International Journal of ChemTech Research
CODEN (USA): IJCRGG ISSN: 0974-4290
Vol.9, No.3 pp 118-126, 2016

Regulation of the banana fruits ripening by using different treated food paper packaging

Abd El-Naby S.K. M.[1]*, El-Sonbaty M.R.[1], Maha Ibrahim M. [2], Mona Nassar A. [3]

[1]Horticultural Crops Technology Department, National Research Center, 33 El-Bohouth St., Dokki, P.O. 12622, Giza, Egypt
[2]Cellulose and Paper Department, National Research Center, 33 El-Bohouth St., Dokki, P.O. 12622, Giza, Egypt
[3]Packaging and Packing Department, National Research Center, 33 El-Bohouth St., Dokki, P.O. 12622, Giza, Egypt.

Abstract: The objective of the present work was to study how we can control the regulation of the banana fruits ripening when using polyurethane foam as coating mixture for food packaging paper material. For this purpose, a surface treatment to the food packaged paper (TFP) was carried out by coating with polyurethane (PU) and tannic acid (T) to be compared with the untreated food packaged paper (UTFP). When Maghrabi banana fruits were at their mature stage, they were treated with either scratch or ethrel followed by packaging with UTFP and TFP to delay and/or manage ripening to reach of the commercial and economic value as well as providing a delicious fruits for consumers. All treated fruits were divided into two groups; the first group was held at room temperature, while the second group was stored at 15 ± 1 °C. Sampling on the periodical time was carried for good quality and respiration rate till ripening stage. The results showed that banana fruits at their mature stage could be treated with ethrel when packed with TFP coated with both PU and T under room temperature condition, whereas under storage at 15 ± 1 °C, and scratch method can be used with the same coated paper for packaging where it achieves good quality for banana fruits.
Keywords: Banana fruits ripening, Food packaging paper, Ethrel, Scrape, Polyurethane foam, Tannic acid.

Introduction

The natural ripening of banana fruits, i.e. pulp softening, starch/sugar conversion and pigment changes, is co-ordinated by the increased of production of ethylene by the fruit pulp[1,2,3]. Bananas are typical climacteric fruits which are ripen in the presence of the increased respiration and ethylene production[4]. The main problem associated with banana fruit was the tendency to deteriorate quickly through physiological changes leading to ripening. The development of the techniques to delay and/or manage ripening would enhance the commercial and economic value to provide a delicious product for consumers. These techniques include ethylene addition and/or removed and inhibition of ethylene action through chemical or physical means and it is not limited on cold storage.

Essential oils are typically volatile substances produced by many plant species, however, when it was absorbed into packaging paper it was used to protect fruits from water loss and pathogens[5]. Some studies were carried out to control the initiation of ripening process in fruits harvested such as, externally applied volatiles like ethanol and acetaldehyde in banana [6,7,8]. and in date [9].

A wide range of papers and paperboards are commercially available to meet market needs. The surface finish, i.e. appearance, can be varied mechanically. Additives introduced at the stock-preparation stage provide special properties. Coatings are applied to either one or both surfaces, smoothed and dried, which offer a variety of appearance and performance features which are enhanced by subsequent printing and conversion resulting in various types of packaging material[10].

The main materials, or substrates, used in flexible packaging until the middle of the twentieth century are comprised paper, aluminium foil and regenerated cellulose film (RCF). Paraffin wax-coated paper was widely used as a barrier to moisture, moisture vapour and volatiles, which has product-release properties. Food products affected by moisture will gain or lose moisture until it becomes equal to the relative humidity (RH) of the atmosphere to which they are exposed. In the case of a packed product, this environment will be existing within the sealed package [10].

Coating is the simplest method of adding other functions to paper. The active functional material is either applied from a solvent solution, water-based dispersion or as a solid, in the molten state. Solvent-based coatings are applied to paper by gravure which mainly comprise varnishes which impart heat resistance so that the surface does not pick under heat-sealing bars. Wax is the oldest paper-based functional coating material, where originally paraffin wax was used. From the 1950s, the main wax component has been microcrystalline wax to which polymers such as polyethylene (PE) and ethylene vinyl acetate (EVA) have been added by blending to improve the barrier in folded areas and also the hot tack in heat sealing[10].

