MATURITY AND POST-HARVEST STUDIES IN MANGO (*Mangifera indica* Linn.)

BY

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THESIS

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DECLARATION

I hereby declare that this thesis entitled "Maturity and Post-harvest studies in mango (*Mangifera indica* Linn.)" 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,
May, 1982.

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CERTIFICATE

Certified that this thesis entitled "Maturity and Post-harvest studies in mango (*Mangifera indica* Linn.)" is a record of research work done independently by Kumari Jessy. M. Kuriakose under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

Vellanikkara,
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CERTIFICATE

We, the undersigned members of the Advisory Committee of Kumari Jessy. M. Kuriakose, a candidate for the degree of Master of Science in Horticulture agree that the thesis entitled "Maturity and Post-harvest studies in mango (*Mangifera indica* Linn.)" may be submitted by Kumari Jessy. M. Kuriakose in partial fulfilment of the requirement for the degree.

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INTRODUCTION

INTRODUCTION

Among the pre-harvest factors affecting the quality and storage life of fruits the time of harvest is of considerable importance. The harvest has to be made at optimum maturity so as to ensure the post-harvest quality as well as storage life. While premature harvest mainly results in the poor quality of ripe fruits, overmaturity may end up in reduced storage life of the produce. Fixing of optimum maturity standards has therefore been one of the aspects, which has received considerable attention from the scientists engaged in the field of post-harvest physiology.

Mango is one of the major fruit crops grown in Kerala. However, research on mango in Kerala has, so far, been confined only to propagation and cultural aspects. The harvest of mangoes in the State at present is based on visual judgement rather than on scientific considerations. The cause of inconsistent quality of mango fruits available in the markets of Kerala could often be traced to harvesting of fruits at improper maturity. Fixing of optimum maturity standards for mangoes in Kerala will be of wider practical utility. Under the climatic conditions of Kerala the earliest possible harvest before the early rains has greater significance, since the quality of fruits are greatly impaired even by the early showers.

The storage life of mangoes all the more is affected by the stage of harvest. Designing inexpensive storage methods is as important as fixing optimum maturity standards. Harvesting of fruits at optimum maturity coupled with suitable storage method will ultimately help the fruit grower and consumer to reduce storage loss as well as to ensure the quality of fruits.

The present studies were taken up in order to study the physico-chemical changes taking place in five varieties of mangos viz., Bennet Alphonso, Mundappa, Suwarnarekha, Olour and Neelum in order to fix optimum maturity standards. Storage experiments were also taken up to find out the most suitable methods of storage for these varieties.

The suitability of the five varieties for canning was also assessed.

The objectives of the present series of studies may be summarised as follows:-

i) to study the physico-chemical changes of fruits during the course of maturity to fix optimum maturity standards

ii) to find out the best method of storage

iii) to study the suitability of the varieties for canning.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

The storage life of any fruit is largely governed by the stage of maturity at harvest, variety, method and conditions of storage mainly temperature and relative humidity. Each variety of fruit may respond in a different way to each method of storage which in turn depends on the stage of maturity at harvest. Biochemical and physical changes associated with growth and maturity of mango fruits and possible correlation between chemical constituents and quality of the fruit were the object of study of several workers in the past, which are briefly reviewed below.

1. BIOCHEMICAL CHANGES DURING MATURATION

1.1. Carbohydrates

The natural drift of metabolic changes in developing fruits of Krishanbhog and Langra varieties of mango at different growth stages have been studied by Singh et al. (1937) to find out whether there is any correlation with the above changes and the storage behaviour. They reported that the starch content of mangoes rose during the first 49 days and subsequently decreased, probably due to the hydrolysis of starch into sucrose, accompanied by a fall in acid content.

Leley et al. (1943) working on Alphonso mango found that during the period of adolescence (first 60 days) starch and nonreducing sugars increased continuously while reducing sugars decreased. The period of maturation (next 30 days) was biochemically characterised by the accumulation of starch, the increase being from 1% to 13% at the time of maturation. Soule and Hatton (1955) reported that immature fruits of Haden, Zill, Irwin, Sensation and Keitt varieties had low T.S.S. while mature fruits had higher T.S.S. (7.2-8.4) and T.S.S./acid ratio (6:1-23:1). An increase in starch content and T.S.S. during the picking season (May 10-July 29) was reported in Haden, Irwin, Zill, Sensation, Kent and Keitt varieties of mango by Soule and Harding (1956). In Egypt, Azzouni and Salama (1956) concluded that the evaluation of T.S.S. was an important index of maturity as the same increased with maturity in all varieties they studied (Hindi-Be-Zinnara-9%, Mabrouka-8.5% and Pairi-8%).

Popenoe and Long (1957) reported that starch content was related to maturity of hard green mangoes. The starch content at full maturity varied with variety. It was usually 5% in hard green mangoes while in Irwin and Zill varieties it was 7% and 12% respectively. The starch content, however, was not considered by them as useful commercial measure. Popenoe et al. (1958) on the other hand reported that Haden and Zill varieties of mango were acceptably mature when the

fruits contained 5% starch. They concluded that starch content of fruits was the best index for predicting maturity. Mukherjee (1959) reported that starch content increased from 0.5% to 9% at the end of the period of maturity in Dashehari, Langra and Fajri Zafrani varieties. He considered this factor as quite useful in judging the correct stage of maturity.

Harding and Hatton (1967) found a close association of starch content and maturity of fruits. Teaotia et al. (1967) working on maturity determination in Langra mango found that the starch content and starch-to-acid ratio were the best indices for judging fruit maturity. The fully mature fruits had the highest starch-to-acid ratio of more than 4.

From an investigation on maturity indication in mango varieties - Dashehari and Langra - Singh (1967) concluded that 50% of the total starch at maturity was strongly correlated to maturity of unripe mangoes as indicated by organoleptic tests after artificial ripening. As the period of maturation advanced the T.S.S. and T.S.S./acid ratio increased and these constituents also had strong correlation with maturity.

Supporting Leley et al. (1943), Mukherjee (1959) and Popence and Long (1957), Lakshminarayana et al. (1970) from

their study on developmental physiology of mango fruit concluded that accumulation of starch continued at a slow rate from 0% to 4% upto 12th week and at a rapid rate from 4% to 9% during 12th to 16th week period. According to them the nonreducing sugars and total sugars in the initial samples showed a gradual increase upto the stage of full maturity whereas the reducing sugar content (3%) was reduced to a lower level (2%). Askar et al. (1972) also supported this view and he emphasised the T.S.S. content as a possible parameter for predicting maturity.

Singh et al. (1976) reported that fully mature fruits of variety Neelum were characterised by T.S.S. (11.6%), total sugars (8.1-8.2%) and starch content (6.6-6.7%). According to Singh et al. (1978), the T.S.S. percentage and starch/acid ratio were the indices of maturity for the cultivars Taimuria and Sukul.

1.2. Acidity

Singh et al. (1937) reported that the acidity of peel and the kernel decreased during the period of adolescence and the same in the flesh showed a gradual decrease during the period of maturation along with the accumulation of starch. Leley et al. (1943) found a gradual decrease in acidity when the fruits reached maturity. The acid content of the fruit was not found to be a good criterion for

maturity in Haden, as it did not change appreciably until ripening (Harkness, 1949).

Harding et al. (1954) reported that, in general, the pH value of juice increased as picking season advanced. Similar results were reported by Soule and Hatton (1955) in Florida mangoes. Azzouni and Salama (1956) reported from Egypt that a continuous increase in pH value occurred as the fruits of Hindi, Pairi and Mabrouka varieties advanced towards maturity. They concluded that in all the three varieties, the fully mature fruits had a pH value of about 3.

Singh (1967) reported that though in the varieties Dashehari and Langra the active acidity (pH) showed a slight and continuous increase, unlike Langra it was not correlated with maturity in Dashehari. Krishnamurthy and Subramanyam (1970) also showed the possible correlation of pH with maturity.

Lakshminarayana et al. (1970) reported that in the variety Alphonso the acidity reached its peak around 8th week and it decreased at harvest maturity being only 3% in the flesh. In the peel the acidity decreased during the period of adolescence and thereafter it remained steady at 1% till harvest. Askar et al. (1972) also supported this view.

1.3. Ascorbic acid content

The ascorbic acid content of the fruits greatly contributes towards quality especially in respect of its nutritive value. This constituent is subjected to frequent changes during growth, maturation and ripening of mango fruit. Since mangoes are very rich source of ascorbic acid, some efforts were made to correlate it with fruit maturity.

Crawford and Perry (1933), though tried to correlate ascorbic acid content with maturity, observed no clearcut and striking relationship between these two. Mustard and Lynch (1945) found that Florida mangoes when picked at the beginning of change of colour had a lower ascorbic acid content than either fully ripe or green mangoes. Harding et al. (1954) also found that there was little connection of maturity with ascorbic acid content of mango fruit, though they found a gradual decrease in ascorbic acid content throughout the picking season. A similar decrease in ascorbic acid content was reported by Soule and Hatton (1955).

As the fruits reached maturity a downward trend in ascorbic acid content was reported by Spencer et al. (1956) and according to them little change accompanied the maturation period in Amini, Mulgoa, Pico, Dashehari, Langra and Fajri varieties of mango. Azzouni and Salama (1956) reported

that in general, the highest ascorbic acid content was present in freshly picked mature fruits and thereafter a gradual decrease took place until the minimum level reached in the ripe fallen fruits.

Singh and Chadha (1961) reported that the ascorbic acid content (317.18-570 mg/100 g of flesh) decreased during the first seven weeks after fruit set to a very low level (12.2-105.4 mg/100 g of flesh). Singh (1967) reported that the ascorbic acid content could not be correlated with maturity in varieties Dashehari and Langra. He found that though in the variety Dashehari the ascorbic acid content decreased gradually, no distinct and consistent change in ascorbic acid content was noticed in Langra.

Lakshminarayana et al. (1970) reported that in the variety Alphonso the ascorbic acid content of the whole fruit increased soon after fruitset, reached its peak value around 5th week, declined thereafter upto 8th week and then remained more or less steady till harvest. They reported higher ascorbic acid content in the peel compared to flesh and suggested that it might be due to the presence of phenolic constituents which react with 2,6-dichlorophenol indophenol. Lakshminarayana (1973) reported that during ripening the fruits from different pickings undergo change in chemical constituents such as ascorbic acid, titrable acids, carbohydrates and carotenoids in a similar trend characteristic of a fully mature ripening fruit.

1.4. Tannin content

The tannins are markedly astringent in taste. These influence the eating quality of the fruit to a great extent. Since fruits of some varieties contain appreciable quantities of tannins there exists the possibility of relating the tannin content of fruits with maturity.

Harding and Soule (1958) reported that the phenolic compounds (tannic acid) generally remained constant from one picking to another in various mango varieties grown in Florida. But it was found that tannins decreased gradually as mango fruits reached maturity. Though present in relatively small quantities they could be suitably employed as indices of maturity (Azzouni and Salama, 1956). Singh (1967) reported that in the varieties Langra and Dashehari the tannin content (as gallotannic acid) decreased as picking season advanced and appeared to have some relationship with fruit maturity. Lakshminarayana et al. (1970) reported that in initial stages of development the fruits of variety Alphonso were highly astringent, but it decreased towards maturity.

1.5. Maturity indices

The study of the metabolic changes in developing fruits of Krishanbhog and Langra mango by Singh et al. (1937) revealed that the growth rate increased during earlier stages

and gradually declined with age. The respiration index of the fruit showed 2 maxima, one during the early stages and the other during the senescent stage. At all stages of development, respiratory drift ran fairly parallel the percentage of reducing sugars. It was experimentally shown that the decline in respiratory activity was due to the hindrance of the gaseous exchange through the hard endocarp and fleshy mesocarp. An inverse relationship was indicated between the acid contents of the fruit and the respiration quotient. He divided the life cycle of mango fruits into four stages, each characterised by certain physiological and chemical changes - juvenile phase (7-21 days), adolescent phase (21-49 days), climecteric phase (49-77 days) and senescent phase (77 days).

Leley et al. (1943) studied the physiological changes occurring in Alphonso mango during growth and ripening. He divided the life of the fruit (105 days) into 3 phases - adolescence (first 60 days), maturation (next 30 days) and senescence (next 15 days). He suggested to harvest the fruit at the highest weight during the period of maturation when respiration remained at a constant low value. The particular time of harvest in this preclimacteric phase depended on the type of storage and transport conditions.

Lakshminarayana (1973) reported that though the harvested fruits underwent climacteric in CO_2 production irrespective

of the stage of development, the length of preclimacteric phase depended principally on the stage of maturation of the fruit when out. Various workers have suggested different criteria to assess maturity index at harvest of the fruit to suit different purposes.

The skin colour in mango is essentially due to the presence of pigments in a few cell layers near the surface of the fruit. The fruit colour along with general appearance is commonly used as an index of maturity by the consumers while making purchases. These characteristics, however, seem to change continuously throughout the life of the fruit especially during maturation and ripening.

Cheema and Dhani (1934) working on export of Alphonso mango to Europe reported four different stages of maturity termed as A, B, C and D, based on shape, size and colour of the fruit. The fruits having shoulders in line with the stem-end and olive green skin colour were identified with stage A. The stage B was indicated by the shoulders outgrowing the stem-end and olive green skin colour of the fruits. During the stage C the shoulders of the fruit outgrew the stem-end and skin colour lightened towards yellow. The stage D included ripe fruits having typical flush developed on the skin and were considered suitable only for local markets. They considered stage B as the best stage for picking unripe mangoes for export.

Leley et al. (1943) reported that at the time of maturation, fruits of variety Alphonso had their shoulders outgrown the stem-end, together with lightened skin colour and yellow flesh. Marloth (1947) suggested that in South African mango varieties (Peach and Sabre) the 'black' green colour disappeared at maturity. Harkness and Cobin (1950) concluded that Haden mangoes could be picked based on the percentage of colour-break fruits.

From the study on standardisation of maturity in varieties Dashehari and Langra, Singh (1967) suggested that in Dashehari the skin colour changed from green to light yellow especially near the stem-end as the fruit reached maturity, whereas in Langra there were no colour changes. Jacobs (1970) reported that the stage of maturity for air export in cv. Haden was when the dark green colour had acquired a yellowish tinge starting from the bloom end and also a change in flesh colour from white to yellow starting from the seed. Rao et al. (1970) reported that the skin colour was not a reliable index of maturity in var. Beneshan.

Malevski et al. (1977) reported that the external colour would serve as maturity index in the cv. Haden. Both maximum yellow and maximum red colour intensity could serve as good indices.

Krishnamurthy and Subramanyam (1970) suggested that the parameters for optimum maturity of the fruit of variety Pairi

were olive green surface colour and 200 ± 20 g in weight with outgrown shoulders. Lakshminarayana et al. (1970) observed that Alphonso mangoes reached harvest maturity in 16 weeks after fruitset. The weight continued to increase till harvest. The growth of fruit in terms of length, diameter and weight slowed between 9 and 14 weeks at the time of development of the stone. The moisture content of the fruit at maturity was about 80%. Lelyveld (1975) reported that rapid growth rate started to decrease in mature fruits with an average length of 80 mm. Lelyveld and Smith (1979) reported that fruits that would sink in water have attained physiological maturity. The practical method to assess this stage was when a combined 15% slowly rising and sinking fruits were found.

Popenoe and Long (1957), Harding and Soule (1958) and Mukherjee (1959) suggested that specific gravity was a determining factor associated with maturity. According to Mukherjee (1959), the specific gravity fell in early stages from 0.985-1.02 to 0.96-0.985 upto 4th week and then increased to 1.03. Jacobs (1970) reported that fruits of Haden variety reached harvest maturity with a specific gravity of 1.02. On the contrary, Rao et al. (1970) reported that since sinkers and floaters (in water) alike produced ripened fruits of satisfactory quality, specific gravity might not be a good index of maturity. Singh et al. (1976) reported specific gravity

of 1.037 with fully mature fruits of variety Neelum. Singh et al. (1978) also confirmed specific gravity as a reliable index of maturity. According to him, the optimum time of harvest for Taimuria and Sukul cultivars were the second weeks of July and August respectively.

Mann and Singh (1976) reported that number and colour of lenticel might serve as indices of maturity. With Dashehari, lenticel numbers per unit area declined with advancing fruit maturity. With Langra, the same remained fairly constant. With both Dashehari and Langra, enhanced palatability was associated with later picking accompanied by a change in lenticel colour from creamy white to brown.

Rao and Srinath (1967) studied the important role of atmospheric temperature in determining the time taken from flowering to maturity of mango fruits. Their study was based on the observations by Oppenheimer (1947) and Osterwalder (1949) that it was possible to forecast the date of maturity of fruits in normal seasons, once the average temperature sum of a variety was worked out for a number of seven years. They concluded that the normal maturation period of the fruit (var. Beneshan) was 117 days on an average with a standard error of 0.66. 1426 $\pm$ 44.8 CDD (Centigrade Degree Days) were approximately needed for Beneshan mangoes to attain maturity in Palestine areas. In support of this view Iyer et al. (1976) found that the fruits on periphery of the tree reached maturity earlier than fully shaded fruits in the interior with higher

fruit weight, higher percentage of edible matter, higher TSS, higher glucose, fructose and sugar/acid ratio.

Teaotia and Bhan (1966) reported that to obtain high quality Indian pineapples, it could be harvested when the specific gravity was in the range of 0.98 to 1.02, TSS content 14.8 to 17% and TSS/acid ratio 20.83-27.24 and when the fruit had developed a yellowish to brownish yellow colour. Earlier harvesting is possible when the TSS is 10&12.5 and skin colour is greenish yellow. Chandha et al. (1972) reported that for canning purpose pineapple fruit (var. Kew) should be harvested within 150-160 days of maturity.

Tripathi and Gangwar (1971) revealed that for guava (var. Chittidar) specific gravity was a good index for fixing maturity.

2. CHANGES DURING RIPENING

2.1. Carbohydrates

Leley et al. (1943) reported that starch was completely hydrolysed during ripening in Alphonso mango with the formation of sucrose. Further studies by Mukherjee and Prasad (1972) and Gutierrez et al. (1976) supported their view and reported a gradual increase in sucrose, glucose and fructose with progress of ripening. Modi and Reddy (1967) observed five fold increase in the total pentose content and observed that synthesis of fructose was 1.5 timesmore than that of glucose.

2.2. Organic acids

The nonvolatile organic acids were among the major cellular constituents undergoing changes during ripening. The citric acid, malic acid and ascorbic acids decreased during ripening with a pH shift from 2.0 to 5.5 (Modi and Reddy, 1967; Mattoo, 1969 and Baque *et al.*, 1977).

2.3. Proteins and aminoacids

In mango 19 common aminoacids have been detected, of which alanine, tryptophan, isoleucine, valine and glycine increased progressively with ripening whereas lysine, proline and threonine were catabolised during ripening and a small net increase in protein content occurred during ripening (Mattoo, 1969). This was contrary to the report by Vines and Grierson (1966) that a consistent decline in aminoacids occurred during ripening in carambola.

2.4. Lipids

Ripening was associated with an increase in glyceride content and change in fatty acid composition. Considerable increase in the levels of total lipids has been observed in the ripening mango (Bandyopadhyay and Gholap, 1973).

2.5. Volatile products

The volatile components were responsible for the specific odour of fruits. Ethylene was one of the most important

volatile compounds produced during climacteric by the fruits. It being an autocatalytic accelerator of ripening, stimulates activities of catalase and peroxidase by inactivating their inhibitors (Biale et al., 1954; Burg, 1962 and Mattoo and Modi, 1969).

2.6. Enzymes

The chemical and physical changes during ripening were mainly attributed to enzymes. The enzyme activity was mainly regulated by β carotene and fatty acids (Mattoo et al., 1968). The main enzymes were catalase, peroxidase, glycolytic enzymes, hydrolytic enzymes, invertase, transaminases, citrate cleavage enzymes and chlorophyllase. The inhibitors of the enzymes disappeared during ripening (Pantastico et al., 1975).

2.7. Tannine

Pope (1929) reported that there was considerable amount of tannin in the harvested fruits which decreased considerably as ripening proceeded. Singh (1967) observed that mature mango fruits contained 2.675 to 3.305 per cent of tannins (as gallotannic acid) which decreased during ripening (1.365-0.470).

2.8. Pigments

Pantastico et al. (1975) reported that after the fruit was mature chlorophyll degradation would be started by the enzyme chlorophyllase. There was drastic synthesis of

carotenoids during the last stages of ripening.

2.9. Pectic substances

Pentzer and Heinze (1954) reported that the insoluble intracellular and cellwall constituents such as pectin compounds and hemicellulose were degraded at later stages of ripening by respiratory mechanism. Therefore, as the fruit ripened, insoluble protopectin decreased and soluble pectin increased. When fully ripe, the pectic substances again decreased forming pectic acid. Pectin and its hydrolytic products formed a good source of volatile emanations.

3. PRESERVATION

The harvested fruit is a variable biological system which undergoes a succession of complex changes - physiological and biochemical - at the expense of the stored food material which declines and accelerates the process of aging as evidenced by change of colour, texture, flavour and quality (Dalal and Subramanyam, 1970). Several workers have tried to limit these post-harvest physiological activities and extend the shelf life of mango fruits, adopting different storage methods.

The fruits respire by taking in oxygen and giving out CO_2 and heat. There is also loss of moisture from the fruits through natural pores by transpiration. The enzymatic breakdown of reserves and lose of resistance to microbial invasion

reduce the storage life of fresh fruits. Removal of heat without loss of quality is the most desired method for extension of storage life of fruits. Pre-cooling and refrigerated storage at optimum conditions reduce the metabolic rate with relative increase in storage life (Dalal and Subramanyam, 1970).

Mann and Singh (1975) in their study on the effect of pre-cooling (hydrocooling) on Langra fruits whether it would be able to withstand certain transit period before it was put in cold storage, concluded that Langra mangoes at different stages of maturity after precooling and then two or four days exposure to room temperature could be successfully stored for 35-45 days, depending upon the stage of maturity. Pre-cooling helped in increasing the satisfactory storage life by way of suppression of intensity of respiration and prolongation of the duration of respiratory climacteric. When fruits were picked from the tree, the rate of respiration became faster and the process of pre-cooling removed field heat and saved the fruit from meeting an early physiological death. Fruits of advanced maturity remained in good condition only for shorter duration due to the short preclimacteric phase after separation from the tree.

Studies at Central Food Technological Research Institute, Mysore (CFTRI) have shown that pre-cooling of mango in air or by water prior to storage at optimum cool temperature was

not useful in controlling the low temperature breakdown. Incorporation of scald inhibitors, fungicides and ripening stimulants in water used for hydrocooling was of little use in controlling the low temperature breakdown (Dalal and Subramanyam, 1970).

The mango fruit has short storage life at ambient temperature and is vulnerable to microbial infection during storage. Investigations on cold storage of mangoes at The Cold Storage Research Scheme Laboratories, Kirkee, India have shown that fruits at B and C stages of maturity were suitable for cold storage (45-48°F) and storage below 45°F resulted in severe pitting and rotting of fruits without ripening on transference to 68°F or to room temperature (Cheema et al., 1939).

From the study on cold storage of Indian fruits, Karmarkar and Joshi (1940) reported that out of 28 varieties of mango tested only six were found to keep well in cold storage (45-48°F). Ripe yellow fruits turned brown at 52°F and below. Only fruits which were still green and hard kept well at 45-48°F and ripened satisfactorily at ordinary temperature. Below 45°F, the fruits suffered from chilling injury with pits and sunken areas on the skin and the same was very severe at 35°F.

Work at CFTRI (1952) has shown that fully grown fruits of Raspuri and Seedling mangoes had a storage life of 42 days when the same were stored at 42-45°F (RH 85-90%) whereas Alphonso mangoes had a storage life of 28 days (47-50°F and 85-90% RH). Such fruits ripened uniformly at a temperature

of 62-65°F after removal from cold storage. Singh et al. (1952) reported that the optimum conditions for cold storage of Bangalora were storage temperature of 42-48°F and RH of 85-90%, the storage life being 7 weeks.

Vickers (1964) reported that three varieties of mango ie., Apple, Boribo and Ngowe were stored at 40-44°F for two, three and four weeks respectively. The score for appearance and taste of mature fruits after two weeks was highest for apple. Apple and Ngowe ripened rapidly after removal from the store and were suitable for consumption only if they were marketed close to the port of unloading. Jacobs (1970) reported that for cold-stored fruits susceptibility to cold injury varied with ripeness of fruits and temperature of storage and a high incidence of decay occurred in fruits from orchards subjected to very thorough pest control measures. Dalal and Subramanyam (1970) reported that fruits stored at 50, 55 and 65°F were soft and their peel developed yellow colour. But such fruits showed greater loss in weight, failed to ripen and were highly susceptible to infection. In contrast, green mature mangoes stored at 85°F ripened uniformly with development of desired aroma, flavour, colour and taste with reduced storage life of 12-15 days. Srivastava et al. (1971) observed no marked deterioration in either variety (Neelum and Romani) for the first 62 days of storage at 4°C when they were placed at the climacteric stage, except for a

considerable decrease in the Vitamin C content. Sadasivan (1971) reported that fruits of Neelum showed chilling injury at 6 ± 1°C and 9 ± 1°C within 15 days. Therefore, fruits of this variety should be stored at a temperature above 9 ± 1°C. Aziz et al. (1975) observed positive correlation between rising storage temperature (0 to 15°C) and loss of acidity as well as fall of alcohol - insoluble solids.

Mukherjee and Srivastava (1979) reported that the freezing point of juice was lowered as TSS content of the fruit increased by gradual hydrolysis of starch to sugars at room as well as low temperature. Therefore, by gradually increasing the T.S.S. chilling injury even at 5.5°C could be eliminated that would otherwise have chilled at 7°C.

Lakshminarayana and Subramanyam (1970) reported that fermentative decarboxylation occurred in cold stored mangoes (var. Alphonso) in atmosphere containing 10 or 15% carbon dioxide. Singh (1977) reported that in gas storage with different concentrations of CO_2 at 45°F, 48°F and 52°F, Alphonso mangoes suffered either from internal breakdown or rotted more quickly than fruits kept under ordinary cold storage conditions.

Kane and Marcellin (1979) reported that mango fruits (vars. Amelie and Julie) with least storage rot and best eating quality would be obtained when stored in an atmosphere containing 5% CO_2 and 5% O_2 and the storage life was four weeks.

Apelbaum et al. (1977) reported that ripening of mango fruits was markedly delayed when the pressure in the storage chamber was reduced to below 100 mm Hg. The prolongation of storage life was inversely related to the pressure. Fruits stored at 75 mm and 100 mm Hg pressure started to ripen only after 35 and 25 days respectively as against 16 days in the case of control fruits (760 mm Hg). All fruits stored at subatmospheric pressure ripened 3-4 days after transference to shelf life at 25°C. Below 50 mm Hg. the fruits were dessiccated. The application of wax emulsion to freshly harvested fruits protects them from excessive moisture loss, higher rate of respiration and heat build up or thermal decomposition and as a result the texture and quality of the fruits will be maintained as near the fresh condition as possible for a long time. Incorporation of an approved fungicide to wax emulsion protects the fruits from microbial spoilage (Dalal et al., 1971).

Mathur (1956) reported that fruits of mango (var. Badami) treated with 2.7% solids of aqueous fungicidal wax emulsion and stored at room temperature were kept for 19 days as against 12 days for the control. This treatment was found to lessen physiological loss in weight, increase retension of vitamin C and moisture, delay ripening and decrease wastage. Singh et al. (1967) reported that out of various wrapping materials, perforated polythene wae most effective to lessen physiological loss in weight at a temperature of 54°C.

At CFTRI, two aqueous wax emulsion composition (W and O) were standardised containing 12 per cent total solids, for extending the storage life of fresh fruits and vegetables. The research at CFTRI have shown that for mango fruits the best concentrations of wax emulsion (W) are 6 or 4 per cent with incorporation of suitable fungicides (SOPP WE - 0.5% or Flit 406 WE - 0.4% or Flit 406 PHS BWE - 1%). The storage life of Alphonso, Badami, Bombay-Calcutta and Himsagar - Calcutta were 18, 14, 8 and 6 days respectively as against 11, 7, 6 and 4 respectively in the control with wax emulsion (W/b) at ambient temperature (70-90°F). Storage temperature above 110°F was found uneconomical. It was estimated that for waxing 100 mangoes it costed only 26 paise (Dalal et al., 1971). On the contrary, Ram and Date (1971) considered waxing (containing 6.4% SOPP) uneconomic for Taimuria and Kataki Bihar, since the storage life was extended by only three days.

Deol and Bhullar (1972) reported that weight loss and losses due to diseases and physiological disorders were the least with fruits (var. Samar Bahist) stored (at room temperature) after treatment with fungicidal wax.

Singh et al. (1967) and Deol and Bhullar (1972) studied the effects of wrapping materials and growth regulators on the storage life of mango fruit and concluded that at 34°C weight loss was least with perforated polythene compared with cellophane tissue paper for the varieties Dashehari and Samar Bahist.

Cuevasruiz et al. (1972) reported that gamma irradiation (75 Krad.) of five Puerto Rican mangoes extended the shelf life by seven days at 68°F and delayed fungal spoilage. Irradiation had no appreciable effect on ascorbic acid, carotenoids, carbohydrate and total acidity of the fruit.

Canning is one of the process of permanent preservation of mango. There is a lot of scope in India for canning industry since mangoes are harvested in large quantities. In India, mangoes are usually canned in the form of slices. Only ripe, but firm ones of good variety are well-suited for the purpose. The Indian varieties Dashehari, Safeda and Alphonso have proved to be best suited for this purpose (Singh, 1960).

The Pilot-plant studies at CFTRI on the processing of important tropical fruits and their economic stability have proved that for canning 686 mangoes, it costs Rs.713/- when cans of 1 lb butter size were used (Pruthi et al., 1955).

Studies at Philippines on the acceptability of canned mango juice from four varieties, at three colour stages of maturity, have revealed that the variety Picco is the best followed by Carabao, Katchamita and Sipsipin in the decreasing order of acceptability. Juice from firm yellow fruit was preferred to that from fruit at less advanced or more ripening stages. The results of analysis of the relation between acceptability of canned juice and the physical and chemical

properties of the fresh fruit indicated that pH, TSS and total titrable acidity of the fruit were better guide than penetrometer readings to the adequacy of fruit for processing (Leon and Lima, 1966).

