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INTEGRATED ZERO-WASTE POST-HARVEST PROCESSING TECHNOLOGIES FOR VALUE-ADDED KIWIFRUIT PRODUCT DEVELOPMENT

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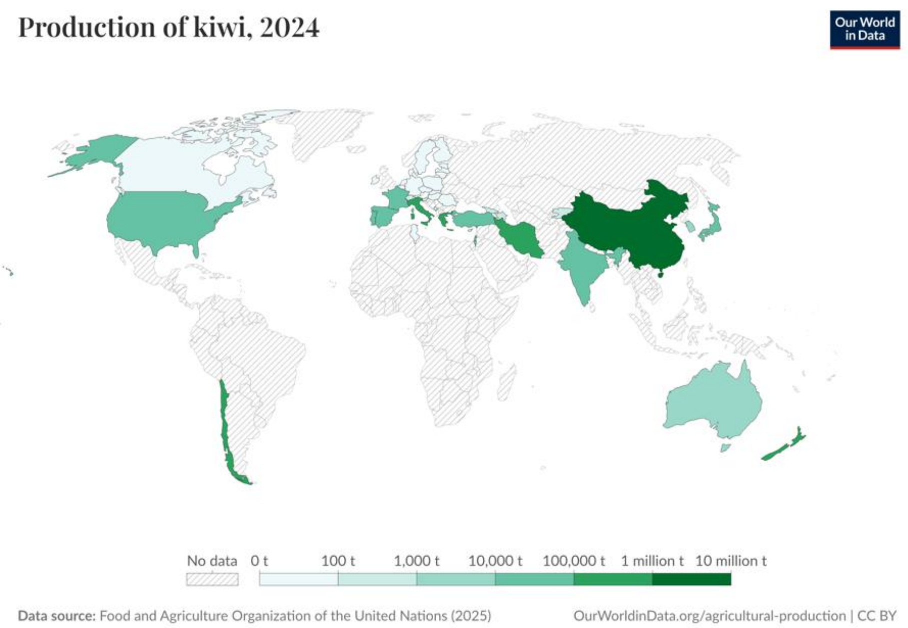
Abstract: Kiwifruit (Actinidia deliciosa) production in Uzbekistan is limited and mainly focused on fresh consumption, with underdeveloped post-harvest processing and value addition. This study develops an integrated zero-waste technology for producing diversified high-value kiwifruit products. The experimental design involved controlled hot-air dehydration, fruit pastille production, and conversion of processing residues into liqueur products. Hot-air drying at 50°C for 16 hours was applied to ensure preservation of bioactive constituents and product quality. Processing 20 kg of fresh kiwifruit resulted in 1.4 kg of dried product and 3.095 kg of fruit pastilles. Additionally, 14 liters of liqueur were obtained from peel and residual biomass. The results confirm the technical feasibility of a multi-output, zero-waste processing system. The proposed approach significantly reduces post-harvest losses while enhancing resource-use efficiency. It thereby contributes to rural income diversification and strengthens agro-industrial value chains. Overall, the model demonstrates strong potential for sustainable horticultural development in Central Asia.

Keywords: Kiwifruit (Actinidia deliciosa), zero-waste technology; hot-air dehydration; rural income diversification; agro-industrial value chain, sustainable horticulture.

