QUALITY EVALUATION OF CASHEW APPLE OF HIGH YIELDING VARIETIES

By
VILASACHANDRAN, T.

THESIS

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DECLARATION

I hereby declare that this thesis entitled "Quality evaluation of cashew apple of high yielding varieties" is a bonafide record of research work done by me during the course of research work and the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title of any other University or Society.

Vellanikkara,
1st August, 1978

Vilasachandran, T.

CERTIFICATE

Certified that this thesis is a record of research work done independently by Sri. Vilasachandran, T. under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to him.

31/8/78

Prof. V.K. Damodaran
PROFESSOR
DEPARTMENT OF HORTICULTURE
(Processing Technology)

Vellanikkara,
31st August, 1978.

CERTIFICATE

We, the undersigned members of the advisory committee of Sri. Vilasachandran, T. a candidate for the degree of Master of Science in Horticulture with major in Horticulture agree that the thesis entitled "Quality evaluation of cashew apple of high yielding varieties" may be submitted by Sri.Vilasachandran, T. in partial fulfilment of the requirement for the degree.

31/8/78

(PROF.V.K.DAMODARAN)
ADVISOR AND CHAIRMAN

(DR.P.[illegible] NAIR)
MEMBER

(DR.A.I.JOSE)
MEMBER

(SRI.P.V.PRABHAKARAN)
MEMBER

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(Vilasachandran, T.)

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INTRODUCTION

I N T R O D U C T I O N

Cashew growing and cashewnut processing are very important in the economy of our country. A native of Brazil, which was introduced into India in the sixteenth century, it has established itself in the southern states, particularly on the western and eastern coasts. Cashew is grown mostly on the poorest soils where no other crop can be profitably grown. Until recently, India had almost a monopoly of cashewnut marketting in the world trade. The export of cashewnut and cashew shell liquid fetches over 100 crores of rupees in our export trade. Cashewnut processing industry which is concentrated in Kerala gives direct employment to about 1.5 lakh persons. The collection of nut, transport and connected ancillary works provide part-time employment to a large number of persons. According to the latest statistics available for the year 1975-76 the area under cashew in Kerala, is estimated to be 1,05,940 hectares and the production of rawnuts was estimated as 1,18,870 metric tonnes. For the working of the cashewnut processing factories of Kerala throughout the year, it is estimated that about 4.5 lakhs tonnes of rawnuts are required. Since the internal production is far below the requirements,

a major part of the requirements are being met by importing raw nuts from African countries. During the year 1977 a total quantity of 64,379 metric tonnes of raw nuts were imported for the processing industry. In recent years, it has become more and more difficult to import raw nuts from other countries because large mechanical processing plants have been set up in those countries. Therefore, there is urgent need to increase our raw nut production substantially in the next few years, if this vital industry is to survive.

Inspite of its importance in the agricultural industrial and commercial economy of our state, little attention is paid by growers in its culture and management. In fact, cashew is not considered as a crop requiring proper management for effective crop production. Apart from sowing some seeds in the most casual manner, no attention is paid in its culture except for the collection of nuts, when the trees begin to yield. None of the management practices like manuring, intercultivation, pest and disease control are done in cashew gardens. As a result of this, the productivity of cashew at present is extremely poor and the income from cashew is very low.

The cashew apple which is actually the swollen peduncle is practically wasted in our state. On the basis of the raw nut produced in our state the potential for cashew apple production is atleast 6 lakhs tonnes. This huge quantity of apple is practically wasted at present. The heavy loss which the country is incurring on account of the wastage of the cashew apple has been estimated to be of the order of Rs. 20 crores in 1962. With the increased production of cashewnut envisaged in our planning programme, the production of cashew apple also has increased considerably. Almost all cashew producing countries like Brazil, Malayasia and some of the African countries are utilising the cashew apple for the production of liquors and other fruit products. In our country, Goa which has substantial area under cashew is fully utilising the apple production for the manufacture of a liquor called 'Feni'. Studies in research centres have shown that a number of fruit products like jam, jelly and soft drinks like cashew apple juice, cashew apple cordial, cashew squash etc. can be prepared from cashew apples. Cashew apple juice is a rich source of vitamin C and it also contains 10-12% sugar. However the presence of an astringent principle in the cashew

apple juice makes it unacceptable for consumption as such. Methods of removing this astringent principle have been developed in the research centres. But inspite of all this, the utilisation of this valuable by-product has not reached any significant level. Only 15 per cent of total output of cashew apple is utilised at present, in the whole of India. Perhaps the best method of utilising the cashew apple will be the evolution of varieties which produce apple of high quality and devoid of the astringent principle. It has been found that there is considerable variation in the quality of cashew apple which offers scope for selecting varieties which are capable of producing superior quality apples that can be used for consumption as raw fruit or as a processed product without any astringent taste.

The income from cashew growing is very low and that is the reason why little attention is paid by the growers in the management of the crop. Effective measures of utilisation of cashew apples will increase the income from this crop and it will be the best incentive for increasing the production of cashewnut in the state.

Since the cashew apples are not utilised to any significant extent in our state, no attention was paid so far in identifying varieties which produce superior quality apples. In the light of the immense possibility of utilising the cashew apple, a study of the quality of apples obtained from the sixteen varieties now put under comparative yield trial under the All India Co-ordinated Cashew Improvement Project was undertaken during the bearing seasons of 1976-77 and 1977-78. The morphological characters as well as the chemical composition of apples and the residue left after the extraction of the juice were studied. The variability in quality factors of apple between the sixteen varieties as well as between seedling progenies of the same variety were studied in detail. The results of these studies are presented in the following sections.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

The cashew apple which is a false fruit botanically is practically wasted at present, in India. Very little research work has been done on the production and processing of cashewnut and its by products and the same is much more true with regard to its apple. However, these problems have attracted the attention of a number of workers in India and abroad. The work done on various aspects of cashew apple is briefly summarised in the following pages.

Availability of cashew apple

Precise statistics of the production and utilisation of cashew apple in India are not available. However, the proportion of the apple to the whole fruit and the total weight of nuts produced have been estimated by different workers Anon (1941), Jain *et al* (1952), Aiyadurai (1966), Anon (1967), Rao (1969), Patwardhan (1970), Nair (1974), Anon (1976) and Nemani (1978). According to these reports, the production of cashew apple in India ranged from 2.5 to 15 lakhs tonnes per year.

Cashew apple utilisation

Thevet (1558) recounted that cashew apples and

their juice were consumed in Brazil. Thevet provided the first drawing of cashew, showing the local people harvesting the fruits and squeezing juice from cashew apples into a large jar.

Gandvo (1576) stated that cashew apple was a refreshing fruit during the hot season.

Sousa (1587) reported that cashew apple and its juice were thought to have medicinal value.

Ayyar (1930) suggested that the raw cashew apple juice being rich in sugar could be employed for the production of alcohol and vinegar.

Anon (1934-35) reported that the cashew apple juice deteriorated rapidly unless sterilized by heat or treated with preservatives.

The Department of Industries, Madras (1934-35) suggested a method for the preparation of edible syrup from cashew apple juice.

Anon (1941) stated that the cashew apple was soft and juicy. He found that when tender, it was acidic and highly astringent. It was also stated that the fruit was edible and yielded a delicious beverage and a wine on fermenting which retained the flavour of the fresh fruit.

Iyengar and Kale (1951) stated that fibrous nature and astringent taste of cashew apple was due to the presence of tanins and substances of phenolic nature. Similar views were expressed by Jain et al. (1952) and Anon (1967).

Jain et al. (1951) stressed the need of cashew apple utilisation and described the methods of preparation of juice, syrup and canned fruits with cashew apple.

Morton (1960) and Chakravarty (1961) have reported that cashew apple with fibrous flesh, exotic flavour, fine and pleasing aroma and rich sugar content was an asset to the processing industry.

Sastri et al. (1963) reported that cashew apple juice was susceptible for browning. They added that the quantity as well as nature of leucoanthocyanins, ascorbic acid, malic acid and dextrose present in the juice were responsible for browning.

Aiyadurai (1966) pointed out that the utilisation of cashew apple for the preparation of various products involved addition of large quantity of sugar and so the cost of the finished product was high.

Anon (1967a) stated that the skin of cashew was tender and it bruised easily leading to rapid fermentation of apple mostly due to rough handling during plucking and transport.

Johnson (1972) remarked that the utilisation of cashew apples by local people of Asia and Africa for making cashew wine dated back to 300 years. He stated that the tempting factor behind the introduction of cashew to India by the Portugeuse in the sixteenth century seems to be the potential value of cashew apple for its medicinal properties and also for its juice which could be fermented into a good wine.

Nair (1974) reported that in Goa, approximately 70 per cent of the total production of cashew apples was utilised for liquor production. He concluded that 35 per cent of the total income from cashew plantation, represented the income from apples.

Balasubramaniam (1977) remarked that the fragmented and scattered nature of cashew plantations in our state had created problems in collection and utilisation of apple economically.

Johnson (1977) stated that 'Caju' (Brazilian term for cashew) was harvested by the local people for

consumption as raw apple or for its conversion into various preparations.

According to Remani (1978) the important qualities of cashew apple for processing are its juicy nature, medicinal properties, high carbohydrate content, admissible colour, appreciable flavour and good taste.

Botanical status and morphological features of apple

Dutta (1929), Jain et al. (1952), Khan (1961), Aiyadurai (1966), Anon (1967), Rao (1969), Morton (1970) and Patwardhan (1970) have described the botanical status and the morphological features of cashew apple. According to these workers, cashew apple is a false fruit, being the swollen pedicel, which became juicy towards the last phase of fruit development.

Colour of apple

Iyengar and Kale (1951) observed that cashew apple is bright orange or yellow in colour and fibrous in texture.

Jain et al. (1952) reported that the colour of cashew apple varied between different shades of purple, red and yellow.

Singh and Mathur (1953) found that the percentage of T.S.S. and reducing sugars were slightly higher, in yellow fruits as compared to the red ones and acidity was lower in yellow fruits. They concluded that the yellow fruits were distinctly sweeter as compared to red ones as judged by analytical and organoleptic tests.

Aiyadurai (1966) summarised the studies on cashew apple characters and indicated the existence of several intermediate forms between the common yellow, red and pink types with a mixture of these colours in varying intensities.

Anon (1967) stated that cashew apples have been classified on the basis of their colour into two main groups viz. red and yellow.

Morton (1970) reported that cashew apple is bright yellow to red in colour and the yellow type is distinctly sweeter than the red.

Weight, length and circumference of apple

A study of the variability of economic characters of the cashew trees raised from seed at the Agricultural Research Stations, Taliparamba and Nileshwar showed that

the weight of cashew apple varied from 0.7 to 2.4 oz. and represented 82.4 to 91.4 per cent of the whole fruit including nut.

Sondhi (1962) found that the weight of cashew apple varied from 13 g to 140.7 g.

Anon (1967) reported that the length of cashew apple ranged from 2 inches to 3 inches width from 1.5 inches to 2 inches and weight from 40 to 85 grams.

Juice content

Sreenivasan (1935) observed that each cashew apple yielded 20 to 25 cc of juice.

Jain et al. (1951) recorded that cashew apple yielded 50 to 60 per cent juice of its weight.

Rao et al. (1952) stated that storage of cashew apple at -20°F resulted in an increase in the volume of the juice extracted by 14 per cent.

Singh and Mathur (1953) reported that the juice recovery of red fruits (70.3 per cent) were higher than that of yellow ones (68.7 per cent).

Johar (1957) observed that juice contributed 50 to 60 per cent by weight of cashew apple.

Sastri et al. (1962) reported that yield and quality of juice was influenced by the method of extraction and maturity of the fruit. They found that the screw type juice extractor gave an yield of 66 per cent juice as compared to 38 per cent in the case of basket press and that the ripe fruits yielded more juice than unripe ones.

Sondhi (1962) studied the juice content in cashew apple and reported that it ranged between 46.9 per cent and 84.3 per cent.

On reviewing the performance of cashew trees at the Agricultural Research Stations, Taliparamba and Nileshwar, Anon (1967) reported that weight of juice per apple ranged between 0.3 to 1.1 oz., volume of juice per apple was in between 10.6 and 31.3 cc and the recovery of juice varied from 34.1 to 61.7 per cent.

Anon (1967a) stated that more than 60 per cent of the weight of the fruit can be extracted as juice by pressing and the average yield of juice ranged from 50 to 70 per cent.

Chemical composition of cashew apple

A number of workers have studied the physical and chemical composition of cashew apple.

Sreenivasan (1935) studied the composition of cashew apple juice and reported that it contained 10.4 per cent of total solids, of which 94 per cent consisted of sugars, mostly invert sugars. He found that in addition to solids and sugars there were tannins, acids and pigments.

Joachim and Pannaithesekere (1940) reported that cashew apple contained 320 to 350 mg ascorbic acid per 100 ml cashew apple juice. Mithra (1940), Iyengar and Kale (1951) and Morton (1960) also have analysed the ascorbic acid in cashew apple juice and according to them the range of ascorbic acid in cashew apple was from 146 to 372 mg per 100 g juice.

According to the Health Bulletin (1941), cashew apple contained moisture (87.9 per cent), Proteins (0.2 per cent), Fat (0.1 per cent), Carbohydrate (11.6 per cent) mineral matter (0.2 per cent), Calcium (0.01 per cent), phosphorus (0.01 per cent) and iron (0.4 mg per 100 g).

Tkatchenko and Intengun (1949) found that the juice of cashew apple was a good source of water soluble vitamins viz. ascorbic acid, riboflavin and thiamin.

Jain (1951) reported that cashew apple juice had brix (13.5 per cent), total sugars as invert

(12.28 per cent) reducing sugars (12.28 per cent), acidity as malic (0.27 per cent) tannin (0.33 per cent) and pH 4.2. More or less similar results on the composition of cashew apple juice have been reported by Johar (1957), Khan (1961), Aiyadurai (1966), Patwardhan (1970), Haendler and Duvernellil (1971) and Lossner(1971).

Singh and Mathur (1953) studied the chemical composition of yellow and red fruits with regard to T.S.S., reducing sugars, total acidity, ascorbic acid and moisture in juice and concluded that yellow fruits were distinctly superior to red ones.

Siddappa and Bhatia (1954) identified the sugars in cashew apple by paper chromatography as glucose (++) and fructose (+). Their study revealed that sucrose and arabinose were not present in cashew apple.

Ventura and Hollanda (1958) reported that the soluble sugars identified in the fleshy peduncle were glucose, fructose and sucrose and each of these increased during maturation.

Chakravarty (1961) reported the presence of three sugars viz., glucose, fructose and sucrose in cashew apple. He observed that as the fruit ripened, sucrose practically disappeared and the sugar present was only dextrose, together with traces of fructose.

Sastri et al.(1962) studied the chemical composition of cashew apples from various selections at C.C.R.S. Ullal and reported that they contained 10 to 12 per cent sugar (mostly dextrose) 0.3 to 0.5 per cent malic acid, 150 to 300 mg per cent ascorbic acid, 84.2 per cent moisture, 0.84 per cent tannin, 2.8 per cent ether extractives and 0.92 to 0.99 per cent (on fresh weight basis) crude fibre.

Based on detailed studies of physico-chemical composition of cashew apple juice, Sondhi (1962) reported the range of variation of its constituents as follows. T.S.S.(7.2 to 18.3), acidity W/W (0.1 to 0.7 per cent) brix/acid ratio (14.2 to 104.3), pH (3.7 to 4.6), true ascorbic acid (85 to 283.1 mg/100 gm juice), sugars (5.3 to 17.7 per cent), total tannin (0.2 to 0.9 per cent), true tannin (0 to 0.7 per cent), and protein (0.2 to 0.3 per cent).

Anon (1963) while reviewing the possibilities of cashew apple utilisation stated that its juice had a brix of 12 to 14 per cent, containing 10.5 to 12.5 per cent sugars (all reducing) about 0.35 per cent acid as malic, 170 to 236mg ascorbic acid/100 ml, 0.35 per cent tannin and 0.3 per cent oil.

Sastri et al. (1963) reported that the loss of ascorbic acid in cashew apple juice and its blends at the end of 32 weeks' storage was found to be 49 to 66 per cent at 37°C and 29 to 54 per cent at room temperature. They also found that the colour of cashew apple juice was highly susceptible to heat treatment and prolonged storage.

Pariera et al. (1966), Anon (1967), Anon (1967a) and Anon (1976) have studied the physical and chemical composition of cashew apple under varying conditions and according to them, the range of different constituents were as follows:-

Ascorbic acid (180 to 261.5 mg/100 g juice), moisture (82.2 to 87.8 per cent), protein (0.2 to 0.8 per cent) fat (0.1 to 0.6 per cent), carbohydrate (11.1 to 11.9 per cent), crudefibre (0.9 per cent) minerals (0.2 to 0.4 per cent), calcium (0.004 to 0.01 per cent) phosphorus (0.01 to 0.021 per cent) and iron (0.2 mg/100 gm).

Composition and utilisation of cashew apple residue

Chakravarthy (1961) reported that cashew apple residue obtained after the juice extraction contained 9.5 per cent protein on dry matter basis.