Effect of post-harvest treatments on control of serious storage diseases (Anthracnose decay and stem end rot) of mango

Wang et al. (1964) reported that, of several post harvest treatments (hot water - 126°F, Dithane M-22 and Dowicide A-1%), hot water treatment for ten minutes gave very good control of anthracnose (Colletotrichum gloeosporioides) decay, when stored at 42.8° or 86°F. Jacobs et al. (1973) reported that post-harvest immersion of green mature fruits in a benomyl suspension (55°C) for 5 minutes gave excellent control of anthracnose during storage at 10°F. On the contrary, Spadling and Reeder (1972) reported that dipping in water, benomyl, thiabendazole or SOPP at 130°F for 5 minutes gave almost complete control of anthracnose decay whereas the same at 70°C for two minutes failed to control rot.

Research at CFTRI have shown that hot water (52°C) alone gave good control of diplodia stem end rot (Diplodia natalensis)/anthracnose decay when applied one day after harvest, in the varieties Alphonso and Pairi. Hot water (52°C) + Zineb (0.375%), one or seven days after harvest or hot water + sodium diethyl dithio carbomate (0.4%) seven days

after harvest also improved colour, texture and aroma after seven days, with the onset of delayed climacteric (Subramanyam and Moorthy, 1973).

Chang (1975) reported that post-harvest hot water (52-54°C) treatment of Irwin mangoes for 10-30 minutes gave fungistatic effect and were safely stored at a temperature of 20°C. Singh and Bhargava (1977) were of the opinion that dipping guava fruits for five minutes in Benlate 2000/3000 ppm + 0.2% V/V paraffinic mineral oil and water (25 ± 1°C) gave very good control of post harvest diseases.

Studies at IARI have shown that diplodia stem end rot spread through the vascular system of pedicel and it caused development of only unripe fruits. Removing the infected pedicels from the stored mangoes was recommended to enable slightly infected fruit to be used for local consumption. The pedicel should be cut so as to leave about 0.5 cm and the cut-end coated with Bordeaux paste (Srivastava and Urgapal, 1965).

MATERIALS AND METHODS

MATERIALS AND METHODS

These investigations were carried out in the College of Horticulture, Vellanikkara, during the year 1979-81. Twenty three year old trees, growing in the Instructional Farm, Mannuthy, were selected for the different field observations and the laboratory work was done in the College of Horticulture. Five different varieties viz., Bennet Alphonso, Mundappa, Suwarnarekha, Olour and Neelum were included in the studies.

Sampling methods

Studies on maturity of the fruit were conducted adopting the completely Randomised Design (CRD) and there were four replications for each treatment. Fruits of same maturity (days) were marked and observations were taken at seven days intervals starting from A stage (60-74 days after fruit set depending on variety). The following physical and chemical characters were recorded at the time of each sampling.

1. PHYSICAL CHARACTERS

1.1. length

1.2. girth (maximum)

1.3. weight of whole fruit (average of 10 fruits)

1.4. volume (by water displacement method)

1.5. specific gravity (weight/volume)

2. CHEMICAL CHARACTERS

The following chemical components were analysed after taking appropriate samples.

2.1. starch

2.2. sugars (reducing, nonreducing and total)

2.3. titrable acidity

2.4. ascorbic acid content

2.5. T.S.S.

2.6. vitamin A (as carotene)

2.7. drymatter content

2.8. moisture content

1. PHYSICAL CHARACTERS

For the study of following physical characters, four samples of ten fruits were drawn from four trees.

1.1. length

1.2. girth

1.3. weight

1.4. volume

1.5. specific gravity

The length was measured from the base to the apex of the fruits using a vernier calipers. Girth was measured at the maximum point using a non-elastic twine and a centimetre scale. All these measurements were made in centimetre. Weight of

in hot air oven at 70°C till there was no further reduction in weight. The moisture content was worked out as the loss in weight as a result of drying and expressed as percentage of the fresh weight.

3. STANDARDISATION OF THE STAGE OF HARVEST OF FRUITS

Along with fruits harvested for assessing the physico-chemical changes, ten fruits of the same maturity (days) were ripened in wooden boxes. The temperature at which the fruits were kept for artificial ripening was 30 ± 1°C (R.H. 85-90%).

Organoleptic tests were carried out by a panel of ten judges and they rated the quality of the fruits by assigning marks, adopting the rating given by Singh (1967).

Caregory	Marks
Poor	<1.01
Fair	1.01 to 2
Good	2.01 to 3
Excellent	3.01 to 4

The average score was worked out for each sample from the ratings made by the panel of judges and comparisons made. The palatability ratings (score) was considered as the criteria of maturity of the fruits.

STORAGE STUDIES

Storage studies were conducted using fruits from three

stages of maturity adopting seven methods of storage at two temperatures as detailed below.

Stages of maturity

1. A (S_1)
2. B (S_2)
3. C (S_3)

Methods of storage

1. Polythene bags (300 gauges)
2. Polythene bags (250 gauges)
3. Polythene bags (150 gauges)
4. Polythene bag (300 gauges) + waxing
5. Waxing of the fruit
6. Polythene bag (300 gauges) + $KMnO_4$
7. Control

Temperatures

1. 6 $\pm$ 0.5°C
2. Room temperature (28-30°C)

Ten fruits of the same stage of development (A, B and C) selected at random from the periphery of the trees constituted one treatment. All the 42 treatments were tried in five replications. Soon after separation from the tree, the fruits were dipped in hot water (52-54°C) for 10 minutes (Chang, 1975) in order to get fungistatic effect against Colletotrichum gloeosporioides and then cooled to room temperature.

The hot water treated fruits were kept in polythene bags punched on an area of 2 cm^2, at the rate of 0.25 sq.cm per punch for aeration and then sealed and stored.

Polythene bag (300 gauges) + waxing

The waxed fruits were placed in punched (2 cm^2) polythene bags of 300 gauge, sealed and stored.

Waxing of the fruit

The hot water treated fruits were dipped in paraffin wax emulsion (4%) containing Benlate (0.1%).

Benlate (2 g) was added to the melted, undiluted paraffin wax and the latter was then diluted to 4% by adding two litres of distilled water to 80 g of paraffin wax and then stirred well so as to form a colloidal suspension.

Polythene bag (300 gauges) + $KMnO_4$)

About 125 g of well dried sawdust taken in cloth bags was soaked in saturated potassium permanganate solution for half an hour and excess solution was drained off before keeping in punched polythene bags containing the hot water treated fruits and the bags were then sealed.

Control

The fruits were kept in well aerated wooden crates and then artificially ripened in paddy straw.

One fruit from each replication was sampled out at 4 days intervals from all the treatments for determining

the lose in weight and quality analysis. The chemical characters viz., T.S.S., sugars, titrable acidity, ascorbic acid and carotene content of the ripe fruits were determined. Ripening was assessed based on colour and texture. The economic storage life was calculated as the number of days from harvest till the commencement of spoilage of 80 per cent of the ripe fruits. The storage life and the qualitative characters of the fruits at final sampling was considered as criteria of efficiency of the storage methods.

Permanent Preservation by Canning

The fruits of all varieties were harvested when fully mature and ripened at room temperature and canned. Before canning the fruits were analysed for chemical composition of the flesh viz., T.S.S., reducing sugar, nonreducing sugar, total sugar, acidity and ascorbic acid content. Also the flesh was scored for its physical appearance and taste.

The fruits were then hand peeled using sharp knife. The cheeks were then cut out and quartered. The cans were then filled with 16 g each of the slices along with sugar syrup (40°B) and citric acid (0.25%). The cans were finally exhausted for seven minutes at 90°C sealed and then processed in boiling water for 30 minutes. The product was then cooled in cold water and stored at room temperature.

Sampling was done from seventh month onwards and quality

was assessed using the score card given elsewhere. The external appearance of the can, appearance of syrup, vacuum pressure and drained weight were noted on each sampling (Ranganna, 1977). Slices and syrup were analysed separately for the chemical characters viz., acidity, reducing sugar, nonreducing sugar, total sugar, T.S.S. and ascorbic acid content, at every sampling.

Score card for quality grades of canned product made from different varieties of mango

	Quality	Score
Colour	Excellent	5
	Good	4
	Satisfactory	3
	Fair	2
	Poor	1
Aroma	Excellent	5
	Good	4
	Satisfactory	3
	Fair	2
	Poor	1
Taste	Excellent	5
	Good	4
	Satisfactory	3
	Fair	2
	Poor	1
Texture	Excellent	5
	Good	4
	Satisfactory	3
	Fair	2
	Poor	1

Score	Category
1 - 1.4	Poor
1.5 - 2.4	Fair
2.5 - 3.4	Satisfactory
3.5 - 4.4	Good
4.5 - 5.0	Excellent

STATISTICAL ANALYSIS

The proportionate changes $\left(\frac{\text{Final value-Initial value}}{\text{Initial value}}\right)$ in all characters determining the quality of fruits were obtained. Analysis of variance technique for nested classification as explained in Snedecor and Cochran (1967) was adopted. Critical differences were calculated wherever needed. Direct and indirect effects of the different characters on maturity of fruit were estimated by the method of Path Coefficients as given in Dewey and Lu (1959).

RESULTS

R E S U L T S

GROWTH AND MATURITY OF THE FRUIT

Growth and maturity of the fruit in terms of length, girth, weight, volume and specific gravity from A stage to ripening, at weekly intervals are presented in Tables 1.a, b, c, d and e.

1. PHYSICAL CHARACTERS

1.1. Length of fruits

In the case of Bennet Alphonso, the mean length of fruit at A stage (60 days after fruitset) was 8 cm and at full maturity (116 days after fruitset) it was 9 cm having an increase of only 1 cm during the period of 56 days. Forty per cent of this growth in length occurred during the first 14 days followed by 35 per cent during the next fortnight, 26 per cent during the third fortnight and 5 per cent during the last fortnight (Table 1.a and Fig.1).

For the variety Mundappa the mean length at A stage (67 days after fruitset) was 8 cm and at full maturity (116 days after fruitset) it increased to 10 cm showing an increase of 2 cm during the period of 49 days. The increase in length was 47.5 per cent during the first 14 days and 32 per cent during the next 14 days. During the next 14 days the increase in length constituted 15.5 per cent and towards the last seven days it accounted for only 5 per cent

(Table 1.b and Fig.1). In the case of Suwarnarekha, Olour and Neelum also a similar trend was noticed (Tables 1.c, d and e and Fig.1).

1.2. Girth of fruits

For the variety Bennet Alphonso, the mean maximum girth of fruits at A stage was 16.5 cm and at full maturity it was 18 cm. Out of this increase of 1.5 cm in girth, the first 14 days accounted for 36.67 per cent increase and the percentage of increase in girth during the next 14 days was 30. An increase of 26.67 per cent was seen during the next 14 days. The last 14 days constituted an increase of only 6.67 per cent (Table 1.a and Fig.2).

In the case of Mundappa, the mean maximum girth at A stage was 20.69 which was 24.65 at full maturity. The first 14 days showed an increase of 54.55 per cent. An increase of 26.26 per cent was observed during the next 14 days. The next 14 days accounted for an increase of 14.14 per cent and the last seven days gave an increase of only 5.05 per cent (Table 1.b and Fig.2). In Olour also the same trend was observed (Table 1.d and Fig.2).

In the variety Suwarnarekha, the mean maximum girth at A stage was 22.7 cm and at full maturity it was 25.6 cm. Out of an increase of 2.9 cm, the first 14 days accounted for 27.59 per cent. The percentage of increase in girth

during the next 14 days was 31.03 and the same rate was observed during the next 14 days also. The last 14 days accounted for 10.34 per cent increase (Table 1.c and Fig.2). In Neelum also the trend was more or less similar (Table 1.e and Fig.2).

1.3. Weight of fruits

The data showed that in the variety Bennet Alphonso, the mean weight of the fruit at A stage was 125 g and at full maturity it was 152.8 g contributing an increase of 27.8 g during the period of 56 days. The maximum percentage of weight increase occurred during the second fortnight (50.51) and the minimum during the last fortnight (2.88) (Table 1.a and Fig.3).

In Mundappa, the mean weight of the fruit at a stage was 185.18 g and at full maturity 340.5 g. The total increase in weight was 155.32 g out of which 78.15 per cent occurred during the first 28 days. During the next 14 days 18.47 per cent increase of the total increase in weight occurred. The last seven days accounted for only 3.39 per cent increase (Table 1.b and Fig.3).

The data showed that in Suwarnarekha, the mean weight of fruits at A stage was 163.93 g and at full maturity it was 332.2 g. An increase in percentage of 75 occurred during the first four weeks. The increase in weight during the next 14 days was 17.85 per cent and the last

14 days accounted for 7.16 per cent increase in weight (Table 1.c and Fig.3).

In Olour, the mean weight of fruit at A stage was 156.83 g and at full maturity 241 g showing an increase of 84.17 g during the period of 56 days. The first four weeks accounted for an increase of 73.64 per cent while an increase of 6.5 per cent was only noticed during the last two weeks (Table 1.d and Fig.3).

In Neelum the mean weight of fruit at A stage was 80.51 g and 230.81 g at full maturity. Maximum increase in weight of 73.19 per cent occurred during the first four weeks (Table 1.e and Fig.3).

1.4. Volume of fruits

The data revealed that in Bennet Alphonso from A stage the increase in volume was rapid during the first four weeks (Table 1.a and Fig.4). In Mundappa the mean volume of fruit at A stage was 198.9 cc and at full maturity it was 339.82 cc. The first four weeks accounted for an increase of 72.57 per cent (Table 1.b and Fig.4).

The data showed that in Suwarnarekha after A stage the increase in volume was rapid during the first four weeks contributing 91.21 per cent increase of the total. The last four weeks contributed an increase in volume of 8.79 per cent only (Table 1.c and Fig.4).

In Olour the increase in volume was rapid from 74th to 102nd day accounting for an increase of 75.6 per cent. Thereafter although the total volume continued to increase the percentage of increase was low (Table 1.d and Fig.4).

Similarly in Neelum the mean volume recorded an increase of 97.01 per cent upto 102nd day and thereafter the percentage of increase decreased (Fig.4).

1.5. Specific gravity of fruits

In Bennet Alphonso the specific gravity of fruits at A stage was 0.94 and it increased to 1.01 on 102nd day and then remained constant upto full maturity (Table 1.a). In Mundappa the specific gravity increased from 0.93 at A stage to 1.0 on 95th day and thereafter remained steady (Table 1.b). In Suwarnarekha specific gravity of 0.819 at A stage increased to 1.0 at 109th day and thereafter remained constant till full maturity (Table 1.c). In Olour the specific gravity increased to 1.01 on 123rd day and then remained constant (Table 1.d). In Neelum the specific gravity at A stage was 0.94 which showed a gradual increase upto 109th day (1.01). Upto full maturity the specific gravity remained the same (Table 1.e).

The above results clearly indicated that in all the varieties during maturation about 2/3 of the total growth of fruits took place during the first four weeks after A stage.

parameters of mature fruits and palatability of the ripe fruits at different stages of ay in variety Bennet Alphonso

Maturity (days)		Girth cm	Weight g	Volume cc	Specific gravity	Palatability ratings (score)
60 (A)	8.00	16.50	125.00	132.70	0.94	0.59
67	8.20 (20.00)	16.80 (20.00)	129.00 (14.39)	135.79 (16.67)	0.95	0.62
74	8.40 (20.00)	17.05 (16.67)	134.80 (20.86)	139.83 (21.79)	0.96	0.80
81	8.60 (20.00)	17.25 (13.33)	141.20 (23.03)	144.08 (22.92)	0.98	0.83
88 (B)	8.75 (15.00)	15.50 (16.67)	148.86 (27.55)	149.16 (27.40)	1.00	0.95
95	8.90 (15.00)	17.72 (14.67)	151.30 (8.78)	150.85 (9.12)	1.00	0.98
102	8.95 (5.00)	17.90 (12.00)	152.00 (2.52)	150.94 (0.49)	1.01	1.75
109	9.00 (5.00)	17.97 (4.67)	152.80 (2.88)	151.24 (1.62)	1.01	1.95
116 (C)	9.00	18.00 (2.00)	152.80	151.24	1.01	2.00
123 (ripe)	9.00	18.00	150.00	149.70	1.00	2.28

The values given in parenthesis are the percentage of increase of total growth

A - A stage
B - B stage
C - C stage

Table 1.b Physical parameters of mature fruits and palatability ratings of the ripe fruits at different stages of maturity in variety Mundappa

Maturity (days)	Length cm	Girth cm	Weight g	Volume cc	Specific gravity	Palatability ratings (score)
67 (A)	8.00	20.69	185.18	198.90	0.93	1.21
74	8.52 (26.00)	21.88 (30.05)	225.21 (25.77)	230.91 (22.72)	0.96	1.25
81	8.95 (21.50)	22.85 (24.50)	256.30 (20.02)	255.13 (17.19)	0.99	1.28
88	9.35 (20.00)	23.62 (19.44)	280.00 (15.26)	277.95 (16.19)	0.99	1.32
95 (B)	9.59 (12.00)	23.89 (6.82)	306.56 (17.10)	301.16 (16.47)	1.00	1.53
102	9.80 (10.50)	24.17 (7.07)	326.89 (13.09)	320.57 (13.77)	1.00	1.93
109	9.90 (5.00)	24.45 (7.07)	335.24 (5.38)	334.24 (9.70)	1.00	2.83
116 (C)	10.00 (5.00)	24.65 (5.05)	340.50 (3.39)	339.82 (3.96)	1.00	2.89
123 (ripe)	10.00	24.65	335.50	339.00	1.00	3.21

The values given in parenthesis are the percentage of increase of total growth

A - A stage
B - B stage
C - C stage

Table 1.c Physical parameters of mature fruits and palatability ratings of the ripe fruits at different stages of maturity in variety Suwarnarekha

Maturity (days)	Length cm	Girth cm	Weight g	Volume cc	Specific gravity	Palatability ratings (score)
60 (A)	8.90	22.70	163.93	200.16	0.82	0.91
67	9.50 (19.35)	23.10 (13.79)	195.80 (18.94)	231.17 (23.48)	0.85	0.91
74	10.00 (16.13)	23.50 (13.80)	225.14 (17.44)	260.88 (22.50)	0.86	0.95
81	10.50 (16.13)	23.90 (13.79)	258.20 (19.64)	291.75 (23.38)	0.89	0.95
88	11.00 (16.13)	24.40 (17.24)	290.13 (18.98)	320.59 (21.84)	0.91	0.98
95 (B)	11.40 (12.90)	24.90 (17.24)	308.26 (10.78)	324.48 (2.95)	0.95	1.00
102	11.80 (12.90)	25.30 (13.79)	320.16 (7.07)	327.04 (1.94)	0.98	1.52
109	11.90 (3.23)	25.50 (6.90)	329.74 (5.70)	329.74 (2.04)	1.00	1.68
116 (C)	12.00 (3.23)	25.60 (3.44)	332.20 (1.46)	332.20 (1.86)	1.00	1.79
123 (ripe)	12.00	25.60	330.20	331.53	1.00	1.97

The values given in parenthesis are the percentage of increase of total growth

A - A stage
B - B stage
C - C stage

Table 1.d Physical parameters of mature fruits and palatability ratings of the ripe fruits at different stages of maturity in variety Oleur

Maturity (days)	Length cm	Girth cm	Weight g	Volume cc	Specific gravity	Palatability ratings (score)
74 (A)	7.40	16.35	156.83	165.43	0.95	0.95
81	7.80 (22.22)	17.72 (33.01)	175.63 (22.34)	183.33 (24.15)	0.96	0.95
88	8.20 (22.22)	18.20 (11.57)	188.38 (15.15)	194.41 (14.95)	0.97	1.05
95	8.60 (22.22)	18.90 (16.87)	205.26 (20.05)	207.52 (17.69)	0.98	1.21
102 (B)	9.00 (22.22)	19.50 (14.46)	218.81 (16.10)	221.47 (18.81)	0.99	1.25
109	9.06 (3.33)	20.00 (12.05)	227.90 (10.80)	228.13 (8.98)	1.00	1.59
116	9.10 (2.22)	20.30 (7.23)	235.53 (9.06)	234.83 (9.04)	1.00	1.93
123	9.15 (2.78)	20.50 (4.82)	240.00 (5.31)	238.10 (4.41)	1.01	2.92
130 (C)	9.20 (2.78)	20.50	241.00 (1.19)	239.56 (1.97)	1.01	2.95
137 (ripe)	9.20	20.50	237.00	235.82	1.01	3.39

The values given in parenthesis are the percentage of increase of total growth

A - A stage
B - B stage
C - C stage

Table 1.e Physical parameters of mature fruits and palatability ratings of the ripe fruits at different stages of maturity in variety Neelum

Maturity (days)	Length cm	Girth cm	Weight g	Volume cc	Specific gravity	Palatability ratings (score)
60 (A)	6.50	16.90	80.51	85.38	0.94	1.53
67	7.23 (22.46)	17.50 (15.79)	110.26 (19.80)	115.94 (21.21)	0.95	1.58
74	7.90 (20.62)	17.80 (7.89)	132.13 (14.55)	137.35 (14.86)	0.96	1.58
81	8.36 (14.15)	18.70 (23.68)	165.51 (22.21)	170.10 (22.74)	0.97	1.63
88	8.80 (13.54)	19.50 (21.05)	190.51 (16.63)	193.41 (16.18)	0.99	1.75
95 (B)	9.16 (11.08)	20.00 (13.16)	210.30 (13.17)	212.42 (13.20)	0.99	1.81
102	9.40 (7.38)	20.30 (7.89)	225.13 (9.87)	225.13 (8.82)	1.00	1.92
109	9.60 (6.15)	20.46 (4.21)	228.00 (1.91)	226.87 (1.21)	1.01	2.92
116	9.70 (3.08)	20.65 (5.00)	229.30 (0.86)	227.48 (0.42)	1.01	3.13
123 (C)	9.75 (1.54)	20.70 (1.32)	230.81 (0.53)	229.43 (1.35)	1.01	3.25
130 (ripe)	9.75	20.70	226.35	225.22	1.01	3.71