Moreover, organic acids, such as tannic acid (T), have been extensively used on foods for years and are classified as generally regarded as safe (GRAS). Also[11] found that banana fruits immersed in T at 0.25-0.5% and stored in tightly closed plastic containers; showed a longer storage period.

On the other hand, coating the fruits and vegetables are to prolong shelf life by reducing moisture loss, restricting oxygen exchange, lowering respiration and transpiration, retarding ethylene production, and sealing in flavor volatiles [12]. Furthermore, it creates modified atmosphere and reduces weight loss during transportation and storage by controlling the permeability and gaseous exchange [13]. One advantage for the use of coating of fruits like banana is that the skin is not normally consumed. These materials play an integrated role in many of the biochemical changes that occur during the ripening such as moisture, ash [14], sugar [15], color, and texture [16]. Therefore, the objective of this study was to determine the effect of coated papers, by PU with and without T and nano-sliver nitrate ($AgNO_3$), as a coating mixture, on the ripening rate and eating quality of Maghrabi banana.

Materials and Methods

1. Plant material

Mature bunches are judged using a combination of banana with age of 14 weeks after shooting and grade of three quarters were picked from well grown and uniform plants of *Musa sp.* AAA type Cv., namely Maghrabi, which are grown in a private orchard in Giza, Governorate, Egypt. Bunches were left and stored after harvesting in ripening hall at 22 ± 2 °C in the Agriculture Development System Project laboratory (A.D.S.) for one day as a wilting period. Bunches were de-handed then the third, fourth, fifth, sixth and seventh hands were cut from the top into individual fingers to avoid differences in physiological development. Fingers were washed, drained and divided into two groups, in which the first group was subjected to be scratched (scrape) to the neck with stabile deep and area, while the second group was exposed to submerged treatment at 1000 ppm ethrel (2-dichlorophosphonic acid) for 3 minutes. Every one of the two groups was then randomized and covered with UTFP and TFP coated with different natural materials that can regulate ethylene production. The packaged groups were labeled in numbers from 1 to 7 as following: (1) for UTFP; (2) for TFP coated on one face with PU mixture dissolved in tetrahydrofurane; (3) for TFP coated with T; (4) for TFP coated with $AgNO_3$; (5) for TFP coated with mixture of PU and T dissolved in tetrahydrofurane; (6) for TFP coated with mixture of PU and $AgNO_3$ dissolved in tetrahydrofurane; and (7) for TFP coated PU mixture dissolved in benzene.

Treatments were replicated three times and each replicate consisted of twenty banana fingers. Fruits of all treatments were placed in two standard carton boxes (45-35-10 cm) and stored at two different conditions, one at room temperature and the other at room with temperature of 15 ± 1 °C and relative humidity of 85-90% until they reached a suitable degree of ripening between 5 to 7 degrees according to 17. The characteristics indexes of the Maghrabi banana fingers, at maturity, were: color degree (1), peeling condition (1), firmness "lb/inch^2" (17.33), soluble solids content (SSC%) 1.73, titratable acidity (TA%) 0.529 and SSC/TA ratio was 3.29.

