



Effect of Storage Time and Room Temperature on Physicochemical and Geometric Properties of Banana (*Musa Spp.*) Fruit

Tolcha Techane Alemu

Department Of Post Harvest Management, Jimma University College of Agriculture and Veterinary Medicine Ethiopia.

Abstract

Information of banana (*Musa spp.*) fruit on physicochemical and geometric properties are important to maintain quality parameters. Banana is the most consumed fruit and has great importance for small-scale farmers and has a healthy diet. This study investigated the effect of storage time and room temperature on the physicochemical and geometric properties of banana fruit. Due to its attractive texture and color bananas is popular. However, because of perishability, it has a short shelf life. Banana fruit physicochemical and geometric properties (weight loss, hardness and penetration, color, pH, total soluble solids, and titratable acidity) were significantly affected by storage time and room temperature. During storage at room temperature, the color values L-value (lightness) and b-value (yellow) were increased (36.4 to 52.1 and 22.93 to 42.34) respectively. However, the value decreased from -15 to -25.1. Weight loss and TSS also increased from 10.4 to 14.3 and 3-15°Bx respectively. TA decreased from 0.47 to 0.14 and pH increased 4.2 to 7.3. Hardness with peel and without peel decreased from 1089.5 to 316.76 N and 937-183.46 N respectively. Penetration with peel and without peel decreased from 72.5 to 18.81 and 52.25 to 10.88 N respectively. Therefore, storage time and room temperature were affecting the physico-chemical and geometric properties of stored banana fruits at room temperature and CRD design was used for analysis. Based on the research, limitation further research is needed to study the effect of storage time at room temperature on nutrition composition, ant-oxidants, size, and shape of stored bananas by taking more time.

Keywords: Banana, Physicochemical Properties, Storage time, Room temperature

1. Introduction

Banana (*Musa spp.*) fruit is the most popular fresh fruit in all over the world. It is the major fruit crop grown in many developed and developing countries [1]. Bananas is the most commonly consumed fruits and it has great importance to small-scale farmers in the developing countries of the tropics and subtropics [2]. [3] stated that banana is the world's second most important fruit crop after oil palm. About 87% of the entire bananas grown worldwide are produced by small-scale farmers for consumption or sale to local and regional markets [4]. This makes banana to be the prime leading fruit crop in terms of volume and value in the world market [5]. In most world countries both developed and developing production of banana fruits becoming more due to its benefit. In 2020, bananas production for southwest Asia continent countries like Viet Nam was 2.19 million tonnes and its production of increased from 470,000 tonnes in 1971 to 2.19 million tonnes in 2020 growing at an average annual rate of 3.37% [6]. According to [7], in Ethiopia about 107,890.60 hectares of land is covered by fruit crops. From these bananas contributed about 58.59% of the fruit crop area followed by avocados which contributed 16.53% of the area.

Fruits and vegetables are universally considered vital elements in a healthy diet. Like other fruits and vegetables, banana fruits are the most popular fruit and one of the world's most important staple foods, along with rice, wheat, and maize [8]. Not only they provide crucial vitamins and proteins, but also have health-giving qualities [9]. It is a good source of potassium, magnesium,

copper, manganese, vitamin C and B6. Banana is also a good source of energy, low in protein and fat content, and has several medicinal properties [10]. Due to its attractive texture, good glucose sugar and flavor bananas are popular by consumers.

Banana (*Musa spp.*) is a highly perishable fruit. The perishability of the banana fruit is attributed to immense physiological changes after harvest [11]. The port of total postharvest loss on bananas is considered to be 30-40% [12]. Postharvest pest and diseases affect a wide variety of banana fruit that lack appropriate postharvest storage facilities, particularly in developing countries. Infection by fungi and bacteria may occur during the growing season, at harvest time, during handling, storage, transport, and marketing, or even after purchase by the consumer 26.5% of which 56% of the loss occurred at the retail level due to rotting before reaching to consumers in Ethiopia [13]. Temperature is the most important environmental factor that influences the deterioration of harvested climacteric fruit. It has been shown that temperature has a profound effect on the rates of biological reactions [14]. Physical injuries to the produce must be avoided wherever possible during the handling and distribution of fruits [15]. Postharvest losses are one of the concerns of food security and poverty reduction strategies in many developing countries including Ethiopia and Vietnam [16]. Banana fruit contains low fat, an excellent source of dietary fiber, vitamin C, vitamin B6, and manganese [17]. The presence of potassium and fiber in large amounts in bananas also helps to combat atherosclerosis, which can lead to heart attack and stroke [18].

