POST HARVEST QUALITY EVALUATION OF OKRA [*Abelmoschus esculentus* (L.) Moench]

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DECLARATION

I hereby declare that this thesis entitled "**Post harvest quality evaluation of okra [*Abelmoschus esculentus* (L.) Moench]**" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar title, of any other university or society.

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CERTIFICATE

Certified that this thesis entitled "**Post harvest quality evaluation of okra [*Abelmoschus esculentus* (L.) Moench]**" is a record of research work done independently by Ms. Bini. N. (2001-12-12) 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.

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ABBREVIATIONS

%	Percentage
Ca	Calcium
CD	Critical difference
cm	Centimeter
DMC	Dry matter content
et al	And others
Fig	Figure
g	Gram (s)
ha	Hectare
i.e.	That is
kg	Kilogram (s)
mg	Milligram (s)
ml	Milli litre
ns	Not significant
SE	Standard error
viz	Namely

Introduction

1. INTRODUCTION

Okra [*Abelmoschus esculentus* (L.) Moench] is an annual vegetable crop grown in tropical and subtropical regions. It comes under the family Malvaceae and is valued as a tender vegetable.

The immature fruits are highly nutritious and are having some medicinal properties. High iodine content of the fruits helps to control goitre while leaves are used in inflammation and dysentry. The fruits also help in cases of renal colic, leucorrhea and general weakness.

In India, the crop has not been used as a leafy vegetable as in Far East countries. It has yet multiple uses. The dry seeds contain 13–22 per cent good edible oil and 20–24 per cent protein. The oil is used in soap, cosmetic industry and as vanaspati while protein is used for cattle feed preparations. The crushed seed is fed to cattle for more milk production and the fibre is utilized in jute textile and paper industry.

Apart from this they are also used for thickening of soups and gravies because of their high mucilage content. Okra has a high nutritive value compared to many other vegetables. The amino acid composition resembles that of soybean but the protein efficiency ratio is higher.

However, one of the problems in the utilization of okra is the development of fibre. The fibre formation is influenced by the stage of harvest and also the genotypes of the vegetable.

Okra has a high potential as a vegetable both in internal and export market. If the harvest is even slightly delayed the vegetables becomes fibrous rendering it totally useless. If it is harvested very early the yield is affected. Thus it is necessary to fix the correct stage of harvest to ensure maximum utilization and maximum profit to the farmer. Not much study has been undertaken in this area. With this in view the present investigation

"Post-harvest quality evaluation of okra [*Abelmoschus esculentus* (L.) Moench]" was carried out with the following objectives.

1. To evaluate the nutritional quality of 20 cultivars of okra
2. To determine the appropriate stage of harvest
3. To evaluate and compare the shelf-life of okra cultivars
4. To evaluate the change in physico-chemical characters of selected cultivars during storage

Review of Literature

2. REVIEW OF LITERATURE

Research works on the quality and storage aspects of *Abelmoschus esculentus* is less when compared to that of other vegetables.

Most of the works available under this topic were carried out outside Kerala. Efforts have been made to include as much information as possible.

2.1 NUTRITIONAL QUALITY

Abelmoschus esculentus, commonly known as okra, is an easy growing, tasty and nutrient-rich tender vegetable widely used in many countries.

Nutrient evaluation studies undertaken in other tender vegetables were also included wherever necessary.

Chauhan and Bhandari (1971) reported that the young pods of okra are very nutritious with good edible quality but they soon develop fibre making them useless as a vegetable.

Standal *et al.* (1974) studied *Abelmoschus manihot* for protein, ascorbic acid and provitamin A content. Reported values for the nutrient composition per 100 g fresh leaves were protein 5.7 g, provitamin A 13000 I.U. and vitamin C 118 mg.

Saimbhi and Jassal (1975) evaluated the nutrient content in terms of calories, protein, carbohydrates, vitamin A, vitamin C and minerals in certain vegetables such as peas, tomatoes, okra and spinach. The highest protein and vitamin C / ha were obtained with a rotation of peas and tomatoes and the highest vitamin A was obtained with tomatoes, okra and spinach.

Woolfe *et al*. (1977) studied the mucilages extracted from okra fruits. The mucilages are acidic polysaccharides with associated protein

and minerals that are not heat stable. They observed 0.2 to 0.3 per cent mucilage content in a typical Ghanian okra soup.

The nutritive value of local varieties of fresh and sundried okra fruits and seeds were evaluated by El-Nahry *et al*. (1978). They analysed moisture, protein, fat, ash, calcium and other minerals in fresh and dried fruits and seeds of okra cultivars Baladi, Eskandarini and Gold Coast. All fruits contained high levels of calcium, Iron, fibre and ash and low levels of carbohydrate and fat. The composition varied in different cultivars. They reported the calcium content as 984.5 mg/kg in okra.

Ifon and Bassir (1980) analysed some selected vegetable species along with okra for crude fat, fibre, dry matter and crude protein. The protein content of the green vegetables ranged between 17.2 per cent to 28.5 per cent, fibre 8.5 to 9.0 per cent, crude fat 2.7 to 8.1 per cent and dry matter 7.7 to 24.7 per cent of fresh weight.

Elangovan *et al*. (1983) evaluated the okra hybrids and their parents for crude fibre content. The crude fibre content ranged from 13.3 per cent to 14.7 per cent in different lines studied.

The mineral contents in okra in on a dry weight basis ranged from 0.11 to 0.76 (Sodium), 0.36 to 1.07 (Potassium), 0.24 to 0.73 (Calcium), 0.66 to 1.76 (Magnesium) and 0.35 to 0.56 (Iron) as reported by Faboya, 1983.

Oyolu (1983) examined the patterns of chemical composition in vegetable species with special reference to okra. Data are tabulated on mean fruit size, dry matter content, crude fibre, crude protein soluble sugars, starch, Ca content etc. of Abelmoschus.

El-Mahdy and El-Sebaiy (1984) studied the mucilages extracted from okra fruits. Okra mucilages showed the highest viscosity.

Tomoda *et al*. (1985) in a study on plant mucilages, have described the isolation and characterization of mucilage with special reference to okra mucilage.

Aswathi and Jaiswal (1986) analysed *Momordica charantia* cultivars for various physical and biochemical constituents and organoleptic properties. Cultivar Faizabadi was promising for crude protein, ash, Phosphorus and crude fibre content. On the basis of cooking quality and organoleptic evaluation, Kareli, Faizabadi and Kalyanpur Baramasi were found superior.

Candlish *et al.* (1987) studied the dietary fibre and starch contents of some South East Asian vegetables, and found that okra is one of the richest sources of total dietary fibre along with other 23 vegetables studied.

Chavan *et al*. (1991) analysed the chemical composition of freshly harvested tender fruits of 18 okra cultivars. The cultivars Khindi, Sri Lanka, Sel-4, B.M-105, Sel-6 and Parbhani Kranti had better overall nutritional composition than other cultivars.

Al-Jobori *et al*. (1992) determined the major, minor and trace elements in samples of 20 vegetables including okra, from different locations in Iraq. The elemental analysis was made by instrumental neutron activation analysis (INAA) and found out that these vegetables are good sources of some essential elements.

El-Din and Helmy (1996) studied the composition and quality of green mature and fully mature okra seeds. Whole ground and sieved fully mature okra seeds had higher percentages of protein, fat, fibre and ash but lower content of total carbohydrate than whole ground and sieved green mature okra seeds.

Quattrucci *et al*. (1996) determined the moisture, protein, ash and total lipid contents in the fruits of five Greek okra cultivars along with

vitamin content and levels of soluble and total dietary fibre. The best nutritional quality was found in pods of cultivar Pyleas.

Raja *et al*. (1997) studied the levels of crude protein and some inorganic elements in eight selected green vegetables including okra. The levels of crude protein ranged between 1.03 and 5.23 per cent on a fresh weight basis. Levels of Magnesium, Potassium and Calcium ranged between 0.18 and 3.38, 2.46 and 4.93 and 0.11 and 4.72 g/100 g respectively on dry weight basis.

Khalifa *et al*. (1998) opined that the whole seeds and defatted flour of okra contained 23.56 and 60.06 per cent protein, 21.29 and 4.45 per cent oil, 16.66 and 5.44 per cent crude fibre, 4.46 and 8.19 per cent ash, respectively.

Supatra Sen and Mukherji (1998) estimated that the mineral accumulation in fruits of okra and tomato were season–dependent. The highest concentration was recorded in summer in okra and in winter in tomato.

According to Ijomah *et al*. (2000) okra leaves and fruits contain high concentration of calcium and hence it can serve as a good source for dietary calcium.

Nutritive value and organoleptic qualities of 20 genotypes of Thamara Venda were studied and compared with Pusa Sawani, the cultivated variety. The mean value of fat, calcium, iron and vitamin C were found to be higher in Thamara Venda genotypes than in Pusa Sawani. Crude fibre content was lower than the control variety. Thamara Venda genotypes were found to have higher acceptability than Pusa Sawani (Sona Thampi and Indira, 2000).

Duzyaman and Vural (2003) studied numerous okra genotypes of American, Indian, European and Turkish origin for their pod properties and nutritive values. The improved cultivars from USA exhibited slow

fibre development. Dry matter accumulation was higher in the Turkish and African cultivars varying between 18.15 and 17.2 per cent while this remained between 15.6 and 13.6 per cent in the Indian cultivars and between 14.4 and 11.7 per cent in the American cultivars. Three lines from Turkey had the top protein levels.

2.2 INFLUENCE OF STAGE OF HARVEST ON QUALITY

The quality of okra as a vegetable is very much influenced by the stage of harvest. Attempts made by various workers to determine the correct stage of harvest of okra are reviewed hereunder.

Burrel and Ebright (1940) observed that okra fruits at the immature stage are rich in vitamin C which decreased as the pods matured.

Parthasarathy and Sambandam (1977) studied the pod length, girth, weight and crude fibre content in okra cultivars Local, AE-11, AE-34 and Red Wonder. Fruits of local AE-34 and Red Wonder were edible upto the seventh day after flower opening and those of AE-11 upto the sixth day. The crude fibre content of edible pods was only 26 to 40 per cent of that of fully developed fruits.

Rao and Sulladmath (1977) studied okra cultivars Pusa Sawani and Dwarf Green Long Pod from 5–14 days after flowering, and found that dry matter and alcohol–insoluble solids declined up to seven or eight days after flowering and thereafter increased. Crude fibre content rose rapidly after eight days. Ascorbic acid content attained a maximum after eight days and thereafter declined.

Longe *et al*. (1982) studied the changes in composition and carbohydrate constituents of okra with age. Mean values for four varieties of okra obtained at 1, 4, 7 and 10 days after flowering were, crude protein 19.5 per cent, fibre 18.8 per cent, ash 8.6 per cent and starch 3.2 per cent. Protein and free sugars decreased with age while fibre and starch increased.

Balasubramanian and Sadasivam (1987) analysed the seeds of cultivar Pusa Sawani for protein, oils, amino acids and starch contents from seventh to 42nd day after flowering. Protein, oil and starch contents increased gradually from day seven to day 42.

Hodossi and Pankotai (1987) studied the elemental composition of okra and changes in it at different growth stages. Twenty elements were determined from 10 to 55 days after flowering and found that the elements decreased with age.

Singh *et al*. (1990) opined that okra fruits should be harvested six to nine days after flowering for maximum crop yield and nutrient values. They analysed five okra cultivars for fruit weight, Nitrogen, Phosphorus, Iron, protein, sugar and crude fibre content. Fruit weight increased from fruit set upto 21 days. Nitrogen, Phosphorus, Iron, protein and starch contents decreased gradually with the age of the fruits whereas crude fibre content increased.

Iremiren *et al*. (1991) observed that the age at which okra fruits were harvested had no effect on vegetative growth or yield / ha. But fruits harvested more than seven days after pod set were of poorer quality mainly due to an increase in crude fibre and a reduction in the moisture, crude protein and ash content of older pods.

Farghali *et al*. (1994) studied twelve okra genotypes for physical and chemical changes in growth of okra fruit in relation to maturity. Differences in parameters varied between sampling times within genotypes. All the traits measured increased markedly upto eight days after flowering. After that all parameters continued to increase slightly, except fibre content. Some of the local accessions seemed to have edible quality for a longer period than the imported cultivars.

Ketsa and Chutichudet (1994) analysed the pod growth, development, biochemical changes and maturity indices of okra cultivar

OK# 2. Developmental changes in okra cultivar OK # 2 were studied between one and twelve days after flowering. The results showed that the changes in length and fruit weight followed simple sigmoidal curves. Soluble solid content and pericarp fibre content increased while ascorbic acid content decreased towards fruit maturity.

Gherbin *et al*. (2000) carried out a study to investigate the growth habit of okra pods, the weight and content of protein, fibre, mucilage and some mineral elements from flowering to full ripening. Fruit weight showed a remarkable increase during the first ten days from flowering and mucilage attained maximum content about six days from flowering. Crude fibre content increased during the whole cycle, reaching a value of about nine per cent on dry weight basis after one week from flowering.

Ekka *et al*. (2001) studied the physiochemical changes in okra cultivars Pusa A-4 and Parbhani Kranti during development. Pod length and diameter increased gradually with maturity and was highest on the ninth day of flowering. The dry matter percentage which was highest in Parbhani Kranti (15.83 per cent) six days after flowering decreased gradually to the lowest level seven days after flowering. The fibre content which was higher in Parbhani Kranti (12.43 per cent) than Pusa A-4 (1.94 per cent) gradually increased with maturity, but was lowest (7.86 per cent) four days after flowering.

2.3 ACCEPTABILITY STUDIES

Scientific methods of sensory analysis of food are becoming increasingly important in evaluating the acceptability of food product. Organoleptic qualities play an important role in sensory analysis of fruits and vegetables. For finding consumer acceptability organoleptic evaluation of any food product is essential.

On the basis of cooking quality and organoleptic evaluation, the cultivars, Kareli, Faizabadi and Kalyanpur Baramassi were found superior in *Momordica charantia* (Aswathi and Jaiswal, 1986)

Organoleptic qualities such as colour, flavour, taste, texture and appearance are assessed with a panel of selected judges (Watts *et al*., 1989). The combination which got the highest scores was selected for shelf-life studies.

According to Mc Dermott (1992) sensory method in which palatability is evaluated by a panel of judges is essential to every standardisation procedure because they ensure all important questions of the food tastes, smells, looks and feels.

Organoleptic qualities of 20 genotypes of Thamara venda were studied and compared with Pusa Sawani by Sona Thampi and Indira (2000). They observed that higher acceptability was shown by Thamara venda genotypes.

2.4 STORAGE STUDIES

The reports available on the storage of okra were scanty. Efforts have been made to collect as many literature as possible.

