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Transforming strawberry processing in India: New developments, challenges and opportunities- a review

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Abstract
Strawberry (*Fragaria ananassa*) is a nutrient-rich fruit with high commercial potential, yet its perishability poses challenges for farmers and processors. India's strawberry cultivation has expanded due to controlled-environment agriculture but post-harvest losses, inadequate infrastructure and supply chain inefficiencies hinder processing growth. The sector remains small-scale primarily producing jams and dried strawberries though demand for frozen, organic, and nutraceutical products are rising. Government initiatives like PMFME and Operation Greens support the industry, yet high processing costs, regulatory hurdles, and consumer preference for fresh strawberries remain obstacles. Future trends indicate increasing demand for organic, functional, and sustainable strawberry-based products. Technological advancements such as AI, IoT and block chain can enhance processing efficiency. Strengthening cold storage, promoting processed products, and investing in research and innovation can drive industry growth. With improved policies and market strategies, India can emerge as a key player in global strawberry processing. This review discusses the various challenges and opportunities in this segment which will help the entrepreneurs and growers to make informed decisions regarding strawberries processing.

Keywords: Strawberry processing, post-harvest losses, non-thermal techniques, supply chain optimization, sustainable processing techniques

1. Introduction
Strawberry (*Fragaria ananassa*) is one of the most beloved and nutrient-dense fruit and they are eaten by many because of their sweet taste, vivid colour and many health advantages. Their high antioxidant, vitamin C, managanese and dietary fiber content makes them a popular ingredient in many food and drink recipes (Wani *et al.* 2023) [38]. But because they are high;y perishable, they present a big problem for farmers, traders and processors alike. If not managed effectively, this can lead to significant post harvest losses (Yahia *et al.* 2019) [39]. Strawberry cultivation has rapidly expanded in India as a result of rising demand in both domestic and foreign markets (Basu *et al.* 2007) [3]. Harvested traditionally in the cool climates of Himachal Pradesh, Uttarakhand and Mahabaleshwar (Maharashtra), strawberry farming has now spread to other areas thanks to the development of controlled- environment agriculture which includes hydroponics and poly-house cultivation. Kumar & Agrawal (2023) [17] stated that the Indian strawberry industry still faces a number of challenges in spite of its expansion such as inadequate cold storage infrastructure, ineffective supply chain management and a lack of knowledge among farmers about cutting- edge processing
Processing strawberries offers a practical way to increase the fruit's shelf life, lower post-harvest losses and produce value- added goods like powders, jams, purees and freeze-dried snacks (Sengar *et al.* 2023) [31]. There is a huge opportunity for investment in strawberry processing facilities throughout India due to the growing demand for processed and convenience foods by Ravi & Prasad (2020). Furthermore, novel processing techniques like fermentation, freeze-drying and high-pressure processing (HPP) have created new markets for functional foods and nutraceutical make from strawberries (Vieiera *et al.* 2024).
Government programs like Operation Greens, The PM Formalization of Micro Food Processing Enterprises (PMFME) Scheme and subsidies for cold storage infrastructure have all contributed to the growth of India's food processing industry by Singh (2023). Nevertheless, obstacles like high upfront investment costs, a lack of technological knowledge and regulatory compliance continue to impede the expansion of the strawberry

processing sector by Sansavini (2006) [29].

With an emphasis on development in processing technologies, government regulations, market trends and potential future developments, this article attempts to examine the state of strawberry processing in India today. By addressing these factors interested parties can gain a better understanding of the opportunities and difficulties involves in processing strawberries and take well-informed action to increase its profitability and sustainability.

Table 1: The following table presents the macro-nutrients and micro-nutrients present in strawberries across different growth stages as reported by Balan *et al*. 2024 [2].

Nutrient	Amount	Growth Stage
Total Nitrogen	169-176 mg/l	Flowering, Fruiting
Ammonium	3.7-11.8 mg/l	Flowering, Fruiting
Phosphorous	47 mg/l	Flowering, Fruiting
Potassium	212-232 mg/l	Flowering, Fruiting
Calcium	127-137 mg/l	Flowering Fruiting
Magnesium	36-37 mg/l	Flowering, Fruiting
Sulfur	36-44 mg/l	Flowering, Fruiting
Manganese	1.4-1.48 mg/l	Flowering, Fruiting
Iron	2.6-2.8 mg/l	Flowering, Fruiting

2. Current Scenario of Strawberry Processing in India

2.1. Major Strawberry-Producing Regions

India's strawberry industry is mostly centered in Maharashtra especially in the Mahabaleshwar area which is renowned for the producing premium strawberries which constitute almost 85 per cent of the total production in India (Kotwal, 2023) [16]. Parts of Northeast India, Uttrakhand, Himachal Pradesh, Punjab, Haryana and parts of Jammu and Kashmir are additional important production regions by Josh and Negi (2011) [14]. Because it allows for year-round production under controlled conditions, hydroponics strawberry farming in urban areas has gained popularity in recent years. Growing cultivation in a variety of climates has opened up new processing and value-adding opportunities.

