Review Article

Post-Harvest Methodology and Technology for Horticultural Products in Agricultural Commercial Areas of Pakistan

Asfand Raheel[1], Syed Zulfiqar Ali[2], Muhammad Waris[2], Muhammad Basharat[2], Basheer Ahmed[2], Muhammad Arshad Ullah[3], Syed Ishtiaq Hyder[4] and Taqi Raza[4*]

[1]Institute of Horticultural Sciences, University of Agriculture, Faisalabad, Pakistan; [2]Department of Plant Pathology, Baluchistan Agriculture College, Quetta, Pakistan; [3]Pakistan Agricultural Research Council, Islamabad. Pakistan; [4]National Agricultural Research Centre Islamabad, Pakistan.

Abstract | Electronic nose is an instrument, which comprises an array of electronic chemical sensors with partial specificity and an appropriate pattern-recognition system, capable of recognizing simple or complex odors. In the food industry, electronic nose is popularly used to detect smells and flavors of a wide range of food items. Latest steps are required for postharvest management through which the economy of horticultural products around the globe is almost at minimal losses. This review is highlighting the basic but truly important postharvest advancements to retain and maintain quality and quantity of vegetables and fruits. Significant outcomes are to be ensured in pre-harvest and postharvest handling and controlling the postharvest decay losses with these advanced techniques. Keeping an eye on good agricultural practices (GAP) standards, new advanced approaches should be reflected as gear of a combined decay control strategy. Postharvest decay is totally dependent upon harvest and handling practices. Environmental conditions mainly affect the fruit infection and source of contamination under subtropical climate while in tropical climates contamination of horticultural products affecting postharvest decay. Packaging of products in the fields may reduce the production costs but it heavily increased the postharvest decay. Mechanical damage impact can be identified the post-harvest decay by developing regression models. Additionally, new packaging materials have been introduced to avoid mechanical injuries and decline the chances of contamination, bruises and decays. Postharvest treatments includes biological agents, fungicides, herbal and natural products, edible coatings and heat treatments can be efficaciously applied in a vast and specific commodity range to prevent great losses.

Received | April 20, 2021; **Accepted** | July 07, 2021; **Published** | August 18, 2021
***Correspondence** | Taqi Raza, National Agricultural Research Centre Islamabad, Pakistan; **Email:** taqiraza85@gmail.com
Citation | Raheel, A., S.Z. Ali, M. Waris, M. Basharat, B. Ahmed, M.A. Ullah, S.I. Hyder and T. Raza. 2021. Post-harvest methodology and technology for horticultural products in agricultural commercial areas of Pakistan. *Pakistan Journal of Agricultural Research,* 34(4): 700-705.
DOI | https://dx.doi.org/10.17582/journal.pjar/2021/34.4.700.705
Keywords | Climatic conditions, Fungicide and mycotoxin contamination, Mechanical harvesting, Pre and post-harvest storage

Introduction

30 to 40 percent of the total production is spoiled and wasted due to lack of post-harvest management in agricultural sector of developing countries up to the consumption. In the world, the total fruit and vegetable production has approximately 392 to 486 million tons respectively. Considering the post-harvest methodologies and technologies, reduction in qualitative and quantitative losses of horticultural products maintains the overall product up to the customer consumption. For higher postharvest longevity, acquiring the hygienic agricultural practices should be priority (Wasala *et al*., 2014). Several factors

like market availability, transportation facilities, food preservation techniques, harvesting and handling methods play an important role in post-harvest loses of horticultural goods. By taking advantage from the latest techniques and approaches, the developed states have reduced the losses in postharvest up to some mark but un-availability of mechanized methods and lack of awareness the developing countries are facing an immense challenge (Hodges *et al*., 2011). Weight and volume deterioration are considered under quantitative measurements while nutrient, color, aroma defined as the qualitative losses (Buzby and Hyman, 2012).

Because of both pre-post factors, decays may occur in products and the cause of pre harvest concealed contamination or infection during harvest. These latent infections further develop into symptomatic disease during storage, transportation and marketing of mostly fleshy horticultural products. The shelf and table life of vegetables and fruits partly depends upon pre-harvest managements and partly on post-harvest handling. Efficient and sensible handling methods should be considered which are low in cost but high in profit afterwards when they prevent postharvest decay. It is an unelectable issue for the life of commodity and simultaneously maintains the nutritional value of the products (Michailides and Manganaris, 2009).

