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INFLUENCE OF PADDY HUSK ON THE RIPENING OF FRUIT OF *Zizyphus mauritiana* Lamk

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ABSTRACT

The present investigation was aimed to study the influence of paddy husk on the ripening of detached fruits of *Zizhyphus mauritiana* Lamk. The control fruits were kept in the laboratory (room temperature), while the experimental fruits were treated with paddy husk. The fruits retained their green colour only for two days, on the third day the fruit colour changed to greenish yellow. While on the fourth day the colour become brownish. Hence, the acceptable storage period of *Zizhyphus mauritiana* fruits is only four days and afterwards the fruits became over ripened. All the studies were carried out using the peel and pulp of the fruit tissues individually and the following results were obtained during the process of ripening. The fruit firmness, titratable acidity, chlorophyll content, proteins, starch, ascorbic acid and phenols decreased during ripening both in the treated and control fruits. On the other hand, total soluble solids, pH, carotenoids, anthocyanin and sugar increased.

Keywords: fruit, *zizhyphus mauritiana,* paddy husk, ripening, firmness, TSS, titratable acidity, pH, pigments, protein, starch, sugar.

INTRODUCTION

The jujube belongs to the genus *Zizyphus*, which is in the Rhamnaceae or buckthorn family. The genus includes about 40 species of plant in tropical and subtropical regions of the northern hemisphere (Lyrene, 1979) of which the species *Zizhyphus jujube* Mill and *Zizhyphus mauritiana* LAMK. Are the most important in terms of distribution and economic significance? The former is native to China, where it is known as the Chinese date or Chinese jujube. It is the less tropical of the two species, tolerating temperatures as low as -29°C, and is deciduous. *Zizhyphus mauritiana* is evergreen and is commercially most important in India, where it is known as Indian Jujube or ber. In Tamilnadu it is called Elandhai.

The fruit resembles the common date in shape and colouring. The shiny, parchment- like reddish-brown skin covers a mild, rather sweet, some what pity flesh which is crisp when eaten fresh. The fruit ripens in September and October. The plants begin to bear fruits three years after planting.

The ripening of fruits may be defined as the sequence of changes in colour, flavour and texture which lead to the state at which the fruit is acceptable to eat. This does not necessarily mean that this is a fixed physiological state it can and does vary from one type of fruit to another and in some cases the changes may even run in opposite direction. The readily apparent phenomena associated with the ripening of the majority of fruits include changes in colour, which involve loss of chlorophyll leading to the unmasking of underlying pigments and the synthesis of new pigments, alteration in flavour, which includes changes in acidity, astringency and sweetness themselves dependent on the organic acids, phenolics, sugars and volatiles present in the tissues and changes in texture. Other visible changes include the abscission of the fruit from the vine or tree and in some fruits, increased wax development of the skin, underlying those changes, observed by the sense of colour, taste and texture (Sensory changes) are a series of basic changes in the composition and metabolism of the fruits (Rhodes, 1970).

Physiological and biochemical changes in maturing jujubes have been assessed as indices of the ripeness of the fruit. Such changes include an increase in the total soluble solids, loss of chlorophylls, decrease in titratable acidity accumulation of carotenoids and increase in ascorbic acid content. The jujube fruit will ripen either on the tree or after harvest, providing that picking is done at the proper stage of maturity. Jujube fruits ripened on the tree generally have a short storage and shelf- life, and the best results are obtained if they are picked before the onset of ripening (Al-Niami and Abbas, 1988; Al- Niami *et al*., 1989; Abbas, 1994b).Further more, jujube fruits even when picked at the proper stage of maturity have a short storage life, at room temperature. Experience and research have shown that fruit colour (golden- yellow) percentage, titratable acidity and total soluble solids are the most important maturity indices for jujube fruits grown in the Basrash region, but research in India indicates that the specific gravity of the fruit and fruit colour (golden-yellow) are more suitable maturity indices.

Physico- chemical characteristic features such as fruit firmness, total soluble solids, titratable acidity and pH changes during fruit ripening was studied by several workers in detail (Ulrich , 1970; Martinez *et al*.,1993; Wang *et al*., 1993; Kojima *et al*., 1994; Argenta *et al*., 1995; He wage *et al*., 1995; Firmin, 1997;Robin *et al*., 1997; Wu rihru *et al*.,1997; Kang Inkyu *et al*., 1998; Majumder,1998 and Nerd *et al*., 1998).

The total soluble solids (TSS) content of the fruit is generally low during initial stages of growth, but increases throughout the growth period and reaches a peak value in physiologically mature fruits (Bal and Singh, 1978b; Bal, 1980; Jawanda and bal, 1980; Saggar, 1988; Abbas *et al*., 1994a).

In cherimoya fruit, during ripening, considerable loss in firmness was recorded and the soluble solids

increased progressively from 13.3 to 18.7 Brix and pH of juice decreased strongly on the other hand, titratable acidity increased from 0.06 to 0.36 g of citric acid equivalent in 100g fresh weight (Martinez *et al*., 1993). In apple cultivars of gala, golden delicious and Fuji during ripening the TSS and fruit firmness were determined by Argenta *et al.* (1995).

The colour changes during ripening of fruits result largely from the loss of chlorophyll, the synthesis of carotenoids and the synthesis of pigmental phenolic compounds such as anthocyanins. In any one commodity, the typical colour change in ripening may result from only one or from any combination of these processes (Burton, 1982). The change in colour from green to red is a consequence of chlorophyll degradation and accumulation of large amount of carotenoids within the plastids as the chloroplasts present in the mature-green fruit are transformed in to chromoplasts (Gross and Ohad, 1983a).

The disappearance of chlorophyll a and b during the maturation of pears passé-creassane was found to be a reaction of the first order. In the process, chlorophyll a decreased more rapidly than chlorophyll b (Laval- Martin, 1969). In the flavedo of citrus fruits, Hamlin oranges, Robinson tangerines and marsh grape fruits, the total chlorophyll content decreased and the ratio of chlorophyll a/b decreased as well (Jahn, 1973). The same trend has been observed in pummelo (Gross *et al*., 1983b). On the other hand, in some fruits it has been shown that chlorophyll b is rapidly destroyed (Gross, 1981).

The green colour immature jujube fruit is attributed to the presence of chlorophylls (Bal and Mann, 1978; Bal and Josan, 1980). With incipient ripening yellow pigments (β carotenes) are produced and become more apparent as the chlorophyll content decreases, which gives the fruit its notable golden - yellow colour. In general, the chlorophyll content drops gradually as the fruit develops with a final rapid decline coinciding with ripening (Bal *et al*., 1978; Bal and Singh, 1978a; Saggar, 1988; Abbas *et al*., 1988, 1994a).

The carotenoid pigments are widely distributed among living organisms, both animal and vegetable. As the carotenoids are synthesized only in plants (apart from certain bacteria), their level in vegetable matter are much higher than in animal matter (Isler, 1971). The yellow, orange and red colours of many fruits are due to the presence of carotenoids have been reviewed by Goodwin (1952, 1976), Bauerfeind (1981), Knee (1988) and Minguez-Mosquera (1994). Studies on the carotenoid changes during development and ripening have been comparatively limited. Some workers have dealt solely with the gross change in carotenoid content (Miller *et al.*, 1941). The compositional changes of the individual carotenoids with maturation and ripening have been increasingly explored in recent years. Systematic investigations of pigment changes in ripening fruits have recently been carried out, providing a basis for detailed studies on carotenogenesis as a function of ripening.

Anthocyanins are a very diverse range of pigments localized within the vacuole of plant cell (Timberlake, 1981). The water soluble anthocyanins which are responsible for the various shades of red and blue of many fruits, are one of the major flavonoid classes (Gross, 1987). Anthocyanins are β-glycoside of anthocyanin- pyran derivatives with a C6: C3: C6 carbon skeleton, of which the six commonest are Pelargonidin, Delphinidin, Cyanidin, Petunidin, Paeonidin and Malvidin (Van Buren, 1970).The external expression of anthocyanin pigmentation depends on pH, and it gives red colour in acid medium and blue in neutral and alkaline medium, but it seems unlikely that localized pH is a major factor in determining the colour of anthocyanin containing fruits (Ribereau Gayon, 1982). Anthocyanins are located mainly in the skin of the fruits as in plums, apples, pears, grapes and American cranberries. In other fruits, they are found both in skin and flesh, predominating in the skin as in some sweet cherries, or more evenly distributed as in sour cherries (Hrazdina, 1982). During maturation, the anthocyanins are synthesized at an increasing rate, especially near maturity, reaching a maximum in the fully ripe fruits. As the anthocyanin content increase gradually during maturation, the total anthocyanin content is considered to be an index of maturity, besides being one of the most important quality parameters (Dekazos and Birth, 1970; Kushman and ballingar, 1975; Watada and Abbott, 1975; Drake *et al*., 1982).

