

Post-harvest fruit handling processes: from placement to waste valorisation

Sanda Stanivuković^{}, Srđan Lakić^{}, Boris Pašalić^{}

University of Banja Luka, Faculty of Agriculture, Banja Luka, Bosnia and Herzegovina

Abstract

The paper deals with an analysis of the post-harvest fruit handling process, with a special emphasis on critical points in the supply chain, from primary selection to waste valorisation. Post-harvest fruit handling is defined as an integral system of processes necessary to preserve the nutritional value and quality of the fruit, as a living organism that continues its metabolic functions even after separation from the parent plant. The paper presents the basic stages of harvesting, transport, and primary processing in order to emphasise that inadequate logistics and hygiene are the main causes of mechanical damage and microbiological contamination, which leads to losses of between 40–50% of the total volume at the global level. Attention is also paid to modern packaging technologies. Innovative packaging solutions, such as smart and active packaging, incorporating nanocomposites and real-time monitoring sensors, were analysed to extend the shelf life of fruit. In addition, the paper also focused on the treatment of agricultural waste in retail. Economic and environmental causes of fruit waste were identified, such as the insistence on “aesthetic perfection” and inefficient inventory management. The waste of edible fruit not only causes an economic cost, but also an environmental disaster caused by methane emissions in landfills. Finally, the paper affirms the concept of fruit waste valorisation in a circular economy system. Parts of fruit, such as peel and seeds, are seen as exceptional sources of bioactive compounds and fibres for the production of functional foods. Overall, the implementation of advanced post-harvest technologies and efficient processing of fruit waste serves as the only path towards reducing the ecological footprint and improving the economic profitability of the food industry.

Key words: Modern packaging methods, Fruit quality, Sustainability, Waste analysis

Introduction

Post-harvest handling of fruit is presented by scientists as an integral system of procedures that includes all the stages the fruit goes through when it is separated from the mother plant until the moment of final consumption or processing. Consequently, it should be emphasised that fruit, as living organisms, continues metabolic functions even after the interruption of the physiological flow of nutrients from the mother plant (Beaulah et al., 2024). The development of effective preservation strategies through biological, ecological, and technological factors that affect quality is reflected in the slowing down of physiological changes and the extension of shelf life (De Wit et al., 2024). Post-harvest losses are not only economic losses for producers and traders, but they also represent a global challenge for food security because a large part of fresh produce never reaches consumers' tables (Imonioro & Oshio, 2024). To achieve high-quality fruit and economic justification of storage, it is important to pay attention to the initial treatment in the orchard, determine the optimal moment of harvesting, and then proceed with the actual harvesting and transportation of the fruit (Pašalić, 2010).

The effective management of post-harvest processes requires a multidisciplinary approach. All fruit species require specific conditions in terms of temperature, humidity, and air composition, which makes the process of handling fruit extremely complex. For example, respiration intensity and sensitivity to ethylene directly suggest the technology that will be applied during storage and transportation (Budhathoki et al., 2022). Slowing down the aging of fruit and preventing pathological changes that lead to rotting are effectively regulated by preventive measures applied before the actual harvest and during post-harvest procedures (De Wit et al., 2024). The main goals of post-harvest management are to maintain low temperatures to reduce moisture loss, slow down undesirable chemical changes, and minimise physical damage during fruit manipulation (Imonioro & Oshio, 2024). On the other hand, the quality loss of nuts is significantly influenced by moisture content, as well as cleaning, drying, and storage processes (Stanivuković et al., 2021).

Contemporary research is increasingly focusing on the valorisation of waste generated during storage processes, which requires innovative solutions within the principles of a circular economy (Fox et al., 2023). Waste that appears on market shelves or as a by-product of industrial processing is not only seen as a burden on the environment but also as a wealth of bioactive compounds, dietary fibres, and functional ingredients (Gomes et al., 2025). This paper analyses these processes in detail, from harvesting and primary processing through modern

solutions in packaging to the quantitative and qualitative analysis of waste and its transformation into products with added value.