18 January 2023: Received | 05 April 2023: Revised | 19 May 2023: Accepted | 18 June 2023: Available Online

Citation: Tolcha Techane Alemu (2023). Effect of Storage Time and Room Temperature on Physicochemical and Geometric Properties of Banana (*Musa Spp.*) Fruit. *Journal of Plant Biota*. DOI: <https://doi.org/10.51470/JPB.2023.2.1.19>

Tolcha Techane Alemu | ttolche@gmail.com

Copyright: © 2023 by the authors. The license of *Journal of Plant Biota*. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<http://creativecommons.org/licenses/by/4.0/>).

Since banana fruits are highly perishable in nature they undergo many physiological and biochemical changes that lead to ripening and senescence. According to [19] in developing and developed countries banana fruit is considered to be the best of all fruit crops because of its excellent flavor, attractive fragrance, beautiful peel color, delicious taste, and nutritional value. Despite its nutritional and health importance, there is a huge postharvest loss of this fruit due to its perishable nature. However properties and shelf life of bananas can be extended by controlling storage temperature and food industries can use it during scarcity to consume and produce different products. To reduce postharvest loss and to increase the shelf life, efforts are needed to develop postharvest technologies to manage storage temperatures that are not health hazardous and would suit the climatic and socio-economic conditions of countries [20]. Therefore, appropriate temperature management is the most important tool for extending shelf life and maintaining the quality of banana fruit as well preserve physico-chemical and geometric properties.

Therefore this study aims to investigate the effect of storage time and room temperature on physico-chemical and geometric properties of banana fruits.

2. Materials and Methods

Description study of the area

The experiment was conducted in the Viet Nam national University of Agriculture (VNUA) at the laboratory of Food Processing and technology.

Sample collection and preparation

Unripe and free from any defects banana fruits were purchased from the supermarket around VNUA in University Viet Nam from the producer and it was transported into the food science laboratory at VNUA. After it was transported into the laboratory, it put at room temperature and relative humidity (22°C–28°C and 82%–85% RH) according to (Opara et al., 2012; Ahmad et al., 2006). During the determination of physicochemical and geometric properties, banana fruits were cut at 2 cm and hardness and penetration were determined.

Experimental design and treatment application

The experiment was laid out in a completely randomized design (CRD) with four replications considering storage at room temperature and storage time by using Minitab software version 16. The factors consisted of (1) storage time and (2) room temperature and eighteen banana fruits were used.

Data Were Collected

Physiological Weight loss

The percentage of physiological weight loss was determined by using the methods of [21]. Weight loss of fruits was calculated from the initial weight of fruits per treatment and at each storage interval period. It was determined using a sensitive balance (type JD2000-2). Fruit weight daily variation from the initial measurement was expressed as a weight loss %.

$$\text{Weight loss (\%)} = \frac{\text{Initial weight} - \text{final weight}}{\text{Initial Weight}} \times 100$$

Hardness and penetration

The hardness and penetration with peel and without peel were measured by using a textural analyzer instrument according to [22]. During the measurement of hardness and penetration of

banana fruits with peel and without peel first, the texture analyzer was adjusted at force 107 N, and speed was adjusted at 92 mm/min. maximum and low height or distance adjusted at 66.99 mm and 50.41mm respectively. For calibration, 2000N weight was used. Then hardness and penetration were measured three times per fruit every day. On both ends of the fruit, the stem-calyx axis was measured for hardness and penetration.

Color

The color of each fruit was measured three times at six parts at both two side and at middleside three parts and in the opposite side also three parts. This was done at mid-way along the stem-calyx axis with a chromameter (model CR-400, Konica Minolta, Japan) on each opposite side of fruit. According to [23] the following values for color were reported for the CIELAB scale: L* (lightness; a* (greenness; and b* (yellowness).