Sondhi (1962) observed that cashew apple residue was good source of protein (8.72 per cent to 9.12 per cent on dry weight basis), pectin (8.2 to 11.2 per cent on dry weight basis), ascorbic acid (33 to 61.2 mg/100 gm) and minerals like calcium, iron and phosphorus. He suggested that this material could perhaps be utilised for recovery of low methoxyl pectin or as a cattle feed.

Aiyadurai (1966) suggested that the fibre contained in apples would be utilised as a residual material for preparing materials like hard boards.

Variation in qualities of apple

Albuquerque et al (1960) noticed wide variation in weight and size of cashew apples. They found that yellow apples were less astringent, heavier and softer than red apples.

Sondhi (1962) observed that wide variation existed in physico-chemical characters of cashew apple juice.

Sastry et al.(1962) studied the variation in tannin content of cashew apples at different stages of maturity in both red and yellow varieties and reported that sharp decrease of tannin and progressive increase of ascorbic acid was noticed as fruit ripened. They

observed regional variation in tannin content, and summarised that polyphenol constituents in cashew apple juice was influenced by region and the variety.

Sastri et al. (1962) reported the variation in chemical composition of different selections namely Chrompet (63), Kutuparamba (40), Manjeri (38), Rio de Janeiro, Pattukotai (65), Maduranthakam (64), Kanchangad (19), Ullal (5), Itchapur (69), Permannur (9), Udayarpalayam (59), Nileshwar (28), Derlakatta (7), Manjeri (37), Talapady (22), Wynad (43) and Guntur (67) with regard to the colour of apple, brix, acidity, ascorbic acid and tannin. They recorded variation in all these characters from selection to selection.

Damodaran (1977) reported that along with other economic characters, considerable variation existed in the mean weight, size, colour and shape of apples of the F1 progenies of the same parental combinations.

Correlation between average weight and juice recovery

Sondhi (1962) reported slight increase in juice yield with the increase in weight of fruits.

On reviewing the correlation studies between the apple characters, Aiyadurai (1966) stated that the heavier and longer the apple, the higher was the juice content.

Methods of preparing cashew apples for processing

The Department of Industries, Madras (1934-35) recommended to treat the cashew apple juice with slaked lime to precipitate the undesirable constituents of cashew apple juice.

Chakraborty et al.(1962) reported that steam treatment of fruits for ten minutes at 10 lb pressure per sq. inch (0.64 kg/sq.cm) reduced the residual oil content and the retention of tannin in the final product is only in traces.

Exploratory trials conducted in C.F.T.R.I, Mysore have evolved various methods for preparing cashew apple or cashew apple juice for processing by removing the acrid and astringent principles. These methods include steam treatment, addition of either of lime juice, 5 per cent gelatine or 5 per cent pectin solution. Treating the fruits in boiling solution of sulphuric acid (0.2 N) or common salt (2 per cent) and immersing the fruit in 2 per cent common salt solution are found to be effective in removing the tannin and oil content of apples.

Cashew apple products

Investigations and trials at C.F.T.R.I., Mysore have developed recipes for the production of edible

products from cashew apples after successfully removing the acrid and astringent principles. These include cashew apple juice, clarified juice, cloudy juice, cashola, cashew apple syrup, cashew apple jam, candy, canned cashew apple, cashew apple chutney, curried vegetable and pickle.

Johnson (1977) has given a detailed account of the cashew apple products and cashew apple juice products utilised in Brazil. According to him the main preserved items made from cashew apple in Brazil are stewed apples in syrup (doce emcalda), the typical sweet (doce of jam consistency), cooked pulp formed into balls and covered with sugar (caju cristalizado), cooked and partially dried apples in syrup (caju amerixa), jelly, beverage with included fruit, cashew juice used as a refreshing drink and to flavour ice creams, cashew apple juice combined with milk and sugar (cajuda), processed juice, canned cashew apple juice, pasteurised and filtered juice (cajuina), concentrated and sweetened juice (cremel de caju), vitamin enriched juice (caju vita) and the wine obtained by the fermentation of cashew apple juice.

MATERIALS AND METHODS

MATERIALS AND METHODS

These studies were carried out on four year old cashew trees planted in 1973 under the comparative yield trial of existing high yielding trees. There were altogether sixteen varieties under the trial which were assembled from the four cashew research stations at Anakkayam (Kerala), Vengurla (Maharashtra), Vridhachalam (Tamil Nadu) and Bapatla (Andhra Pradesh). There were three replications under the trial. The yield and other economic characters are under study, under the All India Co-ordinated Cashew Improvement Project. The apple characters were studied in the present investigation with a view to identify trees bearing better quality fruits, so that the apples which are not utilised at present can be made use of. Laboratory studies were done in the College of Horticulture, Vellanikkara. The different characters studied with the objective of selecting varieties yielding superior quality apples are briefly discussed below. The extent of variability within the seedling progenies of the sixteen varieties was also studied. The chemical composition of the cashew apple residue after the extraction of the juice were also investigated.

Sampling and layout

Representative samples of ten fully ripe apples were collected from each tree and these were divided into two samples, one to determine the juice content and the other to find out the chemical composition on dry basis.

To compare between varieties, nine trees (i.e. three trees from each replication) were selected with the help of random sampling technique. Variations within a variety were studied by collecting samples from all the twentyseven trees in a variety.

The apple, its juice, residue and dehydrated apple were studied for the following characters:-

1. Morphological characters of apple

    1.1 Colour

    1.2 Shape

    1.3 Weight

    1.4 Length

    1.5 Diameter

    1.6 Length/diameter ratio

2. Chemical composition of juice

    2.1 Percentage juice recovery

    2.2 T.S.S.

2.3 Sugars - Reducing and total

2.4 Acidity

2.5 Ascorbic acid

2.6 Tannin - Total and true

2.7 Specific gravity

2.8 Brix/acid ratio

2.9 Sugar/acid ratio

2.10 Oil content

3. Other chemical constituents of the apple

3.1 Moisture

3.2 Protein

3.3 Ether extractives

3.4 Carbohydrate

3.5 Crude fibre

3.6 Pectin as calcium pectate

3.7 Ash content - Total and acid insoluble

3.8 Calcium

3.9 Phosphorus

3.10 Iron

4. Composition of apple residue

4.1 Residue recovery

4.2 Moisture content

4.3 Protein

4.4 Pectin as calcium pectate

4.5 Ascorbic acid

Varieties studied

Following sixteen varieties were studied as indicated below.

Anakkayam	Bapatla	Vridhachalam	Vengurla
K 10-2	BLA-1	M 10/4	Ansur 1-27
BLA 139-1	BLA-40	M 6/1	Vengurla 36-3
BLA 256-1	BLA-273	M 76/1	Sawantwadi
H4-7	BLA-56	*K27-1	Vengurla 37-3

*One variety received from the cashew research station Vridhachalam did not establish well and therefore it was substituted by K 27-1 of the Anakkayam Station.

1. Morphological characters of apple

1.1 Colour

The colour of the apple when fully ripe was noted and categorised under three groups namely red, yellow and mixed shades of these colours.

1.2 Shape

Shape of all fruits were noted as conical, cylindrical, rhomboid and pyriform.

1.3 Weight

The weight of ten apples were determined and the mean (average) weight was recorded.

1.4 Length

Length of ten apples was measured and the average was worked out.

1.5 Diameter

Diameter of ten apples were measured at the central region with the help of a thread and a scale and the average was recorded.

1.6 Length/diameter ratio

The ratio was arrived at by dividing the length of the apple with its average diameter.

2. Chemical composition of juice

The following characters were estimated from the juice extracts of the different varieties.

2.1. Percentage juice recovery

Juice was extracted from apples of known weight and the recovery of juice was calculated in percentage.

2.2 Total soluble solids

T.S.S. was determined by a hand juice Brix refractometer at room temperature and the results

were expressed as percentage.

2.3 Sugars

2.3.1 Reducing sugars

Reducing sugars were estimated as per the methods described by Ranganna (1977) and was expressed as percentage.

2.3.2 Total sugars

Total sugars in cashew apple juice was estimated as per the analysis procedure described by Ranganna(1977) and the total sugar as invert sugar obtained were expressed as percentage.

2.4 Acidity

Acidity of the juice was determined as per the method described by A.O.A.C. (1960). Ten ml of the juice was titrated against 0.1 N Na OH and expressed as percentage in terms of malic acid. The indicator used was phenophthalein.

2.5 Ascorbic acid

The procedure for analysis described by Johnson(1948) was followed in the estimation of ascorbic acid in the juice.

2.6 Tannin : Total and true

Volumetric method of analysis by A.O.A.C.(1970) was followed in the estimation of tannin. Total tannin and true tannin were calculated and expressed as percentage.

2.7 Specific gravity

The weight of ten ml juice was determined in a chemical balance and the specific gravity was calculated.

2.8 Brix/acid ratio

This was arrived at by dividing the T.S.S. with titratable acidity and this was reckoned as a measure of fruit quality.

2.9 Sugar/acid ratio

The value was obtained by dividing the reducing sugars with titratable acidity.

2.10 Oil content (Non tannin materials)

Oil content as percentage of cashew apple juice was calculated for all the sixteen varieties by subtracting the true tannin percentage from the total tannin percentage.

3. Other chemical constituents of the apple

3.1 Moisture content

Apples were chopped into small pieces and the chopped pieces were dried in an air oven at 70°C for 18 hrs. The moisture content of apples of all the sixteen varieties was then worked out from the weight lost during drying and expressed as percentage of fresh apple weight.

3.2 Protein

Protein was estimated by determining the nitrogen content in the dry sample according to the procedure laid down by A.O.A.C. (1955) and multiplying the same by the factor 6.25.

3.3 Ether extractives

Two gram of the ground dried material was extracted with petroleum ether using a soxhlet apparatus and crude fat was worked out as percentage of fresh apple weight.

3.4 Carbohydrate

Carbohydrate as percentage of fresh apple weight was calculated for all the sixteen varieties by subtracting, the sum total of the percentages of

moisture, ash, ether extractives, protein, crude fibre, pectin as calcium pectate and acidity from 100. (Ranganna, 1977).

3.5 Crude fibre

A.O.A.C. (1970) procedure was followed for the estimation of crude fibre and was expressed as percentage of fresh edible apple.

3.6 Pectin as calcium pectate

The analysis procedure described by Ranganna(1977) was followed.

3.7 Ash content

3.7.1 Total ash

Weighed 5 g dried material into a silica dish. Ignited the dish and its contents on a Bunsen burner to free it from carbon. Ashed the material at 525°C for 6 hrs, cooled the dish and weighed. The difference in weights was calculated as total ash content and expressed as percentage of total ash per fresh fruit weight.

3.7.2 Acid insoluble ash

Added 25 ml of dilute hydrochloric acid (10 per cent wt/wt) to the ash obtained (in total ash

estimation). Covered it with a watch glass and boiled gently over a low flame for 5 min. Filtered the boiled solution through an ashless filter paper. Washed the residue thoroughly with hot water. Returned the residue along with the paper to the original dish, ignited, cooled, weighed and recorded as percentage acid insoluble ash per fresh apple material.

3.8 Calcium

Calcium in an aliquot of the tripple acid extract of the sample was determined using a flame photometer (Jackson, 1973).

3.9 Phosphorus

0.5 g of the ground sample was digested in concentrated perchloric acid, sulphuric acid and nitric acid mixture in the proportion of 1:2:9 and made upto 100 ml with distilled water. 10 ml of this made up solution was taken for the estimation of phosphorus. Phosphorus in this extract was determined colorimetrically using vanadomolybdophosphoric yellow colour method in nitric acid system (Jackson, 1973).

3.10 Iron

Ash solution of the sample prepared by dry ashing

of 5 g dried material was made upto 100 ml with distilled water. Ten ml of this made-up solution was taken for the estimation of iron. Iron in this extract was determined by O phenonthroline, colorimetric method (Jackson, 1973).

4. Composition of cashew apple residue

4.1 Residue Recovery

The residue left after juice recovery was weighed and recorded as percentage recovery of cashew apple residue per fresh fruit weight.

4.2 Moisture content

The apple residue was chopped and dried at 70°C in an airoven for 18 hrs. From the loss in weight, the moisture in residue was worked out and expressed as percentage of fresh residue weight.

4.3 Protein

Digested 0.5 g of dried and ground residue material. The resultant solution was made upto 100 ml. Nitrogen of this sample was estimated by Kjeldahl method. Calculated the nitrogen of the sample and expressed as percentage of fresh residue weight. Multiplied the percentage of nitrogen by 6.25 to get the protein percentage.

4.4 Pectin as calcium pectate

Pectin was estimated as calcium pectate in the residue. The same method as in the case of pectin estimation of apple was followed here also. The result was expressed as percentage of calcium pectate in fresh residue.

4.5 Ascorbic acid

Ten gram fresh residue was ground in a mortar with 25 ml of 4 per cent oxalic acid. Filtered it through Whatman No.42, and the filtrate so got was made upto 100 ml with 4 per cent oxalic acid. Ten ml of this made up solution was titrated against standard indophenol dye. Ascorbic acid was calculated using the dye factor and expressed as mg per 100 g fresh residue.

5. Statistical analysis of data

5.1 To compare between varieties

All the results obtained from the experiment were arranged in appropriate tables. From these tables, variety x replication, two way tables were prepared to obtain the sum of squares due to different

sources of variation. The data were analysed statistically. The experimental errors, sampling errors and critical differences were calculated to compare the means of various varieties to find out the promising varieties.

5.2 To study the variation within a variety

The mean, sum of squares of individual observations, correction factor, standard deviation, coefficient of variation and range were calculated taking into account the analytical data of apples from all the 27 trees of a variety.

5.3 Correlation study

Correlation coefficient between average weight and juice recovery was calculated using the standard statistical formula. Simple correlation coefficients and linear regression equations were worked out.

Snedecor et al. (1967) was followed in the statistical analysis of the data.

RESULTS

RESULTS

The results of the investigations carried out on the physico-chemical composition of the cashew apples of sixteen high yielding varieties are presented below.

1. Morphological characters of the apple

1.1 Colour and shape

The colour of apples of different varieties broadly come under three categories - red, yellow and mixed shades of these two colours.

The apples were classified under four categories on the basis of their shape, namely conical, cylindrical, pyriform and rhomboid.

The percentage of seedling progenies of the different varieties classified on the basis of colour and shape are presented in Table 1 and represented in Plates I to XVI.

It may be seen from the table that considerable variation in the colour and shape of apples existed between different varieties and between progenies of the same variety. While some varieties like BLA-1, BLA-56 and K 27-1 produced apples of uniform colour to a large content, there was considerable variation in the shape of different varieties of cashew. If both colour and shape are taken into consideration, the variety K 27-1 showed a high degree of uniformity (88.2 per cent in respect of colour and 77.78 per cent with regard to shape).