Achinewhu (1983) analysed fresh and cooked okra fruits for the change in vitamin C content. Vitamin C content of okra fruits in fresh was as high as 98.8 mg/100 g but losses through exposure and storage and traditional cooking methods were considerable. Ascorbic acid content in vegetables ranged between 21.3 to 98.8 mg/100 g. The traditional cooking methods caused a loss of around 32 to 68 per cent in vitamin C content. After storage in shade the loss was estimated to 22 to 34 per cent.

Baxter and Waters (1990) examined the chemical changes in okra stored in air and controlled atmosphere (CA). The experiment was done to determine the effects of air storage and controlled atmosphere storage on changes in sugars, organic acids, proteins, amino acids and ascorbic acid

contents within the tissue. Fruits were sampled at three days intervals for 12 days. CA storage found to be good in nutrient retention compared with air stored fruits.

Ratnapala and Peiris (1994) studied the effect of harvesting stage and storage conditions on storage life of okra. Fruits were harvested at two stages : immature (6–8 cm long) and mature (10–12 cm long). Immature fruits exhibited a higher weight loss compared with mature fruits. In comparison with control all other storage methods reduced crude fibre content of fruits.

According to an experiment conducted by Malik *et al*. (2000), the quality of okra was influenced by the position of fruit on mother plant, stage of harvest of fruits and ambient storage conditions. The variety studied was Varsha Upahar and the study was conducted in Hisar, Haryana. Seed quality also was affected greatly by the position of fruit and harvesting stage.

Materials and Methods

3. MATERIALS AND METHODS

The present investigation on "Post harvest quality evaluation of okra [*Abelmoschus esculentus* (L.) Moench]" was undertaken at the Department of Processing Technology, College of Agriculture, Vellayani during the period 2001-2003.

The study was carried out in two parts. In the first part twenty cultivars were evaluated for physico-chemical quality parameters. Five best cultivars were selected out of these twenty based on their organoleptic quality under storage. In the second part of the study fruits from these five cultivars were harvested at three different stages and were stored under ambient conditions upto eight days and evaluated for physico-chemical quality parameters.

3.1 MATERIALS

The basic materials for study consisted of the following cultivars of okra (Table 1).

Table 1 Basic materials for study

Code	Cultivars	Source	Main features of fruits
V_1	AE 214	College of Horticulture, Vellanikkara, Thrissur	Light green, medium sized, pubescent
V_2	AE 210	College of Horticulture, Vellanikkara, Thrissur	Light green, thin fruits
V_3	AE 211	College of Horticulture, Vellanikkara, Thrissur	Light green, glossy
V_4	AE 219	College of Horticulture, Vellanikkara, Thrissur	Dark green, pubescent, medium sized

V_5	AE 265	College of Horticulture, Vellanikkara, Thrissur	Light green, thin elongated
V_6	AE 275	College of Horticulture, Vellanikkara, Thrissur	Dark green, medium sized
V_7	AE 279	College of Horticulture, Vellanikkara, Thrissur	Light green, plumpy medium sized
V_8	AE 260	College of Horticulture, Vellanikkara, Thrissur	Light green, thin fruits
V_9	Selection 13	College of Agriculture, Vellayani, Trivandrum	Light green, soft, medium sized
V_{10}	Kiran	College of Agriculture, Vellayani, Trivandrum	Light green, thin elongated
V_{11}	Aruna	College of Horticulture, Vellanikkara, Thrissur	Red fruited
V_{12}	Salkeerthi	College of Horticulture, Vellanikkara, Thrissur	Light green, glossy
V_{13}	Pothencode Local	Collected from Pothencode, Trivandrum	Dark green, elongated
V_{14}	Kanjiramkulam Local	Collected from Kanjiramkulam, Trivandrum	Medium green, elongated, glossy
V_{15}	Maranalloor Local	Collected from Maranalloor, Trivandrum	Dark green, thin
V_{16}	Balaramapuram Local	Collected from Balaramapuram, Trivandrum	Light green, elongated
V_{17}	Pachalloor Local	Collected from Pachalloor, Trivandrum	Light green, pubescent
V_{18}	Kattakkada Local	Collected from Kattakkada, Trivandrum	Light green, elongated
V_{19}	Nemom Local	Collected from Nemom, Trivandrum	Dark green, glossy
V_{20}	Venganoor Local	Collected from Venganoor, Trivandrum	Light green medium sized

The seeds of cultivars were collected and grown in the Instructional Farm, College of Agriculture, Vellayani to get fruits in sufficient quantity.

3.2 METHODS

3.2.1 Assessment of the nutritional quality and shelf-life of okra fruits

Flowers were tagged on the day of opening and fruits were harvested at three stage of harvest such as five, seven and nine days after flower and analysed for nutritional quality. Fruit weight and nutritional aspects such as crude fibre, mucilage, moisture, protein, fat, vitamin C, calcium, dry matter content and organoleptic quality were analysed for each stage of harvest.

The parameters such as fruit weight, mucilage and vitamin C were analysed on the day of harvest of the fruits. Other parameters were analysed from oven dried samples of harvested fruits on dry weight basis.

Fruit Weight

Fruit weight was assessed by taking the average weight of five fruits selected at random from each stage of harvest.

Crude Fibre

Crude fibre content of the fruits was determined by the method of acid-alkali treatment (Sadasivam and Manickam, 1992).

Mucilage

Mucilage content was separated from fresh fruits by extraction with ethyl alcohol (Hirst and Jones, 1955).

Twenty five grams of fresh fruit sample was taken. One hundred ml water was added and kept for 24 hours. Then it was filtered through a muslin cloth into a flask. Fifty ml ethyl alcohol was added to the extract and then filtered through a pre-weighed filter paper. Residue along with filter paper was dried and weighed.

$$\text{Mucilage content (\%)} = \frac{\text{Final weight of sample}}{\text{Initial weight of sample}} \times 100$$

Moisture

Moisture content was determined by oven drying method (Ranganna, 1977).

Protein

Protein content was estimated using micro-kjeldhal method of nitrogen estimation.

Protein content = Nitrogen (%) x 6.25

(Sadasivam and Manickam, 1992).

Fat

Fat content of the fruit was estimated by extraction with petroleum ether (Sadasivam and Manickam. 1992).

Vitamin C

Vitamin C was estimated by volumetric method using 2,6-dichlorophenol indophenol dye (Sadasivam and Manickam, 1992).

Calcium

Calcium content in the fruit was estimated by Ethylene Diamine Tetra Acetic acid (EDTA) titration method (Jackson, 1958).

Dry Matter Content

Dry matter content was estimated based on oven drying method and expressed as per cent fresh weight (Sistrunk *et al*., 1960).

Organoleptic Quality

For organoleptic evaluation the tagged fruits were harvested, washed and cut into small pieces of uniform size. 25 g of each sample was cooked for constant time (8 minutes). Salt was added to taste, water drained off

and the samples were subjected to organoleptic assessment by a panel of judges selected from a group of students and staff through triangle test as suggested by Mahony (1985).

For scoring a scale of one to five was used, five representing the optimum for all quality characteristics.

The major quality attributes included in the score card were colour, doneness, texture, taste and overall acceptability.

Shelf-life

Shelf-life was assessed based on organoleptic evaluation. The harvested fruits at three stages (five, seven and nine days after flower opening) were stored under ambient conditions for zero, two, four, six and eight days and subjected to organoleptic evaluation. The organoleptic scores obtained for 20 cultivars of okra under different storage intervals were compared upto the last interval of storage. From that five cultivars were selected as having better shelf life when compared to others.

3.2.2 Assessment of changes in nutritional quality during storage

Based on organoleptic evaluation scores obtained, five cultivars were selected for assessing the changes in nutrient content during storage. From the selected cultivars five, seven and nine days old fruits were harvested and stored under ambient conditions. They were analysed at zero, two, four, six and eight days for nutritional and organoleptic changes.

Under the storage evaluation study, the changes occurring in, fruit weight, crude fibre, mucilage, moisture, protein, fat, vitamin C, calcium, dry matter content and organoleptic quality, during different intervals were analysed using the same methods of analysis as in the above study.

3.3 STATISTICAL ANALYSIS

The data were analysed in the form of a CRD with 2 factors in the initial part of study and with 3 factors in the next part.

In the initial part of study, the main factors were as follows.

1. Cultivars (V)

The 20 cultivars studied were represented as V_1, V_2, V_3, -------, V_{20}.

2. Stage of harvest (S)

The main factor S were at three levels S_1, S_2, S_3.

S_1 = 5 days after flowering

S_2 = 7 days after flowering

S_3 = 9 days after flowering

V x S interaction effect was analysed for each character under study.

In the second part of study three main factors i.e., V, S and D as described below, were studied.

1. Cultivar (V)

From 20 cultivars 5 were selected for study based on organoleptic evaluation. They were V_1, V_4, V_8, V_9 and V_{14}.

2. Stage of harvest (S)

Similar to that of initial part.

3. Storage Interval (D)

The main factor D was studied at five levels.

D_1 = 0 days under storage

D_2 = 2 days under storage

D_3 = 4 days under storage

D_4 = 6 days under storage

D_5 = 8 days under storage

In the second part, the four interaction effects were VS, VD, SD and VSD of which the interaction VS and VD were relevant with respect to the present study. Hence they were analysed in the study.

Results

4. RESULTS

The results of the study on "Post harvest quality evaluation of okra [*Abelmoschus esculentus* (L.) Moench]" are presented below.

4.1 NUTRITIONAL QUALITY OF OKRA FRUITS

4.1.1 Fruit Weight

The fruit weight of 20 cultivars of okra harvested at five, seven and nine days after flower opening were analysed and presented in Table 2.

On comparing the fruit weight of 20 cultivars of okra, cultivar V_{17} (26.60 g) recorded highest fruit weight. Cultivars V_1 and V_9 were on par and significantly different from others. The average fruit weight ranged from 21.82 g (V_1) to 26.60 (V_{17}).

The stage of harvest had pronounced influence on fruit weight. The values at three stages S_1, S_2 and S_3 were significantly different from each other in all the 20 cultivars concerned. The average fruit weight in each stage was recorded as 20.57 g (S_1), 24.53g (S_2) and 27.90 g (S_3) respectively.

There was significant difference between the combination with regard to VS interaction. The highest value was recorded for the combination v_{16} s_3 (30.70 g).

4.1.2 Mucilage

Mucilage content was expressed in percentage of fresh fruit weight and presented in Table 3. Between the 20 cultivars compared, there were no significant difference for mucilage content. The highest mucilage content was recorded for V_2 (0.28 %) and lowest for V_5 (0.19 %).

Table 2. Fruit weight (g)

Cultivars (V)	Stage of harvest			Mean (V)
	S_1	S_2	S_3	
V_1	19.50	21.83	24.13	21.82
V_2	20.36	23.03	26.40	23.67
V_3	18.20	24.80	27.76	23.58
V_4	25.20	25.96	27.46	26.21
V_5	21.03	24.43	29.30	25.58
V_6	17.60	23.43	30.60	24.21
V_7	21.40	24.83	26.50	24.24
V_8	18.93	22.63	28.33	24.96
V_9	17.43	22.76	25.36	21.94
V_{10}	22.23	25.86	27.10	24.82
V_{11}	18.70	23.23	26.20	23.01
V_{12}	22.30	24.66	28.96	24.38
V_{13}	20.70	23.50	27.50	25.05
V_{14}	21.60	24.53	28.23	24.54
V_{15}	20.43	25.13	27.23	25.93
V_{16}	22.20	25.90	30.70	25.11
V_{17}	21.20	25.90	29.56	26.60
V_{18}	20.63	25.93	27.43	26.04
V_{19}	21.20	26.40	30.53	25.01
V_{20}	20.70	25.93	28.79	26.38
Mean (S)	20.57	24.53	27.90	

CD (0.05)	SE
V : 0.69	V : 0.24
S : 0.26	S : 0.63
VS : 1.21	VS : 0.43

Table 3 Mucilage content (%)

Cultivars (V)	Stage of harvest			Mean (V)
	S_1	S_2	S_3	
V_1	0.25	0.24	0.22	0.23
V_2	0.32	0.31	0.22	0.28
V_3	0.22	0.21	0.20	0.21
V_4	0.25	0.26	0.25	0.25
V_5	0.19	0.21	0.19	0.19
V_6	0.22	0.22	0.20	0.21
V_7	0.27	0.28	0.27	0.27
V_8	0.24	0.24	0.23	0.24
V_9	0.27	0.27	0.24	0.25
V_{10}	0.26	0.25	0.24	0.25
V_{11}	0.27	0.25	0.24	0.26
V_{12}	0.25	0.23	0.21	0.23
V_{13}	0.23	0.22	0.20	0.22
V_{14}	0.29	0.24	0.22	0.25
V_{15}	0.31	0.22	0.20	0.24
V_{16}	0.22	0.23	0.21	0.22
V_{17}	0.21	0.20	0.19	0.20
V_{18}	0.27	0.26	0.25	0.26
V_{19}	0.21	0.23	0.21	0.22
V_{20}	0.25	0.25	0.22	0.24
Mean (S)	0.25	0.24	0.22	

CD (0.05)	SE
V : ns	V : 0.23
S : ns	S : 0.24
VS : ns	VS : 0.01

There were no significant difference between the three stages of harvest also. The average values for 3 stages were recorded as 0.25 per cent (S_1), 0.24 per cent (S_2) and for 0.22 per cent (S_3).

V x S interaction was also not significant statistically. The highest value was recorded for v_2s_1 (0.32 per cent) and lowest for v_5s_1 (0.19 per cent).

4.1.3 Moisture

Moisture content was expressed in percentage of fresh fruit weight and presented in Table 4.

Significant differences were not exhibited by the 20 cultivars compared for moisture content. All values were on par.

The average moisture content was highest for V_{15} (90.81 per cent) and lowest for V_{13} (88.62 per cent).

The highest moisture content of 90.68 per cent was observed in the first stage of harvest (S_1) and the lowest of 88.88 per cent, in the third stage (S_3).

V x S interaction was not found statistically significant. The highest moisture content was recorded for the combination v_2s_1 (91.53 per cent) and lowest for $v_{18}s_3$ (88.00 per cent), which was on par with all other interactions.

4.1.4 Dry Matter Content (DMC)

DMC, expressed in percentage of fruit weight, are presented in Table 5.

The DMC showed no significant difference between the cultivars as well as between the different stage of harvest. The values for the cultivars ranged between 9.08 per cent (V_{15}) to 10.62 per cent (V_{13}).