Total soluble solids (TSS)

The TSS was determined following the procedures described by [22]. A refractor meter (WAY-2s Abb'e, 0-20 °Brix) was used to determine TSS by placing 1 to 2 drops of clear juice on the prism.

TA content

Banana juice was prepared and titrated with 0.1 N NaOH up to pH 8.1 using phenolphthalein as an indicator was calculated as percentage malic acid [22].

$$\text{TA (\%)} = \frac{(C \times 100 \times \text{ml of NaOH} \times N \text{ of NaOH})}{(\text{ml of sample})} \times D$$

where C is constant = 0.067 (for malic acid), N of NaOH = 0.1, mL of NaOH = readings of sample volume, and D (dilution factor).

pH value

pH 7 buffer was used to determine the pH, a aliquot of juice was extracted from the sample fruit and the pH of the juice was measured with a pH meter (UB-10 pH/mV meter ultrabasic). Method of [24] was used.

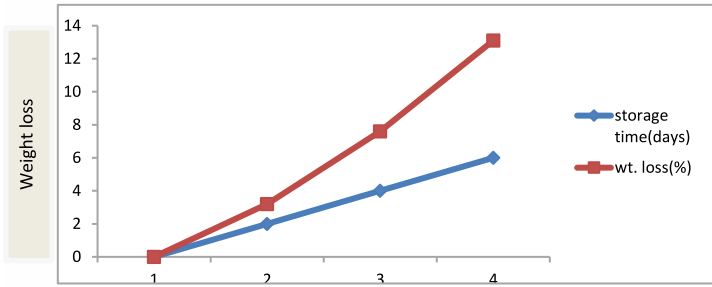
Statistical analysis

Data analysis was performed using genetic origin laboratory, narrative, and descriptive statistics. An Excel application was used for raw data analysis. Duncan's multiple range test procedure was used to distinguish treatment measures with $p \leq 0.05$.

Results and Discussion

Physiological Weight loss

Physiological weight loss increase as storage duration increases at room temperature loss of weight increased. This circumstance resulted from increased fruit evaporation of water brought on by temperature. Similar findings were reported by [25] who showed 5.5% weight loss in Cavendish banana fruit during storage at 14°C for two weeks and [26] who discovered higher weight loss at (22.5°C) compared to a lower temperature (17.5°C).



Storage time (days)
Figure 1: The relationships between weight loss and storage time banana fruit temperature.



Figure 2: Color of Stored Banana for 0, 3, 5, and 7 Days

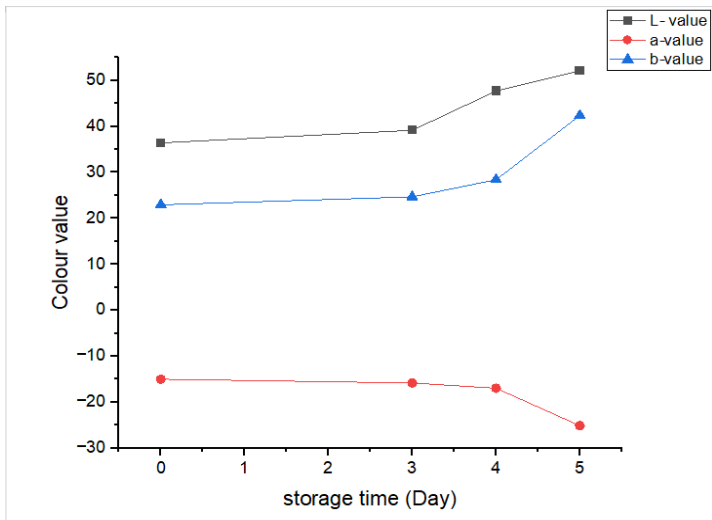


Figure 3: Effect of storage time on color value (L,a , and b value)

Changes in color values (-L, -a, -b) during the storage period of seven days at room temperature were presented in the above graph fig. 3. It can be observed from fig.3 that the lightness value which is -L value and yellowness b- value increased during the storage period of seven days. The increase in the color score

during storage might be due to a series of physicochemical changes like the breakdown of chlorophyll and an increase in carotenoid pigments of the pulp caused by enzymatic oxidation and photodegradation. This might be due to the chlorophyll degradation, which subsequently reveals the yellow carotenoid pigments. These results concurred with those of [28] who stated that mature fruit has a green peel hue.