Table 1 Variability in colour and shape of cashew apple of different varieties

Varieties	COLOUR OF APPLE Percentage of trees producing			SHAPE OF APPLE Percentage of trees having			
	Yellow	Red	Mixed shade	Conical	Cylindrical	Pyriform	Rhomboid
Ansur 1-27	55.8	27.5	16.7	33.34	44.54	0.00	22.22
Vengurla 36-3	7.7	53.8	38.5	55.60	11.10	11.10	22.22
Sawantwadi	0.0	60.0	40.0	11.10	44.45	44.45	0.00
Vengurla 37-3	0.0	86.4	13.6	22.22	66.67	0.00	11.11
BLA - 1	100.0	0.0	0.0	11.10	44.45	44.45	0.00
BLA - 40	84.2	0.0	15.8	33.33	22.22	44.45	0.00
BLA - 56	90.0	5.0	5.0	22.22	44.45	33.33	0.00
BLA - 273	76.9	15.4	7.7	0.00	22.22	44.45	33.33
M 10/4	87.5	4.2	8.3	33.34	33.34	22.22	11.11
M 6/1	50.0	18.2	31.8	11.11	11.11	0.00	77.78
K 27-1	88.2	0.0	11.8	11.11	77.78	0.00	11.11
M 76-1	69.6	8.7	21.7	33.34	22.22	11.10	33.34
H 4-7	39.1	13.0	47.9	44.45	11.11	22.22	22.22
K 10-2	30.8	0.0	69.2	66.70	33.30	0.00	0.00
BLA 139-1	79.0	0.0	21.0	66.70	22.20	0.00	11.10
BLA 256-1	83.3	0.0	16.7	22.22	22.22	33.34	22.22

Plate I Size and shape of cashew apples of the variety Ansur 1-27

Plate II Size and shape of cashew apples of the variety Vengurla 36-3


ANSUR


VET. GUR 36

Plate III Size and shape of cashew apples of the variety Sawantwadi

Plate IV Size and shape of cashew apples of the variety Vengurla 37-3

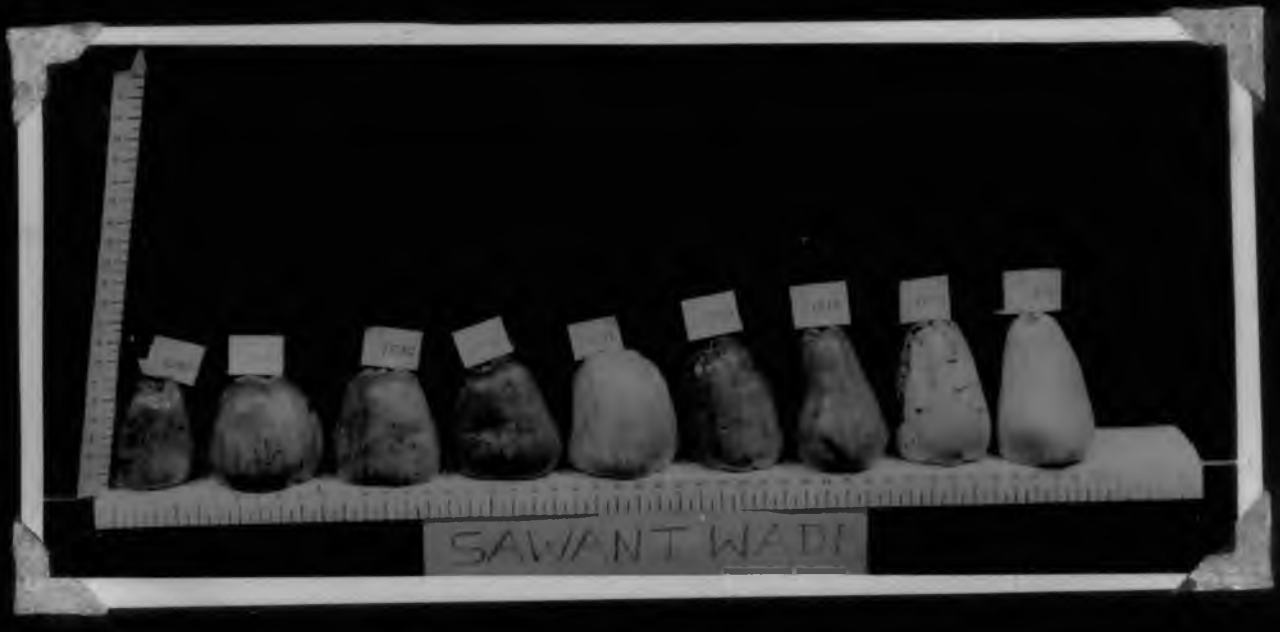

SAWANTWADI

Plate V Size and shape of cashew apples of the variety BLA-1

Plate VI Size and shape of cashew apples of the variety BLA - 40


TREE I OF BLA


TREE 40

Plate VII Size and shape of cashew apples of the variety BLA-56

Plate VIII Size and shape of cashew apples of the variety BLA - 273


TREE 56


TREE 273

Plate IX Size and shape of cashew apples of the variety M 10/4

Plate X Size and shape of cashew apples of the variety M 6/1


M 10/4


M 6/1

Plate XI Size and shape of cashew apples of the variety K 27-1

Plate XII Size and shape of cashew apples of the variety M 76 - 1


K 27-1


M 76-1

Plate XIII Size and shape of cashew apples of the variety H 4-7

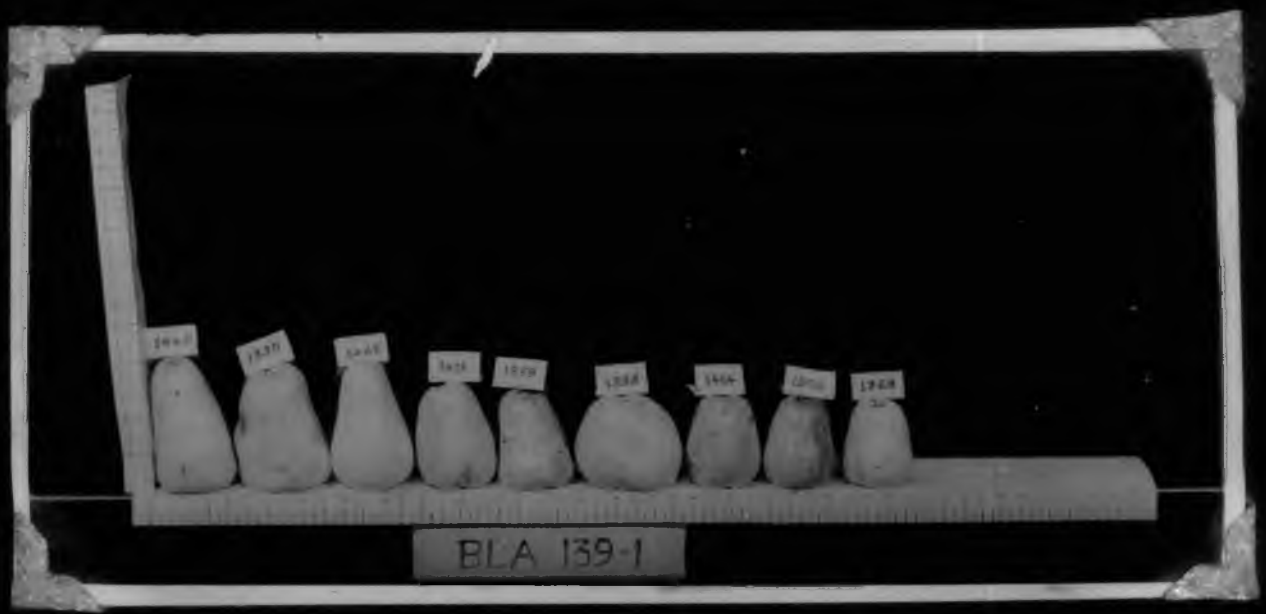
Plate XIV Size and shape of cashew apples of the variety K 10-2


H4-7


K 10-2

Plate XV Size and shape of cashew apples of the variety BLA 139-1

Plate XVI Size and shape of cashew apples of the variety BLA 256-1


BLA 139-1


BLA 256-1

1.2 Weight, length, diameter, length/diameter ratio and juice content of apples.

The average weight of apples of different varieties and the measurements of length, diameter, length/diameter ratio the percentage juice recovery and average juice content per apple are given in Table 2 and represented in Fig. 1 and 2.

The data show that the variety K 10-2 produced the largest sized apples (75.4 g) followed by Sawantwadi. Smallest type apples were produced by the variety BLA 256-1 which weighed only 29.2 g.

In respect of length, diameter and length/diameter ratio, K 10-2 ranked first followed by Sawantwadi. With regard to percentage juice recovery and juice content per apple K 10-2 topped the list giving an yield of 64 per cent, followed by Sawantwadi which gave a juice recovery of 62.5 per cent.

The data show that the varieties differ significantly in average weight, length, diameter and percentage juice recovery.

Table 2 Weight, length, maximum diameter, length/diameter ratio and juice content of apples of different varieties (Mean values)

Varieties	Average weight (g)	Length (cm)	Maximum diameter (cm)	Length/ diameter ratio	Juice recovery %	Juice content per apple (g)
Ansur 1-27	47.9	6.3	4.75	1.33	57.4	27.49
Vengurla 36-3	40.8	6.1	4.90	1.24	57.6	23.50
Sawantwadi	50.2	7.3	5.13	1.42	62.5	31.38
Vengurla 37-3	32.3	5.8	4.08	1.42	48.5	15.67
BLA - 1	39.0	5.7	4.81	1.19	60.5	23.60
BLA - 40	41.1	6.7	4.59	1.46	55.5	22.81
BLA - 56	36.2	6.2	4.36	1.42	53.4	19.33
BLA - 273	39.7	6.2	4.87	1.27	54.1	21.48
M 10/4	40.4	6.2	4.75	1.31	44.9	18.14
M 6/1	43.3	6.9	4.59	1.50	60.5	26.20
K 27-1	45.3	7.1	4.65	1.53	53.2	24.10
M 76-1	32.3	5.6	4.30	1.30	59.2	19.12
H 4-7	39.4	6.3	4.65	1.35	51.5	24.23
K 10-2	75.4	9.4	5.06	1.86	64.0	48.26
BLA 139-1	31.9	6.0	4.24	1.42	58.6	18.69
BLA 256-1	29.2	4.9	4.39	1.12	58.2	16.99
F value	9.82**	9.34**	2.08*	--	8.26**	--
C.D. (P = 0.05)	9.92	0.94	0.59	--	5.13	--

* Significant at 5% level.
** Significant at 1% level.

FIG.1

SHOWING VARIETAL VARIATION IN AVERAGE WEIGHT OF CASHEWAPPLES.

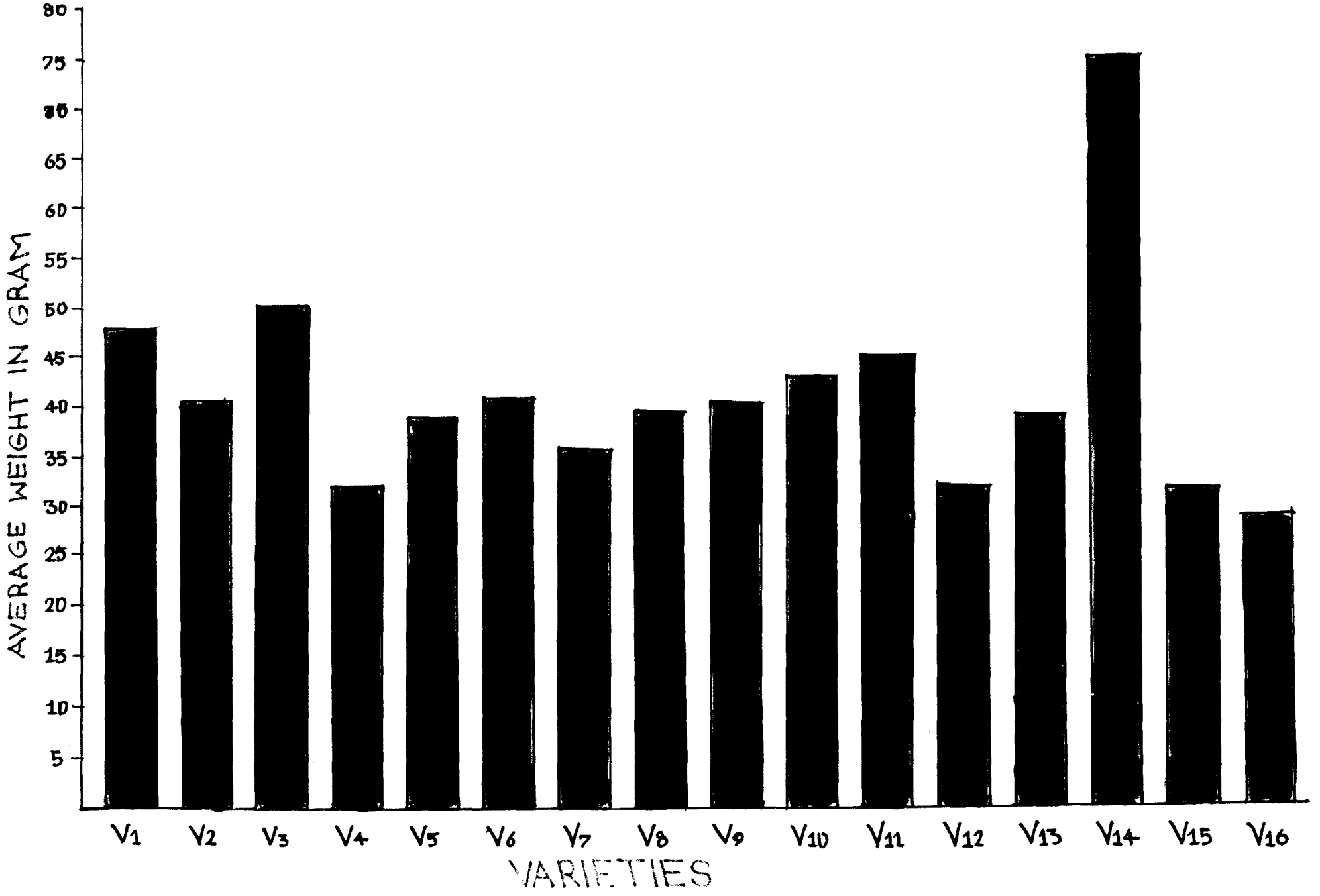
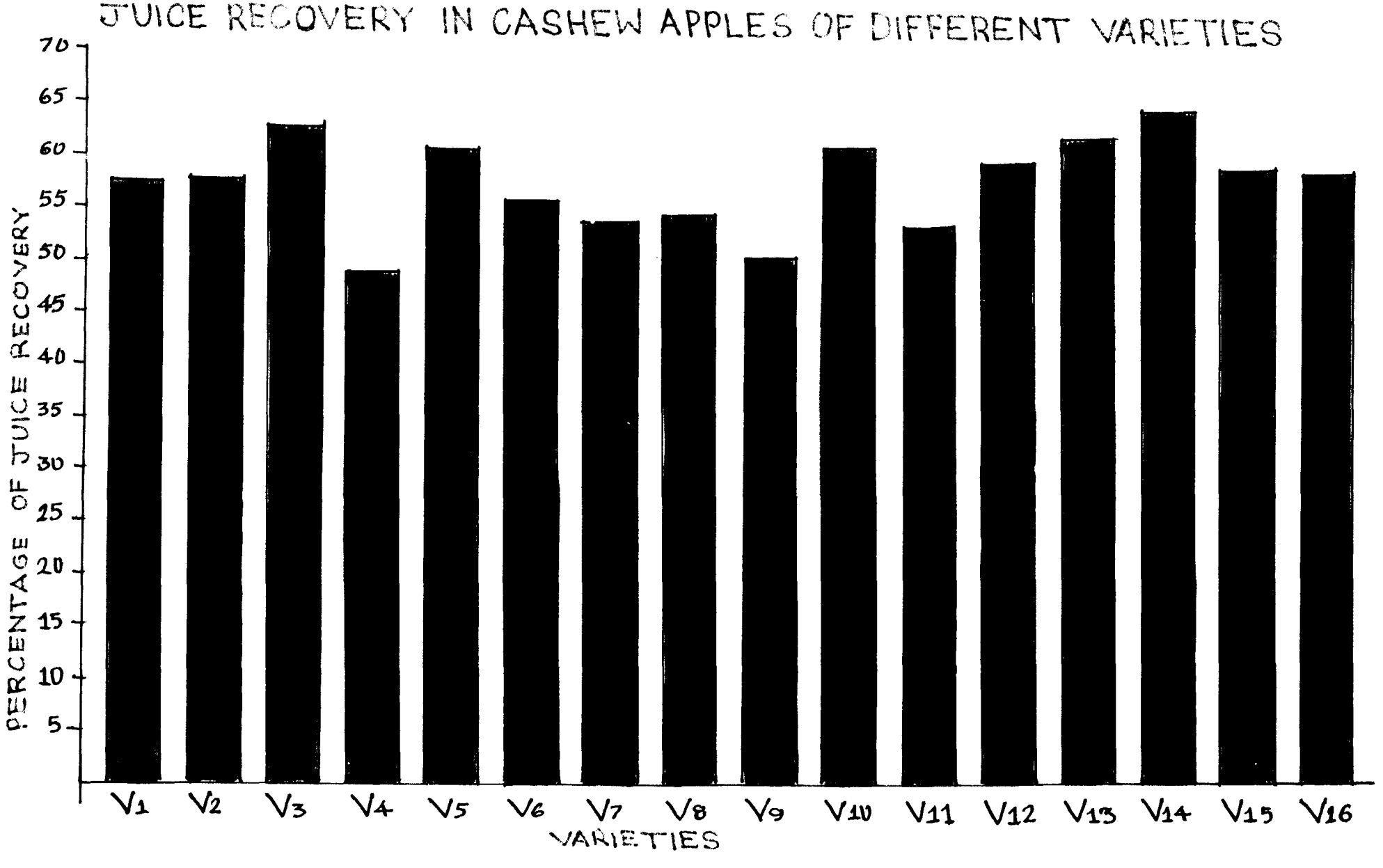


FIG. 2.


JUICE RECOVERY IN CASHEW APPLES OF DIFFERENT VARIETIES
PERCENTAGE OF JUICE RECOVERY
70
65
60
55
50
45
40
35
30
25
20
15
10
5
V1
V2
V3
V4
V5
V6
V7
V8
V9
V10
V11
V12
V13
V14
V15
V16
VARIETIES

2. Chemical composition of apple juice

2.1 T.S.S., sugars, acidity, ascorbic acid and tannin

The above constituents in the juice of the apples of different varieties were analysed and expressed as percentage of ingradients per 100 g of juice. The total soluble solids, reducing sugars (Fig.3) acidity as malic acid (Fig.4), ascorbic acid as mg/100 g and total tannin (Fig.5) and true tannin were estimated and presented in Table 3 (a).