Discussion

Processes for handling fruit intended for direct marketing

The main goal of fruit harvesting is to collect fruit at the optimal stage of maturity with maximum efficiency and minimise mechanical damage. Given that harvesting is the most economically demanding phase of production, it requires a high degree of responsibility, especially with sensitive species such as cherries, peaches, and berries. To preserve fruit quality, it is necessary to adhere to hygienic and technical measures, such as using clean packaging to prevent pathogens, careful handling of the fruit to avoid damage, and harvesting during cooler parts of the day. Key factors to prevent post-harvest deterioration include avoiding work immediately after rain, storing picked fruit in the shade, mandatory pre-cooling, and efficient logistics to the warehouse to minimise exposure to the sun (Pašalić & Stanivuković, 2022).

Harvesting and handling of fruit are complex operations that depend on the specifics of the culture, where determining the optimal degree of maturity is crucial for the quality of the final product. Maintaining the quality of stored fruit depends on a variety of factors; however, determining the optimal harvest time represents one of the decisive factors that directly influences the fruit storage process (Stanivuković et al., 2013). It is advisable to harvest at lower temperatures to preserve sensory properties and prevent microbial spoilage, and the method of harvesting depends on the delicacy of the fruit and the purpose of the product (Yildiz, 2017). Harvesting methods can be manual, mechanised, semi-mechanised, or automated (Pašalić & Stanivuković, 2022; Zhang et al., 2024). Manual harvesting is still widely used in production due to lower initial investments, and it is characterised by flexibility in the intensity of work, which can be a limiting factor if working with fruit of smaller dimensions or collecting fruit from thorny species. In addition, manual harvesting requires much more time than mechanised harvesting, which can be a decisive factor in preserving the freshness of the fruit (Prasad et al., 2018). Semi-mechanised harvesting represents a combined approach that includes manual picking with the help of adequate mechanisation (Pašalić & Stanivuković, 2022). Mechanised harvesting is characterised by increasing the efficiency and speed of harvesting using cutting, plucking, threshing, or combing methods (Prasad et al., 2018). Automated harvesting is characterised by the integration of automatic perception, which results in labour cost savings and the continuous promotion of modern agriculture in the direction of improving the technology of equipment, automation, and intelligence (Zhang et al., 2024).

Transport represents the segment that carries the greatest risk of mechanical damage to the fruit that is not immediately visible at the time of occurrence due to vibrations, shocks, and extreme external temperatures, which later results in a decline in fruit quality (Imonioro & Oshio, 2024). Sensors for monitoring the temperature and humidity of the air inside the means of transport significantly reduce the damage to the fruit and allow a quick reaction to the failure of the cooling systems (Du et al., 2025). In addition to heat stress, transport also carries the risk of mutual contamination if the fruit are transported in a vehicle that has not been adequately cleaned beforehand, where pathogens such as *Aspergillus flavus* and *Fusarium oxysporum* develop, leading to rapid deterioration in the packing centre (Budhathoki et al., 2022; Abadi et al., 2020). If the fruit is not sold directly but stored, it is important to note that the main goal of storage is to extend the time of consumption to preserve the visual and nutritional value of the fruit during shelf life (Stanivuković et al., 2015). In addition, it is important to note that traditional varieties have good nutritional values, which are reflected in the content of flavonoids, phenols, and the ability to remove free radicals, which suggests suitable storage characteristics (Stanivuković et al., 2017).

When arriving at the packing centre (packhouse), fruit enters the phase of primary processing, which aims to eliminate external contaminants by washing or cleaning the fruit, where microorganisms and residues of agricultural chemicals are removed. However, it is important to carry out quick drying after washing to avoid the appearance of mould in the packaging. Disinfection is also performed using sodium hypochlorite at concentrations that are safe for consumption and effective in eliminating surface pathogens (Beulah et al., 2024). The market value of fruit is defined by operations such as sorting and grading, where sorting is the primary step of removing diseased, damaged, or deformed fruit, while grading qualifies fruit based on weight, size, colour, and degree of maturity. Based on this, premium prices are achieved for high-quality fruit, and industrial processing follows for those of lower quality (Budhathoki et al., 2022; Beulah et al., 2024). Advances in technology have led to the development and implementation of optical sensors and artificial intelligence, which have made it possible to analyse thousands of fruit per minute and detect internal defects that the human eye cannot see. In addition to physical characteristics, non-invasive internal quality measurements are also applied, such as sugar content using near-infrared spectroscopy (NIR), which guarantees consumers a consistent taste (Du et al., 2025).