2. Ripening properties

Weight loss: It was calculated by periodical weighing compared to the beginning weight. **Peel color**: It was recorded using the standard color scale of [17] and examined as 1: for green, 2: for green with trace of yellow, 3: for more green than yellow, 4: for more yellow than green, 5: for green tip, 6: for all yellow and 7: for yellow flecked with light brown. **Peeling condition**: It was scored as follows: 1: for unpeeling, 2: for hard peeling, 3: for peeling and 4: for easy peeling. **Firmness:** It was measured on unpeeled fingers using hand pressure tester with 5/16 plungers and was recorded in Lb/inch^2. **Soluble Solid Content (SSC)**: It was measured in the juice by using a zeiss hand refractometer [Atago PR-32 (Paletto Co., CTD) Japan, serial No.9948134]. **Titratable Acidity (TA):** It was measure in the juice and was calculated as a percentage of malic acid fresh weighted according to the [18]. **SSC/TA Ratio:** It was calculated from the obtained data. **Respiration rate (Carbon dioxide)**: Fruits of each treatment were weighed and placed in 1.1 L jars which were sealed for 24 h before every periodical sample with a cap and a rubber septum. CO_2 samples of the headspace were removed from a septum with a syringe and injected into Servomex Inst (0-100) Model 1450 C (Food Package Analyser) model No.01450CIDMA 020522010 Serial No.1422C/22,1417C/23, to measure carbon dioxide production [19,20]. Respiration rate (Rr) was calculated as ml CO_2/Kg/h according to the following equation:

$$\mathbf{Rr} = \frac{\textbf{Concentration of } CO_2 \textbf{ for sample}}{\mathbf{100}} \times \frac{\textbf{Jar space size (L) X 1000}}{\textbf{Sample weighting (Kg) x Time of close jar (h)}}$$

Note that measurements were taken before the jars were opened immediately.

Statistical analysis: The Statistical analysis of the obtained data was carried out according to [21].

Results and Discussion

1. The effects of packaging treatments of scratched or treated with ethrel fruits on respiratory rate of banana fruits

The data represented in Table (1) revealed that the scratched banana fruits, that were paged in TFP coated with one of the abovementioned coating mixtures, produces low CO_2 at maturity stage and tends to increase in the ripening stage, i.e. after three weeks from scratching and packaging treatments. Carbon dioxide values in the beginning were between 2.12 to 2.64 ml/Kg/h and reached to 15.47–20.1 ml/Kg/h in the ripening stage, where the color degree was 6.0 to 6.2. For fruits packaged with TFP coated with either PU/T mixture or PU only showed a lower CO_2 values than fruits packed with either UTFP or other TFP coated with other coating mixtures after 24 h from packaging, while in the ripening process one notified that TFP coated with PU/T mixture or PU only or PU/$AgNO_3$ mixture gave lower CO_2 values than controlled (UTFP) and other TP coating with other mixture.

Table 1: Respiratory rate in ml/Kg/h of Maghrabi banana fruits as affected by scratch of fruits with different food packaging papers

Packaging treatment*	period (day)			
	1	8	15	24
1	2.17	8.1	13.8	17.1
2	2.15	3.76	12.84	16.69
3	2.64	4.63	14.78	20.1
4	2.51	9.25	17.14	17.86
5	2.12	3.68	10.3	15.47
6	2.18	3.23	8.36	16.95
7	2.5	4.88	17.03	18.73

*** The coating mixtures codes are as given in the experimental part**

On the other hand, it was clear from Table(2) that treating the banana fruits with ethrel before paged in one of the packaging TFP showed lower CO_2 concentration after 24 h from packaging compared with those at the ripening process, while the CO_2 values were slightly high when compared with scratched fruits. Carbon dioxide values in the beginning were 2.93–3.31 ml/Kg/h and reached to 17.0–19.4 ml/Kg/h at the ripening process, where the color degree was 7.0. All CO_2 values of ethrel treated fruits, in either the beginning or the ripening stage, were lower than those for the controlled fruits. Also, coating with either PU/T mixture or PU/$AgNO_3$ mixture, at mature stage, gave lower CO_2 values than both the controlled one and the other coating treatments, while coating with either PU/$AgNO_3$ mixture or PU only and PU/T mixtures, at the ripening stage, gave lower CO_2 values compared with both the controlled and the other coating treatments.

