zhang, L.L. and Lin, Y.M. 2008. Evaluation of the antioxidant activity of *Syzygium cuminii* leaves. *Molecules*, **13**: 2545-2556.

Sagrawat H., Mann A.S. and Kharya M.D. 2006. Pharmacological potential of *Eugenia jambolana*: A review. *Pharmacognosy Magazine*, **2**: 96-105.

Schauss, A.G., Wu, X., Prior, R.L., Ou, B., Patel, D., Huang, D. and Kababick, J.P. 2006. Phytochemical and nutrient composition of the freeze-dried amazonian palm berry. *Journal of Agricultural and Food Chemistry*, **54**: 8598-8603.

Sehwag, S. and Das, M. 2014. Nutritive, therapeutic and processing aspects of jamun (*Syzygium cuminii* Skeels)-An overview. *Indian Journal of Natural Products and Resources*, **5**(4): 295-307.

Shahnawaz, M. and Sheikh, S.A. 2011. Physicochemical characteristics of jamun fruit. *Journal of Horticulture and Forestry*, **3**(10): 301-306.

Shahnawaz, M., Sheikh, S.A. and Nizamani, S.M. 2009. Determination of nutritive values of jamun fruit (*Eugenia jambolana*) products. *Pakistan Journal of Nutrition*, **8**: 1275-1280.

Shahnawaz, M., Sheikh, S.A., Bhangar, M.I. and Ahmed, E. 2010. Total phenolic compounds and antioxidant activity of jamun fruit (*Eugenia jambolana*) products. *Pakistan Journal of Food Science*, **20**: 31-41.

Sham Singh, Krishnamurthi, S. and Katyal, S.L. 1967. Fruit culture in India (revised edition), *Indian Council of Agricultural Research*, New Delhi.

Sharma, G. and Sharma, N. 2011. Pollen characteristics, pollination behaviour and pollinizer compatibility of some exotic and indigenous almond genotypes. *Advances in Horticultural Science*, **25**(1): 3-13.

Sharma, J.N. and Sheshadri, T.R. 1955. Survey of anthocyanins from Indian sources part II. *Journal of Science Indian Res*earch, **14**: 211-214.

Sharma, M., Gehlot, R., Singh, R. and Siddiqui, S. 2009. Studies on physico-chemical composition fresh guava and jamun fruits. *Haryana Journal of Horticultural Sciences*, **38**(2): 68-69.

Shinde, Y.S. 1984. Survey for selection of superior types of custard apples (*Annona squamosa* L.) in Marathwada region. M.Sc. (Agri.) Thesis, MAU, Parbhani.

Shrikanta, A., Kumar, A. and Govindaswamy, V. 2015. Resveratrol content and antioxidant properties of underutilized fruits. *Journal of Food Science and Technology*, **52**(1): 383-390.

Shukla, A.K., Singh, D., Meena S.R. and Dhandar, D.G. 2006. Survey and collection of aonla germplasm from Eastern Uttar Pradesh. *Indian Journal of Arid Horticulture*, **1**(l): 69-70.

Siddig., Abdelgadir, A.E., Elbadawi, A.A., Mustafa, E.M. and Mussa, A.A. 2015. Structural characterization and physical properties of *Syzygium cuminii* Flowering Plant. *International Journal of Innovative Research in Science, Engineering and Technology*, **4**: 2694-2699.

Silva, D.H.S., Plaza, C.V., Bolzani, V.S. and Cavalheiro, A.J. 2006. Antioxidants from fruits and leaves of *Eugenia jambolana*, an edible myrtaceae species from Atlantic forest. *Plant Medicine*, **72**: 1038.

Singh, A.K., Bajpai, A. and Ravishankar. 2009. National network project on underutilized fruits. Annual progress report, Central Institute for Subtropical Horticulture, Lucknow. *Indian Journal of Plant Genetics Resources*, **25**(2): 197-221.

Singh, A.K., Bajpai, A., Singh, A., Singh, A. and Reddy, B.M.C. 2007. Evaluation of variability in jamun (*Syzygium cuminii* L.) using morphological and physico-chemical characterization. *Indian Journal of Agricultural Science*, **77**(12): 845-848.

Singh, I.S. 2001. Minor fruits and their uses. *Indian Journal of Horticulture*, **58**(1- 2): 178-182.

Singh, I.S., Srivastava, A.K. and Singh, V. 1999. Improvement of some under-utilized fruits through selection. *Indian Journal of Applied Horticulture*, **1**(1): 34-37.

Singh, S. and Singh, A.K. 2012. Studies on variability in jamun (*Syzygium cuminii* Skeels) from Gujarat. *Asian Journal of Horticulture*, **7**(1): 186-189.

Singh, S., Krishnamurthy, S. and Katyal, S.L. 1967. Fruit culture in India, ICAR, New Delhi, **9**: 255.