The values given in parenthesis are the percentage of increase of total growth

A - A stage
B - B stage
C - C stage

FIG. 1 - PERCENTAGE INCREASE IN LENGTH OF FRUITS

AT DIFFERENT STAGES OF MATURITY

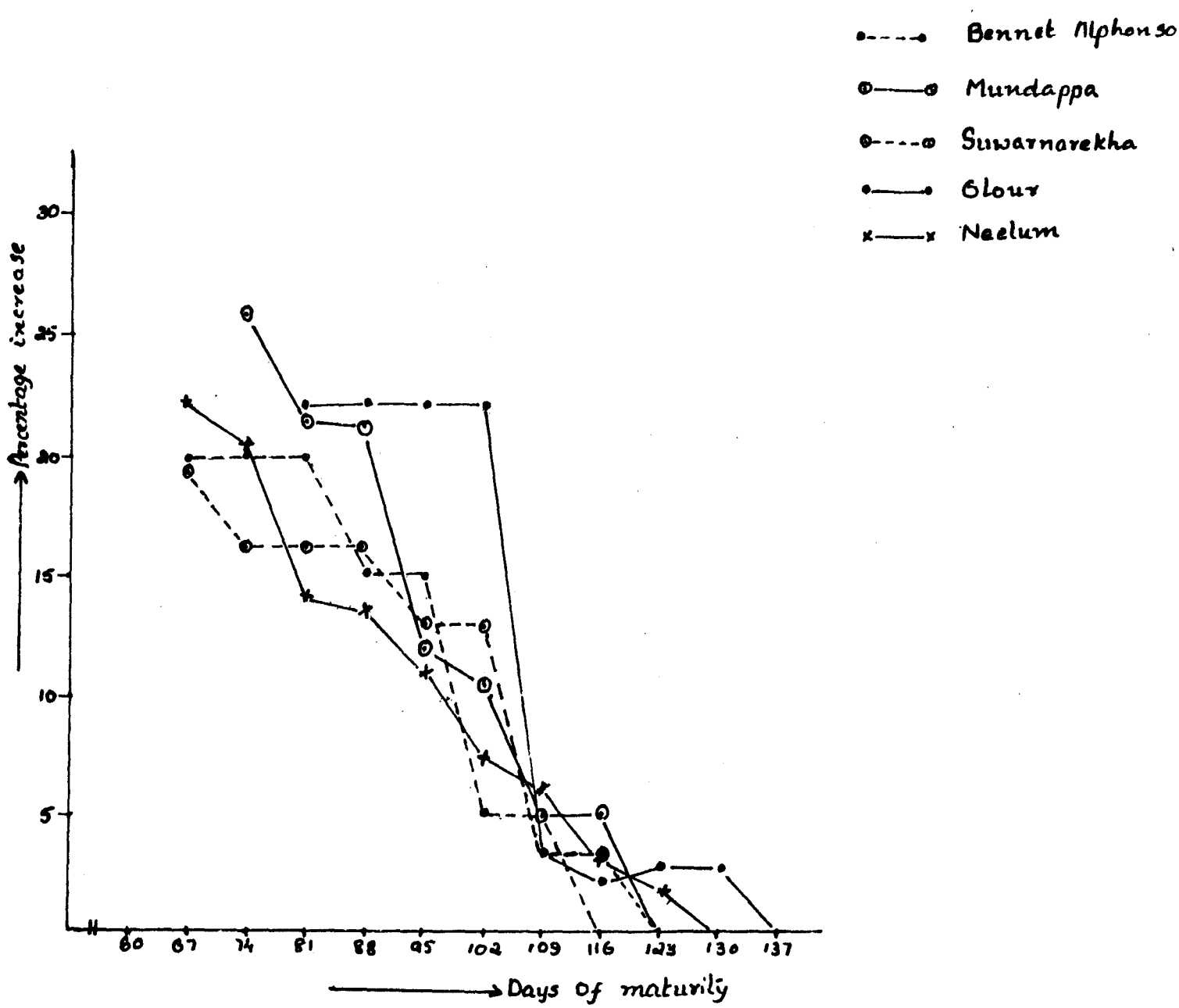


FIG.2 - PERCENTAGE INCREASE IN GIRTH OF FRUITS AT DIFFERENT STAGES OF MATURITY

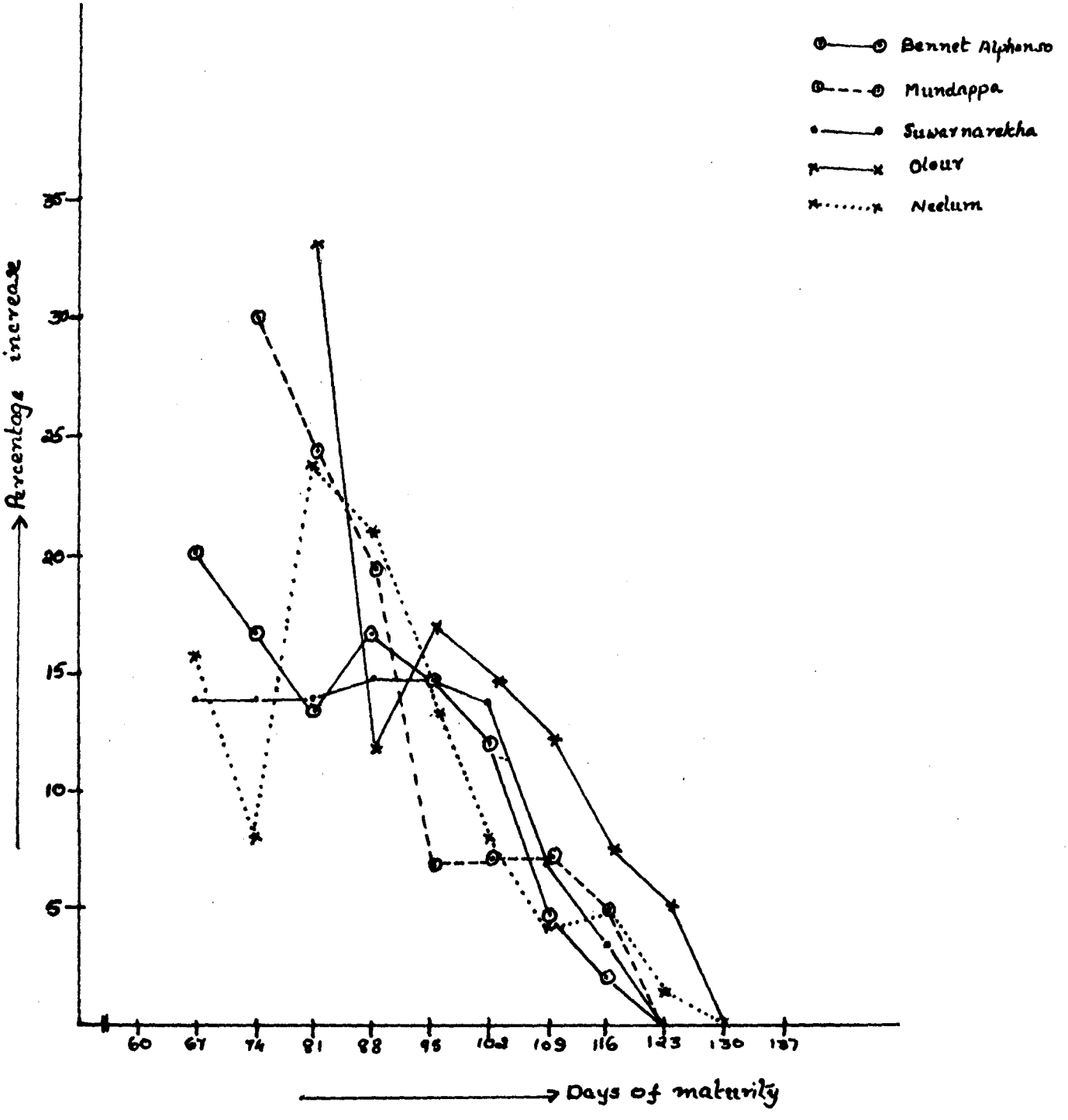


FIG. 3 - PERCENTAGE INCREASE IN WEIGHT OF FRUITS AT DIFFERENT STAGES OF MATURITY

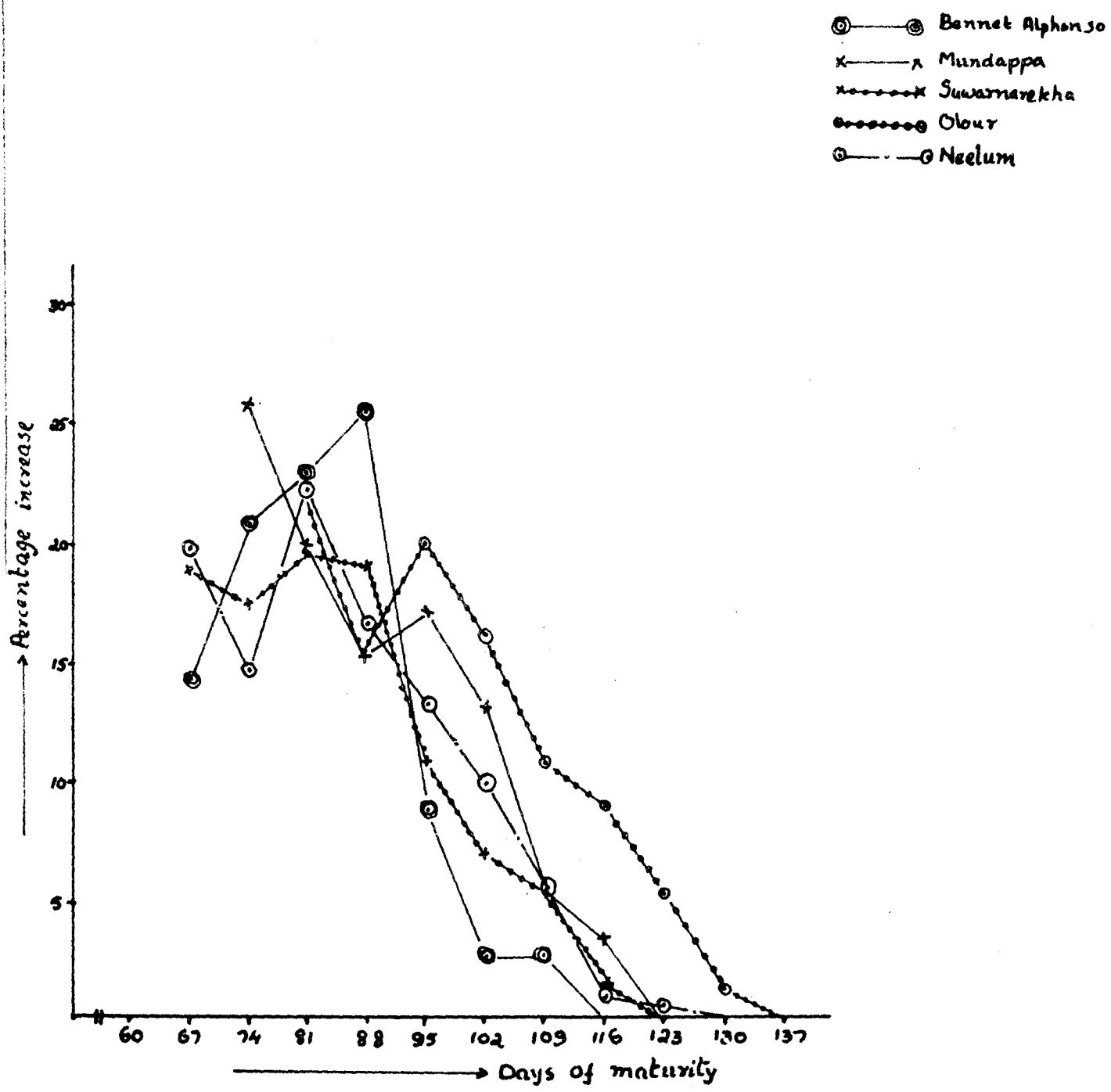
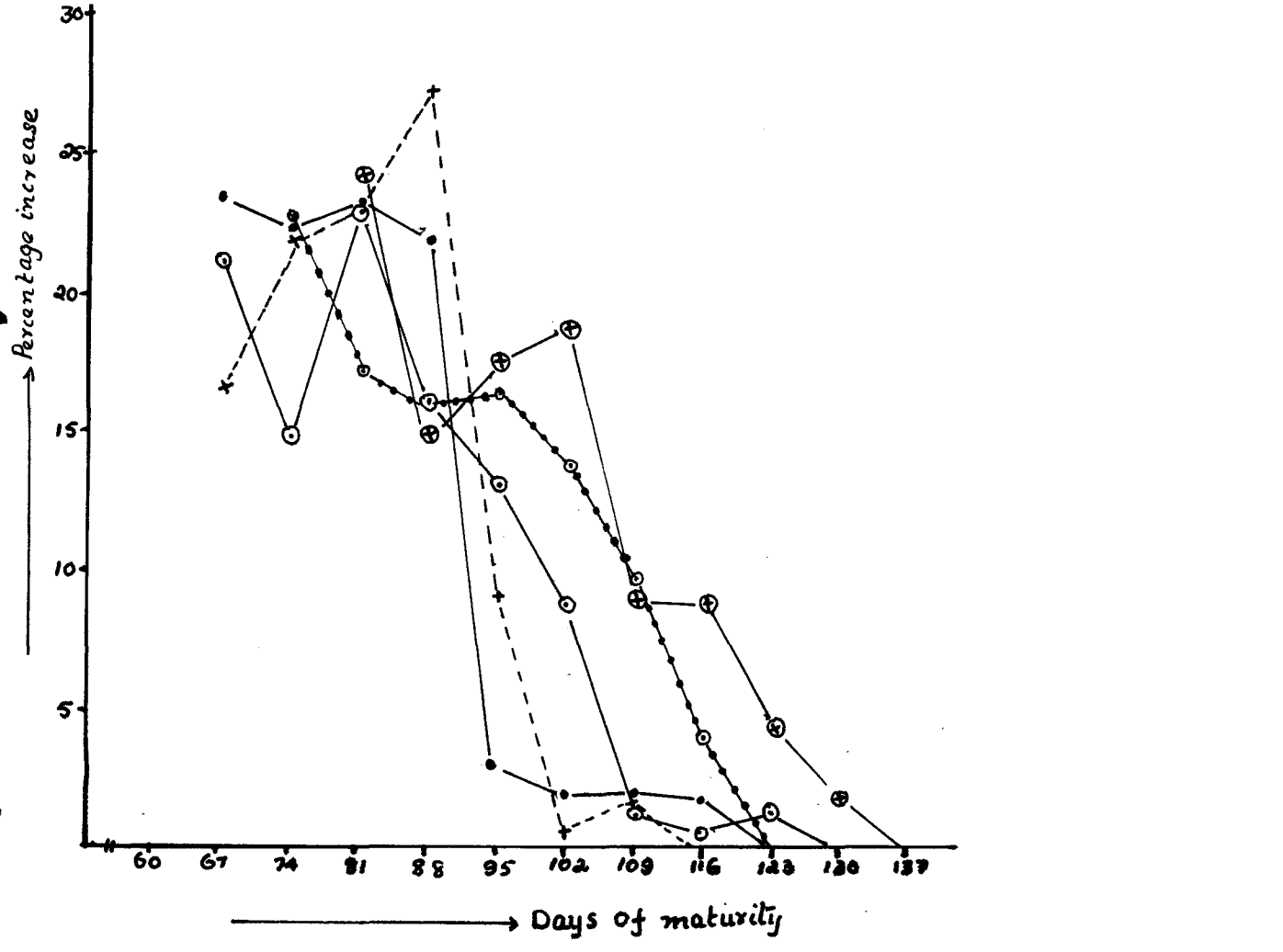


FIG.4 - PERCENTAGE INCREASE IN VOLUME OF FRUITS AT DIFFERENT STAGES OF MATURITY



In general there existed a relationship between length and weight on one hand and maturity standard on tha other. In the case of other parameters variations were noticed in relation to maturity standard. In all varieties except Mundappa significant correlation was observed between specific gravity and maturity standard (Tables 2.a, b, c, d and e). In Mundappa at 5 per cent level all other parameters had significant correlation with maturity. A 1 per cent level, the volume (0.865) and weight (0.851) of the fruits had significant correlation with maturity (Table 2.b). In Suwarnarekha significant correlation (5 per cent level) was observed between length, weight and specific gravity and maturity of the fruits. At 1 per cent level, only specific gravity (+0.876) and length (+0.805) were correlated with maturity (Table 2.c). In Olour, except volume all other physical parameters were significantly correlated with maturity (5 per cent level) and at 1 per cent level only specific gravity (+0.816) of the fruits had significant correlation with maturity (Table 2.d). In Neelum, maturity had significant correlation (5 per cent level) with all the physical parameters studied. Only specific gravity and girth correlated with maturity at 1 per cent level in this variety (Table 2.e).

Table 2.a Correlation between maturity and the physical parameters in variety Bennet Alphonso

Characters	Girth (cm)	Weight (g)	Volume (cm^3)	Specific gravity	Maturity (Organoleptic quality)
1. Length	0.99**	0.979**	0.980*	0.979*	0.828**
2. Girth		0.970**	0.970**	0.974*	0.878**
3. Weight			0.999**	0.999**	0.760*
4. Volume				0.998**	0.750*
5. Specific gravity					0.769*

** Significant at 1% level

* Significant at 5% level

Table 2.b Correlation between maturity and the physical parameters in variety Mundappa

Characters	Girth (cm)	Weight (g)	Volume (cm^3)	Specific gravity	Maturity
1. Length	0.996**	0.992**	0.988**	0.958**	0.785*
2. Girth		0.982**	0.976**	0.975**	0.756*
3. Weight			1.00**	0.922**	0.851**
4. Volume				0.910*	0.865**
5. Specific gravity					0.609

** Significant at 1% level

* Significant at 5% level

Table 2.c Correlation between maturity and the physical parameters in variety Suwarnarekha

Characters	Girth (cm)	Weight (g)	Volume (cm^3)	Specific gravity	Maturity
1. Length	0.356	0.997**	0.971**	0.978**	0.805**
2. Girth		0.342	0.298	0.380	0.445
3. Weight			0.985**	0.963**	0.760*
4. Volume				0.902**	0.659
5. Specific gravity					0.876**

** Significant at 1% level

* Significant at 5% level

Table 2.d Correlation between maturity and the physical parameters in variety Olour

Characters	Girth (cm)	Weight (g)	Volume (cm^3)	Specific gravity	Maturity
1. Length	0.987**	0.679*	0.630	0.980**	0.730*
2. Girth		0.716*	0.668*	0.991**	0.786*
3. Weight			0.998**	0.740*	0.685*
4. Volume				0.691*	0.648
5. Specific gravity					0.816**

** Significant at 1% level

* Significant at 5% level

Table 2.e Correlation between maturity and the physical parameters in variety Neelum

Characters	Girth (cm)	Weight (g)	Volume (cm^3)	Specific gravity	Maturity
1. Length	0.989**	0.994**	0.994**	0.991**	0.754*
2. Girth		0.994**	0.992**	0.995**	0.772**
3. Weight			1.00**	0.992**	0.718*
4. Volume				0.989**	0.704*
5. Specific gravity					0.787**

** Significant at 1% level

* Significant at 5% level

2. CHEMICAL CHARACTERS

2.1. Titrable acidity

In all the varieties studied the acidity of fruits declined during the course of maturation. There was substantial variation between varieties throughout the period of maturation, at all stages of growth (Tables 3.a,b,c,d and e and Fig.5). At full maturity, in Bennet Alphonso and Olour more or less the same acidity was observed (Tables 3.a and d).

2.2. Reducing sugar

The change in reducing sugar content from A stage to full maturity in all the varieties was inconsistent. In all the varieties studied the reducing sugar content was more at full maturity than that at A stage (Tables 3.a,b,c,d and e and Fig.6). At full maturity the reducing sugars were maximum in Bennet Alphonso and it was minimum in Neelum.

2.3. Nonreducing sugar

The change in nonreducing sugar content during maturation was irregular in all the varieties studied (Tables 3.a,b,c,d and e). Only in the variety Olour an increasing trend was observed from A stage to full maturity (Table 3.d). At A stage the range in nonreducing sugar content was from 2.9 to 5.35 per cent and at full maturity it ranged from 3.98 to 5.01 per cent. Except in the case of Bennet Alphonso and

Neelum the nonreducing sugar content in all other varieties was more than that at A stage, at full maturity.

2.4. Total sugar

In all the varieties studied the total sugar content showed an increase in the beginning followed by a decrease, ultimately again showing an increase. Compared to A stage all the varieties exhibited higher content of total sugars at full maturity (Tables 3.a,b,c,d and e and Fig.7).

2.5. Starch

In all varieties, throughout the period of maturation the starch content gradually increased (Tables 3.a,b,c,d and e and Fig.8).

2.6. Carotene

Considerable increase in carotene content was observed throughout the period of maturation in all the varieties studied. The rate of increase was slow at early stages, but, towards the end it was rapid. At full maturity the carotene content was 0.0016, 0.00067, 0.0006, 0.0004 and 0.00075 per cent in Bennet Alphonso, Mundappa, Suvarnarekha, Olour and Neelum respectively (Tables 3.a,b,c,d and e and Fig.9).

2.7. T.S.S.

During the period of maturation the T.S.S. content of

all the varieties showed a similar trend as that of the total sugar content (Tables 3.a,b,c,d and e and Fig.10).

2.8. Moisture and drymatter

The data on moisture and drymatter content of the fruits in all the varieties during maturation are presented in Tables 3.a,b,c,d and e (Fig.11).

The moisture content showed gradual decrease from A stage to full maturity in all the varieties, whereas the drymatter content exhibited just the reverse trend.

2.9. Ascorbic acid

The ascorbic acid content gradually declined towards maturity in all the varieties. At A stage the range in ascorbic acid content was 12.5 to 67.58 mg/100 g and that at full maturity it ranged from 10.91 to 66.30 (Tables 3.a,b,c,d and e and Fig.12).

2.10. Starch/acid and sugar/acid ratio

In all the varieties studied, the starch/acid ratio increased upto full maturity from A stage. In Bennet Alphonso, Mundappa and Suwarnarekha the sugar/acid ratio increased, then decreased, ultimately showing an increase. On the other hand in Olour and Neelum, the same showed an increasing trend throughout the period of maturation. The

variation in sugar/acid ratio among the varieties was from 2.16 to 4.23 at A stage and 6.61 to 17.65 at full maturity (Tables 3.a,b,c,d and e).

Path Coefficient Analysis

When maturity of fruit was considered as a function of acidity of fruit, reducing sugar content, nonreducing sugar content, total sugar percentage, starch percentage, carotene content, T.S.S. and moisture content, the component chemical characters explained 98.40 per cent variation in maturity of fruits as explained by organoleptic tests of the ripened fruits (R^2=0.984) (Table 4 and Fig.13). Reducing sugar content had the maximum positive direct effect (1.958) on maturity of fruit though the correlation coefficient was only 0.654. This was followed by starch percentage (1.753). Starch content had positive direct effect on maturity though the correlation coefficient was negative (-0.652). T.S.S. also had appreciable positive direct effect on maturity (0.947). Though the correlation coefficient of total sugar percentage on maturity was positive, the direct effect was -0.881. Carotene content, though had significant positive correlation (0.810) with maturity, its direct effect was negative and comparatively negligible (-0.087).

Table 3.a Chemical composition of mature fruits and palatability ratings of the ripe fruits at different stages of maturity in variety Bennet Alphonso

Maturity (days)	Acidity %	Reducing sugar %	Nonreducing sugar %	Total sugar %	Starch %	Carotene %	T.S.S. %	Moisture %	Dry-matter %	Ascorbic acid mg/100 g	Starch/acid ratio	Sugar/acid ratio	Palatability ratings (score)
60 (A)	3.52	4.20	5.35	9.55	7.80	0.00020	10.00	81.80	18.20	15.29	2.24	2.71	0.59
67	3.49	5.15	5.32	10.47	7.82	0.00020	10.50	81.50	18.50	15.29	2.24	3.00	0.62
74	3.48	5.15	5.32	10.47	7.82	0.00022	10.50	80.10	18.90	15.28	2.24	3.00	0.80
81	3.46	5.13	5.32	10.45	7.89	0.00026	10.40	81.00	19.00	15.25	2.28	3.02	0.83
88 (B)	3.42	5.12	5.30	10.42	7.90	0.00030	10.40	80.80	19.20	15.25	2.31	3.05	0.95
95	3.42	5.00	5.40	10.40	7.92	0.00040	10.40	80.10	19.90	15.13	2.32	3.04	0.98
102	3.40	4.35	5.49	9.84	7.95	0.00055	9.80	80.00	20.00	14.95	2.34	2.89	1.75
109	2.32	4.20	5.49	9.69	7.95	0.00076	9.80	79.90	20.10	14.39	3.43	4.18	1.95
116 (C)	1.32	5.82	5.01	10.83	7.95	0.00160	11.00	79.90	20.10	14.39	6.02	8.20	2.00
123 (ripe)	1.00	6.20	5.55	11.75	1.90	0.00800	11.80	80.40	19.60	10.12	1.90	11.75	2.28

Table 3.b Chemical composition of mature fruits and palatability ratings of the ripe fruits at different stages of maturity in variety Mundappa

Maturity (days)	Acidity %	Reducing sugar %	Nonreducing sugar %	Total sugar %	Starch %	Carotene %	T.S.S. %	Moisture %	Dry-matter %	Ascorbic acid mg/100 g	Starch/acid ratio	Sugar/acid ratio	Palatability ratings (Score)
67 (A)	2.43	3.90	3.15	7.05	3.50	0.00010	7.10	82.00	18.00	12.50	1.44	2.90	1.21
74	2.42	4.30	3.05	7.35	3.51	0.00010	7.40	81.80	18.20	11.93	1.45	3.04	1.25
81	1.40	3.80	3.21	7.01	3.55	0.00015	7.00	81.20	18.80	11.68	2.54	5.01	1.28
88	1.38	3.30	3.21	6.51	3.85	0.00017	6.60	80.50	19.50	11.45	2.79	4.72	1.32
95 (B)	1.30	2.90	3.25	6.15	3.95	0.00020	6.20	79.50	20.50	11.89	3.04	4.73	1.50
102	1.30	2.60	3.93	6.53	3.95	0.00038	6.80	78.60	21.40	11.73	3.04	5.02	1.93
109	1.10	4.35	4.00	8.35	3.99	0.00050	8.50	77.20	22.80	11.70	3.63	7.60	2.83
116 (C)	1.00	4.52	4.00	8.52	4.00	0.00067	9.60	77.00	23.00	10.91	4.00	8.52	2.89
123 (ripe)	0.58	9.38	4.25	13.63	0.93	0.00200	14.00	79.70	20.80	8.32	1.60	23.50	3.21

Table 3.c Chemical composition of mature fruits and palatability ratings of the ripe fruits at different stages of maturity in variety Suwarnarekha

Maturity (days)	Acidity %	Reducing sugar %	Nonreducing sugar %	Total sugar %	Starch %	Carotene %	T.S.S. %	Moisture %	Dry-matter %	Ascorbic acid mg/100 g	Starch/acid ratio	Sugar/acid ratio	Palatability ratings (score)
60 (A)	1.95	2.50	2.90	5.40	3.30	0.00008	6.40	83.50	16.50	25.10	1.69	2.77	0.91
67	1.90	2.50	3.03	5.53	3.40	0.00018	6.60	83.10	16.90	25.10	1.74	2.84	0.91
74	1.80	2.15	3.08	5.23	3.45	0.00024	6.40	82.20	17.80	25.05	1.92	2.91	0.95
81	1.82	2.05	3.05	5.10	3.76	0.00029	6.00	81.40	18.60	25.00	2.07	2.80	0.95
88	1.82	2.05	3.05	5.05	3.82	0.00034	6.00	81.10	18.90	24.93	2.10	2.77	0.98
95 (B)	1.70	1.92	3.00	4.92	4.08	0.00040	5.90	80.50	19.50	24.52	2.40	2.89	1.00
102	1.20	2.00	3.55	5.55	4.08	0.00040	5.95	79.25	20.80	23.20	3.40	4.63	1.52
109	1.00	2.73	3.93	6.66	4.09	0.00048	6.90	78.40	21.60	22.12	4.09	6.66	1.68
116 (C)	0.90	2.95	3.98	6.93	4.09	0.00060	8.00	78.30	21.70	20.20	4.54	6.92	1.79
123 (ripe)	0.20	8.90	3.95	12.85	0.60	0.00150	13.90	80.10	19.90	13.50	3.00	64.25	1.97

Table 3.d Chemical composition of mature fruits and palatability ratings of the ripe fruits at different stages of maturity in variety Olour

Maturity (days)	Acidity %	Reducing sugar %	Nonreducing sugar %	Total sugar %	Starch %	Carotene %	T.S.S. %	Moisture %	Dry matter %	Ascorbic acid mg/100 g	Starch/acid ratio	Sugar/acid ratio	Palatability ratings (score)
74 (A)	1.89	3.59	4.40	7.99	7.07	0.00010	7.00	84.80	15.20	67.58	3.74	4.23	0.75
81	1.80	3.63	4.40	8.03	7.08	0.00010	7.10	84.10	15.90	67.50	3.93	4.46	0.95
88	1.76	3.63	4.42	8.05	7.10	0.00013	7.20	83.70	16.30	66.85	4.03	4.57	1.05
95	1.75	3.64	4.42	8.06	7.15	0.00015	7.40	83.50	16.50	66.84	4.06	4.61	1.21
102 (B)	1.66	3.65	4.44	8.09	7.25	0.00015	7.50	82.70	17.30	66.80	4.37	4.87	1.25
109	1.66	3.55	4.50	8.05	7.25	0.00025	7.20	81.60	18.40	66.55	4.37	4.85	1.59
116	1.60	3.42	4.63	8.05	7.25	0.00026	7.20	80.40	19.60	66.50	4.53	5.03	1.93
123	1.52	3.63	4.75	8.18	7.28	0.00029	7.70	78.30	21.70	66.43	4.79	5.38	2.92
130 (C)	1.30	3.80	4.79	8.59	7.28	0.00040	8.50	77.90	22.10	66.30	5.60	6.61	2.95
137 (ripe)	0.90	6.95	4.98	11.93	2.04	0.00140	12.50	79.10	20.90	46.10	2.27	13.26	3.39

Table 3.e Chemical composition of mature fruits and palatability ratings of the ripe fruits at different stages of maturity in variety Neelum

Maturity (days)	Acidity %	Reducing sugar %	Nonreducing sugar %	Total sugar %	Starch %	Carotene %	T.S.S. %	Moisture %	Dry-matter %	Ascorbic acid mg/100 g	Starch/acid ratio	Sugar/acid ratio	Palatability ratings (score)
60 (A)	2.75	1.50	4.45	5.95	5.13	0.00010	5.80	81.90	18.10	39.00	1.87	2.16	1.53
67	2.71	1.55	4.48	6.03	5.35	0.00014	6.20	81.80	18.20	38.32	2.01	2.23	1.58
74	2.55	1.55	4.48	6.03	5.45	0.00020	6.20	81.40	18.60	36.87	2.14	2.36	1.58
81	2.23	1.59	4.45	6.04	5.49	0.00023	6.20	81.10	18.90	36.85	2.46	2.71	1.63
88	1.80	1.59	4.40	5.99	5.90	0.00025	5.90	80.30	19.70	36.80	3.28	3.33	1.75
95 (B)	1.52	1.63	4.31	5.94	5.98	0.00030	6.10	79.70	20.30	36.72	3.93	3.91	1.81
102	1.30	1.88	4.23	6.11	6.15	0.00035	6.30	78.30	21.70	36.50	4.73	4.76	1.92
109	0.98	1.88	4.44	6.32	6.87	0.00042	6.30	77.20	22.80	36.29	7.01	6.45	2.92
116	0.45	1.80	4.49	6.29	6.90	0.00053	6.20	76.10	23.90	36.20	15.33	13.98	3.13
123 (C)	0.40	2.86	4.20	7.06	6.90	0.00075	7.10	73.80	24.20	29.50	17.25	17.65	3.25
130 (ripe)	0.25	7.18	5.65	12.83	0.25	0.00230	12.90	77.70	22.30	20.10	1.00	51.32	3.71

