Postharvest treatments and shelf life of some tropical fruits.

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Abstract

Fruits are perishable horticultural crops grown in tropical and subtropical areas of the world. It is a richest source of micro nutrients and phytochemicals that contributed a significant role in human health. Mango, avocado, papaya, guava and pine apple are popular and economically important tropical fruits due to their essential nutritional properties and appreciated eating quality. However, in developing countries, up to 50% of those fruits are lost after harvest due to improper postharvest handling practices. Edible coating, dip in calcium chloride solution, hot water treatment and drying are easily applicable postharvest treatments used in the preservation of such tropical fruits. Shelf life of mangoes coated using edible coating material can be extended up to 18 days without rotting and developing unpleasant flavour relative to coated guava, papaya, avocado and pine apple fruits. Dipping harvested fruits in various concentration of calcium chloride solution exhibited different storage life. Consequently, mango fruits treated with 10% of calcium chloride solution preserved for 30 days at 12°C and 85-90% relative humidity. Guava fruits treated by hot water at 45°C for 3 minute last up to 31 days under room temperature. In this review maximum shelf life up to 9 months was found for Avocado fruit dried using freeze drying method.

Keywords: Fruits, Shelf life, Edible coating, Calcium chloride, Hot water treatment, Drying

Introduction

Fruits are perishable horticultural crops that contain high amount of water (75%-90%) by wet basis. Most fruits are grown in tropical and subtropical areas of the world and are used of income generation for those who engaged in its production. Global production of tropical fruits were estimated to 100 million tonne since 2018 with increasing more than 8 million tonne from 2017 production year. From this total of world tropical fruit production developing countries share estimated to 99% of production annually [1].

Most tropical fruits have played a significant role in human diet in terms of nutritive and medicinal values. Fruits are also a richest source of micro nutrients (vitamins and minerals) as well as phytochemicals. Mango, avocado, papaya, guava and pine apple are popular and economically important tropical fruits due to their nutritional composition (vitamins, minerals, fibre and other phytochemical compounds) and appreciated eating quality (attractive colour, sweet taste and pleasant flavour) [2].

Major limitation of these tropical fruits on marketing, storage and transportation are extensive postharvest loss and shorter shelf life [3]. Postharvest losses of fruits are occurring at all stages of post-harvest operation, starts immediately after the time of harvest to its final destination due to improper postharvest handling practices [4]. Thus, postharvest losses of fruits are estimated 5-20% in developed countries and 20-50% in developing countries. Therefore, harvested fruits could be subjected to different postharvest treatments in order to preserve and ensure availability of such tropical fruits during marketing, off season and storage.

In developing countries, application of several advanced postharvest loss reduction mechanisms is important for mitigating food insecurity. Postharvest treatments will slow down the physiological processes in fresh fruits such as respiration, senescence and ripening to prolong the shelf life of fresh commodities [5]. Plenty of technologies like Hot water treatments, edible coating, postharvest thermal treatments, dipping in food grade chemicals and other non-thermal treatments have been applied on several fruit for preserving their physicochemical quality and reducing losses during postharvest life. Therefore, this article is aimed to summarize some postharvest treatments applied on selected tropical fruits and its impacts on their respective shelf life [6-8].

Literature Review

Postharvest physiology of fruits: Harvested fruits are considered as a living organism because their metabolic functions continue during postharvest life. These fruits undergo different physiological processes like respiration, ripening and senescence that must be controlled to extend products shelf life [9]. Improper management of such metabolic processes of harvested fruits during storage can contributed to major losses in both quantitative and qualitative. Respiration is the metabolic processes which utilizes oxygen to breakdown stored organic materials (carbohydrates, proteins and fats) into simple end products with a release of energy [10]. Increased respiration rate results accelerated ripening and senescence that shorten product shelf life.

There is a possibility of extended product storage life by modification of the internal gas composition of storage atmosphere that minimizes the fruits respiration rate. Ripening is part of the natural senescence of the whole fruits [11]. It is an irreversible process that contributes to changes in chemical composition, skin colour, total soluble solids, flavour and texture. It improves the fruit eating quality and shortened the postharvest life [12-15]. Ripening and natural senescence of fruits can be delayed by lower temperature, elimination of mechanical damage and reducing ethylene production [16].