Singh, V., Singh H.K. and Singh, I.S. 2004. Evaluation of aonla varieties (*Emblica officinalis*) for fruit processing. *Haryana Journal of Horticulture Science*, **33**(1&2): 18-20.

Solomon, R., Radhakrishna, J. and Hareesh, C. 2014. Reproductive ecology of *Syzygium alternifolium* (Myrtaceae), an endemic and endangered tropical tree species in the southern eastern ghats of India. *Journal of Threatened Taxa*, **6**(9): 6153-6171.

Soncharan, P., Shanmugarajan, T.S., Somasundaram, N.M. and Niladri, M. 2010. Protective effect of *Syzygium cuminii* seeds against doxorubicin induced cardiotoxicity in rats. *International Journal Pharmacy Life Science*, **6**: 343- 349.

Srimathi, P., Saasthri, G. and Venkataslam, E.P. 2010. Effect of fruit colour on fruit, seed and seedling quality characters in jamun. *Progressive Horticulture*, **33**(1): 27-31.

Srivastava, V., Kumar, P. and Rai, P.N. 2012. Correlation study for physico-chemical characters in Jamun. *HortFlora Research Spectrum*, **1**(1): 83-85.

Srivastava, V., Rai, P.N. and Kumar, P. 2010. Studies on variability in physicochemical characters of different accession of jamun (*Syzygium cuminii* Skeels). *Pantnagar Journal of Research*, **8**(1): 139-142.

Stephen, A. 2012. *Syzygium cuminii* Skeels: A multipurpose tree, its phytotherapic and pharmacological uses. *Journal of Phytotherapy and Pharmacology*, **1**(4): 22-32.

Subramaniyan, S., Parvathi, S. and Anbu, S. 1989. Jamun the delidious fruit. Kisan World.

Suradkar, N.G., Pawar, V.S. and Shere, D.M. 2017. Physicochemical, proximate and bioactive composition of jamun (*Syzygium cuminii*) fruit. *International Journal of Chemistry Studies*, **5**(3): 470-472.

Swami, S.B., Thakor, N.J. and Haldankar, P.M. 2012. Jamun (*Syzygium cuminii*): A review of its food and medicinal uses. *Food Science and Nutrition*, **3**: 100-111.

Tarai, R. K., Kundu, S., Ghosh, B. and Mitra, S. 2006. In proceedings of the national symposium on production, utilization and export of underutilized fruits with commercial potentialities, Kalyani, Nadia and West Bengal, India. pp. 79-82.

Tarai, R.K., Kundu, S. and Ghosh, B. 2005. Quality studies of some minor fruits of West Bengal. *Environment and Ecology*, **23**(4): 711-713.

Vaishnava, M.M., Tripathy, A.K. and Gupta, K.R. 1992. Flavonoid glycosides from roots of *Eugenia jambolana. Fitoterapia*, **63**: 259-260.

Van-Acker, S.A., Tromp, M.N., Griffioen, D.H., Van Bennekom, W.P., Van Der Vijgh, W.J. and Bast, A. 1996. Structural aspects of antioxidant activity of flavonoids. *Free Radical Biology and Medicine*, **20**(3): 331-342.

Vanangamudi, K., Venkatesh, A., Balaji, B., Vanangamudi, M. and Rai, R.S.V. 2000. Prediction of seed storability in neem (*Azadirachta indica*) and jamun (*Syzygium cuminii*) through accelerated ageing test. *Journal of Tropical for Science*, **12**(2): 270-275.

Vasi, S. and Austin, A. 2009. Antioxidant potential of *Eugenia jambolana* seeds. *Journal of Biological Science*, **9**(8): 894-898.

Veigas, J., Narayan, M., Laxman, P. and Neelwarne, B. 2007. Chemical nature, stability and bioefficacies of anthocyanins from fruit peel of *Syzygium cuminii* Skeels. *Food Chemistry*, **105**: 619-627.

Venkateswarlu, G. 1952. On the nature of the colouring matter of the jambul fruit (*Eugenia jambolana*). *Journal of Indian Chemistry Society*, **29**(6): 434-437.

Verma, A.N. and Ghosh, S.P. 1979. North Eastern hills-Citrus germplasm collection and evaluation. *Indian Horticulture*, **24**(3): 2-4.

Wu, X., Beecher, G.R., Holden, J.M., Haytowitz, D.B., Gebhardt, S.E. and Prior, R.L. 2006. Concentrations of anthocyanins in common foods in the United States and estimation of normal consumption. *Journal of Agricultural and Food Chemistry*, **54**: 4069-4075

Zhang, L.L. and Lin, Y.M. 2009. Antioxidant tannins from *Syzygium cuminii* fruit. *African Journal of Biotecnology*, **8**: 2301-2309.

Zhishen, J., Mengcheng, T. and Jianming, W. 1999. The determination of flavonoid contents in mulberry and their scavenging effects on superoxide radicals. *Food Chemistry*, **64**(4): 555-559.