2.2. Processing Industry Overview

With few large-scale processing facilities, India's strawberry processing sector is still in its infancy (Verma and Joshi, 2000) [35]. Traditional strawberry preserves, jams and dried strawberries are the main products of the majority of the current operations which are small-scale or cottage industries (Samtani *et al* 2019) [28]. However there is a trend toward more expensive, sophisticated processed strawberry products as a result of growing urbanization and shifting consumer preferences (Mok *et al* 2014).

2.2.1. Growing Demand for Processed Strawberry Products

By 2025, the Indian market for processed strawberry products is expected to grow significantly due to an increasing focus on healthy eating, rising disposable incomes, and demand for convenience foods. Some of the key trends shaping the industry include:

- **Expansion of Frozen and Freeze-Dried Strawberries:** The demand for frozen strawberries has risen in the retail and food service sectors due to their longer shelf life and versatility in desserts, smoothies, and bakery products by Fischer (2019) [9].
- **Growth in Functional and Nutraceutical Strawberry Products:** With consumers becoming more health-conscious, there is a surge in demand for strawberry-based functional foods, including antioxidant-rich powders, probiotic beverages, and vitamin-fortified snacks (Roussos *et al.* 2022) [26].
- **Rise in Organic and Chemical-Free Strawberry Products:** The organic food segment is witnessing robust growth, with more farmers and processors adopting organic certifications to meet the increasing demand for pesticide-free strawberries and processed products by Dague (2014) [8].
- **Development of Ready-to-Eat and Ready-to-Drink Products:** Companies are introducing innovative strawberry-based ready-to-eat and ready-to-drink products, such as strawberry-flavored protein bars, yogurts, and cold-pressed juices, to cater to the fast-paced lifestyles of urban consumers by Rubin and Rubin (2006) [27].
- **Emergence of Strawberry Powders for Long-Term Storage and Value Addition:** Strawberry powder is gaining popularity as a versatile ingredient used in baking, beverages, dairy products, and functional foods. The ability to retain the fruit's nutritional properties while extending shelf life has made strawberry powder a preferred choice for both industrial and home use.

2.2.2. Challenges in the Indian Strawberry Processing Industry

Despite the promising trends, the Indian strawberry processing industry faces multiple challenges:

- **High Post-Harvest Losses:** Due to inadequate cold storage facilities and transportation inefficiencies, a significant percentage of strawberries perish before reaching processing units (Priyadarshi *et al.* 2024) [23].
- **Limited Large-Scale Processing Infrastructure:** Most strawberry processing is still carried out at a small scale, with a lack of investment in industrial-level processing plants (Chemat *et al.* 2017) [6].
- **Supply Chain and Market Access Issues:** Farmers often struggle to get fair prices due to middlemen-driven supply chains and lack of direct access to processing units or retail markets.
- **Regulatory and Certification Challenges:** Processors face difficulties in obtaining food safety certifications, which can hinder exports and limit market expansion.

2.3. Government Support and Policy Initiatives

The Indian government has recognized the potential of the strawberry processing sector and has introduced several initiatives to support its growth. Key policies and programs include:

- **PM Formalization of Micro Food Processing Enterprises (PMFME) Scheme:** This initiative provides financial and technical support to small-scale food processors, including those involved in strawberry processing by White and Wilson (2024).
- **Operation Greens (TOP to TOTAL):** Initially launched for tomato, onion, and potato processing, this scheme has expanded to include strawberries, offering subsidies for cold storage, processing infrastructure, and market linkages by Praveen (2023) [22].
- **Agri-Export Policy:** The Indian government is encouraging fruit exports, including processed

strawberry products, through incentives and streamlined export procedures.
- **State-Specific Initiatives:** Several state governments, particularly in Maharashtra, Himachal Pradesh, and Uttarakhand, are providing subsidies and incentives to boost strawberry farming and processing.