Over the last two decades, postharvest technology has evolved, there's insufficient importance on pre-harvest factors and its influence on postharvest decay. During or before post harvesting, initial steps are taken to avoid decay issues. Removal of propagules, which infects the crop in the field are the cause of latent inborn infection which plays an important fact in postharvest management. Significance of these processes, majority of agricultural industries that are dealt with horticultural products and by-products have established a guide line known as good agricultural practices (GAP) These GAP should be started as soon crops are on bloom till harvest.

Objectives

- To minimize horticultural products losses during harvesting to costumer consumption.
- To maintain products quality through sustaining qualitative determinations i.e. Exterior, texture, aroma and nutritive value.

Materials and Methods

Following are the contextual framework based on three primary basic methodologies i.e. qualitative, quantitative and mixed methods based on studies and surveys.

Edible coatings and natural products

In highly perishable fruit products, edible coatings are innovative and alternative means in postharvest chemical treatment (Valverde *et al*., 2005; Martinez-Romero *et al*., 2006). Their rate of succession is high giving a promising outcome in extending shelf life. During processing, these edible coatings act as a barrier during packaging, processing and in storage which ultimately enhance the quality and slow down the deterioration process. They are safe in use because they are made-up of natural biocides (antimicrobial compounds) (Petersen *et al*., 1999). Zein, alginate, starch, lipids, cellulose, milk proteins and wax are mainly used as edible coating on products (Cha and Chinnan, 2004). At commercial level, characteristics such as barrier properties, adhesion, low in cost and simple for production (Diab *et al*., 2001). In means of preservation, *aloe vera* gel has been used for quality maintenance and to avoid fungal activity or other pathogens *A. alternate*, *P. digitatum*, *P. expansum* and *B. cinerea* (Saks and Barkai, 1995) and can be extended to other commodities (Valverde *et al*., 2005).

Fungicides treatment

Because of high efficacy, many new fungicides replaced previously materials in managing the diseases of pre-harvest and postharvest of stoned fruit. Boscalid, cyprodinil, fenhexamid, pyrimethanil and pyraclostrobin have been very effective against brown rot fungi which is the main cause of fruit decay (Adaskaveg *et al*., 2005).

Inorganic compounds application

Microbial antagonists having potential when applied after harvesting than in the field. But these postharvest bio agents cannot control latent infections (Ippolito and Nigro, 2000). The influence of antagonistic yeast (Pichia membranaefaciens) on improving oxidative stress caused by (*P. expansum*) in cherries at maturity stage revealed no decay in yeast treated fruits up to 5 days after inoculation (Xu and Tia, 2008). The authors emphasized the antioxidant defense as an essential mechanism of antagonistic yeast in justifying pathogen induced oxidative stress to post-harvest

Links Researchers

produces and controlling post-harvest diseases.

Biological agents

Bio products i.e. nonpathogenic Pseudomonas strains ESC_{10}, ESC_{11} gave adaptable results and other products like ionized copper, calcium chloride, hydrogen dioxide and potassium carbide were ineffectual in managing soft rot (Edmunds and Holmes, 2009). Other ingredients like vinegar and acetic acid were very nominal in reducing the postharvest decay of pome and stone fruits (Sholberg and Gaunce, 1996).

Heat treatments

Over the last few years, horticultural crops were treated with heat effects after harvesting and their results are recently acknowledged (Mulas and Schirra, 2007).

Post-harvest technologies

Several preservation technologies like cold storage, modified-atmosphere packaging (MAP) and edible coating have been used for assured the vegetables and fruits; safe and hygiene.

Cooling

During storage and processing of vegetables and fruits, pre-cooling declines the temperature up to the level where it minimizes the chemical changes in the food product (Wijewardane, 2014). Researcher advised that maintaining temperature in storage rooms and cold rooms are suitable for products because it reduces the heat up to 75-90% but the hydro-cooling cleaning system reduced the temperature five times faster than air cooling systems. Examples are of broccoli and sweet corn which were cooled with liquid icing. General estimation is found that half kg of ice reduced the temperature of 1.5 kg of the food product. For leafy vegetables, vacuum cooling was preferable because the vacuum removes the heat from the leaf tissues through vacuum pressure without drying them up (Bachmann and Earles, 2000).

Storage

Physiochemical quality of fruits at maturity level during storage minimized the total sugar level and decay process. Product maturity affects the quality parameters like total soluble solid (TSS) and total sugar content (TSC), weight and shelf life (Siddiqui *et al*., 2013a, b). It also observed in the mango which gradually increases with the increasing in time of storage (Roma *et al*., 2005). To prevent the mineral and vitamin losses, several vegetables and fruits require appropriate relative humidity (RH) and temperature (Abadias, 2008).