Table 2: Respiratory rate in ml/Kg/h of Maghrabi banana fruits as affected by ethrel with different food packaging papers

packaging treatment*	period (day)			
	1	8	15	24
1	3.31	14.33	19.02	19.4
2	3.19	15.45	18.5	17.93
3	3.3	12.48	18.31	18.85
4	3.24	14.73	17.84	18.49
5	2.93	14.06	19.96	18.25
6	2.96	12.52	17.21	17
7	3.03	14.85	17.34	19.08

*** The coating mixtures codes are as given in the experimental part**

In addition,[22] they have mentioned that using very low concentration of ethylene initiates the ripening of banana and thus the CO_2 increased gradually. The values of the different coating treatments were reflected in a delay with ripening compared to the control fruit. In addition, there was a rise in CO_2 during storage and according to [23]. this might be possibly due to the initiation of ripening at storage which causes climacteric changes at any point during ripening ranging from colors 2 to 5. Also, the observed results have been agreed by those obtained by [24].

2. Effect of packaging treatments of scratched banana fruits or fruits that are treated with ethrel at room temperature on the quality hold

All banana fruits exposed to ethrel showed a lower weight loss, color, firmness and total acidity, as well as a higher soluble solid content/total acidity (SSC/TA) ratio compared with scratched fruits that were held at room temperature conditions. According to this, one can mentioned that after 10 days, ethrel treatment causes good ripening of banana fruits than scratched treatment.

In the scratched fruits, the differences were observed between different packaging papers used, in which coating with PU/T mixture gave lower weight loss (18.52), color index (6), peeling degree (3.5) and

SSC/TA ratio (29.03) and in addition a higher firmness (10.1) and total acidity (0.878) compared to the other packaging treatments.

On the other hand, in case of ethrel fruits, coated papers with PU only appeared to have lower weight loss (9.48), peeling degree (3.6), SSC/TA ratio (39.96) and higher SSC (26.5) and TA (0.663) values comparing to other packaging treatments. Moreover, under room temperature condition, one can use ethrel treatment when fruits are packed in TFP coated with PU/T mixture compared to other coated ones where the banana fruits achieve moderate fruit quality at the end.

Figures (1 and 2) illustrated the results of this study, where it can express the effect of the different TFP coated with different coating mixtures on the ripening and eating quality of Maghrabi banana. The comparison of fruit characteristics at mature age and at ripening stage can be concluded by the fact that with the ripening process all the characteristics are increased while acidity and firmness decreased. This observation was in agreements with data showed by [25,7].

The loss in fruit weight, which was noticed, can be mainly due to water loss as a result of evaporation and transpiration beside the amount of dry matter loss caused by respiration. [26] has mentioned that peel color index increased after the burst of ethylene production. The findings of ethrel used are confirmed by those of [27,28], where they reported that treating mango fruits with dose of ethylene gas cause a higher soluble solid accumulation and acidity reduction. With the use of packaging materials, [29] noticed that the possible mechanism for the retardation of ripening is due to anaerobic conditions that can occur, therefore, causing inhibition or slowing down the ripening process in some ways.

