Research Paper

STUDY OF ADVANCED MATURITY STAGES OF BANANA

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ABSTRACT

Banana (Musa sp var 'Robusta') of three advanced stages of maturity i.e. stage 5, 6 and 7 were analysed for their physic-chemical and mechanical properties. Fruits were treated with 500 ppm ethrel solution and kept for ripening under controlled conditions at 20±1 °C and maturity stages were selected on the basis of standard colour chart. As the ripening progressed, various physical changes observed in fruit such as increased in pulp to peel ratio, decreased in intensity of greenness of peel and also polyphenol oxidase activity decreased. Mechanical properties decreased significantly from stage 5 to stage 7. A significant difference ($p \leq 0.05$) in firmness was found at different stages of ripeness of bananas. A similar trend was observed for other mechanical properties viz. cohesiveness, chewiness, fracture force and stiffness during the different stages of ripening. Moisture content, titratable acidity, pectin content, total sugar and TSS of pulp showed increasing trend from stage 5 to stage 7 whereas starch content progressively decreased during ripening

KEYWORDS Banana, Ripening, Physical, Mechanical, Chemical

INTRODUCTION

Banana (*Musa* spp.) is the fourth most important food crop in the world after rice, wheat and maize with a world production of around 80 million metric tons in 2006 [1] and in the world India is the largest producer of banana with an annual production of 23.205 million MT from an area of 0.647 million ha [2]. Dwarf Cavendish and 'Robusta' are the most popular banana varieties commonly grown in India and are the main stays of Indian banana industry for both internal and export trades.

In banana, post harvest compositional changes following are important since banana is a climacteric fruit. Dramatic changes in banana peel colour and pulp texture occur during the rise in respiration during storage of climacteric fruits. The changes occurred during ripening are in physical, mechanical and chemical properties of banana fruits. Skin colour changes from green to yellow, firmness is decreased, fruit gets softened and starch is converted into sugar [3][4][5].

Mainly colour changes in banana during ripening is based on the peel colour rather than the pulp colour and hence colour of banana peel has been used in the assessment of the stages of ripeness of banana. Commercial standard colour charts are available in which 7 stages of peel color were reproduced and translated to a numerical scale where Stage 1=all green, 2= green with trace of yellow, 3= more green than yellow , 4= more yellow than green, 5= yellow with trace of green, 6= full yellow, 7= full yellow with brown spots. According to colour chart, in terms of peel colour slight difference occurs among the advanced stages of maturity i.e. stage 5, 6 and 7 as compared to initial stages.

Knowing the physical and mechanical properties of banana fruit and changes in these parameters during different ripening stages is the most important attributes to design handling, sorting, peeling, processing and packaging system. Knowing these properties of agricultural products would help designer engineers to apply forces and dimensions of machine's units properly to protect fruits from bruises, injuries, decay lesions and numerous other defects that emanate as results of post-harvest processing treatments. In many fruits such as banana and mango, the level of ripeness associates with physical and mechanical properties of fruits.

The present study aimed to quantify the changes in physico-chemical and mechanical properties in banana fruits at advanced stages of maturity during ripening.

MATERIALS AND METHODS

Banana (*Musa* sp var 'Robusta') bunches at optimum stage of maturity were brought from an orchard and banana hands were separated. Selected banana hands were washed thoroughly with potable water and dipped in in 500 ppm ethrel (2-chloro ethyl phosphonic acid) solution for 5 min. Treated fruits were then dried under fan to remove surface moisture and packed in perforated plastic baskets and covered with polyethylene sheet to create high RH and kept for ripening at 20±1 °C [6][7]. Fruits of advanced ripening stages viz. stage 5, 6 and 7 (according to standard banana colour chart as shown in Fig.1) were selected for the present study.

Physical Parameters

Pulp to peel ratio of fruit of each selected stage was determined by dividing weight of pulp by peel weight. Changes in colour of peel and pulp was also observed visually and recorded during the respective stage of maturity. Banana polyphenol oxidase (PPO) was extracted and assayed according to the method described by Galeazzi et al.[8].

Mechanical Properties

Mechanical properties viz. firmness, cohesiveness, chewiness, fracture force, stiffness of whole fruit was determined by using Texture Analyzer TA plus (Lloyds, England) controlled by a *PC*- based data acquisition card in a personal computer with the software Nexgen V 4.5. 8mm cylindrical probe [9], the cross head speed was 50mm/min and deformation % was kept at 30. The samples were placed on a fixed plate on its lateral surface and the puncture test was carried out at 2 cm away from the middle of the fruit. Firmness values were expressed as the maximum force (N) required until tissue failure.