2.4. Future Prospects and Industry Growth by 2025
With improved infrastructure, legislative backing, and growing technology improvements, the Indian strawberry processing business is expected to grow quickly. By 2025, some anticipated developments include:
- **Integration of Smart Farming and Precision Agriculture:** Precision farming methods powered by AI will assist maximize strawberry productivity and quality, guaranteeing a consistent supply for processing facilities.
- **Expansion of Cold Chain and Logistics Infrastructure:** Investing in refrigerated transportation and cold storage will increase the availability of fresh strawberries for processing and decrease post-harvest losses.
- **Emergence of Direct-to-Consumer (D2C) Brands:** It is anticipated that more food startups and well-established businesses would introduce their own direct-to-consumer (D2C) platforms, providing processed strawberry goods to customers directly through online sales.
- **Increase in Strawberry-Based Functional and Health Foods:** The health and wellness sector will witness substantial growth in probiotic strawberry beverages, fortified strawberry powders, and nutraceuticals.
- **Greater Participation from Private and Foreign Investors:** Large-scale strawberry processing facilities in India are expected to attract both domestic and foreign investors as the sector develops.

India's strawberry processing industry has the potential to become a global leader by proactively tackling the obstacles and seizing new opportunities, which would benefit growers, processors, and consumers equally financially.

3. Advanced Processing Techniques in the Strawberry Industry
To meet consumer expectations for sustainability, safety, and quality, strawberry processing methods must be improved. Each of the designated processing methods is covered in full in this thorough exposition.

3.1. Minimal Processing Technologies
The freshness of strawberries is preserved via minimal processing processes, allowing for a longer shelf life while retaining their nutritional and sensory attributes.
- **Cold Plasma:** Ionized gas, which is used in this cutting-edge technology, effectively kills bacteria and fungi on strawberries' surfaces without the need for high temperatures. Because the fruit's cellular structure is preserved during the cold plasma process, its flavor, texture, and nutritional value are all retained. Fresh produce is particularly vulnerable to foodborne viruses like Salmonella and Listeria, which can be decreased by cold plasma therapy, according to studies. By delaying ripening processes, it may extend shelf life, according to ongoing research.
- **High-Pressure Processing (HPP):** HPP uniformly applies high pressure (up to 600 MPa) to strawberries that are packaged. This procedure preserves the nutritional value while inactivating infections and spoiling organisms. Because HPP-treated strawberries are more likely to maintain their original color and flavor than heat-treated ones, this process is especially attractive to consumers who are concerned about their health. The advantages include a decrease in the need for preservatives and a 2-4 week increase in shelf life when stored properly.
- **UV Light:** By exposing strawberries to ultraviolet light, UV light processing successfully disinfects the fruit while causing the least amount of damage to its flavor and texture. By focusing on surface and watery bacteria, this technique dramatically lowers microbial burdens. According to studies, UV processing can lower the number of mold spores, preventing spoiling and improving the strawberries' safety while being distributed.

3.2. Drying & Dehydration Methods
Drying and dehydration methods transform strawberries into shelf-stable products with concentrated flavors and extended shelf lives.
- **Freeze Drying:** By freezing strawberries at extremely low temperatures and subsequently lowering the ambient pressure, this advanced technique enables ice to sublimate straight from solid to gas by Chaves & Zaritzly (2018) [5]. As a result, the strawberry's structure remains lightweight and intact while retaining over 90% of its flavor and nutrients. Freeze-dried strawberries are a versatile natural ingredient that can be readily rehydrated for use in smoothies and baked goods.
- **Spray Drying:** Spray drying involves atomizing strawberry puree into a thin mist and introducing it into a hot air chamber, which quickly evaporates the moisture by Jayaeaman & Gupta (2020) [13]. Through this procedure, the liquid is turned into a powder, commonly known as strawberry powder, which can be used in sweets, beverages, and flavorings. Spray-dried powders are useful for manufacturers looking for convenience because they can have a long shelf life and be transported easily.
- **Osmotic Dehydration:** Strawberries are submerged in a hypertonic sugar solution to undergo osmotic dehydration. The fruit loses moisture during the osmosis process, which also makes it sweeter by Sarvani & Saxena (2021) [34]. This technique makes strawberries more flavorful and improves their texture, which makes them perfect for use in snacks and pastries. This method is being investigated more and more because it may be able to increase the finished product's microbiological stability and decrease its water activity while yet preserving its sensory qualities.