Table 4 Moisture content (%)

Cultivars (V)	Stage of harvest			Mean (V)
	S_1	S_2	S_3	
V_1	90.70	90.10	88.90	89.90
V_2	91.53	91.40	89.16	90.70
V_3	90.20	90.36	89.30	89.95
V_4	91.10	91.06	89.16	90.44
V_5	90.28	90.26	89.06	89.87
V_6	91.20	91.16	89.37	90.57
V_7	91.10	91.00	88.88	90.32
V_8	91.04	90.88	89.13	90.35
V_9	90.43	90.19	89.10	89.91
V_{10}	90.10	90.00	88.23	89.44
V_{11}	90.77	91.13	89.23	90.38
V_{12}	91.10	91.06	88.36	90.17
V_{13}	90.10	90.36	85.40	88.62
V_{14}	91.28	90.89	88.90	90.35
V_{15}	91.26	91.00	90.17	90.81
V_{16}	90.09	89.70	89.56	89.78
V_{17}	90.13	90.03	89.03	89.73
V_{18}	90.73	90.76	88.00	89.83
V_{19}	90.75	90.89	89.54	90.39
V_{20}	89.80	90.00	89.16	89.65
Mean (S)	90.68	90.61	88.88	

CD (0.05)
V : ns
S : ns
VS :ns

SE
V : 2.21
S : 3.58
VS :3.88

Table 5. Dry matter content (%)

Cultivars (V)	Stage of harvest			Mean (V)
	S_1	S_2	S_3	
V_1	11.14	9.33	9.80	10.09
V_2	10.90	8.47	8.70	9.35
V_3	10.76	9.80	10.03	10.20
V_4	10.84	8.92	8.93	9.56
V_5	10.92	9.72	9.91	10.18
V_6	10.50	8.80	8.92	9.41
V_7	11.19	8.94	9.06	9.73
V_8	10.90	8.91	9.14	9.65
V_9	10.92	9.51	9.81	10.08
V_{10}	11.93	9.81	9.90	10.58
V_{11}	10.95	9.22	9.83	10.00
V_{12}	10.97	8.91	8.94	9.61
V_{13}	11.94	9.94	9.99	10.62
V_{14}	11.16	8.75	9.21	9.71
V_{15}	9.90	8.40	8.93	9.08
V_{16}	10.44	9.91	8.94	10.10
V_{17}	10.96	9.54	9.90	10.13
V_{18}	11.98	8.76	8.90	9.88
V_{19}	10.73	9.70	9.77	9.94
V_{20}	10.94	9.92	9.93	10.27
Mean (S)	11.00	9.25	9.45	

CD(0.05) SE

V :ns V :2.20

S :ns S :2.38

VS :ns VS :1.84

The values between the stages of harvest ranged from 9.25 per cent (S_2) to 11 per cent (S_1).

It was observed that there was significant difference between different stages of harvest in all the cultivars with respect to interaction between V and S. The highest value (11.98 per cent) was recorded for the combination $v_{18}s_1$ while the lowest (8.4 per cent) was in $v_{15}s_2$.

4.1.5 Fat

Fat content, expressed in percentage of fruit weight are presented in Table 6.

There was no significant difference in the fat content between the three stages of harvest and also between the different cultivars.

The highest fat content (13.03 per cent) was found in cultivar V_6 and lowest (10.93 per cent) in cultivar V_{16}.

The effect of cultivars and stage of harvest on fat content was also not significant.

Highest fat value was recorded for the combination $v_{10}s_2$ (12.76 per cent) and lowest for $v_{19}s_3$ (10.32 per cent).

4.1.6 Protein

Protein content, expressed as percentage of dry fruit weight, are presented in Table 7.

There were no significant difference in the protein content both between the stage of harvest and between different cultivars. The protein content ranged between 14.71 per cent (V_4) and 16.19 per cent (V_9).

The interactions between cultivars and stages of harvest were also having no significant effect on the protein value. Highest value was recorded for the combination v_9s_2 (16.71 per cent) and lowest for v_{15} s_3 and $v_{17}s_3$ (15.01).

Table 6 Fat content (%)

Cultivars (V)	Stage of harvest			Mean (V)
	S_1	S_2	S_3	
V_1	12.21	13.13	12.12	12.48
V_2	11.59	11.94	11.13	11.55
V_3	11.42	11.61	10.91	11.31
V_4	12.01	12.43	11.63	12.02
V_5	11.06	11.27	10.71	11.01
V_6	12.99	13.29	12.81	13.03
V_7	12.73	13.00	12.51	12.75
V_8	11.10	11.23	10.61	10.98
V_9	12.91	11.13	12.20	12.08
V_{10}	12.00	12.76	12.60	12.45
V_{11}	11.02	11.30	10.93	11.08
V_{12}	12.16	12.30	11.90	12.12
V_{13}	11.24	11.60	10.80	11.22
V_{14}	12.03	12.08	11.64	11.92
V_{15}	12.10	12.20	12.00	12.10
V_{16}	11.00	11.10	10.70	10.93
V_{17}	11.10	11.32	10.71	11.04
V_{18}	12.00	12.21	12.80	12.33
V_{19}	11.03	11.16	10.32	10.84
V_{20}	12.04	12.08	11.91	12.01
Mean (S)	11.68	11.96	11.55	

CD (0.05)	SE
V : ns	V : 2.85
S : ns	S : 1.11
VS : ns	VS : 2.94

Table 7 Protein content (%)

Cultivars (V)	Stage of harvest			Mean (V)
	S_1	S_2	S_3	
V_1	15.21	15.67	15.03	15.30
V_2	15.18	15.71	15.02	15.30
V_3	14.91	15.05	14.85	14.94
V_4	14.67	14.95	14.52	14.71
V_5	15.09	15.36	15.02	15.16
V_6	15.65	15.95	15.20	15.60
V_7	15.98	16.01	15.62	15.87
V_8	15.22	15.91	15.12	15.42
V_9	16.05	16.71	15.81	16.19
V_{10}	15.60	15.91	15.02	15.51
V_{11}	15.36	15.80	14.97	15.38
V_{12}	15.33	15.86	15.11	15.43
V_{13}	15.32	15.47	15.08	15.29
V_{14}	15.62	15.79	15.42	15.61
V_{15}	15.07	15.12	15.01	15.06
V_{16}	15.03	15.21	15.00	15.08
V_{17}	15.01	15.17	15.01	15.06
V_{18}	15.11	15.35	15.03	15.16
V_{19}	15.63	15.77	15.60	15.66
V_{20}	15.08	15.16	15.01	15.08
Mean (S)	15.30	15.60	15.12	

CD (0.05)	SE
V : ns	V : 1.18
S : ns	S : 2.59
VS : ns	VS : 2.05

4.1.7 Crude fibre

Crude fibre content was estimated as percentage of dry fruit weight and are presented in Table 8.

There were no significant differences between the different cultivars with respect to the crude fibre content.

The average fibre content value was the highest for V_5 (9.64 per cent) and lowest for V_{14} (8.47 per cent).

Crude fibre content was, however significantly influenced by the different stages of harvest. The highest value of 14.31 per cent was observed in S_3 while the lowest of 5.57 per cent was observed in S_1. S_2 (7.48 per cent) was on par with S_1.

V x S interaction was not statistically significant. Highest crude fibre content was recorded for the combination $v_{16}s_3$ (15.23 per cent) and the lowest for $v_{13}s_1$ (5.01 per cent).

4.1.8 Vitamin C

Vitamin C content, expressed in mg/100g of fresh fruit weight and are presented in Table 9.

It was observed that there were significant difference in the vitamin C content for different cultivars. The highest value of 14.33 mg was observed in cultivar V_9 which was significantly higher than the rest of the cultivars. Cultivars V_{11} (14.20 mg) and V_3 (14.12 mg), though on par were also significantly different from the rest. The lowest value 12.58 mg was observed in Cultivar V_{13}.

The vitamin C content did not significantly differ between the three different stages of harvest. The values ranged between 12.89 mg (S_1) and 14.07 mg (S_2).

Table 8. Crude Fibre Content (%)

Cultivars (V)	Stage of harvest			Mean (V)
	S_1	S_2	S_3	
V_1	5.96	7.67	14.17	9.27
V_2	5.64	7.08	14.09	8.94
V_3	5.13	7.16	13.97	8.75
V_4	5.03	7.96	13.95	8.98
V_5	5.81	7.94	15.16	9.64
V_6	5.85	7.60	14.90	9.45
V_7	5.84	7.51	14.84	9.40
V_8	5.19	7.06	13.95	8.73
V_9	5.03	7.02	13.94	8.66
V_{10}	5.51	7.28	14.08	8.96
V_{11}	5.86	7.76	15.03	9.55
V_{12}	5.91	7.73	14.39	9.34
V_{13}	5.01	7.16	15.17	9.11
V_{14}	5.17	7.06	13.18	8.47
V_{15}	5.82	7.61	14.36	9.26
V_{16}	5.52	7.14	15.23	9.30
V_{17}	5.31	7.65	13.24	8.73
V_{18}	5.95	7.91	14.61	9.49
V_{19}	5.91	7.61	13.95	9.15
V_{20}	5.86	7.58	14.01	9.15
Mean (S)	5.57	7.48	14.31	

CD (0.05)	SE
V : ns	V : 3.13
S : 3.39	S : 1.21
VS : ns	VS : 2.42

Table 9 Vitamin C content (mg/100g fresh weight)

Cultivars (V)	Stage of harvest			Mean (V)
	S_1	S_2	S_3	
V_1	13.25	14.01	13.24	13.50
V_2	13.01	14.92	12.95	13.62
V_3	13.75	15.01	13.61	14.12
V_4	13.60	14.12	13.60	13.77
V_5	12.90	14.09	13.59	13.52
V_6	12.25	13.73	12.35	12.77
V_7	13.88	14.60	13.11	13.86
V_8	12.19	13.63	13.09	12.97
V_9	13.96	15.18	13.91	14.33
V_{10}	12.45	13.90	12.41	12.92
V_{11}	13.81	15.14	13.61	14.20
V_{12}	12.37	13.50	12.68	12.85
V_{13}	12.14	13.19	12.41	12.58
V_{14}	12.35	14.50	12.05	12.63
V_{15}	12.90	13.85	12.90	13.21
V_{16}	13.09	14.15	13.01	13.41
V_{17}	12.84	13.19	12.14	12.72
V_{18}	12.16	13.02	12.65	12.61
V_{19}	12.42	14.14	13.11	13.22
V_{20}	12.60	13.69	12.74	13.01
Mean (S)	12.89	14.07	12.95	

CD (0.05)	SE
V : 0.21	V : 3.48
S : ns	S : 2.89
VS : 0.36	VS : 0.12

4.1.9 Calcium

There were no significant differences between the cultivars for calcium content. Highest calcium was shown by cultivar V_{11} (112.52 mg) and lowest by V_{17} (109.64 mg). The stages of harvest also did not show any significant difference. The values obtained were 110.87 mg (S_1), 11.22 mg (S_2) and 110. 54 mg (S_3).

V x S interaction was not statistically significant in influencing calcium content. Highest calcium content was recorded for the combination v_2s_1 (112.94 mg).

4.1.10 Organoleptic Quality

Organoleptic quality was assessed by comparing the organoleptic scores obtained, and are presented in Table 11.

The mean scores obtained for the cultivars V_9 (20.78), V_{14} (19.94), V_4 (19.53) V_8 (19.25) V_1 (19.10) and V_{10} (18.45) were significantly different from that of other cultivars.

Highest organoleptic score was obtained for V_9 (20.78) and lowest for V_{19} (15.72) which was on par with V_2, V_{11} and V_{13}.

The stage of harvest had significantly influenced the organoleptic quality. The highest score of 18.96 was obtained in fruit harvested at second stage (S_2) while the lowest of 15.11 was found in third stage (S_3).

The organoleptic quality was also influenced by the effect of interaction between the cultivars and stage of harvest. Among the different combinations the highest score was obtained for v_9s_1 (21.52) and the lowest for v_2s_1 and v_5s_3 (13.34).

4.2 SHELF–LIFE ASSESSMENT

Shelf-life of 20 cultivars of okra were compared based on mean organoleptic scores obtained during five storage intervals. Organoleptic evaluation was performed after cooking and are presented in Table 12.

Table 10. Calcium content (mg/100g)

Cultivars (V)	Stage of harvest			Mean (V)
	S_1	S_2	S_3	
V_1	109.86	110.55	110.01	110.14
V_2	112.94	112.91	111.60	112.48
V_3	110.75	110.80	110.10	110.55
V_4	110.57	110.90	110.32	110.60
V_5	109.80	110.21	109.00	109.68
V_6	110.20	110.50	110.07	110.26
V_7	111.24	111.65	111.75	111.54
V_8	112.17	112.61	111.89	112.22
V_9	111.67	111.93	111.13	111.58
V_{10}	110.94	111.03	110.47	110.82
V_{11}	112.56	112.96	112.05	112.52
V_{12}	111.83	112.31	111.58	111.91
V_{13}	110.51	110.95	110.30	110.59
V_{14}	110.39	110.84	110.30	110.51
V_{15}	110.29	110.76	110.18	110.42
V_{16}	110.57	110.71	110.14	110.47
V_{17}	109.60	110.19	109.13	109.64
V_{18}	110.17	110.59	109.82	110.19
V_{19}	111.08	111.28	110.85	111.07
V_{20}	110.30	110.64	110.18	110.37
Mean (S)	110.87	111.22	110.54	

CD (0.05)	SE
V : ns	V : 0.12
S : ns	S : 2.55
VS : ns	VS : 0.20

Table 11 Organoleptic quality

Cultivars (V)	Stage of harvest			Mean (V)
	S_1	S_2	S_3	
V_1	19.74	20.77	16.78	19.10
V_2	16.47	17.44	13.34	15.75
V_3	17.68	18.20	14.29	16.27
V_4	20.33	21.10	17.17	19.53
V_5	17.20	17.86	13.34	16.14
V_6	17.72	18.26	14.37	16.78
V_7	17.77	18.27	13.88	16.64
V_8	20.23	20.44	17.06	19.25
V_9	21.52	22.27	18.57	20.78
V_{10}	19.25	19.65	16.45	18.45
V_{11}	16.84	16.48	13.98	15.76
V_{12}	17.59	19.18	14.09	16.95
V_{13}	16.89	17.38	13.09	15.79
V_{14}	20.80	21.24	17.77	19.94
V_{15}	17.87	19.01	15.05	17.31
V_{16}	18.26	18.33	14.90	17.16
V_{17}	19.20	19.45	15.31	17.99
V_{18}	17.43	18.51	14.26	16.74
V_{19}	16.67	17.02	13.47	15.72
V_{20}	18.09	18.58	15.16	17.27
Mean (S)	18.37	18.96	15.11	