FIG·6 - ACID CONTENT OF FRUITS AT DIFFERENT STAGES OF MATURITY

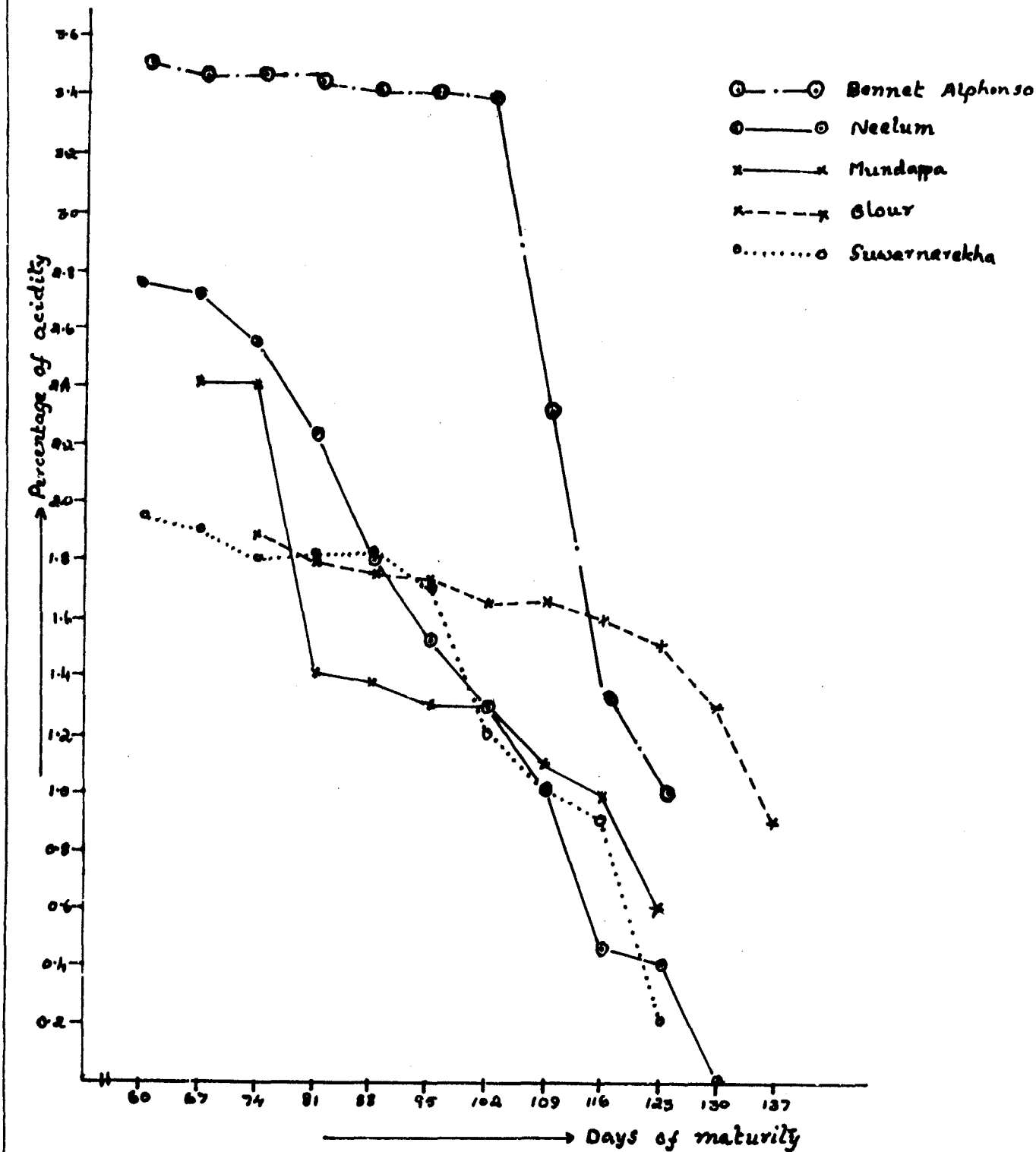


FIG. 6 - REDUCING SUGAR CONTENT OF FRUITS AT DIFFERENT STAGES OF MATURITY

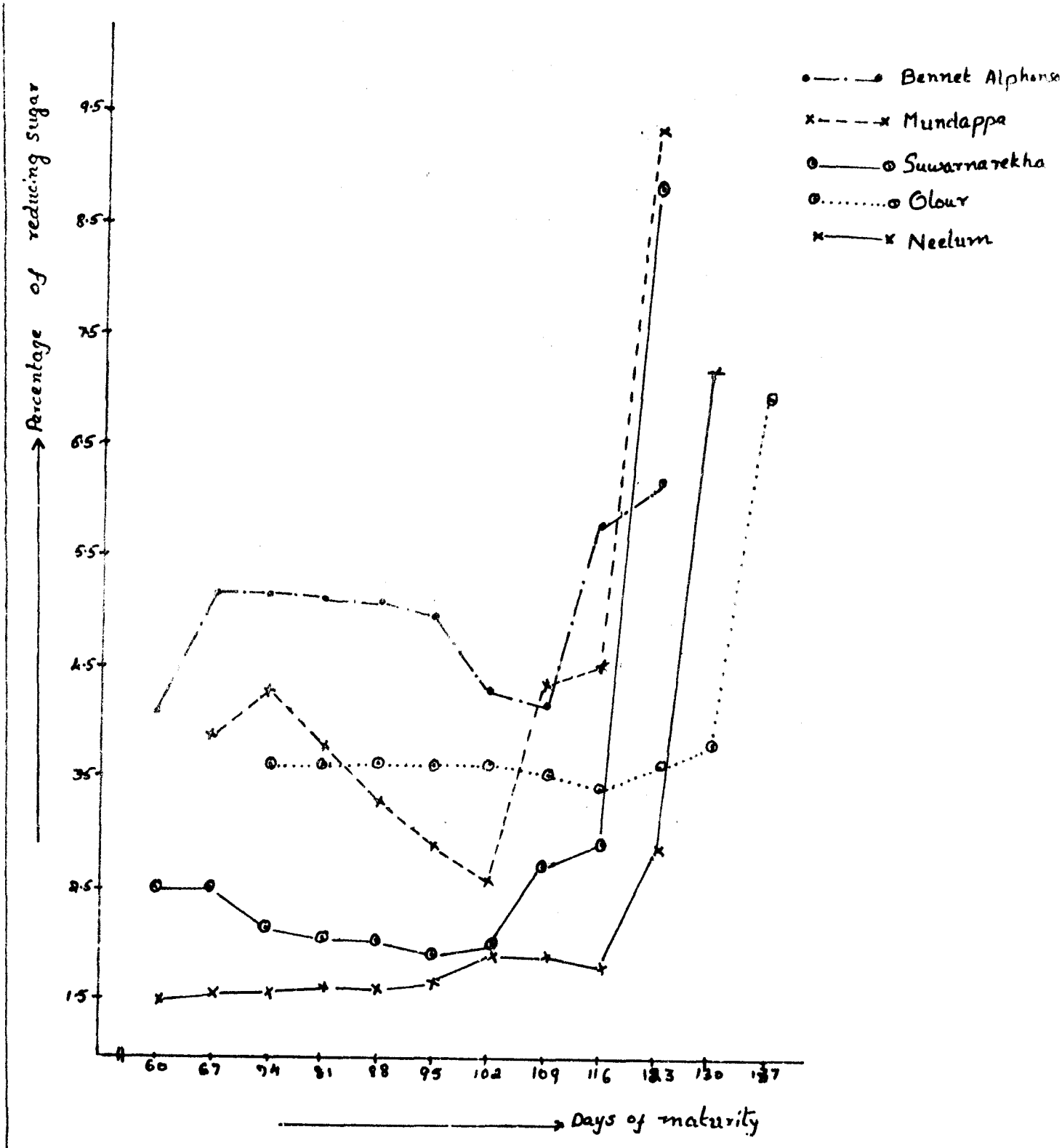


FIG. 7 - TOTAL SUGAR CONTENT OF FRUITS AT DIFFERENT STAGES OF MATURITY

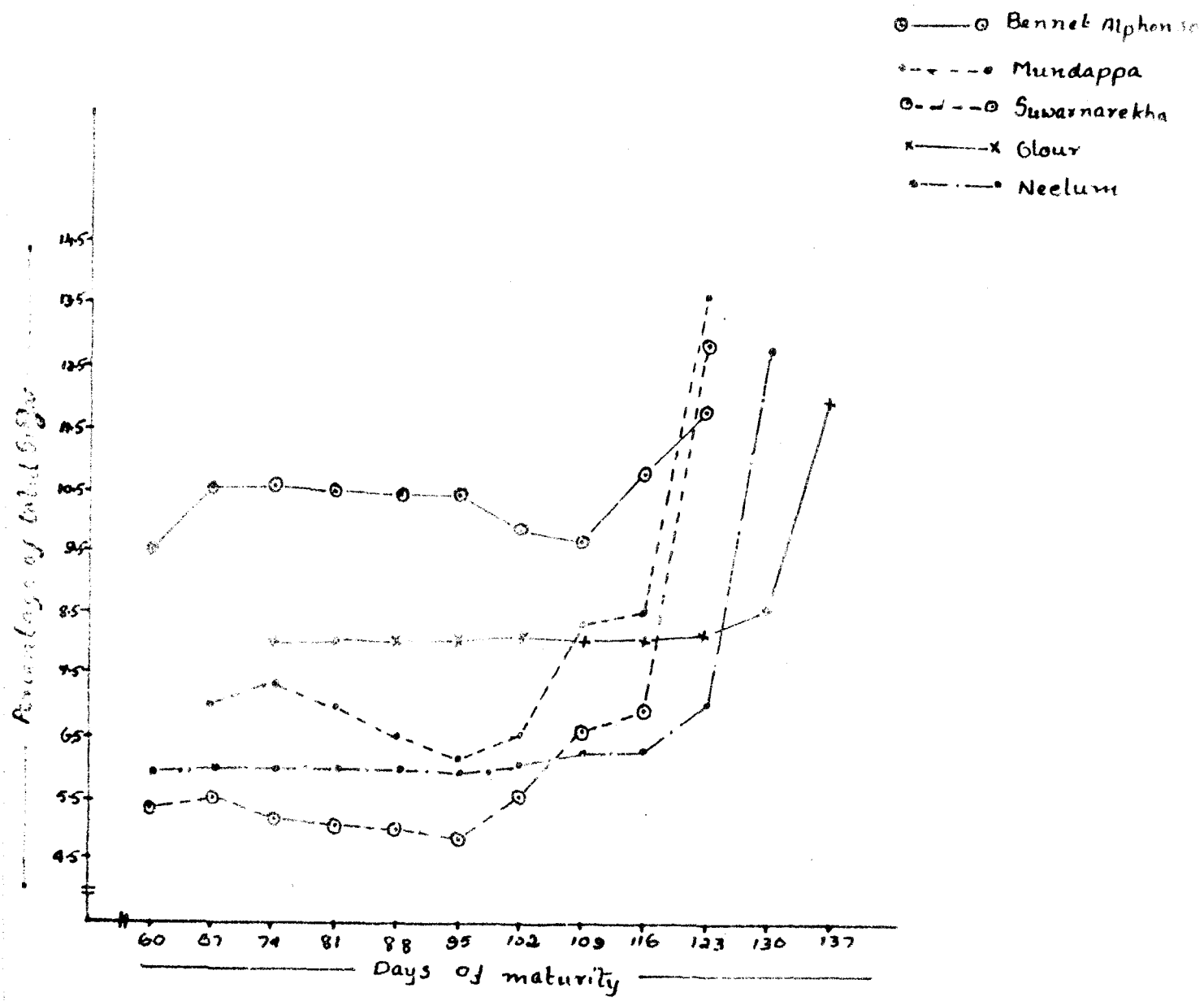


FIG. 8 - STARCH CONTENT OF FRUITS AT DIFFERENT STAGES OF MATURITY

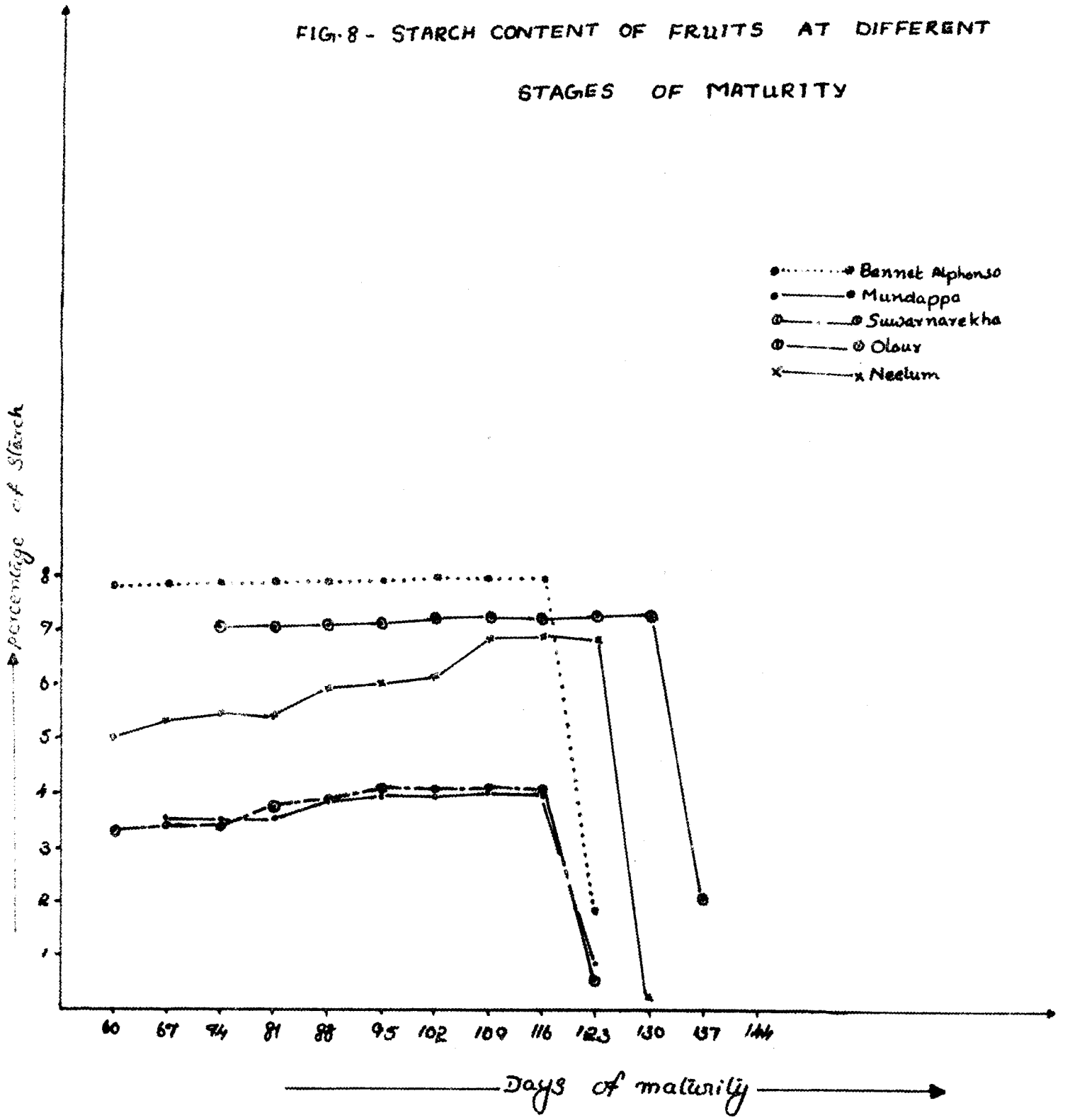


FIG. 9 - CAROTENE CONTENT OF FRUITS AT DIFFERENT STAGES OF MATURITY

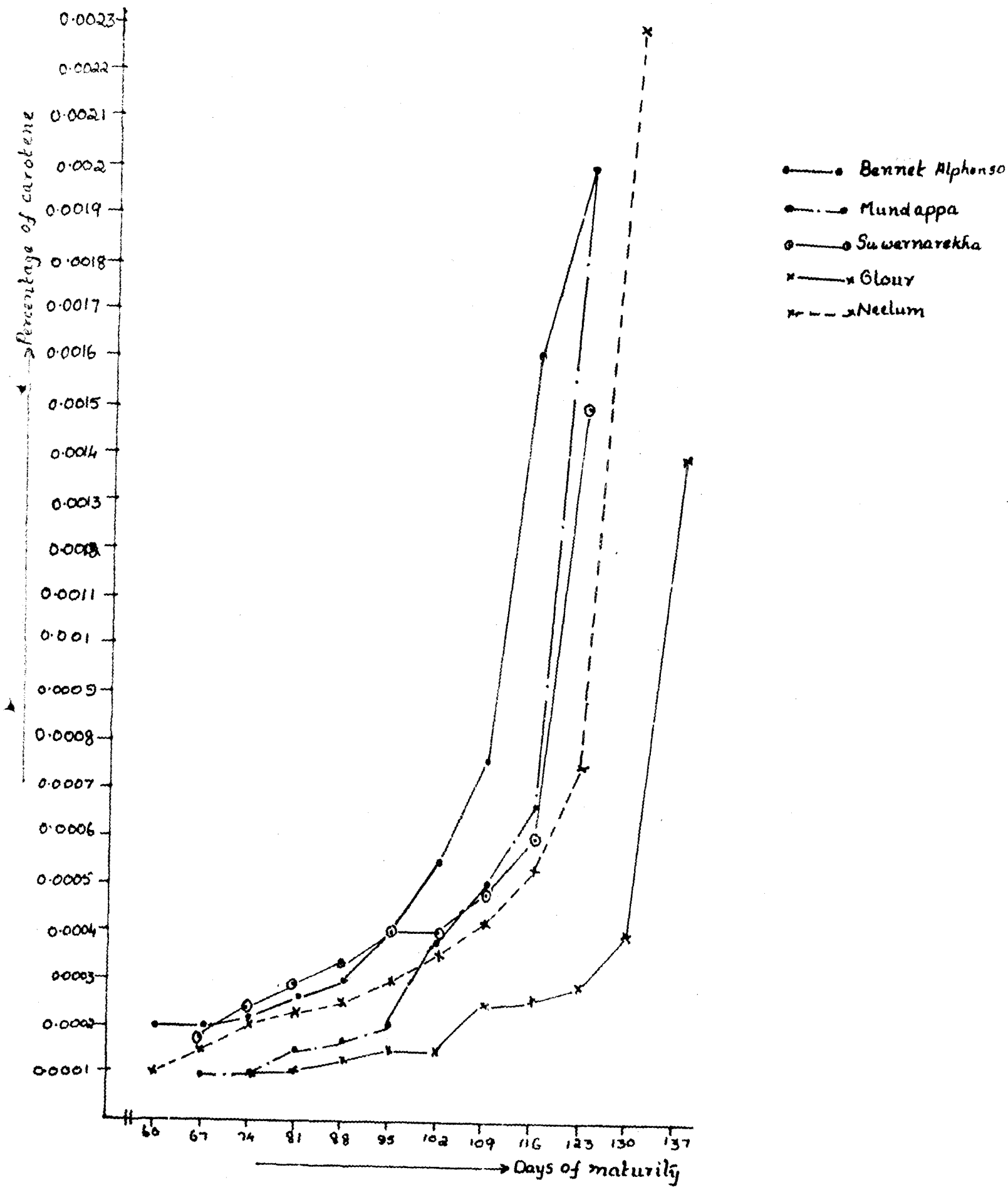


FIG.10 - T.S.S. CONTENT OF FRUITS AT DIFFERENT STAGES OF MATURITY

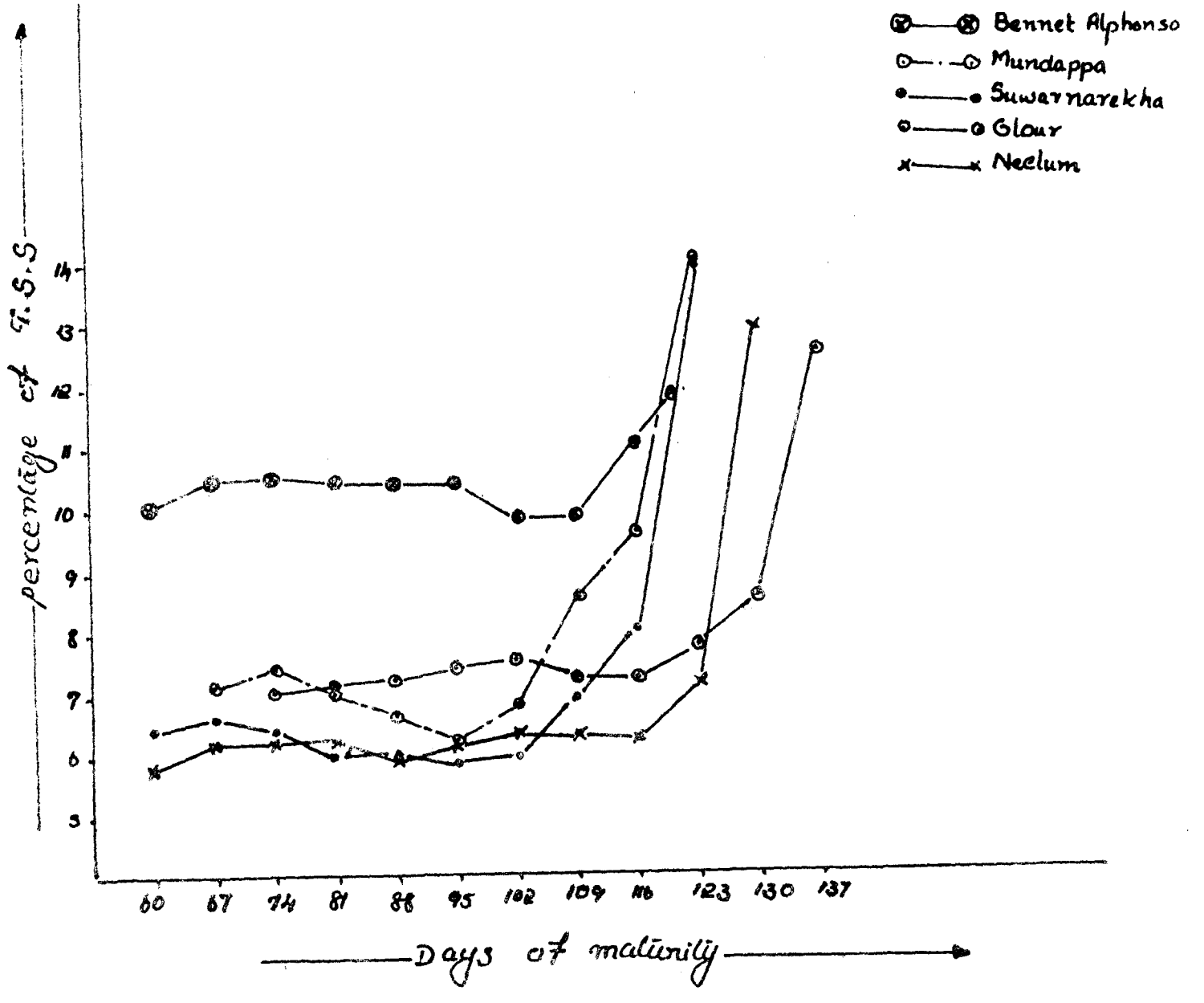


FIG-11 - MOISTURE CONTENT OF FRUITS AT DIFFERENT STAGES OF MATURITY

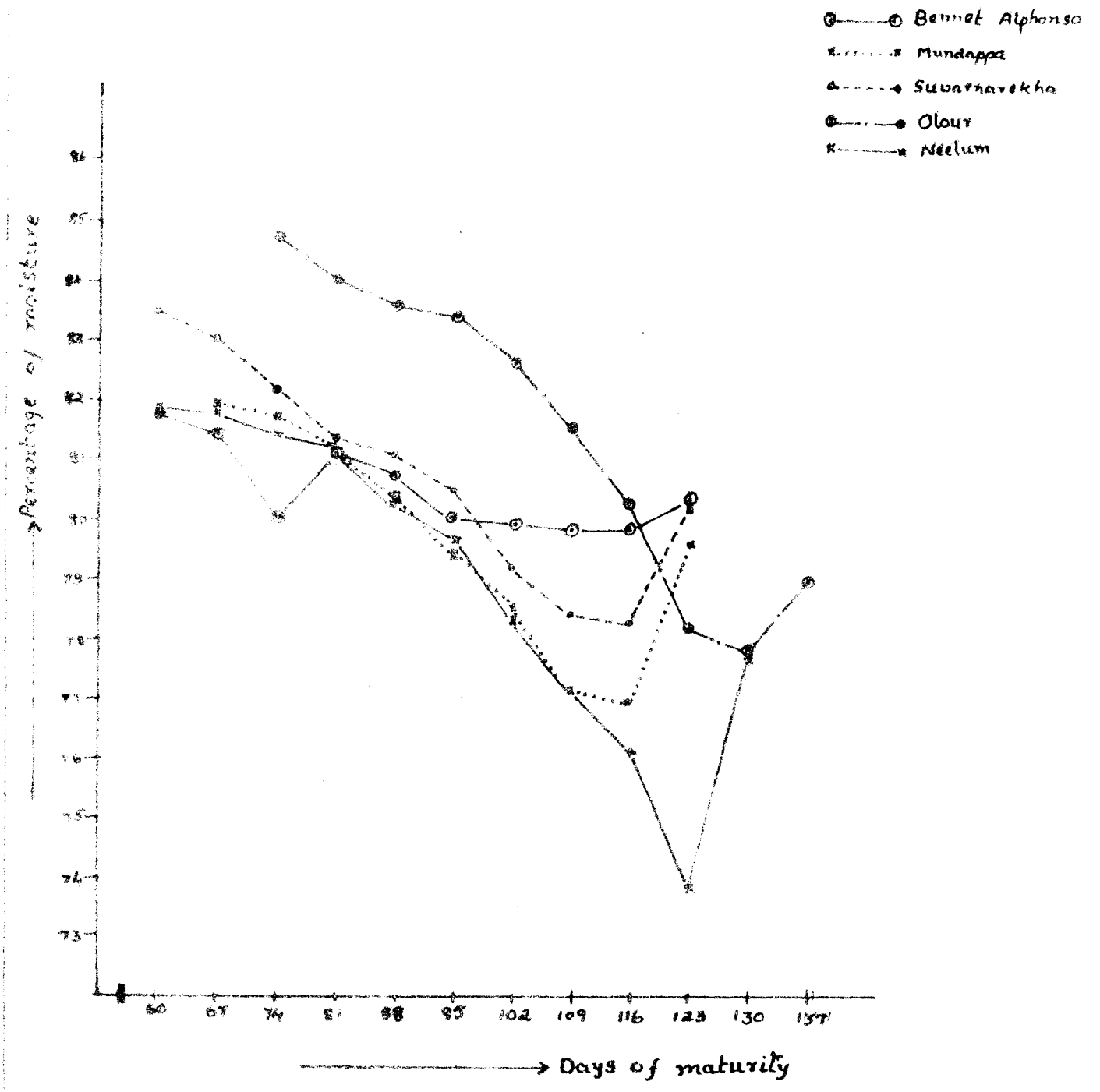


FIG. 12 - ASCORBIC ACID CONTENT OF FRUITS AT DIFFERENT STAGES OF MATURITY

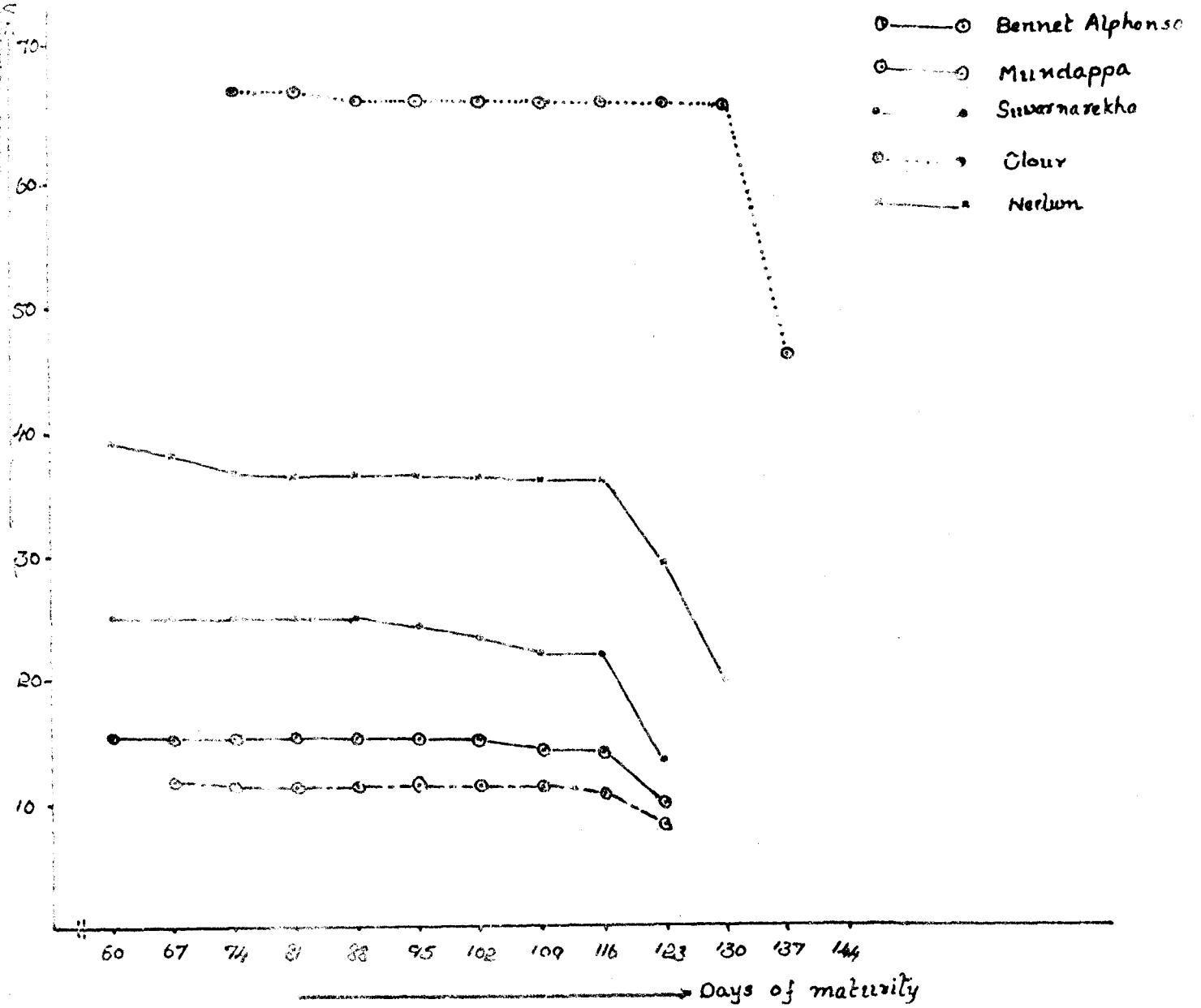


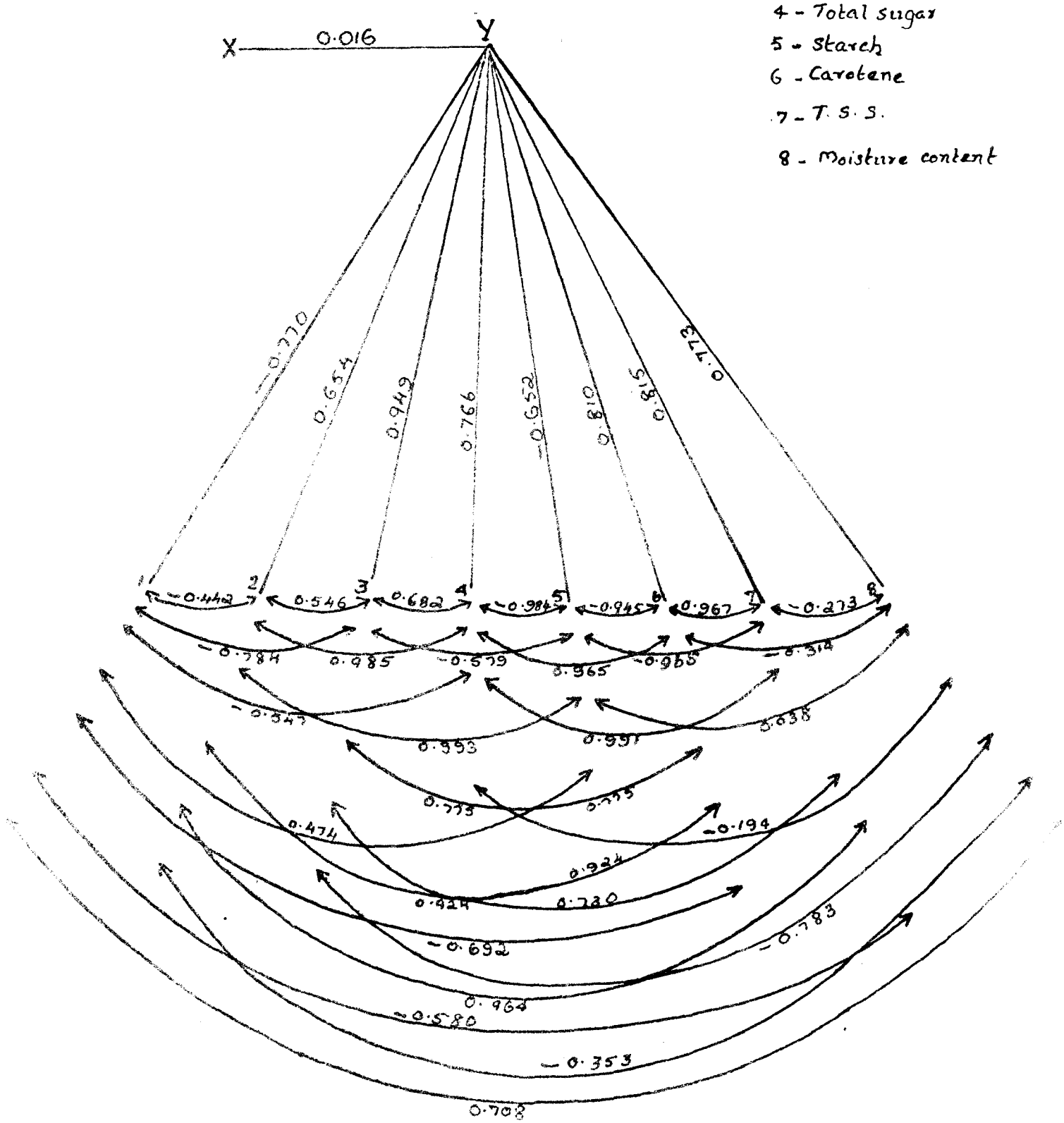
Table 4 Direct and indirect effects of chemical constituents on maturity of fruits

Characters	r^*	Direct effect	Indirect effect via character							
			Acidity %	Reducing sugar %	Nonreducing sugar %	Total sugar %	Starch %	Carotene %	T.S.S. %	Moisture %
Acidity of fruit (%)	-0.770	-0.142	-	-0.865	-0.587	0.482	0.831	0.060	-0.549	0.00600
Reducing sugar (%)	0.654	1.958	-0.063	--	0.409	-0.868	-1.741	-0.080	0.913	0.00030
Nonreducing sugar (%)	0.949	0.749	0.111	1.070	-	-0.601	-1.003	-0.068	0.690	-0.00060
Total sugar (%)	0.766	-0.881	0.078	1.929	0.511	-	-1.725	-0.084	0.939	0.00020
Starch (%)	-0.652	1.753	-0.067	-1.944	-0.428	0.867	-	0.082	-0.914	0.00003
Carotene (%)	0.810	-0.087	0.098	1.809	0.580	-0.850	-1.657	-	0.916	-0.00030
T.S.S.(%)	0.815	0.947	0.082	1.888	0.550	-0.873	-1.692	-0.084	-	-0.00020
Moisture (%)	-0.773	0.0008	-0.101	-0.069	-0.586	0.168	0.067	0.027	-0.259	-

r^* = Correlation coeffients between maturity of fruit and the chemical constituents

FIG. 13 - PATH DIAGRAM SHOWING THE DIRECT AND INDIRECT EFFECTS OF THE CHEMICAL CONSTITUENTS ON MATURITY OF THE FRUIT

Y - Maturity
X - Residual factor
1 - Acidity
2 - Reducing sugar
3 - Non reducing sugar
4 - Total sugar
5 - Starch
6 - Carotene
7 - T. S. S.
8 - Moisture content



STORAGE STUDIES

The storage life and the qualitative changes of stored fruits under different storage methods were studied and compared.