Introduction

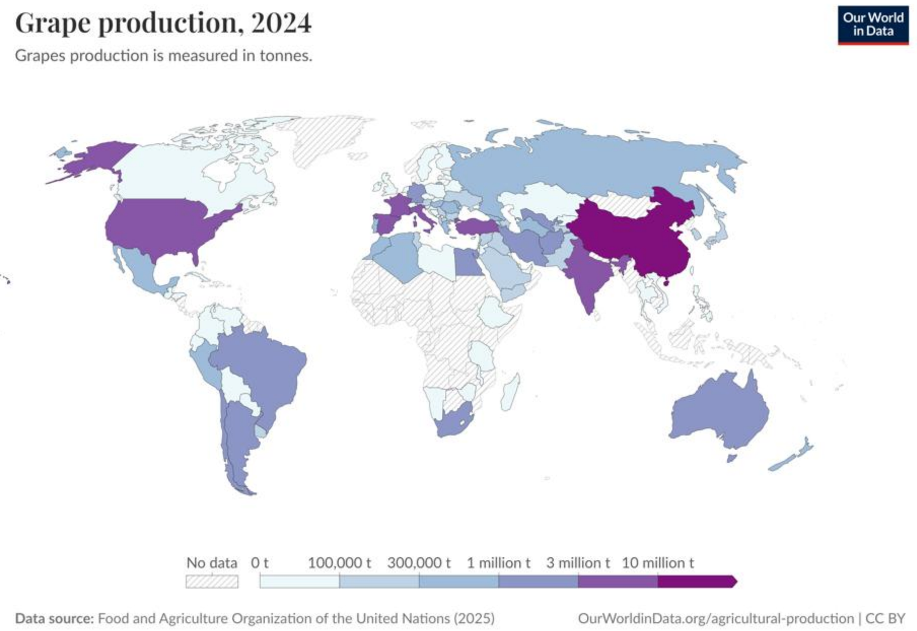
The cultivation of emerging berry crops, particularly kiwifruit, has undergone notable global expansion in recent years. Kiwifruit (Actinidia spp.), a member of the Actinidiaceae family, is native to the Yangtze River region of the People's Republic of China (Waswa et al., 2024). It has developed into a horticultural commodity of considerable economic and nutritional importance, with extensive cultivation across Asia, Europe, Oceania – most notably New Zealand and the Americas. Although approximately 55 species have been identified, commercial production is largely concentrated on two principal species (Nazir et al., 2024). In 2023, Asia accounted for the largest share of the global kiwifruit supply, contributing 62.90% of total output and 75.31% of the cultivated area. Europe followed with 18.88% of production and 16.51% of cultivated area, while Oceania ranked third with 15.04% and 5.21%, respectively. The farming was recorded in 25 countries, but, at the international level, production is highly concentrated among a limited number of major producing countries. According to FAOSTAT (2025), China remains the dominant producer with approximately 2.15 million tons annually, followed by New Zealand (667,792 tons), Italy (463,910 tons), Greece (342,330 tons), Iran (294,659 tons), and Chile (194,664 tons). Together, these nations represent the principal contributors to the agricultural system, with a combined annual total output of approximately 4.43 million tons (Liu et al., 2025). This marked concentration demonstrates a significant systemic structural asymmetry in the international agro-horticultural framework. Reliance on a restricted number of producing regions further increases exposure to pronounced localized climatic, economic, and geopolitical shocks.



Picture 1. Production of kiwi, 2024

Source: Food and Agriculture Organization of the United Nations (2025)

Kiwifruit, native to China, has undergone significant global expansion, with numerous countries contributing to its growing market importance (Chen et al., 2023). This pattern is associated with consumer preference for products that provide both quality assurance and affordability (Chechitko et al., 2024). Climate change further reinforces this transition. Rising temperatures are altering agro-climatic suitability, enabling the introduction of crops into new regions and driving shifts in cultivated species (Kopec, 2024). Empirical evidence from Turkey indicates that increasing seasonal air temperatures have already affected production conditions, highlighting the necessity for adaptive management strategies (Gurbuz et al., 2024). In this context, the Republic of Uzbekistan is emerging as a prospective producer, where cultivation is gradually increasing, primarily within smallholder farming systems. However, national production remains limited, estimated at approximately 50 tons annually. Despite this modest scale, the country demonstrates strong potential for sectoral development. The country possesses a well-established and economically significant viticulture sector, with annual grape production reaching approximately 1.83 million tons, underscoring its strategic role in national horticulture (FAO, 2024). Kiwifruit and grape cultivation exhibit notable agronomic and technological similarities, including trellising systems, canopy management, irrigation practices, and post-harvest handling. These parallels enable effective knowledge transfer and facilitate the incorporation of kiwifruit into existing production systems. Consequently, established viticultural infrastructure and farmer expertise can be leveraged to support the progressive development. This agronomic compatibility provides a competitive advantage by encouraging crop diversification and enhancing efficiency. It also lowers diversification costs and supports the integration of kiwifruit into existing production systems.