The naturally occurring ascorbic acid in fruits is L.ascorbic acid. The main contribution of fruits and its processed products for the nutrition of mankind is undoubtedly their supply of the anti- scorbutic vitamin (L.ascorbic acid-vitamin-c). As the result of stability of ascorbic acid in fruit juices, only small losses are usually encountered during actual processing (Mapson, 1970). Ascorbic acid content of jujube fruits of both species is initially low, and continued to increase till the fruit reached physiological maturity. Afterwards fruit become ripened and the content of the ascorbic acid gradually decreased (Abbas *et al*., 1988, 1994a).

Holden (1976) stated that chlorophyll breakdown in the ripening fruit is clearly linked with the degradation of protein and probably also of lipids. During ripening of apples (Lewis *et al.*, 1970) pears (Hansen, 1967) and cantaloupe (Rowan *et al*., 1969), there was a net increase in protein. In bananas, the protein content increased significantly before the onset of the climacteric but thereafter to the climacteric the protein level remained constant (Sacher, 1967).A decreased in total protein was found in assays of four different batches of Haas and Fuerte avocados (Wong, 1967).In ripening tomato, protein changes ranged from a decreased to an increase and conflicting trend have been reported for tomato (Hobson *et al*., 1971). Certain increases in protein content were found during the climacteric in cantaloupe (Rowan *et al*., 1969) and in Pome (Hulme and Rhodes, 1971) fruits. Proteolytic activity declined during the course of ripening in tomato and papaya (Goldschmidt, 1986). The protein content of the fruit falls during development from an initially high value in the green fruit to a minimum value as the fruit becomes physiologically mature, then rises again to a peak value as the fruit enters the ripening phases and finally decreases toward overripeness. The protein content of ripe

jujube fruit is generally less than 1%, which is well within the range reported for the fresh fruits (Burton, 1982).

As fruit begin to soften, starch deposits are degraded and sugars and flavour components are accumulated (Bathgate *et al*., 1985). Hydrolysis of starch is a major event during ripening of fruits (Loesecke and Von, 1949). In banana, the green and unripe fruit is rich in reserve carbohydrate in the form of starch. During ripening almost entire starch is converted into simple sugars, such as sucrose, fructose and glucose. Only 1-2 percent of starch remains in the ripe fruits (Barnell, 1941; Surendranathan and Nair, 1973; Nakamuru *et al*., 1979 and Terra *et al*., 1983).

The flavour of a fruit is compounded mainly of its content of sugars, of acids and of numerous volatile aroma components, which are present in very small quantities but elicit a considerable olfactory response. Changes of flavour during post harvest ripening typically result from an increase in sugar at the expense of reserve carbohydrate, a decrease in acids, which may be respired and considerable increase in the production of volatile aroma components (Burton, 1982). The metabolism of cellular components important to fruit taste such as sugar, organic acids, polysaccharides, pigments, aromatic compounds change drastically with fruit development. Especially, it is important to improve the quality of fruit and to increase the yield by controlling the sugar metabolism during fruit development (Yamaki, 1995). The content of sugar increased during fruit ripening was studied in detail by a number of workers (Yamaki, 1995; El Bulk *et al*., 1997; Venkitakrishnan *et al*., 1997; Lester, 1998 and Prabha *et al*., 1998). Changes in sugar during development of jujube fruit also vary with the species. In *Z. spina- Christi*, reducing sugars tend to accumulate over most of the growth period of the fruit, but there is a rapid synthesis of sucrose as the fruit enters the ripening phase. With *Z. mauritiana* fruits, however, both reducing sugars and sucrose continue to increase upto the stage of harvest maturity (Bal *et al*., 1979; Jawanda and Bal, 1980; Bal, 1981). Paper chromatographic separation of sugars of *Z. spinachristi,* fruit revealed the presence of glucose, fructose and sucrose with traces of rhamnose. Whereas in *Z. mauritiana* fruit, (Bal *et al*. (1979) found that glucose, fructose were the major sugars in the fruits of *Z. jujuba,* with traces of rhamnose and lactose (Tasmatov, 1963).

Phenols are the by-product of the metabolism of aromatic amino acids (Neish, 1964). Phenolic compounds enjoy a wide distribution in the plant kingdom, and they are particularly prominent in fruits where they are important in determining colour and flavour. Normally phenolic content decreases as the fruit mature (Williams, 1959). The level of phenolics in fruits vary widely from specie to species, variety to variety, season to season and location to location. The great majority of the phenolic components found in fruits have no particular taste characteristic when tasted at low concentration in the pure form. The exception to this general rule is the sourness associated with phenolic acids, the astringency of condensed flovans and the bitterness associated with some of the citrus flavonoids (Van Buren, 1970). Aziz *et al*. (1976) observed a general decline in total phenolic content in the pulp of banana fruit during ripening. The loss of phenol was more rapid in the peel. Similar results have been obtained in the studies of Venkaiah and Babu (1977). Studies of fruit phenolics have shown that in fruits of *Z. jujuba, Z. mauritiana* and *z. spina-christi* the content is high during the early stages of fruit growth, then declines and reached its lowest level in ripe fruits (Kuliev and Akhundov, 1976; Bal and Singh, 1978c; Abbas *et al*., 1994a).

In the present investigation an attempt has been made to study the influence of paddy husk during the ripening of detached fruit of *Zizhyphus mauritiana* LAMK.

MATERIALS AND METHODS

The detached fruit of *Zizyphus mauritiana* Lamk was selected for the present ripening study. It belongs to the family Rhamnaceae and it bears drupe type of fruits. The fruits were picked from the tree at mature full green stage in the home garden of Sendurai, Ariyalure district, Tamilnadu. The unripened mature fruits were kept in laboratory of Botany Department at room temperature of 28 ± 2°C with humidity of 85 percent. All the experiments were conducted with 7 replicates. The control fruits were ripened naturally while the experimental fruits were allowed to ripen in the paddy husk. The peel and pulp of the fruit were used to study the ripening process.

Physical parameters

(a). Fresh weight, dry weight and weight loss

The fruit samples were dried at 90- 100°C for five hours. The moisture content percentage was calculated by detecting dry weight (W2) and wet weight (W1) of the fruit, using the formula,

$$\frac{W_1 - W_2}{W_1} \times 100$$

(b). Fruit firmness

Fruit firmness was determined by using screw gauge, by hand force.

(c). Total soluble solids

Total soluble solids in the fruits were determined by using a refractometer P20 (Model RL2) and their concentration was designated in Brix degree at 33°C.

(d). Total titratable acidity

The juice was obtained from 100g of the fruit. The total titratable acidity was determined by diluting the juice with 25 ml of deionized water and titrating to pH 8.1 with 0.1M sodium hydroxide. Results were expressed in citric acid equivalent 100g of fresh weight.

(e). pH

The range of pH was determined by pH meter. 100g of pericarp tissue was ground with mortar and pestle.

Fruit juice was diluted with 25 ml of deionized water and the pH was estimated.

Bio-chemical studies

Pigment changes

(a). Chlorophyll and carotenoid estimation

Hundred milligram of fruit material was ground in a mortar and pestle with 20 ml of 80 percent acetone. The supernatant was saved. The pellet was re-extracted with 5 ml of 80 percent acetone each time, until it became colourless. All the supernatants were pooled and utilized for chlorophyll determination. The chlorophyll content in the 80 percent acetone extracts was determined by Arnon's method (1949) using the following formulae. Absorbance was read at 645 nm and 663 nm in a Spectronic- 20.