The development of carotenoids in fruit stored at 18-34°C underwent a series of changes, and one of the major changes was an increase in carotenoids from 498 to 8071 ug/100 g, which caused the color of Alphanso and other varieties of mango to change from light green or green or dark green to light green or yellow or orange-yellow [28];[29]. The greenness of the banana which is a-value was decreased slowly; during storage time increased. This is due to the fact that, the breakdown of the chlorophyll in the peel happened and the development of small brown flecks over the peel. The work of [30] also supports this idea. Therefore, storage temperature and time significantly affect the color quality characteristics of banana fruit. During storage time the value of L* and b* were increased and value a* was decreased.

Hardness and Penetration

Hardness and penetration were measured by using a texture analyzer and adjusting speed and height as well as force. After that, samples were put under the probe of a texture analyzer, and direct reading was taken through observing and recording. The below two figures show the effect of storage time on hardness and penetration with peel and without peel of banana fruits studied for (0,3,5 and 7) days.

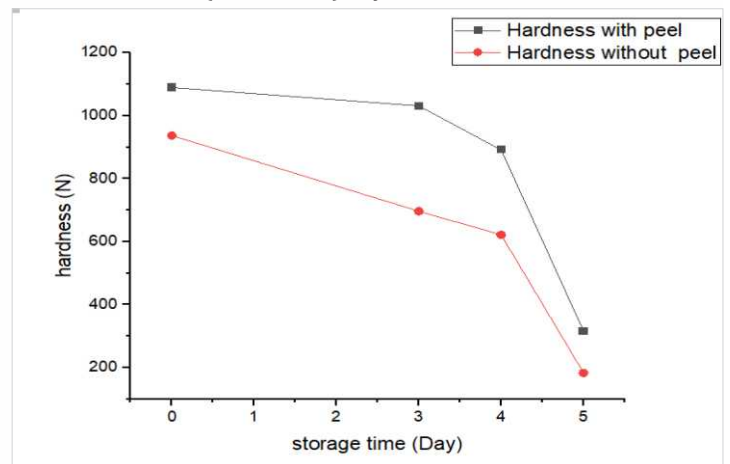


Figure 4: Effect of storage time on banana hardness

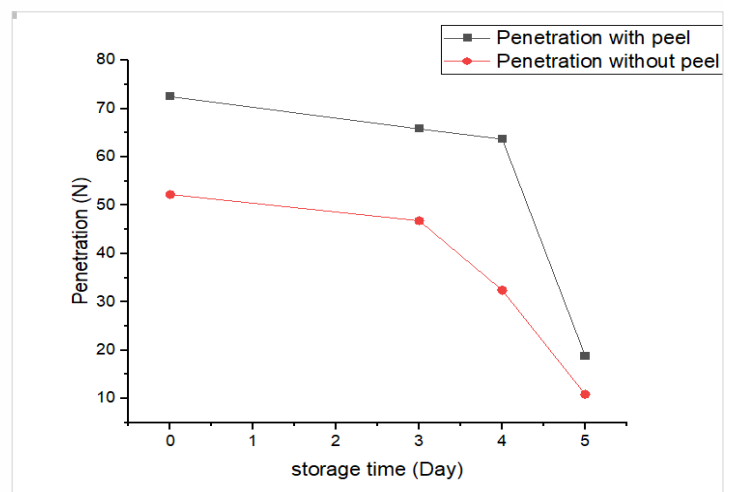


Figure 5: Effect of storage time on penetration of banana fruit

Storage time had a significant effect on banana fruit hardness and penetration (Figures 4 and 5). The hardness and penetration of the banana gradually reduced throughout the storage period and decreased quickly. Figure 4 shows that as storage time increases, both hardness with peel and without peel decrease. The hardness with peel decreases gradually, and then decreases sharply but the hardness of banana without peel decreases rapidly. Fig. 5 shows that as storage time increases, penetration force decreases. The penetration of banana fruits without peel during storage time decreased rapidly. This could be due to outer part cell wall removed and the breakdown of different insoluble compounds. [31] state that the reductions in hardness and penetration value during storage might be due to the breakdown of insoluble compounds. The breakdown of the cell wall is another reason why banana hardness and penetration decrease over time when they are stored. These works were further assisted by the activity of the fast changes in hardness during the ripening phases [32]. The processes of starch breakdown into soluble sugars, water loss from the peel, and a reduction in hardness and penetration are also linked to the processes of fruit softening. The writings of [33] support this notion as well.