Picture 2. Grape production, 2024

Source: Food and Agriculture Organization of the United Nations (2025)

Literature Review

Kiwifruit is a climacteric, highly perishable fruit prone to softening, quality deterioration, off-flavor development, uneven ripening (Chai et al., 2024), and pathogen-induced soft rot (Xie et al., 2024). Its moisture content (~80%) increases susceptibility to physicochemical degradation and microbial spoilage (Vincenzo et al., 2024), thereby reducing shelf life. Compounding these limitations, its genotypes are highly vulnerable to cold stress at temperatures near 0 °C. The extent of damage depends on physiological ripeness, and poor temperature regulation can lead to irreversible freezing damage and rapid deterioration (Burdon and Wang, 2024). It may also induce peel pitting and browning, thus reducing marketability (Xiong et al., 2024). In an effort to reduce postharvest losses, controlled atmosphere storage has been thoroughly analyzed as an effective preservation strategy. By precisely modulating oxygen and carbon dioxide concentrations, controlled atmosphere conditions suppress respiratory metabolism and delay fruit maturation processes (Xia et al., 2024). Optimized conditions, such as 4.2–4.8% CO_2 and 14.0–14.8% O_2, enhance physiological resilience by stimulating antioxidant enzyme activity, reducing malondialdehyde accumulation, and suppressing ethylene production and lipoxygenase activity (Yang et al., 2025). In parallel, regulation of temperature, relative humidity, gas composition, and ethylene exposure is essential to maintain sensory and nutritional quality while minimizing fungal proliferation (Bakoğlu and Gunes, 2024). In addition, biopreservation strategies have been extensively investigated, including the use of beneficial microorganisms such as antagonistic yeasts and bacteria. These approaches also involve natural elicitors that trigger host defense mechanisms and chemical agents such as 1-methylcyclopropene and jasmonates (Ma et al., 2025).

In this context, omics-based approaches, including transcriptomics, metabolomics, proteomics, and their integrative analyses, are essential for elucidating molecular networks that govern stress adaptation (Habibi et al., 2024). Within this conceptual setting, multi-omics studies have improved the understanding of abiotic stress responses, including freezing, chilling, and cold-chain fluctuations, through the identification of key metabolic markers such as flavonoids, lipids, and organic acids. They have further revealed regulatory hubs, including HsfA3a, that regulate genotype-specific stress tolerance (Yang et al., 2025). These molecular insights are further strengthened by advanced genomic resources such as the Kiwifruit PanGenome Database (KPGD). This platform consolidates structural variants, SNPs, and transcriptomic datasets within unified systems. This integration supports fine-scale trait dissection and accelerates progress in comparative genomics and molecular breeding strategies (Li et al., 2025). Beyond stress physiology, metabolite-level omics analyses have also expanded the functional characterization of kiwifruit composition. In this regard, kiwifruit contains a substantial starch fraction (10–25% fresh weight), comparable to that of potato (6–25%). This highlights its relevance as a model for linking metabolic regulation with nutritional functionality. The starch exhibits a B-type crystalline structure and irregular granule morphology. It also possesses distinctive physicochemical properties, including high resistant starch content, low pH, and notable antioxidant capacity. These properties together enhance its nutritional value. They also contribute to physiological effects such as modulation of postprandial glycemic response (Lan et al., 2024). Collectively, the convergence of omics technologies, genomic resources, and metabolite-level characterization enables a comprehensive perspective for kiwifruit research (Ozturk et al., 2024).

Discussion

The two most commercially important kiwifruit species are Actinidia chinensis and Actinidia deliciosa. These species encompass a broad range of cultivars exhibiting pronounced genetic and phenotypic variability in fruit morphology, including shape, size, and weight. They also differ in sensory attributes such as aroma, texture, and flavor, in skin characteristics such as thickness, coloration, and hairiness or smoothness, and in postharvest shelf life (Ryu et al., 2024). For experimental analysis, Actinidia deliciosa fruits were obtained from two independent commercial suppliers, namely “Aromat Fresh and Healthy Kiwi Fruit” and Barakat kiwifruit from the Astara district, Gilan Province, Iran. Fruits were harvested at commercial maturity and selected under strict criteria ensuring uniformity in size and shape, while defective specimens were excluded to maintain sample homogeneity. All samples were transported under controlled conditions designed to preserve their physicochemical integrity prior to laboratory processing. A total of ten representative fruits (n = 10) were selected for detailed physicochemical characterization. The evaluated parameters included fruit weight (g), height (cm), width (cm), and grammage (g/cm), as well as total soluble solids (°Brix) and titratable acidity (%). Descriptive statistical analysis was performed to determine mean values, standard deviation, and range, thereby providing a robust assessment of morphological variability and processing-relevant quality attributes. Prior to analysis, fruits were thoroughly washed with tap water, rinsed with tap water, and drained for 10 min. Fruits were subsequently manually peeled and sliced into uniform 8 mm sections using a stainless-steel slicer, randomly allocated to experimental treatments to ensure unbiased sample distribution.