Chlorophyll a (mg / l) = 12.7 A663-2.69 A645
Chlorophyll b (mg / l) = 22.9 A645-4.68 A663
Total Chlorophyll (mg/l) = 20.2 A645+8.02 A663

Carotenoids were estimated by the method of Krik and Allen (1665) using the following formulae

$\Delta A\ 480 + 0.114 \times \Delta A\ 663 - 0.638 \times \Delta A\ 645$

(b). Estimation of total anthocyanins

Anthocyanins were estimated following the method of Fuleki and Francies (1968). Hundred grams of the fruit material was blend with 100 ml of ethanolic HCL in blender at full speed. The extract was transferred to a 500 ml glass stoppered bottle and it was stored overnight in a refrigerator at 4°C. The extract was transferred to 500 ml volumetric flask and was made upto the volume. The extract was prepared for spectrophotometric measurement. 25 ml of extract was filtered through a fine porosity, sintered glass funnel. A small aliquot of the filtrate was diluted with ethanolic HCL to yield optical density (OD) and was stored in the dark for 2 hours and the colour of the extract was read in a Spectronic-20 at 535nm.

Estimation of ascorbic acid

Hundred gram of the fruit sample was ground in a mortar and pestle. The solution was made-up to 100 ml using 0.4% oxalic acid and 10 ml of the juice extract was pipetted out in a conical flask and titrated against the dye (2,6 dichlorophenol indophenol dye) till the solution in the flask attained a pink colour. The titration was repeated for constant value and the amount of ascorbic acid in a 100g of fruit was calculated.

Estimation of protein

Protein content was estimated following the method of Lowry *et al*. (1951).

Extraction procedure

Hundred gram of the fruit material was macerated with a mortar and pestle with 10 ml of 20 per cent Trichloroacetic acid (TCA). The homogenate was centrifuged for 15minutes at 600 rpm. The supernatant was discarded. To the pellet 5 ml of 0.1 N NaOH was added and centrifuged. The supernatant was taken and made upto 5 ml with 0.1 N NaOH. This extract was used for the estimation of total protein. The absorbance was read at 600 nm in a Spectronic -20.

Estimation of starch

Starch was extracted and estimated following the method of Clegg (1956). The residue left behind after the alcoholic xtract of the material was taken for the starch extraction and estimation. Starch was solubilized with 52 per cent perchloric acid for 50 minutes, filtered and was made up to 100 ml in a volumetric flask, with distilled water. One to two ml of perchloric acid extract was diluted with 5 ml of deionised water in a test tube and 10 ml of anthrone reagent was added in cold. The contents were heated for 7.5 minutes at 100°C in a boiling water bath. The test tubes were cooled rapidly and the colour intensity was read at 630 nm in a spectonic-20. Starch content was calculated using a standard graph prepared with glucose.

Estimation of soluble sugars

Soluble sugars, reducing and non- reducing, were estimated following the method of Nelson (1944).

Extraction

Two g of fruit materials was macerated in a mortar and pestle with 80 per cent ethyl alcohol. The homogenate was centrifuged at 800 rpm for 15 minutes. The supernatant was saved and made upto 20 ml with 80 per cent ethyl alcohol. This extract was used to estimate both reducing and non-reducing sugars.

Estimation of reducing sugars

To 1 ml of ethanolic extract, 1 ml of fresh Nelson's reagent (Prepared by mixing copper tartrate solution and copper sulphate solution 25:1 (v/v) was added. The mixture was heated in a boiling water bath for 20 minutes, cooled and 1 ml of Nelson's Arsenomolybdate reagent was added. The solution was diluted to 25 ml with distilled water. The intensity of the resulting blue colour was read at 520 nm in a Spectronic-20. The content of the reducing sugar was calculated from glucose standard graph.

Estimation of non-reducing sugars

Non-reducing sugars were hydrolysed to reducing sugars and total sugar was estimated.

Hydrolysis

One ml ethanolic extract was evaporated to dryness in a boiling water bath. To the residue 1 ml of distilled water and 1 ml of concentrated H2SO4 were added. The mixture was hydrolysed by incubating in an oven at 50°C for 30 minutes. The solution was neutralized with 1N NaOH.

Estimation of total sugar

Total sugars of the hydrolyzed sample was estimated by using Nelson's Arsenomolybdate method. Non-reducing sugars content was calculated by subtracting the value of reducing sugars from the total sugar.

Estimation of total phenols

Total phenols were extracted and estimated following the method of Chandramohan *et al*. (1973) and quantitative estimation was done based on Bray and Thorpe (1954) method. Three gram of fruit material was homogenized in 10 ml of 80 per cent ethanol. The homogenate was filtered through a cheese cloth. The residue was extracted with 80 per cent ethanol and filtrate was made upto 15 ml (1g of material in 5 ml of ethanol). To 1 ml of the ethanolic extract, 1 ml of folin-ciocalteu reagent and 2 ml of 20 per cent sodium carbonate was added. The mixture was boiled in a boiling water bath for 1 minute. Then it was cooled immediately in running water and the volume was raised to 25 ml. The colour intensity was read at 725 nm in a Spectronic-20. The phenolic content was expressed in catechol equivalent. The various results obtained from the experimental study were statistically analysed (mean, standard error and correlation) and are presented in tables.

RESULTS

The present investigation was made to study the influence of paddy husk on the ripening of detached fruits of *Zizyphus mauritiana* Lamk. The control the fruits were kept in the laboratory (room temperature). The experimental fruit were treated in paddy husk. The fruit retained its green colour only for two days, on the third day the fruit showed greenish yellow colour, on the fourth day the colour of the fruit turned brown from greenish yellow. Hence, the acceptable storage period of *Zizyphus mauritiana* fruit is only four days afterwards the fruit became over ripened.

1. Fruit firmness and total soluble solids

The results on the changes in fruit firmness and total soluble solids are presented I Table-1.The total soluble solids gradually increased from mature green to brown ripened stage. The fruit firmness study was made in the peel. The fruit firmness was found to decrease gradually in both control and treated fruits. The total soluble solids content was more in treated than that of the control.

2. Total titratable acidity and pH

The changes in the titratable acidity and pH are presented in Table-2. The changes in titratable acidity gradually decreased from green mature stage to brown ripened stage. On the other hand, the pH gradually increased in peel and pulp of the fruit both in treated and control. The treated fruits showed more pH than control fruits. The titratable acidity of the peel and pulp of the fruits both in treated and control gradually increased. The titratable acidity was more in treated than in control. The statistical analysis of the results of titratable acidity and pH of peel and pulp of both treated and control fruits showed a positive correlation. The correlation coefficient values were 0.9073, 0.9129, 0.9918 and 0.9113. The observed co-efficient values are significant at 1 per cent level.

PIGMENT CHANGES

Chlorophylls

The results on the chlorophyll pigment changes are presented in Table-3. The chlorophyll a, b and total chlorophyll content gradually decreased during the ripening of the fruits. (Peel and pulp) both in treated and control. The peel was found to contain more chlorophyll than pulp. The content of chlorophyll a was more than that of chlorophyll b. The chlorophyll a/ b ratio was high in the green unripen fruit but as the fruit ripened the chlorophyll a/ b ratio decreased. The loss of chlorophyll was rapid in treated fruits than that of control. The chlorophyll content was retained only for four days in the peel of the control fruits. While in the pulp, the chlorophyll content retention was only three days. In treated fruits, the chlorophyll content retention period was three days in peel and two days in pulp.

Carotenoid

The results on the carotenoid content changes are presented in Table-4. The total carotenoid content gradually increased from green mature stage to brown ripened stage of the fruits both in peel and pulp. The peel has more content than pulp. In the treated fruits the content of the carotenoid was more than in the control.

Anthocyanins

The results on the changes in anthocyanin content are presented in Table-5. The total anthocyanin content of the peel and pulp of the fruit was found to increase gradually both in treated and control during the fruit ripening. The total anthocyanin content was more in peel than in pulp. The increase was more in treated over control fruits.

Proteins

The results on the changes in protein content are presented in Table-6. The total protein content of the peel and pulp of the fruit was found to increase gradually both in treated and control during the fruit ripening.

Starch

The results on the changes in starch content are presented in Table-7. The total starch content of the peel and pulp of the fruit was noticed to decrease gradually both in treated and control during the fruit ripening.

Sugars

The results on the changes of reducing sugars, non- reducing sugars ant total sugars are presented in Table-8. The total sugar content of the peel and pulp of both treated and control fruits during ripening were observed to increase gradually from green mature stage to

brown ripened stage. The non-reducing sugar content was more than that of reducing sugars. The sugar content was more in treated than in control in peel and pulp of fruit during the ripening.

Ascorbic acids

The results on the changes in ascorbic acid content are presented in Table-9.The total ascorbic acid content of peel and pulp of the fruit decreased gradually both in treated and control during the fruit ripening.