Modern ways of packing fruit

Modern market standards emphasise the need for functional and aesthetically acceptable packaging which directly affects the preservation of the

product's healthiness, sales volume, and income. Following the trends in developed countries, domestic manufacturers are increasingly harmonising their packaging methods with the requirements of modern consumers and sales chains (Pašalić & Stanivuković, 2022).

In the modern food industry packaging has become an active participant in maintaining the physiological state of the fruit, in addition to providing protection against mechanical damage, vibrations, and compressions that are inevitable during distribution, which preserves the hygienic integrity of the product (Ahmed et al., 2025). In addition, product identification through barcodes, QR codes, and RFID chips stands out as a secondary function of packaging, which enables quality management and quick withdrawal of goods in case of need (Mkhari, 2025). Modern packaging enables the regulation of the gas composition inside the packaging, absorption of excess moisture that favours the development of mould, release of antimicrobial compounds, and reduction of light intensity and UV radiation that can cause photooxidation and degradation of vitamins and pigments on the surface of the fruit (Nian et al., 2022). The "scavenger" function of ethylene is particularly important, as it chemically binds to this maturation gas and delays senescence (Dimopoulou et al., 2025). This feature allows fruit, such as strawberries, or small packages of freshly cut fruit to remain in use twice as long as conventional packaging (Rodriguez et al., 2024).

Packaging materials are undergoing certain changes in terms of material selection. Traditional materials such as low-density polyethylene (LDPE) or polypropylene (PP) are still used because of their low prices and excellent moisture barrier properties; however, their non-degradability creates enormous environmental pressure (Kumar et al., 2025). As an alternative, bioplastics obtained from renewable sources such as starch, cellulose, chitosan, and polylactic acid (PLA) have emerged (Nian et al., 2022). These materials initially had poorer mechanical characteristics; however, research in the field of nanotechnology enabled their significant improvement through the creation of nanocomposites (Li et al., 2025). The use of natural active agents is becoming an increasingly popular method for preserving fresh-cut fruit (Rodriguez et al., 2024).

Mkhari et al. (2025) state that "smart" packaging is a special way of packaging that uses sensors and indicators to monitor the state of the product in real time, including time and temperature indicators (TTI), freshness indicators, gas sensors, and biosensors.

Generation and treatment of fruit waste

According to the framework proposed by Östergren et al. (2014), food waste includes both edible and non-edible parts (such as bones or peels) that are removed from the supply chain for disposal or energy recovery purposes.

Although this concept includes food thrown into landfills or used for bioenergy, it excludes pre-harvest losses, packaging, and by-products used in non-food industries (e.g., for pet food or cosmetics). The main difference between the definition of these authors and the official position of the European Commission is based on the treatment of unused crops in the fields: while Östergren et al. (2014) recognise them as waste, EU regulations do not classify them in that category if they are plowed or left unharvested (Sanchez Lopez et al., 2020)."

One of the most significant causes of waste is the insistence on "aesthetic perfection," where customers and traders reject fruit that has minor surface defects or irregular shapes or sizes, regardless of the fact that such fruit is nutritionally valuable. For this reason, farmers discard as much as 30% of their production before it reaches the market (De Moraes et al., 2022). Markets often purchase a larger quantity of products so that the shelves always look full and attractive, without paying attention to surpluses that expire (Fredes et al., 2023). In addition, traders' lack of information about the environmental consequences of food waste and the inexperience of staff in handling fresh goods lead to huge problems, through improper handling of fruit, mixing of fruit that are differently sensitive to ethylene, and stacking products in unsuitable places, all of which result in the deterioration of fruit and the creation of waste (Abadi et al., 2020).