In the treatment M_1 (storage in polythene bags 300 gauges) the storage life on an average was 24.6 days. Significant difference was found between varieties, the variety Bennet Alphonso exhibiting the highest (30.1 days) and Suwarnarekha the least (20 days) storage life. Bennet Alphonso was followed by Neelum (28.01 days), Mundappa (24.4 days) and Olour (21.3 days) respectively (Table 5.a).

In the method M_2 (storage in polythene bags 250 gauges) also significant difference in storage life was observed between varieties. The storage life on an average was 23.7 days. Bennet Alphonso ranked first (30.1 days) followed by Neelum (26.8 days), Mundappa (23.7 days), Olour (20.9 days) and Suwarnarekha (16.7 days) respectively (Table 5.a).

Trials with M_3 (storage in polythene bags 150 gauges) showed that Neelum and Suwarnarekha were on par giving an average storage life of 23.2 and 22.8 days respectively. Bennet Alphonso significantly differed from the rest of the varieties giving an average storage life of 18.1 days. Mundappa and Olour were on par in storage life (17.8 days) (Table 5.a).

In the method M_4 (polythene bag 300 gauges + waxing) the mean storage life was 24.5 days. Bennet Alphonso, Mundappa and Neelum differed significantly giving an average storage life of 30, 26.2 and 24.7 days respectively. Varieties Suwarnarekha and Olour were on par (Table 5.a).

In the treatment M_5 (waxing of the fruits) the mean storage life was 22 days. Neelum was significantly superior to other varieties giving an average storage life of 24 days. Neelum was followed by Mundappa (23.2 days) and Bennet Alphonso (23 days) which were on par. Suwarnarekha and Olour differed significantly in storage life, the storage life being 20.7 and 19.6 days respectively (Table 5.a).

In method M_6 (polythene bag + $KMnO_4$) all varieties responded differently. The mean storage life was 25.5 days. Neelum gave maximum storage life (29.7 days) followed by Bennet Alphonso (29 days), Mundappa (25.6 days), Olour (23.1 days) and Suwarnarekha (20.3 days) respectively (Table 5.a).

In the case of M_7 (control) also, all varieties differed significantly. The mean storage life in the untreated control was 16.7 days. Neelum had the maximum storage life (19.5 days) followed by Suwarnarekha (19.1 days), Bennet Alphonso (18.1 days), Mundappa (17.8 days) and Olour (15 days) respectively (Table 5.a).

In all methods of storage, fruits harvested at B stage (S_2) gave significantly prolonged shelf life. Under M_1, fruits from B stage recorded an average life of 25.6 days, whereas it was 24.7 days for C stage (S_3) and 23.6 days for A stage (S_1). At S_2, the storage life of fruits under M_2, M_3, M_4, M_5, M_6 and M_7 were 24.5, 20.1, 25.8, 24.3, 26.0 and 18.4 days respectively (Table 5.b).

In all the five varieties studied, significant difference in storage life was observed between the three stages of maturity. Of the three stages, for all varieties S_2 gave the longest storage life of 23.5 days. Except Mundappa, in all other varieties S_2 was followed by S_1. An overall comparison showed that the varieties Bennet Alphonso and Neelum were significantly superior to other varieties giving an average storage life of 25.1 and 25 days respectively (Table 5.c).

The storage life varied widely between the two temperatures. At room temperature (28-30.6°C) the storage life was maximum for the waxed fruits kept in polythene bags (300 gauges) giving an average storage life of 19.6 days followed by fruits kept in polythene bags along with $KMnO_4$ (18.4 days) as well as fruits stored after waxing (18.3 days) (Table 6.). Storage at 6 ± 0.5°C brought about longest storage life for fruits under all methods compared to storage at room temperature. At this temperature, longest storage

Table 5.a Storage life (in days) of fruits under different methods of storage

	M_1	M_2	M_3	M_4	M_5	M_6	M_7	Mean
Bennet Alphonso	30.10 (5.486)	30.10 (5.485)	18.10 (4.257)	30.00 (5.474)	23.00 (4.786)	29.00 (5.357)	18.10 (4.259)	25.10 (5.01)
Mundappa	24.40 (4.940)	23.70 (4.870)	17.80 (4.213)	26.20 (5.121)	23.20 (4.817)	25.60 (5.059)	17.80 (4.216)	22.40 (4.75)
Suwarnarekha	20.00 (4.475)	16.79 (4.087)	22.80 (4.779)	21.10 (4.592)	20.70 (4.548)	20.30 (4.500)	19.10 (4.375)	19.20 (4.38)
Olour	21.30 (4.620)	20.90 (4.570)	17.80 (4.220)	21.00 (4.580)	19.60 (4.430)	23.10 (4.810)	15.00 (3.874)	19.70 (4.44)
Neelum	28.01 (5.304)	26.80 (5.179)	23.20 (4.811)	24.70 (4.965)	24.00 (4.894)	29.70 (5.444)	19.50 (4.412)	25.00 (5.00)
Mean	24.60 (4.96)	23.70 (4.87)	18.60 (4.31)	24.50 (4.95)	22.00 (4.69)	25.50 (5.05)	16.70 (4.09)	

The values given in parenthesis are the transformed values

C.D Varieties - 0.033
C.D Methods - 0.039
C.D variety x Method - 0.088

M_1 - Polythene bags 300 gauges
M_2 - Polythene bags 250 gauges
M_3 - Polythene bags 150 gauges
M_4 - Polythene bags 300 gauges + waxing
M_5 - Waxing of the fruit
M_6 - Polythene bags 300 gauges + $KMnO_4$
M_7 - Control

Table 5.b Storage life (in days) of fruits harvested at different stages under different methods of storage

	M_1	M_2	M_3	M_4	M_5	M_6	M_7	Mean
S_1	4.857 (23.6)	4.810 (23.1)	4.428 (19.6)	4.856 (23.6)	4.490 (20.2)	5.100 (26.0)	4.04 (16.3)	4.65 (21.6)
S_2	5.064 (25.6)	4.953 (24.5)	4.484 (20.1)	5.074 (25.8)	4.93 (24.3)	5.10 (26.0)	4.29 (18.4)	4.85 (23.5)
S_3	4.971 (24.7)	4.861 (23.6)	4.020 (16.2)	4.91 (24.1)	4.73 (22.4)	4.95 (24.5)	3.95 (15.6)	4.63 (21.4)
Mean	4.96 (24.6)	4.87 (23.7)	4.31 (18.6)	4.95 (24.5)	4.69 (22.0)	5.05 (25.5)	4.09 (16.7)	

The values given in parenthesis are the $\overset{ve}{\wedge}$ transformed values

C.D (Methods) - 0.039
C.D (Stages) - 0.026
C.D (Method x Stage) 0.068

S_1 - A stage
S_2 - B stage
S_3 - C stage

Table 5.c Storage life (in days) of mango varieties harvested at different stages

	Bennet Alphonso	Mundappa	Suwarnarekha	Olour	Neelum	Mean
S_1	24.80 (4.980)	20.80 (4.560)	18.90 (4.350)	19.70 (4.440)	24.40 (4.941)	21.60 (4.650)
S_2	26.80 (5.173)	24.20 (4.918)	20.20 (4.495)	20.20 (4.492)	26.80 (5.175)	23.50 (4.850)
S_3	23.90 (4.887)	22.30 (4.718)	17.90 (4.228)	19.40 (4.400)	24.10 (4.909)	21.40 (4.630)
Mean	25.10 (5.010)	22.40 (4.750)	19.20 (4.380)	19.70 (4.440)	25.00 (5.00)	

The values given in parenthesis are the transformed values

C.D (varieties) - 0.033
C.D (stages) - 0.026
C.D (variety x stage)- 0.057

S_1 - A stage
S_2 - B stage
S_3 - C stage

life was observed for fruits kept in polythene bags (300 gauges) as well as those stored in polythene (300 gauges) along with $KMnO_4$ (34 and 33.9 days respectively). In both methods, storage life varied widely between varieties. Regarding fruits kept in polythene bags 300 gauges longest storage life was observed for the variety Bennet Alphonso (43.4 days) followed by Neelum (37.2 days) and the least for Suwarnarekha (26.9 days). Similar trend was there in the case of fruits stored in polythene bags along with $KMnO_4$ (Table 7.). Even-though at room temperature the waxed fruits gave significantly prolonged storage life (18.3 days) compared to the untreated fruits (7.3 days), at low temperature just a reverse trend was observed. The waxed fruits had a storage life of only 26.6 days while the untreated fruits could safely be stored for 30.1 days.

1. Weight of fruits

The change in weight of fruits after ripening, kept under different storage conditions were studied and the results are presented in Tables 8.a,b and c.

In all varieties, the fruits ripened under M_5 and M_4 maintained maximum weight. The lose in weight was maximum under M_7 (0.089) and this was on par with M_3 in the case of varieties Bennet Alphonso, Suwarnarekha and Neelum. In Bennet Alphonso M_3 was on par with M_2 and M_7.

Table 6 Storage life (in days) of fruits under different methods of storage at room temperature

	M_1	M_2	M_3	M_4	M_5	M_6	M_7	Mean
Bennet Alphonso	19.90 (4.46)	19.20 (4.38)	9.20 (3.03)	21.70 (4.66)	19.00 (4.36)	18.80 (4.34)	8.90 (2.99)	16.20 (4.03)
Mundappa	18.60 (4.31)	15.50 (3.94)	11.20 (3.35)	18.70 (4.33)	19.00 (4.36)	18.40 (4.29)	8.50 (2.91)	15.40 (3.93)
Suwarnarekha	13.90 (3.73)	11.20 (3.34)	8.90 (2.98)	19.70 (4.44)	17.90 (4.23)	15.60 (3.95)	5.80 (2.41)	12.80 (3.58)
Olour	14.10 (3.76)	13.30 (3.65)	8.30 (2.88)	16.60 (4.07)	15.40 (3.93)	17.30 (4.16)	5.60 (2.36)	12.50 (3.54)
Neelum	20.30 (4.50)	18.10 (4.26)	13.20 (3.64)	21.80 (4.67)	20.30 (4.50)	21.90 (4.68)	8.01 (2.82)	17.30 (4.16)
Mean	17.20 (4.15)	15.30 (3.91)	10.10 (3.18)	19.60 (4.43)	18.30 (4.28)	18.40 (4.29)	7.30 (2.70)	

The values given in parenthesis are the transformed values

C.D (varieties) - 0.07

C.D (methods) - 0.08

C.D (variety x method)- 0.19

Table 7 Storage life (in days) of fruits under different methods of storage at low temperature (6 ± 0.5°C)

	M_1	M_2	M_3	M_4	M_5	M_6	M_7	Mean
Bennet Alphonso	43.40 (6.59)	42.40 (6.51)	30.00 (5.48)	39.60 (6.29)	27.10 (5.21)	40.60 (6.37)	30.60 (5.53)	36.00 (6.00)
Mundappa	33.60 (5.80)	31.00 (5.57)	25.80 (5.08)	32.60 (5.71)	27.90 (5.28)	33.80 (5.81)	30.50 (5.52)	30.70 (5.54)
Suwarnarekha	26.90 (5.19)	27.20 (5.22)	26.20 (5.12)	24.50 (4.95)	25.80 (5.08)	28.80 (5.37)	24.90 (4.99)	26.30 (5.13)
Olour	30.30 (5.50)	30.00 (5.48)	31.00 (5.57)	25.80 (5.08)	24.40 (4.94)	29.80 (5.46)	29.05 (5.39)	28.50 (5.34)
Neelum	37.20 (6.10)	37.20 (6.10)	35.80 (5.98)	27.70 (5.26)	27.90 (5.28)	37.20 (6.10)	36.00 (6.00)	34.00 (5.83)
Mean	34.00 (5.83)	33.40 (5.78)	29.60 (5.44)	29.80 (5.46)	26.60 (5.16)	33.90 (5.82)	30.10 (5.49)	

The values given in parenthesis are the transformed values

C.D (varieties) - 0.06

C.D (methods) - 0.07

C.D (variety x method) - 0.16

The loss in weight was significant between varieties, Olour giving the least (0.037) followed by Bennet Alphonso (0.051), Neelum (0.056) and Suwarnarekha (0.061) which were on par. The weight loss was maximum in Mundappa (0.084) (Table 8.a). For all varieties under all methods of storage the mean loss of weight was on par with stages S_2 and S_3 (Table 8.b).

2. Acidity of fruit

The reduction in acidity of fruits was maximum under M_7 (0.653) and M_3 (0.636) which were on par and least under M_4 (0.353). Bennet Alphonso showed maximum decrease in acidity (0.580) followed by Neelum (0.560), Suwarnarekha (0.530) and Olour (0.510) respectively. Mundappa gave the least decrease (0.431) (Table 9.a).

At all stages, the extent of decrease in acidity after storage varied with varieties and methods of storage (Tables 9.b and c). At S_1 the least decrease in acidity was observed in fruits of Suwarnarekha (0.413) followed by those of Olour (0.53) and Mundappa (0.607) respectively. The proportionate decrease in acidity after storage was maximum in Neelum and Bennet Alphonso which were on par. At S_2 and S_3, the acidity of ripe fruits significantly varied between varieties, Bennet Alphonso shewing the highest acid content (Table 9.b). Among the seven methods of storage, at S_1 the decrease in acidity of ripe fruits was least under M_4 (0.411) and M_5 (0.421) and highest under M_3 (0.676) and M_7 (0.692).

The same trend in acid content was observed at S_2 also. At S_3, M_4 and M_5 varied significantly, the fruits ripened under M_4 showing the highest acid content while those ripened under M_3 and M_7 showed the least (Table 9.c).

3. Total sugar

Analysis of data in table 10.a showed that in all stages and in all varieties, the fruits ripened under M_7 gave the highest and significant increase in total sugar (0.70) followed by those kept under M_5 (0.655) and M_3 (0.650) which were on par. The total sugar content was least in fruits stored under M_4, while it was highest when kept under M_7, for all varieties except Mundappa. In the case of Mundappa, M_2 (0.772) and M_1 (0.765) brought about significant increase in total sugar content compared to M_7. Under all methods significant difference was observed between varieties. Under M_1, M_3, M_5 and M_7, Suwarnarekha showed the highest increase in total sugar content whereas under M_2, M_4 and M_6, Neelum showed the highest. At all stages, the extent of increase in total sugar content varied with varieties and methods of storage. The varietal variation was significant at all stages, at S_1 Neelum giving the highest increase in total sugar content. For fruits harvested at S_2 and S_3, the highest increase in total sugar content was observed in Suwarnarekha (Table 10.b). At all stages, the total sugar

content was maximum in fruits kept under M_7 and minimum in those kept under M_4 (Table 10.c).

4. Ascorbic acid

The fruits ripened under M_5 had the highest ascorbic acid content which was on par with M_4 and the least in fruits ripened under M_3 which was on par with M_6, M_2 and M_1. The decrease in ascorbic acid content of ripened fruits on storage varied with varieties. Olour showed the least decrease (0.196) and for this variety M_1 showed the least decrease (0.13) while M_7 had the highest (0.275) (Table 11.a). At all stages the ascorbic acid content of the ripe fruits varied with varieties and methods of storage. At S_1 and S_2 fruits of Olour showed the lowest decrease in ascorbic acid content and at S_3, Olour was on par with Suwarnarekha. At all stages, fruits of Mundappa had the least ascorbic acid content after ripening under different methods (Table 11.b). At S_1, S_2 and S_3 the fruits ripened under M_5 and M_4 had the highest ascorbic acid content (Table 11.c). At S_1, M_3 was on par with M_2, M_7 and M_6 and at S_2 the same was on par with M_6, M_1 and M_2. At S_3, the lowest ascorbic acid content was observed in fruits ripened under M_6 and this was on par with M_7, M_2 and M_3 (Table 11.c).

Table 8.a Loss of weight of fruits under different methods of storage (g)

	M_1		M_2		M_3		M_4	
	Initial	Final	Initial	Final	Initial	Final	Initial	Final
Bennet Alphonso	162.0	152.1 (0.061)	181.3	168.6 (0.07)	175.0	162.8 (0.07)	186.0	182.3 (0.02)
Mundappa	231.2	213.2 (0.078)	236.2	214.2 (0.093)	245.3	216.4 (0.118)	232.6	221.2 (0.049)
Suwarnarekha	305.1	322.4 (0.079)	308.3	326.4 (0.063)	301.6	323.8 (0.079)	300.2	338.3 (0.034)
Olour	203.2	196.5 (0.033)	208.3	199.6 (0.042)	200.6	193.4 (0.036)	210.6	206.2 (0.021)
Neelum	180.6	171.8 (0.049)	176.6	166.2 (0.059)	182.5	166.4 (0.088)	183.9	178.4 (0.030)
Mean	216.8	203.8 (0.06)	218.2	204.0 (0.065)	215.7	198.9 (0.078)	218.6	211.8 (0.031)

The values given in parenthesis are the proportion of the loss of weight

$$\left(\frac{\text{loss of weight}}{\text{Initial}}\right)$$

C.D (varieties) - 0.005
C.D (Methods) - 0.005
C.D (Variety x Method) 0.0124

(contd.)

Table 8.a continued

	M_5		M_6		M_7		Mean	
	Initial	Final	Initial	Final	Initial	Final	Initial	Final
Bennet Alphonso	193.0	189.9 (0.016)	189.0	180.5 (0.045)	192.0	177.8 (0.074)	182.6	173.3 (0.051)
Mundappa	229.5	218.5 (0.048)	242.5	226.3 (0.067)	229.3	197.9 (0.137)	235.2	215.4 (0.084)
Suwarnarekha	305.9	340.0 (0.017)	305.8	338.4 (0.049)	302.1	323.2 (0.082)	304.14	285.59 (0.061)
Olour	196.3	193.6 (0.014)	205.1	195.1 (0.049)	206.6	194.2 (0.06)	204.4	196.8 (0.037)
Neelum	194.6	189.3 (0.027)	198.9	189.4 (0.048)	192.6	175.1 (0.091)	187.1	176.6 (0.056)
Mean	218.2	211.9 (0.029)	218.9	207.7 (0.051)	220.1	200.5 (0.089)		

Table 8.b Loss of weight of fruits harvested at different stages of maturity and stored under different methods(g)

	M_1		M_2		M_3		M_4	
	Initial	Final	Initial	Final	Initial	Final	Initial	Final
S_1	203.3	187.8 (0.076)	205.6	189.6 (0.078)	200.6	182.7 (0.089)	205.3	197.5 (0.038)
S_2	220.6	210.7 (0.045)	221.9	209.5 (0.056)	218.3	202.6 (0.072)	220.2	214.5 (0.026)
S_3	226.5	212.9 (0.060)	227.1	213.0 (0.062)	228.3	211.6 (0.073)	230.3	223.9 (0.028)
Mean	216.8	203.8 (0.06)	218.2	204.0 (0.065)	215.7	198.9 (0.078)	218.6	211.8 (0.031)

The values given in parenthesis are the proportion of lose of weight

C.D (Methods) - 0.005
C.D (Stages) - 0.003
C.D (Method x Stage) - 0.008

(contd.)

Table 8.b continued

	M_5		M_6	
	Initial	Final	Initial	Final
S_1	201.5	194.4	206.2	193.4
	(0.035)		(0.062)	
S_2	225.6	219.7	219.1	219.7
	(0.026)		(0.048)	
S_3	227.5	221.6	231.5	221.3
	(0.026)		(0.044)	
Mean	218.2	211.9	218.9	207.7
	(0.029)		(0.051)	

M_7		Mean	
Initial	Final	Initial	Final
201.3	179.2	203.4	189.2
(0.110)		(0.07)	
230.3	212.6	222.3	211.2
(0.077)		(0.05)	
228.6	210.3	228.5	216.3
(0.081)		(0.053)	
220.1	200.5		
(0.089)			

Table 9.a Change in acidity of fruits under different methods of storage(%)

	M_1		M_2		M_3		M_4	
	Initial	Final	Initial	Final	Initial	Final	Initial	Final
Bennet Alphonso	2.76	1.45 (0.475)	2.76	0.81 (0.705)	2.76	0.74 (0.732)	2.76	1.68 (0.391)
Mundappa	1.57	0.92 (0.415)	1.57	0.87 (0.448)	1.57	0.72 (0.542)	1.57	1.09 (0.305)
Suwarnarekha	1.52	0.65 (0.571)	1.52	0.56 (0.632)	1.52	0.53 (0.649)	1.52	0.94 (0.380)
Olour	1.62	0.71 (0.564)	1.62	0.64 (0.603)	1.62	0.59 (0.638)	1.62	1.19 (0.267)
Neelum	1.56	0.66 (0.576)	1.56	0.59 (0.620)	1.56	0.60 (0.618)	1.56	0.90 (0.424)
Mean	1.80	0.86 (0.520)	1.80	0.72 (0.602)	1.80	0.66 (0.636)	1.80	1.16 (0.353)

The values given in parenthesis are the proportion of change in acidity ($\frac{\text{change in acidity}}{\text{Initial acidity}}$)

(contd.)

C.D (Methods) - 0.021

C.D (Varieties) - 0.018

C.D (Variety x Method) 0.047

Table 9.a continued

	M_5		M_6	
	Initial	Final	Initial	Final
Bennet Alphonso	2.76	1.42 (0.487)	2.76	1.20 (0.567)
Mundappa	1.57	1.05 (0.329)	1.57	0.94 (0.404)
Suwarnarekha	1.52	1.07 (0.297)	1.52	0.79 (0.477)
Olour	1.62	1.16 (0.283)	1.62	0.72 (0.555)
Neelum	1.56	0.79 (0.495)	1.56	0.72 (0.536)
Mean	1.80	1.12 (0.378)	1.80	0.89 (0.508)

M_7		Mean	
Initial	Final	Initial	Final
2.76	0.74	2.76	1.16
	(0.701)		(0.580)
1.57	0.67	1.57	0.89
	(0.574)		(0.431)
1.52	0.50	1.52	0.71
	(0.672)		(0.530)
1.62	0.56	1.62	0.81
	(0.653)		(0.510)
1.56	0.52	1.56	0.69
	(0.664)		(0.560)
1.80	0.62		
	(0.653)		

Table 9.b Change in acidity of fruits harvested at different stages of maturity(%)

	Bennet Alphonso		Mundappa		Suwarnarekha		Olour		Neelum		Mean	
	Initial	Final	Initial	Final	Initial	Final	Initial	Final	Initial	Final	Initial	Final
S_1	3.54	1.26 (0.643)	2.42	0.95 (0.607)	1.95	1.14 (0.413)	1.89	0.89 (0.53)	2.75	0.98 (0.643)	2.51	1.09 (0.567)
S_2	3.42	0.97 (0.717)	1.30	0.79 (0.395)	1.70	0.79 (0.59)	1.66	0.77 (0.538)	1.52	0.67 (0.558)	1.92	0.84 (0.560)
S_3	1.32	0.82 (0.378)	1.00	0.71 (0.290)	0.90	0.37 (0.571)	1.30	0.70 (0.459)	0.40	0.21 (0.485)	0.98	0.55 (0.437)
Mean	2.76	1.16 (0.580)	1.57	0.89 (0.431)	1.52	0.71 (0.530)	1.62	0.81 (0.50)	1.56	0.69 (0.560)		

The values given in parenthesis are the proportion of change in acidity

C.D (varieties) - 0.018

C.D (stages) - 0.014

C.D (variety x stage) 0.031

Table 9.c Change in acidity of fruits harvested at different stages of maturity and stored under different methods (%)

	M_1		M_2		M_3		M_4	
	Initial	Final	Initial	Final	Initial	Final	Initial	Final
S_1	2.51	1.08 (0.568)	2.51	0.88 (0.650)	2.51	0.81 (0.676)	2.51	1.48 (0.411)
S_2	1.92	0.84 (0.563)	1.92	0.72 (0.625)	1.92	0.62 (0.676)	1.92	1.15 (0.403)
S_3	0.98	0.56 (0.430)	0.98	0.46 (0.530)	0.98	0.44 (0.554)	0.98	0.74 (0.246)
Mean	1.80	0.86 (0.520)	1.80	0.72 (0.602)	1.80	0.66 (0.636)	1.80	1.16 (0.353)

The values given in parenthesis are the proportion of change in acidity

C.D (methods) - 0.021
C.D (stages) - 0.014
C.D (method x stage)- 0.036

(contd.)

Table 9.c continued

	M_5		M_6		M_7		Mean	
	Initial	Final	Initial	Final	Initial	Final	Initial	Final
S_1	2.51	1.45 (0.421)	2.51	1.12 (0.554)	2.51	0.77 (0.692)	2.51	1.09 (0.567)
S_2	1.92	1.16 (0.396)	1.92	0.84 (0.560)	1.92	0.58 (0.696)	1.92	0.84 (0.560)
S_3	0.98	0.67 (0.317)	0.98	0.58 (0.410)	0.98	0.42 (0.571)	0.98	0.55 (0.437)
Mean	1.80	1.12 (0.378)	1.80	0.89 (0.508)	1.80	0.62 (0.653)		

Table 10.a Change in total sugar content of fruits under different methods of storage (%)

	M_1		M_2		M_3		M_4	
	Initial	Final	Initial	Final	Initial	Final	Initial	Final
Bennet Alphonso	10.27	10.74 (0.046)	10.27	10.89 (0.060)	10.27	11.55 (0.125)	10.27	10.70 (0.042)
Mundappa	7.24	12.78 (0.765)	7.24	12.83 (0.772)	7.24	12.70 (0.754)	7.24	11.28 (0.558)
Suwarnarekha	5.75	11.01 (0.914)	5.75	11.36 (0.976)	5.75	11.62 (1.020)	5.75	10.19 (0.772)
Olour	8.22	10.89 (0.325)	8.22	10.74 (0.307)	8.22	11.05 (0.344)	8.22	9.25 (0.125)
Neelum	6.32	11.39 (0.802)	6.32	12.61 (0.995)	6.32	12.72 (1.013)	6.32	11.37 (0.799)
Mean	7.35	11.56 (0.570)	7.35	11.94 (0.622)	7.35	12.14 (0.650)	7.35	10.74 (0.459)

The values given in parenthesis are the proportion of change in total sugar $\left(\frac{\text{change in total sugar content}}{\text{Initial total sugar content}}\right)$

C.D (methods) - 0.011

C.D (varieties) - 0.0096

C.D (method x variety) 0.025

(contd.)

Table 10.a continued

	M_5		M_6	
	Initial	Final	Initial	Final
Bennet Alphonso	10.27	11.13 (0.084)	10.27	11.20 (0.091)
Mundappa	7.24	12.54 (0.732)	7.24	12.50 (0.727)
Suwarnarekha	5.75	12.06 (1.097)	5.75	10.85 (0.887)
Olour	8.22	10.74 (0.306)	8.22	10.29 (0.252)
Neelum	6.32	12.99 (1.055)	6.32	12.03 (0.904)
Mean	7.35	12.18 (0.655)	7.35	11.56 (0.570)

M_7		Mean	
Initial	Final	Initial	Final
10.27	12.00	10.27	11.17
	(0.168)		(0.088)
7.24	12.62	7.24	12.45
	(0.745)		(0.720)
5.75	12.21	5.75	11.32
	(1.123)		(0.970)
8.22	11.16	8.22	10.58
	(0.358)		(0.288)
6.32	13.33	6.32	12.35
	(1.110)		(0.954)
7.35	12.51		
	(0.700)		

Table 10.b Change in total sugar content of fruits harvested at different stages of maturity(%)

	Bennet Alphonso		Mundappa		Suwarnarekha		Olour		Neelum		Mean	
	Initial	Final	Initial	Final	Initial	Final	Initial	Final	Initial	Final	Initial	Final
S_1	9.55	10.38 (0.087)	7.05	10.98 (0.558)	5.40	9.36 (0.733)	7.99	10.36 (0.297)	5.95	10.83 (0.820)	7.00	10.49 (0.499)
S_2	10.42	11.35 (0.089)	6.15	12.88 (1.094)	4.92	11.05 (1.246)	8.09	10.78 (0.333)	5.94	13.22 (1.225)	6.94	12.47 (0.797)
S_3	10.83	11.77 (0.087)	8.52	12.88 (0.512)	6.93	13.38 (0.931)	8.59	10.61 (0.235)	7.06	12.83 (0.817)	8.12	12.32 (0.517)
Mean	10.27	11.17 (0.088)	7.24	12.45 (0.720)	5.75	11.32 (0.970)	8.22	10.58 (0.288)	6.32	12.35 (0.954)		

The values given in parenthesis are the proportion of change in total sugar content

C.D (varieties) - 0.0096

C.D (stages) - 0.0073

C.D (variety x stage) - 0.016

Table 10.c Change in total sugar content of fruits harvested at different stages of maturity and stored under different methods (%)

	M_1		M_2		M_3		M_4	
	Initial	Final	Initial	Final	Initial	Final	Initial	Final
S_1	7.00 (0.468)	10.28	7.00 (0.544)	10.81	7.00 (0.536)	10.75	7.00 (0.364)	9.55
S_2	6.94 (0.757)	12.19	6.94 (0.810)	12.56	6.94 (0.856)	12.88	6.94 (0.615)	11.21
S_3	8.12 (0.486)	12.07	8.12 (0.511)	12.77	8.12 (0.561)	12.08	8.12 (0.398)	11.35
Mean	7.35 (0.570)	11.54	7.35 (0.622)	11.92	7.35 (0.650)	12.13	7.35 (0.459)	10.72

The values given in parenthesis are the proportion of change in total sugar content

C.D (methods) - 0.011
C.D (stages) - 0.0073
C.D (method x stage) - 0.0196

(contd.)