Shelf life: Shelf life is the period of time that food products retained its microbial safety, nutritive value and sensorial attributes begins from the time the food is manufactured to its starts of deterioration [17]. During this period, a food product remained acceptable without significantly, losing its sensory, chemical, physical, functional, microbiological and nutritional properties under different radiation, gas concentration, redox potential, packaging material and storage condition [18-22]. Proper temperature and relative humidity are critical to obtain an extended shelf life of stored fruits. When harvested fruits stored at higher than critical temperatures set for recognized produce, the storage life will be shortened [23]. Similarly, if harvested fruits are stored at a lower than critical temperatures set by scientific organization for selected produce, their shelf life could affected by either freezing or chilling injury [24-26].

Edible coating: Edible coatings are thin layers of edible materials and environmentally safe technology that can be applied by dipping, spraying or painting on different fruits and vegetables [27]. It controls moisture transfer, oxygen or carbon dioxide migration and oxidation processes to improve the mechanical integrity or handling characteristics of the food [28-30]. In addition, edible coatings help to preserves colour, texture and volatile compounds of fresh fruits, maintain the structural integrity and protects against mechanical damages [31]. Edible coatings has a major advantage of extending the shelf life of food products, control material exchange, enhancing safety, improve nutritive value, sensory attributes and attractiveness of food products because of active ingredients incorporated to food matrix during coating [32].

The success of edible coatings for fresh products totally depends on the control of internal gas composition [33]. Several specific requirements described for edible coating by Arvanitoyannis and Gorris, are manifested that it could have good barrier to water, not deplete oxygen or build up excessive carbon dioxide, a minimum of 1%-3% oxygen is required a to avoid a shift from aerobic to anaerobic respiration, reduce water vapour permeability, carry active agents (antioxidants, vitamins, etc.) and retain volatile flavour compounds [34], melt above 40°C without decomposition, easily emulsifiable, never interfere with the quality of fresh fruit, should have low viscosity and be economical [35].

Different types of edible coatings can be prepared from protein, carbohydrate, lipid materials and their derivatives. Edible coating also contains food grade plasticizers, additives, antioxidants and antimicrobial compounds that can be applied to many fruits and fruit products [36]. Carbohydrate based edible coatings like polysaccharides, starch, modified starch; chitosan and pectin are commonly used among natural bio polymer [37]. Edible coatings processed from cassava starch applied to strawberries were contributed efficiently in reducing respiration rate, delaying weight loss, firmness loss and retained its sensorial acceptability during storage period [38].

Protein based edible coatings have good film forming properties and good adherence to hydrophilic surfaces [39]. Lipid based edible coatings are the hydrophobic, block the transport of moisture and water vapour, improve surface appearance, maintain quality attributes and prolong the postharvest life of some fruits [40-42]. Waxes are the most efficient lipid based edible coatings substances to decrease the water vapour pressure and was the first coating used in fruits especially in citrus fruits [43].

Increased shelf life at least three days relative to uncoated fruit were reported by Gallo for guava fruit coated in immersion solution consisting between 5 and 10% of Potato starch, sodium alginate, carrageenan, pectin and glycerol between 10 and 30% at 50°C, then dried at 50°C for 30 minutes stored at 25°C and 50%-70% Relative humidity [44]. The potato starch and pectin based coatings are highly efficient and good in the preservation of the sensorial characteristics of the fruit (size, yellow colour and aroma) with 15 days [45].

Shelf life of waxed mango fruit exceeds up to four days than non-waxed mango fruit exhibited shelf stable up to 15 days that stored at room temperature [46]. According to research finding by Srinivasa, mango fruits stored in chitosan covered boxes indicated an extension of shelf life up to 18 days and without any microbial growth and off flavour. Extended shelf life up to 13 days was recorded for Papaya fruits treated with 5% of wax emulsion while 9 days noted for untreated papaya fruit stored at room storage condition [47].

Avocado fruits coated with gelatine corn starch films have shown increased in shelf life by reducing moisture migration, gas exchange and delaying over repining. In addition, pine apple treated using Alginate based edible coating containing 0.3% (w/v) lemongrass showed extended shelf life for 10 days by arresting physiological changes of pine apple fruits stored at 10°C and 65% relative humidity [48]. Gellan edible coating composed of gellan gum 0.56% (w/v), glycerol 0.89% (w/v) and sunflower oil 0.025% (w/v) considerably lowers the respiration rate, reduces weight loss and preserves the stiffness, colour and sensory attributes of freshly sliced pineapple in low temperature conditions. After 16 days of storage at 5°C, there was no significant difference in the pH, titratable acidity and TSS of coated and untreated samples. Cut pineapple can be kept fresh for a long time in the refrigerator with the help of the gellan edible coating solution.