Samp	**Weig**	**Heig**	**Widt**	**Gramma**	**°Bri**	**Acidi**

le No.	ht (g)	ht (cm)	h (cm)	ge (g/cm)	x (TSS)	ty (%)
1	130.40	26.02	23.97	5.01	11.2	1.20
2	107.50	24.02	20.71	4.47	12.5	1.10
3	120.16	27.22	22.83	4.41	13.2	1.05
4	109.75	25.38	20.76	4.32	11.8	1.25
5	69.76	19.87	20.91	3.51	10.5	1.40
6	66.45	22.35	17.68	2.97	12.0	1.30
7	151.69	22.53	33.27	6.72	14.1	0.95
8	65.50	23.45	19.21	2.79	10.8	1.50
9	78.46	23.10	19.32	3.40	11.6	1.35
10	98.30	24.80	21.50	3.96	12.9	1.15

Table 1. Physical and Chemical Characteristics of Kiwifruit Samples (n = 10)

Source: Author – Gafurov Gafur (2026).

Parameter	Mean	Std. Dev.	Min	Max
Weight (g)	99.77	27.44	65.50	151.41
Height (cm)	23.87	2.22	19.87	27.22

Width (cm)	22.02	4.05	17.68	33.27
Grammage (g/cm)	4.16	1.07	2.79	6.72
°Brix (TSS)	12.06	1.16	10.5	14.1
Acidity (%)	1.23	0.16	0.95	1.50

Table 2. Summary Statistics of Measured Parameters

Source: Author – Gafurov Gafur (2026).

Maintaining the physicochemical and sensory integrity of fresh-cut kiwifruit remains a critical challenge for the industry due to its direct impact on consumer acceptance and marketability. Thus, controlled drying is widely applied to extend shelf life by reducing water activity and suppressing microbial proliferation and enzymatic degradation. Among available technologies, convective drying system is recognized for its energy efficiency and capacity to retain product attributes. However, its performance is often attenuated through hybrid and synergistic configurations that more effectively mitigate thermal and oxidative stresses. Previous studies have demonstrated that hybrid dehydration methods improve color retention and reduce surface damage in products such as carrots and grapes (Hassoun et al., 2025). This underscores the importance of process optimization for quality preservation. Against this background, kiwifruit slices and pulp were dehydrated using an industrial-scale hot-air system Global Doosung Engineering Co., Ltd., Republic of Korea. The equipment operates under forced convective heat transfer with precise programmable control of temperature, airflow velocity, and processing time. It integrates a thermostatically regulated heating module, high-efficiency axial fans ensuring homogeneous air distribution, and a multi-tray stainless-steel chamber designed to promote uniform heat and mass transfer across samples. Drying was conducted at 50 °C for 16 hours under steady-state conditions to achieve efficient moisture removal while minimizing degradation of thermolabile bioactive constituents, including vitamins, pigments, and volatile aroma compounds. Stable thermal gradients and controlled airflow dynamics ensured consistent dehydration kinetics, restricted structural collapse, and mitigated case hardening. These conditions collectively preserved structural integrity and effectively maintained physicochemical stability

Kiwifruit, widely referred to as the "monarch of fruits," has increasingly emerged as a globally significant horticultural commodity in recent years (Lin et al., 2024). The peel constitutes a rich reservoir of bioactive compounds, including chlorophyll, polyphenols, and flavonoids, which contribute substantially to antioxidant capacity (Akbulut et al., 2024). In conventional processing, particularly during kiwifruit wine production, fruits are peeled and juiced prior to fermentation, generating considerable by-product streams and contributing to industrial waste (Sun et al., 2024). These residues represent valuable biomass that can be repurposed as organic fertilizers or serve as feedstock for the recovery of antioxidants and other high-value bioactive compounds with functional properties (Parri et al., 2024). Kiwifruit-derived extracts have demonstrated bleaching efficacy comparable to hydrogen peroxide, highlighting their potential as natural alternatives in functional applications (Pecho et al., 2026). In parallel, as one of the most successfully domesticated fruit crops, kiwifruit has achieved substantial improvements in key quality attributes, including flavor profile, yield potential, and postharvest storage performance (Nazir et al., 2024). Within this context, optimization of peelability represents a critical frontier for further market expansion, particularly in response to increasing consumer demand for convenience and hygienic handling. From a sustainability perspective, circular bioeconomy approaches enhance resource efficiency, valorize agro-industrial waste, and enable the development of novel value-added products (Nguyen et al., 2025). The integration of bioeconomy and circular economy principles defines the circular bioeconomy as a system in which biomass is converted into diversified product streams, including materials, chemicals, biofuels, and food (FAO, 2025).