Table 10.c continued

	M_5		M_6	
	Initial	Final	Initial	Final
S_1	7.00	11.17 (0.596)	7.00	9.71 (0.387)
S_2	6.94	12.78 (0.841)	6.94	12.50 (0.801)
S_3	8.12	12.41 (0.528)	8.12	12.42 (0.530)
Mean	7.35	12.16 (0.655)	7.35	11.54 (0.570)

M_7		Mean	
Initial	Final	Initial	Final
7.00 (0.599)	11.19	7.00 (0.499)	10.49
6.94 (0.900)	13.19	6.94 (0.797)	12.47
8.12 (0.603)	13.02	8.12 (0.517)	12.32
7.35 (0.700)	12.50		

Table 11.a Change in ascorbic acid content (mg/100 g) of fruits under different methods of storage

	M_1		M_2		M_3		M_4	
	Initial	Final	Initial	Final	Initial	Final	Initial	Final
Bennet Alphonso	14.64	11.11 (0.241)	14.64	11.10 (0.248)	14.64	9.78 (0.332)	14.64	11.92 (0.186)
Mundappa	11.77	7.52 (0.357)	11.77	6.79 (0.423)	11.77	6.72 (0.429)	11.77	7.65 (0.350)
Suwarnarekha	23.27	15.29 (0.343)	23.27	15.38 (0.339)	23.27	15.78 (0.322)	23.27	19.45 (0.164)
Olour	66.89	58.19 (0.130)	66.89	51.97 (0.223)	66.89	51.90 (0.224)	66.89	54.52 (0.185)
Neelum	35.07	22.62 (0.355)	35.07	23.50 (0.330)	35.07	23.71 (0.324)	35.07	29.88 (0.148)
Mean	30.33	22.30 (0.265)	30.33	20.84 (0.313)	30.33	20.44 (0.326)	30.33	24.05 (0.207)

The values given in parenthesis are the proportion of change in ascorbic acid content

$$\left(\frac{\text{change in ascorbic acid content}}{\text{initial ascorbic acid content}}\right)$$

C.D (Methods) - 0.039
C.D (Varieties) - 0.033
C.D (Methods x Varieties) 0.088

(contd.)

Table 11.a continued

	M_5		M_6	
	Initial	Final	Initial	Final
Bennet Alphonso	14.64	11.91 (0.182)	14.64	7.96 (0.456)
Mundappa	11.77	7.49 (0.364)	11.77	7.06 (0.398)
Suwarnarekha	23.27	21.29 (0.085)	23.27	17.71 (0.239)
Olour	66.89	54.45 (0.186)	66.89	50.30 (0.248)
Neelum	35.07	30.09 (0.142)	35.07	19.15 (0.454)
Mean	30.33	24.26 (0.200)	30.33	20.62 (0.320)

M_7		Mean	
Initial	Final	Initial	Final
14.64	10.64	14.64	10.92
	(0.273)		(0.254)
11.77	8.47	11.77	7.39
	(0.280)		(0.372)
23.27	16.87	23.27	17.45
	(0.275)		(0.250)
66.89	48.50	66.89	53.78
	(0.275)		(0.196)
35.07	22.66	35.07	24.55
	(0.354)		(0.300)
30.33	21.23		
	(0.300)		

Table 11.b Change in ascorbic acid content (mg/100 g) of fruits harvested at different stages of maturity

	Bennet Alphonso		Mundappa		Suwarnarekha		Oleur		Neelum		Mean	
	Initial	Final	Initial	Final	Initial	Final	Initial	Final	Initial	Final	Initial	Final
S_1	15.29	10.96 (0.283)	12.50	7.82 (0.374)	25.10	17.77 (0.292)	67.58	59.60 (0.118)	39.00	26.29 (0.326)	31.89	22.96 (0.280)
S_2	15.25	11.86 (0.222)	11.89	7.61 (0.360)	24.52	18.68 (0.238)	66.80	52.10 (0.220)	36.72	25.15 (0.315)	31.04	22.63 (0.271)
S_3	13.39	9.94 (0.258)	10.91	6.76 (0.380)	20.20	15.61 (0.227)	66.30	49.41 (0.254)	29.50	21.80 (0.261)	28.06	20.32 (0.276)
Mean	14.64	10.92 (0.254)	11.77	7.39 (0.372)	23.27	17.45 (0.250)	66.89	53.78 (0.196)	35.07	24.55 (0.300)		

The values given in parenthesis are the proportion of change in ascorbic acid content

C.D (Varieties) - 0.033

C.D (Stages) - 0.026

C.D (Varieties x Stages) - 0.057

Table 11.c Change in ascorbic acid content of fruits harvested at different stages of maturity and stored under different methods (mg/100g)

	M_1		M_2		M_3		M_4	
	Initial	Final	Initial	Final	Initial	Final	Initial	Final
S_1	31.89	24.97 (0.217)	31.89	21.11 (0.338)	31.89	20.51 (0.357)	31.89	25.26 (0.208)
S_2	31.04	21.73 (0.300)	31.04	21.79 (0.298)	31.04	21.05 (0.322)	31.04	24.52 (0.210)
S_3	28.06	20.20 (0.280)	28.06	19.59 (0.302)	28.06	19.61 (0.301)	28.06	22.42 (0.201)
Mean	30.33	22.30 (0.265)	30.33	20.84 (0.313)	30.33	20.44 (0.326)	30.33	24.05 (0.207)

The values given in parenthesis are the proportion of change in ascorbic acid content

C.D (Methods) - 0.039
C.D (Stages) - 0.026
C.D (Method x Stages) 0.068

(contd.)

Table 11.c continued

	M_5		M_6		M_7		Mean	
	Initial	Final	Initial	Final	Initial	Final	Initial	Final
S_1	31.89	26.05 (0.183)	31.89	21.59 (0.323)	31.89	21.53 (0.325)	31.89	22.96 (0.280)
S_2	31.04	25.30 (0.185)	31.04	21.54 (0.306)	31.04	22.57 (0.273)	31.04	22.63 (0.271)
S_3	28.06	22.29 (0.207)	28.06	18.63 (0.336)	28.06	19.16 (0.306)	28.06	20.32 (0.276)
Mean	30.33	24.26 (0.200)	30.33	20.62 (0.320)	30.33	21.23 (0.300)		

5. Carotene content

The increase in carotene content was equal under all methods (Table 12.a). The change in carotene content significantly varied between varieties. Mundappa showed the highest increase (7.554) followed by Bennet Alphonso (4.612) and Olour (4.736) which were on par. The least increase was exhibited by Suwarnarekha (1.977). Fruits of Mundappa ripened under M_4 (9.754), M_1 (9.144), M_7 (7.341) and M_3 (7.31) showed the highest increase in carotene content and this was on par with Olour under M_5 (7.35).

At each stage the increase in carotene content varied with varieties and methods of storage (Tables 12.b and c). At S_1, Mundappa showed the highest increase (12.043) followed by Bennet Alphonso (8.912). Suwarnarekha brought about the least increase (2.162) and this was on par with Neelum (2.637). At S_2, the fruits of Mundappa and Olour had the highest increase in carotene content whereas at S_3, Bennet Alphonso ranked first (Table 12.b). Comparing the efficiency of different methods at S_1, S_2 and S_3, it was found that at S_1 the fruits ripened under M_4 and at S_2, the same under M_5 and M_1 had the highest increase in carotene content whereas at S_3 the fruits ripened under all methods had the same extent of increase in carotene content (Table 12.c).

6. T.S.S.

The T.S.S. content of fruits after storage under each method was different and the same varied with varieties. Generally Neelum recorded the highest increase in T.S.S. and Bennet Alphonso the least (Table 13.a). For the latter the increase in T.S.S. content under M_7 (0.258) and M_3 (0.197) was significantly higher to all other methods closely followed by M_2 and M_4. In the case of Mundappa fruits stored under M_3 had the highest T.S.S. content. In Suwarnarekha, M_7 and M_5 were on par and significantly superior to all other methods. For Olour and Neelum the T.S.S. content of fruits stored under M_7 was significantly higher to that of those stored under all other methods.

At all stages, varietal variation in T.S.S. content was significant. Fruits of Neelum harvested at S_2 recorded maximum increase in T.S.S. content (1.19) (Table 13.b). The increase in T.S.S. content varied between stages (Table 13.b). The fruits harvested at S_2 recorded the maximum increase (0.711). The efficiency of each method varied with stage of harvest. At S_1, M_7 was on par with M_3 and the increase in total sugar content under these methods was significantly higher to that under all other methods. The fruits ripened under M_4 and M_6 had the least T.S.S. content. At S_2 as well as S_3, M_7 was significantly superior to other methods bringing about an increase in T.S.S. content of 0.853 and 0.579 respectively while M_4 was the least efficient bringing about an increase of only 0.553 and 0.335 respectively (Table 13.c).

Table 12.a Change in carotene content of fruits under different methods of storage(%)

	M_1		M_2		M_3		M_4	
	Initial	Final	Initial	Final	Initial	Final	Initial	Final
Bennet Alphonso	0.0007	0.0023 (2.230)	0.0007	0.004 (4.674)	0.0007	0.0041 (4.920)	0.0007	0.0038 (4.476)
Mundappa	0.00032	0.0032 (9.144)	0.00032	0.0025 (6.712)	0.00032	0.0027 (7.310)	0.00032	0.0034 (9.754)
Suwarnarekha	0.00036	0.0010 (1.856)	0.00036	0.0011 (1.981)	0.00036	0.0012 (2.303)	0.00036	0.0010 (1.839)
Olour	0.00022	0.0011 (4.090)	0.00022	0.0011 (4.156)	0.00022	0.0012 (4.250)	0.00022	0.0011 (4.153)
Neelum	0.00038	0.0017 (3.470)	0.00038	0.0017 (3.567)	0.00038	0.0018 (3.718)	0.00038	0.0017 (3.446)
Mean	0.0004	0.0022 (4.583)	0.0004	0.0021 (4.218)	0.0004	0.0022 (4.501)	0.0004	0.0023 (4.733)

The values given in parenthesis are the proportion of change in carotene content

$$\left(\frac{\text{change in carotene content}}{\text{initial carotene content}}\right)$$

C.D (Methods) - 1.214
C.D (Varieties) - 1.026
C.D (Method x varieties) 2.713

(contd.)

Table 12.a continued

	M_5		M_6		M_7		Mean	
	Initial	Final	Initial	Final	Initial	Final	Initial	Final
Bennet Alphonso	0.0007	0.0036 (4.176)	0.007	0.004 (4.644)	0.0007	0.0042 (5.038)	0.0007	0.0039 (4.612)
Mundappa	0.00032	0.0023 (6.238)	0.00032	0.0024 (6.38)	0.00032	0.0027 (7.341)	0.00032	0.0027 (7.554)
Suwarnarekha	0.00036	0.0010 (1.689)	0.00036	0.0009 (1.750)	0.00036	0.0012 (2.422)	0.00036	0.0011 (1.977)
Olour	0.00022	0.0018 (7.350)	0.00022	0.091 (4.103)	0.00022	0.0013 (5.050)	0.00022	0.0013 (4.736)
Neelum	0.00038	0.0017 (3.420)	0.00038	0.0017 (3.488)	0.00038	0.0018 (3.704)	0.00038	0.0017 (3.544)
Mean	0.0004	0.0022 (4.570)	0.0004	0.0020 (4.070)	0.0004	0.0023 (4.710)		

Table 12.b Change in carotene content of fruits harvested at different stages of maturity(%)

	Bennet Alphonso		Mundappa		Suwarnarekha		Oleur		Neelum		Mean	
	Initial	Final	Initial	Final	Initial	Final	Initial	Final	Initial	Final	Initial	Final
S_1	0.0002	0.002 (8.912)	0.0001	0.0013 (12.043)	0.00008	0.0003 (2.162)	0.0001	0.0005 (4.200)	0.0001	0.0004 (2.637)	0.0001	0.0007 (5.991)
S_2	0.0003	0.0017 (4.536)	0.0002	0.0019 (8.343)	0.0004	0.0014 (2.397)	0.00015	0.0013 (7.914)	0.0003	0.0021 (6.062)	0.0003	0.0021 (5.850)
S_3	0.0016	0.0078 (3.885)	0.00067	0.0022 (2.276)	0.0006	0.0014 (1.372)	0.0004	0.0012 (2.093)	0.00075	0.0022 (1.935)	0.0008	0.0021 (1.613)
Mean	0.0007	0.0039 (4.612)	0.00052	0.0027 (7.554)	0.00036	0.0011 (1.977)	0.00022	0.0013 (4.736)	0.00038	0.0017 (3.544)		

The values given in parenthesis are the proportion of change in carotene content

C.D (Varieties) - 1.026

C.D (Stages) - 0.794

C.D (Varieties x Stages) 1.776

Table 12.c Change in carotene content of fruits harvested at different stages of maturity and stored under different methods (%)

	M_1		M_2		M_3		M_4	
	Initial	Final	Initial	Final	Initial	Final	Initial	Final
S_1	0.0001	0.0006 (5.383)	0.0001	0.0007 (5.683)	0.0001	0.0007 (6.253)	0.0001	0.0009 (7.554)
S_2	0.0003	0.0023 (6.800)	0.0003	0.0019 (5.352)	0.0003	0.0019 (5.460)	0.0003	0.0018 (5.110)
S_3	0.0008	0.0021 (1.565)	0.0008	0.0021 (1.619)	0.0008	0.0022 (1.790)	0.0008	0.0020 (1.537)
Mean	0.0004	0.0022 (4.583)	0.0004	0.0021 (4.218)	0.0004	0.0022 (4.501)	0.0004	0.0023 (4.733)

The values given in parenthesis are the proportion of change in carotene content

C.D (Methods) - 1.214

C.D (Stages) - 0.794

C.D (Methods x Stages) 2.102

(contd.)

Table 12.e continued

	M_5		M_6		M_7		Mean	
	Initial	Final	Initial	Final	Initial	Final	Initial	Final
S_1	0.0001	0.0006 (5.295)	0.0001	0.0006 (5.290)	0.0001	0.0007 (6.478)	0.0001	0.0007 (5.991)
S_2	0.0003	0.0024 (7.030)	0.0003	0.0019 (5.357)	0.0003	0.0021 (5.845)	0.0003	0.0021 (5.850)
S_3	0.0008	0.0019 (1.398)	0.0008	0.0021 (1.571)	0.0008	0.0022 (1.812)	0.0008	0.0021 (1.613)
Mean	0.0004	0.0022 (4.570)	0.0004	0.0020 (4.070)	0.0004	0.0023 (4.710)		

Table 13.a Change in T.S.S. content of fruits under different methods of storage (%)

	M_1		M_2		M_3		M_4	
	Initial	Final	Initial	Final	Initial	Final	Initial	Final
Bennet Alphonso	10.47	11.56 (0.106)	10.47	11.83 (0.130)	10.47	12.53 (0.197)	10.47	11.71 (0.118)
Mundappa	7.63	12.35 (0.619)	7.63	12.60 (0.652)	7.63	13.19 (0.729)	7.63	10.67 (0.398)
Suwarnarekha	6.77	11.71 (0.730)	6.77	11.80 (0.743)	6.77	12.45 (0.839)	6.77	10.76 (0.590)
Olour	7.67	9.93 (0.295)	7.67	10.34 (0.348)	7.67	10.79 (0.407)	7.67	9.13 (0.190)
Neelum	6.33	11.40 (0.801)	6.33	12.54 (0.981)	6.33	12.72 (1.009)	6.33	11.36 (0.794)
Mean	7.77	11.74 (0.511)	7.77	12.20 (0.570)	7.77	12.71 (0.636)	7.77	11.02 (0.418)

The values given in parenthesis are the proportion of change in T.S.S.
$\left(\frac{\text{change in T.S.S.}}{\text{initial T.S.S.}}\right)$

C.D (Methods) - 0.023
C.D (Varieties) - 0.019
C.D (Methods x varieties) 0.051

(contd.)

Table 13.a continued

	M_5		M_6	
	Initial	Final	Initial	Final
Bennet Alphonso	10.47	11.52 (0.100)	10.47	11.41 (0.090)
Mundappa	7.63	11.78 (0.544)	7.63	11.77 (0.543)
Suwarnarekha	6.77	12.73 (0.880)	6.77	11.31 (0.671)
Olour	7.67	10.06 (0.312)	7.67	9.97 (0.300)
Neelum	6.33	13.13 (1.074)	6.33	12.15 (0.920)
Mean	7.77	12.80 (0.580)	7.77	11.66 (0.500)

M_7		Mean	
Initial	Final	Initial	Final
10.47	13.17	10.47	11.97
	(0.258)		(0.143)
7.63	12.83	7.63	12.17
	(0.681)		(0.595)
6.77	12.85	6.77	11.95
	(0.898)		(0.765)
7.67	11.04	7.67	10.20
	(0.440)		(0.33)
6.33	13.39	6.33	12.38
	(1.115)		(0.956)
7.77	13.05		
	(0.679)		

Table 13.b Change in T.S.S. content of fruits harvested at different stages of maturity(%)

	S_1		S_2		S_3		Mean	
	Initial	Final	Initial	Final	Initial	Final	Initial	Final
Bennet Alphonso	10.00	11.81 (0.181)	10.40	11.90 (0.144)	11.00	15.87 (0.443)	10.47	11.97 (0.143)
Mundappa	7.10	10.39 (0.464)	6.20	11.41 (0.841)	9.60	14.21 (0.480)	7.63	12.17 (0.595)
Suvarnarekha	6.40	10.17 (0.589)	5.90	11.91 (1.018)	8.00	13.50 (0.688)	6.77	11.95 (0.765)
Olour	7.00	9.47 (0.353)	7.50	10.20 (0.360)	8.50	10.80 (0.270)	7.67	10.20 (0.330)
Neelum	5.80	10.76 (0.856)	6.10	13.36 (1.190)	7.10	12.94 (0.823)	6.33	12.38 (0.956)
Mean	7.26	10.81 (0.489)	7.22	12.35 (0.711)	8.84	13.02 (0.473)		

The values given in parenthesis are the proportion of change in T.S.S. content

C.D (Stages) - 0.015

C.D (Varieties) - 0.019

C.D (Varieties x Stage) 0.033

Table 13.c Change in T.S.S. content of fruits harvested at different stages of maturity and stored under different methods (%)

	M_1		M_2		M_3		M_4	
	Initial	Final	Initial	Final	Initial	Final	Initial	Final
S_1	7.26	10.50 (0.446)	7.26	10.91 (0.503)	7.26	11.62 (0.600)	7.26	9.91 (0.365)
S_2	7.22	11.91 (0.650)	7.22	12.43 (0.722)	7.22	12.83 (0.778)	7.22	11.21 (0.553)
S_3	8.84	12.69 (0.436)	8.84	12.43 (0.487)	8.84	13.59 (0.537)	8.84	11.80 (0.335)
Mean	7.77	11.74 (0.511)	7.77	12.20 (0.570)	7.77	12.71 (0.636)	7.77	11.02 (0.418)

The values given in parenthesis are the proportion of change in T.S.S. content

C.D (Methods) - 0.023
C.D (Stages) - 0.015
C.D (Methods x Stages) - 0.039

(contd.)

Table 13.c continued

	M_5		M_6		M_7		Mean	
	Initial	Final	Initial	Final	Initial	Final	Initial	Final
S_1	7.26	11.22 (0.546)	7.26	9.90 (0.363)	7.26	11.65 (0.605)	7.26	10.81 (0.489)
S_2	7.22	12.53 (0.736)	7.22	12.14 (0.682)	7.22	13.38 (0.853)	7.22	12.35 (0.711)
S_3	8.84	12.95 (0.465)	8.84	12.99 (0.470)	8.84	13.96 (0.579)	8.84	13.02 (0.473)
Mean	7.77	12.80 (0.580)	7.77	11.66 (0.500)	7.77	13.05 (0.679)		

CANNING QUALITY

Ripe fruits of the different varieties were canned as slices in sugar syrup and their physico-chemical characters at specific time-intervals of storage were studied for a period of 14 months. The data on physical condition of the product ie., colour of flesh, appearance of syrup, taste, aroma, texture, vacuum pressure, drained weight and external appearance of the can are presented in Tables 14.a,b,c,d and e.

Regarding the chemical composition of fruits before canning, the T.S.S. per cent in Mundappa was 13.8, in Suwarnarekha 12.5, in Olour 12.2, in Neelum 13.6 and in Bennet Alphonso 13.0. The reducing sugar content was maximum in Mundappa (9.8 per cent) followed by Neelum (9.24 per cent), Olour (8.45 per cent), Suwarnarekha (8.3 per cent) and Bennet Alphonso (8.18 per cent). In nonreducing sugar content also varietal variation was observed, being 4.5 per cent in Neelum, 4.2 per cent in Suwarnarekha, 4.12 par cent in Bennet Alphonso, 4.1 per cent in Mundappa and 3.5 per cent in Olour. Total sugar was maximum in Mundappa (13.9 per cent) followed by Neelum (13.7 per cent), Suwarnarekha (12.54 per cent), Bennet Alphonso (12.3 per cent) and Olour (11.95 per cent). The titrable acidity was highest in Suwarnarekha (0.6 per cent) followed by Mundappa, Olour and Bennet Alphonso (0.5 per cent each) and least in Neelum (0.2 per cent). The acidity in terms of pH was highest in Suwarnarekha (4.3) followed by

Mundappa, Olour and Bennet Alphonso (4.5 each) and lastly Neelum (4.9). In ascorbic acid content (mg/100 g) Olour ranked first (43.9), Neelum second (15.8), Suwarnarekha third (14.1), Bennet Alphonso fourth (8.0) and Mundappa fifth (5.9) (Table 15).

Before canning the flesh colour was excellent in Suwarnarekha, good in Mundappa, Olour and Bennet Alphonso and satisfactory in Neelum. In taste Neelum came first (excellent) followed by Mundappa and Olour (good) and finally Suwarnarekha and Bennet Alphonso (satisfactory) (Table 16).

The data pertaining to the monthly physical condition of the canned product are given in Tables 14.a,b,c,d and e. Neelum proved to be the best for canning, scoring the highest (84.5 per cent) followed by Mundappa (71.5 per cent), Olour (65 per cent), Suwarnarekha (56.5 per cent) and Bennet Alphonso (52 per cent) at last sampling on 22-6-81 ie., 14 months after canning. At first sampling (22-11-80) ie., seven months after canning also Neelum scored the highest (85.0 per cent) and the quality was maintained even after 14 months showing that this variety is the best suited for canning in terms of quality retention as well as shelf life. The reduction in score was only 0.5 per cent at the last sampling. The second best for canning was Mundappa since it scored the second highest at first sampling (73.5 per cent) and the reduction in score after 14 months was only 2 per cent.

At first sampling Mundappa was followed by Olour (68.5 per cent) and even if slightly cloudy from 12th month onwards it held the same rank and the reduction in score was 3.5 per cent. According to the first sampling on seventh month, Bennet Alphonso came fourth (67.5 per cent), but at final sampling gave way to Suwarnarekha showing that the latter is better to maintain the quality, the reduction being 7.5 per cent whereas in Bennet Alphonso it was 15.5 per cent. In case of Suwarnarekha the syrup seemed cloudy from 13th month onwards. At final sampling the syrup was clear in Neelum, Mundappa and Bennet Alphonso. The poor quality with Bennet Alphonso might be due to poor aroma and texture.

The vacuum pressure of cans of all varieties was in the satisfactory range ie., 13-15 lbs/sq.inch even after 14 months. Vacuum pressure was the highest in Suwarnarekha (15 lbs/sq. inch) followed by Neelum (14 lbs/sq.inch). Mundappa, Olour and Bennet Alphonso had the same vacuum pressure (13 lbs/ sq.inch). Appearance of the can was normal in all the varieties. The drained weight was 49.85 per cent in Neelum, 49.7 per cent in Bennet Alphonso, 49.65 per cent in Mundappa, 48.5 per cent in Suwarnarekha and 48.44 per cent in Olour at last sampling.

Neelum maintained the excellent taste for 12 months. Thereafter also it maintained good taste even upto 14 months.

Table 14.a Physical condition of the canned product (Variety Bennet Alphonso)

Sl. No.	Physical characteristics	Storage period in months							
		7	8	9	10	11	12	13	14
1	Colour of flesh	Good	Good	Good	Good	Good	Good	Good	Good
2	Appearance of syrup	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear
3	Taste	Satis-factory	Satis-factory	Satis-factory	Satis-factory	Good	Good	Good	Satis-factory
4	Aroma	Fair	Fair	Fair	Satis-factory	Fair	Fair	Poor	Poor
5	Texture	Good	Good	Good	Good	Good	Fair	Fair	Fair
6	Vacuum pressure (lbs/sq.inch)	-	-	-	-	-	-	-	13.00
7	Drained weight (%)	49.95	49.95	49.92	49.90	49.90	49.90	49.86	49.70
8	External appearance of the can	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal
9	Score card value (%)	67.50	67.00	65.50	65.85	69.00	54.00	53.00	52.00

Size of can - A2½
Date of canning - 22-4-'80
Date of first opening - 22-11-80
Date of last opening - 22-6-'81

Table 14.b Physical condition of the canned product (Variety Mundappa)

Sl. No.	Physical characteristics	Storage period in months							
		7	8	9	10	11	12	13	14
1	Colour of flesh	Good	Good	Good	Good	Good	Good	Good	Good
2	Appearance of syrup	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear
3	Taste	Good	Good	Good	Good	Good	Good	Good	Good
4	Aroma	Satis-factory	Satis-factory	Satis-factory	Good	Satis-factory	Satis-factory	Satis-factory	Satis-factory
5	Texture	Satis-factory	Satis-factory	Satis-factory	Satis-factory	Satis-factory	Satis-factory	Satis-factory	Satis-factory
6	Vacuum pre-ssure (lbs/sq.inch)	-	-	-	-	-	-	-	13.00
7	Drained weight (%)	50.20	50.20	50.10	50.04	50.00	50.00	49.90	49.65
8	External appearance of the can	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal
9	Score card value (%)	73.50	72.00	74.00	75.00	75.00	74.50	71.50	71.50

Table 14.c Physical condition of the canned product (Variety Suwarnarekha)

Sl. No.	Physical characteristics	Storage period in months							
		7	8	9	10	11	12	13	14
1	Colour of flesh	Good	Good	Good	Satis-factory	Good	Good	Good	Satis-factory
2	Appearance of syrup	Clear	Clear	Clear	Clear	Clear	Clear	Slightly cloudy	Cloudy
3	Taste	Satis-factory	Satis-factory	Fair	Fair	Fair	Fair	Fair	Fair
4	Aroma	Good	Good	Good	Satis-factory	Good	Satis-factory	Satis-factory	Satis-factory
5	Texture	Satis-factory	Satis-factory	Satis-factory	Satis-factory	Satis-factory	Satis-factory	Satis-factory	Satis-factory
6	Vacuum pressure (lbs/sq.inch)	-	-	-	-	-	-	-	15.00
7	Drained weight (%)	49.69	49.62	49.45	49.25	49.20	49.20	49.00	48.50
8	External appearance of the can	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal
9	Score card value (%)	64.00	66.50	63.50	61.50	60.50	59.50	57.50	56.50

Table 14.d Physical condition of the canned product (Variety Olour)

Sl. No.	Physical characteristics	Storage period in months							
		7	8	9	10	11	12	13	14
1	Colour of flesh	Excellent	Excellent	Excellent	Good	Good	Good	Good	Good
2	Appearance of syrup	Clear	Clear	Clear	Clear	Clear	Slightly cloudy	Cloudy	Cloudy
3	Taste	Good	Good	Good	Good	Good	Satisfactory	Satisfactory	Satisfactory
4	Aroma	Satisfactory	Satisfactory	Satisfactory	Satisfactory	Satisfactory	Satisfactory	Satisfactory	Satisfactory
5	Texture	Satisfactory	Satisfactory	Satisfactory	Satisfactory	Satisfactory	Satisfactory	Satisfactory	Satisfactory
6	Vacuum pressure (lbs/sq.inch)	-	-	-	-	-	-	-	13.00
7	Drained weight (%)	49.90	49.83	49.78	49.45	49.22	48.90	48.75	48.44
8	External appearance of the can	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal
9	Score card value (%)	68.50	72.00	74.00	68.20	67.50	59.00	66.50	65.00

Table 14.e Physical condition of the canned product (Variety Neelum)

Sl. No.	Physical characteristics	Storage period in months							
		7	8	9	10	11	12	13	14
1	Colour of flesh	Excellent	Excellent	Excellent	Good	Excellent	Excellent	Excellent	Good
2	Appearance of syrup	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear
3	Taste	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Good	Good
4	Aroma	Good	Good	Fair	Good	Fair	Fair	Fair	Good
5	Texture	Good	Good	Good	Good	Good	Good	Good	Good
6	Vacuum pressure (lbs/sq.inch)	-	-	-	-	-	-	-	14.00
7	Drained weight (%)	50.50	50.50	50.40	50.32	50.28	50.28	50.16	49.85
8	External appearance of the can	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal
9	Score card value (%)	85.00	89.00	89.50	88.20	85.00	85.50	84.70	84.50

Table 15. Chemical composition of the flesh before canning

Variety	T.S.S. %	Reducing sugar %	Nonreducing sugar %	Total sugar %	Acidity %	Acidity pH	Ascorbic acid (mg/100 g)
Bennet Alphonso	13.00	8.18	4.12	12.30	0.50	4.50	8.00
Mundappa	13.80	9.80	4.10	13.90	0.50	4.50	5.90
Suwarnarekha	12.50	8.30	4.20	12.54	0.60	4.30	14.10
Olour	12.20	8.45	3.50	11.95	0.50	4.50	43.90
Neelum	13.60	9.24	4.50	13.70	0.20	4.90	15.80

Table 16 Physical appearance and taste of the flesh before canning

Variety	Colour of flesh	Taste
Bennet Alphonso	Good	Satisfactory
Mundappa	Good	Good
Suwarnarekha	Excellent	Satisfactory
Olour	Good	Good
Neelum	Satisfactory	Excellent

Taste and Colour grades	Score
1. Excellent	1-1.4
2. Good	1.5-2.4
3. Satisfactory	2.5-3.4
4. Fair	3.5-4.4
5. Poor	4.5-5.0

Bennet Alphonso maintained the satisfactory taste upto 14 months. But taste improvement (good) was noticed during 11th, 12th and 13th months of storage. Suwarnarekha maintained satisfactory taste only upto 8 months and thereafter it decreased (fair). In Olour the taste was good upto 12th month and thereafter it was only satisfactory.