Packaging

By controlling the atmospheric oxygen and carbon dioxide within the packaging of products increased the shelf life of any product (Yumbya *et al*., 2014). Workneh *et al*. (2012) found in their observation that preserving the fresh vegetables and fruits up to long period without any quality deterioration, active packaging is most suitable.

Active packaging

Active packaging is the efficient barrier for moisture and gas emission during storage and marketing periods, which reduced the contamination chances and facilitated the handling processes (Ozdemir and Floros, 2004). Active packaging performance is the most suitable for numerous fruits and vegetables (Han and Floros, 2007). This type of active packaging system worked as reducer of oxygen which mainly decreases the respiration process of the packed commodities and carbon dioxide which increased the temperature of the product that retards the growth of micro-organisms. The moisture reduction the fastly controls the deterioration of the products. We can regulate time and temperature by indicators.

Perforated films

Perforated films kept the fruit and vegetable safe because of gaseous exchange through perforated layer as well as the entrance of gasses from polymeric film are balanced through gaseous movement rate (Fishman *et al*., 1996).

Modified atmospheric packaging

Modified atmospheric pressure (MAP) enhanced the table life of the product. Through this, the fruit life is increased from 3 to 4 weeks at 100 degrees which shows the best result than 1 week without modified packaging (Mohamed *et al*., 1996). This method decreases the ethylene production which reduces the enzymatic activity and improves the tomato quality with 3 percent oxygen and 20 percent carbon dioxide level (Sozzi *et al*., 1999). Ayhan *et al*. (2008) compared that carrots stored at 80 percent oxygen and 10 percent carbon dioxide extended the shelf life than at 5 percent oxygen. Through advance packaging technologies, different compositions can prevent the deterioration and increasing the shelf life of the horticultural products under cold storage (Argenta, 2004).

Future research

In post-harvest bio-control strategy and mode action of antagonistic yeast in postharvest diseases control play an important role by providing significant guidance for further research. In addition, biological agents with low risk fungicides should be carried out side by side to identify the best suitable for postharvest treatment with minimum environmental impact and taking in view the customer safety. Comparative studies are also required for the harvested products from conventional, integrated and organic production systems should also be carried out.

Future approach technologies

Keeping an eye on world population which rapidly increases expected in 2050 are 10.50 billion approximately which means the per capita demand of horticultural products has been increased. We can meet the difference by controlling the post-harvest losses. According to Kader and Rolle (2004) out of 100 the 95 percent research investment is directed to enhance the horticultural productivity in which only 5 remaining percent investment is involved in the postharvest losses reduction. Serious research and investment are required to minimize the losses especially in developing countries. Very limited resources were used for extension and research in postharvest processing of horticultural products during past 20 years (Kitinoja *et al*., 2011).

Conclusions and Recommendations

Numerous innovations and methods have developed which directly affects the quality of agricultural products and decrease the post-harvest decay. The ultimate goal is to provide safe and healthy product to the consumers with maximum organic residues and lower the chemical application and there is no doubt in that the handling of these agricultural products have direct effect on postharvest decay. No compromise on the health especially on life of products in storages to market till retailed stored periods. To overcome the scarcity of products, more emphasis is required around the globe. It will definitely increase the availability (per capita) by using modern technologies and just because of losses reduction without enforcing any other resources for enhancing the productivity and so production.

Novelty Statement

This work has been established on the basis of latest methodologies. With the up to date data, the said review paper is need of the day for commercial area of Pakistan where the negligence in packaging and processing of the agricultural goods to avoid and overcome the post-harvest losses. All the aspect and possibilities has been reviewed.

Author's Contribution

Asfand Raheel: Conceived the idea and write the paper according to idea.
Syed Zulfiqar Ali: Prepared the review paper outlines and provided technical input each step.
Muhammad Waris: Wrote the abstract and keywords.
Muhammad Basharat: Collected the data and shared with the team for collaborative work.
Basheer Ahmed: Formatted the paper according to the journal requirements.
Muhammad Arshad Ullah: Technically improve the structure and back ground of the review paper.
Syed Ishtiaq Hyder: Improve the English and grammar of the manuscript.
Taqi Raza: Arranged the reference and citation if the paper according to journal requirement. Submitted final manuscript.

Conflict of interest

The authors have declared no conflict of interest.