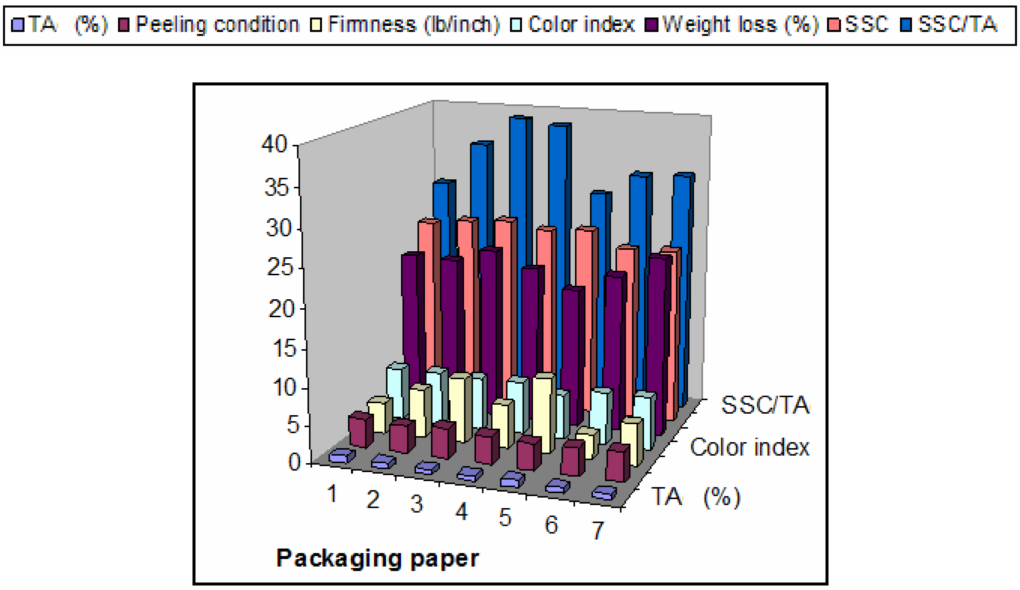

Figure 1: Effect of packaging treatments on banana fruit quality of scratched fruits held at room temperature

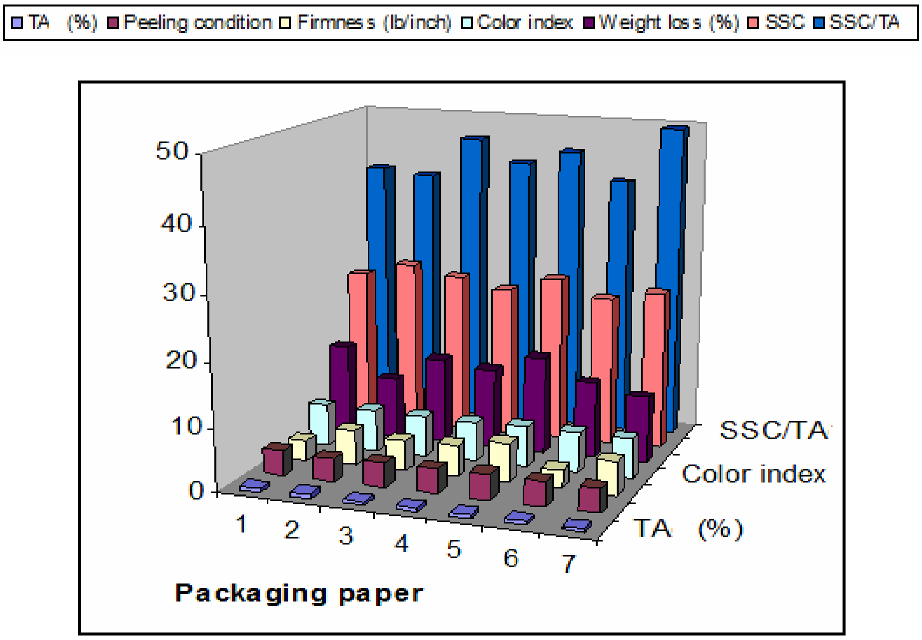

Figure 2: Effect of packaging treatments on banana fruit quality of ethrel treated fruits held at room temperature

3. Effect of packaging treatments on banana fruits quality under storage at 15 ± 1 °C

Different scratched fruits reduce weight loss, color index, firmness, SSC and TA and increase peeling degree and SSC/TA ratio compared with ethrel treated fruits when storage at 15 ± 1 °C. So, the scratch caused the improvement of banana fruits ripening after 24 days compared with the ethrel. In Figures(3 and 4), one can notice that in the scratched fruits, packaging treatments have shown that TFP coated with PU/T mixture gave a lower SSC (8.85), TA (0.122) and color index (4.5), whereas coating with $AgNO_3$ only showed a lower weight loss (10.08) and color index (4.5). Also, coating with PU only appeared to have a lower firmness (7.9) and SSC/TA ratio (43.37), whereas in the treated fruits with ethrel, coating TFP with $AgNO_3$, only recorded a lower weight loss (11.63) and color index (6). Moreover, coating with PU/T had a lower peeling degree (3.4) and color index (6), whereas coating with PU only showed a lower firmness (8), TA (0.206) and SSC/TA ratio (19.37).