CD (0.05)	SE
V : 0.32	V : 2.55
S : 0.13	S : 0.12
VS : 0.57	VS : 0.20

Table 12 Shelf life Assessment- based on organoleptic scores

Cultivars	Storage intervals																			
	0th day of storage				2nd day of storage				4th day of storage				6th day of storage				8th day of storage			
	S_1	S_2	S_3	Mean (S)	S_1	S_2	S_3	Mean (S)	S_1	S_2	S_3	Mean (S)	S_1	S_2	S_3	Mean (S)	S_1	S_2	S_3	Mean (S)
V_1	19.75	20.50	16.76	19.00	18.78	20.03	15.31	18.04	17.53	18.57	12.58	16.23	15.30	13.93	7.23	12.15	8.80	7.05	4.43	6.76
V_2	16.84	17.44	13.34	15.87	15.27	17.07	11.59	14.64	14.34	14.93	8.40	12.55	12.10	11.40	4.40	9.30	6.22	5.40	2.28	4.63
V_3	17.68	18.56	14.29	16.84	16.42	18.05	12.59	15.69	15.50	16.20	9.45	13.72	12.15	12.81	3.93	9.63	6.11	5.50	2.09	4.57
V_4	20.33	21.10	17.17	19.53	19.84	20.94	15.71	18.83	18.34	18.95	12.78	16.69	14.74	14.36	7.93	12.34	9.74	7.94	4.92	7.53
V_5	17.20	17.86	13.34	16.14	16.46	16.93	11.34	14.91	15.07	14.91	8.53	12.83	13.37	11.78	4.64	9.93	6.73	5.88	2.36	4.99
V_6	17.72	18.26	14.37	16.78	17.10	17.41	12.80	15.77	16.61	15.68	9.20	3.83	13.80	11.88	5.36	10.35	6.85	5.90	2.39	5.05
V_7	17.77	18.27	13.88	16.64	17.44	17.36	12.02	15.61	16.46	15.76	9.61	13.94	14.03	11.69	5.52	10.42	6.25	5.90	2.14	4.76
V_8	20.23	20.61	17.06	19.30	19.84	20.21	15.71	18.59	18.19	18.08	10.82	15.70	15.76	13.98	6.91	12.22	8.11	8.36	4.95	7.14
V_9	21.52	22.27	18.57	20.78	20.66	21.57	16.80	19.67	19.35	19.81	13.50	17.55	16.85	15.49	7.99	13.45	9.92	9.19	5.02	8.04
V_{10}	19.25	19.65	16.45	18.45	18.29	18.87	14.70	17.29	17.30	16.61	10.55	14.82	15.01	12.63	6.48	11.37	6.58	5.94	4.29	5.61
V_{11}	16.64	16.18	13.83	15.55	16.23	15.13	11.54	14.30	14.47	14.02	8.41	12.30	12.55	9.51	4.73	8.93	6.25	4.99	2.19	4.47
V_{12}	18.59	19.20	14.09	16.96	16.77	18.42	12.40	15.86	14.37	16.37	9.65	12.46	12.70	12.38	5.63	10.23	6.73	6.14	2.47	5.12
V_{13}	16.89	17.39	13.09	15.79	15.59	16.89	11.31	14.60	13.68	14.61	8.78	12.36	11.66	10.70	4.50	8.95	6.12	4.99	1.92	4.34
V_{14}	20.80	21.24	17.77	19.94	20.34	20.64	15.82	18.93	19.40	18.32	11.63	18.78	17.83	14.81	8.16	13.61	9.97	8.37	5.57	7.97
V_{15}	17.87	19.01	15.05	17.31	17.70	18.56	13.15	16.47	16.34	16.27	9.71	14.11	14.16	12.56	7.69	11.47	6.67	6.68	4.32	6.09
V_{16}	18.26	18.33	14.90	17.16	17.54	17.58	13.69	16.27	16.19	15.43	9.77	13.79	14.47	11.87	7.74	11.36	6.66	5.71	3.80	5.76
V_{17}	19.20	19.45	15.31	17.99	18.54	18.50	13.47	16.84	17.67	16.45	8.91	14.34	15.44	12.75	6.75	11.64	7.43	6.80	4.27	6.27
V_{18}	17.43	18.52	14.26	16.74	16.51	17.86	12.59	15.65	15.59	15.12	8.63	13.11	12.69	11.56	6.56	10.27	6.51	5.65	4.23	5.47
V_{19}	16.67	17.02	13.47	15.72	16.31	16.90	11.35	17.85	15.47	14.42	8.28	12.73	13.73	13.49	6.83	11.35	6.29	4.99	4.13	5.14
V_{20}	18.09	18.58	15.16	17.27	17.21	17.44	12.95	15.86	16.76	15.13	8.57	13.49	14.40	12.09	6.67	11.05	7.02	5.62	4.34	5.66
Mean (S)	18.39	18.97	15.11	17.49	17.64	18.32	13.34	16.43	16.43	16.78	9.81	14.36	14.14	12.58	6.28	11.00	7.25	6.35	3.51	5.70

	0th day		
	V	S	VS
SE	0.12	3.72	0.21
CD	0.34	0.13	0.59

	2nd day		
	V	S	VS
SE	0.12	2.73	0.21
CD	0.34	0.13	0.59

	4th day		
	V	S	VS
SE	0.76	0.29	1.32
CD	2.14	0.82	3.70

	6th day		
	V	S	VS
SE	0.25	0.87	0.44
CD	0.71	0.27	1.23

	8th day		
	V	S	VS
SE	0.11	2.15	0.18
CD	0.30	0.12	0.51

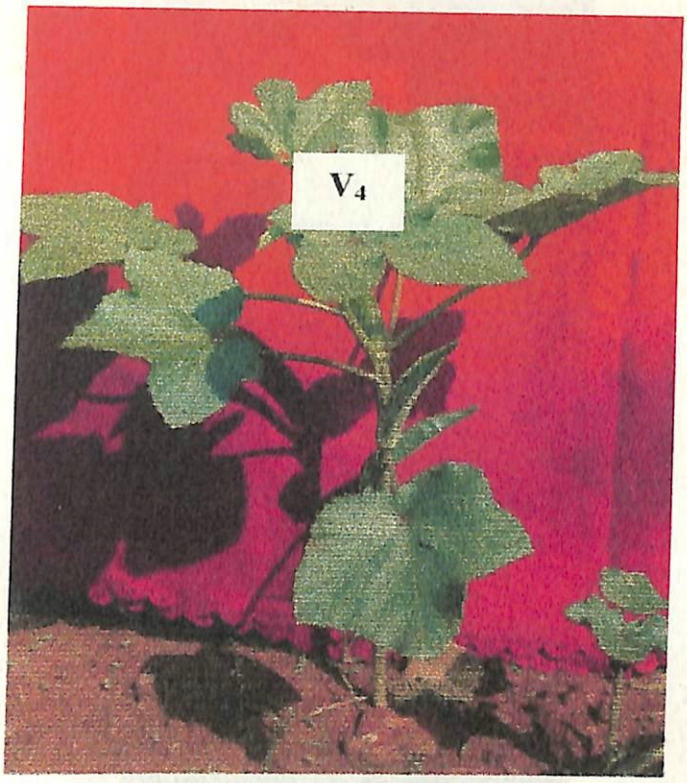

Plate 1. V_4 – AE 219

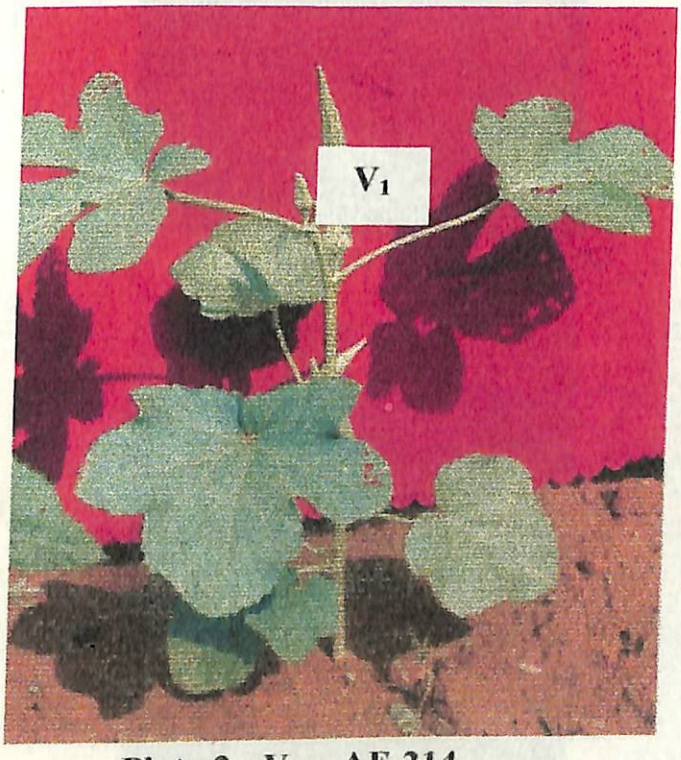

Plate 2. V_1 – AE 214

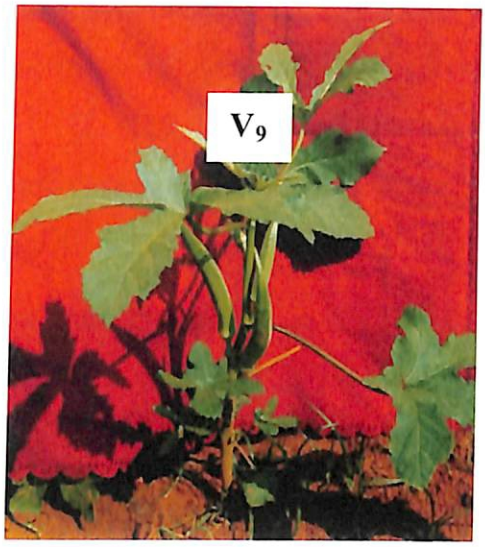

Plate 3. V_9 – Selection 13

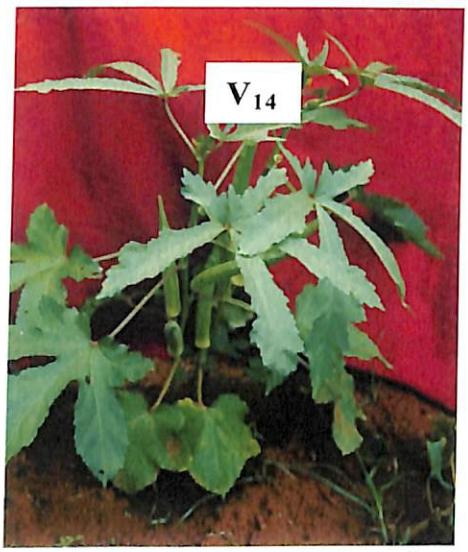

Plate 4. V_{14} – Kanjiramkulam local

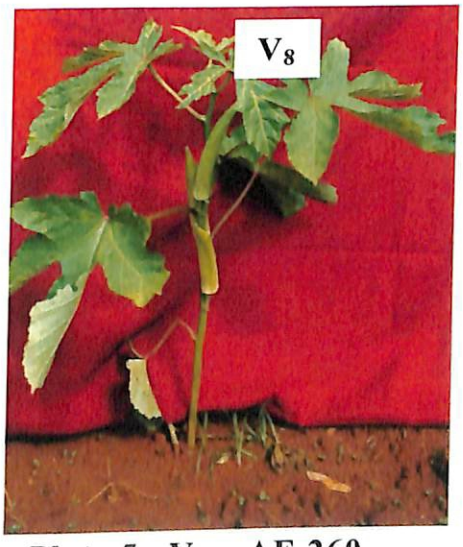

Plate 5. V_8 – AE 260

The organoleptic scores obtained immediately after harvesting (zero day of storage) for 20 cultivars of okra showed that the cultivar V_9 (20.78), V_{14} (19.94), V_4 (19.53), V_8 (19.30) and V_1 (19.00) were significantly different from other cultivars. The scores were found decrease with increasing number of days of storage.

The results showed that the cultivars V_1, V_4, V_8, V_9 and V_{14} were having the highest organoleptic scores in different stages of harvest. Hence these five cultivars were selected for shelf- life evaluation.

The study revealed that fruits harvested at the second stage (S_2) maintain the highest organoleptic score throughout the storage period.

The scores obtained at eighth day of storage were 8.04 (V_9), 7.97 (V_{14}), 7.53 (V_4), 7.14 (V_8) and 6.76 (V_1).

4.3 CHANGE IN NUTRITIONAL QUALITY DURING STORAGE

4.3.1 Fruit Weight

The fruits of okra harvested at five, seven and nine days after flowering were stored under ambient conditions for 0, 2, 4, 6 and 8 days and the average fruit weight was found out (Table 13 and 14).

The influence of cultivar (V), stage of harvest (S) and storage interval (D) on weight of stored okra fruits was significant.

Among five cultivars selected for storage studies, fruit weights of cultivars, V_4, V_9 and V_{14} were significantly different from that of V_1 and V_8 which were on par.

The highest average fruit weight was observed in cultivar V_9 during storage (18.34 g).

Fruit weight decreased with the number of days of storage. Lowest weight was observed during D_5 (12.27 g) which was significantly different from that of other cultivars.