References

Abadias, M., 2008. Microbiological quality of fresh, minimally-processed fruit, vegetables and sprouts from retail establishments. Int. J. Food Microb., 123: 121–129. https://doi.org/10.1016/j.ijfoodmicro.2007.12.013

Adaskaveg, J.E., H. Forster, W.D. Gubler, B.T. Teviotdale and D.F. Thompson. 2005. Reduced-risk fungicides help manage brown rot and other fungal diseases of stone fruit. California Agric., 59: 109–114. https://doi.org/10.3733/ca.v059n02p109

Argenta, L.C., 2004. Production of volatile compounds by Fuji apples following exposure to high CO_2 or low O_2. J. Agric. Food Chem., 52: 5957–5963. https://doi.org/10.1021/jf049495s

Ayhan, Z., O. Esturk and E. Tas. 2008. Effect of modified atmosphere packaging on the quality and shelf life of minimally processed carrots. Turk. J. Agric., 32: 57–64.

Bachmann, J. and R. Earles. 2000. Postharvest handling of fruits and vegetables. Appropriate technology transfer for rural areas. NCAT Agric. Special., pp. 1-19.

Buzby, J.C. and J. Hyman. 2012. Total and per capita value of food loss in the United States. Food Policy, 37: 561-570. https://doi.org/10.1016/j.foodpol.2012.06.002

Cha, D.S. and M.S. Chinnan. 2004. Biopolymer-based antimicrobial packaging: A review. Crit. Rev. Food Sci. Nutr., 44: 223– 237. https://doi.org/10.1080/10408690490464276

Diab, T., C.G. Biliaderis, D. Gerasopoulos and E. Sfakiotakis. 2001. Physicochemical properties and application of pullulan edible films and coatings in fruit preservation. J. Sci. Food Agric., 81: 988–1000. https://doi.org/10.1002/jsfa.883

Edmunds, B.A. and G.J. Holmes. 2009. Evaluation of alternative decay control products for control of postharvest Rhizopus soft rot of sweet potatoes. APS Net February Feature: APS, St. Paul MN. https://doi.org/10.1094/PHP-2009-0206-01-RS

Fishman, S., V. Rodov and S. Ben-Yehoshua. 1996. Mathematical model for perforation effect on oxygen and water vapor dynamics in modified-atmosphere packages. J. Food Sci., 61: 956-961. https://doi.org/10.1111/j.1365-2621.1996.tb10910.x

Han, J.H. and J.D. Floros. 2007. Active packaging. In: Tewari, G. and Juneja, V.K., editors. Advances in Thermal and Non-Thermal Food Preservation. Ames, Ia: Blackwell Professional, pp. 167–183.

Hodges, R.J., J.C. Buzby and B. Bennett. 2011. Postharvest losses and waste in developed and less developed countries: Opportunities to improve resource use. J. Agric. Sci., 149: 37-45. https://doi.org/10.1017/S0021859610000936

Ippolito, A. and F. Nigro. 2000. Impact of preharvest application of biological control agents on postharvest diseases of fresh fruits and vegetables. Crop Prot., 19: 715–723. https://doi.org/10.1016/S0261-2194(00)00095-8

Kader, A.A. and R.S. Rolle. 2004. The role of postharvest management in assuring the quality and safety horticultural crops. Food and agriculture organization. Agric. Ser. Bull., 152: 52.

Kitinoja, L., S. Saran, S.K. Roy and A.A. Kaderc. 2011. Postharvest technology for developing countries: challenges and opportunities in research, outreach and advocacy. J. Food Sci. Agric., 91: 597–603. https://doi.org/10.1002/jsfa.4295

Martinez-Romero, D., N. Alburquerque, J.M. Valverde, S.C.D.V. Guillen and M. Serrano. 2006. Postharvest sweet cherry quality and safety maintenance by Aloe vera treatment: A new edible coating. Postharv. Biol. Tech., 39: 93–100. https://doi.org/10.1016/j.postharvbio.2005.09.006

Michailides, T.J. and G.A. Manganaris. 2009. Harvesting and handling effects on post-harvest decay. Stewart Post-harvest Rev., 2: 2-7. https://doi.org/10.2212/spr.2009.2.3

Mohamed, S., B. Taufik and M.N.A. Karim. 1996. Effect of modified atmosphere packaging on the physiochemical characteristics of ciku (*Achrassapota* L) at various storage temperature. J. Sci. Food Agric., 70: 231–240. https://doi.org/10.1002/(SICI)1097-0010(199602)70:2<231::AID-JSFA489>3.0.CO;2-V