The data presented in the table show that the type M 6/1 had the highest T.S.S. (14.67 per cent) and reducing sugars (13.37 per cent) followed by Vengurla 36-3 which recorded a T.S.S. of 13.44 per cent and the reducing sugar percentage of 12.91. In respect of acidity BLA-273 (0.58 per cent) ranked first, followed by Vengurla 37-3 which had an acid content of 0.50 per cent. With respect to ascorbic acid content, K 27-1 had the highest quantity (321.16 mg/100g of juice) followed by BLA-40 which recorded 308.68 mg/100g juice. With regard to total tannin, the juice of BLA-40 had the minimum tannin of 0.33 per cent followed by H 4-7 with 0.37 per cent total tannin. The data indicate that there exist significant variation between varieties with respect to T.S.S., reducing sugars, ascorbic acid, total tannin and true tannin, but no significant variation between varieties was noted in respect of acidity.

Table 3 (a) Chemical composition of cashew apple juice of high yielding varieties

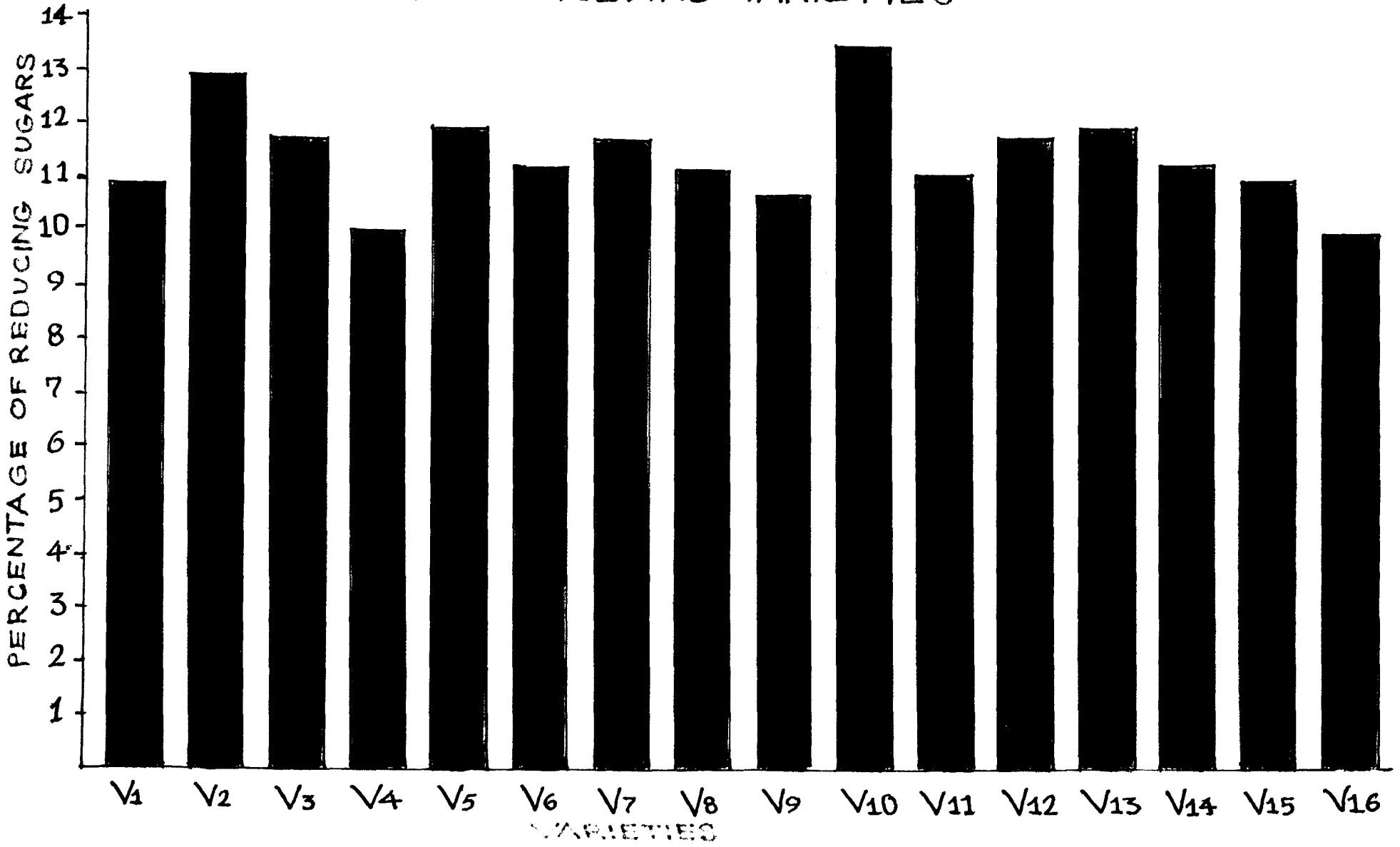
(Mean values expressed as percentage)

Varieties	T.S.S. %	Reducing sugars %	Total sugar %	Acidity as malic %	Ascorbic acid mg/100g	Tannin %	
						Total	True
Ansur 1-27	12.67	10.93	10.93	0.38	261.33	0.47	0.27
Vengurla 36-3	13.44	12.91	12.91	0.46	239.30	0.52	0.25
Sawantwadi	12.67	11.70	11.70	0.39	242.87	0.49	0.25
Vengurla 37-3	11.06	9.99	9.99	0.50	289.48	0.74	0.36
BLA - 1	13.22	11.93	11.93	0.47	253.05	0.47	0.24
BLA - 40	12.72	11.16	11.16	0.45	308.68	0.33	0.20
BLA - 56	13.56	11.74	11.74	0.42	238.47	0.51	0.28
BLA - 273	12.61	11.09	11.09	0.58	247.50	0.56	0.29
M 10/4	11.67	10.56	10.56	0.51	283.84	0.58	0.29
M 6/1	14.67	13.37	13.37	0.46	241.81	0.45	0.25
K 27-1	12.06	10.96	10.96	0.40	321.16	0.56	0.25
M 76-1	12.83	11.73	11.73	0.36	224.52	0.49	0.27
H 4-7	13.33	11.92	11.92	0.37	243.30	0.37	0.22
K 10-2	12.89	11.17	11.17	0.45	230.28	0.49	0.28
BLA 139-1	11.89	10.89	10.89	0.44	251.30	0.46	0.31
BLA 256-1	11.56	9.88	9.88	0.44	220.84	0.39	0.27
F value	2.67*	2.87**	2.87**	1.26^{NS}	2.21*	5.93**	2.93**
C.D.(P = 0.05)	1.57	1.58	1.58	NS	57.35	0.11	0.06

* Significant at 5% level
** Significant at 1% level
NS Not significant

FIG.3.

REDUCING SUGARS IN CASHEW APPLE JUICE OF - HIGH YIELDING VARIETIES



FIG·4.

ACIDITY IN CASHEW APPLE JUICE OF DIFFERENT VARIETIES.

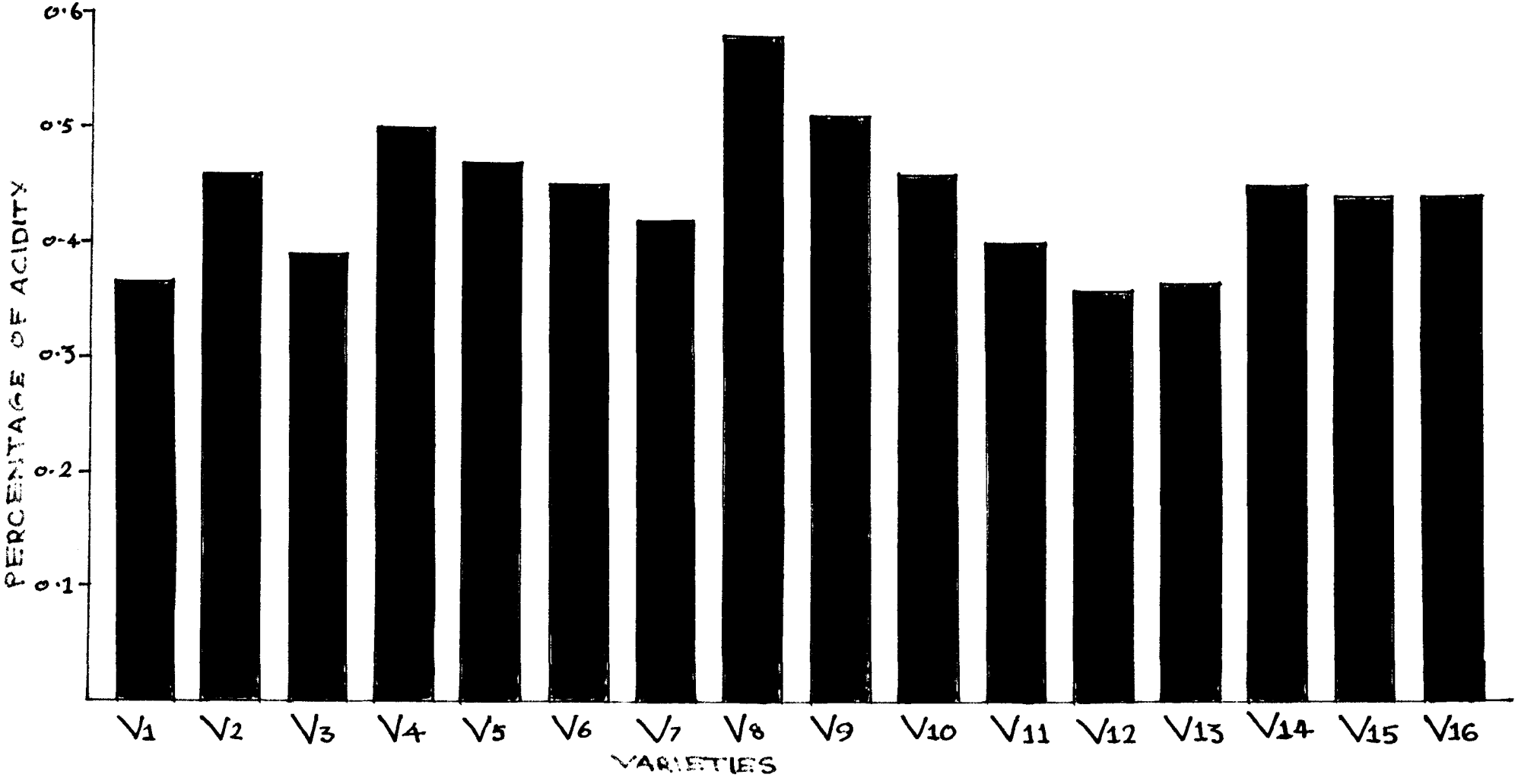
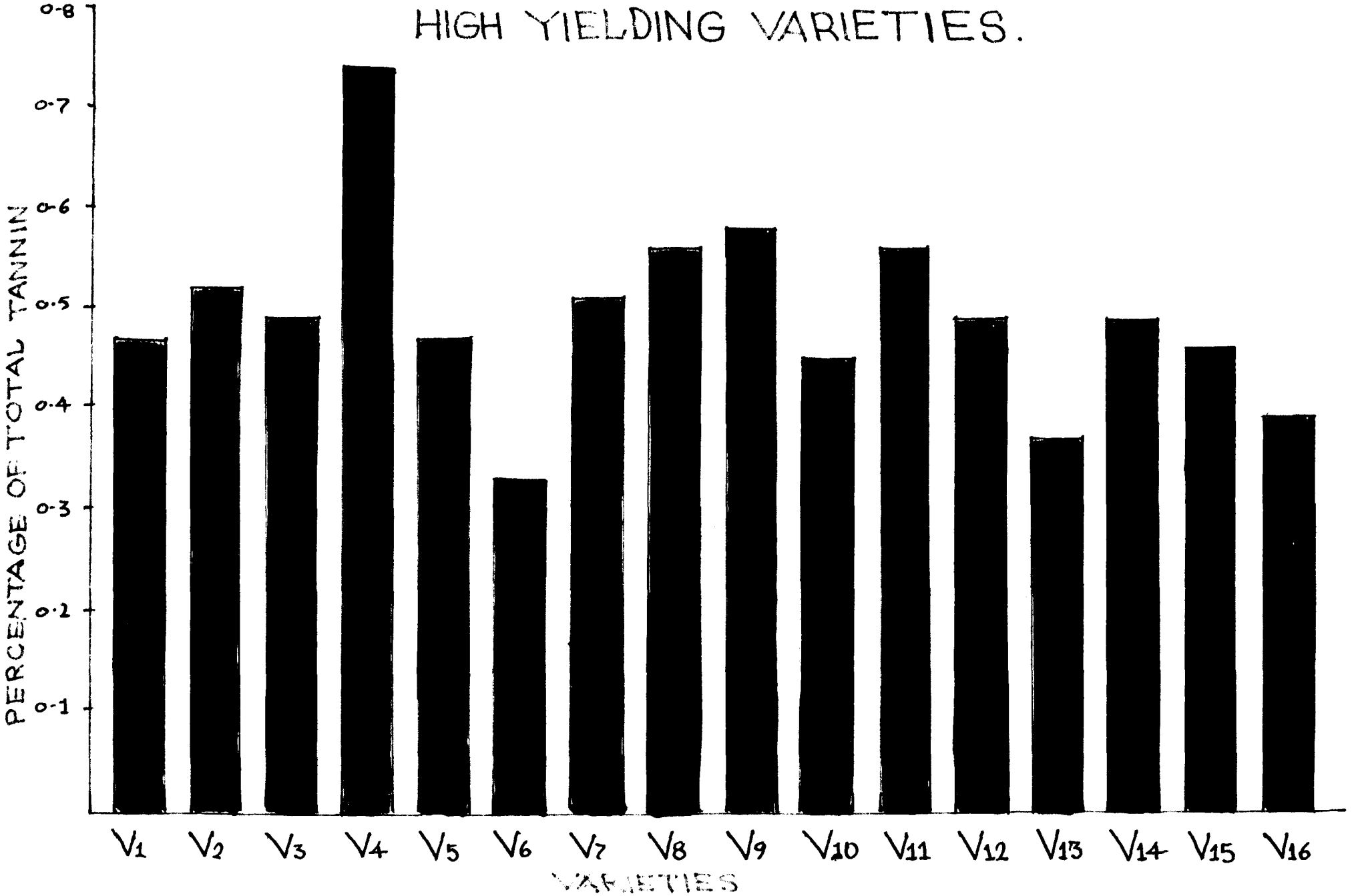


FIG. 5.

TOTAL TANNIN IN CASHEW APPLE JUICE OF - HIGH YIELDING VARIETIES.



2.2 Specific gravity, brix/acid ratio, sugar/acid ratio and oil content of cashew apple juice

The specific gravity, brix/acid ratio, sugar/acid ratio and the oil content are important parameters relating to the quality of fruit juices. The above characters relating to the sixteen varieties of cashew are presented in Table 3 (b).

In specific gravity, M 6/1 (1.066) was the highest followed by Sawantwadi which had a specific gravity of 1.061. With respect to brix/acid ratio the variety H 4-7 (39.6) had the highest ratio, followed by Ansur 1-27 which had a ratio of 38.68. The variety H 4-7 (35.45) topped the list in respect of sugar/acid ratio which was followed by M 76-1 with a ratio of 34.21. The data show that varieties differ significantly with respect to specific gravity but there is no significant difference in respect of brix/acid ratio and sugar/acid ratio.

3. Chemical constituents in apple

3.1 Moisture, protein, ether extractives, crude fibre and pectin

The moisture content, protein, ether extractives, carbohydrates (Fig.6), crude fibre and pectin content(Fig.7), of different varieties were estimated and their data are presented in Table 4 (a).

The data show that the varieties differ significantly in protein content, volatile constituents as represented by ether extractives, crude fibre and pectin content.

It may be seen from the table that the variety M 10/4 (0.92 per cent) had the highest protein content followed by BLA-40 which had a protein content of 0.81 per cent. In respect of pectin also the variety M 10/4 (0.72 per cent) ranked first followed by Vengurla 36-3 which recorded 0.71 per cent calcium pectate. Moisture content is found to be the lowest in BLA-1 (85.47 per cent) followed by M 10/4 with 85.99 per cent of moisture. Vengurla 37-3 (0.76 per cent) and Vengurla 36-3 (0.69 per cent) recorded higher ether extractives. Maximum carbohydrate content was recorded by BLA-1 (11.53 per cent) followed by Ansur 1-27 which recorded a carbohydrate content of 10.62 per cent. BLA-273 (0.91 per cent) produced apples having highest crude fibre content followed by BLA-40 with a crude fibre content of 0.88 per cent.