Phenols

The results on the changes in phenolic content are presented in Table-10. The total phenolic content of peel and pulp of the fruit decreased gradually both in treated and control during the ripening.

The statistical analysis of the results of anthocyanin and total phenol content of peel and pulp both in treated and control fruits showed a negative correlation. The correlation co-efficient values were -0.8572, -0.9812, -0.9926 and -0.9576. The observed co-efficient values are significant at one per cent level.

DISCUSSIONS

In the present investigation an attempt has been made to study the influence of paddy husk on the ripening of fruit of *Zizhyphus mauritiana* Lamk. The peel and pulp of the fruit was used to study the ripening process. *Zizhyphus mauritiana* is a tropical fruit. It is commonly called the Indian ber. It is evergreen and commercially most important fruit in India. The unrinkled fruit, which is slightly more acidic is preferred for preserving in syrup or glaceing and it has some medicinal significance (Kader and Mitcham, 1999). *Zizhyphus mauritiana* is a non-climacteric fruit. The climacteric and non-climacteric fruits considerably differ in their ripening process (Biale and Young, 1981).The control fruits were kept in the laboratory (room temperature). The experimental fruits were treated with paddy husk. The fruit retained its green colour only for two days, on the third day the fruit showed greenish yellow colour, on the fourth day the colour of the fruit turned brownish. Hence, the acceptable storage period of *Zizhyphus mauritiana* fruit is only four days afterwards the fruit became over ripened.

Physiological and biochemical change in maturing jujube have been assessed as indices of the ripeness of the fruit. Such changes include an increase in the total soluble solids, loss of chlorophyll, decrease in titratable acidity accumulation of carotenoids and decrease in ascorbic acid content. The jujube fruits ripened on the tree generally have a short storage and shelf-life, and the best results are obtained if they are picked before the onset of ripening (A1- Niami and Abbas, 1988; A1- Niami *et al*., 1989; A1- Sareh, 1989 and Abbas, 1994b).Further more, jujube fruits even when picked at the proper stage of maturity have a short storage life at room temperature. Experience and research have shown that fruit colour (golden – yellow), percentage of titratable acidity and total soluble solids are the most important maturity indices for jujube fruits grown in the Basrash region , but research in India indicates that the specific gravity of the fruit and fruit colour (golden yellow) are more suitable maturity indices, Physico-chemical characteristic feature such as fruit firmness, total soluble solids, titratable acidity and pH changes during fruit ripening was studied by several workers in detail (Ulrich, 1970; Martinez *et al*., 1993; Wang *et al*., 1993; Argenta *et al*., 1995; Kojma *et al*., 1994; Pal and Sampath kumar, 1995; Ramachandra,1995; Firmin,1997; Robin *et al*., 1997; Wu rihru *et al*., 1997;Majumder,1998; Nerd *et al*., 1998 and Kang Inkyu *et al*., 1998).

In jujube, the total soluble solids (TSS) content of the fruit is generally low during initial stages of growth, but increases through the growth period and reaches a peak value in physiologically mature fruits (Bal and Singh, 1978b; Bal, 1980; Jawanda and Bal, 1980; Saggar, 1988; Abbas *et al*., 1994a).

In cherimoya fruit during ripening, considerable loss in firmness was recorded and the soluble solids increased progressively from 13.3 to 18.7 Brix and the pH of jujube decreased strongly. On the other hand, titratable acidity increased from 0.06 to 0.36g of citric acid equivalent in 100 g fresh weight (Matinez *et al*., 1993).In apple cultivars of Gala golden delicious and fuji during ripening, the TSS and fruit firmness were determined by Argenta *et al*. (1995).

The total soluble solids gradually increased from mature green to brown ripened stage (Table-1).The fruit firmness study was made in the peel and fruit firmness was found to decrease gradually in both control and treated fruits. The total soluble solids content was more in treated than that of the control. The studies on Martinez *et al*. (1993) showed that in cherimaya fruits during ripening there was considerable loss in the fruit firmness while the total soluble solids increased. Similar findings were observed by Abbas (1988) and A1-Niami *et al*. (1989) in *Zizhyphus jujube* without giving any treatments.

The changes of titratable acidity gradually decreased from green mature stage to brown ripened stage (Table-2). On the other hand, the pH gradually increased in peel and pulp of the fruits both in treated and control, the treated fruits showed more pH than control fruits.

The titratable acidity of the peel and pulp of the fruits both in treated and control were gradually increased. The titratable acidity was more in treated than in control were gradually increased. The titratable acidity was more in treated than in control. The correlation analysis showed positive correlation with the correlation, co-efficient values of 0.9073, 0.9129, 0.9918 and 0.9913. It is highly significant at 1 per cent level. Similar trend was studied by Al-Sareh (1989), in *Zizhyphus mauritiana*. The titratable acidity decreased during fruit ripening. In general, the level of organic acids declined during fruit ripening may be probably due to their utilization in the respiratory metabolism (Ulrich, 1970).

The colour changes during ripening of fruits result largely from the loss of chlorophyll, the synthesis of carotenoids and the synthesis of pigmental phenolic compounds such as anthocyanins. In any one commodity, the typical colour change in ripening may result from only

one or from any combination of these processes (Burton, 1982).The change in colour from green to red is a consequence of chlorophyll degradation and accumulation of large amount of carotenoids within the plastids as the chloroplast present in the mature- green fruit are transformed into chromoplast (Gross and Ohad, 1983).

The chlorophyll a, b and total chlorophyll content gradually decreased during the ripening of the fruits. (Peel and pulp) both in treated and control (Table-3). The peel was found to contain more chlorophyll than pulp. The content of chlorophyll a was more than that of chlorophyll b. The chlorophyll a/ b ratio was high in the green unripen fruit but as the fruit ripened the chlorophyll a/ b ratio decreased. A similar decrease in chlorophyll a / b ratio has been observed in pear passecrassane (Laval-Martin, 1969). The loss of chlorophyll was rapid in treated fruits than that of control. The loss of chlorophyll was rapid in treated fruits than that of control. The chlorophyll content was retained only for four days in the peel of the control fruits. While in the pulp, the treated fruits the chlorophyll content retention period was three days in peel and two days in pulp. The disappearance of chlorophyll a and b was found to be a reaction of the first order. In the process chlorophyll a decreased more rapidly than chlorophyll b and there was a decrease in chlorophyll a/ b ratio (Laval-Martin, 1969). On the other hand is some fruits it has been found that chlorophyll b is more rapidly destroyed (Grass, 1981).A similar finding was observed in Zizhyphus mauritiana.

The green colour of immature jujube fruit is attributed to the presence of chlorophylls (Bal *et al.*, 1978; Bal and Josan, 1980). With incipient ripening yellow pigments (β carotenes) are produced and become more apparent as the chlorophyll content decrease, which gives the fruit its notable golden-yellow colour. In general, the chlorophyll content drops gradually as the fruit develops with a final rapid decline coinciding with ripening (Bal et al., 1978; Bal and Singh, 1978a; Saggar, 1988; Abbas *et al*., 1988, 1994a).

The total carotenoid content gradually increased from green mature stage to brown ripened stage of the fruits both in peel and pulp (Table-4). The peel has more content than pulp. In the treated fruits, the content of the carotenoid was more than in the control.

During ripening, Carotenogenic fruits turn gradually yellow, orange or red as chloroplast decomposes and carotenogenesis take over. This change is correlated with conversion of chloroplasts into chromoplasts.

Carotenoid changes during fruits ripening were studied in detail by a number of workers (Fraser *et al*., 1994; Moya *et al*., 1994; Minguez-Mosquera et al., 1994; Zhou Yuchan *et al*., 1994; Huguency *et al*., 1995; Chen hsiu Yu *et al*., 1996; Deli *et al*., 1996; and Deli and Toth, 1997).

In *Capsicum annuum,* the concentration of the principle chlorophyllic and carotenoid pigment during fruit ripening in the Bola and Agridulce varieties were analysed in different stages of ripeness. The chlorophyll disappeared while the caroteniod content increased and this indicated there was a net synthesis of pigments (Minguez-Mosquera *et al*., 1994).