Picture 3. Representative Actinidia deliciosa fruits utilized in the experimental study, obtained from two independent commercial suppliers, “Aromat Fresh and Healthy Kiwi Fruit” and Barakat, located in Astara, Gilan Province, Iran.

Source: Author – Gafurov Gafur (2026).

Consumer demand for fruit-based alcoholic beverages is increasingly shifting toward products with reduced alcohol content, enhanced antioxidant functionality, and distinctive sensory profiles (Klimczak et al., 2024). In kiwifruit-derived fermentations, aroma formation follows a sequential evolution involving native fruit volatiles, fermentation-derived metabolites, and aging-related transformations (Ascrizzi et al., 2022). During maturation, controlled oxidation and esterification reactions regulate the balance of alcohols, esters, and organic acids, thereby improving aroma complexity, flavor integration, and mouthfeel (Stanzer et al., 2023). However, industrial kiwifruit wine production is constrained by prolonged aging requirements and persistent sensory limitations, including excessive sourness, astringency, weak aroma intensity, and structural imbalance, which hinder standardization and scalability (Moysidou et al., 2024). Extended maturation cycles and a dominant alcoholic profile further limit commercialization potential (Huang et al., 2022). Although process intensification strategies such as yeast selection, staged nitrogen supplementation, and ultrasonic treatment have been explored, their operational complexity and cost restrict industrial adoption (Zhang et al., 2023). Within this context, peel represents an underutilized substrate for value-added liqueur production. Rich in phenolics, flavonoids, and other bioactive compounds, the peel offers simultaneous opportunities for functional enhancement and agro-industrial waste reduction. Its incorporation into fermentation systems enables direct conversion of processing residues into peel-based liqueur with improved nutritional and sensory attributes. Supporting this approach, fermentation has been shown to significantly enhance antioxidant activity and total phenolic content compared with pulp-based and commercial wines (Liu et al., 2024). These findings indicate that kiwifruit peel utilization enables scalable, cost-effective substrate restructuring for superior next-generation liqueur production.

Conclusions

Conventional food preservation relies on polyethylene and polystyrene-based packaging. However, their persistence and slow degradation significantly increase environmental burden and hinder sustainability goals (Yan et al., 2024). Although essential for protecting food from oxygen, light, and moisture and extending shelf life (Eranda et al., 2024), their limitations require integrating preservation with biomass valorization in circular systems. In this context, a coupled biorefinery approach was developed to strategically redirect kiwifruit peel and residual biomass from waste streams into value-added products. Controlled maceration and extraction were applied to convert these by-products into a secondary liqueur system. Bioactive transfer was achieved using 14 L of Uzbek vodka “Vodka Since 1867 Supreme” (40% ABV; rectified ethyl alcohol of food origin and potable water; compliant with national standards) as the extraction medium. The resulting mixture was matured in a 20 L inert glass vessel under environmentally controlled conditions. The integrated strategy was evaluated comprehensively over three months. From 20 kg of fresh kiwifruit, 1.4 kg of dehydrated product and 3.095 kg of fruit pastille were obtained, demonstrating effective valorization into shelf-stable matrices. In parallel, 4.915 kg of peel and residual biomass were fully upcycled into 14 L of kiwifruit-based liqueur, confirming effective bioconversion of waste into a functional liquid product. Final products were stored in borosilicate glass containers compliant with FDA, LFGB, and DGCCRF standards, ensuring stability and safe long-term preservation. Collectively, these results establish a scalable resource recovery framework integrating packaging-related sustainability constraints with multi-stream kiwifruit biomass upgrading, thereby yielding physicochemically consistent, high-value products.