Table 3(b) Specific gravity, brix/acid ratio, sugar/acid ratio and oil content of cashew apple juice of different varieties

(Mean values)

Varieties	Specific gravity	Brix/acid ratio	Sugar/acid ratio	Oil content %
Ansur 1-27	1.058	38.68	33.25	0.20
Vengurla 36-3	1.057	34.83	33.48	0.27
Sawantwadi	1.061	35.78	32.88	0.24
Vengurla 37-3	1.047	25.38	23.09	0.38
BLA - 1	1.061	29.04	26.31	0.23
BLA - 40	1.053	29.43	26.02	0.13
BLA - 56	1.056	33.44	29.54	0.23
BLA - 273	1.053	22.37	19.70	0.27
M 10/4	1.051	24.31	21.84	0.29
M 6/1	1.066	35.79	32.16	0.20
K 27-1	1.053	32.65	29.44	0.31
M 76-1	1.056	37.45	34.21	0.22
H 4-7	1.057	39.60	35.45	0.15
K 10-2	1.060	29.47	25.63	0.21
BLA 139-1	1.053	27.27	25.18	0.15
BLA 256-1	1.049	29.94	25.90	0.12
F value	3.45**	0.86NS	1.35NS	--
C.D. (P = 0.05)	0.0078	NS	NS	--

** Significant at 1% level
NS Not significant

Table 4(a) Chemical composition of cashew apples of high yielding varieties

(Mean values expressed as percentage of fresh apple)

Varieties	Moisture %	Protein %	Ether extractives %	Carbohydrate %	Crude fibre %	Pectin as calcium pectate %
Ansur 1-27	86.23	0.50	0.52	10.62	0.80	0.54
Vengurla 36-3	86.16	0.54	0.69	10.25	0.75	0.71
Sawantwadi	88.37	0.72	0.55	8.13	0.69	0.54
Vengurla 37-3	87.14	0.72	0.76	9.43	0.78	0.39
BLA - 1	85.47	0.77	0.51	11.53	0.62	0.31
BLA - 40	86.69	0.81	0.39	9.77	0.88	0.42
BLA - 56	86.82	0.71	0.40	9.98	0.71	0.35
BLA - 273	86.16	0.72	0.55	10.33	0.91	0.31
M 10/4	85.99	0.92	0.57	10.22	0.78	0.72
M 6/1	86.69	0.46	0.49	10.16	0.75	0.55
K 27-1	86.50	0.65	0.55	10.21	0.67	0.61
M 76-1	86.88	0.74	0.52	9.96	0.71	0.37
H 4-7	86.13	0.67	0.44	10.60	0.75	0.60
K 10-2	87.25	0.48	0.50	9.72	0.70	0.67
BLA 139-1	86.97	0.80	0.44	9.50	0.72	0.70
BLA 256-1	88.12	0.42	0.41	8.91	0.77	0.57
F value	0.80^{NS}	24.44**	13.98**	--	12.55**	36.23**
C.D.(P = 0.05)	NS	0.084	0.075	--	0.059	0.07

NS Not significant
** Significant at 1% level

FIG. 6.

REPRESENTING VARIATION IN CARBOHYDRATE CONTENT OF CASHEW APPLES OF HIGH YIELDING VARIETIES.

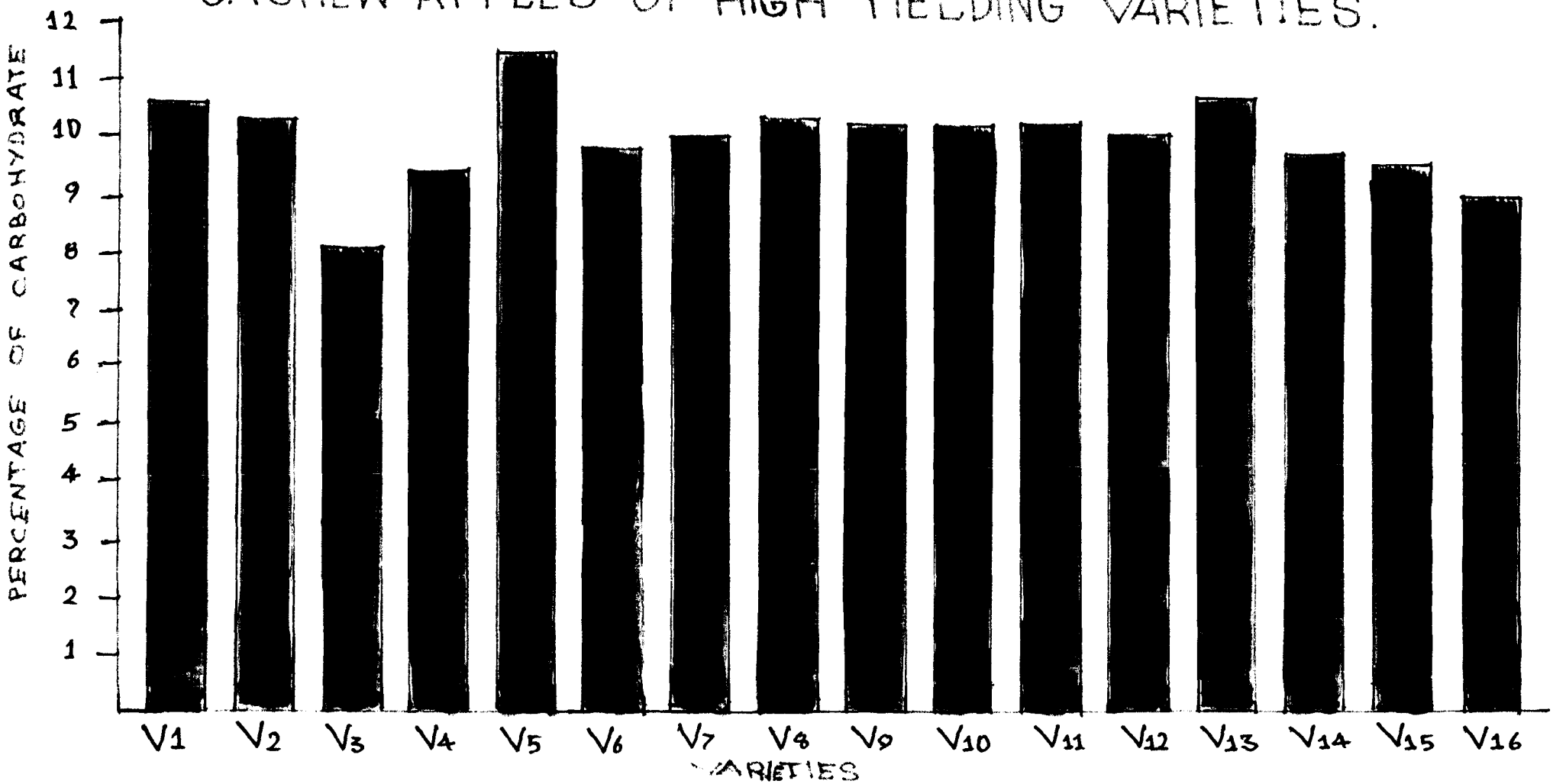
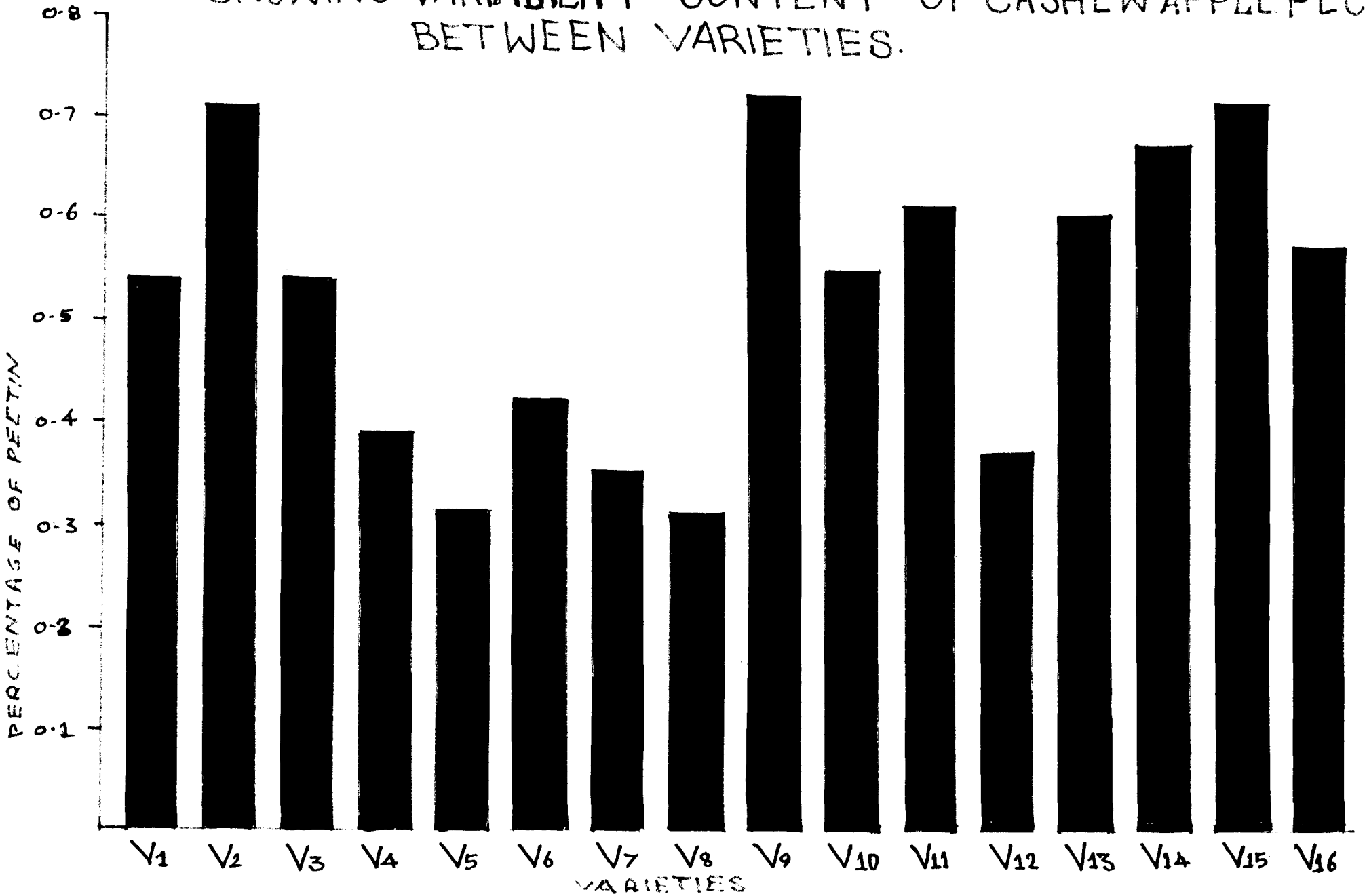


FIG. 7.

SHOWING VARIABILITY CONTENT OF CASHEW APPLE PECTIN BETWEEN VARIETIES.



3.2 Total ash, acid insoluble ash, calcium, phosphorus and iron content of apples

The above constituents of the cashew apple were estimated in respect of the sixteen varieties. The percentage of these constituents are given in Table 4 (b).

The data show that the varieties differ significantly in total ash, acid insoluble ash, calcium, phosphorus and iron content of apples. The variety BLA-40 had the highest mineral content with 0.015 per cent of calcium, 0.027 per cent of phosphorus and 0.0016 per cent of iron. It was closely followed by Sawantwadi with 0.013 per cent calcium, 0.026 per cent phosphorus and 0.0015 per cent of iron.

Table 4 (b) Chemical composition of cashew apples of high yielding varieties (contd.)

(Mean values expressed as percentage of fresh apple)

Varieties	Total ash %	Acid insoluble ash %	Calcium %	Phosphorus %	Iron %
Ansur 1-27	0.57	0.33	0.006	0.020	0.0011
Vengurla 36-3	0.63	0.35	0.014	0.025	0.0013
Sawantwadi	0.76	0.40	0.013	0.026	0.0015
Vengurla 37-3	0.53	0.29	0.008	0.016	0.0010
BLA - 1	0.51	0.27	0.012	0.017	0.0010
BLA - 40	0.79	0.41	0.015	0.027	0.0016
BLA - 56	0.78	0.52	0.011	0.021	0.0012
BLA - 273	0.71	0.42	0.112	0.023	0.0013
M 10/4	0.57	0.33	0.010	0.019	0.0013
M 6/1	0.62	0.45	0.008	0.014	0.0009
K 27-1	0.60	0.34	0.012	0.022	0.0015
M 76-1	0.61	0.39	0.008	0.017	0.0012
H 4-7	0.58	0.37	0.009	0.018	0.0012
K 10-2	0.39	0.23	0.011	0.012	0.0008
BLA 139-1	0.59	0.42	0.005	0.012	0.0008
BLA 256-1	0.54	0.31	0.008	0.016	0.0011
F value	17.46**	6.66**	12.11**	9.0**	6.88**
C.D.(P = 0.05)	0.072	0.082	0.0022	0.0044	0.00029

** Significant at 1% level

4. Composition of cashew apple residue

Chemical composition of the residue left after the extraction of juice of cashew apples were estimated. The percentage recovery of residue, moisture, protein (Fig.8), pectin (Fig.9) and ascorbic acid are presented in Table 5.

It may be seen from the table that the residue of the variety M 10/4 had a protein content of 1.99 per cent followed by BLA - 40 which had 1.82 per cent of protein. The highest percentage of pectin was obtained from the residue of BLA 139-1 (1.64 per cent) followed by 1.62 per cent in the variety M 10/4. The residue of variety BLA - 40 ranked first in ascorbic acid content with 65.61 mg per 100 g followed by K 27-1 with 63.60 mg per 100 g. Varieties differed significantly in respect of moisture, protein, pectin and ascorbic acid content of the residue.

Table 5. Variability in composition of cashew apple residue left after the extraction of juice between varieties.

(Mean value as percentage of fresh residue)

Varieties	Residue recovery %	Moisture %	Protein %	Pectin as calcium pectate %	Ascorbic acid mg/100g
Ansur 1-27	38.57	81.13	0.75	0.96	60.80
Vengurla 36-3	40.12	81.06	1.26	1.56	56.81
Sawantwadi	38.87	82.72	1.73	1.25	57.20
Vengurla 37-3	41.60	83.64	1.78	1.11	57.42
BLA - 1	34.22	82.89	1.77	0.73	51.11
BLA - 40	43.39	82.70	1.82	0.90	65.61
BLA - 56	43.81	80.64	1.49	0.81	55.53
BLA - 273	44.71	80.46	1.54	0.63	53.49
M 10/4	47.38	82.44	1.99	1.62	62.17
M 6/1	38.91	81.63	1.17	1.31	56.39
K 27-1	44.66	84.07	1.36	1.36	63.60
M 76-1	43.13	81.53	1.60	0.70	57.76
H 4-7	37.27	81.88	1.62	1.41	52.36
K 10-2	36.76	82.29	1.04	1.58	47.42
BLA 139-1	39.69	81.59	1.78	1.64	48.72
BLA 256-1	42.02	80.96	0.93	1.33	44.30
F value	1.61^{NS}	6.09**	17.3**	22.00**	4.59**
C.D. (P = 0.05)	NS	1.23	0.25	0.22	7.96

NS Not significant
** Significant at 1% level

FIG. 8.

VARIETAL VARIABILITY IN PROTEIN CONTENT OF CASHEW APPLE RESIDUE.