The changes that occur in the anthocyanin level during the ripening of *Zizhyphus mauritiana* fruit influence by paddy husk is shown in Table-5. The anthocyanin content of the peel and pulp of the fruit was found to increase gradually both in treated and control during the fruit ripening. The total anthocyanin content was more in peel than in pulp. The increase was more in treated over control fruits. A few recent reports deal with the systematic investigation of anthocyanins during ripening. The anthocyanin content of fruit pericarp gradually increased from mature intense green stage to intense red ripened stage (Suganthi, 1999). Anthocyanins are located mainly in skin of the fruits as in plums, apples, pears and grapes. In other fruits they are found both in the skin and in the flesh, predominating in the skin as in some sweet – cherries or more evenly distributed as in sour cherries (Hrazdina, 1982). In pomegranate during ripening, six anthocyanin pigments were found to be responsible for the red colour of the fruits (Gil *et al*., 1995).

The total protein content of the peel and pulp of the fruit was found to increase gradually both in treated and control during the fruit ripening (Table-6). A similar decrease in total protein was found in assays from different batches of Hass and Fuerteavocades (Wong, 1967). But a different trend was observed in apples (Lewis *et al*., 1970) and on cantaloupe (Rowan *et al*., 1969) where there was a net increase in protein during ripening. This is a inconsistent with the concept that two pools exist for aminoacids are much less accessible for protein synthesis.

Certain proteins which are synthesized at high rate early in the climacteric, are synthesized at a lower rate as ripening proceeds while for other proteins the reverse is true (Dilley,1970). The increased degradation or decreased protein synthesis or both may be responsible for the decreased protein.

The Table-7 shows the starch during ripening of fruit of *Zizhyphus mauritiana.* The content of starch increased from mature intense green stage to intense red stage. Hydrolysis of starch is major event during ripening of fruits (Loesecker, 1949).As fruit begin to soften, starch deposits are degraded and sugar and flavour components are accumulated (Bathygate *et al.*, 1985). In banana, the green and unripe fruits are rich in reserve carbohydrate in the form of starch. During ripening almost entire starch is converted in simple sugars, such as sucrose, fructose and only 1-2 percent of starch remains in the ripe fruits (Barnell, 1941; Surendranathan and Nair, 1973; Nakamura *et al*., 1979 and Terra *et al*., 1983).

The Table-8 shows that the sugar content of the peel and pulp of both treated and control fruits during ripening were observed to increase gradually for green mature stage to brown ripened stage. The non- reduced sugar content was more than that of reducing sugars. The sugar content was more in treated than in control in peel and pulp of fruit during the ripening. In the soft fruits reducing sugar predominate, while in the grape almost the whole of the sugar content consists of non- reducing sugar,

glucose and fructose (Peynaud and Ribereau- Gayer, 1971).

The content of sugar increased during fruit ripening was studied in detail by a number of workers (Yamaki *et al*., 1995; El Bulk *et al*., 1997; Venkitakrishnan *et al*., 1997; Lester *et al*., 1998 and Prabha *et al*., 1998).Similar observation has been seen in *Capsicum annuum* (Suganthi, 1999).

The Table-9 shows the ascorbic acid content of jujube fruits of both species is initially low and continued to increase till the fruit reached and the content of the ascorbic acid gradually decreased (Abbas *et al*., 1994a,1988).Similar finding was observed in *Zizhyphus mauritiana.*

The Table-10 shows that the phenolic content during ripening of fruit of *Zizhyphus mauritiana.* The total phenolic content of peel and pulp of the fruit gradually decreased both in treated and control during the ripening. The level of phenolics in fruits varies widely from species to species, variety to variety, season to season and location to location. The great majority of the phenolic compounds found in fruits have no particular taste characteristics when tasted at low concentration in the pure form. The exception to this general rule is the sourness associated with phenolic acids, the astringency of condensed flavans and the bitterness associated with some of the citrus flavonoids (Van Buren, 1970).

A statistical analysis of results on total phenol content and total anthocyanin content showed negative correlation and the correlation co-efficient values are highly significant at 1% level.

The phenolic content is responsible for the formation of various coloured pigments (anthocyanins). Though, the phenolic contents showed dedcreasing trend, the fruit showed brown colour due to the conver sion of phenols into quinines.

CONCLUSIONS

The paddy husk has the property of hastening of ripening of the detached fruits of *Zizhyphus mauritiana*.

REFERENCESS

Abbas M.F., Al-Niami J.H. and Saggar R.A.M. 1994a. Some aspects of developmental physiology of jujube fruit (Z.spina-Christi (L) Willd). Dirasat. 21B: 171-181.

Abbas M.F., Al-Niami J.H. and A1-Sareh E.A. 1994b. The effect of ethephon on the ripening of fruits of jujube. J.Hort.Sci. 69: 456-466.

Abbas M.F., Al- Niami J.H. and Al-Ani R.F. 1988. Some physiological characteristic of fruits of fruits of jujube (Z.spina-Christi (L.)Willd) at different stages of maturity.J.Horti.Sci. 63: 337-339.

A1-Niami J.H. and Abbas M.F. 1988. The effect of temperature on certain chemical changes and the storage behavior of jujube fruit Cv.Bambawi. J.Hort.Sci. 63: 723-724.

Al-Niami J.H., Abbas M.F. and Asker M.A. 1989. The effect of temperature on some chemical constituents and storage behaviour of jujube fruit Cv.Zaytoni, Basrah,J.Agri. sci. 2: 31-36.

A1-Sareh E.A. 1989. Studies on the ripening and storage of jujube fruit. M.Sc. thesis, Basrah University, Iraq. p. 135.

Argenta L.C., Bender R.J., Kreus C.L. and Mondarado M. 1995. Maturity patterns and harvesting indices of apple cultivars, gala, Golden delecious and fuji. Padores de maturacase indices de colheita de macas CVS.Gala, Golden delicious pesquisa *Agropecuaria prasileria*. 30(10): 1259- 1266.

Arnon D.I. 1949. Copper enzymes in isolated chloroplast in *Beta vulgaris*. plant Physiol. 24: 1-15.

Aziz A.B.A., Abdul Wahah,F.K. and Elghandour. M.A. 1976.Effect of different storage temperature on phenolic compounds inn banana and mango fruit. Sci.Hort. 4 : 309-315.

Bal J.S. and Mann S.S. 1978. Ascorbic acid content of ber (*Z.mauritiana* Lamk) during growth and maturity. Sci.and Cul. 44: 238-239.

Bal J.S. and Singh P. 1978a. Developmental physiology of ber (*Z.Mauritiana* Lamk) Var.Umaran. I.Physical changes. Ind. Food pack. 32: 59-61.

Bal J.S. and Singh P. 1978b. Developmental physiology of ber (*Z.Mauritiana* Lamk) Var.Umaran.II.Major chemical changes,with reference to total soluble solids, acidity, pH, Sugar and starch. Ind. Food Pack.32: 62-65.

Bal J.S. and Singh P. 1978c. Developmental physiology of ber (*Z.Mauritiana* Lamk) Var.Umaran. III.Minor chemical changes with reference to total phenolics, ascorbic acid (Vitamin C) and Minerals. Ind. Food Pack. 32: 66-69.

Bal J.S., Jawanda J.S. and Singh S.N. 1979. Developmental physiology of ber (*Z.mauritiana* Lamk) Var.Umaran. IV. Changes in amino acids and sugars at different stages of fruit ripening. Ind. Food pack. 33: 33-35.

Bal J.S. 1980. Some aspects of developmental physiology of ber (*Z.mauritiana* Lamk). Pro.Horti. 12: 5-12.

Bal J.S and Josan J.S. 1980 Changes in chlorophyll content of ber during growth and maturation. Sci. and Cul. 46: 238-239.

Bauernfeind J.C. (Ed).1981. Carotenoids as colorants and vitamin A precursors.Academic Press, London and New York.

Barnell H.R. 1941. XIII studies intropical fruits: Carbohydrate metabolism of the banana fruit during storage at 53°F and ripening at 68°F. Annals of Bot. 20: 607- 645.

Burton W.G. (Ed.). 1982. Post-harvest physiology of food crops, Longman press, London and New York.

Bathgate B., Purton M.E., Grierson D. and Goodenough P.W. 1985.Plastid protein changes during the conversion of chloroplasts to chromoplast in ripening tomatoes. Planta. 165:197-204.

Chandramohan D., Purushothama D. and Kothandaram R. 1973. Soil phenols and plant growth inhibition. Plant and Soil. 39: 303-308.