Quantitative losses at the global level suggest that approximately one-third of the total food production is lost, with fruit and vegetables making up the largest share of this loss, often exceeding 40–50% of the total volume (Saeteros-Hernández et al., 2025). In the United States, fruit losses at the retail level alone amount to approximately 9%, whereas at the consumer level, an additional 19% of available quantities are lost (Porat et al., 2018). In Sweden, measurements showed that the total waste of fruit and vegetables in supermarkets is approximately 4.3% of the delivered quantities, where most of the loss was caused by the rejection of goods during reception due to poor quality in transport (Eriksson et al., 2012). In Romania, fruit and vegetables account for 13–17% of total food waste, which directly affects the economic viability of the catering and trade sectors (Negrusa et al., 2025).

Qualitative losses refer to the loss of nutritional value, such as the degradation of vitamin C, and antioxidants, before the fruit shows visible signs of rotting (De Wit et al., 2024). For consumers, qualitative losses represent paying the full price of a product that no longer has the promised nutritional value, leading to a drop in trust in the brand or retail chain (De Moraes et al., 2022). A significant part of the waste is made up of unavoidable parts such as the peel, stone, and stem, which represent 20–50% of the total mass of the fruit, depending on the species (Joshi, 2020).

Most defective or unsold fruit end up in municipal landfills, which is a problem for the environment because large amounts of methane and toxic water

are created during decomposition, which can pollute groundwater (Joshi, 2020; Saeteros-Hernández et al., 2025). In many countries, there is no obligation to separate organic waste in retail, so the fruit is discarded together with the packaging, which prevents later composting or energy use (De Moraes et al., 2022). Alternative methods to prevent environmental degradation include the use of nutrient waste for animal feed, composting, food donation, and anaerobic digestion (Pal & Mitra, 2025; Saeteros-Hernández et al., 2025; De Moraes et al., 2025).

Throwing away edible fruit has devastating economic and ecological consequences; from an economic point of view, food waste represents a direct loss of resources (Gomes et al., 2025). If food losses were considered as a single country, it would rank third as the largest contributor of greenhouse gases in the world (Sial et al., 2024). It is estimated that the global economic cost of food waste exceeds trillions of dollars annually, where for retailers, it represents a direct write-off of profits and often requires the payment of fees for waste disposal (Porat et al., 2018; Pal & Mitra, 2025). From an ecological perspective, methane is produced during the decomposition of fruit, which is 21–25 times more powerful in causing the greenhouse effect than carbon dioxide (CO₂). In addition, if a high content of organic matter enters water courses, it leads to eutrophication, which results in the extinction of aquatic organisms (Pal & Mitra, 2025; Plazzotta et al., 2020). The transition to circular economy models, where every part of the fruit is reused, is the only sustainable option for the future of the food industry (Gomes et al., 2025).

Valorisation of fruit waste in the food industry

Food waste is a valuable source of chemical compounds, and the inedible parts of the fruit contain higher concentrations of bioactive compounds than the edible parts of the fruit itself (Gomes et al., 2025). For example, banana peels make up 30–40% of the total weight and are rich in dietary fiber, whereas mango peels (which make up 7–24% of the mass) are rich in polyphenols and antioxidants (Joshi, 2020). The chemical complexity of food waste is reflected in the fact that it is an ideal raw material from which pectin is extracted, which is used the most in the food industry and is obtained from apple and citrus waste (Plazzotta et al., 2020). In addition, the seeds of certain species are rich in polyunsaturated fatty acids and phytosterols, which have a positive effect on human health (Gomes et al., 2025). Understanding these various properties of food waste is the first step in converting it into a high-value resource (Joshi, 2020).

Researchers have isolated antioxidants, polyphenols, carotenoids, and flavonoids and reused them as functional additives in the food industry (Gomes et al., 2025). These extracts act as natural preservatives, preventing oxidation and

prolonging product freshness without the use of synthetic additives (Nirmal et al., 2023). In addition, the application of these compounds in the production of natural colours as substitutes for synthetic colours is highlighted, where anthocyanins and betacyanins are isolated from fruit with dark skin (Kumar et al., 2025). Functional fibers obtained from food waste are used to enrich bakery products, control the glycemic index, and improve digestive tract health (Pal & Mitra, 2025). Food waste is also used in the meat processing industry, where it softens the tissue and improves the structure of the meat (Joshi, 2020). These ingredients turn "invisible" waste into "visible" value on product labels (Gomes et al., 2025).