Chemical Properties

Banana pulp of 3 ripening stages viz. stage 5, 6 and 7 has been analysed for their compositional changes.

Moisture content in the pulp of was determined by drying in oven at 70 °C±1^{0}C for 12 h. Total ash, fat and protein content (Micro-kjeldhal method) were determined according to the method described in A.O.A.C.[10]. Titratable acidity was determined by direct titration of diluted pulp with 0.1N NaOH as described by Ranganna [11] and TA was expressed as a % of malic acid. Pectin in the pulp was determined as calcium pectate [12]. Total sugar content were analyzed as per Shaffer -Somogyi method and starch in the alcohol insoluble solids was hydrolyzed using HCL and the resultant reducing sugar was determined by Shaffer -Somogyi method given in Ranganna [11]. TSS was measured as ^{0} Brix at 20^0 C with Hand Refractometer. The necessary corrections were made when the measurements were carried out at temperatures other than 20^{0}C.

Statistical Analysis

For each treatment, three samples were randomly selected and the average values of three experiments were reported. Experimental data were analyzed using analysis of variance (*ANOVA*). Tukey's multiple comparison test was employed for mean separation. The level of significance was at 5%. The analysis was performed using the Daniel's XL Toolbox version 4.00.

Table 1. Changes in physical characteristics in banana fruits at different stages of maturity during ripening at 20^{0}C

Parameters	Stage of ripening		
	5	6	7
Pulp/peel ratio	2.0	2.3	2.7
Peel colour	Yellow with green tip	All yellow	Yellow slightly flecked with brown
Pulp colour	White	White-Creamy	Yellowish creamy
PPO activity (U ml^{-1} min^{-1})	33.18	30.22	27.84

Table 2. Changes in mechanical properties in banana fruits at different stages of maturity during ripening at 20^{0}C

Parameters	Stage of ripening		
	5	6	7
Firmness (N)	37.29 ±0.70^a	27.35 ±1.00^b	22.57±2.35^c
Cohesiveness	0.06± 0.001^a	0.05± 0.004^a	0.04± 0.002^b
Chewiness (kgf)	4.80± 0.11^a	3.78±0.20^b	2.68±0.14^c
Fracture force (kgf)	0.03±0.001^a	0.02± 0.001^b	0.02± 0.002^b
Stiffness (kgf/mm)	0.58± 0.05^a	0.37± 0.04^b	0.28±0.07^b

In each row, means followed by the same letter are not significantly different ($p \leq 0.05$)

Table 3. Changes in chemical composition of banana at different stages of maturity during ripening at 20^{0}C

Parameter	Stage of ripening		
	5	6	7
Moisture %	73.87±0.23^a	74.24±0.22^a	74.92±0.09^b
Ash %	0.683±0.006^a	0.675±0.005^a	0.645±0.009^b
Fat %	0.24±0.004^a	0.28±0.006^b	0.28±0.005^b
Protein %	0.81±0.002^a	0.80±0.008^a	0.78±0.003^b
% Titratable Acidity (as mallic acid)	0.37±0.004^a	0.41±0.013^b	0.48±0.004^c
Pectin (as calcium pectate) %	0.37±0.012^a	0.41±0.01^b	0.66±0.02^c
Total sugar %	13.38±0.53^a	16.67±0.23^b	18.48±0.45^c
Starch %	7.05±0.22^a	4.09±0.11^b	1.56±0.14^c
TSS (^{o}Brix)	19.2±0.2^a	20.73±0.115^b	23.07±0.115^c

In each row, means followed by the same letter are not significantly different ($p \leq 0.05$)

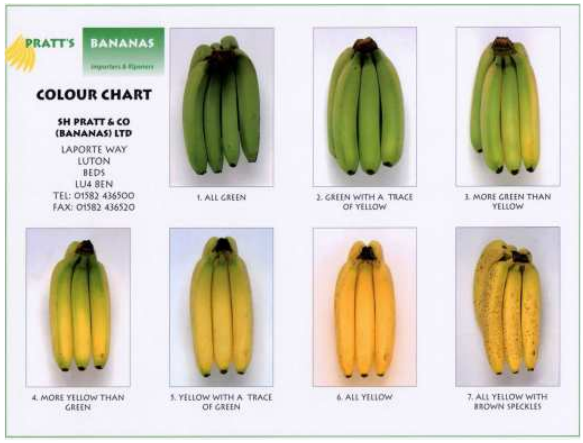

Fig.1 Standard Colour chart by SH Pratt & Co (Bananas) Ltd. (Luton)