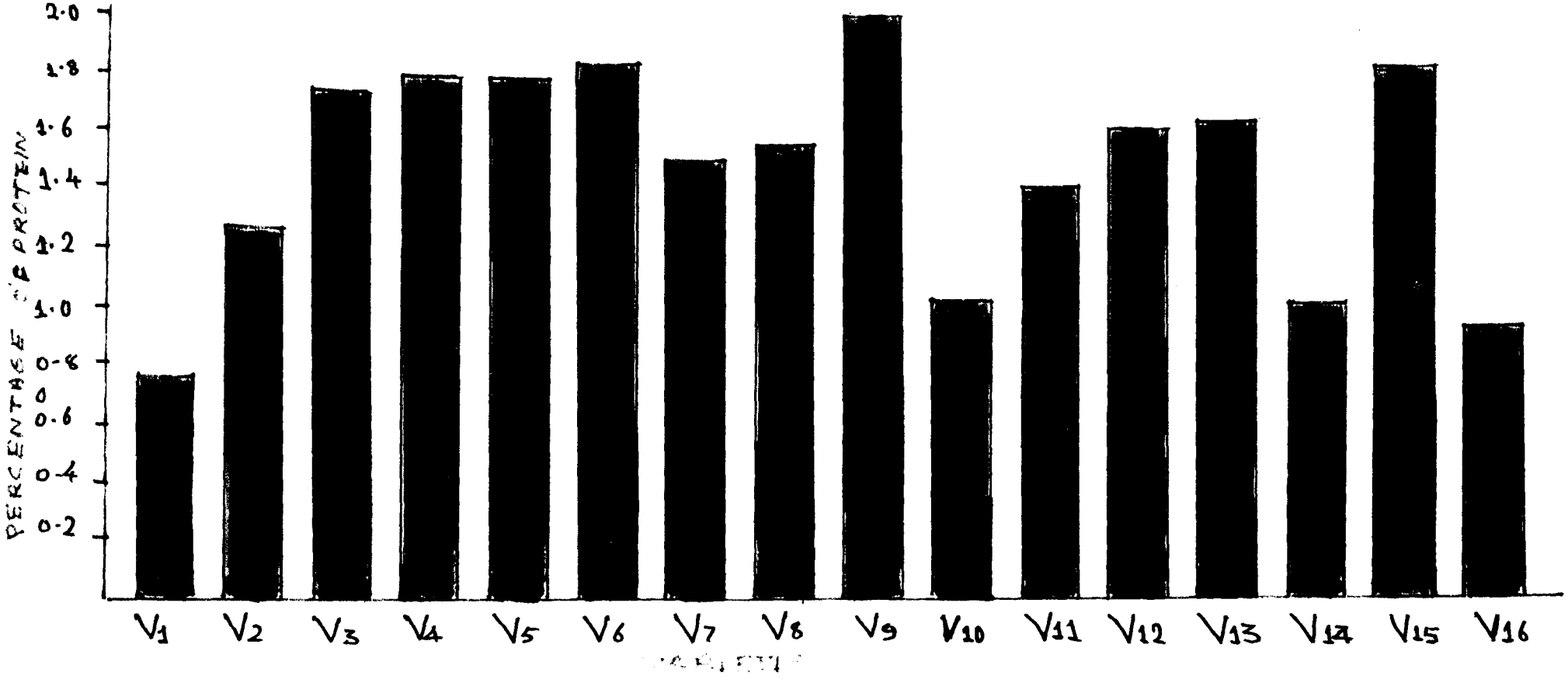
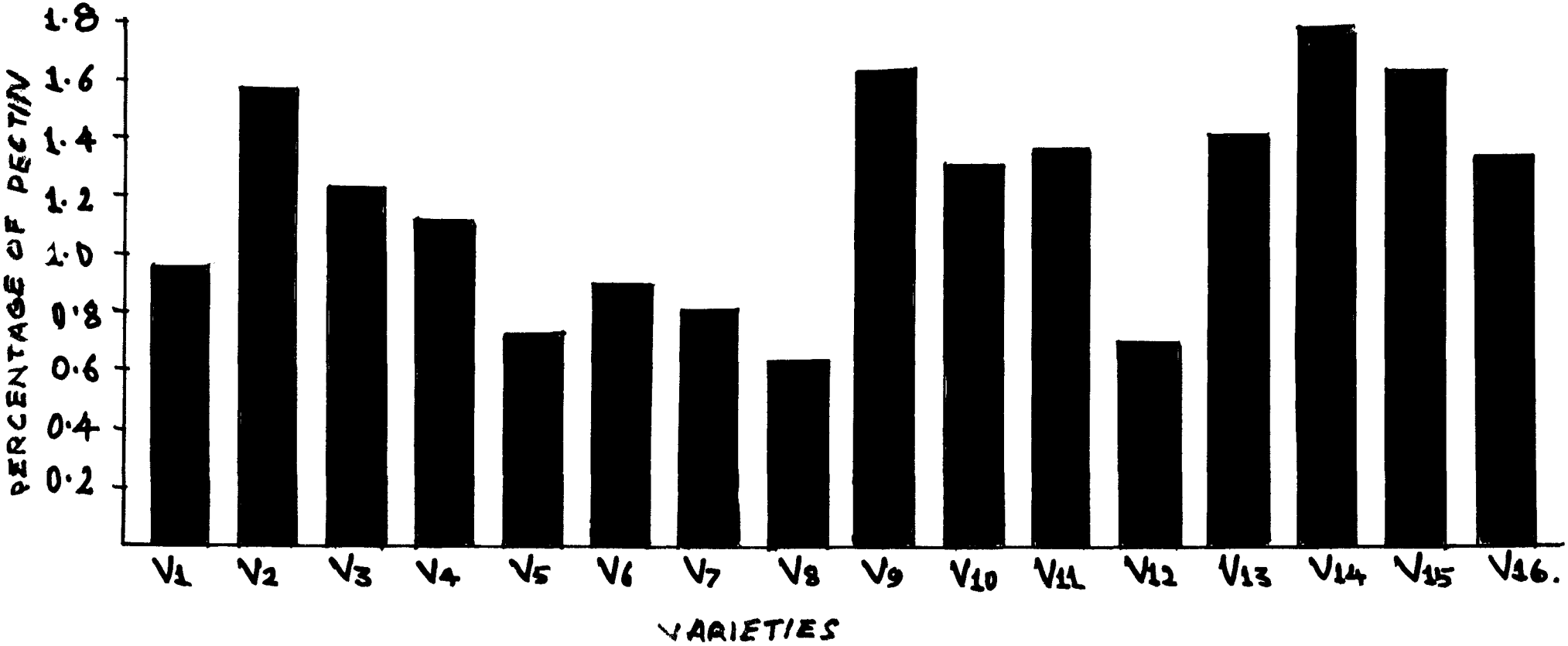


FIG. 9

PECTIN IN CASHEW APPLE RESIDUE OF DIFFERENT VARIETIES



5. Correlation between average weight and percentage juice recovery of apple

The correlation between the mean values of weight and percentage juice recovery of apples of all the sixteen varieties was positive,, the coefficient of correlation being 0.41.

Regression equation of percentage juice recovery of apples on weight of apples was worked out.

Table 6. Correlation between weight and percentage juice recovery and regression equation of apples of high yielding varieties

Correlation coefficient 'r'	0.41
Linear regression equation (Y = a+bx)	48.96 + 0.19 x

Y Juice recovery

x Average weight

6. Variability in apple characters of seedling progenies of high yielding varieties

The seedling progenies of all the varieties under study showed variability in their physico-chemical characters. The mean, range and coefficient of variation with respect to the chemical and physical characteristics viz., weight, percentage juice recovery, total soluble solids, reducing sugars, acidity as malic acid, ascorbic acid, total tannin, true tannin, brix/acid ratio, sugar/acid ratio, moisture, protein, ether extractives, crude fibre, pectin, total ash, acid insoluble ash, calcium, phosphorus and iron of apples of the progenies of the different varieties and the range of variability are presented in tables 7(a), 7(b), 8(a), 8(b), 8(c), 9 (a), 9(b), 9 (c), 9 (d) and 9(e). Coefficient of variation is taken as the index to indicate the extent of variability of the mean values presented in the above tables.

It is evident from these tables that there existed variability in respect of chemical composition of the progenies of the same variety. The minimum and maximum variability in respect of the different characters of the apple of the seedling progenies of the sixteen varieties studied are tabulated in Table 7.

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Table 7. Varieties, the progenies of which show minimum and maximum variability in cashew apple characters

Character	Variety	
	Minimum variability	Maximum variability
T.S.S.	K 10-2 (7.89)	Sawantwadi (15.62)
Sugar	K 10-2 (6.93)	Sawantwadi (21.73)
Brix/acid ratio	K 10-2 (16.55)	Sawantwadi (54.76)
Moisture	K 10-2 (0.81)	Vengurla 37-3 (4.01)
Iron	K 10-2 (13.83)	Ansur 1-27 (75.9)
True tannin	BLA 139-1 (11.3)	Vengurla 36-3(28.59)
Pectin	BLA 139-1 (3.1)	Vengurla 37-3(31.05)
Total ash	BLA 139-1 (6.6)	Ansur 1-27 (24.14)
Acid insoluble ash	BLA 139-1 (8.74)	Ansur 1-27 (29.4)
Juice recovery	BLA 256-1 (5.81)	Vengurla 37-3 (21.81)
Crude fibre	BLA 256-1 (5.76)	Vengurla 37-3 (12.87)
Total tannin	BLA 256-1 (13.52)	M 10/4 (29.78)
Ether extractives	H 4-7 (5.9)	M 6/1 (20.3)
Phosphorus	H 4-7 (14.46)	K 10-2 (32.1)
Average weight	Vengurla 36-3 (13.6)	Ansur 1-27 (39.1)
Acidity	Vengurla 37-3 (15.74)	Vengurla 36-3 (42.96)
Ascorbic acid	BLA 273 (11.22)	Vengurla 36-3 (100.68)
Sugar/acid ratio	Sawantwadi (13.04)	Vengurla 37-3 (58.9)
Protein	M 10/4 (8.57)	M 6/1 (35.14)
Calcium	K 27-1 (17.6)	K 10-2 (60.83)

Coefficient of variation shown in brackets.

Table 7(a). Variability in weight and juice recovery of cashew apples of seedling progenies of high yielding varieties (Mean values)

Varieties	Average weight (g)			Juice recovery %		
	Mean	Range	C.V.	Mean	Range	C.V.
Ansur 1-27	52.48	19.62 - 92.05	39.10	59.01	46.80 - 74.02	12.61
Vengurla 36-3	43.15	32.02 - 55.50	13.60	59.44	51.60 - 68.80	7.28
Sawantwadi	50.57	28.90 - 66.00	19.24	62.80	46.00 - 74.24	12.71
Vengurla 37-3	44.08	23.90 - 65.50	30.44	57.20	41.40 - 74.60	21.81
BLA - 1	52.94	28.60 - 86.00	31.45	65.69	55.20 - 78.60	9.82
BLA - 40	55.03	30.70 - 81.33	34.29	59.38	51.70 - 78.50	11.01
BLA - 56	50.74	30.80 - 92.50	30.33	58.49	50.60 - 71.50	10.96
BLA - 273	46.00	31.40 - 74.80	27.30	56.26	51.40 - 65.20	7.31
M 10/4	49.09	32.20 - 68.80	24.22	50.57	40.30 - 68.90	15.70
M 6/1	50.96	30.80 - 78.80	35.52	62.25	55.12 - 71.90	7.02
K 27-1	47.71	23.80 - 82.80	38.48	54.05	48.60 - 62.20	7.16
M 76-1	40.94	22.20 - 68.50	29.73	59.31	51.20 - 74.02	10.84
H 4-7	48.00	27.50 - 73.20	29.50	64.33	57.50 - 71.30	7.01
K 10-2	74.08	50.60 -103.70	23.00	63.27	54.40 - 72.20	7.51
BLA 139-1	42.38	24.50 - 68.20	33.58	60.56	54.80 - 68.10	6.29
BLA 256-1	32.45	24.20 - 50.20	25.08	59.00	55.80 - 68.50	5.81

C.V. Coefficient of variation

Table 7(b). Variability in brix/acid ratio and sugar/acid ratio of cashew apples of seedling progenies of high yielding varieties

(Mean values)

Varieties	Brix/acid ratio			Sugar/acid ratio		
	Mean	Range	C.V.	Mean	Range	C.V.
Ansur 1-27	39.13	17.50 - 81.20	43.21	33.90	14.42 - 66.80	44.23
Vengurla 36-3	38.48	12.50 - 58.30	36.54	37.21	12.10 - 57.70	37.13
Sawantwadi	32.25	15.30 - 51.60	54.76	21.69	14.20 - 51.80	13.04
Vengurla 37-3	30.25	11.30 - 88.90	46.27	27.66	10.20 - 83.90	58.90
BLA - 1	31.07	21.60 - 53.60	25.97	28.01	18.10 - 50.60	27.95
BLA - 40	27.70	17.50 - 42.20	25.34	24.19	15.00 - 35.30	25.28
BLA - 56	32.89	17.10 - 56.00	25.02	29.10	15.40 - 48.90	27.71
BLA - 273	23.18	15.80 - 33.30	21.07	20.45	14.20 - 30.20	22.50
M 10/4	25.62	12.50 - 43.75	36.53	22.65	10.20 - 39.43	36.60
M 6/1	37.20	20.92 - 62.07	32.57	33.73	15.43 - 55.24	33.30
K 27-1	37.61	20.00 - 58.33	27.53	34.08	18.55 - 52.92	27.68
M 76-1	37.00	20.69 - 60.87	28.54	35.11	19.50 - 55.20	27.31
H 4-7	41.70	19.35 - 72.86	46.80	37.56	17.42 - 89.30	47.70
K 10-2	28.43	21.15 - 36.11	16.55	24.75	19.04 - 31.94	17.70
BLA 139-1	31.16	17.14 - 58.33	32.70	27.67	15.14 - 47.90	31.30
BLA 256-1	27.33	16.41 - 69.44	49.52	23.63	14.06 - 63.30	53.40

C.V. Coefficient of variation

Table 8(a) Variability in T.S.S. and acidity of cashew apple juice of seedling progenies of high yielding varieties

Varieties	T.S.S. %			Acidity %		
	Mean	Range	C.V.	Mean	Range	C.V.
Ansur 1-27	12.78	10.0 - 16.0	11.84	0.39	0.16 - 0.77	42.30
Vengurla 36-3	14.38	12.0 - 18.0	12.95	0.43	0.24 - 0.96	42.96
Sawantwadi	11.97	9.0 - 16.5	15.62	0.41	0.27 - 0.70	31.87
Vengurla 37-3	11.85	10.0 - 16.0	13.76	0.52	0.18 - 0.93	15.74
BLA - 1	13.37	11.0 - 16.0	9.57	0.45	0.28 - 0.58	19.51
BLA - 40	12.47	10.7 - 16.0	11.60	0.47	0.32 - 0.64	22.15
BLA - 56	13.10	11.0 - 15.0	11.80	0.42	0.28 - 0.70	22.57
BLA - 273	12.58	11.0 - 15.0	9.46	0.56	0.42 - 0.76	17.02
M 10/4	11.69	9.0 - 15.0	14.97	0.51	0.31 - 0.99	33.25
M 6/1	14.16	11.0 - 18.0	15.62	0.42	0.22 - 0.70	31.36
K 27-1	12.53	11.0 - 15.0	9.43	0.36	0.26 - 0.57	25.19
M 76-1	12.91	10.0 - 16.0	10.69	0.37	0.23 - 0.60	28.41
H 4 -7	13.33	11.0 - 16.0	10.29	0.38	0.16 - 0.70	38.08
K 10-2	12.54	11.0 - 15.0	7.89	0.45	0.38 - 0.59	16.60
BLA 139-1	12.39	10.5 - 14.0	9.58	0.43	0.24 - 0.70	26.96
BLA 256-1	11.83	10.0 - 13.5	8.51	0.50	0.18 - 0.76	31.20

C.V. Coefficient of variation

Table 8 (b) Variability in juice composition of cashew apples of seedling progenies of high yielding varieties (contd..)

Varieties	Ascorbic acid mg/100g			Sugar %		
	Mean	Range	C.V.	Mean	Range	C.V.
Ansur 1-27	253.10	174.0 - 424.2	23.19	10.97	8.34 - 14.02	11.82
Vengurla 36-3	225.35	156.5 - 467.4	100.68	13.87	11.60 - 17.30	12.87
Sawantwadi	237.40	183.9 - 387.3	22.44	11.05	8.80 - 14.60	21.73
Vengurla 37-3	267.00	186.6 - 363.1	18.83	10.70	8.10 - 15.10	16.28
BLA - 1	255.95	192.4 - 387.4	18.54	12.00	10.00 - 14.60	11.41
BLA - 40	302.97	144.0 - 500.0	26.75	10.86	9.00 - 12.70	8.90
BLA - 56	245.30	164.0 - 355.3	21.36	11.54	10.10 - 13.90	10.66
BLA - 273	252.50	201.7 - 303.2	11.22	11.07	9.80 - 12.70	8.80
M 10/4	270.42	200.00- 349.8	15.49	10.36	8.20 - 13.60	14.30
M 6/1	256.22	196.7 - 360.2	13.84	12.80	9.80 - 16.47	14.37
K 27-1	300.75	213.5 - 391.9	16.45	11.37	10.10 - 13.40	8.77
M 76-1	232.52	194.0 - 288.0	12.71	12.97	9.13 - 13.46	15.22
H 4-7	241.60	201.2 - 322.4	13.47	11.97	9.60 - 14.30	10.46
K 10-2	238.76	201.2 - 264.1	11.52	10.88	9.90 - 12.60	6.93
BLA 139-1	237.74	148.6 - 363.6	21.84	11.01	8.50 - 12.20	9.05
BLA 256-1	222.23	100.3 - 295.3	24.94	9.2	8.30 - 11.80	13.67

C.V. Coefficient of variation

Table 8(c). Variability in juice composition of cashew apples of seedling progenies of high yielding varieties (contd.)