Mulas, M. and M. Schirra. 2007. The effect of heat conditioning treatments on the postharvest quality of horticultural crops. Stewart Postharv. Rev., 3: 1-6. https://doi.org/10.2212/spr.2007.1.2

Ozdemir, M. and J.D. Floros. 2004. Onions: Postharvest Operation, Organization: Massey University, Private Bag, Active food packaging technologies. Crit. Rev. Food Nutr., 44: 185–193. https://doi.org/10.1080/10408690490441578

Petersen, K., P.V. Nielsen, G. Bertelsen, M. Lawther, M.B. Olsen, N.H. Nilsson and G. Mortensen. 1999. Potential of biobased materials for food packaging. Trends Food Sci. Technol., 10: 52–68. https://doi.org/10.1016/S0924-2244(99)00019-9

Roma, V.F., K.M. Moneruzzaman, A.B.M.S. Hossain, W. Sani, M. Saifuddin and M.L. Rooney. 2005. Introduction to active food packaging technologies. In: Han, J.H., editor. Innovations in Food Packaging. Oxford, UK: Elsevier Academic, pp. 63–79. https://doi.org/10.1016/B978-012311632-1/50037-1

Saks, Y. and R. Barkai-Golan. 1995. Aloe vera gel activity against plant pathogenic fungi. Postharvest Biol. Tech., 6: 159–165. https://doi.org/10.1016/0925-5214(94)00051-S

Sholberg, P.L. and A.P. Gaunce. 1996. Fumigation of stone fruit with acetic acid to control postharvest decay. Crop Protec., 15: 681–686. https://doi.org/10.1016/S0261-2194(96)00039-7

Siddiqui, M.W., C.M. Momin, P. Acharya, J. Kabir, M.K. Debnath and R.S. Dhua. 2013a. Dynamics of changes in bioactive molecules and antioxidant potential of Capsicum chinense Jacq. cv. Habanero at nine maturity stages. Acta Physiol. Plant, 35: 1141-1148. https://doi.org/10.1007/s11738-012-1152-2

Siddiqui, M.W., J.F. Ayala-Zavala and R.S. Dhua. 2013b. Genotypic variation in tomatoes affecting processing and antioxidant attributes. Crit. Rev. Food Sci. Nutr., (In Press). https://doi.org/10.1080/10408398.2012.710278

Sozzi, G.O., G.D. Trinchero and A.A. Fraschina. 1999.Controlled atmosphere storage of tomato fruit: low oxygen or elevated carbon dioxide levels alter galactosidase activity and inhibit exogenous ethylene action. Agric. Food Chem., 79: 1065–1070. https://doi.org/10.1002/(SICI)1097-0010(199906)79:8<1065::AID-JSFA319>3.0.CO;2-U

Valverde, J.M., D. Valero, D. Martinez-Romero, F. Guillen, S. Castillo, M. Serrano. 2005. Novel edible coating based on Aloe vera gel to maintain table grape quality and safety. J. Agri. Food Chem., 53: 7807–7813. https://doi.org/10.1021/jf050962v

Wasala, C.B., C.A.K. Dissanayake, D.A.N. Dharmasena, C.R. Gunawardane and T.M.R. Dissanayake. 2014. Postharvest losses, current issues and demand for postharvest technologies for loss management in the main banana supply chains in Sri Lanka. J. Post-Harvest Tech., 2: 80-87.

Wijewardane, N.A., 2014. Effect of pre-cooling combined with exogenous oxalic acid application on storage quality of mango (*Mangifera indica*). J. Post-Harvest Tech., 2: 45-53.

Workneh, T.S., G. Osthoff and M. Steyn. 2012. Effects of preharvest treatment, disinfections, packaging and storage environment on quality of tomato. J. Food Sci. Technol., 49: 685–694. https://doi.org/10.1007/s13197-011-0391-3

Xu, X.B. and S.P. Tian. 2008. Reducing oxidative stress in sweet cherry fruit by Pichia membranaefaciens: A possible mode of action against Penicilliumexpansum. J. Appl. Microb., 105: 1170–1177. https://doi.org/10.1111/j.1365-2672.2008.03846.x

Yumbya, P., J. Ambuko, S. Shibairo and W. Owino. 2014. Effect of modified atmosphere packaging (MAP) on the shelf life and postharvest quality of purple passion fruit (*Passiflora edulis* Sims). J. Post-Harvest. Tech., 2(1): 25-36.