RESULTS AND DISCUSSION

Physical Properties

As the ripening proceed, pulp to peel ratio was increased from 2.0 in stage 5 to 2.7 in stage 7 when the fruits become fully ripened. (Table1). This could be due to the osmotic transfer of moisture from the peel to the pulp as sugar content of pulp increased. It has been suggested that pulp to peel ratio can be considered as a coefficient of ripeness [13]. The intensity of greenness of the peel also decreased from stage 5 to stage 7. These changes during ripening period (loss of greenness and increase in yellowness) may occur as a result of the breakdown of the chlorophyll in the peel tissue. Whereas the pulp colour changes from whitish to yellowish creamy with fruit ripening. Maximum polyphenol oxidase activity was observed at maturity stage 5 (33.18 U ml^{-1} min^{-1}) which was gradually decreased as ripening progressed. Similar results were reported by Montgomery and Sgarbieri [14].

Mechanical Properties

Results indicated that as the ripening progressed, mechanical properties decreased dramatically from stage 5 to stage 7 (Table 2). A significant difference ($p \leq 0.05$) in firmness was found at different stages of ripeness of bananas. The firmness of banana fruits decreased significantly from 37.29N at 5th stage to 22.57N at 7th stage of ripening. Similar results were reported by Mahmoud Soltani et al.[15] and Peleg [16] in banana. A similar trend was observed for other mechanical properties viz. cohesiveness, chewiness, fracture force and stiffness during the different stages of ripening.

Thompson [17] reported that the softening of banana fruit during ripening treatment is associated with the conversion of starch to sugar, the breakdown of pectin substances and the movement of water from the rind of the banana to pulp during ripening and this could be the major cause for decreasing the various mechanical properties of banana during ripening.

Chemical Composition

Compositional study of banana pulp of selected maturity stages has been carried out. Results indicated that (Table 3), a significant increase in moisture content of the pulp was observed from stage 5 (73.87%) to stage 7 (74.92%). The increase in pulp moisture content during ripening may be due to carbohydrate breakdown and osmotic transfer from the peel to pulp [18]. A significant decrease in ash

and protein content was recorded in between stage 5 and 7. During ripening, there was increase in fat % i.e. from 0.24% to 0.28% at stage 5 and 6 respectively. Thereafter no significant increase was recorded at stage 7. A significant difference ($P \leq 0.05$) was found between titratable acidity of pulp of each stage. Mean values of titratable acidity shows that this parameter increases gradually until the fruit reaches to full-ripe stage (stage 7). It confirms the earlier findings by Lustre [19]. Loesecke [13]reported a sharp increase in acidity in course of banana fruit ripening.

In the pulp of bananas, pectin content increase significantly from 0.37 to 0.66 % at maturity stage 5 to stage 7.Conrad [20] reported that during ripening of fruits pectin increases at the expense of protopectin. The interconversion of pectic substance is presumed to be involved in the characteristic softening which occurs during fruit ripening.

The results indicated that a progressive increase in total sugar content and decrease in starch content was observed during ripening. This could be due to the hydrolysis of starch into sugar during ripening [21][22]. These results were in accordance with Garcia and Lajolo [23]. At stage 7, maximum TSS was observed (23.07 ^{o}Brix) followed by 6th and 5th stage of ripening. Increase of TSS is an important trait of hydrolysis of starch into soluble sugars such as glucose, sucrose and fructose [24]. This increase was reported by Kulkarni et.al.[6] and Marriot et al. [4].

CONCLUSION

The research focused on the changes in banana fruits particularly during last stages of ripening. It may be concluded that in advanced stages of maturity of banana viz. stage 5, 6,7 though the slight changes observed in terms of peel colour but significant changes with respect to some mechanical properties and physico-chemical parameters opted. This data of respective stage of ripeness would assist in scheduling harvesting, transportation, processing and marketing operations efficiently.

ACKOWLEDGEMENT

The author is highly thankful to Dr. V.S. Patel, Director, SICART, Vallabh Vidyanagar for providing the facilities of laboratory to carry out some part of the work.