.Table 13. Effect of cultivar (V) and storage interval (D) on fruit weight of okra during storage (g)

Cultivars (V)	Storage Interval (D)					Mean (V)
	D_1	D_2	D_3	D_4	D_5	
V_1	22.61	20.49	17.48	15.50	11.02	17.42
V_4	24.34	22.36	19.81	18.10	14.87	19.89
V_8	22.91	20.91	17.82	15.09	10.56	17.67
V_9	23.56	21.47	18.47	15.32	11.85	18.13
V_{14}	23.68	21.66	18.50	15.43	10.80	18.24
Mean (D)	23.42	21.37	18.41	15.88	12.27	

CD (0.05)
V : 0.12
D : 0.13
VD : 0.26

SE
V : 0.09
D : 0.04
VD : 0.09

Table 14. Effect of cultivar (V) and stage of harvest (S) on fruit weight of okra during storage (g)

Cultivars (V)	Stage of harvest (S)			Mean (V)
	S_1	S_2	S_3	
V_1	14.14	17.43	20.70	17.42
V_4	16.21	19.52	23.95	19.89
V_8	13.18	18.06	21.79	17.67
V_9	12.29	17.15	24.96	18.13
V_{14}	16.03	18.47	20.22	18.24
Mean (S)	14.37	18.13	22.32	

CD (0.05)
V : 0.12
S : 0.09
VS : 0.20

SE
V : 0.04
S : 0.03
VS : 0.07

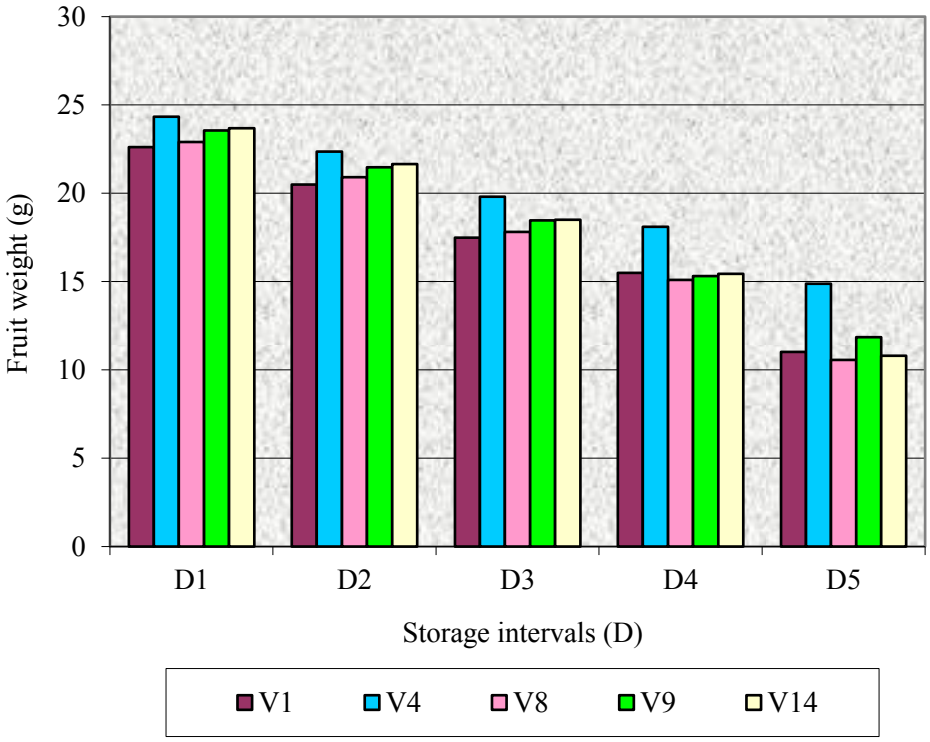

Fig. 1 Effect of cultivar (v) and storage intervals (D) on fruit weight of okra during storage

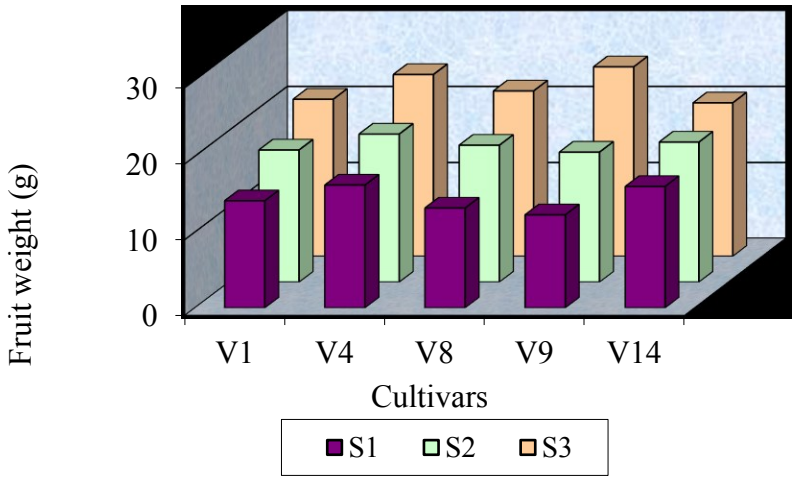

Fig. 2 Effect of cultivar (V) and stage of harvest (S) on fruit weight of okra during storage

Among the interactions V x D and V x S interaction were found significant. Highest value under V x D interaction was for v_4d_1 (24.34 g) and lowest for v_1d_5 (11.02g).

Under V x S interaction, the combination v_9s_3 (24.96 g) was highest and v_1s_1 (14.14) was lowest.

4.3.2 Crude fibre

The main effects of V, D, and S were found to have significant influence on the crude fibre development during storage of okra fruits (Table 15 and 16).

The cultivars V_1, V_4, V_8, V_9 and V_{14} were found to be significantly differing from each other and highest value was recorded for V_1 (9.55 per cent) while the lowest value was observed for V_{14} (8.74 per cent).

The change in fibre content during different storage intervals was also significant. The crude fibre content increased with the storage intervals. The highest was recorded at D_5 (9.51 per cent).

Among the interactions V x D and V x S interactions were significant.

Under V x D interactions all the combinations were significant from each other. The highest value was shown by the combination v_1d_5 (9.96 per cent) and lowest by v_{14} d_1 (8.47 per cent).

Under V x S interactions also all the combinations were significantly from each other. Highest fibre content was recorded for the combination v_1s_3 (14.53 per cent) and lowest for v_9s_1 (5.25 per cent).

4.3.3 Mucilage

The main effects of V, D and S were having significant influence on mucilage content of okra under storage (Table 17 and 18).

Cultivars V_9 and V_{14} were having the highest value (0.20 per cent) under storage, followed by V_1 and V_4 which were on par. Cultivar V_8 (0.18 per cent) was significantly different from others.

Table 15 Effect of cultivar and storage intervals on crude fibre content of okra on storage (%)

Cultivars (V)	Storage Interval (D)					Mean (V)
	D_1	D_2	D_3	D_4	D_5	
V_1	9.29	9.35	9.48	9.67	9.96	9.55
V_4	8.98	9.04	9.21	9.37	9.66	9.25
V_8	8.73	8.79	8.93	9.12	9.42	9.00
V_9	8.67	8.72	8.85	9.04	9.32	8.92
V_{14}	8.47	8.52	8.67	8.99	9.15	8.74
Mean (D)	8.83	8.88	9.03	9.22	9.51	

CD (0.05)
V : 0.01
D : 0.02
VD : 0.02

SE
V : 0.001
D : 0.01
VD : 0.01

Table 16. Effect of cultivars and stage of harvest on crude fibre content of okra on storage (%)

Cultivars (V)	Stage of harvest (S)			Mean (V)
	S_1	S_2	S_3	
V_1	6.27	7.85	14.53	9.55
V_4	5.29	8.14	14.32	9.25
V_8	5.43	7.23	14.34	9.00
V_9	5.25	7.20	14.32	8.92
V_{14}	5.40	7.23	13.60	8.74
Mean (S)	5.53	7.53	14.22	

CD (0.05)
V : 0.01
S : 0.009
VS : 0.02

SE
V : 0.001
S : 0.01
VS : 0.01

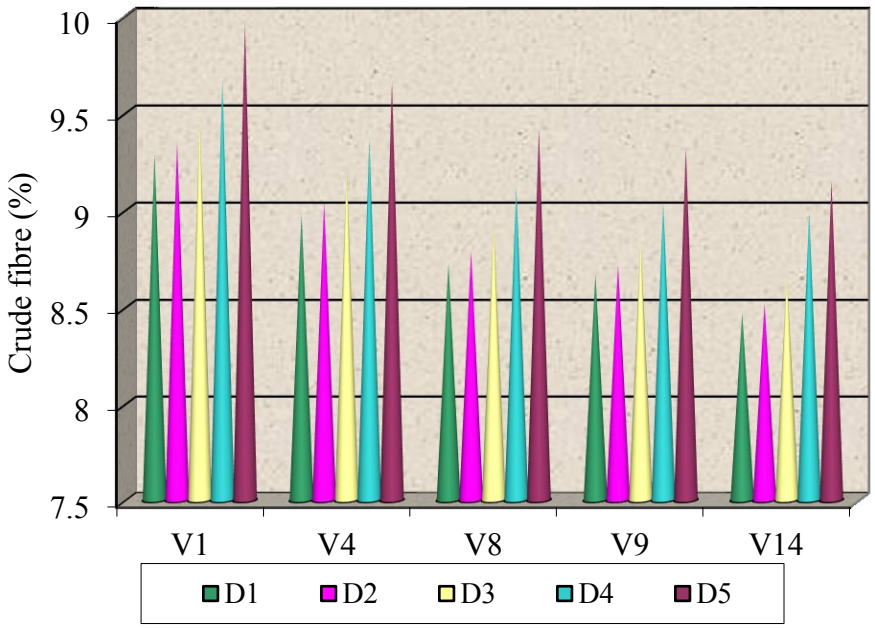

Fig. 3 Effect of cultivar (V) and storage intervals (D) on crude fibre content of okra on storage

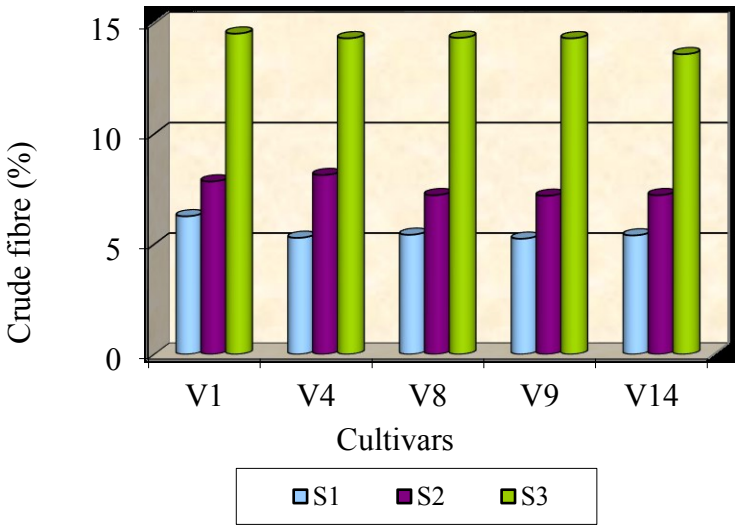

Fig. 4 Effect of cultivars (V) and stage of harvest (S) on crude fibre content of okra on storage

Mucilage content was found to be highest at stage D_1 (0.25 per cent) and lowest at D_5 (0.13 per cent).

It was observed that the mucilage content of fruit was significantly higher (0.20 per cent) in both S_1 and S_2 stages of harvest. Mucilage content decreased at the third stage of harvest (0.18 per cent).

The interactions, V x D and V x S had significant influence on mucilage content. Under V x D interaction, the combination $v_{14}d_1$ (0.25 per cent) recorded highest mucilage content v_8d_5 showed the lowest.

Under V x S interaction the highest mucilage was exhibited by the combination $v_{14}s_1$ (0.23 per cent) and lowest by v_1s_3 (0.17 per cent) which was on par with $v_{14}s_3$ and v_8s_3.

4.3.4 Moisture

The main effects of V, D and S and their interactions were analysed and are presented in Table 19 and 20.

The effect of cultivar (V) on average moisture content under storage was significant. Highest value was recorded for V_4 (62.04 per cent) and lowest for V_1 (61.03 per cent).

The effect of storage interval (D) on moisture content was highly significant. The moisture content decreased from 90.19 per cent to 26 per cent during storage from D_1 to D_5.

The values of moisture content recorded for S_1, S_2 and S_3 were significantly different. The highest value was obtained at S_1 (64 per cent) and the lowest in S_3 (56.57 per cent).

The effect of interactions between V x D and V x S were significant. Under V x D interactions all the combinations were significantly different from each other. The highest moisture content was recorded for v_4d_1 (90.44 per cent) and lowest for v_4d_5 (24.40 per cent).

Table 17. Effect of cultivars (V) and storage intervals (D) on mucilage content in okra on storage (%)

Cultivars (V)	Storage Interval (D)					Mean (V)
	D_1	D_2	D_3	D_4	D_5	
V_1	0.24	0.22	0.19	0.16	0.13	0.19
V_4	0.24	0.22	0.19	0.16	0.13	0.19
V_8	0.24	0.22	0.18	0.15	0.12	0.18
V_9	0.25	0.23	0.20	0.17	0.13	0.20
V_{14}	0.25	0.23	0.21	0.17	0.14	0.20
Mean (D)	0.25	0.23	0.19	0.17	0.13	

CD (0.05)
V : 0.001
D : 0.01
VD : 0.01

SE
V : 0.01
D : 0.01
VD : 0.01

Table 18. Effect of cultivars (v) and stage of harvest (S) on mucilage content in okra on storage (%)

Cultivars (V)	Stage of harvest (S)			Mean (V)
	S_1	S_2	S_3	
V_1	0.20	0.19	0.17	0.19
V_4	0.19	0.20	0.18	0.19
V_8	0.19	0.18	0.17	0.18
V_9	0.21	0.20	0.19	0.20
V_{14}	0.23	0.20	0.17	0.20
Mean (S)	0.20	0.20	0.18	

CD (0.05)
V : 0.001
S : 0.01
VS : 0.01

SE
V : 0.01
S : 0.001
VS : 0.01

Table 19. Effect of cultivars (V) and storage intervals (D) on moisture content during storage (%)

Cultivars (V)	Storage Interval (D)					Mean (V)
	D_1	D_2	D_3	D_4	D_5	
V_1	89.90	72.35	63.11	54.45	25.31	61.03
V_4	90.44	74.05	63.45	55.55	24.40	62.04
V_8	90.36	72.48	62.71	54.65	25.69	61.18
V_9	89.94	72.35	62.29	54.44	26.39	61.08
V_{14}	90.32	72.55	63.14	54.17	25.88	61.21
Mean (D)	90.19	72.76	62.94	54.66	26.00	

CD (0.05)	SE
V : 0.03	V : 0.01
D : 0.03	D : 0.01
VD : 0.07	VD : 0.02

Table 20. Effect of cultivars (v) and stage of harvest (S) on moisture content during storage (%)

Cultivars (V)	Stage of harvest (S)			Mean (V)
	S_1	S_2	S_3	
V_1	63.60	61.17	58.30	61.03
V_4	65.58	61.72	58.82	62.04
V_8	63.37	61.23	58.93	61.18
V_9	63.12	61.48	58.65	61.08
V_{14}	64.34	61.16	58.13	61.21
Mean (S)	64.00	61.35	56.57	

CD (0.05)	SE
V : 0.03	V : 0.01
S : 0.02	S : 0.01
VS : 0.05	VS : 0.02

With regard to V x S interactions the highest value was shown by v_4s_1 (65.58 per cent) and lowest by $v_{14}s_3$ (58.13 per cent).

4.3.5 Protein

The main effects and interaction effects of V, D and S on protein content were analysed and are presented in Table 21 and 22.

The influence of cultivars (V) on protein content under storage was significant. Highest protein value was recorded by V_9 (16.16 per cent) and lowest by V_4 (14.67 per cent).

Under storage, the average protein values for D_1, D_2 and D_5 were significantly different from that of D_4 and D_3 which were on par. The protein content decreased from 15.46 per cent (D_1) to 15.43 per cent (D_5) under storage.

The effect of stage of harvest on protein content under storage was significant. The highest protein content value was recorded at S_2 (15.76 per cent) and lowest in S_3 (15.13 per cent).

The effect of interactions between V x D and V x S were significant. Under V x D interaction the highest protein value was shown by v_9d_1 (76.22 per cent) which was on par with v_9d_2 and lowest by the combination $v_{14}d_4$ (14.51 per cent). With regard to V x S interaction the highest protein value was recorded for v_9s_2 (16.66 per cent) and lowest for v_4s_3 (14.48 per cent).