More broadly, the study demonstrates that transitioning from raw fruit marketing to integrated bioprocessing systems can substantially enhance rural value capture, income diversification, and agro-industrial resilience under climate stress, water scarcity, and market volatility (Bilgihan et al., 2025). The proposed zero-waste framework is operationally relevant, offering a pathway to reposition the emerging kiwifruit sector as a high-value agro-industrial niche supporting sustainable rural development in emerging economies. Within this system, dried kiwi and fruit pastille exhibit stable physicochemical integrity and uniform structural quality. This is reflected in consistent olive-green coloration and a balanced sweet–acid sensory profile, indicating effective preservation of intrinsic quality attributes during controlled processing and dehydration. Their composition and processing stability further support functional applicability for targeted dietary groups, including athletes, individuals requiring energy-dense products, and consumers under regulated sugar intake. In parallel, kiwifruit-derived liqueur produced from peel and residual biomass displays pronounced aromatic complexity and physicochemically consistent sensory characteristics, reflecting efficient extraction and retention of bioactive compounds during maceration. Its balanced organoleptic profile enables versatile application in premium gastronomy, particularly in desserts such as cakes and ice cream, where it enhances flavor integration and sensory depth. Collectively, these findings confirm full-fraction utilization of kiwifruit biomass within an integrated, scalable, zero-waste processing strategy. The simultaneous production of dried products, fruit pastilles, and liqueur improves material efficiency, reduces post-harvest losses, and strengthens cross-sectoral linkages between horticultural production and beverage applications. Overall, the approach establishes a scalable biomass-to-product framework enabling full-fraction valorization, improving value-chain diversification via circular bioeconomy-driven rural transformation.

References

1. Akbulut, M., Çoklar, H., Bulut, A.N., Hosseini, S.R. (2024). Evaluation of Black Grape Pomace, a Fruit Juice by-Product, in Shalgam Juice Production: Effect on Phenolic Compounds, Anthocyanins, Resveratrol, Tannin, and in Vitro Antioxidant Activity. Food Sci. Nutr. 2024, 00, 1-13. https://doi.org/10.1002/fsn3.4104

2. Ascrizzi, R., Pieracci, Y., Melai, B., Cioni, P. L., Narri, P., Flamini, G., Pistelli, L. (2022). Preliminary study on red wine aroma: The volatile profiles of six grape cultivars in different vinification phases. Fermentation, 8(12), 753. https://doi.org/10.3390/fermentation8120753

3. Bakoğlu, N. and Gunes, N.T. (2024). Impact of harvest time on cold storage performance in Kiwifruit. J. Food Compos. Anal., 135.

4. Bilgihan, A., Hanks, L., Line, N.D., Mody, M.A. (2025). Hospitality marketing research: Bridging the practical gap. International Journal of Contemporary Hospitality Management, 37 (1), pp. 316-332.

5. Burdon, J.N. and Wang, R. (2024). Postharvest: Fresh fruit harvest, storage and supply. In Kiwifruit: Botany, Production and Uses; Richardson, A.C., Burdon, J.N., Ferguson, A.R., Eds.; CABI: Wallingford, UK, pp. 353–374.

6. Chai, J., Yang, B., Xu, N., Jiang, Q., Gao, Z., Ren, X., Liu, Z. (2024). Effects of Low Temperature on Postharvest Ripening and Starchiness in ‘Cuixiang’ Kiwifruit. LWT, 209.

7. Chai, J., Li, J., Liu, Q., Chen, Z., Liu, Z. (2024). Differential changes in respiratory metabolism and energy status in the outer pericarp and core tissues affect the ripening of ‘Xuxiang’ kiwifruit. Postharvest Biology and Technology, 212, https://doi.org/10.1016/j.postharvbio.2024.112876

8. Chechitko, V., Antoniv, A., Adamchuk, L. (2024). Analytical review of the market of raw materials and innovative technologies of health-improving food products of plant origin. Animal Science and Food Technology, 15 (3), 115–133. https://doi.org/10.31548/animal.3.2024.115

9. Chen, Q.; Ma, X.; Hu, J.; Zhang, X. (2023). Comparison of comprehensive performance of kiwifruit production in China, Iran, and Italy based on energy and carbon emissions. Ecol. Model, 483.

10. Eranda, D. H. U., Chaijan, M., Panpipat, W., Karnjanapratum, S., Cerqueira, M. A., Castro-Muñoz, R. (2024). Gelatin-chitosan interactions in edible films and coatings doped with plant extracts for biopreservation of fresh tuna fish products: a review. Int. J. Biol. Macromol. 280:135661. https://doi.org/10.1016/j.ijbiomac.2024.135661

11. FAOSTAT (2025). Kiwi fruit production in the world. http://www.fao.org/faostat/en/#data/QC

12. FAO (2025). Promoting bioeconomy through agriculture practice in Eastern Europe and Central Asia. Food and Agriculture Organization. https://www.fao.org/family-farming/detail/en/c/1731969/

13. Habibi, F., Boakye, D.A., Chang, Y., Casorzo, G., Hallman, L.M., Madison, M., Clavijo-Herrera, J., Sarkhosh, A., Liu, T. (2024). Molecular Mechanisms Underlying Postharvest Physiology and Metabolism of Fruit and Vegetables through Multi-Omics Technologies. Sci. Hortic., 324.