Discussion

Calcium chloride treatments: Post harvest application of calcium may delay senescence in fruits with no detrimental effect on consumer acceptability. Calcium chloride application on harvested fruits could have valuable role to prevent mechanical and physiological damage on fruit by making fruit cell walls hard and inhibit enzyme production of fungi and bacteria that cause fruit rotting [49]. Shelf life up to 15.32 days was observed for papaya fruits treated with 3.0% of $CaCl_2$ as compared to untreated fruits attained shelf life of 9 days. Similar research report by Priyanka showed that papaya fruits treated in $CaCl_2$ at 2% extended the shelf life of fruit more than 9 days of storage.

In other way, Guava fruits treated for 2 to 4 minutes in 1% and 2% of calcium chloride recorded a potential shelf life of more than 9 days under room storage condition [50]. According to Galvis extended shelf life up to 30 days was noted for mango fruits dipped in 10% of calcium chloride solution at ambient temperature and stored at 12°C and 85%-90% relative humidity. Similarly, Calcium chloride ($CaCl_2$) treatment significantly reduced relative weight loss, delayed the development of purple skin colour, blemishes, disease incidence and severity in avocado fruits stored for 18 days compared to untreated control [51].

Calcium chloride ($CaCl_2$) can also change intracellular and extracellular processes that can slow down fruit ripening, maintain cell walls so that it can inhibit fruit softening and reduce mechanical and microbiological damage [52]. Mold incidence and severity appeared on pineapple dipped in the$CaCl_2$ solution after the 16^{th} day of storage but it exhibited better sensory properties, particularly on texture, colour and overall acceptance after storage for 40^{th} days. Extended shelf life was reported by Youryon and Wongs for Pineapple fruits immersed in 1%, 2% and 3% of $CaCl_2$ solution and kept under mild low temperature storage condition [53].

Hot water treatment: Hot water treatments are postharvest thermal treatments that applied on fruits by immersion, rinsing and brushing at desired temperature ranges and duration for retaining quality and microbial safety of fresh fruits. It is effective, particularly for fungal pathogen control because fungal spores and latent infections are either on the surface layers or under the peel of the fruit. The application of hot water treatments on different fruits have been increased in order to disinfestations of insect pests, prevent fungal rots and increase fruit resistance to chilling injury.

The use of hot water as a disinfestations and maintaining quality of fresh fruits are affected by number of factors including maturity stage, cultivar type, temperature and duration. Many fruits tolerate exposure to water temperatures of 50°C-60°C for up to 10 min, but shorter exposure at these temperatures can control many post-harvest plant pathogens. In contrast, hot water dips for fruit require 90 min exposure to 46°C. Several Authors reported that hot water treatment of fruits at different temperatures for several minutes to hour was applied for maintaining fruit quality during marketing and storage.

Hot water treatment of mango fruits resulted reduced post-harvest decay, improved colour, appearance of mango fruits. Mango fruit preliminarily treated with hot water significantly maintained firmness during 7 days of storage at ambient conditions. Hot water treatment could reduce disease incidence and maintain postharvest quality during storage and prolong the shelf life of papaya fruit. Extended storage stability and marketability was reported for Pineapple and avocado fruits treated by hot water at different temperature and time combination. Related research finding revealed that Guava fruits treated with hot water at 45°C for 3 minute last up to 31 days under room temperature of 5°C ± 2°C and 85 to 90% relative humidity.

Drying: Drying is one of the oldest, simple, cost effective, safe and wide spread methods of food preservation. It removes a large amount of water contained in products so that the growth of microorganisms and reaction lead to deterioration are inhibited. It also reduces the weight and bulk of fruits which reduces transport and storage costs. Successful and appropriate fruit drying techniques produce healthy dried fruit products with good flavour, texture and colour. Despite, drying does not improve food quality to obtain desired preservation and good quality of dried products sort and select the best quality of fruits for drying.