Chen Hsiu Yu, Lu Yu Kuang, Chou Changhong and Yang Chiming. 1996. Analysis of pigment degradation in exocarp of Papaya during late ripening. J. Chin. Agric. Chem. Soc. 34(4): 460-468.

Clegg K.M. 1956. The application of the anthrone reagent to the estimation of starch in cereals. J. Sc. Food. Agric. 7: 40-44.

Dekazos E.D and Birth G.S. 1970. A maturity index for blue berries using light transmittance. J. Am. Soc. Hort. Sci. 95: 610-614.

Deli J., Matus Z. and Toth G. 1996. Carotenoid composition in the fruit of *Capsicum annum* Cv. Szentesi Kossazaru during ripening. Agri. Food. Chem. 44(3): 711-716.

Deli J. and Toth G. 1997. Carotenoid composition of the fruits of *Capsicum annum* Cv. Bovet 4 during ripening. Department of medical chemistry, University Medical School of Pecs. 205(5): 388-391.

Drake S.R., Proebsting E.L. and Spayed S.E. 1982. Maturity index for the colour grade of canned dark sweet cherriest. J. Am. Soc. Hort. Sci. 107: 180-183.

El-Bulk R.E., Babiker E.F.E., El-Tinay A.H. 1997. Changes in chemical composition of guvava fruits during development and ripening. Food Chem. 59(3): 395-399.

Firmin A. 1997. Physico- chemical changes in papaya during storage. Tropical Science. 37(1): 49-51.

Fraser P.D., Truesdale M.R., Bird C.R., Schuch W., Bramley P.M. 1994. Carotenoid biosynthesis during tomato fruit development. Evidence for tissue-specific gene expression. Plant Physiol. 105(1): 405-413.

Fuleki T. and Francies F.J. 1968. Quantitive methods for anthocyanins. Purification and determination of cranberry anthocyanins . J. Sci. Food. Agri. 68(1): 77-81.

Gil M.I.,Garic-Viguera C., Artes F., Tomas-Barberan F.A. 1995. Changes in pomegranate juice pigmentation during ripening. J. Sci. Food. Agri. 68(1): 77-81.

Goodwin T.W. (Ed.).1952.The comparative bio-chemistry of the carotenoids. Chapman and Hall, London.

Goodwin T.W. (Ed.). 1976. Chemistry and bio-chemistry of plant pigments, Vol.1, 2nd edn, Academic Press, London and New York.

Goldschmidt E.E. 1986. Maturation, ripening, senescence and their control: A comparison between fruits and leaves. In: S.P. Monselise (Ed.), Hand book of fruit set and development. CRC Press, Boca Raton, Florida, USA. pp. 483- 491.

Gross J. 1981. Pigment changes in the flavedo and dancy tangerine (*Citrus reticulate*) during ripening. *Z. pflanzenphysiol*.103: 451-457.

Gross J. and Ohad I. 1983. In vitro fluorescence spectroscopy of chlorophyll in various unripe and ripe fruit. Photochem. Photobiol. 37: 195- 200.

Gross j., Timberg R. and Graef M. 1983 a. Pigment and ultra structural changes in the developing pummelo (*citrus grandis*) Glocath. Bot. Gza.144: 401-406.

Habson G.E. and Davies J.N. 1971. The tomato, In : A.C Hulme (Ed.).The Biochemistry of fruit and their products, Vol.2. Academic Press. London and New York. pp. 33-373.

Hansen E. 1967. Ethylene-stimulated metabolism of immature "Bontleit pears. Proc.Am.Soc.Hort.Sci. 91: 863-867.

Hewage K.S., Wainwright H. and Luo. Y. 1995.Effect of ethanol and acetaldehyde on banana ripening. J. Hort. Sci. 70(1): 51-55.

Holden M. 1976. Chlorophyll In: T.W.Goodwind (Ed.) Chemistry and Biochemistry of plant pigments Vol.1: 1 edn, Academic Press, London and New York. pp. 1-37.

Hrazdina G. 1982. Anthocyanins.In: J.B. Harbone and T.J.Marbry (Eds.). The flavonoids: advance in Research. Chapman and Hall, London. pp. 135-188.

Hulme A.C. and Rhodes M.J.C. 1971. Pome fruits In: A.C. Hulme. (Ed.). The biochemistry of fruit and their product, Vol.2, Academic Press. London and New York. pp. 33-373.

Islern O. (Ed.). 1971. Carotenoids; Birkhauser Verlag; Basel. p. 30.

Jahn O.L. 1973. Degreening citrus fruit with post- harvest applications of 2-chloroethyl phosphoric acid (ethyphon).

Jawanda J.S. and BAL J.S. 1980. A comparative study on growth and development of 26-2 and kaithili cultivars of ber. Punjab Hort. Journal. 20: 41-46.

Kader and Mitcham Spring. 1999. Chinese jujube (Chinese Date) *Zizyphus jujube* Indian jujube (Ber). *Zizyphus Mauritiana*. Pomology, 212, Lecture, ≠19.11.

Kang Inkyu, Chang Kyunghe, Byun Jackyun.1998. Chenges in activities of cell wall hydrolases during ripening and softening in persimmon fruits. Journal of the Korean society for Horticultural science. 39(1): 46-50.

Kojima K., Sakurai N., Kuraish S., Kokubo A. 1994. Changes in firmness and chemical constituents of banana fruits during ripening. Jap. J. Trop. Agri. 38(4): 293-297.

Knee M. 1988. Carotenol esters in developing apple fruits. Phytochem. 27: 1005-1009.

Kuliev A.A. and Akhundov R.M. 1976. Chenges in ascorbic acid and catechin contents of Z.jujube Mill fruits during ripening. Horticultural Abstracts. 47: 4141.

Kushman L.J and ballingar W.D. 1975. Relation of quality indices of individual blue berries to photoelectric measurment of anthocyanin content. J. Am. Soc. Hort. Sci. 100: 561- 564.

Krik and Allen. 1665. In chlorophylls (Ed.) J.W.Goodwin in chemistry and biochemistry of plant pigments, Academic press, London and New York.

Laval-Martin D. 1969. Variation de la teneus en chlorophylles an cours de la maturation on fonctive de la temperature chez la pears passé- crassana physiol Veg. 7: 251-259.

Lester G. 1998. Physico-chemical chericterization of hybrids honey dew muskmelon fruit (Cucumis *melo* L. *var indorus* Naud) following maturation, abscission and post harvest storage. J. Am. Soc. Hort. Sci. 23(1): 126-129.

Lewis L.N. and Varner J.E. 1970. Synthesis of cellulase during abscission of *phaseolus vulgaris* leaf explants. Plant Physiol. 46: 194-199.

Loesecke H.W. and Von. 1949. Bananas. Interscience, Publishers, New York. p. 189.

Lowry O.H., Rosanbrouh N.J., Farr.A.L. and Randall R.1951.

Lyrene P.M. 1979. The jujube tree (*Z. jujube* Mill). Fruit variety journal. 33: 100-104.

Majumder K.1998. Changing pattern of pectic substances in developing fruits of *Psidium guajava* L. Ind. J. Plant Physiol. 3(1): 42-45.

Mapson L.W. 1970. Vitamins in fruits. In: A.C. Hulme (Ed.) Bio-chemistry of fruits and their products. Vol.I, Academic Press, New York, London. pp.369-383.

Martinez G., Serrano M.N., Pretel M.T., Riquelem F. and F.Romojaro. 1993. Ethylene biosynthsis and physico-chemical changes during fruit ripening of cherimoya (Annona cherimola).J.Hort.Sci. 68(4): 477-483.

Martinez G., Serrano M., Pretel M.T., Riquelem F. and F.Romojaro. 1993. Ethylene biosynthesis and physico-chemical changes during fruit ripening of cherimoya (*Annona cherimola*). J.Hort. Sci. 68(4): 477-483.

Miller E.V., Winston J.R. and Schomer H.A. 1941. Physiological studies of plastids pigments in rinds of maturing oranges. J. Agric. Res. 60: 259-267.

Minguez- Mosquera, M.I. and Demaso Hornero- Mendez. 1994. Formation and transformation of pigments during the fruit ripening of *Capsicum annuum* cv. Bola and Agridulce. J. Agri. Food. Chem. 42(1): 38-44.