Under storage condition of 15 ± 1 °C, one can use scratch treatment when packaging the fruits in TFP coated with PU/T compared to the other packaging treatments, where it achieved good quality for banana fruits. SSC in fruit was associated with sensory sweetness, which is the most important indicator of the quality and eating acceptability. Also, the acidity affected the flavor of the fruits.

In this respect, greater firmness and low SSC in any treatment indicates that ripening was delayed. This was in agreement with the results reported by [30]. Also, [7] reported that peeling condition is used as a good criterion for evaluation the ripening of banana fruits. [31] noted that 89% of the consumers prefer banana in color range 4, 5 and 6, and also,[32] reported that peel color changes is related to the firmness and that the soluble solids content were highly correlated and proceed simultaneously throughout the ripening process.

In general, this study shows that banana fruits at mature stage could be treated by ethrel then paged with TFP coated with PU/T mixture compared to other packaging treatments under room temperature condition, whereas, under storage at 15 ± 1 °C, one can use scratch with TFP coated with PU/T coating mixture compared to other packaging treatments which achieves good quality for banana fruits.

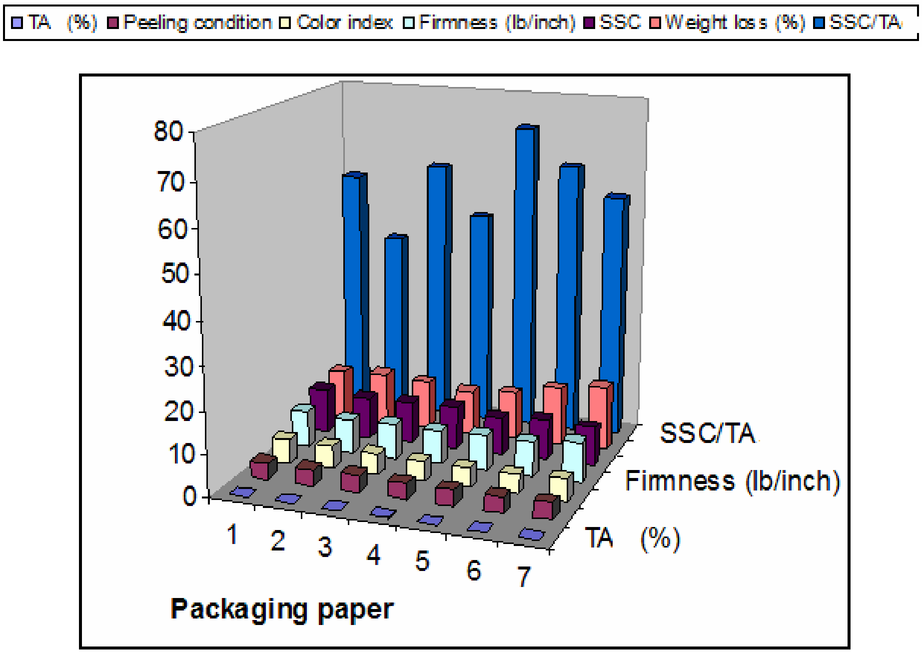

Figure 3: Effect of packaging treatments on banana fruit quality of scratched fruits under storage at 15 ±°C