Generally, the reduction in score during storage might be due to the breakdown of insoluble Pectin substances to soluble forms [34] formed in the tissues during ripening. These findings are correlated with [35] in Vietnam, who reported that firmness of Buoi mango was highly dependent on storage temperature. Similar observations were reported by [36] in green mature Alphaso and other 7 varieties of mango that firmness was decreased from (28.96-17.46 lbs/sq.inch) at 18- 34°C due to a series of physico-chemical changes.

Total soluble solid (TSS)

The effect of storage time on TSS of banana fruits studied by using hand refractometre and its effect presented by below Figure 6.

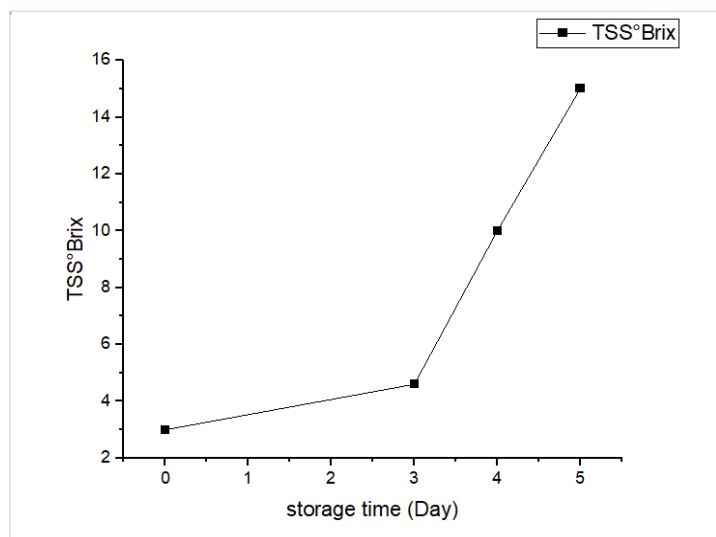


Figure 6: Effect of storage time on total soluble solid of banana fruit

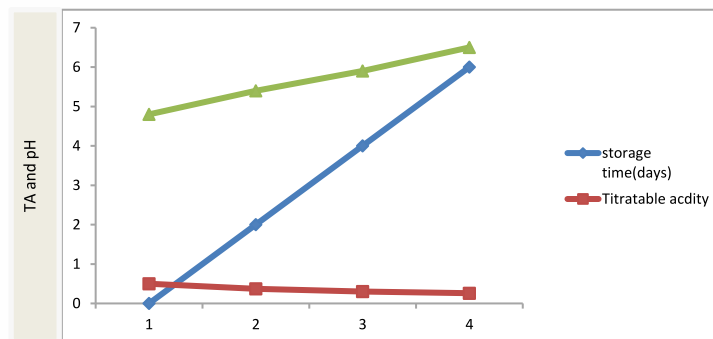
Fig. 6 demonstrates that the amount of total soluble solid rose as storage duration at room temperature increased.

TSS had a value of 3 °Bx at 0 days, and by 3 days, it had increased to 4.6 °Bx. TSS steadily increases in value from 0 to 3 days. Due to an increase in the ripening stage, it increases exponentially from 4.6 °Bx to 15 °Bx after three days. The change in cell wall

structure and conversion of complex carbohydrates into simple sugars during storage could be to blame for the rise in total soluble solids (TSS). [37] shared similar opinions, noting that storage temperature also affects TSS levels and that TSS contents were low (14.15%) at high temperatures (25°C) in comparison to higher (16.6%) TSS concentrations at low. This is because, when the fruit ripens, the phosphorylase enzyme breaks down the fruit's carbohydrates into simple sugars, converting them from starch into soluble sugars. Because of the rise in ripening stage and conversion of starch into soluble sugars, the total soluble solid of banana fruit increased as storage duration increased.