"Upcycling" represents a concept where completely new products are created from food waste, which is increasingly popular among consumers who care about sustainability. For example, tropical fruit can provide by-products that can be transformed into fruit butters, healthy salad dressings, or even fermented drinks rich in probiotics (Pal & Mitra, 2025). The remains of pressed fruit can be rehydrated and fermented to produce vinegar or functional water with antioxidant properties (Nirmal et al., 2023). New products satisfy two needs, namely they reduce the ecological footprint of the food industry and provide nutritionally richer food to modern humans (Pal & Mitra, 2025).

Conclusion

Post-harvest fruit losses systematically threaten food security and resource sustainability, necessitating advanced technologies and ecological awareness. Key steps in addressing these issues include temperature control, sophisticated packaging, logistics digitalisation, and smart sensors. According to the principles of circular economy, waste must be upcycled into new products, energy, and functional ingredients. Optimising invested resources requires cross-sector collaboration between science, agriculture, and industry, alongside education regarding "imperfect" fruit, while the entire process first requires raising public awareness through educational workshops. Concurrently, establishing legal frameworks and producer subsidies can effectively incentivise food donation systems to mitigate food insecurity. In conclusion, this holistic approach ensures an efficient, profitable, and sustainable agri-food system.

Acknowledgements

This paper was supported by the Ministry of Scientific and Technological Development and Higher Education of the Republic of Srpska through the project "The Importance and Application of the Bioactive Potential of Fruit and Vegetables in the Development of the Food Industry" in support of COST Action

CA 24111 "European Network for Valorising Food Processing Waste into Sustainable Fibers (ENFiber)" (Contract number: 19.032-966-49/25).

References

- Abadi, B., Mahdavian, S., & Fattahi, M. (2020). The waste management of fruit and vegetable in wholesale markets: Intention and behavior analysis using path analysis. *Journal of Cleaner Production*, 279(2), 123802. <https://doi.org/10.1016/j.jclepro.2020.123802>
- Ahmed, M. M., Nabi, M. H. B., Mia, M. S., Ahmad, I., & Zzaman, W. (2025). Valorization of plant-based agro-waste into sustainable food packaging materials: Current approaches and functional applications. *Applied Food Research*, 5(2), 101368. <https://doi.org/10.1016/j.afres.2025.101368>
- Beaulah, A., Rajadurai, K. R., & Maanchi, S. (2024). Postharvest handling of fruit and vegetables. *Greenaria: An Agricultural Monthly e-Magazine*, 2(12), Article G-24-1221. <https://greenaria.in/wp-content/uploads/2025/02/POSTHARVEST-HANDLING-OF-FRUIT-AND-VEGETABLES.pdf>
- Budhathoki, P., Pandey, S. K., & Magar, P. D. (2022). Review on post-harvest handling of fruit and vegetables to minimize loss. *Food and Agri Economics Review (FAER)*, 2(1), 37-40. <https://doi.org/10.26480/faer.01.2022.37.40>
- De Moraes, C. C., Costa, F. H., Da Silva, A. L., César, A., Delai, I., & Pereira, C. R. (2022). Causes and prevention practices of food waste in fruit and vegetable supply chains: How is Brazil dealing with these issues? *Waste Management*, 154(3), 320-330. <https://doi.org/10.1016/j.wasman.2022.10.021>
- De Wit, M., Liguori, G., & Vaštakaitė-Kairienė, V. (2024). Editorial: Preharvest and postharvest factors affecting fruit and vegetables quality, physiology, and shelf-life. *Frontiers in Plant Science*, 15, 1522530. <https://doi.org/10.3389/fpls.2024.1522530>
- Dimopoulou, M., Graikou, K., Chinou, I., & Gortzi, O. (2025). A review of nanotechnology in food, smart packaging and potential public health impact. *Applied Sciences*, 16(1), 168. <https://doi.org/10.3390/app16010168>
- Du, L., Huang, X., Li, Z., & Qin, Z. (2025). Application of smart packaging in fruit and vegetable preservation: A review. *Foods*, 14(3), 447. <https://doi.org/10.3390/foods14030447>
- Eriksson, M., Strid, I., & Hansson, P. A. (2012). Food losses in six Swedish retail stores: Wastage of fruit and vegetables in relation to quantities delivered. *Resources, Conservation and Recycling*, 68, 14-20. <https://doi.org/10.1016/j.resconrec.2012.08.001>