4.3.6 Fat

The main effects and interaction of V, D and S on fat content of okra during storage are presented in Table 23 and 24.

The effect of cultivar (V) on fat content was highly significant. Highest value for fat was recorded for cultivar V_9 (12.75 per cent) and lowest for V_8 (11.01 per cent).

With regard to storage the intervals D_3, D_4 and D_5 were on par. Highest fat value was recorded for D_1 (12.15 per cent) which was on par with D_2 and lowest for D_5 (12.04 per cent).

Table 21. Effect of cultivars (V) and storage intervals (D) on protein content during storage (%)

Cultivars (V)	Storage Interval (D)					Mean (V)
	D_1	D_2	D_3	D_4	D_5	
V_1	15.31	15.28	15.26	15.23	15.16	15.25
V_4	14.73	14.71	14.69	14.66	14.58	14.67
V_8	15.43	15.40	15.38	15.36	15.29	15.37
V_9	16.22	16.21	16.17	16.16	16.06	16.16
V_{14}	15.61	15.59	15.55	15.51	15.43	15.56
Mean (D)	15.46	15.44	15.41	15.40	15.31	

CD (0.05)
V : 0.01
D : 0.009
VD : 0.01

SE
V : 0.001
D : 0.001
VD : 0.01

Table 22. Effect of cultivars (v) and stage of harvest (S) on protein content during storage (%)

Cultivars (V)	Stage of harvest (S)			Mean (V)
	S_1	S_2	S_3	
V_1	15.16	15.61	14.98	15.25
V_4	14.61	14.93	14.48	14.67
V_8	15.18	15.85	15.09	15.37
V_9	16.07	16.66	15.76	16.16
V_{14}	15.57	15.74	15.37	15.56
Mean (S)	15.32	15.76	15.13	

CD (0.05)
V : 0.01
S : 0.009
VS : 0.01

SE
V : 0.001
S : 0.01
VS : 0.01

Table 23. Effect of cultivars (V) and storage intervals (D) on Fat content during storage (%)

Cultivars (V)	Storage Interval (D)					Mean (V)
	D_1	D_2	D_3	D_4	D_5	
V_1	12.48	12.46	12.41	12.39	11.43	12.41
V_4	12.62	12.34	12.32	12.20	12.26	12.24
V_8	10.97	10.74	10.32	11.24	11.20	11.01
V_9	12.75	12.73	12.71	12.67	12.65	12.73
V_{14}	11.91	11.90	11.87	11.85	11.70	11.85
Mean (D)	12.15	12.12	12.05	12.07	12.04	

CD (0.05)
V : 0.04
D : 0.04
VD : 0.09

SE
V : 0.01
D : 0.01
VD : 0.03

Table 24. Effect of cultivars (v) and stage of harvest (S) on Fat content during storage (%)

Cultivars (V)	Stage of harvest (S)			Mean (V)
	S_1	S_2	S_3	
V_1	12.11	13.10	12.02	12.41
V_4	11.94	13.19	11.59	12.24
V_8	10.99	11.19	10.85	11.01
V_9	12.86	13.10	12.22	12.73
V_{14}	11.99	11.96	11.61	11.85
Mean (S)	11.98	12.51	11.66	

CD (0.05)
V : 0.04
S : 0.03
VS : 0.07

SE
V : 0.01
S : 0.01
VS : 0.02

The effect of stage of harvest (S) was also significant and the highest value was recorded at S_2 (12.51 per cent) while the lowest was at S_3 (11.66 per cent).

The effect of interactions between V x D and V x S were significant. Under V x D interaction the highest fat value was recorded for the combination v_9d_1 (12.75 per cent) and lowest value for v_8d_3 (10.62 per cent).

With regard to V x S interaction, the highest fat value was shown by v_4s_2 (13.19 per cent) and lowest by v_8s_3 (10.85 per cent).

4.3.7 Vitamin C

The main effects of V, D and S as well as their interaction effects on Vitamin C content of okra on storage are presented in Table 25 and 26.

The influence of cultivars on vitamin C was significant and the highest vitamin C value was observed for V_9 (11.98 mg) and lowest for V_8 (10.47).

With regard to storage intervals all the values were significantly different from each other. The vitamin C value ranged from 13.45 mg to 8.30 mg from D_1 to D_5 storage intervals. Stage of harvest (S) also influenced the vitamin C value significantly. The highest vitamin C value was recorded at S_2 (14.17 mg) and lowest at S_3 (11.49 mg).

The effect of interactions between V x D and V x S were significant statistically. Under V x D interaction the highest vitamin C value was obtained for the combination v_9d_1 (14.35 mg) and lowest for v_8d_5 (6.27 mg). With regard to V x S, highest vitamin C value was shown by v_9s_2 (15. 17 mg) and lowest by v_8s_3 (7.91 mg).

4.3.8 Calcium

The main effects and interactions of V, D and S were recorded and are presented in Table 267 and 28.

Table 25. Effect of cultivars (V) and storage intervals (D) on vitamin C content in okra on storage (mg/100 g)

Cultivars (V)	Storage Interval (D)					Mean (V)
	D_1	D_2	D_3	D_4	D_5	
V_1	13.17	12.29	11.16	10.19	8.21	11.00
V_4	13.44	12.55	11.41	10.31	8.28	11.20
V_8	12.64	11.72	10.75	9.62	6.27	10.47
V_9	14.35	13.43	12.21	9.89	8.92	11.98
V_{14}	13.64	12.66	11.71	10.55	7.37	11.41
Mean (D)	13.45	12.53	11.45	10.34	8.30	

CD (0.05)
V : 0.02
D : 0.03
VD : 0.05

SE
V : 0.01
D : 0.01
VD : 0.02

Table 26. Effect of cultivars (V) and stage of harvest (S) on vitamin C content in okra on storage (mg/100 g)

Cultivars (V)	Stage of harvest (S)			Mean (V)
	S_1	S_2	S_3	
V_1	11.08	13.91	8.02	11.00
V_4	11.28	14.16	8.16	11.20
V_8	10.01	13.47	7.91	10.47
V_9	11.42	15.17	9.36	11.98
V_{14}	11.10	14.14	9.00	11.41
Mean (S)	10.98	14.17	8.49	

CD (0.05)
V : 0.02
S : 0.03
VS : 0.04

SE
V : 0.01
S : 0.01
VS : 0.02

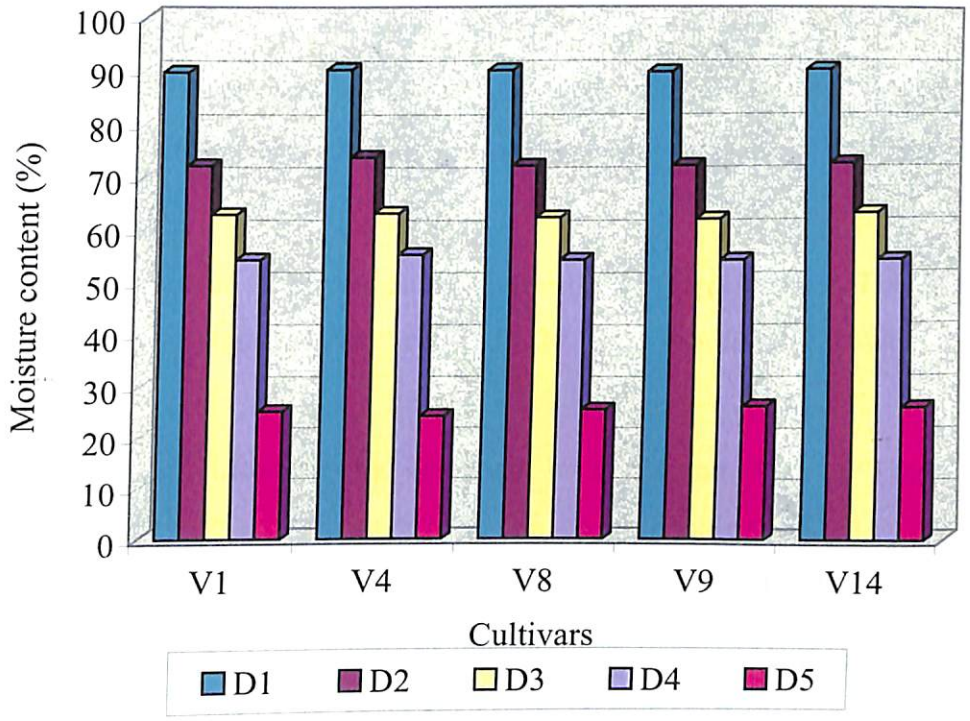

Fig. 5 Effect of cultivars (V) and storage intervals (D) on moisture content of okra during storage

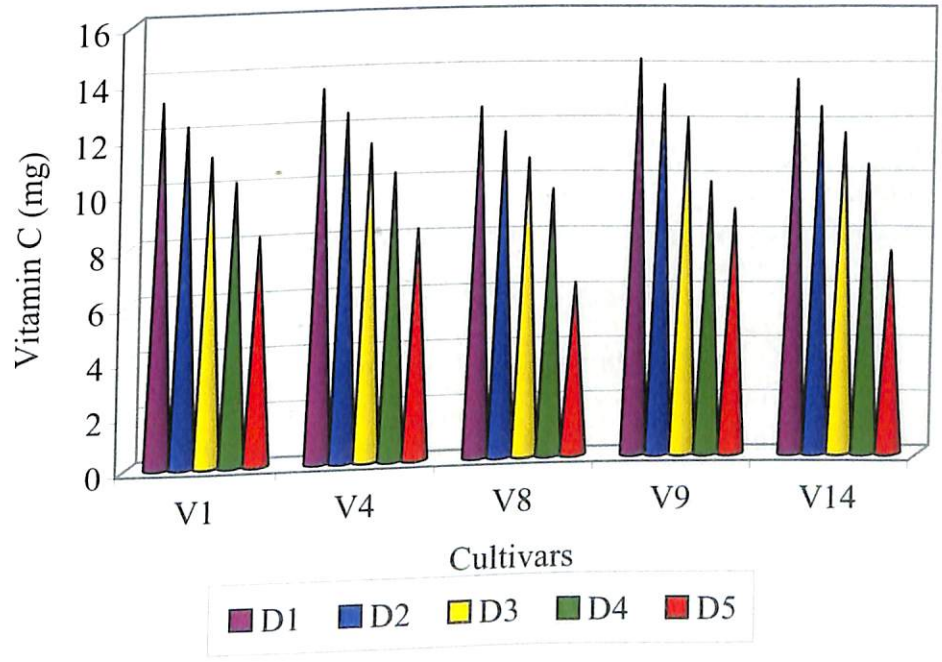

Fig. 6 Effect of cultivars (V) and storage intervals (D) on vitamin C content of okra on storage

Calcium content was significantly influenced by cultivar (V). The highest calcium content was recorded in V_8 (112.12 mg) and lowest in V_1 (110.08 mg).

Calcium content was also significantly influenced by the storage intervals. Calcium content during storage ranged between 111.03 mg (D_1) to 110.76 mg (D_5).

The influence of S on calcium content was significant. The highest calcium value was recorded at S_2 (111.27 mg) while the lowest at S_3 (110.57 mg).

The effect of interactions between V x D and V x S were also significant. Under V x D interaction, the combination v_8d_1 (112.22 mg) recorded highest calcium value and v_1d_4 (110.07 mg) recorded lowest value.

With regard to V x S the combination v_8s_2 (112.51 mg) recorded the highest value and v_1s_1 (110.03 mg) showed the lowest value.

4.3.9 Dry Matter Content (DMC)

The main effects and interactions of V, D and S were analysed for dry matter content of okra on storage and are presented in Table 29 and 30.

The influence of cultivars on DMC was significant in all cases. The highest DMC value was recorded for V_1 (10.35 %) and lowest for V_4 (9.74 %).

The progressive increase in DMC during storage was significant, values ranging between 9.86 per cent and 10.13 per cent.

Stage of harvest also significantly influence the DMC.

With regard to storage intervals, D_1 and D_5 was significant to each others. D_3 and D_4 were on par and significant from others. The highest DMC was recorded at D_5 (10.13 %).

Highest DMC was recorded during S_1 (11.16 %) on comparing the values at different stage of harvest. Stage of harvest influenced DMC significantly.

Table 27. Effect of cultivars (V) and storage intervals (D) on calcium content in okra on storage (mg/100 g)

Cultivars (V)	Storage Interval (D)					Mean (V)
	D_1	D_2	D_3	D_4	D_5	
V_1	110.21	110.19	110.13	110.07	110.68	110.08
V_4	110.61	110.5	110.53	110.48	110.36	110.51
V_8	112.22	112.18	112.13	112.08	111.96	112.12
V_9	111.62	111.60	111.53	111.47	111.35	111.51
V_{14}	110.53	110.49	110.37	110.46	110.31	110.43
Mean (D)	111.03	111.01	110.94	110.91	110.76	

CD (0.05)	SE
V : 0.04	V : 0.01
D : 0.03	D : 0.01
VD : 0.02	VD : 0.01

Table 28. Effect of cultivars (V) and stage of harvest (S) on calcium content in okra on storage (mg/100 g)

Cultivars (V)	Stage of harvest (S)			Mean (V)
	S_1	S_2	S_3	
V_1	110.03	110.43	109.77	110.08
V_4	110.55	110.81	110.18	110.51
V_8	112.07	112.51	111.77	112.12
V_9	111.73	111.85	110.96	111.51
V_{14}	110.36	110.76	110.18	110.43
Mean (S)	110.95	111.27	110.57	

CD (0.05)	SE
V : 0.04	V : 0.01
S : 0.03	S : 0.01
VS : 0.07	VS : 0.03

Table 29. Effect of cultivars (V) and storage intervals (D) on dry matter content of okra on storage (%)

Cultivars (V)	Storage Interval (D)					Mean (V)
	D_1	D_2	D_3	D_4	D_5	
V_1	10.29	10.34	10.37	10.51	10.25	10.35
V_4	9.55	9.59	9.67	9.71	10.16	9.74
V_8	9.68	9.77	10.11	9.90	9.89	9.87
V_9	10.08	10.12	10.21	10.25	10.18	10.17
V_{14}	9.69	9.76	9.79	9.85	10.14	9.85
Mean (D)	9.86	9.92	10.03	10.04	10.13	

CD (0.05)
V : 0.01
D : 0.02
VD : 0.02

SE
V : 0.04
D : 0.01
VD : 0.01

Table 30. Effect of cultivars (V) and stage of harvest (S) on dry matter content of okra on storage (%)