The chemical composition of the canned product (syrup and slices) during first and last opening is given in Tables 17.a and b.

During first opening the T.S.S. per cent of syrup was maximum in Neelum (39.5) followed by Bennet Alphonso (39.25). Mundappa had T.S.S. content of 38 per cent followed by Suwarnarekha and Olour (36 each). At last opening the change in T.S.S. was only 0.5 per cent in Neelum (39 per cent), 0.75 per cent in Suwarnarekha (35.25 per cent), 1 per cent in Mundappa (37 per cent) 1.75 per cent in Bennet Alphonso (37.5 per cent) and 2.5 per cent in Olour (33.5 per cent).

The reduction in reducing sugar content of the syrup during the period of seven months was the least in Neelum (2.1 per cent). In Mundappa, the decrease was 2.7 per cent, in Suwarnarekha 2.8 per cent, in Bennet Alphonso 5.8 per cent and 7.8 per cent in Olour. At last opening the reducing sugar content was maximum in Neelum (40.2 per cent) followed by Bennet Alphonso (36.7 per cent). In Olour it was 30.5 per cent, in Suwarnarekha 29.3 per cent and in Mundappa 28.9 per cent.

The nonreducing sugar content of the syrup at first and last opening was maximum in Mundappa, being 6.2 and 6 per cent respectively showing a decrease of only 0.2 per cent during the period of seven months. In Suwarnarekha the decrease in nonreducing sugar content from 1st opening (4.0 per cent) to last opening (3.5 per cent) was 0.5 per cent. At first opening it was 2.9 per cent, 1.3 per cent and 1.8 per cent in Olour, Neelum and Bennet Alphonso respectively showing a decrease of 1.5, 0.1 and 0.8 per cent respectively.

The data showed that at first opening the total sugar content in the syrup was maximum in Bennet Alphonso (44.3 per cent) followed by Neelum (43.6 per cent), Olour (41.2 per cent), Mundappa (37.8 per cent) and Suwarnarekha (35.1 per cent) respectively showing a decrease of 6.6, 5.2, 9.3, 3.0 and 1.3 per cent respectively at last opening.

Regarding acidity in the syrup at first opening, it was maximum in Neelum (0.45 per cent) and more or less the same in all the varieties at final opening except Bennet Alphonso (0.49 per cent). The increase in acidity was the least in Neelum (0.17 per cent) followed by Bennet Alphonso (0.19 per cent). The decrease was almost the same (0.26-0.27 per cent) in all the other varieties.

Compared to the first sampling, the ascorbic acid content decrease in the syrup was the least in Neelum and Mundappa (0.1 per cent). In Suwarnarekha, Olour and

Bennet Alphonso the decrease was 0.3, 0.7 and 0.9 per cent respectively. At final opening the same order in the level of ascorbic acid content (mg/100 g) was followed as that at first opening, ie., Olour (4.8), Neelum (3.7), Mundappa (3.5), Suwarnarekha (2.3) and Bennet Alphonso (1.8) at first opening and 4.1, 3.6, 3.4, 2.0 and 0.9 per cent respectively at final opening.

The chemical analysis of the slices showed that at first opening the T.S.S. per cent was the highest in Suwarnarekha (30.5 per cent) followed by Olour, Neelum and Bennet Alphonso (30 per cent each) and finally Mundappa (29.5 per cent). The T.S.S. content was found to increase by 5.7 per cent in Mundappa (35.2 per cent), 5.3 per cent in Neelum (35.3 per cent), 5 per cent in Bennet Alphonso (35 per cent), 3.5 per cent in Suwarnarekha (34.0 per cent) and 3.2 per cent in Olour (33.2 per cent). The increase in T.S.S. content of the slices at last opening compared to that before canning was 22.0 per cent in Bennet Alphonso, 21.7 per cent in Neelum, 21.5 per cent in Suwarnarekha, 21.4 per cent in Mundappa and 21.0 per cent in Olour.

At last opening the reducing sugar content of the slices was maximum in Neelum (28.57 per cent) followed by Bennet Alphonso (27.15 per cent), Mundappa (25.39 per cent), Olour (23.26 per cent) and Suwarnarekha (20.57 per cent). Compared to first opening the reducing sugar content was low in Mundappa the decrease being 3.2 per cent. A similar trend

was observed in Olour also. The decrease was 1.84 per cent. In all the other three varieties, increase in the reducing sugar content was observed, the increase being 9.05, 6.47 and 4.38 per cent respectively in Bennet Alphonso, Neelum and Suwarnarekha. Before canning the reducing sugar content was maximum in Mundappa (9.8 per cent) followed by Neelum (9.24 per cent). But the increase in reducing sugar content was maximum in Neelum (19.33 per cent) followed by Bennet Alphonso (18.97 per cent) and Mundappa showed only an increase of 15.59 per cent. Olour and Suwarnarekha showed an increase of 14.81 per cent and 12.23 per cent respectively.

At last opening, the nonreducing sugar content of the slices was maximum in Mundappa (11.2 per cent) followed by Olour (30.4 per cent), Suwarnarekha (9.3 per cent), Bennet Alphonso (8.3 per cent) and Neelum (5.9 per cent). Before canning the nonreducing sugar content was maximum in Neelum (4.5 per cent), but it gave only an increase of 1.4 per cent at last opening as against 7.1 per cent in Mundappa, 6.6 per cent in Olour, 5.1 per cent in Suwarnarekha and 4.18 per cent in Bennet Alphonso. At first opening Neelum had the highest nonreducing sugar content (17.3 per cent) and the increase was 12.8 per cent. Between first and last opening, the nonreducing sugar content had decreased considerably in Neelum (11.4 per cent), Suwarnarekha (4.5 per cent) and Bennet Alphonso (3.8 per cent), whereas the same increased in Olour (4.8 per cent) and Mundappa (1.1 per cent).

Before canning the total sugar content was maximum in Mundappa (13.9 per cent) followed by Neelum (13.7 per cent) whereas after canning the same was the highest in Neelum (36.47 per cent) followed by Mundappa (35.59 per cent), Bennet Alphonso (35.45 per cent), Olour (33.36 per cent) and Suwarnarekha (29.87 per cent). The maximum increase in total sugar, due to canning based on the last sampling, was observed in Bennet Alphonso (23.15 per cent) followed by Neelum (22.77 per cent), Mundappa (21.69 per cent), Olour (21.41 per cent) and Suwarnarekha (17.33 per cent).

The acidity of flesh before canning was maximum in Suwarnarekha (0.6 per cent) followed by Mundappa, Olour and Bennet Alphonso (0.5 per cent each) and Neelum (0.2 per cent). At last opening acidity was maximum in Suwarnarekha and Bennet Alphonso (0.71 per cent each) followed by Olour (0.63 per cent). Acidity was the least in Mundappa and Neelum (0.59 per cent). At final opening the maximum acidity was exhibited by Neelum (0.39 per cent), followed by Bennet Alphonso (0.21 per cent), Olour (0.13 per cent), Suwarnarekha (0.11 per cent) and Mundappa (0.09 per cent). At first opening also maximum increase in acidity was exhibited by Neelum (0.37 per cent) and the least by Mundappa (0.02 per cent). At first opening Mundappa proved more stable in acidity compared to other varieties. Between first and last opening Neelum and Suwarnarekha proved to be the most stable, the

Table 17.a Chemical composition of syrup of the canned product

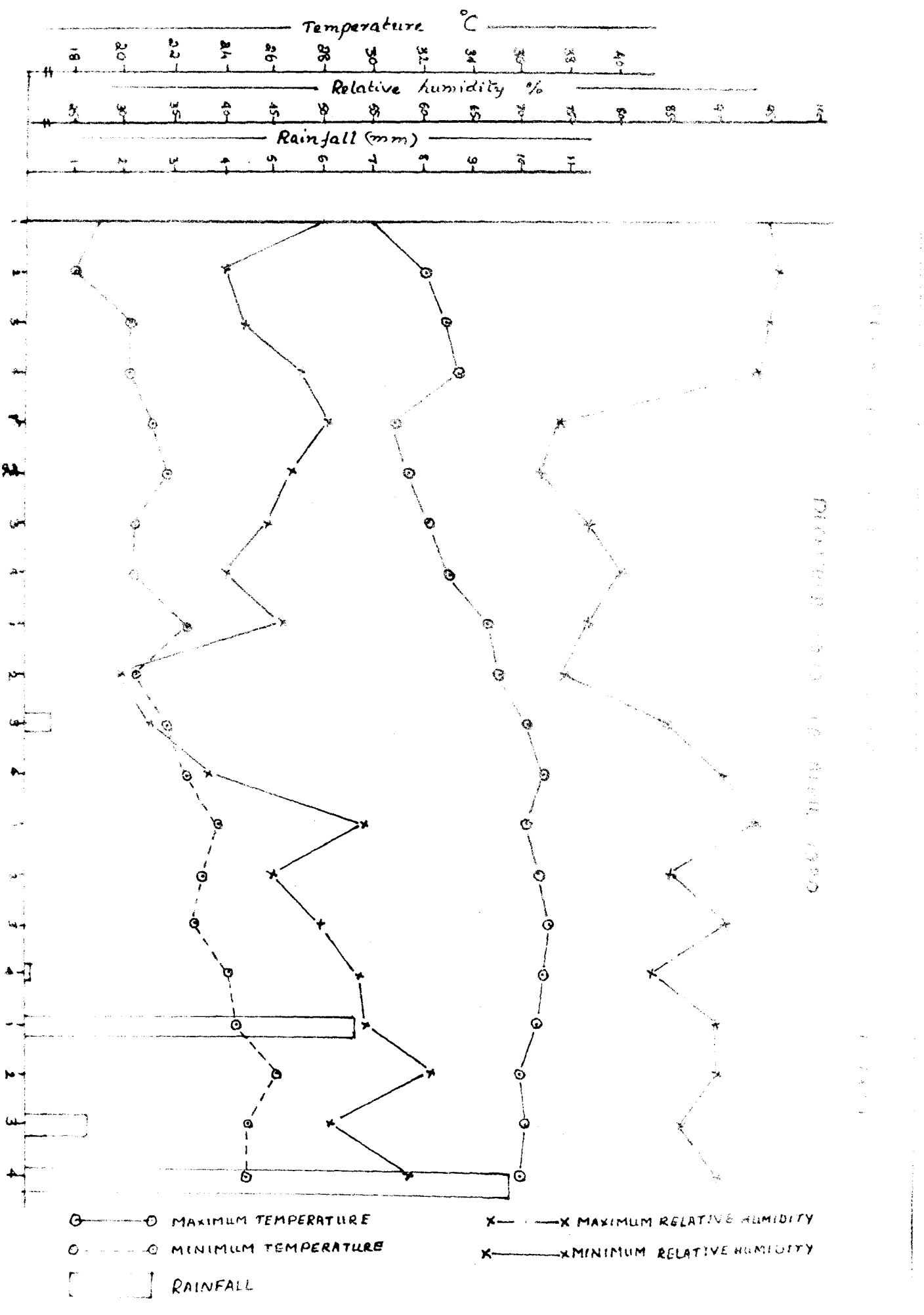
Variety	T.S.S. %		Reducing sugar %		Nonreducing sugar %		Total sugar %		Acidity %		Acidity pH		Ascorbic acid (mg/100 g)	
	1st opening	Last opening	1st opening	Last opening	1st opening	Last opening	1st opening	Last opening	1st opening	Last opening	1st opening	Last opening	1st opening	Last opening
Bennet Alphonso	39.25	37.50	42.50	36.70	1.80	1.00	44.30	37.70	0.30	0.49	5.20	4.80	1.80	0.90
Mundappa	38.00	37.00	31.60	28.90	6.20	6.00	37.80	34.80	0.34	0.60	5.20	3.50	3.50	3.40
Suwarnarekha	36.00	35.25	32.10	29.30	4.00	3.50	35.10	33.80	0.35	0.62	5.10	3.50	2.30	2.00
Olour	36.00	33.50	38.30	30.50	2.90	1.40	41.20	31.90	0.38	0.65	4.70	3.30	4.80	4.10
Neelum	39.50	39.00	42.30	40.20	1.30	1.20	43.60	38.40	0.45	0.62	4.50	3.50	3.70	3.60

Table 17.b Chemical composition of slices of the canned product

Variety	T.S.S. %		Reducing sugar %		Nonreducing sugar %		Total sugar %		Acidity %		Acidity pH		Ascorbic acid (mg/100 g)	
	1st opening	Last opening	1st opening	Last opening	1st opening	Last opening	1st opening	Last opening	1st opening	Last opening	1st opening	Last opening	1st opening	Last opening
Bennet Alphonso	30.00	35.00	18.10	27.15	12.10	8.30	30.20	35.45	0.60	0.71	4.30	4.30	2.60	1.10
Mundappa	29,50	35.20	28.59	25.39	10.10	11.20	35.69	35.59	0.52	0.59	4.40	4.30	3.60	3.40
Suwarnarekha	30.50	34.00	16.19	20.53	13.80	9.30	29.99	29.87	0.69	0.71	4.10	4.10	2.50	2.00
Olour	30.00	33.20	25.10	23.26	5.30	10.10	30.10	33.36	0.62	0.63	4.20	4.20	4.90	4.10
Neelum	30.00	35.30	22.10	28.57	17.30	5.90	39.40	36.41	0.57	0.59	4.30	4.30	5.10	3.60

increase being only 0.02 per cent; Clour and Bennet Alphonso being the least stable (0.11 per cent).

The statistical analysis pertaining to the various data are presented in Appendices.


Temperature °C
18 20 22 24 26 28 30 32 34 36 38 40
Relative humidity %
30 35 40 45 50 55 60 65 70 75 80 85 90 95
Rainfall (mm)
1 2 3 4 5 6 7 8 9 10 11
April - 1985
May - 1985
June - 1985
July - 1985
August - 1985
September - 1985
October - 1985
November - 1985
December - 1985
MAXIMUM TEMPERATURE
MINIMUM TEMPERATURE
RAINFALL
MAXIMUM RELATIVE HUMIDITY
MINIMUM RELATIVE HUMIDITY

DISCUSSION

DISCUSSION

The results of the studies on growth and maturity of the fruits, comparative efficiency of the different storage methods at different stages of maturity and the suitability of varieties for canning of mango fruits are discussed below.

STUDIES ON GROWTH AND MATURITY OF FRUIT

The studies on maturity of the five varieties of mango fruits have shown that the growth of fruits by way of increased length, girth, weight and volume continued till the fruits attained full maturity. The maximum increase (2/3) in these parameters occurred during the first four weeks of maturation. The low rate of increase noticed in the present study towards the last phase is a natural growth phenomena and the results are in agreement with the view of Singh et al. (1957) and Lelyveld (1975) that the growth rate gradually declined with age. During the period of maturation the specific gravity of fruits increased upto four to six weeks depending upon the variety and thereafter remained steady. Mukherjee (1959) also reported a similar growth trend in mangoes.

On correlating the physical changes of fruits with maturity standards it was found that there existed a relationship between length as well as weight with maturity standard. The relationship between weight of fruits and maturity was explained by Krishnamurthy and Subramaniam (1970)

who suggested that the parameters for optimum maturity of the fruit of the variety Pairi was 200 ± 20 g in weight with outgrown shoulders. Lelyveld (1975) reported that when the mature fruits attained a length of 80 mm, the rapid growth rate decreased. In all varieties except Mundappa, significant correlation was observed between specific gravity and maturity standard. Singh et al. (1978) confirmed specific gravity as a reliable index of maturity for the fruits of Neelum. In the present study the specific gravity of fruits at A stage was in the range of 0.82-0.95 which gradually increased as the fruit matured attaining a value of 1.0-1.01 towards the last stage. The increase in specific gravity at early stages might be due to the proportionate increase in weight in comparison to volume and this clearly indicated the accumulation or synthesis of food material within the fruit.

In all varieties studied, the acidity showed a declining tendency throughout the period of maturation. This is in agreement with the findings of Leley et al. (1943), Harding et al. (1954) and Lakshmainarayana et al. (1970). Though the acid content had significant negative correlation (-0.770) with maturity, it could not serve as a good criterion of maturity in all the varieties studied, where the direct effect was very insignificant (0.142). These results confirm the findings of Harkness (1949).

The change in reducing sugar content during the period of maturation was inconsistent in all the varieties. In general the reducing sugar content at full maturity was at a higher level compared to that at A stage as against the findings of Lakshminarayana et al. (1970). The present work revealed that reducing sugar content could serve as a good criterion of maturity since it had the maximum positive direct effect (1.958) on maturity.

The starch content which varied between varieties showed a gradual increase throughout the period of maturation in all the varieties studied. The starch/acid ratio also showed a similar trend. At full maturity the starch content was 7.95 per cent in Bennet Alphonso while in Mundappa, Suwarnarekha, Olour and Neelum it was 4.0, 4.09, 7.28 and 6.90 per cent respectively. This observation supported the findings of Popenoe and Long (1957) and Mukherjee (1959). The starch content also proved to be quite useful factor in judging the correct stage of maturity since it had appreciable direct effect (1.753) on maturity standard. Earlier Popenoe et al. (1958), Mukherjee (1959) and Teaotia et al. (1967) had suggested that the direct evaluation of starch was the best index for predicting maturity.

The T.S.S. content also had appreciable direct effect (0.947) on maturity and therefore it might also serve as a criterion for judging maturity. Similar results were reported by Askar et al. (1972).

In all the varieties studied, the carotene content went on increasing. As maturity advanced, the rate of increase was at a higher rate. Diaz (1980) reported that during maturation the B carotene content increased and in ripe fruits the same was twice as compared to green mature fruits.

STORAGE STUDIES

In terms of storage life, among different method studied, storing fruits in polythene bags of 300 gauges with $KMnO_4$ was found to be the best. The storage life of fruits in 300 gauge polythene bags alone was also equally good and this was on par with storage of waxed fruits in 300 gauge polythene bags. In each method of storage, the shelf life varied widely between varieties. Of the above three methods, storage in 300 gauge polythene bags was the most effective for the variety Bennet Alphonso while for Neelum maximum storage life was observed when fruits were kept in polythene bags of 300 gauges along with $KMnO_4$. Of the five varieties studied, Bennet Alphonso and Neelum proved to have maximum keeping quality. Similar storage studies conducted by Garg et al. (1971) showed that treatment of mango fruits with Waxol-W emulsion as well as pre-packaging in 200 gauge polythene bags and storage at room temperature (29-35°C) as well as at low temperature (5.5-7.2°C) decreased rate of respiration and prolonged shelf life.

In all methods of storage, fruits harvested at B stage gave significantly prolonged storage life. Similar results were reported by Singh et al. (1952) who suggested that for prolonged storage life at 48°F and 68°F mangoes should be harvested at B stage of maturity.

The storage life varied widely between the two temperatures. At room temperature the storage life was maximum for the waxed fruits kept in 300 gauge polythene bags followed by storage in polythene bags along with $KMnO_4$. Compared to storage at room temperature, storage at 6 ± 0.5°C brought about longer storage life for fruits under all methods. At room temperature, the storage life was maximum for the waxed fruits kept in 300 gauge polythene bags while at low temperature the same was maximum for the fruits kept in 300 gauge polythene bags.

Similar increase in storage life at low temperature has been reported by several workers (Singh et al., 1952; Mathur et al., 1953; Singh et al., 1967 and Mann and Singh, 1975). Mathur et al. (1953) found that Seedling mangoes could best be stored for 42 days at a storage temperature of 42-45°F. The prolonged shelf life at lower temperature is evidently due to the low rate of metabolic activities that take place within the fruit at lower temperature.

The fruits ripened after waxing with or without polythene

covering maintained maximum weight irrespective of the varieties. The extent of change in weight of fruits ripened under different methods varied between varieties. Olour showed the least decrease followed by Bennet Alphonso and Neelum. For all varieties under all methods, the fruits harvested and stored at A stage showed considerable decrease in weight (0.070) as compared to those harvested and stored at B (0.05) and C (0.053) stages. Garg et al. (1971) reported that in variety Dashehari skin coating (6% waxol), pre-packaging (1 kg lots in 200 gauge polythene bags with 0.6% ventilation) as well as a combination of both at room temperature (29-35°C) reduced weight loss and spoilage and there was better retention of vitamin C and acidity. The combined treatment was more effective than either alone. Deol and Bhullar (1972) from their study on the effect of wrappers and growth regulators on the storage life of mango fruits suggested that though weight loss was progressive with all treatments it was least with fungicidal wax and polythene wrappers. This could be attributed to the low rate of transpiration under such conditions. Lakshminarayana (1973) studied the storage behaviour of mango fruits harvested at different maturity (days). He concluded that the physiological loss in weight of ripe fruits was greater until about the ninth week of maturity.

The fruits ripened without any treatment as well as those kept in polythene bags (150 gauges) showed the lowest

acid content while the waxed fruits kept in polythene bags had the highest acidity. On ripening, the extent of decrease in acidity varied with varieties. Bennet Alphonso showed the highest decrease (0.58) followed by Neelum (0.560), Suwarnarekha (0.53) and Olour (0.510) respectively. The varietal response varied with stages. When the fruits were harvested at stage A and then stored, at the end of storage period the least decrease in acidity was observed in fruits of Suwarnarekha followed by Olour and Mundappa and it was the highest in Neelum and Bennet Alphonso. At stages B and C, among the five varieties, fruits of Bennet Alphonso had the highest acidity. Regarding the fruits harvested at A and B stages, the waxed fruits with as well as without polythene bags had the highest acidity and least in fruits ripened without any treatment as wellias those ripened in polythene bags (150 gauges). At stage C, on ripening, the acidity of waxed fruits with and without polythene bags varied significantly. The highest acidity was observed in waxed fruits kept in polythene bags while the lowest in fruits stored without any treatment as well as those kept in polythene bags (150 gauges).

Singh et al. (1937), Singh et al. (1967), Verma and Bajpai (1971) and Mann and Singh (1975) reported that during ripening the acidity decreased irrespective of the cultivars and methods of storage. Singh et al. (1967) concluded that, of several wrapping materials and/or a coating of fungicidal

wax on the storage life of mangoes held at 34°C, the wax + polythene treatment resulted in higher acidity than other treatments. Verma and Bajpai (1971) stored four 'oultivars' of mango at -20°F and suggested that during each stage of ripening the acid content of fruits varied with varieties. Bandyopadhyay and Gholap (1973) reported that ripening was associated with increase in glyceride content and change in fatty acid composition. He suggested that the levels of more saturated acids changed little while the linoleic acid level fell and linoleic and palmitoleic acid levels increased and that the ratio of palmitic to oleic acid levels was below unity in ripe fruits while it was above unity in raw and half ripe fruits.

Under all stages and varieties, the fruits stored without any treatment showed the highest total sugar content followed by the waxed fruits as well as those kept in polythene bags (150 gauges). The waxed fruits kept in polythene bags had the lowest total sugar content. Under all methods the total sugar content of the ripened fruits varied significantly with varieties. On ripening the fruits of Suwarnarekha kept in polythene bags (300 and 150 gauges), as well as the waxed and untreated fruits had the highest total sugar content compared to other varieties. On the other hand, when the fruits were ripened in polythene bags (250 gauges), polythene bag + waxing and waxing alone, the variety Neelum

showed the highest increase in total sugar content. In all methods, the varieties Bennet Alphonso, Mundappa and Olour proved inferior to Neelum and Suwarnarekha. At all stages the total sugar content varied with varieties and methods of storage. At A stage the variety Neelum and at stages B and C the variety Suwarnarekha gave the highest increase in total sugar content.

Choudhry and Farooqi (1969) reported that irrespective of the methods of storage, the total sugars increased until the fruit was ripe. Verma and Bajpai (1971) suggested that during storage (-20°F) the reducing, nonreducing and total sugar content varied with varieties. He found that in Fazali Kalan the reducing sugars decreased gradually in storage while the reverse trend was observed in the case of nonreducing sugar content. Lakshminarayana (1973) reported that the total sugars of ripe fruits increased as maturity advanced and maximum sweetness was found in ripe fruits, harvested after 16 weeks development. Asis et al. (1975) from their study on the effect of chilling and non-chilling temperatures on the chemical compounds of mango fruits concluded that the total sugar content increased with duration of storage, the increase being more pronounced at higher temperatures. The changes in the sugar content of the fruits held at 0°C for various periods were similar in pattern, but less marked than at higher temperatures. The increase in

total sugar content during ripening might be due to the conversion of starch accumulated during maturation to reducing as well as nonreducing sugars (Singh et al., 1937).

The waxed fruits irrespective of stage of harvest, ripened with as well as without polythene covering had the highest ascorbic acid content after storage. The fruits stored in polythene bags (150 and 250 gauges), polythene + $KMnO_4$ and those stored without any treatment had the least and almost equal amount of ascorbic acid on being ripe. The ascorbic acid content varied between varieties. The fruits of Olour had the highest ascorbic acid content after storage. For the same variety, significant difference in ascorbic acid content was observed between different methods of storage. Regarding Olour, the fruits stored in polythene bags (300 gauges) exhibited the highest ascorbic acid content while the least in those stored without any treatments. At A and B stages, the fruits of Olour showed the lowest decrease in ascorbic acid content while at C stage Suwarnarekha also had the same amount of decrease in ascorbic acid content after storage.

Mathur (1956) from his study on the effect of fungicidal wax on the storage behaviour of Badami mango fruits suggested that treatment with fungicidal wax emulsion increased retention of ascorbic acid. Garg et al. (1971) observed that treatment of Dashehari mango fruits with 6% waxol-W emulsion, pre-packaging (1 kg lots in 200 gauge polythene bags) as well

as a combination of both brought about better retention of ascorbic acid by the ripe fruits as compared to fruits stored without any treatment.

The carotene content increased on ripening and was not affected by the methods of storage. Modi et al. (1965) reported that carotene content increased progressively during ripening since the concentration of mevalonic acid also showed the same trend. Mevalonic acid in presence of cofactors ATP and Mg^{2+} was found to stimulate carotenogenesis. Mattoo et al. (1968) reported that during the climacteric rise, the heat labile and nondialysable inhibitors of enzymes present in unripe fruits disappeared. Diaz (1980) found that the concentration of β carotene in ripe fruits showed to be twice as compared to green mature fruits.

The change in carotene content significantly varied with varieties. The fruits of Mundappa stored in polythene bags (300 gauges), polythene bags + waxing as well as without any treatment gave the highest increase in carotene content. Similar changes were also observed in the case of fruits of Suwarnarekha kept in polythene bags (150 gauges) as well as in the waxed fruits of Olour kept in polythene bags. Comparing the efficiency of different methods at A, B and C stages, it was found that at A stage the waxed fruits kept in polythene bags and at B stage the waxed fruits as well as those kept in polythene bags (300 gauges) gave the highest

increase in carotene content. At C stage the fruits ripened under all methods had the same extent of increase in carotene content.

The method of storage also influenced the T.S.S. content. Fruits stored without any treatment in general gave the highest T.S.S. content, followed by storage in 150 gauge polythene bags. Varietal variation was however, noticeable. For the variety Suwarnarekha, storage after waxing also proved superior in increasing the T.S.S. content. For the variety Mundappa the fruits stored in polythene bags 150 gauges gave the highest T.S.S. content after storage.

Singh et al. (1967) studied the effects of various wrapping materials and/or coating of fungicidal wax on the storage life of mangoes kept at 34°C. He conoluded that the wax + polythene treatment resulted in lower T.S.S. than all other treatments.

The extent of increase in T.S.S. content of fruits varied with the three stages. The increase was highest when fruits were harvested at B stage.

In terms of storage life, among different methods studied, storing fruits in polythene bags 300 gauges with $KMnO_4$ was found to be the best. The storage life of fruits in 300 gauges polythene bags alone was equally good. Storing fruits in polythene bags along with $KMnO_4$ although improved the storage life, was not much pronounced.

The methods of storage besides affecting the shelf life also profoundly influenced the qualitative changes that took place during storage. The loss in weight was at its maximum when the fruits were stored as such without any treatment. This loss in weight to a great extent could be reduced by different methods of storage. Of the different treatments, waxing was found to be the best in reducing the loss of weight in storage. This is interesting from the point of view of storage loss. Although waxing alone was not found to be as effective as storage in 300 gauge polythene bags in terms of shelf life, superiority of waxing in conjunction with storage in polythene bags is demonstrated in the studies. In other words waxing alone as well as waxing and storage in polythene bags resulted in least storage loss.

The stage of maturity had profound influence on storage life as well as on the quality of fruits at ripening. In the present study three stages of maturity were fixed for storage studies is., stage A, B and C. The three distinct stages were based on morphological characters of the fruit. The fruits having shoulders in line with the stem end and olive green skin colour were identified with stage A. The stage B was indicated by the shoulders outgrowing the stem end and olive green skin colour of the fruits. At C stage the shoulders of the fruit outgrew the stem end and skin colour lightened towards yellow.

Based on the morphological and visual characteristics it was presumed that fruits attained maturity from A stage. The results have shown that maximum storage life and best ripening quality was attained when fruits were harvested at B stage. The stage A even if arbitrarily considered as mature, cannot be reckoned as best stage for harvest, since the loss in quality after ripening was maximum. The total sugar and T.S.S. contents after ripening was always less in fruits harvested at A stage compared to B stage. When the fruits were harvested later at stage C the storage life as well as the extent of increase in total sugar and T.S.S. contents was less as compared to the fruits at B stage. This showed that between the three stages harvesting at the stage B was definitely superior as far as quality in terms of total sugar and T.S.S. content was considered. So also a later harvest resulted in fruits being acidic at the time of ripening. So the stage B can be fixed as the best for harvest of mango under conditions of Kerala.