TA and pH

During the storage period the TA value decreases and the pH value increases. The decrease in acidity may be due to the susceptibility of citric acid to oxidative breakdown affected by the aging environment [38]. An increase in pH during mango ripening was reported by other authors [39] and was similar to that observed in the present study.



Storage time (days)

Figure 7: The relationships between storage time, pH and titratable acidity

Figure 7 shows that with increasing pH, the titratable acidity decreased significantly ($p < 0.05$). The decrease in acidity may be due to its conversion to sugar and its further utilization in metabolic processes in the fruit. These results are further consistent with those of the [40] Alfonso who discovered the titratable acidity value of mangoes.

Conclusion

Physico-chemical and geometric properties of banana fruit were affected by storage time and room temperature. Therefore, storage of banana fruit for a long period of time at room temperature is not good because of physico-chemical and geometric properties were affected. As storage time increased at room temperature properties like physiological weight loss, pH, and TSS were increased. However, hardness and penetration with peel and without peel and, TA were decreased. Color value like lightness (L-value) and yellowness (b-Value) were increased and but greenness (a-value) was decreased. To extend the shelf life of banana fruits and to maintain physicochemical and geometric properties it is not necessary and recommended to store under room temperature rather than low optimum temperature. Therefore, controlling the ripening temperature is crucial for obtaining the greatest banana fruit possible within a certain marketable shelf life. Further research is needed to study the effect of longer storage time at room temperature on nutrition composition, antioxidants, size and shape of stored banana fruit.