Moya S.Y., Mejia L.A., Gonzalez de Mejia E. and Vazquez F.A. 1994. Effect of ripening and drying on provitamin carotenoids in pepper (*Capsicum annum* Var. Anaheim). Efcto de la Maduration Yel Secado en el contenido de carotenoids pro-vitamin A en chile (Capsicum *annum* Var. Anakeim). Arch. Lat. Am. Nut. 44: 41-46.

Nakamuru R., Ito T. and Inaba A. 1979. Effect of accelerated (or) delayed ripening on the hardness, sugar content and acidity of bananas. Scientific report of the Faculty of Agric, Okarjama University. 54: 15-25.

Neish A.C. 1964. Major pathways of biosynthesis of phenols. In: J.B. Harborne (ed.), Biochemistry of phenolic compounds. Academic Press, London. 295-359.

Nelson N. 1944. A photometric adaptation of the somogyi method for the determination of glucose. J. Biol. Chem. 153: 375- 380.

Nerd A., Mizrahi Y. 1998. Fruit development and ripening in yellow pitaya. J. Am. Soc. Hort. Sci. 23(4): 560-562.

Pal D.K. and Sampath kumar P. 1995. Changes in the physico- chemical and biochemical composition of custard apple (Annona squamosa L.) fruit during growth, development and ripening. J. Hort. Sci. 70(4): 569-572.

Peynaud E. and Ribereau-Gayon P. 1971. The grape. In: A.C. Hulme (Ed.), The Biochemistry of fruit and their products. Vol. 2. Academic Press. London. pp. 171-205.

Prabha T.N. and Bhagyalakshmi N. 1998. Carbohydrate metabolism in ripening banana fruit. Phytochem. 48(6): 915- 919.

Ram chandra.1995. Biochemical changes during maturity and storage in guava fruits. Ind . J. Hill. Farm. 8(1): 16-21.

Ribereau-Gayon P. 1982. The anthocyanin of grapes and wines. In: P. Markakis (Ed.), Anthocyanins as food colour, Acedemic Press London and New York. pp. 209- 244.

Rhodes M.J.C. 1970. The climacteric and ripening of fruits In: A.C. Hulme (Ed.).The Biochemistry of fruits and their products. Vol. 1, Academic Press. London and New York. pp. 521-532.

Robin J.P., Abbai. P. and Salmon J.M. 1997. Firmness and grape berry maturation. Definition and development of different rheological parameters during ripening. International des science de la vigne et due vin. 31(3): 127-138.

Rowan K.S., Mc Glasson W.B. and Pratt H.K. 1969. Changes in adenosine pyrophosphate in cantaloupe fruit ripening normally and after treatment with ethylene. J. Exp. Bot. 20: 145- 155.

Sacher J.A. 1967. Studies of permeability RNA and protein turnover during aging of fruits and leaf tissues. In: H.W. Woolhouse (Ed.).Aspects of biology of Ageing, Soc. Exp. Biol. Symp. Cambridge University Press. pp. 269-274.

Suganthi. 1999. Biochemical changes associated with the fruit ripening of *Capsicum annum* L.var.K1-A (Samba type), M. Phil. Dissertation. Annamalai University.

Saggar R.A.M. 1988. Some aspects of developmental physiology of jujube fruit. M. Sc. Thesis. Basrah University, Iraq. p. 106.

Surendranathan K.K. and Nair P.M. 1973. Alternation in carbohydrate metabolism of irradiated Cavendish banana phytochem. 12: 241- 249.

Tasmatov L.T. 1963. *Zizyphus jujube*-in industry. Sadovadstvo. 6: 30-31.

Terra N.N., Garcia E. and Lajota F.M. 1983. Starch sugar transfermation during banana ripening. The behaviour of UDP glucose pyrophophorylase sucrose synthetase and invertase. J. Food. Sci. 48: 1097-1100.

Timberlake C.F. 1981. Anthocyanins in fruits and vegetables. In: J. Friend and M.J.C. Rhodes, (Ed.) recent advances in the biochemistry of fruits and vegetables, Academic Press. pp. 221-247.

Ulrich R. 1970. Organic acids, In: A.C. Hulme (Ed.,) The Biochemistry of fruits and their products, Vol.1. Academic Press London and New York. pp. 89-115.

Venkaiah B. and Babu C.K. 1977. Polyphends in the aqueous acetone extracts of the peel of ripening fruit. Plant Biochem. 4: 39-42.

Venkitakrishnan M., Panjatcharam V., Kumaravelu G., Ramanujam M.P. 1997. Physico-chemical changes during maturation and ripening of jambolan fruit. Ind. J. Plant Physiol. 2(4): 267- 270.

Vanburen J. 1970. Fruit phenolics. In: A.C. Humle (Ed.). The Biochemistry of fruit and their products, Academic Press, London and New York. pp. 269-300.

Wang T., Gonzalez A.R., Gbur E.E. and Aselage J.M. 1993. Organic acid changes during ripening of processing peaches. J. Food. Sci. 40: 1278- 1279.

Watada A.E. and Abbott J.A. 1975. Objective methods of estimating anthocyanidin content for determining colour grade of grapes. J. Food. Sci. 40: 1278-1279.

Williams D.H. 1959. Beriont der Wirsenschaftech technician kamission der internationalen frucht sof. Urinos. 259-263 (Symposium fruchtsaft fruchtsafkongentrate Bristol).

Wong B. 1967. The relationship between permeability characteristics active uptake, incorporate of aminoacids, the amount of protein and RNA in senescing avocado fruit tissue. MA Thesis. Calif State Univ., Los Angeles. p. 50.

Wu Yihru, Kuo Yinkang, Yang Yaushiang. 1997. The relationship between pectin, calcium and fruit softening in honey red grapevines. In: Proceeding of symposium on enhancing competitiveness of fruit industry, Taichung, Taiwan.

Yamaki S. 1995. Physiology and Metabolism of fruit development biochemistry of sugar metabolism and comparatmentation in fruits. Acta Hort. 398: 109-120.

Zhou Yuchan, Tang Youlin, Tan xinjie. 1994. Changes of major carotenoid contents during ripening of mango fruit (Mangifera indica L. cv. Zihua). J. Trop. Sub-Trop. Bot. 2(2): 77-79.

Table-1. Influence of paddy husk on changes in fruit firmness and total soluble solid during fruit ripening of *Zizyphus mauritiana* Lamk.

Days	**Fruit firmness** (kg cm^2)				**Total soluble solids** (% Brix)			
	Control		**Treated**		**Control**		**Treated**	
	Peel	**Pulp**	**Peel**	**Pulp**	**Peel**	**Pulp**	**Peel**	**Pulp**
	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE
1	12.5 ± .62	--	10.2 ± .61	--	16 ± 0.64	21.0 ± .26	16 ± 0.8	21.0 ±0.84
2	10.0 ±0.40	--	7.4 ±0.37	--	16.9 ±0.84	22.0±1.54	17.0 ±1.02	22.6 ±1.35
3	8.8 ± 0.61	--	4.3 ± 0.25	--	17.2 ± .20	22.2±0.88	17.9 ±1.25	22.8 ±1.14
4	5.2 ± 0.31	--	3.5 ± 0.24	--	17.6 ± .05	22.8±1.14	18.6 ±0.74	23.2 ±1.39

Values are mean ± SE of 7 samples expressed in $Kgcm^2$ and percentage of Brix.

Table-2. Influence of paddy husk on changes in pH and titratable acidity during fruit ripening of *Zizyphus mauritiana* Lamk.

Days	**pH**				**Titratable acidity + Citric acid equivalent $100g^{-1}$**			
	Control		**Treated**		**Control**		**Treated**	
	Peel	**Pulp**	**Peel**	**Pulp**	**Peel**	**Pulp**	**Peel**	**Pulp**
	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE
1	4.5 ± 0.22	4.5 ± 0.18	4.4 ± 0.26	4.5 ± 0.27	15 ± 0.00	23±0.00	15 ±0.00	23 ±0.01
2	4.5 ± 0.18	4.5 ± 0.27	4.5 ±0.31	4.6 ± 0.32	17 ±0.01	24±0.01	18 ± 0.01	24 ±0.01
3	4.6 ± 0.27	4.6 ± 0.23	4.6 ± 0.18	4.6 ± 0.18	20 ± 0.00	25±0.01	20 ± 0.00	26 ±0.01
4	4.6 ± 0.32	4.8 ± 0.33	4.7 ± 0.23	4.9 ± 0.24	23 ± 0.01	26±0.01	24 ± 0.01	28 ±0.01

Values are mean ± SE of 7 samples expressed in percentage of basis.