Cultivars (V)	Stage of harvest (S)			Mean (V)
	S_1	S_2	S_3	
V_1	11.21	10.04	9.82	10.35
V_4	10.96	9.09	9.06	9.74
V_8	11.24	9.24	9.13	9.87
V_9	11.09	9.90	9.52	10.17
V_{14}	11.29	9.27	8.98	9.85
Mean (S)	11.16	9.51	9.32	

CD (0.05)
V : 0.01
S : 0.008
S : 0.01

SE
V : 0.01
S : 0.01
VS : 0.01

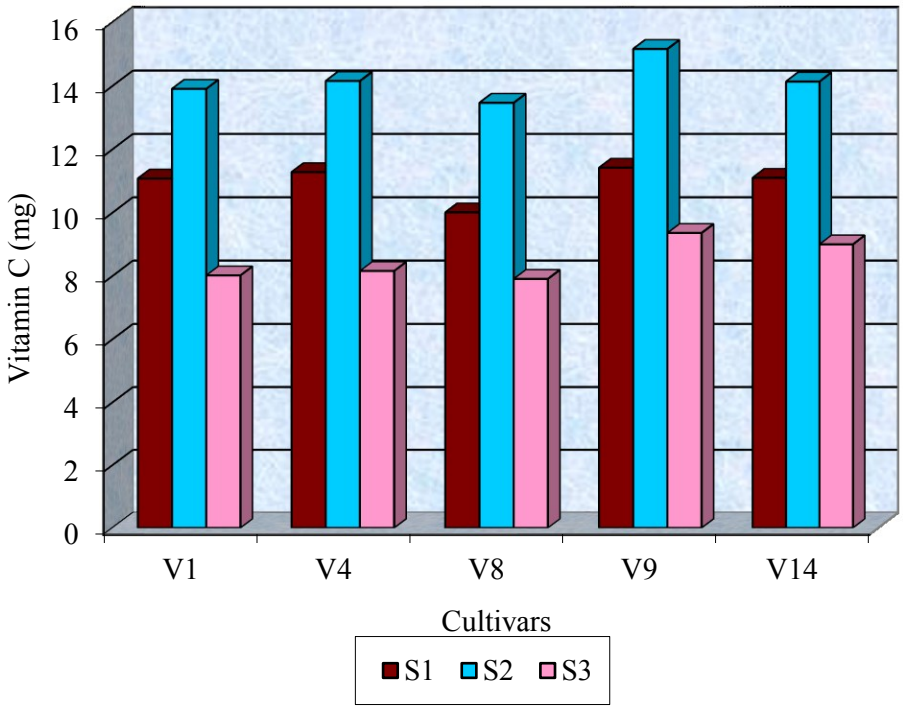

Fig. 7 Effect of cultivars (V) and stage of harvest (S) on vitamin C content in okra during storage

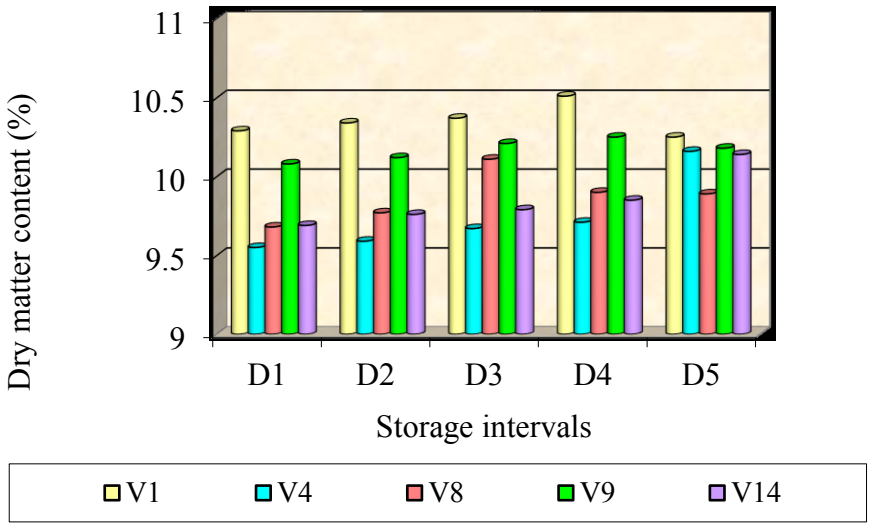

Fig. 8 Effect of cultivars (V) and storage intervals (D) on dry matter content of okra on storage

The effect of interactions, V x D and V x S were significant. All the combinations were significantly different each other with regard to V x D interaction. The combination v_1d_4 (10.51 %) recorded highest DMC value and v_4d_1 (9.55 per cent) recorded the lowest.

Under V x S interaction, highest DMC value was recorded for the combination, v_8s_1 (11.24 %) and lowest by v_4s_3 (9.06 %).

4.3.10 Organoleptic Quality

Organoleptic quality of okra was evaluated after cooking and the mean scores obtained are presented in Table 31 and 32.

The main effects of V, D and S and their interactions were having significant influence in the organoleptic quality.

All the five cultivars were significantly different from each other when the organoleptic scores were compared. The highest average score was recorded for V_9 (14.68) and lowest for V_1(12.75).

With regard to storage intervals, the average organoleptic score decreased significantly from 19.66 (D_1) to 4.39 (D_5) which indicated that organoleptic quality decreased drastically under storage.

The stage of harvest also significantly influence the organoleptic quality, the highest value scored by S_2 (14.84) while the lowest was in S_3 (11.36).

The effect of interactions V x D sand V x S were significant. Under V x D, the highest average score was shown by the combination v_9d_1 (20.79) and the lowest one by v_1d_5 (3.71). On considering V x S, the highest score was recorded for $v_{14}s_2$ (15.07) and lowest for v_8s_3 (10.58).

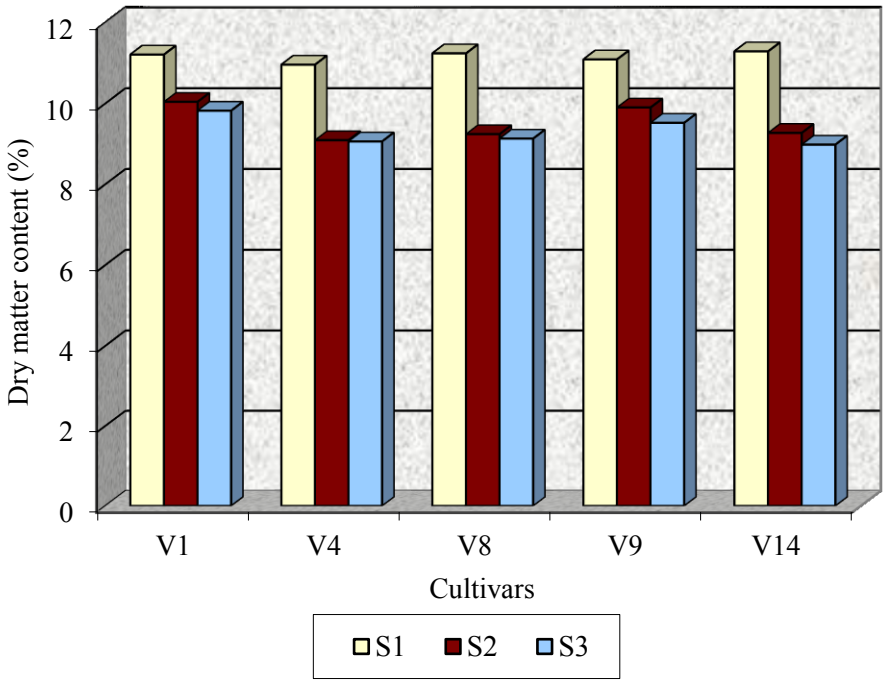

Fig. 9 Effect of cultivars (V) and stage of harvest (S) on dry matter content of okra on storage

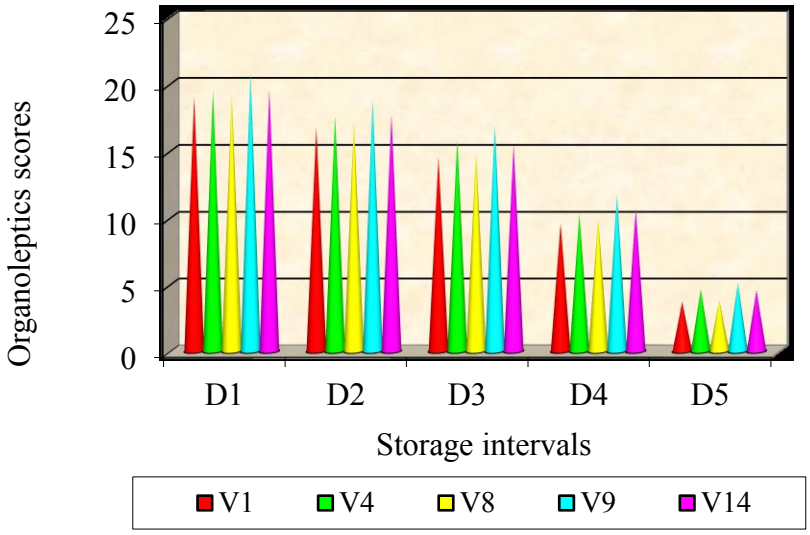

Fig. 10 Effect of cultivars (V) and storage intervals (D) on organoleptic quality of okra under storage

Table 31. Effect of cultivars (V) and storage intervals (D) on organoleptic quality of okra under storage

Cultivars (V)	Storage Interval (D)					Mean (V)
	D_1	D_2	D_3	D_4	D_5	
V_1	19.09	16.80	14.55	9.58	3.71	12.95
V_4	19.54	17.59	15.89	10.30	4.65	13.59
V_8	19.26	17.09	14.83	9.96	3.84	13.00
V_9	20.79	18.79	16.96	11.72	5.12	14.68
V_{14}	19.61	17.75	15.51	10.65	4.59	13.62
Mean (D)	19.66	17.61	15.55	10.44	4.39	

CD (0.05)
V : 0.14
D : 0.12
VD : 0.30

SE
V : 0.05
D : 0.05
VD : 0.11

Table 32. Effect of cultivars (V) and stage of harvest (S) on organoleptic quality of okra on storage

Cultivars (V)	Stage of harvest (S)			Mean (V)
	S_1	S_2	S_3	
V_1	13.39	14.25	10.60	12.75
V_4	14.43	14.88	11.48	13.59
V_8	14.25	14.16	10.58	13.00
V_9	15.51	15.86	12.66	14.68
V_{14}	14.32	15.07	11.48	13.62
Mean (S)	14.36	14.84	11.36	

CD (0.05)
V : 0.14
S : 0.11
VS : 0.24

SE
V : 0.05
S : 0.04
VS : 0.08

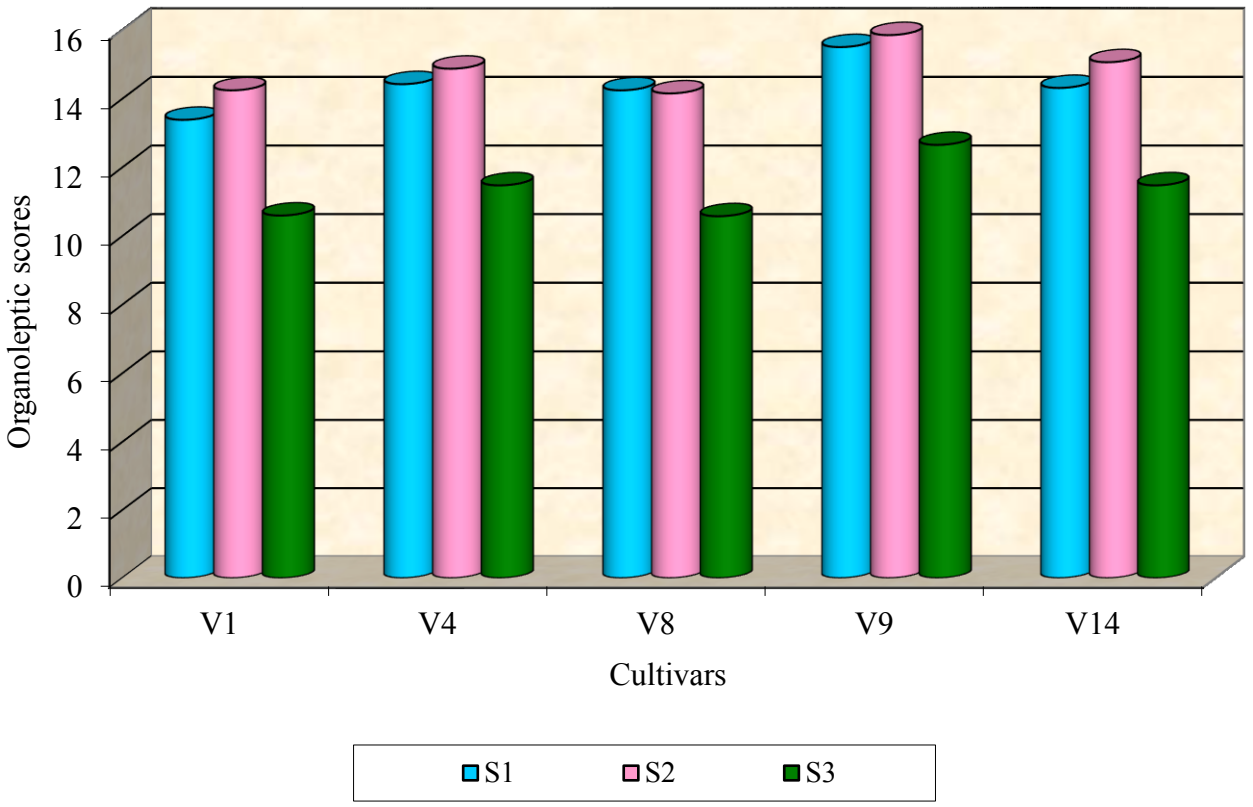

Fig. 11 Effect of cultivars (V) on stage of harvest (S) on organoleptic quality of okra on storage

5. DISCUSSION

The results of the investigation on "Post harvest quality evaluation of okra [*Abelmoschus esculentus* (L.) Moench] are discussed and presented under the following headings.

5.1 NUTRITIONAL QUALITY OF OKRA FRUITS

Among the 20 okra cultivars evaluated for the present study, the cultivar V_{17} (Pachalloor Local) gave the highest average fresh fruit weight (26.60 g). This is possibly due to the larger fruit size as compared to other cultivars. The highest fruit weight, in all the cultivars, was observed at the third stage of harvest *i.e.*, at nine days after flower opening, revealing that the fruit weight increased with increasing stage of maturity at harvest. It may be inferred that this is due to the time available for further physiological growth and development of the fruit. This is also in agreement with the study conducted by Gherbin *et al*. (2000) wherein they have stated that the fresh fruit weight of okra showed a remarkable increase during the first ten days from flowering.