- Fox, S., Kenny, O., Noci, F., & Dermiki, M. (2023). A pilot study on industry stakeholders' views towards revalorization of surplus material from the fruit and vegetable sector as a way to reduce food waste. *Sustainability*, 15(23), 16147. <https://doi.org/10.3390/su152316147>
- Fredes, C., Pérez, M. I., Jimenez, M., Reutter, B., & Fernández-Verdejo, R. (2023). Tailored informational interventions for reducing surplus and waste of fruit and vegetables in a food market: A pilot study. *Foods*, 12(12), 2313. <https://doi.org/10.3390/foods12122313>
- Gomes, B. T., Aguiar, L. L., Sant'Ana, C. T., Costa, A. G. V., Carneiro, J. C. S., & Silva, P. I. (2025). Fruit by-products: Valorization, use and richness of bioactive compounds. *Journal of Food Process Engineering*, 48(11). <https://doi.org/10.1111/jfpe.70249>
- Imonioro, H. E., & Oshio, L. E. (2024). Proper post harvest handling of fruit in minimizing before the table. *Technical and Vocational Education Journal (TAVEJ)*, 9, 115-124. <https://www.tavej.com.ng/index.php/tavej/article/view/91/74>
- Joshi, V. K. (2020). Fruit and vegetable processing waste management - An overview. *International Journal of Food and Fermentation Technology*, 10(2). <https://doi.org/10.30954/2277-9396.02.2020.4>
- Kumar, V., Sonika, Ram, D. K., Sahu, G., Sahu, N. K., & Verma, S. (2025). Sustainable modifications in food packaging: A comprehensive review of biodegradable material revolutions. *Applied Food Research*, 5(2), 101385. <https://doi.org/10.1016/j.afres.2025.101385>
- Li, Z., Cui, S., Wu, D., & Chen, K. (2025). Advancing bio-based biodegradable plastics for fruit and vegetable packaging: Multi-scale modifications for performance enhancement. *Trends in Food Science & Technology*, 165, 105354. <https://doi.org/10.1016/j.tifs.2025.105354>
- Mkhari, T., Adeyemi, J., & Fawole, O. A. (2025). Recent advances in the fabrication of intelligent packaging for food preservation: A review. *Processes*, 13(2), 539. <https://doi.org/10.3390/pr13020539>
- Negrusa, A., Petrescu, D. C., Petrescu-Mag, R. M., Tenter, A., & Piştea, I. C. (2025). Fruit and vegetable waste reduction measures and perceptions in the food service sector among Romanian managers and chefs. *Discover Sustainability*, 6(1). <https://doi.org/10.1007/s43621-025-02093-w>
- Nian, L., Wang, M., Sun, X., Zeng, Y., Xie, Y., Cheng, S., & Cao, C. (2022). Biodegradable active packaging: Components, preparation, and applications in the preservation of postharvest perishable fruit and vegetables. *Critical Reviews in Food Science and Nutrition*, 64(9), 1-36. <https://doi.org/10.1080/10408398.2022.2122924>
- Nirmal, N., Khanashyam, A. C., Shanker M, A., Shah, K., Babu, K. S., Thorakkattu, P., Al-Asmari, F., & Pandiselvam, R. (2023). Valorization of fruit waste for bioactive compounds and their applications in the food industry. *Foods*, 12(3), 556. <https://doi.org/10.3390/foods12030556>