Solar drying: It is the most effective method of drying foods using solar energy and in use in many parts of the world. It is cheaper as it has little or no equipment costs and the produce has to spread on suitable surface and allowed to dry in the sun. Fruits dried in the solar dryer are placed on trays made of screen or wooden dowels, stainless steel, teflon coated fiberglass or plastic. Solar drying technology seems to be one of the most promising alternatives to reduce the postharvest losses, extend shelf life with much preserved colour and texture. Mangoes and pineapples dried in different solar drying and stored in low and high density polyethylene packaging containers could last up to more than six months.

Freeze drying: It is also known as lyophilisation or cryodesiccation is a water removal process typically used to preserve a perishable agricultural commodity or make the commodities more convenient for transport and storage [54]. Freeze drying works by freezing the material and then reducing the surrounding pressure to allow the frozen water in the material to sublimate directly from the solid phase to the gas phase. Freeze Drying (FD) is the best method of dehydration as it gives a final product of the highest quality without heat compared to other methods of food drying. Different fruits dried under freeze drying method exhibited improved colour and maximum retention of vitamin C, chlorophyll, flavour and taste [55].

Fruits dried under modern freeze dryer have a longer shelf life without releasing as much of their nutritional content and sensory characteristics [56]. High quality with preserved colour of Pollock avocado powder to be used in various food applications was obtained using freeze drying method. Avocado fruit dried using freeze drying method have a shelf life of up to 9 months with exhibited slight changes in nutritional quality and sensorial properties.

According to Patel, guava fruits were effectively preserved for long time with low adverse health effects when subjected to freeze drying condition. Similar research finding reported by Jangam, revealed that freeze dried mangoes, avocados and pineapples retained their sensory characteristics and shelf stabilities. The very low water content of freeze dried fruits helps them to have a longer shelf life. However, freeze dried fruits have a high moist air absorption tendency and additional barrier to water absorption solutes such as Arabic gum, tricalcium phosphate and malto-dextrin should be added to increase its shelf stability [57].

Conclusion

Applications of different postharvest treatments to fruits are highly encouraged to preserve and reduce their postharvest loss. Appropriate edible coating materials, hot water treatment, dip in optimum concentration of calcium chloride solution and drying under suitable drying methods are easily applicable postharvest treatments used in the preservation of perishable tropical fruits. Those postharvest treatments have considerable role in ensuring fruits shelf stability, up to 9 months.