References

1. M. Molla, D. Khanam, Z. Firoz, S. Chakma, S. Halder, and M. Salam, "In vitro production of banana plantlets and their validation at hill valleys," *SAARC J. Agric.*, vol. 15, no. 1, pp. 67–76, 2017, doi: 10.3329/sja.v15i1.33150.
2. C. G. Kuyu and Y. B. Tola, "Assessment of banana fruit handling practices and associated fungal pathogens in Jimma town market, southwest Ethiopia," *Food Sci. Nutr.*, vol. 6, no. 3, pp. 609–616, 2018, doi: 10.1002/fsn3.591.
3. J. Cauthen, D. Jones, M. K. Gugerty, and C. L. Anderson, "Banana and Plantain Value Chain: West Africa EPAR Brief No. 239," no. 239, pp. 1–25, 2013.
4. G. E. Gemechu, D. Abewoy, and K. Jaletto, "Post-harvest Loss Assessment of Banana (*Musa spp.*) at Jimma Town Market," *J. Plant Stud.*, vol. 10, no. 1, p. 23, 2021, doi: 10.5539/jps.v10n1p23.
5. Z. Woldu, A. Mohammed, D. Belew, Z. Shumeta, and A. Bekele, "Assessment of Banana Production and Marketing in Ethiopia," *Int. J. Sci. Basic Appl. Res. Int. J. Sci. Basic Appl. Res.*, vol. 24, no. 3, pp. 283–307, 2015, [Online]. Available: <http://gssrr.org/index.php?journal=JournalOfBasicAndApplied>.
6. Q. U. Hduv *et al.*, "%675 &7," vol. 5, pp. 58–64, 2010.
7. G. Wasihun and A. Desu, "Trend of cereal crops production area and productivity, in Ethiopia," *J. Cereal. Oilseeds*, vol. 12, no. 1, pp. 9–17, 2021, doi: 10.5897/jco2020.0206.
8. G. Kassa, E. Yigezu, D. A.-I. J. A. P. Res, and U. 2017, "Determinants of smallholder market participation among banana growers in bench Maji Zone, Southwest Ethiopia," *Int. J. Agric. Policy Res.*, vol. 5, no. 11, pp. 169–177, 2017, [Online]. Available: <https://journalissues.org/wp-content/uploads/sites/5/2017/11/Kassa-et-al.pdf>.
9. A. Painelli, F. Terenziani, J. Amer, and I. Ratera, "Session 1 Session 1 Session 1," no. 06, pp. 210–254, 2008.
10. "BANANA PEEL CAN BE UTILIZE AS A PROMISING ALTERNATIVE FOR," no. October, 2023.
11. J. Yusuf Sukman, "«Эпидемиологическая безопасность» No Title," *Вестник Росздравнадзора*, vol. 4, no. August, pp. 9–15, 2017.
12. C. Saha, M. Ahamed, M. Hosen, R. Nandi, and M. Kabir, "Post-harvest losses of banana in fresh produce marketing chain in Tangail District of Bangladesh," *J. Bangladesh Agric. Univ.*, vol. 19, no. 3, p. 389, 2021, doi: 10.5455/jbau.74902.
13. R. C. Ploetz, G. H. J. Kema, and L. J. Ma, "Impact of Diseases on Export and Smallholder Production of Banana," *Annu. Rev. Phytopathol.*, vol. 53, pp. 269–288, 2015, doi: 10.1146/annurev-phyto-080614-120305.
14. M. E. Mashau, "Assessment of post harvest losses of fruits at Tshakhuma fruit market in Limpopo Province, South Africa," *African J. Agric. Research*, vol. 7, no. 29, pp. 4145–4150, 2012, doi: 10.5897/ajar12.392.
15. Y. Yeshiwas and E. Tadele, "An Investigation into Major Causes for Postharvest Losses of Horticultural Crops and Their Handling Practice in Debre Markos, North-Western Ethiopia," *Adv. Agric.*, vol. 2021, 2021, doi: 10.1155/2021/1985303.
16. D. Habtamu, "Review on Contribution of fruits and vegetables in security in Ethiopia Review on Contribution of Fruits and Vegetables on Food Security in Ethiopia," *J. Biol. Agric. Healthc.*, vol. 6, no. January, pp. 49–58, 2020.
17. J. A. VázquezOvando, "Sensory and physico-chemical quality of banana fruits 'Grand Naine' grown with biofertilizer," *African J. Agric. Research*, vol. 7, no. 33, pp. 4620–4626, 2012, doi: 10.5897/ajar11.2334.
18. G. Valsamakis, A. Tsantsaridou, O. Tsantsaridou, M. Asprogianni, and S. Kalantaridou, "Participation Of Banana Intolerance in Atherosclerosis Review Of the Literature," *J. Nutr. Heal. Food Sci.*, vol. 8, no. 1, pp. 1–11, 2020, doi: 10.15226/jnhfs.2020.001173.
19. O. Of, C. For, and B. Millet, "Plant Archives," vol. 21, no. 1, pp. 1676–1680, 2021.10
20. A. O. F. Fruit *et al.*, "College of Business and Economics Department of Management College of Business and Economics Assessment of Fruit and Vegetable Export Performance By," no. June, 2014.
21. S. Almuraikhy *et al.*, "Interleukin-6 induces impairment in human subcutaneous adipogenesis in obesity-associated insulin resistance," *Diabetologia*, vol. 59, no. 11, pp. 2406–2416, 2016, doi: 10.1007/s00125-016-4031-3.
22. A. Mohapatra and Y. Bhosale, "Physicochemical Changes During Ripening of," vol. 5, no. June 2016, pp. 1340–1348, 2018.
23. H. V. D. V. Facundo, P. D. Gurak, A. Z. Mercadante, F. M. Lajolo, and B. R. Cordenunsi, "Storage at low temperature differentially affects the colour and carotenoid composition of two cultivars of banana," *Food Chem.*, vol. 170, pp. 102–109, 2015, doi: 10.1016/j.foodchem.2014.08.069.
24. M. A. Rouf, "EFFECTS OF DIFFERENT POSTHARVEST TREATMENTS ON SHELF LIFE AND QUALITY OF BANANA A Thesis MASTER OF SCIENCE (MS) IN HORTICULTURE DEPARTMENT OF HORTICULTURE BANGLADESH AGRICULTURAL UNIVERSITY MYMENSINGH," 2012.
25. S. Ahmad, "Effects of storage of bananas in controlled atmosphere before ethylene treatments on its ripening and quality Formation of Agro-Ecological Zones and Crop Suitability Maps in Punjab Province, Pakistan View project Fig production technology View project," vol. 44, no. 3, pp. 219–229, 2006, [Online]. Available: <https://www.researchgate.net/publication/238666757>.
26. J. L. Moreno, T. Tran, B. Cantero-Tubilla, K. López-López, L. A. Becerra Lopez Lavalle, and D. Dufour, "Physicochemical and physiological changes during the ripening of Banana (*Musaceae*) fruit grown in Colombia," *Int. J. Food Sci. Technol.*, vol. 56, no. 3, pp. 1171–1183, 2021, doi: 10.1111/ijfs.14851.