Varieties	Total tannin %			True tannin %		
	Mean	Range	C.V.	Mean	Range	C.V.
Ansur 1-27	0.52	0.32 - 0.78	19.13	0.30	0.24 - 0.39	16.21
Vengurla 36-3	0.51	0.36 - 0.70	21.16	0.25	0.14 - 0.35	28.59
Sawantwadi	0.52	0.38 - 0.67	15.74	0.26	0.16 - 0.37	20.38
Vengurla 37-3	0.68	0.30 - 0.87	26.52	0.34	0.17 - 0.45	26.02
BLA - 1	0.46	0.31 - 0.62	21.65	0.24	0.17 - 0.33	20.52
BLA - 40	0.33	0.24 - 0.48	18.98	0.20	0.14 - 0.32	23.80
BLA - 56	0.48	0.30 - 0.69	20.67	0.26	0.16 - 0.38	25.63
BLA - 273	0.55	0.32 - 0.69	17.68	0.28	0.19 - 0.37	14.46
M 10/4	0.52	0.32 - 0.90	29.78	0.29	0.18 - 0.36	26.49
M 6/1	0.44	0.28 - 0.63	24.99	0.26	0.16 - 0.39	27.50
K 27-1	0.57	0.38 - 0.73	17.35	0.29	0.16 - 0.38	28.36
M 76-1	0.46	0.30 - 0.74	20.18	0.26	0.14 - 0.37	18.77
H 4-7	0.40	0.30 - 0.63	17.65	0.22	0.16 - 0.28	17.91
K 10-2	0.51	0.40 - 0.64	14.55	0.30	0.23 - 0.38	16.41
BLA 139-1	0.45	0.35 - 0.56	14.04	0.30	0.25 - 0.38	11.30
BLA 256-1	0.35	0.30 - 0.55	13.52	0.27	0.21 - 0.37	16.14

C.V. Coefficient of variation

Table 9(a) Variability in chemical composition of cashew apples of seedling progenies of high yielding varieties

(Values expressed as percentage of fresh apple)

Varieties	Moisture %			Protein %		
	Mean	Range	C.V.	Mean	Range	C.V.
Ansur 1-27	86.21	84.50 - 88.20	1.28	0.50	0.31 - 0.75	26.06
Vengurla 36-3	85.25	83.02 - 87.30	1.77	0.56	0.38 - 0.81	26.12
Sawantwadi	88.94	82.50 - 91.90	2.57	0.71	0.56 - 0.88	13.10
Vengurla 37-3	85.76	73.20 - 89.80	4.01	0.75	0.56 - 0.94	11.06
BLA - 1	85.88	82.30 - 87.60	1.84	0.79	0.63 - 1.00	12.60
BLA - 40	86.74	84.30 - 89.50	1.72	0.80	0.63 - 1.00	16.02
BLA - 56	87.40	83.10 - 89.72	1.60	0.68	0.50 - 0.81	16.23
BLA - 273	86.31	84.50 - 87.62	1.03	0.71	0.63 - 0.88	9.30
M 10/4	86.22	83.87 - 87.77	1.24	0.90	0.75-4 1.00	8.57
M 6/1	86.65	84.30 - 87.90	1.37	0.46	0.31 - 0.56	35.14
K 27-1	86.54	84.85 - 87.80	0.88	0.60	0.38 - 0.81	24.35
M 76-1	86.74	85.15 - 88.87	1.31	0.76	0.56 - 0.94	14.10
H 4-7	85.94	84.32 - 87.50	1.08	0.65	0.50 - 0.81	11.40
K 10-2	87.24	86.09 - 88.90	0.81	0.47	0.38 - 0.56	13.76
BLA 139-1	86.50	85.48 - 88.64	1.73	0.86	0.75 - 1.00	10.62
BLA 256-1	87.99	86.62 - 89.90	1.09	0.43	0.31 - 0.56	17.27

C.V. Coefficient of variation

Table 9 (b). Variability in chemical composition of cashew apples of seedling progenies of high yielding varieties (contd..)

(Values expressed as percentage of fresh apple)

Varieties	Ether extractives %			Crude fibre %		
	Mean	Range	C.V.	Mean	Range	C.V.
Ansur 1-27	0.53	0.40 - 0.66	12.4	0.77	0.59 - 0.94	11.77
Vengurla 36-3	0.69	0.44 - 0.90	16.85	0.76	0.61 - 0.89	11.09
Sawantwadi	0.56	0.52 - 0.67	7.73	0.69	0.60 - 0.78	7.94
Vengurla 37-3	0.72	0.51 - 0.87	14.38	0.78	0.65 - 0.92	12.87
BLA - 1	0.52	0.33 - 0.64	19.20	0.63	0.50 - 0.74	10.13
BLA - 40	0.40	0.31 - 0.48	10.03	0.89	0.80 - 0.99	6.39
BLA - 56	0.43	0.32 - 0.59	13.00	0.69	0.58 - 0.82	9. 80
BLA - 273	0.55	0.40 - 0.66	13.80	0.91	0.80 - 0.99	12.60
M 10/4	0.55	0.37 - 0.74	15.12	0.78	0.67 - 0.89	9.56
M 6/1	0.49	0.40 - 0.58	20.30	0.71	0.55 - 0.84	11.80
K 27-1	0.55	0.47 - 0.61	7.78	0.68	0.58 - 0.78	8.90
M 76-1	0.51	0.41 - 0.65	11.01	0.71	0.58 - 0.86	13.70
H 4-7	0.45	0.42 - 0.52	5.90	0.74	0.66 - 0.85	7.90
K 10-2	0.50	0.40 - 0.56	8.63	0.69	0.63 - 0.77	6.71
BRA 139-1	0.45	0.38 - 0.54	10.10	0.74	0.60 - 0.85	10.00
BLA 256-1	0.40	0.35 - 0 47	8.82	0.77	0.70 - 0.85	5.76

C.V. Coefficient of variation

Table 9(c). Variability in chemical composition of cashew apples of seedling progenies of high yielding varieties (contd.)

(Values expressed as percentage of fresh apple)

Varieties	Pectin %			Total ash %		
	Mean	Range	C.V.	Mean	Range	C.V.
Ansur 1-27	0.50	0.32 - 0.74	20.72	0.58	0.30 - 0.79	24.14
Vengurla 36-3	0.70	0.55 - 0.90	15.60	0.65	0.48 - 0.85	17.14
Sawantwadi	0.56	0.42 - 0.70	12.12	0.77	0.70 - 0.88	7.15
Vengurla 37-3	0 45	0.24 - 0.68	31.05	0.54	0.41 - 0.68	18.65
BLA - 1	0.35	0.21 - 0.56	27.50	0.51	0.36 - 0.73	19.16
BLA - 40	0.38	0.26 - 0.58	25.50	0.82	0.62 - 0.97	9.45
BLA - 56	0.36	0.20 - 0.50	24.40	0.76	0.59 - 0.90	13.25
BLA - 273	0.32	0.20 - 0.46	21.60	0.68	0.51 - 0.82	16.57
M 10/4	0.73	0.70 - 0.77	24.63	0.57	0.45 - 0.68	13.70
M 6/1	0.56	0.41 - 0.68	13.90	0.61	0.47 - 0.76	14.70
K 27-1	0.62	0.50 - 0.74	11.80	0.63	0.45 - 0.76	16.20
M 76-1	0.61	0.54 - 0.68	7.16	0.58	0.35 - 0.68	9.06
H 4-7	0.64	0.54 - 0.68	9.16	0.58	0.45 - 0.68	10.51
K 10-2	0.67	0.59 - 0.75	6.70	0.40	0.33 - 0.47	11.84
BLA 139-1	0.71	0.68 - 0.74	3.10	0.60	0.54 - 0.66	6.60
BLA 256-1	0.58	0.51 - 0.65	6.55	0.56	0.42 - 0.69	13.00

C.V. Coefficient of variation

Table 9 (d). Variability in chemical composition of cashew apple of seedling progenies of high yielding varieties (contd.)

(Values expressed as percentage of fresh apple)

Varieties	Acid insoluble ash %			Calcium %		
	Mean	Range	C.V.	Mean	Range	C.V.
Ansur 1-27	0.34	0.14 - 0.58	29.40	0.006	0.004 - 0.011	40.78
Vengurla 36-3	0.35	0.24 - 0.54	25.77	0.015	0.010 - 0.020	21.21
Sawantwadi	0.40	0.36 - 0.48	9.10	0.012	0.007 - 0.016	24.80
Vengurla 37-3	0.29	0.20 - 0.36	13.73	0.009	0.005 - 0.015	34.77
BLA - 1	0.28	0.20 - 0.48	23.50	0.011	0.004 - 0.016	30.88
BLA - 40	0.42	0.34 - 0.59	13.90	0.016	0.004 - 0.019	26.88
BLA - 56	0.50	0.32 - 0.68	20.80	0.010	0.006 - 0.016	23.54
BLA - 273	0.40	0.30 - 0.54	18.30	0.012	0.007 - 0.020	33.85
M 10/4	0.33	0.25 - 0.41	17.30	0.009	0.005 - 0.015	25.50
M 6/1	0.42	0.28 - 0.54	15.60	0.008	0.005 - 0.016	28.64
K 27-1	0.36	0.24 - 0.48	23.40	0.011	0.008 - 0.015	17.60
M 76-1	0.39	0.28 - 0.53	16.40	0.009	0.005 - 0.012	23.60
H 4-7	0.36	0.29 - 0.46	13.37	0.009	0.004 - 0.013	21.16
K 10-2	0.23	0.18 - 0.29	15.74	0.009	0.005 - 0.022	60.83
BLA 139-1	0.42	0.36 - 0.48	8.74	0.006	0.005 - 0.010	19.90
BLA 256-1	0.33	0.23 - 0.42	16.80	0.008	0.005 - 0 011	20.40

C.V. Coefficient of variation

Table 9(e) Variability in chemical composition of cashew apples of seedling progenies of high yielding varieties (contd.)

(Values expressed as percentage of fresh apple)

Varieties	Phosphorus %			Iron %		
	Mean	Range	C.V.	Mean	Range	C.V.
Ansur 1-27	0.022	0.009 - 0.032	26.13	0.0010	0.0006-0.0018	75.90
Vengurla 36-3	0.027	0.020 - 0.038	20.65	0.0008	0.0006 - 0.0019	18.28
Sawantwadi	0.026	0.017 - 0.038	25.70	0.0013	0.0009 - 0.0027	33.54
Vengurla 37-3	0.019	0.011 - 0.030	29.50	0.0012	0.0004 - 0 0015	33.40
BLA-1	0.016	0.010 - 0.027	27.50	0.0009	0.0006 - 0.0016	28.40
BLA - 40	0.027	0.022 - 0.036	28.40	0.0015	0.0010 - 0.0020	29.00
BLA - 56	0.020	0.015 - 0.027	19.00	0.0011	0.0009 - 0.0016	20.00
BLA - 273	0.020	0.015 - 0.033	22.70	0.0013	0.0009 - 0.0015	24.00
M 10/4	0.019	0.011 - 0.029	24.27	0.0011	0.0008 - 0.0016	23.77
M 6/1	0.016	0.011 - 0.024	19.00	0.0009	0.0006 - 0.0012	19.44
K 27-1	0.021	0.016 - 0.032	18.60	0.0015	0.0011 - 0.0022	17.64
M 76-1	0.017	0.013 - 0.023	16.24	0.0012	0.0009 - 0.0017	16.50
H 4-7	0.018	0.014 - 0.023	14.46	0.0012	0.0009 - 0.0015	16.13
K 10-2	0.011	0.010 - 0.015	32.10	0.0008	0.0007 - 0.0010	13.83
BLA 139-1	0.012	0.009 - 0.019	29.90	0.0009	0.0007 - 0.0012	16.30
BLA 256-1	0.016	0.009 - 0.020	22.60	0.0011	0.0007 - 0.0014	21.10

C.V. Coefficient of variation

7. Correlation between average weight and percentage juice recovery for the progenies of the same variety

Correlation between average weight and percentage juice recovery of apples of the seedling progenies of all the sixteen varieties are presented in Table 10.

Table 10. Simple correlation coefficients and linear regression equations between average weight and percentage juice recovery of cashew apples of seedling progenies of high yielding varieties

Varieties	Mean average weight (g) x	Mean juice recovery (%) y	Simple correlation coefficient 'r'	Linear regression equation y = a + bx
Ansur 1-27	52.5	59.0	0.97**	40.52 + 0.35x
Vengurla 36-3	43.2	59.4	0.95**	29.23 + 0.70x
Sawantwadi	50.6	62.8	0.97**	23.36 + 0.78x
Vengurla 37-3	44.1	57.2	0.98**	23.70 + 0.76x
BLA - 1	52.9	65.7	0.96**	46.10 + 0.37x
BLA - 40	55.0	59.4	0.99**	40.67 + 0.34x
BLA - 56	50.7	58.5	0.99**	41.43 + 0.34x
BLA - 273	46.0	56.3	0.96**	42.00 + 0.31x
M 10/4	49.1	50.6	0.90**	21.10 + 0.60x
M 6/1	51.0	62.3	0.99**	50.00 + 0.24x
K 27-1	47.7	54.1	0.78**	45.90 + 0.17x
M 76-1	40.9	59.3	0.59	46.60 + 0.31x
H 4-7	48.0	64.3	0.98**	49.50 + 0.31x
K 10-2	74.1	63.3	0.71**	48.45 + 0.20x
BLA 139-1	42.4	60.6	0.87**	50.81 + 0.23x
BLA 256-1	32.5	59.00	0.78	48.30 + 0.33x

** Highly significant correlation at 1% level

Correlation coefficients between average weight and juice recovery of apples of seedling progenies within a variety were positive and highly significant as evidenced from the table. The linear regression equations for the different varieties were also found to be statistically significant.

DISCUSSION

DISCUSSION

Cashew apple which is an important by-product of cashew is not utilised to any great extent, at present. Eventhough this false fruit contains a good amount of nutrients like sugar, vitamin and minerals, it is not used for human consumption in raw form or as a processed product because of certain acrid and astringent principles which are not acceptable to the taste. Very little effort has been made in the past to critically analyse this valuable product and to find out methods of utilising it. If methods are found out to utilise it in a processed form, it will not only contribute to better returns from cashew growing but also will contribute to the production of substantial quantities of soft drinks, fermented and unfermented juice and other products like jam, jelly, candies etc. It is with the above objective in view that the present investigations were taken up, choosing sixteen improved varieties of cashew now being tested mainly for their yield and nut characters.

The cashew apple and its juice have attracted the attention of scientists from the earliest days. Gandvo (1576) has stated that cashew apple was a refreshing

fruit during the hot season. Dutta (1929), Jain et al. (1952), Khan (1961), Aiyadurai (1966) and a number of workers have described the morphological features of cashew apple of different trees. But their studies do not indicate the variability of cashew apple within the seedling progenies of the same variety.

It was found in the present studies that the colour of apples of different varieties can be grouped under three categories namely red, yellow and mixed shades of these two colours. Kramer (1966) has reported that uniformity in colour is desirable especially in cases where the fruit as such is utilised. In this respect the variety BLA-1 which produced yellow apples only, was found to be the best.

With regard to shape, cashew apples of different varieties come under four groups, namely conical, cylindrical pyriform and rhomboid. Shape of cashew apple has got a profound influence in determining its suitability for processing especially for canning. Apples of cylindrical shape was highly suitable for this purpose as they suffer minimum losses during trimming and handling. Present investigations showed that the variety K27-1 and Vengurla 37-3 have a high proportion of trees producing apples of cylindrical shape. Based

on their suitability in shape, apples of these varieties are recommended for canning.

The seedling progenies of all the sixteen varieties which were studied, exhibited variability in colour and shape in varying proportions. When both colour and shape are considered, the progenies of K27-1 showed the least variability.

In respect of the measurable physical characters like average weight, length, diameter and juice content of apples, the variety K10-2 was significantly superior to all other varieties. This variety produced the largest sized apples of 75.4 g weight, 9.4 cm length and 5.06 cm diameter. The smallest apples were produced by BLA 256-1 the mean weight being only 29.2 g. Such variability between different trees in the same plantation have been reported from Taliparamba and Nileshwar (Anon) and by many other workers - Sondhi (1962) and Anon(1967).

The maximum length ratio (length/diameter ratio) of 1.86 was recorded by the variety K 10-2, followed by K 27-1. Pantastico (1975) have recommended fruits of higher length ratio for more canning recovery. If this recommendation is taken into account, the maximum canning recovery can be expected from the apples of K10-2.

But due to the maximum colour variability and conical shape of apples K 10-2 is not recommended where as K 27-1 which is second in order of length ratio and has recorded lesser variation in colour and shape will be the best variety for canning.

The juice recovery in apples of different varieties has been found to be within a range of 44.9 to 64 per cent. These values are well comparable with the reported values of juice recovery by Jain *et al* (1951) 50 to 60 per cent, Johar (1957) 50 to 60 per cent, Sondhi (1967) 46.9 to 84.3 per cent and Anon (1967) 34.1 to 61.7 per cent. However, the percentage recovery of cashew apple juice obtained in the present studies is much less than the recovery percentage reported by Singh and Mathur (1953) 68.7 to 70.3 per cent.

Kramer and Twigg (1957) have reported that large size of fruit was desirable and economical provided the juice content was high. The results of the present study have shown that apples of K 10-2 have the maximum values for weight (75.4 g), percentage juice recovery (64.0) and juice content per apple (48.26 g) followed by Sawantwadi. It will be economic to select apples of these varieties for the extraction of cashew apple juice.

It was observed in the present studies that the chemical composition of cashew apple juice varied

between varieties as well as between the progenies of the same variety. According to Sreenivasan (1935) the T.S.S. in cashew apple juice was 10.4 per cent of which 9% per cent consisted of invert sugars. Joachim and Pannaithesekere (1940) found that the juice contained 320 to 350 mg of ascorbic acid per 100 ml of cashew apple juice.

Sondhi (1962) has studied the chemical composition of cashew apple juice and the range of variability in respect of major constituents namely T.S.S. (7.2 to 18.3 per cent) Acidity (0.1 to 0.7 per cent) sugars (5.3 to 17.7 per cent), total tannin (0.2 to 0.9 per cent) true tannin (0.0 to 0.7 per cent) and brix/acid ratio (14.2 to 104.3). Results obtained in the present investigation for all these juice constituents were within the range of the values reported by earlier workers.