References

1. Aguilar-Mendez M, Martin-Martinez SE, Tomas SA, et al. Gelatine starch films: Physicochemical properties and their application in extending the postharvest shelf life of avocado (*Persea americana).* J Sci Food Agric. 2008;88(2): 185-93.
2. Altendorf S. Major tropical fruits market review. FAO (Food and Agriculture Organization of the United Nations). Rome, 2019.
3. Arvanitoyannis I, Gorris LGM. Edible and Biodegradable Polymeric Materials Food Packaging or Coating, CRC Press, Florida, 1999;357-371.
4. Azarakhsh N, Osman A, Ghazali HM, et al. Effects of gellan based edible coating on the quality of fresh cut pineapple during cold storage. Food Bioproc Technol. 2014;7(7):2144-51.
5. Azarakhsh N, Osman A, Ghazali HM, et al. Lemongrass essential oil incorporated into alginate based edible coating for shelf life extension and quality retention of fresh cut pineapple. Postharvest Biol Technol. 2014;88:1-7.
6. Barkai-Golan R, Phillips DJ. Postharvest heat treatment of fresh fruits and vegetables for decay control. Plant Dis. 1991;75(11):1085-9.
7. Bodini R, Sobral P, Favaro-Trindade C, et al. Properties of gelatin based films with added ethanol propolis extract. LWT-Food Sci Technol. 2013;51(1):104-10.
8. Castaneda-Saucedo M, Valdés E, Delgado A, et al. Effect of freeze drying and production process on the chemical composition and fatty acids profile of avocado pulp. 2014.
9. Ceballos A, Giraldo G, Orrego C, et al. Effect of freezing rate on quality parameters of freeze dried soursop fruit pulp. J Food Eng. 2012;111(2):360-5.
10. Dhall RK. Advances in edible coatings for fresh fruits and vegetables: a review. Crit Rev Food Sci Nutr. 2013;53(5): 435-50.
11. Djioua T, Charles F, Lopez-Lauri F, et al. Improving the storage of minimally processed mangoes (*Mangifera indica L.)* by hot water treatments. Postharvest Biol Technol. 2009;52(2):221-26.
12. Doymaz I. Influence of blanching and slice thickness on drying characteristics of leek slices. Chem Eng Process. 2008;47(1):41-7.
13. Esper A, Muhlbauer W. Solar drying-an effective means of food preservation. Renew Energy. 1998;15(1-4):95-100.
14. Gallo JQ, Amaro MD, Cabrera DM, et al. Application of edible coatings to improve shelf life of Mexican guava. Acta Hortic. 2003;589-94.
15. Galvis JA, Arjona H, Fischer G, et al. The effects of applying calcium chloride solution (CaCl2) on Van Dyke mango fruit (*Mangifera indica* L.) storage life and quality. 2003.
16. Garcia JM, Aguilera C, Albi MA, et al. Postharvest heat treatment on Spanish strawberry (Fragaria X ananassa cv Tudla). J Agric Food Chem. 1995;43(6):1489-92.
17. Garcia LC, Pereira LM, Sarantopoulos CIG, et al. Effect of antimicrobial starch edible coating on shelf life of fresh strawberries. Packag Technol Sci. 2012;25(7):413-25.
18. Hasmoro HBS, Trisnowati R. Effects of $CaCl_2$ on the Degradation of the Framework and Age of Buah Sawo (*Manilkara zapota L.*) van Royen). Vegetable J. 2014;3(4): 52-62.
19. Hu Q, Zhang M, Mujumdar AS, et al. Effects of different drying methods on the quality changes of granular edamame. Dry Technol. 2006;24(8):1025-32.
20. Huang S, Zhu G, Qin L, et al. Enhancement of efficacy in controlling postharvest decays and extending shelf life of mangoes by combined Pre and postharvest chemical applications. Int J Agric Biol. 2012;14(2):176-82.
21. Husen R, Andou Y, Ismail A, et al. Enhanced polyphenol content and antioxidant capacity in the edible portion of avocado dried with superheated steam. Int J Adv Res. 2014;8:241-8.
22. Irzyniec Z, Klimezak J, Michalowski S, et al. Freeze drying of the black currant juice. Dry Technol. 1995;13(1-2): 417-12.
23. Jangam SV, Joshi VS, Mujumdar AS, et al. Studies on dehydration of Sapota (*Achras zapota*). Dry Technol. 2008;26(3):369-77.
24. Kays SG. Postharvest physiology of perishable plant products. 1991;266.
25. Killadi B, Guarj PS, Lenka J, et al. Optimization of hot water treatment of guava fruits cv.'Shweta' to prolong cold storage. Int J Chem Stud. 2021;9(1):410-5.