3.3. Fermentation and Value Addition
Fermentation technologies facilitate the production of value-added strawberry products that have enhanced nutritional and health benefits.
- **Probiotic Fruit-Based Products:** Probiotics that promote intestinal health can be made by fermenting

strawberries with lactic acid bacteria. These goods may include smoothies and strawberry yogurts. Probiotics added during fermentation have the potential to improve immunity and digestion, making them very enticing to consumers seeking functional foods who are health-conscious (Chen *et al* 2023). Furthermore, the strawberries' flavor diversity is often enhanced by the fermenting process, producing appealing, tart goods.

- **Enzymatic Processing:** An increasing number of people are interested in using enzymes to extract beneficial compounds from strawberries (Giampieri *et al* 2013) [10]. Enzymatic processing can improve the extraction efficiency of bioactive substances with health-promoting qualities, such as flavonoids and antioxidants. Because certain enzymes can also be employed to increase juice yield and clarify strawberry juice, beverage producers find them appealing. More product personalization is possible using this approach, taking into account consumer preferences and health trends.

3.4. Smart Packaging & Preservation

Strawberry preservation and quality assurance during transportation and storage depend on advancements in packaging technology.

- **Edible Coatings:** By forming a barrier against gasses and moisture, these coatings reduce the pace at which strawberries breathe. To further extend shelf life, edible coatings, which are often composed of natural materials like proteins, polysaccharides, and lipids, can also be enhanced with antioxidants. Coatings can increase strawberries' visual appeal by giving them a gloss that makes them more marketable. Additionally, they lessen the need for artificial preservatives, meeting the rising demand for clean labels from consumers (Priyadarshi *et al.* 2024) [23]
- **Modified Atmosphere Packaging (MAP):** MAP is the process of changing the atmospheric composition of packaging, usually by raising the amount of carbon dioxide present. Strawberries' respiration rate is impacted by this atmospheric oxygen decrease, which successfully delays spoiling. To maintain freshness, the gases are meticulously regulated to establish the perfect equilibrium. Strawberries' shelf life can be considerably increased by MAP, guaranteeing that they are consumed in the best possible condition by Rennie & Sunjka (2017) [25].

In addition to improving safety and disease control, each of these cutting-edge processing methods improves the nutritional profiles, tastes, and marketability of strawberries. Adoption and use of these cutting-edge methods will be essential for the strawberry industry's future due to the growing demand for sustainable, high-quality products.

4. Role of Digital Technologies in Strawberry Processing

- **AI and IoT for Quality Control:** Quality control in strawberry processing is being revolutionized by digital technologies such as the Internet of Things (IoT) and artificial intelligence (AI). Strawberries can be automatically graded and sorted according to color, size, and flaws using AI-based vision systems, guaranteeing that only premium fruits make it into the supply chain. During storage and transit, IoT-enabled sensors monitor environmental factors including temperature, humidity, and ethylene levels, preventing spoiling and preserving maximum quality. By examining meteorological data and plant health indicators, AI-driven predictive analytics also help determine the optimal harvesting time (Hassoun *et al.* 2023) [11]
- **Blockchain in Traceability:** From farm to fork, blockchain technology improves strawberry traceability, guaranteeing authenticity and transparency. Farmers, processors, and consumers may follow the origin, cultivation methods, storage conditions, and processing techniques of each strawberry batch using blockchain-based digital ledgers. This increases consumer confidence in processed strawberry goods, lowers food fraud, and increases recall effectiveness in the event of contamination (Vitaskos *et al*. 2024) [37].
- **Smart Sensors in Ripening and Storage**: In order to properly ripen and store strawberries, smart sensors are essential. Modern ethylene sensors aid in controlling storage in a controlled environment, guaranteeing consistent ripening and increasing shelf life. During cold storage and transit, fungal growth and degradation are inhibited by temperature and humidity sensors. Strawberries can be tracked in real time thanks to RFID (Radio Frequency Identification) tags and smart packaging technologies, which also lower post-harvest losses and increase supply chain efficiency (Palumbo *et al*. 2022) [21].
- **Digital Marketing of Processed Strawberry Products**: The way processed strawberry products are marketed to consumers has changed as a result of the growth of internet marketing. Strawberry-based items including jams, purees, and dehydrated snacks are becoming more well-known thanks to influencer partnerships, social media platforms, and e-commerce websites. While augmented reality (AR) experiences improve product interaction, AI-driven tailored marketing methods target particular consumer categories. Digital payment channels and online marketplaces offer easy access to both domestic and foreign markets (Bhat *et al*. 2015) [4].