It was observed that the mucilage content in all the cultivars showed a progressive decrease with the increasing stage of harvest with the exception of four cultivars *viz*., V_4, V_5, V_7 and V_{19}, where there was a slight increase in the second stage of harvest and then a decrease in the third stage. It was also observed that the highest mean mucilage content (0.28 per cent), among all the cultivars was present in the cultivar AE 210 while the lowest (0.19 per cent) was observed in AE 265. However the overall acceptability of both the cultivars was behind the cultivar Selection 13 which had a mean mucilage content of 0.25 per cent. This shows that a moderate amount of mucilage is preferred in okra. The results of the present study are also in conformity with the reports of Sona

Discussion

Thampi and Indira (2000) in which they have stated that mucilage content of *Abelmoschus* genotypes range between 0.27 per cent to 0.49 per cent.

The moisture content in okra fruit in all the 20 cultivars evaluated did not show any significant difference both between the cultivars as well as between the three stages of harvest. The mean moisture content ranged between 88.62 per cent (V_{13}) to 90.81 per cent (V_{15}). This is possibly because the fruits were harvested latest by nine days after flower opening while they were still tender and were not retained on the plant to attain physiological maturity and the reduction in moisture content. This also corroborates with the earlier reports by Sona Thampi and Indira (2000) in which moisture content of *Abelmoschus* genotypes are reported to be ranging between 90.16 per cent to 92.00 per cent.

When the dry matter content of 20 cultivars was compared, it was noticed that the average value for each did not differ statistically, under the same stage of harvest. DMC value was greatly influenced by the stage of harvest. Rao and Sulladmath (1977) in their study opined that dry matter accumulation is dependent on seasonal variations. They pointed out that DMC was higher in summer than during rainy season. The average DMC was highest for the Local cultivar Kattakkada Local at five days after flower opening (11.98 per cent). It exhibited a DMC of 8.76 percent at seven days after flower opening and 8.90 per cent at nine days after flower opening. This is in accordance with the result obtained by Ekka *et al*. (2001). They reported that the percentage of DMC was highest on fourth day after flower opening and then it decreased gradually to a lowest level on seventh day after anthesis followed by an increase. They also opined that the varieties did not differ significantly for DMC in okra. The increase of DMC from 8th day of flowering might be due to depletion of moisture content of pods with the advancement of maturity (Ekka *et al*., 2001).

The fat content ranged between 10.93 per cent (Balaramapuram Local) to 13.03 per cent (AE 275). These results are also in conformity

with the earlier reports of Sona Thampi and Indira (2000), wherein the fat content of *Abelmoschus* was reported to range between 10.45 per cent to 14.83 per cent.

It was observed that the protein content of okra was not considerably influenced by the cultivar difference. The stage of harvest too did not affect the protein content very much. The protein content of fruits of twenty cultivars of okra on a dry weight basis ranged between 14.71 per cent (AE 219) to 16.19 per cent (Selection 13). This is corroborated by the earlier reports of Kordylas (1990) where the protein content was reported as 2.20 per cent on a fresh weight basis. This is also in agreement with the reports of Thakur *et al*. (1993) where it is stated that the mean protein content of okra on a fresh weight basis is 1.90 per cent. In a similar study conducted and as reported by Sona Thampi and Indira (2000) shows that protein content of *Abelmoschus* range between 14.19 per cent to 17.65 per cent.

Okra, as a vegetable, must be harvested at a tender stage. With the advancement of pod development in okra, crude fibre content increases and the delay of even a day or two in harvesting render the pods useless as a vegetable. However harvesting at a very early stage will reduce the yield and thus can become uneconomical to the grower. Thus it becomes necessary to establish the right stage of harvest without affecting either the yield or the quality. In the present study it was found out that the mean crude fibre content was not highly influenced by the difference in cultivars, however, it was greatly influenced by the stage of harvest. The crude fibre content at the ninth day after flower opening ranged between 13.18 per cent (Kanjiramkulam Local) to 15.23 per cent (Balaramapuram Local) while on the fifth day after flower opening it was 5.17 per cent and 5.52 per cent respectively. These findings are substantiated by the earlier findings of Rao and Sulladmath (1977) that reported crude fibre content in okra between five days to fourteen days after flower opening ranged between 4.10

per cent to 32.22 per cent. The studies of Ekka *et al*. (2001) are also in agreement with this.

The vitamin C content in any vegetable is of prime importance from a nutritional point of view. It was observed, in the present study, that the vitamin C content in okra fruits was significantly influenced by the cultivar difference as well as the stage of harvest. Among the twenty different cultivars the mean vitamin C content ranged between 12.58 mg/100 g (Pothencode Local) to 14.33 mg/100 g (Selection 13). Among the three different stages of harvest the mean vitamin C content showed a decreasing tendency after the second stage of harvest, the highest value of 14.07 mg/100 g found in the second stage while the lowest value of 12.89 mg/100 g was observed in the first stage of harvest. Similar results were also obtained in studies conducted by Rao and Sulladmath (1977) and Ekka *et al*. (2001).

The present study revealed that calcium content in okra fruit was not significantly influenced by either the cultivar difference or by the stage of harvest. The mean calcium content ranged from 109.64 mg/100 g (Pachalloor Local) to 112.52 mg/100 g (Aruna). This finding confirms the earlier findings of Thakur *et al*. (1993). This is also in agreement with the findings of Sona Thampi and Indira (2000) wherein the calcium content in *Abelmoschus* was reported to be ranging from 92.60 mg/100 g to 140.60 mg/100 g.

Quality of any vegetable is assessed by various parameters such as texture, colour, flavour, nutritional quality etc. Changes in these parameters will occur according to the cultivar and the stage of harvest. An effective way of assessing the overall acceptable quality of a particular vegetable or any eatables is by subjecting it to organoleptic quality assessment. In the present study it was observed that organoleptic quality scores obtained were highly influenced by the cultivar and the stage of harvest. The highest score was obtained by the cultivar Selection 13 at the

seventh day after flower opening. It was also noticed that in all the cultivars tried the mean organoleptic score was highest at the seventh day after flowering after which it showed a decreasing tendency probably due to changes in texture, flavour etc. These findings are also in conformity with the earlier reports of Rao and Sulladmath (1977) and Ekka *et al*. (2001) both suggesting an ideal stage of harvest of six to seven days after flowering.

5.2 STORAGE STUDIES

Among the 20 cultivars of okra evaluated in the present study five cultivars which obtained the highest organoleptic score for the overall acceptability after having stored for eight days were selected and were subjected to storage studies. They were AE 214, AE 219, AE 260, Selection 13 and Kanjiramkulam Local.

These five cultivars subjected to storage studies under ambient conditions were evaluated at an interval of two days upto eight days for the changes in their physico-chemical characteristics.

It was observed that in the storage studies cultivar and stage of harvest had profound influence on all the characters studied *viz*., fruit weight, crude fibre, mucilage, moisture, fat, protein, vitamin C, calcium, dry matter content and organoleptic quality.

All the five cultivars selected for storage studies exhibited weight loss proportionate to the duration of storage which can be attributed to the loss of stored food for respiration and due to water loss by transpiration. These findings are found to be in agreement with the results obtained by Ratnapala and Peiris (1994).

The crude fibre content was found to increase with the increasing period of storage. This can be attributed to the continued metabolic processes during storage. The nutritive factors such as fat, protein, mucilage, moisture, calcium and vitamin C contents were seen decreasing

proportionately in the five cultivars of okra under storage. This could be attributed to the evaporative and degradative losses taking place in the stored fruits. Considerable reduction was observed in the case of moisture content which rendered the fruit almost useless towards the end of storage. The retention of vitamin C towards the end of storage was highest (8.92 mg/100 g) in cultivar Selection 13 showing 31.20 per cent loss of vitamin C content. Similar results were also reported by Achinewhu (1983) wherein it was observed that 22 to 34 per cent vitamin C was lost during storage.

Dry matter content of the okra fruits under storage showed an increasing trend from the day of harvest to sixth day of storage in all the cultivars studied. The cultivars AE 219 and Kanjiramkulam Local showed the increasing trend till the end of the storage period upto eight days. But the other cultivars exhibited a slight decrease in dry matter content during the last period of storage. The increase in dry matter content during storage could be due to the depletion of moisture content of the fruits under storage (Ekka *et al*., 2001).

Organoleptic quality evaluation scores decreased during the period of storage in all the cultivars. There was a drastic reduction in the mean score from the highest value of 19.66 on the day of harvest to the lowest value of 4.39 on the final day of storage. From the overall results obtained, it could be inferred that the decrease in organoleptic quality during storage could be due to the reduction in nutrient as well as moisture content and also due to the increase in crude fibre content. The maximum quality retention towards the end of storage was noticed in the cultivar Selection 13.

Summary

6. SUMMARY

The present investigation entitled "Post harvest quality evaluation of okra [*Abelmoschus esculentus* (L.) Moench]" was carried out to evaluate the nutritional qualities and shelf-life of okra cultivars and hence to identify suitable cultivars with better quality and shelf-life. The experiment was carried out at the Department of Processing Technology, College of Agriculture, Vellayani, Thiruvananthapuram during the period 2001-2003. Major findings of the study are summarized below.

The study for the evaluation of nutritional quality of okra cultivars revealed that among the twenty cultivars compared, the average fruit weight was found to be highest for Pachalloor Local. The highest fruit weight was noticed at nine days after flower opening in all the cultivars. Average moisture content and mucilage was highest for AE 214. Highest dry matter content was exhibited by the Local cultivar, Pothencode Local. Dry matter content was highest during the firs stage of harvest *i.e.,* five days after flower opening and then it decreased up to seven days after flowering and then showed an increasing trend at nine days after flowering. The cultivar selection 13 showed the highest protein and vitamin C content during the three stages of harvest. Highest fat content was observed in AE 275. Kanjiramkulam Local exhibited the lowest crude fibre content. Red fruited cultivar Aruna showed highest calcium content. Crude fibre content was the lowest during the initial stages of harvest when compared to the final stage *i.e.,* nine days after flower opening. Highest organoleptic quality was recorded for the cultivar Selection 13 at all stages.

Shelf-life assessment was done based on the organoleptic quality of the harvested fruits under storage for five storage intervals. Fruits were harvested at five, seven and nine days after flower opening and organoleptic quality was assessed. Based on the scores obtained, five cultivars were

selected for storage studies. They were AE 214, AE 219, AE 260, Selection 13 and Kanjiramkulam Local.

Five cultivars selected were evaluated for changes in fruit weight and nutrient content under five storage periods such as zero, two, four six and eight days of storage under ambient conditions. There was drastic decrease in fruit weight during storage in all the cultivars throughout the storage period. Highest fruit weight was retained for AE 214. Fibre content was observed to be increased during the end storage period in all cultivars. The lowest crude fibre content under storage was observed for Kanjiramkulam Local. Fibre content was less during initial stage of harvest. Both, mucilage and moisture content, was significantly reduced during storage. Highest mucilage retention was shown by Selection 13 and Kanjiramkulam Local. Moisture content was reduced to about one-third of the initial value towards the end of storage. Highest moisture retention was shown by AE 219.

The nutrient contents such as protein, fat, calcium and vitamin C were reduced during storage, of which the most pronounced and drastic reduction was for vitamin C. The cultivar Selection 13 retained highest protein, fat and vitamin C content during storage. The nutrient retention was more in fruits harvested at seven days after flower opening since under this stage the nutrient content was more than the other two stages compared. Calcium content was also seen reduced during storage and the cultivar AE 260 showed highest calcium value towards the end of storage.

The dry matter content was observed to be increased during storage. It was highly dependent on the stage of harvest also. Dry matter content was high during initial stage and then it decreased upto seven days after flowering followed by an increase.

Organoleptic scores showed a decreasing trend under storage indicating a reduction in eating quality of okra fruits during storage under

ambient conditions. The highest organoleptic quality at the end of storage period was obtained for the cultivar Selection 13.

From the above study it can be concluded that okra can be considered as a nutrient rich vegetable which remains good and tender when harvested at seven days after flower opening. The cultivars with better quality and shelf-life were identified as Selection 13 having the highest organoleptic value followed by Kanjiramkulam Local, AE 260, AE 219 and AE 214.

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*Original not seen

Appendices

APPENDIX – I
KERALA AGRICULTURAL UNIVERSITY
Department of Processing Technology, College of Agriculture, Vellayani

Score card for evaluation of cooked okra fruits

Colour			V_1, V_2, V_3 ---- V_{20}
	Colour well preserved	5	
	Fairly preserved	4	
	Moderately preserved	3	
	Slightly preserved	2	
	Highly bleached	1	
Doneness			
	Well cooked	5	
	Fairly cooked	4	
	Just cooked	3	
	Slightly cooked	2	
	Slightly overcooked	1	
Texture			
	Very soft	5	
	Soft	4	
	Fairly soft	3	
	Fibrous	2	
	Very fibrous	1	
Taste			
	Excellent	5	
	Good	4	
	Fair	3	
	Bad	2	
	Very bad	1	
Overall acceptability			
	Excellent	5	
	Good	4	
	Fair	3	
	Bad	2	
	Very bad	1	

POST HARVEST QUALITY EVALUATION OF OKRA [*Abelmoschus esculentus* (L.) Moench]

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ABSTRACT

The study on "Post harvest quality evaluation of okra [*Abelmoschus esculentus* (L.) Moench]" was carried out at the Department of Processing Technology, College of Agriculture, Vellayani, Thiruvananthapuram during 2001-2003.

The objective of the study was to evaluate the nutritional quality and shelf life of selected cultivars of okra and thus to identify suitable varieties with better quality and shelf- life.

Of the twenty cultivars evaluated Pachalloor Local showed the highest fruit weight. The highest moisture and mucilage content was shown by AE214. Pothencode Local exhibited highest dry matter content. The cultivar selection 13 showed the highest protein and vitamin C content. Fat was highest for AE 275 and calcium for Aruna and the red fruited cultivar. Least crude fibre was shown by Kanjiramkulam Local. All the favourable characters were observed at seven days after flowering. Selection 13 recorded the highest organoleptic quality score.

Five cultivars AE 214, AE 219, AE260, selection 13 and Kanjiramkulam Local were selected for shelf- life evaluation based on organoleptic evaluation scores. Changes were observed in all the characters studied under storage for five intervals. Highest fruit weight was shown by AE 214 towards the end of storage. Kanjiramkulam Local exhibited the least crude fibre under storage. Highest mucilage retention was observed in selection 13 and Kanjiramkulam Local. Moisture retention under storage was higher for AE 219. Highest protein, fat and vitamin C retention was observed in selection 13. All the nutrients showed a reducing trend during storage. Towards the end of storage calcium content was highest in AE 260. Highest dry matter content was obtained for AE 214. Highest organoleptic quality scores were recorded for selection 13 towards the end of storage period.