REFERENCES

1. [UNCTAD] United Nations Conference on Trade and Development (2008). Hand book of statistics: Market information in the commodities areas. Available from: http://www.unctad.org/. Accessed Jan 28.
2. NHB (2009) Database National Horticulture Board. Ministry of Agriculture, Government of India, India
3. Kajuna, S.T. A. R., Bilanski, W. K., & Mittal, G. S., (1997). Txtural changes of banana and plantain pulp during ripening. *J. Sci. Food Agric*, 75, 244–250.
4. Marriott, J., Robinson, M., & Karikari, S. K. (1981). Starch and sugar transformation during the ripening of plantains and bananas. *Journal of Science, Food and Agriculture,* 1021-1026.
5. Prabha, T.N. and Bhagyalakhmi, N. (1998). Carbohydrate metabolism in ripening banana fruit. Phytochemistry, Vol.48 No.6 pp 915-919
6. Kulkarni S.G., Kudachikar V.B. & Prakash M.N. (2010). Studies on physico-chemical changes during artificial ripening of banana (Musa sp) variety 'Robusta'. J Food Sci Technol. (online journal DOI 10.1007/s13197-010-0133-y)
7. Saeed A, Thompson AK, Ishfaq AH, Ali AA (2001). Effect of temperature on the ripening behavior and quality of banana fruit. Int J Agric Biol 3:224–227
8. Galeazzi, M.A.M, Sgarbieri, V.C. and Constantinides, S.M. (1981). Isolation, purification and physicochemical characterization of polyphenol oxidase (PPO) from a Dwarf variety of banana (Musa cavendishii,L). J.Food Sci.: 46:150
9. Saeed,A., Perviez, M. A., Chatha, Z. A., & Thompson, A. K. (2006). Improvement of banana quality in relation to storage humidity, temperature and fruit length. . *International journal of agricultural & biology,* 8(3),377-380.
10. A.O.A.C. (1984). Association of Official Analytical Chemists. *Official Methods of Analysis*, 14th ed. Washington, D.C.
11. Ranganna S (1986) Handbook of analysis and quality control for fruits and vegetables, 2nd edn. McGraw Hill, New Delhi
12. A.O.A.C. (1975). Association of Official Analytical Chemists. *Official Methods of Analysis*. Edited by Horwitz, W. p 1094. Washington, D.C.
13. Loesecke, (1950). Cited by Sen et al. 1982. Some aspects of physico-chemical changes in ripening bananas during ripening in storages. *Prog. Hort*. **14**(1). pp. 79-84.
14. Montgomery, M.W. and Sgarbieri, V.C.(1975). Isoenzymes of banana polyphenol oxidase. Phytochem.14: 1245
15. Soltani,M, Reza Alimardani, Mahmoud Omid (2011). Changes in physico-mechanical properties of anana fruit during ripening treatment. Journal of American Science ;7(5)
16. Peleg M (1977) Textural changes in ripening of banana. J Texture Stud 7:457–463
17. Thompson AK (1996). Postharvest treatments, in *Postharvest Technology of Fruit and Vegetables*, ed. by Thompson AK. Blackwell Publishing. Oxford, pp. 95–124.
18. John P, Marchal J (1995) Ripening and biochemistry of the fruit. In: Gowen S (ed) Banana and plantains. Chapman and Hall, London, pp 434–467
19. Lustre, A.O.; Soriano, M.S.; Morga, N.S.; Balagot, A.H.; Tunac, M.M. (1976). Physico-chemicalchanges in "SABA" bananas during normal and acetylene-induced ripening. *Food Chemistry*, 1, 125-132.
20. Conrad, C.M. (1930). A furfural-yielding substance as a splitting product of protopectin during the ripening of fruits. *Plant Physiol. January 5: 93-103. doi:10.1104/pp.5.1.93*
21. Marriott,J (1980). Bananas- Physiology and Biochemistry of storage and ripening for optimum quality.CRC Crit.Rev.Food Sci.Nutr. 13:41
22. Terra, N.N.; Garcia, E.; and Lajolo, F. M. (1983). Starch sugar transformation during banana ripening: The behavior of UDP glucose Pyrophosphorylase, Sucrose Synthetase and Invertase. *Journal of Food Science,* 48, 1097-1112.
23. Garcia, E.; and Lajolo, F.M. (1988). Starch transformation during banana ripening: the amylase and glucosidase behavior. *Journal of Food Science*, 53, 1181-1188.
24. Stover, R.H.; Simmonds, N.W. (1987). Bananas. 3rd Ed.; John, W. & Sons Inc: New York.