14. Hassoun, A., Aït-Kaddour, A., Dankar, I., Safarov, J., Ozogul, F. and Sultanova, S. (2025). The significance of Industry 4.0 technologies in enhancing various unit operations applied in the food sector: focus on food drying. Food Bioproc Technol. 18(1):109–128.

15. Hu Y. K., Kim S. J., Jang C. S., Lim S. D. (2024). Antioxidant activity analysis of native Actinidia arguta cultivars. Int. J. Mol. Sci.25, 1505. https://doi.org/10.3390/ijms25031505

16. Huang, J., Wang, Y., Ren, Y., Wang, X., Li, H., Liu, Z., Yue, T., Gao, Z. (2022). Effect of inoculation method on the quality and nutritional characteristics of low-alcohol kiwi wine. LWT, 156, Article 113049. https://doi.org/10.1016/j.lwt.2021.113049

17. Klimczak, K.; Cioch-Skoneczny, M.; Ciosek, A.; Poreda, A. (2024). Application of Non-Saccharomyces Yeast for the Production of Low-Alcohol Beer. Foods, 13, 3214.

18. Kopec, P. (2024). Climate Change – The Rise of Climate-Resilient Crops. Plants, 13, 490.

19. Lan, T., Wang, J., Lei, Y., Lei, J., Sun, X., Ma, T. (2024). A new source of starchy flour: Physicochemical and nutritional properties of starchy kiwifruit flour. Food Chemistry, 435, Article 137627. https://doi.org/10.1016/j.foodchem.2023.137627

20. Li, B., Li, X., Wang, Y., Liu, X., Li, K., Li, R., Faiz, M.U., Darlington, U.T., Rao, Z., Wu, Q.; et al. (2025). KPGD: A Kiwifruit Pangenome Database for Comprehensive Mining of Genetic Diversity in the Genus Actinidia. Plant Commun., 6.

21. Lin, M., Gao, Z., Wang, X., Huo, H., Mao, J., Gong, X., Chen, L., Ma, S., Cao, Y. (2024). Eco-Friendly Managements and Molecular Mechanisms for Improving Postharvest Quality and Extending Shelf Life of Kiwifruit: A Review. Int. J. Biol. Macromol., 257.

22. Liu, J., Guan, W., Sun, Z., Ni, Y., He, L., Tian, F., Cai, L. (2024). Application of Cyclocarya Paliurus–Kiwifruit Composite Fermented to Enhance Antioxidant Capacity, Flavor, and Sensory Characteristics of Kiwi Wine. Molecules, 29, 32.

23. Liu, Y., Hao, J., Yang, P., Li, Z., Tchuenbou-Magaia, F., Tang, W. (2025). Development of a novel packaging box with on-demand ripening function for fast kiwifruit logistics. Postharvest Biology and Technology, 227, Article 113595. https://doi.org/10.1016/j.postharvbio.202

24. Ma, H., Liu, N., Xie, G., Tan, S., Xu, Y., Luo, Z. (2025). Postharvest Ripening Combined with 1-MCP Keeps the Shelf Quality of Kiwifruit after Cold Storage by Regulating the Antioxidant System and Defense Enzymes. Postharvest Biol. Technol., 222, 113370.

25. Nazir, M.F., Lou, J., Wang, Y., Zou, S., Huang, H. (2024). Kiwifruit in the omics age: Advances in genomics, breeding, and beyond. Plants, 13, 2156.

26. Nguyen T.H., Wang X., Utomo D., Gage E., Xu B. (2025). Circular bioeconomy and sustainable food systems: What are the possible mechanisms? Cleaner and Circular Bioeconomy, 11, 100145.

27. Ozturk, B., Korkmaz, M., Aglar, E. (2024). Changes in Fruit Quality Properties and Phytochemical Substances of Kiwifruit (Actinidia deliciosa) Grown in Different Agro-Ecological Conditions during Cold Storage. BMC Plant Biol., 24, 795.