26. Kokoszka S, Lenart A. Edible coatings formation, characteristics and use: a review. Pol J Food Nutr Sci. 2007;57:404-11.
27. Kumah P, Appiah F, Opoku-Debrah JK, et al. Effect of hot water treatment on quality and shelf life of Keitt mango. 2011;2(5):806-17.
28. Li X, Zhu X, Zhao N, et al. Effects of hot water treatment on anthracnose disease in papaya fruit and its possible mechanism. Postharvest Biol Technol. 2013;86:437-46.
29. Lurie S. Postharvest heat treatments. Postharvest Biol Technol. 1998;14(3):257-69.
30. Mandal D, Sailo L, Hazarika TK, et al. Effect of edible coating on shelf life and quality of local mango cv. Rangkuai of Mizoram. Res Crops. 2018;19(3):419-24.
31. Bhooriya MS, Bisen BP, Dongre R, et al. Effect of postharvest treatments on shelf life and physicochemical changes of guava fruits. Int J Chem Stud. 2019;7(6): 3096-9.
32. Marques LG, Silveira AM, Freire JT, et al. Freeze drying characteristics of tropical fruits. Dry Technol. 2006;24(4): 457-63.
33. Minh NP. Influence of hot water treatment to quality properties of pineapple (*Ananas comosus)* fruit during storage. Food Res. 2021;5(5):186-94.
34. Mishra M. Lead acetate induced cytotoxicity in male germinal cell of swiss mice. Ind Health. 2003;41(3):291-4.
35. Mongi RJ. Solar drying of fruits and vegetables: dryers' thermal performance, quality and shelf life of dried mango, banana, pineapple and tomato. 2013.
36. Mosquera L, Moraga G, Martínez N, et al. Critical water activity and critical water content of freeze dried strawberry powder as affected by maltodextrin and Arabic gum. Food Res Int. 2012;47(2):201-6.
37. Mujaffar S, Dipnarine TA. The production of a dried avocado (*Persea americana) powder*. Precede Int Conference Emerg Trends Eng Technol. 2020;44-54.
38. Mulokozi G, Svanberg U. Effect of traditional open sun drying and solar cabinet drying on carotene content and vitamin a activity of green leafy vegetables. J Plant Foods Hum Nutr 2003;58(3):1-15.
39. Munhuweyi K, Mpai S, Sivakumar D, et al. Extension of avocado fruit postharvest quality using nonchemical treatments. Agron. 2020;10(2):212.
40. Mutui TM, Kimeu EN, Opile WR, et al. Effect of postharvest treatments on the quality and shelf life of avocado (*Persea americana* Mill.). Afr J Hort Sci. 2011;5.
41. O'Sullivan A, Shaw NB, Murphy SC, et al. Extraction of collagen from fish skins and its use in the manufacture of biopolymer films. J Aquat Food Prod Technol. 2006;15(3): 21-32.
42. Patel P, Sunkara R, Walker LT, et al. Effect of drying techniques on antioxidant capacity of guava fruit. Food Nutr Sci. 2016;7(7):544.
43. Pholoma SB, Emongor V, Tshwenyane S, et al. Physicochemical attributes in mango fruit (*Mangifera indica)* as influenced by storage temperature and hot water treatment. J Exp Agric Int. 2020;42(1):133-41.
44. Poubol J, Techavuthiporn C, Kanlayanarat S, et al. Guava fruit treated with hot water on microbiological quality of fresh cut 'Kimju' and 'Pan Srithong'guava. Int Food Res J. 2018;25(3):903-907.
45. Priyanka S, Sanjay K, Sutanu M, et al. Effect of calcium chloride on postharvest changes in papaya fruits. Asian J Hort. 2012;7(1):113-7.
46. Prusky D, Fuchs Y, Kobiler I, et al. Effect of hot water brushing, prochloraz treatment and waxing on the incidence of black spot decay caused by Alternaria alternata in mango fruits. Postharvest Biol Technol.1999;15(2):165-74.
47. Sandarani MD, Dasanayaka DC, Jayasinghe CV, et al. Strategies used to prolong the shelf life of fresh commodities. J Agric Sci Food Res. 2018;9(1):1-6.
48. Shishehgarha F, Makhlouf J, Ratti C, et al. Freeze drying characteristics of strawberries. Dry Technol. 2002;20(1): 131-45.
49. Singh RK, Singh N. Quality of packaged foods. Innovations Food Packag. Academic Press. 2005;24-44.
50. Srinivasa P, Baskaran R, Ramesh M, et al. Storage studies of mango packed using biodegradable chitosan film. European Food Res Technol. 215(6):504-8.
51. Srinu B, Joshi V, Reddy N, et al. Effect of different postharvest treatments on quality and shelf life of papaya. J Pharmacogn Phytochem. 2017;6(5):1788-92.
52. Tamalea RR, Haryanti P, Wibowo C, et al. Application of dipping on $CaCl_2$ as a postharvest treatment to maintain the quality of pineapple during storage. Asia Pacific J Sustain Agric Food Energy. 2021;9(2):38-45.
53. Temu A, Chove B, Ndabikunze B. Development of enterprise in solar drying of fruit and vegetables for employment creation, Tanzania, 2008;15.
54. Valentina V, Pratiwi RA, Hsiao PY, et al. Sensorial characterization of foods before and after freeze drying. J Aust Food Sci. 2016;1(6):1-5.
55. Wiriya P, Paiboon T, Somchart S, et al. Effect of drying air temperature and chemical pretreatments on quality of dried chilli. Int Food Res J. 2009;16:4-7.
56. Yahia EM, Ariza FR. The Mango. Spanish, 2009;224.
57. Youryon P, Wongs-Aree C. Postharvest application of calcium chloride affects internal browning reduction during low temperature storage of 'Sawi' pineapple. Acta Hortic. 2015;1088:197-200.

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