- Östergren, K., Gustavsson, J., Bos-Brouwers, H., Timmermans, T., Hansen, O. J., Møller, H., Anderson, G., O'Connor, C., Soethoudt, H., Netherlands, T., Qusted, T., Easteal, S., Politano, A., Bellettato, C., Canali, M., Falasconi, L., Gaiani, S., Vittuari, M., Schneider, F., Moates, G., Waldron, K., ... Redlingshöfer, B. (2014). *FUSIONS definitional framework for food waste*. SIK - The Swedish Institute for Food and Biotechnology. Report number: ISBN 978-91-7290-331-9. https://www.researchgate.net/publication/319272558_FUSIONS_definitio_nal_framework_for_food_waste_Full_report
- Pal, N., & Mitra, A. (2025). Unlocking the hidden value of fruit wastes. *Parana Journal of Science and Education*, 11(4), 54-63. <https://sites.google.com/site/pjsciecea>
- Pašalić, B. (2010). *Proučavanje aromatskog kompleksa u klimakterijumskoj fazi sazrijevanja plodova jabuke* [Doctoral dissertation]. Univerzitet u Banjoj Luci, Poljoprivredni fakultet.
- Pašalić, B., & Stanivuković, S. (2022). *Berba i skladištenje voća* [Harvesting and storage of fruit]. Univerzitet u Banjoj Luci, Poljoprivredni fakultet.
- Plazzotta, S., Cottes, M., Simeoni, P., & Manzocco, L. (2020). Evaluating the environmental and economic impact of fruit and vegetable waste valorisation: The lettuce waste study-case. *Journal of Cleaner Production*, 262, 121435. <https://doi.org/10.1016/j.jclepro.2020.121435>
- Porat, R., Lichter, A., Terry, L. A., Harker, R., & Buzby, J. (2018). Postharvest losses of fruit and vegetables during retail and in consumers' homes: Quantifications, causes, and means of prevention. *Postharvest Biology and Technology*, 139, 135-149. <https://doi.org/10.1016/j.postharvbio.2017.11.019>
- Prasad, K., Jacob, S., & Siddiqui, M. W. (2018). Fruit maturity, harvesting, and quality standards. In *Preharvest modulation of postharvest fruit and vegetable quality* (pp. 41-69). Elsevier Inc. <https://doi.org/10.1016/B978-0-12-809807-3.00002-0>
- Rodriguez, O. T., Valero, M. F., Gómez-Tejedor, J. A., & Díaz Barrera, L. E. (2024). Performance of biodegradable active packaging in the preservation of fresh-cut fruit: A systematic review. *Polymers*, 16(24), 3518. <https://doi.org/10.3390/polym16243518>
- Saeteros-Hernández, A., Chalen-Moreano, F., Zurita-Gallegos, R., Badillo-Arévalo, P., Granizo-Villacres, M., Cevallos-Hermida, C., & Viteri-Núñez, D. (2025). Quantitative and Qualitative Characterization of Food Waste for Circular Economy Strategies in the Restaurant Sector of Riobamba, Ecuador: A Case Study Approach. *Biomass*, 5(2), 18. <https://doi.org/10.3390/biomass5020018>
- Sanchez Lopez, J., Caldeira, C., De Laurentiis, V., Sala, S., & Avraamides, M. (2020). *Brief on food waste in the European Union*. European Commission's Knowledge Centre for Bioeconomy.

https://knowledge4policy.ec.europa.eu/sites/default/files/KCB-Food%20waste%20brief_print_HQ.pdf