27. K. Pérez, J. Mercado, and H. Soto-Valdez, "Note. Effect of storage temperature on the shelf life of Hass avocado (*Persea americana*)," *Food Sci. Technol. Int.*, vol. 10, no. 2, pp. 73–77, 2004, doi: 10.1177/1082013204043763.
28. M. M. Ali, R. B. Janius, N. M. Nawi, and N. Hashim, "Prediction of total soluble solids and pH in banana using near infrared spectroscopy," *J. Eng. Sci. Technol.*, vol. 13, no. 1, pp. 254–264, 2018.
29. S. Sultan and Visvanathan Rangaraju, "Changes in colour value of banana var. Grand Naine during ripening," *Biosci. Trends*, vol. 7, no. 9, pp. 726–728, 2014, [Online]. Available: https://www.researchgate.net/publication/262419925_Changes_in_colour_value_of_banana_var_Grand_Naine_during_ripening.
30. P. Properties, "E : Food Engineering and Physical Properties," vol. 69, no. 9, pp. 478–487, 2004.
31. X. Chu *et al.*, "Green Banana Maturity Classification and Quality Evaluation Using Hyperspectral Imaging," *Agric.*, vol. 12, no. 4, pp. 1–18, 2022, doi: 10.3390/agriculture12040530.
32. C. Trakulnaleumsai, S. Ketsa, and W. G. Van Doorn, "Temperature effects on peel spotting in 'Sucrier' banana fruit," *Postharvest Biol. Technol.*, vol. 39, no. 3, pp. 285–290, 2006, doi: 10.1016/j.postharvbio.2005.10.015.
33. P. Rajkumar, N. Wang, G. Elmasry, G. S. V. Raghavan, and Y. Garipey, "Studies on banana fruit quality and maturity stages using hyperspectral imaging," *J. Food Eng.*, vol. 108, no. 1, pp. 194–200, 2012, doi: 10.1016/j.jfoodeng.2011.05.002.
34. H. Song, M. Lee, B. H. Hwang, C. T. Han, J. I. Park, and Y. Hur, "Development and application of a PCR-Based molecular marker for the identification of high temperature tolerant cabbage (*Brassica oleracea* var. Capitata) Genotypes," *Agronomy*, vol. 10, no. 1, 2020, doi: 10.3390/agronomy10010115.
35. G. Girma, "Influence of Postharvest Treatment on Physical Characteristics and Mineral Content of Mango (<i>Mangifera Indica</i> L) Fruit in Arba Minch, Southern Ethiopia," *Int. J. Nutr. Food Sci.*, vol. 5, no. 6, p. 395, 2016, doi: 10.11648/j.ijnfs.20160506.14.
36. N. Value, *Fruit and Vegetable Phytochemicals*. 2017.
37. W. Ahmed *et al.*, "The role of chitosan to prolonge the fresh fruit quality during storage of grapefruit Cv. Ray ruby," *Pakistan J. Bot.*, vol. 50, no. 1, pp. 151–159, 2018. 11
38. B. Tovar, L. I. Ibarra, H. S. Garcia, and M. Mata, "Some compositional changes in Kent mango (*Mangifera indica*) slices during storage.," *J. Appl. Hortic.*, vol. 02, no. 01, pp. 10–14, 2000, doi: 10.37855/jah.2000.v02i01.03.
39. J. Joubert, "Influence of Rind Water Content on Mandarin Citrus Fruit Quality," no. March, pp. 1–160, 2016.
40. I. J. Biosci, S. Maroof, H. A. Rathore, S. Ishaq, I. Hussain, and S. Arif, "Quality assessment of stored watercress (*Nasturtium officinale* R.Br.) vegetable at freezing temperature," *Int. J. Biosci.*, vol. 14, no. 02, pp. 121–133, 2019, doi: 10.12692/ijb/14.2.121-133.