Table-3. Influence of paddy husk on changes in chlorophyll a, b, total chlorophyll and a/b ratio content during fruit ripening of *Zizyphus mauritiana* Lamk.

Days	**Control**								**Treated**							
	Peel				**Pulp**				**Peel**				**Pulp**			
	Chl a	**Chl b**	**Total Chl.**	**a/b ratio**	**Chl a**	**Chl b**	**Total Chl.**	**a/b ratio**	**Chl a**	**Chl b**	**Total Chl.**	**a/b ratio**	**Chl a**	**Chl b**	**Total Chl.**	**a/b ratio**
	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE
1	0.086 ±0.00	0.074 ±0.00	0.160 ±0.00	0.162 ±0.05	0.042 ±0.00	0.030 ±0.00	0.072 ±0.00	1.4 ±0.07	0.085 ±0.00	0.156 ±0.01	1.197 ±0.04	0.032 ±0.00	0.032 ±0.00	0.028 ±0.00	0.060 ±0.00	1.142 ±0.00
2	0.074 ±0.00	0.059 ±0.00	0.133 ±0.00	1.254 ±0.08	0.031 ±0.00	0.010 ±0.00	0.042 ±0.00	3.1 ±0.21	0.042 ±0.00	0.104 ±0.00	1.476 ±0.07	0.018 ±0.00	0.018 ±0.00	0.005 ±0.00	0.023 ±0.00	3.6 ±0.25
3	0.046 ±0.00	0.024 ±0.00	0.070 ±0.00	1.916 ±0.11	0.011 ±0.00	0.007 ±0.00	0.018 ±0.00	1.5 ±0.09	0.008 ±0.00	0.28 ±0.00	2.5 ±0.00					
4	0.024 ±0.00	0.020 ±0.00	0.044 ±0.00	1.200 ±0.04												

Values are mean ± SE of 7 samples expressed in mg/ g fresh weight.

Table-4. Influence of paddy husk on changes in carotenoid content during fruit ripening of *Zizyphus mauritiana* Lamk.

Days	Control		Treated	
	Peel	Pulp	Peel	Pulp
	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE
1	74.958 ± 3.74	50.613 ± 2.02	82.12 ± 5.74	70.57 ± 3.52
2	124.773 ± 4.99	100.198 ± 6.01	134.18 ± 6.70	120.56 ± 7.23
3	132.72 ± 7.96	108.12 ± 7.56	142.82 ± 8.52	140.00 ± 9.8
4	152.28 ± 10.65	128.18 ± 6.40	164.00 ± 6.56	150.68 ± 6.02

Values are mean ± SE of 7 samples expressed in mg/ g fresh weight.

Table-5. Influence of paddy husk on changes in anthocyanin content during fruit ripening of *Zizyphus mauritiana* Lamk.

Days	Control		Treated	
	Peel	Pulp	Peel	Pulp
	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE
1	460 ± 18.4	282 ± 14.1	641 ±32.05	312 ± 12.4
2	480 ± 24	312 ± 18.7	672 ± 40.32	352 ± 17.6
3	522 ± 31.3	352 ± 24.6	728 ± 29.12	378 ± 22.6
4	682 ± 47.7	360 ± 14.4	752 ± 52.64	390 ± 27.3

Values are mean ± SE of 7 samples expressed in µg/ g fresh weight.

Table-6. Influence of paddy husk on changes in protein content during fruit ripening of *Zizyphus mauritiana* Lamk.

Days	Control		Treated	
	Peel	Pulp	Peel	Pulp
	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE
1	114.4 ± 5.57	305.2 ± 12.20	96.6 ± 5.79	254.38 ± 12.71
2	96.56 ± 5.79	285.5 ± 17.13	72.68 ± 5.08	223.18 ± 13.39
3	52.77 ± 3.69	160.81 ± 11.25	58.54 ± 2.34	182.09 ±12.74
4	48.81 ± 1.95	133.09 ± 6.65	42.79 ± 2.13	120.23 ± 4.80

Values are mean ± SE of 7 samples expressed in mg/ g fresh weight.

Table-7. Influence of paddy husk on changes in Starch content during fruit ripening of *Zizyphus mauritiana* Lamk.

Days	Control		Treated	
	Peel	Pulp	Peel	Pulp
	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE
1	261 ± 0.10	3.20 ± 0.22	1.68 ± 0.06	1.68 ± 0.08
2	1.71 ± 0.08	2.60 ± 0.15	0.82 ± 0.04	0.72 ± 0.04
3	1.20 ± 0.07	1.70 ± 0.08	0.62 ± 0.03	0.42 ±0.02
4	0.78 ± 0.05	0.18 ± 0.00	0.32 ± 0.02	0.13 ± 0.00

Values are mean ± SE of 7 samples expressed in mg glucose equivalent / g fresh weight.

Table-8. Influence of paddy husk on changes in reducing sugar, non- reducing sugar and total sugar content during fruit ripening of *Zizyphus mauritiana* Lamk.

Days	Control						Treated					
	Peel			Pulp			Peel			Pulp		
	R.S	N.R.S	Total sugar	R.S	N.R.S	Total sugar	R.S	N.R.S	Total sugar	R.S	N.R.S	Total sugar
	Mean ±SE	Mean ±SE	Mean ±SE	Mean ±SE	Mean ±SE	Mean ±SE	Mean ±SE	Mean ±SE	Mean ±SE	Mean ±SE	Mean ±SE	Mean ±SE
1	0.34 ±0.01	1.58 ± 0.07	1.92 ±0.07	0.33 ±0.01	2.87 ±0.14	3.20 ±0.22	0.06 ±0.00	2.12 ±0.00	2.18 ±0.10	0.63 ±0.03	3.56 ±0.17	4.19 ±0.16
2	0.41 ±0.02	1.78 ±0.12	2.19 ±1.15	0.44 ±0.02	2.98 ±0.11	3.42 ±0.20	0.06 ±0.00	2.18 ±0.10	2.24 ±0.15	0.66 ±0.03	3.62 ±0.14	4.28 ±0.29
3	0.47 ±0.03	1.92 ±0.11	2.39 ±0.11	0.60 ±0.03	3.12 ±0.18	3.72 ±0.18	0.34 ±0.01	2.28 ±0.09	2.62 ±0.15	0.97 ±0.06	3.71 ±0.25	4.68 ±0.28
4	0.51 ±0.04	1.91 ±0.07	2.42 ±0.14	0.66 ±0.04	3.24 ±0.12	3.90 ±0.15	0.40 ±0.02	2.42 ±0.16	2.82 ±0.11	1.07 ± 0.04	3.91 ±0.23	4.98 ±0.24

R.S-Reducing sugar; N.R.S-Non Reducing sugar
Values are mean ± SE of 7 samples expressed in mg glucose equivalent / g fresh weight.

Table-9. Influence of paddy husk on changes in ascorbicacid content during fruit ripening of *Zizyphus mauritiana* Lamk.

Days	Control		Treated	
	Peel	Pulp	Peel	Pulp
	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE
1	4.68 ± 0.18	5.60 ± 0.30	4.32 ± 0.17	5.03 ± 0.25
2	3.72 ± 0.18	4.82 ± 0.28	3.52 ± 0.17	4.92 ± 0.029
3	2.92 ± 0.17	3.93 ± 0.19	2.62 ± 0.15	3.48 ±0.24
4	1.82 ± 0.12	1.42 ± 0.05	1.72 ± 0.12	1.28 ± 0.06

Values are mean ± SE of 7 samples expressed in mg ascorbic acid $100g^{-1}$ of fruit

Table-10. Influence of paddy husk on changes in phenolic content during fruit ripening of *Zizyphus mauritiana* Lamk.

Days	Control		Treated	
	Peel	Pulp	Peel	Pulp
	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE
1	3.14 ± 0.15	2.68 ± 0.10	2.98 ± 0.20	2.58 ± 0.15
2	2.88 ± 0.20	2.18 ± 0.10	2.19 ± 0.13	2.08 ± 0.12
3	1.52 ± 0.09	1.48 ± 0.08	1.32 ± 0.06	1.26 ±0.05
4	1.12 ± 0.04	0.98 ± 0.06	0.99 ± 0.03	0.62 ± 0.03

Values are mean ± SE of 7 samples expressed in mg/ g fresh weight of catechol.