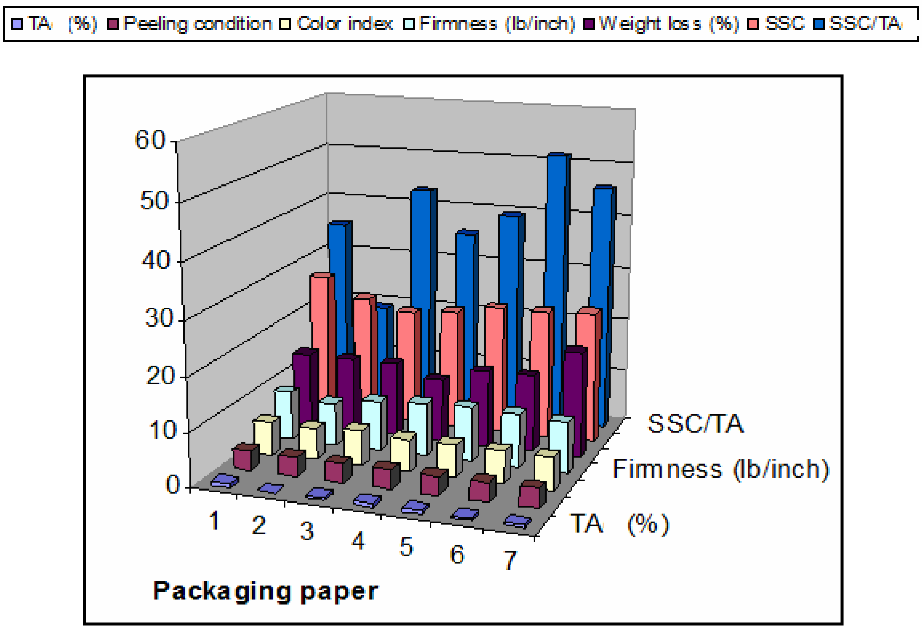

Figure 4: Effect of packaging treatments on banana fruit quality of ethrel treated fruits under storage at 15 ±°C

References

1. Vendrell,M. and McGlasson,W.B.,Inhibition of ethylene production in banana fruit tissue by ethylene treatment .Australian J.of Biol.Sci. 1971.24:885-95.
2. Ke,L. and Tsai,P.,Changes of ACC content and EFE activity in of the peel and pulp of banana fruit during ripening in relation to ethylene production. J. Agric. Asso. of China(Taiwan).1988.143:48-60.
3. Dominguez,M. and Venchell,M.,Ethylene biosynthesis in banana fruit: Evolution of EFE activity and ACC level in peel and pulp duringripening.J.Hort.Sci.1993.68:63-70.
4. Palmer,J.K.,The banana. In: The Biochemistry of Fruits and Their Products. Vol.2 (Hulme, A.C.,Ed.) Academic Press, London.1971. 65-105.