28. Parri, S., Campani, T., Conti, V., Cai, G., Romi, M., Casini, S., Zari, R., Caldini, F., Marsili, L. (2024). New Olive-Pomace Fertilizer Tested with a 2-Tiers Approach: Biomarkers on Eisenia Fetida, Physiochemical Effects on Solanum Lycopersicum and Olea Europaea. J. Environ. Manag., 351, 119915. https://doi.org/10.1016/j.jenvman.2023.119915

29. Pecho O.E., Ghinea R., Pérez M.M., Della Bona A. (2026). Influence of Gender on Visual Shade Matching in Dentistry. J Esthetic Restor Dent. 38(2):15-23.

30. Ryu S.H., Ahn J., Turk A., Kim S.B., Hwang B., Lee M. (2024) Argutinic acid, a new triterpenoid from the fruits of Actinidia Arguta. Nat Prod Sci 30:208–211.

31. Stanzer, D., Hanousek C, K., Blesic, M., Smajic Murtic, M., Mrvčić, J., Spaho, N. (2023). Alcoholic fermentation as a source of congeners in fruit spirits. Foods, 12 (10), 1951. https://doi.org/10.3390/foods12101951

32. Sun, W., Chen, X., Bi, P., Han, J., Li, S., Liu, X., Zhang, Z., Long, F., Guo, J. (2024). Screening and Characterization of Indigenous NonSaccharomyces Cerevisiae with High Enzyme Activity for Kiwifruit Wine Production. Food Chem., 440. https://doi.org/10.1016/J.FOODCHEM.2023.138309

33. Vincenzo, S., Antonio, M., Rosa, R., Roberta, P., Filomena C., Rosa L. M. (2024). "Evolution of Quality Parameters and Bioactivity of Actinidia chinensis cv. Sungold (Kiwifruit) Slices Subjected to Different Drying Conditions Storage for 4 Months." Food 13, no. 13: 2100.

34. Waswa, E. N., Ding, S. X., Wambua, F. M., Mkala, E. M., Mutinda, E. S., Odago, W. O., Hu, G. W. (2024). The genus Actinidia Lindl.(Actinidiaceae): A comprehensive review on its ethnobotany, phytochemistry, and pharmacological properties. Journal of Ethnopharmacology, 319, Article 117222. https://doi.org/10.1016/j. jep.2023.117222

35. Xia, Y., Wu, D.T., Ali, M., Liu, Y., Zhuang, Q.G., Wadood, S.A., Liao, Q.H., Liu, H.Y., Gan, R.Y. (2024). Innovative postharvest strategies for maintaining the quality of kiwifruit during storage: An updated review. Food Front., 5, 1933–1950.

36. Xie, G., Liu, N., Zhang, Y., Tan, S., Xu, Y., Luo, Z. (2024). Postharvest MeJA Maintains the Shelf Quality of Kiwifruit after Cold Storage by Regulating Antioxidant Capacity and Activating the Disease Resistance. Postharvest Biol. Technol., 211.

37. Xiong, S., Ma, Z., Xiong, H., Yuan, M., Jiang, A., Zhang, P. (2024). Preserving refrigeration and shelf life quality of hardy kiwifruit (Actinidia arguta) with alginate oligosaccharides preharvest application. J. Food Sci.89, 7422–7436. https://doi.org/10.1111/1750-3841.17449

38. Yan, J., He, S., Chen, L., Chen, H., Ouyang, K., Wang, W. (2024). Effect of gelatinchitosan-Cyclocarya paliurus flavonoids edible coating film on the preservation of chilled beef. LWT 199:116138. https://doi.org/10.1016/j.lwt.2024.116138

39. Yang, X., Liu, N., Tan, S., Xu, Y., Luo, Z., Xie, G. (2025). Preharvest Methyl Jasmonate Maintain the Shelf Quality of Kiwifruit after Cold Storage by Regulating the Antioxidant System. Postharvest Biol. Technol., 221.

40. Yang, H., Li, Y., Zhang, S., Ding, K., Wang, R., Shan, Y., Ding, S. (2025). Transcriptomic and metabolomic analyses reveal the mechanism of cold chain breaks accelerate postharvest kiwifruit ripening and flavonoid loss. Sci. Hortic., 341, 113958.

41. Zhang, J., Zhao, N., Guo, L., Li, P., Gu, S., Yuan, J., Fan, M. (2023). In-depth exploration on the effects of organic nitrogen addition during different fermentation periods on the quality of cider. LWT, 187, Article 115376. https://doi.org/10.1016/j.lwt.2023.115376