The present studies enabled to fix the following maturity standards for the five varieties studied. The fruits could be considered as mature when it attained 8.75 cm length, 148.86 g weight, 5.12 per cent reducing sugar content, 7.9 per cent starch content and 10.4 per cent T.S.S. with specific gravity 1.0 for the variety Bennet Alphonso. For the variety Mundappa the above physico-chemical characters are 9.59 cm length, 306.56 g weight, 2.9 per cent reducing

sugar content, 3.95 per cent starch content and 6.2 per cent T.S.S. with specific gravity 1.0. Suwarnarekha, Olour and Neelum could be considered mature when the length of fruits was 11.4 cm, 9.0 cm and 9.16 cm respectively while the weight was 308.26 g, 218.81 g and 210.3 g. For these varieties the specific gravity at this stage was in the range of 0.95-0.99. The reducing sugar content at optimum maturity was 1.92, 3.65 and 1.63 per cent respectively in Suwarnarekha, Olour and Neelum. The starch and T.S.S. contents in the fruits were 4.08 and 5.9 per cent for Suwarnarekha, 7.25 and 7.5 per cent for Olour and 5.98 and 6.1 per cent for Neelum.

Varietal response to storage and quality

As discussed earlier, fruits stored in 300 gauge polythene bags had better storage life. Among the varieties Bennet Alphonso and Neelum had better storage life followed by Mundappa and Olour. Suwarnarekha had the least storage life. The third best in keeping quality was Mundappa. The loss of weight in storage was minimum for Olour followed by Bennet Alphonso and Neelum. The fruits of Neelum and Suwarnarekha were least acidic on ripening. In total sugar content, the variety Mundappa came first followed by Neelum while the same was least in variety Olour. The retention of ascorbic acid content in storage was highest in Mundappa followed by Neelum. Bennet Alphonso had maximum carotene content followed by Mundappa. The T.S.S. content was highest

in fruits of Neelum followed by Mundappa, Bennet Alphonso and Suwarnarekha respectively. So in terms of storage life as well as quality of fruits Neelum came best under Kerala conditions. In storage life Bennet Alphonso was on par with Neelum, but in quality Mundappa was the second best.

CANNING QUALITY

The change in T.S.S., reducing sugar, total sugar, acidity and ascorbic acid content of the syrup between the first and last opening, during the period of seven months was least in Neelum which very well shows the stability of the variety for storage after canning.

At final sampling the T.S.S. per cent of the syrup was maximum in Neelum followed by Bennet Alphonso, Mundappa, Suwarnarekha and Olour respectively. The nonreducing sugar content after 14 months storage was maximum in Mundappa and least in Bennet Alphonso. At last sampling the total sugar content was maximum in Neelum and least in Olour. The acidity of the syrup increased during storage period of the canned product. At last sampling, except Bennet Alphonso all other varieties recorded more or less the same acidity. The ascorbic acid content, both at first opening (7 months after canning) and towards the end of storage of the product was high in Olour, followed by Neelum, Mundappa and Suwarnarekha respectively. Bennet Alphonso recorded the least ascorbic acid content initially as well as during the end of the storage of the product.

At final sampling the T.S.S., reducing sugar and total sugar content of the slices was maximum in Neelum. Acidity was also least in Neelum after the period of storage. Only in case of other chemical constituents, other varieties expelled Neelum. In taste also Neelum ranked first at last sampling. The results of the experiment clearly showed that Neelum was the best suited for canning.

The next best variety suitable for canning was found to be Mundappa which recorded 35.2 per cent T.S.S., 35.59 per cent total sugars, 0.59 per cent acidity and 3.4 per cent ascorbic acid contents of the flesh at final sampling. The least suitable variety for canning was found to be Bennet Alphonso which recorded the least score and contained higher acidity and lowest ascorbic acid content.

SUMMARY

S U M M A R Y

The main objectives of the present series of studies were to standardise the stage of harvest as well as to identify the best methods of storage of mango fruits. Suitability of the varieties for canning also formed a part of the study. The salient results obtained from the studies are summarised below.

The studies on maturity of mango fruits have shown that the growth of fruits by way of increased length, girth, weight and volume was maximum (2/3) during the first four weeks of maturation. The length as well as weight of fruits proved to be reliable maturity standards. In all varieties except in Mundappa specific gravity also could be considered as a dependable standard.

Throughout the period of maturation the acidity showed a declining trend while the starch content gradually increased. Since reducing sugar and starch contents of maturing fruits had maximum positive direct effects on maturity those parameters could also serve as reliable criteria of maturity.

Considerable increase in carotene content was observed throughout the period of maturation in all the varieties. The moisture content showed a gradual decrease from A stage to full maturity while drymatter content exhibited just a reverse trend. Towards maturity the ascorbic acid content

showed gradual decline. At full maturity Olour had maximum ascorbic acid content.

The maturity standards for the five varieties of mango fruits studied were fixed in terms of number of days from fruitset, length, weight, specific gravity, reducing sugar, Starch and T.S.S. content of the fruits.

In terms of storage life, among different methods studied, storing fruits in polythene bags with $KMnO_4$ was found to be the best. The storage life of fruits in 300 gauge polythene bags alone, was also equally good. As the thickness of the polythene decreased it had a pronounced effect on the shelf life.

Waxing the fruits and storing without any treatment was not found to be as effective as storing the fruits in polythene bags 250 and 300 gauges. However, when the fruits were waxed and then stored in 300 gauge polythene bags, the storage life was on par with storage in 300 gauge polythene bags.

Besides affecting the shelf life, the methods of storage, also profoundly influenced the qualitative changes that took place during storage. The loss in weight was at its maximum when the fruits were stored as such without any treatment. Of the different treatments, waxing was found to be the best in reducing the loss of weight in storage.

Maximum reduction in acidity was found to be in fruits stored without any treatment as well as those stored in 150 gauge polythene bags. The total sugar content was also high in untreated fruits. Here again storage after waxing did not affect the quality to any appreciable extent. When waxing alone was adopted or when the fruits were stored in 150 gauge polythene bags, the total sugar content of fruits was significantly superior to all other methods of treatments. But when waxing was adopted in combination with polythene 300 gauges the increase in total sugar content was least compared to all other methods of treatments.

Compared to all methods of storage waxing was most effective in retention of ascorbic acid during storage. More the thickness of polythene bags, the more was the retention of ascorbic acid content. The carotene content was not found to be affected by different methods of storage. Carotene content increased towards ripening, the extent of increase being similar under all methods.

As in case of acidity and total sugars T.S.S. was also high in untreated fruits. The quality was slightly reduced when the fruits were stored in polythene bags. The higher the thickness of polythene, the less was the change in T.S.S. content.

The stage of maturity had profound influence on storage life as well as on the quality of fruits at ripening. Between

the three different stages of maturity, maximum storage life was exhibited by fruits collected from B stage. In terms of quality also this stage of harvest was found to be the best.

Among the varieties, Bennet Alphonso and Neelum had better storage life followed by Mundappa and Olour. Suwarnarekha had the least storage life. The loss of weight in storage was maximum for Olour followed by Bennet Alphonso and Neelum. The fruits of Neelum and Suwarnarekha were least acidic on ripening. In total sugar contents, the variety Mundappa came first followed by Neelum, while the same was least in variety Olour. The retention of ascorbic acid content in the storage was highest in Mundappa followed by in Neelum. Bennet Alphonso had maximum carotene content followed by Mundappa. The T.S.S. content was the highest in fruits of Neelum followed by Mundappa, Bennet Alphonso and Suwarnarekha respectively. In terms of storage life as well as quality of fruits Neelum was found to be the best. Bennet Alphonso was on par with Neelum in terms of shelf life, but in quality Mundappa was the second best.

The best variety suitable for canning was found to be Neelum followed by Mundappa, Bennet Alphonso being the least suitable. Neelum exhibited stability of quality in terms of T.S.S., reducing sugar, total sugar, acidity and ascorbic acid content of the syrup, during the period of seven months between the first and last sampling.

REFERENCES

REFERENCES

A.O.A.C. (1980). Official Methods of Analysis of the Association of Official Analytical Chemists, 13th edn. Washington, D.C., pp. 218.

Apelbaum, A., Zauberman, G. and Fuchs, Y. (1977). Subatmospheric pressure storage of mango fruits. Scientia Horticulturae. 7(2): 153-160.

*Askar, A., Tamimi, E.A. and Raouf, M. (1972). The chemical constituents of mango fruits and their behaviour during growth and ripening. Milteilungen Rebe und wein Obstbau und Fruchteverwertung. 22(2): 120-125.

*Aziz, A.B.A., Nabaly, E.S.M., Kader, A.A.S. and Wahab, A.F.K. (1975). Effect of chilling and non-chilling temperatures on some chemical compounds of mango fruits. Egypt. J. Hort. 2(2): 173-185.

*Azzouni, E.M.M. and Salama, S.B. (1956). Studies on the determination of maturity and picking index of the fruits of some varieties of mango. Bull. Fac. Agric. Cairo Univ. 84: 12-15.

Bandyopadhyay, C. and Gholap, A.S. (1973). Changes in fatty acids in ripening mango pulp (variety Alphonso). J. agric. Fd. chem. 21(3): 496-497.

Baque, S.M., Mattoo, A.K. and Modi, V.V. (1977). Glyoxylate metabolism and fatty acid oxidation in mango fruit during development and ripening. Phytochem. 16(1): 51-54.

Biale, J.B., Young, R.E. and Olmstead, A.J. (1954). Fruit respiration and ethylene production. Pl. Physiol. 29: 168-174.

Burg, S.P. (1962). The physiology of Ethylene Formation. A. Rev. Pl. Physiol. 13: 265-302.

C.F.T.R.I. (1952). Cold Storage of mangoes. Bull. Cent. Fd. technol. Res. Inst., Mysore. 2(1): 26.

Chandha, K.L., Melanta, K.R., Lodh, S.B. and Selvaraj, V. (1972). Biochemical changes associated with growth and development of pineapple var. Kew. 1. Changes in Physico-chemical constituents. Indian J. Hort. 29(1): 54-57.

*Chang, C.C. (1975). Hot water treatment of Irwin mango fruit to reduce anthracnose decay. Taiwan Agric. J. Q. 11(2): 69-78.

Cheema, G.S. and Dhani, P.G. (1934). Report on the export of mango to Europe in 1932 and 1933. Bull. Dep. Agric. Bombay. 170: 13-16.

Cheema, G.S., Karmarkar, D.V. and Joshi, B.M. (1939). Investigations on the cold storage of mangoes. Misc. Bull. Imp. Coun. agric. Res. India. 21: 63.

*Choudhry, T.M. and Farooqi, M.A.R. (1969). The post-harvest chemical changes during the ripening of mango fruits. W. Pakist. J. agric. Res. 7(3): 78-96.

Crawfod, M.E.F. and Perry, E.O.V. (1933). The vitamin content of the mango. Biochem. J. 27: 1290-1293.

*Cuevasruiz, J., Graham, H.D. and Luse, R.A. (1972). Gamma radiation effects on biochemical components of Puerto Rican mangoes. J. Agric. Univ. P. Rico. 56(1): 26-32.

Dalal, V.B., Eipeson, W.E. and Singh, N.B. (1971). Wax emulsion for fresh fruits and vegetables to extend their storage life. Indian Fd. Packer. 25(5): 9-15.

Dalal, V.B. and Subramanyam, H. (1970). Refrigerated storage of fresh fruits and vegetables. Climate Control. 3(3): 37-50.

Deol, I.S. and Bhullar, S.S. (1972). Effect of wrappers and growth regulators on the storage life of mango fruit. Punjab hort. J. 12(2/3): 114-119.

xx Dias, N. (1980). A preliminary study on the flavour and aroma components of four mango varieties. J. agric. Univ. P. Rico. 64(2): 12-15.

xx Dewey, D.R. and Lu, K.H. (1959). A correlation and path coefficient analysis of components of crested wheat grass seed production. Agron. J. 51: 515-518.

Garg, R.C., Srivastava, R.K., Ram, H.B. and Verma, R.A. (1971). Role of prepackaging and skin coating on the storage behaviour of mangoes (Mangifera indica Linn.) variety Dashehari. Progve. Hort. 3(2): 49-67.

*Gutierrez, L.E., Cesar, W.D.J.R., Ferrari, S.E. and Guimaraes, G.L. (1976). Soluble carbohydrates in fruits 1. Pomogranate, mango, banana, Myrciaria cauliflora, lemon, pineapple, orange and Eugenia tomentosa. Anais da Escola Superior do Agricultura Luiz de Queiroz. 22: 167-72.

Harding, P.L. and Hatton, T.T. Jr. (1967). Mangoes at their best. Int. Symp. Subtrop. Trop. Hort. 14-15.

*Harding, P.L. and Soule, M.J. (1958). Effect of size and date of sampling on starch, sugars, soluble solids and phenolic compounds in mango. Proc. Fla. Mango Forum. 18: 13-18.

*Harding, P.L., Soule, M.J. Jr. and Sunday, M.B. (1954). Qualities in mangoes. Proc. Fla. Mango Forum. 14: 24-33.

*Harkness, R.W. (1949). Laboratory tests of mango maturity. Proc. Fla. Mango Forum. 9: 21-25.

*Harkness, R.W. and Cobin, M. (1950). Haden mango maturity - observations during 1950. Proc. Fla. Mango Forum. 10: 27-32.

Iyer, C.P.A., Selvaraj, Y., Subramanyam, M.D. and Divakar, N.G. (1976). Characteristics of mango fruits as influenced by exposure to sunlight during growing season. Progve. Hort. 8(1): 57-62.

*Jacobs, C.J. (1970). Marketing mangoes. Fmg. S. Afr. 46(b): 37-40.

Jacobs, C.J., Brodrick, H.T., Swarts, H.D. and Mulder, N.J. (1973). Control of post harvest decay of mango fruit in South Africa. Pl. Dis. Reptr. 57(2): 173-176.

Kane, O. and Marcellin, P. (1978). Incidence of ripening and chilling injury on the oxidative activities and fatty acid compositions of the mitochondria from mango fruits. Pl. Physiol. 61(4): 634-638.

Karmarkar, D.V. and Joshi, B.M. (1940). Cold storage of Indian fruits. Indian Frg. 1: 173-177.

Krishnamurthy, S. and Subramanyam, H. (1970). Respiratory climacteric and chemical changes in the mango fruit, Mangifera indica L. J. Am. Soc. hort. Sci. 95: 333-337.

Lakshminarayana, S. (1973). Respiration and ripening patterns in the life cycle of the mango fruit. J. hort. Sci. 48: 227-233.

Lakshminarayana, S., Subhadra, N.V. and Subramanyam, H.(1970). Some aspects of developmental Physiology of the mango fruit. J. hort. Sci. 45: 133-142.

Lakshminarayana, S. and Subramanyam, H. (1970). Carbondioxide injury and fermentative decarborylation in mango fruit at low temperature storage. J. Fd. Sci. Technol. 7(3): 131-140.

Leley, V.K., Narayana, N. and Daji, J.A. (1943). Biochemical studies in the growth and ripening of the Alphonso mango. Indian J. agric. Sci. 13: 291-299.

*Lelyveld, L.J.V. (1975). Ascorbic acid content and enzyme activities during maturation of mango fruit and their association with bacterial black spot. Agroplantae. 7: 51-54.

Lelyveld, L.J.V. and Smith, J.H.E. (1979). Physiological factors in the maturation and ripening of mango (Mangifera indica L.) fruit in relation to the jelly seed physiological disorder. J. hort. Sci. 54(4):283-287.

*Leon, D.S.Y. and Lima, D.L. (1966). Acceptability of canned mango juice from four varieties and three colour stages of maturity. Philippines J. Sci. 95: 401-409.

*Malevski, Y., Gomezbrito, L. and Silberg, M. (1977). Ripening of mangoes harvested on different dates during the season. Agronomia trop. 27(2): 163-169.

Mann, S.S. and Singh, R.N. (1975). Ripening of Dashehari and Langra cultivars of mango (Mangifera indica L.) at different stages of maturity by various methods. Haryana J. hort. Soc. 4(1/2): 31-39.

Mann, S.S. and Singh, R.N. (1976). Lenticels as an aid for judging the maturity of mango fruit. Sci. Cult. 42(10): 529-531.

*Marloth, R.N. (1947). The mango in South Africa. Part IIIa. Production and Marketing. Fmg. S. Afr. 22: 609-615.

Mathur, P.B. (1956). Effects of a fungicidal wax and a plant growth inhibitor (hormone) on the storage behaviour of fruits and vegetables. Bull. Cent. Fd. technol. Res. Inst., Mysore. 5(5): 112-115.

Mathur, P.B., Singh, K.K. and Kapur, N.S. (1953). Cold storage of mangoes. Indian J. agric. Sci. 23: 65-77.

*Mattoo, A.K. (1969). Some aspects of metabolic changes in the ripening mangoes. Ph.D. thesis submitted to the M.S. University, Baroda, India.

Mattoo, A.K. and Modi, V.V. (1969). Ethylene and ripening of mangoes. Pl. Physiol. 44: 308-310.

Mattoo, A.K., Modi, V.V. and Reddy, V.V.R. (1968). Oxidation and carotenogenesis regulating factors in mangoes. Indian J. Biochem. 5: 111-114.

Modi, V.V. and Reddy, V.V. (1967). Carotenogenesis in ripening mangoes. Indian J. Exp. Biol. 5: 233.

Modi, V.V., Reddy, V.V.R. and Shah, D.V. (1965). Carotene precursors in mangoes. Indian J. exp. Biol. 3: 145-146.

Mukherjee, P.K. (1959). Biochemical and physiological studies during development of mango fruit. Hort. adv. 3: 95-101.

Mukherjee, P.K. and Prasad, A.C. (1972). Post-harvest Physiology of mango. Proc. 3rd Int. Symp. Trop. Fruits and Vegetables (Abst.). p. 79.

Mukherjee, P.K. and Srivastava, R.B. (1979). Increasing the storage life of mango (Mangifera indica L.) by lowering the critical temperature. Progve. Hort. 10(4): 63-69.

*Mustard, M.J. and Lynch, S.J. (1945). Effect of various factors upon the ascorbic acid content of some Florida-grown mangoes. Bull. Agric. Exp. Stn. Florida. 406: 15-17.

*Oppenheimer, C. (1947). The acclimatization of new tropical and subtropical fruit trees in Palestine. Bull. agric. Res. Stn. Rehovot. 44: 184.

*Osterwalder, A. (1949). Die Warmeanspruche Unserer Obstfr Uchte and Trauben Van der Blute bis Zur Reife. Landu. fb. Schweiz. 63: 687-718.

Pantastico, B., Murate, T., Mattoo, A.K., Chachin, K., Ogata, K. and Phan, C.T. (1975). Chemical changes during ripening and senescence. In Post harvest Physiology, Handling and Utilization of Tropical and Subtropical Fruits and Vegetables. 1st edn. The AVI Publishing Company Inc. pp. 103-127.

Pentzer, W.T. and Heinze, P.H. (1954). Post-harvest Physiology of Fruits and Vegetables. A. Rev. Pl. Physiol. 6: 205-224.

*Pope, W.T. (1929). Mango culture in Hawai. Hawai agric. exp. Stan. Bull. 58: 8-11.

Popenoe, J., Hatton, T.T. Jr. and Harding, P.L. (1958). Determination of maturity of hard green Haden and Zill mangoes. Proc. Am. Soc. hort. Soi. 71: 326-329.

Popenoe, J. and Long, W.G. (1957). Evaluation of starch content and specific gravity as measure of maturity of Florida mangoes. Proc. Fla. St. hort. Soc. 70: 272-274.

Pruthi, J.S., Tandon, G.L. and Lal, G. (1955). Pilot Plant studies on the processing of some important tropical fruits and their economic stability. S. Indian Hort. 3(1): 12-15.

Ram, H.B. and Date, W.B. (1971). Studies on the storage behaviour of two late varieties of mangoes treated with fungicidal wax emulsion at room temperature. Indian J. Hort. 28(3): 206-209.

Ranganna, S. (1977). Manual of Analysis of Fruit and Vegetable Products. Taba McGraw-Hill Publishing Co., New Delhi. pp. 2-100.

Rao, P.V.S., Giridhar, N., Prasad, P.S.R.K. and Rao, G.N. (1970). Optimum maturity and harvesting time of mangoes var. Beneshan (Syn. Banganapalle) 1. Physicomorphological features of fruits vs maturity. Indian J. Hort. 27(3&4): 117-122.

Rao, S. and Srinath, M.K. (1967). Heat unit requirements for the maturation of mango, variety Beneshan (syn.) Banganapalle. Indian J. Hort. 24(1&2): 156-159.

Sadasivan, R., Muthuswamy, S., Sundararaj, J.S. and Vasudevan, V. (1971). Note on Chilling injury in mango (Mangifera indica L.) fruits in refrigerated storage. Indian J. agric. Sci. 41(8): 715-716.

Singh, A. (1967). Maturity determination in mango. M.Sc. thesis submitted to the Punjab Agricultural University, Ludhiana.

Singh, K.K. (1977). Refrigerated storage and freezing of mango fruit in India. Punjab hort. J. 17(1/2): 6-12.

Singh, L.B. (1960). The Mango. Botany, Cultivation and utilization. 1st edn. Interscience Publishers Inc., New York. pp. 391-392.

Singh, A.P. and Bhargava, S.N. (1977). Benlate - as an effective post-harvest fungicide for guava fruit. Indian J. Hort. 34: 309-312.

Singh, B.N., Sheshagiri, P.V. and Gupta, S.S. (1937). Ontogenetic drifts in the physiology and chemistry of tropical fruits under orchard conditions. Indian J. agric. Sci. 7: 176-192.

Singh, K.K. and Chadha, K.L. (1961). Factors affecting Vitamin C content of mango. Punjab hort. J. 1(3): 171-174.

Singh, K.K., Kapur, N.S. and Mathur, P.B. (1952). Cold storage of Totapuri (Bangalora) mangoes. Bull. Cent. Fd. technol. Res. Inst., Mysore. 2(3): 149-151.

Singh, K.K., Nijjar, G.S. and Singh, G. (1967). Cold storage studies on Dashehari mango. J. Res. Ludhiana. 4: 516-522.

Singh, U.R., Pandey, I.C., Upadhyay, N.P. and Tripathi, B.M. (1976). Physiological and biochemical changes during maturity of mango (Mangifera indica L.) var. Neelum. Progve. Hort. 8(3): 15-18.

Singh, U.R., Singh, D.V. and Shukla, B. (1978). Determination of maturity indices for Taimuria and Sukul cultivars of mango (Mangifera indica L.). Haryana J. hort. Sci. 7(1/2): 47-49.

Snedecor, G.N. and Cochran, W.G. (1967). Statistical Methods. Oxford and IBH Publishing Co., New Delhi.

*Soule, M.J. Jr. and Hatton, T.T. Jr. (1955). Effect of size of fruit and dates of sampling on physical and chemical characters of mangoes. Proc. Fla. Mango Forum. 15: 16-20.

Spadling, D.H. and Reeder, W.F. (1972). Post harvest disorders of mangoes as affected by fungicides and heat treatments. Pl. Dis. Reptr. 56(9): 751-753.

Spencer, J.L., Morris, M.P. and Kennard, W.G. (1956). Vitamin C concentration in developing and mature fruits of mango (Mangifera indica L.). Pl. physiol. 31: 79-80.

Srivastava, D.C., Verma, A.N., Mishra, H.R. and Sharma, R.K. (1971). Post-harvest changes during low temperature storage of South Indian mango (Mangifera indica L.) varieties Neelum and Romani. Mysore J. agric. Sci. 5(1): 96-100.

Srivastava, D.N. and Urgapal, J.C.D. (1965). Mode of infection and control of diplodia stem end rot of mango (Mangifera indica L.). Indian J. Hort. 22: 77-79.

Subramanyam, H. and Moorthy, N.V.N. (1973). Control of spoilage and ripening in mango fruit by Zineb and Sodium diethyl dithiocarbomate. Pestic. Sci. 4(1):25-31.

Teaotia, S.S. and Bhan (1966). Determination of maturity of harvesting pineapple fruit var. Giant Kew. Indian Agric. 10: 361-365.

Teaotia, S.S., Tripathi, R.S. and Singh, R.D. (1967). Fixing maturity standards for some tropical fruits. Int. Symp. Subtrop. trop. Hort. (Programme and abstracts) pp. 12.

Tripathi, R.S. and Gangwar, B.M. (1971). Biochemical changes as indices of maturity in guava (Psidium guajava L.) Progve. Hort. 3: 17-23.

Verma, T.S. and Bajpai, P.N. (1971). Physico-chemical changes in mangoes (Mangifera indica L.) during low temperature storage. Progve. Hort. 3(3): 5-14.

*Vickers, M.E.H. (1964). An experiment on the cold storage of mangoes on the Kenya Coast. E. Afr. agric. For. J. 30: 46-48.

Vines, H.M. and Grierson, W. (1966). Handling and Physiological studies with the carambola. Proc. Fla. Hort. Soc. 79: 350.

*Wang, H., Huang, C.C. and Chien, H.S. (1964). A study on the post-harvest treatments of mango fruits. Rep. Fengshan trop. hort. Exp. Stn. Taiwan. 32: 7.

*Wang, H., Huang, C.C. and Chien, H.S. (1965). A study on the storage and post-harvest treatment of mango fruits. Rep. Fengshan trop. hort. Expt. Stn. Taiwan. 32: 7.

* Originals not seen

APPENDICES

APPENDIX I

Weather data for the period from December 1979 to April 1980

Month	Temperature °C		Relative humidity (per cent)		Total rainfall (mm)	Number of rainy days
	Maximum	minimum	Maximum	Minimum		
December 1979	32.2	19.4	95	45	Nil	Nil
January 1980	33.5	20.5	80	42	Nil	Nil
February 1980	36.0	22.0	90	30	0.5	1
March 1980	35.0	24.0	95	45	0.1	1
April 1980	35.0	25.0	90	53	18.0	6

APPENDIX II

Analysis of variance for the effect of different storage methods on shelf life and quality of the ripe fruits

Source	df	mean sum of squares						
		Shelf life	Weight	Acidity	Total sugar	Ascorbic acid	Carotene	T.S.S.
Temperature	1	776.80**	0.32**	0.42**	5.54**	10.49**	184.45*	5.06**
Variety	8	5.21**	0.03**	0.42**	16.85**	0.72**	475.67**	11.32**
Method of storage	12	9.28**	0.04**	1.11**	0.51**	0.57**	18.09	0.61**
Stage of harvest	4	2.47**	0.02**	0.95**	4.95**	0.01	1114.22**	3.13**
Variety x Method	48	0.40**	0.029**	0.06**	0.08**	0.13**	23.81	0.08**
Variety x Stage	16	0.18**	0.0019**	0.44**	0.79**	0.13**	243.26**	0.47**
Method x Stage	24	0.25**	0.0011**	0.12**	0.05**	0.04	30.37	0.37**
Variety x Method x Stage	96	0.11**	0.0007	0.09**	0.03**	0.04*	2.60	0.11**
Error	840	0.03	0.001	0.009	0.003	0.03	28.75	0.01

* Significant at 5 per cent level
** Significant at 1 per cent level

MATURITY AND POST-HARVEST STUDIES IN MANGO (*Mangifera indica* Linn.)

BY

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ABSTRACT OF A THESIS

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A B S T R A C T

The present investigations were carried out in the College of Horticulture, during the year 1979-80. The objectives were to study (i) the growth and maturity of mango fruits in order to standardise the harvest indices in five varieties viz., Bennet Alphonso, Mundappa, Suwarnarekha, Olour and Neelum (ii) the effect of different storage methods on the shelf life of fruits harvested at three different stages (A, B and C) and (iii) the suitability of the varieties for canning.

Studies on physico-chemical characters of the fruits throughout the period of maturation were conducted with the view to fix optimum time for harvest. This study brought out that the length, weight, specific gravity (except for Mundappa) reducing sugar, starch and T.S.S. contents could be taken as dependable maturity standard. Based on these parameters the maturity standards have been fixed for the five varieties studied.

The growth of fruits by way of increased length, girth, weight and volume was maximum during the first four weeks of maturation.

From A stage to full maturity the acidity showed a declining trend while starch content increased. The change in reducing sugar content was erratic throughout the period

of maturation. Towards full maturity the moisture and ascorbic acid contents showed gradual decline whereas an increasing trend was observed in case of drymatter content. As maturity advanced, the rate of increase in carotene content also increased.

To prolong the shelf life, the most effective method was to store fruits in polythene bags of 300 gauge thickness along with $KMnO_4$ which gave a mean storage life of 25.5 days. Storage in 300 gauge polythene bags alone was also equally good. The more the thickness of polythene, the longer was the shelf life.

Waxing of fruits was not as effective as storing fruits in 300 and 250 gauges polythene bags, in terms of shelf life, but the extent of reduction in weight at the end of storage life was least in this method. Waxing was also effective in retention of acidity as well as ascorbic acid content during storage. In this method the total sugar content of the ripe fruits was not appreciably affected compared to other methods except control. The waxed fruits on ripening had the same extent of increase in carotene content as those under the other methods. Waxed fruits at the end of storage period had significant increase in T.S.S. content as compared to storage in polythene bags 250 and 300 gauges as well as in polythene bags 300 gauges along with waxing or $KMnO_4$.

Storage of fruits in polythene bags of 300 gauge thickness, at the end of storage period, resulted in reduction of acidity and T.S.S. content compared to waxing. Compared to the untreated fruits, there was more retention of ascorbic acid content in this method.

In terms of storage life as well as quality of fruits at ripening, the best stage for harvest was found to be B stage.

Among the five varieties studied Bennet Alphonso and Neelum had better storage life followed by Mundappa, Suwarnarekha and Olour respectively. The quality of ripe fruits varied with varieties. In terms of storage life as well as quality of fruits Neelum came best. In shelf life though Bennet Alphonso came second, in quality of ripe fruits Mundappa was the second best.

Neelum was found to be the most suitable variety for canning followed by Mundappa. Bennet Alphonso was the least suitable.