5. Plaza,P.; Torres,R.; Usall,J.; Lamarca,N. and Vinas,I.,Evaluation of the potential of commercial post harvest application of essential oils to control citrus decay. J. Hort. Sci. and Biotechnol.,2004.79(6):35-40.
6. Ahmed, D.M. and Abd El-Naby, S.K.M., A study on ripening of Grand Nain banana with ethanol. Minia J.of Agric.Res.&Develop.1999.9:127-144.
7. Abd El-Naby,S.K.M. and Ahmed, D.M.,Effect of acetaldehyde as postharvest treatment on the ripening characteristics of Grand Nain banana. Minia J. of Agric. Res. & Develop. 1999. 9: 107-126.
8. Abd El-Naby,S.K.M., Effect of postharvest treatments on quality aspect of Maghrabi banana fruit .American-Eurasian J. Agric. &Environ. Sci.,2010.8(5):582-587.
9. Abd El-Naby, S.K.M. and Soliman,S.S.,The effect of postharvest treatments with ethanol or calcium chloride on fruit quality of fresh Zaghloul dates. Arab Univ. J. Agric. Sci..2003.1(2): 715-732.
10. Kirwan,J.M., Paper and paperboard – raw materials, processing and properties. In: PAPER AND PAPERBOARD PACKAGING TECHNOLOGY. MARK J. KIRWAN (Ed.), Blackwell Publishing Ltd, UK.2005. PP. 1-49.
11. Morsy,M.H. and Ahmed,F.F.,Storability of Williams and Hindy banana fruits as influenced by some postharvest treatments. Fifth Arabic Conf. of Hort.2001.24-28 March ,Egypt.
12. Baldwin,E.A.; Nisperos,M.C. and Baker, R.A.,Use of edible coating to preserve lightly processed products. Rev. Food Sci.Nutr.1995.35:509-524.
13. Cuq,B. ; Gontard ,N.and Guilbert, S., Edible films and coatings as active layers In Active Food Packaging(M.L.Rooney,Ed.) Champan and Hall, Glassgow U.K.,1995.pp:111-141.
14. Adeyemi, O. and Oladiji,A., Compositional change in banana*(Musa spp.)* fruits during repinening. African J.Biotech.2009.8(5):858-859.
15. Regina,C.A.; Beatriz,M. and Gloria,A., Bioactive amines and carbohydrate changes during ripening of 'Prata' banana(*Musa acuminate x M. balbisiana)*.Food Chemis.,2005.90(4):705-711
16. Chen,C. and Ramaswamy, H., Color and texture change kinetics in ripening bananas. Lebensmittel-Wissenschaft und-Technologie,2002.35(5):415-419.
17. Von Loesecke,H.W., Bananas. Chemistry, Physiology. 2nd Ed. Interscience, New York.1950
18. Association of Official Agriculture Chemists.Official Methods of Analysis of A.O.A.C. Pub. By A.O.A.C.1995. Chap.(4)p.18-20 (37)p.10 .Virginia 22201-3301,USA.
19. Lurie,S. and Pesis,E., Effect of acetaldehyde and anaerobiosis as postharvest treatments on the quality of peaches and nectarines. Postharvest Biology &Tech.1992.1:317-326.
20. Pesis,E. and Ben-Arie,R., Involvement of acetaldehyde and ethanol accumulation during induced deastringency of persimmon fruits. J. Food Sci.,1984.49:896-899.
21. Snedecor,G.A. and Cochran ,W.G., Statistical Methods.1982.7thEd.p.365-372.The Iowa State Univ. press, Ames. Iowa ,USA.
22. Zhang,D.; Huang, B.Y.and Scott,K.J., Some physiological and biochemical changes of "green ripe" banana at relative high storage temperatures. Acta Hort.1993.343:81-85.
23. Marin,D.H.; Blanhenshp,S.M.; Sutton,T.B. and Swallow, W.H., Physiological and chemical changes during ripening of Costa Rican bananas harvested in different seasons. J. Amer. Soc.Hort. Sci. 1996. 121(6):1157-1161.
24. Asguerra,E.P.; Kawada,K.; Kitagawa,H. and Subhodrabandhu,S., Removal of astringency in "A masa" banana (Musa AA group) with postharvest ethanol treatment. Acta Hort.No.1992.321:811-820.
25. Xue,Y.; Kubo,Y. and Nakamura,R., Effects of humidity on the ripening characteristics of banana fruit. Nippon Shokuhin Kogoku Kaishi,1996.43(5):541- 545.
26. Kojima,K., Softening of banana fruit: relationship between firmness and chemical composition. JARQ, Japan Agric. Res. Quarterly1996. 30(4):269-274.
27. Pal,R.K., Influence of ethrel and calcium carbide on respiration rate, ethylene evolution, electrolyte leakage and firmness of "Dashehari" mango (*Mangifera indica L.*). Indian J. Agricultural Sci. 1998. 68 (4):201-203.
28. Medlicott,A.P.; Diaye, M.N.and Sigrist, J.M.M., Harvest maturity and concentration and exposure time to acetylene influence initiation of ripening in mangos. J. Amer. Soc. Hort. Sci.,1990.115(3):426-430.
29. Davies,D.D, Anaerobic respiration and the production of organic acids. In: The Biochemistry of Plants.Vol.2.(Stumpt,P.K. and Conn,E.E. Eds)Academic Press, New York ,1980.851-611.
30. Hewage,K.S.; Wainwright,H. and Luo,Y., Effect of ethanol and acetaldehyde on banana ripening. J.Hort.Sci.,1995.70(1):51-55.

31. Liu,F.W. Ripening bananas with ethephon in three polymeric film packages. HortScience.1978. 13(6):688-690.
32. Medlicott, A.P.; Semple, A.J.; Thompson, A.J.; Blackbourne, H.R. and Thompson A.K., Measurement of colour changes in ripening bananas and mangoes by instrumental chemical and visual assessments. Trop. Agric.1992. 69(2): 161-166.

*****