The highest T.S.S. of 14.67 per cent and the specific gravity of 1.066 was recorded by the variety M 6/1. Kramer (1966) reported that in the processing of juice concentrates the solid content and the yield of juice are equally important and determine the cost of finished product. If this criteria is employed, M6/1 having a juice recovery of 60.5 per cent, T.S.S.of 14.67 per cent and a specific gravity of 1.066 will be the

best variety for the production of juice concentrates followed by K 10-2.

It was found in the present studies that the highest quantity of total and reducing sugars 13.37 per cent was recorded by the apples of the variety M 6/1 followed by Vengurla 36.3 which recorded a sugar content of 12.91 per cent.

The results of the present study have shown that the quantity of total sugars present in the juice and the quantity of reducing sugars in the juice were the same indicating that the sugar present in the juice is entirely reducing sugars. This result is in agreement with the findings of Siddappa and Bhatia (1954), Ventura and Hollanda (1958) and Chakravarty (1961).

It has been reported by a number of workers - Singh and Mathur (1953) and Morton (1970) - that the yellow apples were generally of superior quality as indicated by higher T.S.S. and sugar content and lower acidity, as compared to red apples. But the present studies have shown that such distinction was not true. It was found that the variety M 6/1 which produced 50 per cent progenies having yellow apples had a T.S.S. of 14.67, sugar of 13.37 per cent and acidity of 0.46 per cent

as compared to BLA-1 which produced 100 per cent yellow apple progenies and had a T.S.S. of 13.22, sugar per cent of 11.93 and acidity of 0.47 per cent. Thus it can be summarised that the quality of cashew apple juice was essentially a varietal character which is not determined by its colour, the only exception being Vengurla 37-3, a red apple variety which recorded the lowest T.S.S. However, higher T.S.S. and reducing sugar contents were recorded by the progenies of a variety producing yellow apples than the progenies of the same variety producing red apples.

Studies conducted at the C.F.T.R.I. have shown that maximum sugar content and acidity of 0.39 to 0.42 percentage as malic in cashew apple was desirable for the juice products like cashew apple juice, clarified juice cloudy juice and cashola. Accordingly, apples of M 6/1, Vengurla 36-3 and BLA-56 are found to be better for the preparation of juice products.

In ascorbic acid content, all varieties were found to be promising and K 27-1 topped the list with 321.16 mg/100 g juice followed by BLA-40 which recorded 308.68 mg/100 g. High amounts of ascorbic acid content in cashew apple juice is an important quality factor

for the production of cajuvita, a vitamin enriched juice (Johnson, 1972). On this basis, K27-1 and BLA-40 were the most suitable for 'cajuvita' preparation.

The tannin content which is responsible for the astringent taste was the minimum in BLA-40 (0.33 per cent) and the highest in Vengurla 37-3 (0.74 per cent). It is reported that the tannin and non tannin oil content categorised under total tannin can be effectively removed by steam and chemical treatments. Sastri et al. (1962) reported that steam treatment and chemical treatments were found to affect adversely the other nutrients of the apple. So selecting varieties having low tannin contents will be highly beneficial for the processing industry. In this point of view varieties BLA-40 having a tannin content of 0.33, H4-7 (0.37) and BLA 256-1 (0.39) are important.

The brix/acid ratio and sugar/acid ratio and oil content are found to be varying in different varieties. In respect of brix/acid ratio and sugar/acid ratio there was no significant difference between varieties.

In the present study, it was found that the variety M 10/4 ranked first in protein content (0.92 per cent) and pectin (0.72 per cent). Vengurla 37-3

topped the list in ether extractives (0.76 per cent) BLA-1 in carbohydrate content (11.13 per cent) and BLA-273 in crude fibre content. Similar composition in respect of the above constituents have been reported by a number of workers - Pariera et al. (1966), Anon (1967), Anon (1967a) and Anon (1976).

Earlier workers have reported that high content of pectin is essential for the preparation of cashew apple jam and cashew apple jelly. Apples of M 10/4 and Vengurla 36-3 which recorded high pectin content were found to be most suitable for jam and jelly preparations.

Bernard (1973) reported that carbohydrates are of significance in fruits as they are directly related with sensory attributes of flavour and texture. Similarly Remani (1978) reported that cashew apples if found to be rich in carbohydrate, can be recommended for wine making with least consideration to their tannin content. Apples of BLA-9 and Ansur 1-27 which were rich in carbohydrate were recommended for 'feni' making and for preparation where flavour and texture are important.

The varieties differ significantly in respect of total ash, acid insoluble ash, calcium phosphorus and

iron content in the apples. The total ash was the highest in BLA-40 and the minimum in K 10-2. In respect of mineral contents, results obtained are almost similar to that reported by earlier workers except in iron content which was much less than those reported earlier.

A number of studies have been made by different workers on the nutritive value of cashew apple residue obtained after the extraction of the juice. Chakravarty (1961) has reported that the residue contained 9.5 per cent protein on dry matter basis. Sondhi (1962) has recorded 9.12 per cent protein on dry weight basis, 8.2 to 11.2 per cent pectin on dry weight basis, 33 to 61.2 mg/100 g of ascorbic acid and moderate amounts of minerals like calcium, phosphorus and iron in cashew apple residue.

The residue analysis of the present studies showed that the variety M 10/4 had the highest protein content of 1.99 per cent on fresh weight basis followed by BLA-40 which had 1.82 per cent of protein. In pectin content BLA 139-1 tops the list (1.64 per cent) followed by 1.62 per cent in the type M 10/4. The residue also contained substantial quantity of ascorbic acid ranging from 44.3 mg/100 g to 65.61 mg/100g.

The high amount of pectin contained in the residue indicates the possibility for extracting pectin from the cashew apple residue on a commercial scale. As the residue is rich in protein and ascorbic acid, it can form a nutritive component of cattle feed.

In the present studies, it was found that there was positive correlation between the weight and percentage juice recovery of apples of different varieties. Highly significant correlation was recorded by the seedling progenies of the same variety. Sondhi (1962) and Aiyadurai (1966) have reported similar correlation between the weight of the apple and the percentage recovery of the juice. The present results are helpful to select cashew apples for juice extraction based on size of apple. The linear regression equations of percentage juice recovery of apples on weight of apples for the different varieties were also found to be statistically significant. These equations can be utilised for predicting the expected juice recovery of cashew apples if the weight of the fruit is known.

Variability in apple characters of seedling progenies of the different varieties were studied. It was observed that there existed variation between progenies of the same variety in respect of almost all important

chemical and morphological characteristics.

The varieties showing minimum variability with regard to different characters were identified in the present investigation. Variety K10-2 exhibited least variability with regard to total soluble solids, sugar content, brix/acid ratio, moisture and iron content. Among the varieties studied, apples of seedling progenies of Vengurla 36-3 showed maximum uniformity in average weight, and BLA256-1 in percentage juice recovery, total tannin and crude fibre. Minimum variability in acidity was recorded by the seedling progenies of Vengurla 37-3 whereas BLA-273 showed least variability in ascorbic acid content of apple juice. Lesser variability was recorded in sugar/acid ratio by Sawantwadi, protein content by M 10/4, ether extractives and phosphorus by M4-7 and calcium by K 27-1. Seedling progenies of BLA 139-1 recorded minimum variability with regard to pectin, total ash and insoluble ash. Varieties with least variability in physico-chemical composition of cashew apple will be an asset to processing industry.

In most of the studies conducted by earlier workers the variability reported was between the trees of unknown heridity and grown in different gardens. The present study differs from the earlier ones in the fact that the variability shown are in respect of

seedling progenies of the same mother plants. However, Damodaran (1977) had studied the variability in respect of the F1 hybrid progenies of different cross combinations. He found that there was considerable variability in respect of most of the economic characters of these hybrid progenies. The present study exphasises the need for adopting vegetative propagation methods for the multiplication of selected hybrids or superior mother trees available in the existing population to get superior quality apples with least variability in composition.

It may be seen from the foregoing discussions that there was variability in the physico-chemical qualities of cashew apples of different varieties as well as seedling progenies of the same variety. This indicates the necessity and importance of studying the qualitative aspects of cashew apples in the evolution of better varieties. Therefore, it is suggested that it should form an index of selection for evolving better varieties of cashew.

SUMMARY

S U M M A R Y

The physical and chemical characteristics of apples of sixteen varieties of cashew representing superior selections from the four Cashew Research Stations at Anakkayam (Kerala), Vridhachalam (Tamil Nadu), Vengurla (Maharashtra) and Bapatla (Andhra Pradesh) were studied during the period 1977-78 at the cashew plantation in the main campus of the Kerala Agricultural University at Vellanikkara.

The following were the main findings of these investigations:-

The colour of apple of different varieties came under three categories, namely, red, yellow and mixed shades of these colours.

The shape of apples was either conical, cylindrical pyriform or rhomboid.

Varieties differed in respect of the mean weight, length, diameter, length/diameter ratio and juice content of apples. The variety K 10-2 ranked first in respect of the above physical characters followed by Sawantwadi. Due to their better size and increased juice content apples of K 10-2 and Sawantwadi

can be utilised for the extraction of cashew apple juice.

Cashew apple juice of the variety M 6/1 recorded the maximum T.S.S., specific gravity and sugars. Varieties M 6/1 and K 10-2 are recommended for the production of juice concentrates based on their high juice recovery and solid contents.

The sugar content of the apple juice was entirely in the form of reducing sugars.

With regard to ascorbic acid content K 27-1 and BLA 40 ranked first and second. Apples of these varieties may be utilised for the production of vitamin enriched juices.

The tannin content which was mainly responsible for the astringency in juice was the minimum in BLA-40 followed by H4-7 and BLA 256-1.

No significant difference between varieties were observed in respect of brix/acid ratio and sugar/acid ratio.

Variety M 10/4 recorded the maximum protein and pectin content. Vengurla 37-3 topped the list in ether extractives and BLA-273 in crude fibre content.

Apples of M 10/4 and Vengurla 37-3 which recorded high pectin content can be recommended for jam and jelly preparations.

Apples of BLA-1 and Ansur 1-27 had the highest carbohydrate content and so can be utilised for 'feni' preparation.

The residue of cashew apple left after the extraction of juice was found to be rich in protein and ascorbic acid content and hence it may form a constituent of cattle feed.

Varieties BLA 139-1 and M 10/4 due to their high pectin content in residue may be utilised for extracting pectin.

The results of the study of apples collected from the progenies of different varieties showed that there was considerable variation between the progenies of the same variety with respect to almost all characters studied.

Based on the degree of variability represented by the coefficient of variation, the seedling progenies of the variety K 10-2 showed the minimum variability in respect of T.S.S., reducing sugars,

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brix/acid ratio, moisture content and iron. With regard to true tannin, pectin as calcium pectate, total ash and acid insoluble ash the variety BLA 139-1 had the minimum variability. In respect of juice recovery, crude fibre and total tannin, the progenies of BLA 256-1 showed the minimum variability.

The range of variation in mean weight of apple was minimum in Vengurla 36-3, in acidity Vengurla 37-3, in ascorbic acid content BLA 273, in sugar/acid ratio, Sawantwadi, in protein content of residue M 10/4 and in Calcium, K 27-1.

The study showed that there was positive correlation between the weight and juice content of apples of different varieties.

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APPENDIX I

Analysis of variance for average weight, length, diameter and juice recovery

MEAN SUM OF SQUARES

Source	df	Average weight	Length	Diameter	Juice recovery
Replication	2	0.14	0.06	2.37	9.49
Varieties	15	1045.36**	8.87**	7.81*	234.87**
Experimental error	30	106.43	0.95	3.75	28.45
Sampling error	96	95.75	0.77	4.07	21.82
C.D. (P = 0.05)		9.92	0.94	0.59	5.13

* Significant at 5 per cent level

** Significant at 1 per cent level

APPENDIX II

Analysis of variance for T.S.S., sugar, acidity, ascorbic acid, total tannin and true tannin

MEAN SUM OF SQUARES

Source	df	T.S.S.	Sugar	Acidity	Ascorbic acid	Total tannin	True tannin
Replication	2	0.65	0.46	0.055	600.36	0.005	0.004
Varieties	15	7.22*	7.74**	0.03NS	7834.41*	0.081**	0.013**
Experimental error	30	2.70	2.70	0.024	3549.81	0.014	0.004
Sampling error	96	2.08	1.98	0.017	2899.12	0.009	0.003
C.D.(P = 0.05)		1,57	1.58	--	57.35	0.11	0.064

N.S. Not significant

* Significant at 5 per cent level

** Significant at 1 per cent level

APPENDIX III

Analysis of variance for specific gravity, brix/acid ratio, sugar/acid rato

MEAN SUM OF SQUARES

Source	df	Specific gravity	Brix/acid ratio	Sugar/acid ratio
Replication	2	0.000009	220.09	19.60
Varieties	15	0.000227**	247.60NS	210.34NS
Experimental error	30	0.000066	287.45	155.37
Sampling error	96	0.000038	111.01	86.63
C.D. ($P = 0.05$)		0.0078	--	--

NS Not significant

** Significant at 1 per cent level

APPENDIX IX

Analysis of variance for moisture, protein, ether extractives, crude fibre and pectin

MEAN SUM OF SQUARES

Source	df	Moisture	Protein	Ether extractives	Crude fibre	Pectin
Replication	2	1.19	0.02	0.02	0.003	0.005
Varieties	15	5.17^{NS}	0.19**	0.085**	0.048**	0.192**
Experimental error	30	6.49	0.008	0.006	0.004	0.005
Sampling error	96	1.65	0.014	0.004	0.005	0.009
C.D.(P = 0.05)		--	0.084	0.075	0.059	0.070

NS Not significant

** Significant at 1 per cent level

APPENDIX V

Analysis of variance for total ash, acid insoluble ash, calcium, phosphorus and iron

MEAN SUM OF SQUARES

Source	df	Total ash	Acid insoluble ash	Calcium	Phosphorus	Iron
Replication	2	0.005	0.0013	0.000009	0.00001	0.000000075
Varieties	15	0.099**	0.049**	0.000067**	0.00019**	0.00000055**
Experimental error	30	0.006	0.0073	0.0000055	0.00002	0.00000008
Sampling error	96	0.01	0.0049	0.00001	0.00002	0.00000006
C.D. (P = 0.05)		0.072	0.082	0.0022	0.0044	0.00029

** Significant at 1 per cent level

APPENDIX VI

Analysis of variance for residue recovery, residue moisture, residue protein, residue pectin and residue-ascorbic acid

MEAN SUM OF SQUARES

Source	df	Residue recovery	Residue moisture	Residue protein	Residue pectin	Residue ascorbic acid
Replication	2	3.42	2.27	0.03	0.205	126.89
Varieties	15	109.50^{NS}	9.92**	1.16**	1.10**	313.87**
Experimental error	30	67.99	1.63	0.067	0.05	68.39
Sampling error	96	34.78	1.44	0.097	0.04	133.43
C.D.(P = 0.05)		--	1.23	0.25	0.22	7.96

NS Not significant

** Significant at 1 per cent level

QUALITY EVALUATION OF CASHEW APPLE OF HIGH YIELDING VARIETIES

By
VILASACHANDRAN, T.

ABSTRACT OF A THESIS

Submitted in partial fulfilment of the

requirement for the degree of

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COLLEGE OF HORTICULTURE

VELLANIKKARA, TRICHUR

1978

A B S T R A C T

Physico-chemical characters of cashew apple of sixteen varieties representing superior selections from the four Cashew Research Stations at Anakkayam (Kerala), Vridhachalam (Tamil Nadu), Vengurla (Maharashtra) and Bapatla (Andhra Pradesh) were studied during the period 1977-'78 in four year old trees of the cashew plantation in the main campus of Kerala Agricultural University at Vellanikkara.

The objective of the investigation was to identify varieties producing superior quality apples. Variability in qualitative factors of the apple of sixteen varieties as well as seedling progenies of the same variety was studied in detail.

The study revealed that the variety K 10-2 ranked first in respect of the mean weight, length, diameter, length/diameter ratio and juice content of apples. Variety M 6/1 recorded the maximum T.S.S., specific gravity and sugar. The sugar content of apple juice was entirely in the form of reducing sugars. With regard to ascorbic acid, K 27-1 topped the list. Minimum tannin was recorded by BLA-40. Maximum protein and pectin content was recorded by

M 10/4. Vengurla 37-3 stood first in ether extractives and BLA-273 in crude fibre content. Apples of BLA-1 and Ansur 1-27 had the highest carbohydrate content.

The residue of cashew apple left after extraction of juice was found to be rich in protein and ascorbic acid and so can be utilised as a constituent in cattle feed. Varieties BLA 139-1 and M 10/4 due to their high pectin content in residue may be utilised for extracting pectin.

The study showed that considerable variation existed between the progenies of the same variety with respect to almost all characters studied.

Positive correlation between the weight and juice recovery of apple was observed in all the varieties studied.