- Sial, T. A., Rajpar, I., Khan, M. N., Ali, A., Shan, M., Rajput, A., & Shah, P. A. N. (2024). Impact of fruit and vegetable wastes on the environment and possible management strategies. In A. Núñez-Delgado (Ed.), *Planet Earth: Scientific Proposals to Solve Urgent Issues* (pp. 307-330). Springer, Cham. https://doi.org/10.1007/978-3-031-53208-5_14
- Stanivuković, S., Pašalić, B., & Đurić, G. (2013). Biochemical-physiological characteristics of pear fruit depending on the position on the tree. *Agro-knowledge Journal*, 14(4), 507-521. <https://doi.org/10.7251/AGRSR1304507S>
- Stanivuković, S., Civčić, D., & Đurić, G. (2015). Promjena boje pokožice ploda kruške (*Pyrus communis* L.) tokom skladištenja [Color change in the skin of pear fruit (*Pyrus communis* L.) during storage]. *Agro-knowledge Journal*, 16(3), 377-386. <https://doi.org/10.7251/AGRSR1503377S>
- Stanivuković, S., Žujić, M., Žabić, M., Mičić, N., Bosančić, B., & Đurić, G. (2017). Characterization of old apple cultivars from Bosnia and Herzegovina by means of pomological and biochemical analysis. *Notulae Botanicae Horti Agrobotanici Cluj-Napoca*, 45(1), 97-104. <https://doi.org/10.15835/nbha45110537>
- Stanivuković, S., Pašalić, B., Jakovljević, J., & Ilić, P. (2021). Influence of storage on pomological and sensory characteristics of hazelnut fruit. *Agriculture & Forestry*, 67(1), 205-213. <https://www.agricultforest.ac.me/data/20210331-17%20Stanivukovic.pdf>
- Yildiz, F. (2017). Initial Preparation, Handling, and Distribution of Minimally Processed Refrigerated Fruit and Vegetables. In R. C. Wiley (Ed.), *Minimally Processed Refrigerated Fruit & Vegetables* (pp. 15-65). Springer, Boston, MA. https://doi.org/10.1007/978-1-4939-7018-6_3
- Zhang, J., Kang, N., Qu, Q., Zhou, L., & Zhang, H. (2024). Automatic fruit picking technology: A comprehensive review of research advances. *Artificial Intelligence Review*, 57, 54. <https://doi.org/10.1007/s10462-023-10674-2>

Процеси руковања плодовима воћа након бербе: од пласмана до валоризације отпада

Санда Станивуковић, Срђан Лакић, Борис Пашалић

¹ *Универзитет у Бањој Луци, Пољопривредни факултет, Бања Лука, Босна и Херцеговина*

Сажетак

Рад обухвата анализу процеса манипулације плодовима воћа након бербе, са посебним акцентом на критичне тачке у ланцу снабдијевања, од примарне селекције до валоризације отпада. Постбербена манипулација плодовима дефинише се као интегрални систем процеса неопходних за очување нутритивних вриједности и квалитета плода, као живог организма који наставља своје метаболичке функције и након одвајања од матичне биљке. У раду су представљене основне фазе бербе, транспорта и примарне обраде у циљу наглашавања да неадекватна логистика и хигијена представљају главне узроке механичких оштећења и микробиолошких контаминација, што на глобалном нивоу доводи до губитака између 40-50 % укупног волумена. Пажња је, такође, усмјерена према савременим технологијама паковања. Анализирана су иновативна рјешења приликом паковања, попут паметне и активне амбалаже, које садрже нанокомпозите и сензоре за праћење стања у реалном времену, у сврху продужетка трајања животног вијека плодова. Након тога, фокус се пребацује на настанак и третман пољопривредног отпада у малопродаји. Идентификовани су економски и еколошки узроци бацања плодова воћа, као што је инсистирање на “естетском савршенству” и неефикасно управљање залихама. Бацање јестивих плодова воћа, не изазива само економски трошак, него и еколошку катастрофу изазвану емисијом метана на депонијама смећа. На крају, рад афирмише концепт валоризације отпада од плодова воћа у систему циркуларне економије. Дијелови плодова воћа, као што су покожица и сјеменке, сматрају се као изузетни извори биоактивних једињења и влакана за производњу функционалне хране. Закључно, имплементација напредних постбербених технологија и ефикасна прерада отпада од плодова воћа служи као једини пут према смањењу еколошког отиска и унапређење економске профитабилности прехранбене индустрије.

Кључне ријечи: савремене методе паковања, квалитет воћа, одрживост, анализа отпада

Corresponding author: Sanda Stanivuković
E-mail: sanda.stanivukovic@agro.unibl.org

Received: May, 21, 2026
Accepted: July 10, 2026