5. Government Policies and Initiatives

5.1. Schemes: like PMFME, Operation Greens, and Strawberry Processing Subsidies. The Indian government has introduced several schemes to support strawberry processing:

- **PM Formalization of Micro Food Enterprises (PMFME)**: Provides financial assistance to micro food enterprises, including strawberry processors, for technology upgradation and marketing support.
- **Operation Greens**: Initially launched for tomato, onion, and potato, this scheme now extends to perishable crops like strawberries, providing subsidies for storage, transportation, and processing.
- **Subsidies for Strawberry Processing**: Various state governments offer subsidies for cold chain infrastructure, dehydration units, and fruit processing plants, reducing the financial burden on entrepreneurs.

5.2. Role of FSSAI and Export Potential: Processed

strawberry products are subject to food safety regulations set by the Food Safety and Standards Authority of India (FSSAI). Quality assurance for both domestic consumption and exports abroad is ensured by strict adherence to FSSAI standards by Rameshbabu & Swaminathan (2024) [24]. India's capacity to export processed strawberries is expanding, especially in regions like the Middle East, Europe, and North America where consumers are looking for value-added and organic strawberry products.

5.3. Incentives for Startups in Strawberry Processing: Startups in the strawberry processing industry might receive funding, incubation, and mentorship help from government programs like Startup India and Agripreneurship Development Programs. Credit-linked capital subsidies, tax breaks, and financial incentives all promote industry innovation.

6. Challenges Hindering Growth of the Strawberry Processing Sector

6.1. Post-Harvest Losses and Supply Chain Inefficiencies

Due to their extreme perishability, strawberries suffer large post-harvest losses. Transportation delays, insufficient storage facilities, and ineffective cold chain logistics all contribute to spoiling by Bisht & Singh (2024).

6.2. High Cost of Processing Equipment

Establishing strawberry processing facilities, including equipment for freezing, drying, and packaging, requires a significant financial outlay by Khetarpaul (2005) [15]. Limited access to reasonably priced equipment and technologies is a problem for small-scale processors.

6.3. Regulatory Hurdles and Food Safety Compliance

It can be difficult for small and medium-sized businesses (SMEs) in the strawberry processing sector to comply with many regulatory requirements, secure licenses, and maintain food safety standards by Obiero (2022) [20].

6.4. Consumer Perception and Preference for Fresh Over Processed

Because of worries about additives and preservatives, a large number of Indian consumers choose fresh strawberries over processed ones. It's still difficult to spread the word about the advantages of processed strawberry products by Siddiqui (2019) [32].

7. Future Trends and Opportunities in Strawberry Processing

7.1. Demand for Organic and Functional Strawberry-Based Products

Customers are looking for organic and useful strawberry-based goods enhanced with probiotics, vitamins, and antioxidants as health consciousness rises (Santos *et al* 2024) Strawberry products without added sugar or preservatives are becoming more and more popular.

7.2. Scope of Plant-Based and Clean-Label Strawberry Products

Innovation in strawberry processing is being propelled by the clean-label movement. Dairy substitutes, plant-based yogurts, and minimally processed strawberry snacks satisfy consumer demands for natural ingredients and transparency (Ingugilia *et al* 2023).

7.3. Potential of Nutraceuticals from Strawberry Processing Waste

Bioactive substances with possibility of use as nutraceuticals can be found in strawberry by-products, including leaves, seeds, and the pulp by Mohammadi (2024) [19]. These can be used to provide a zero-waste processing approach in pharmaceutical, cosmetic, and health supplement applications.

7.4. Sustainable Processing Techniques for Eco-Friendly Production

Sustainable processing methods including minimal processing, solar drying, and biodegradable packaging are becoming more and more popular. These methods lessen their negative effects on the environment and support international sustainability objectives (Almalki *et al.* 2023) [1].

8. Conclusion and Way Forward

Strawberry is an important commercial commodity and its processing is changing as a result of the incorporation of digital technologies including artificial intelligence (AI), the Internet of Things (IoT), block chain and smart sensors, which enhance quality, traceability, and efficiency. The industry is supported by government programs and subsidies, although obstacles including high processing costs and post-harvest losses still exist. Strategies for improving strawberry processing in India include strengthening cold storage and logistics to reduce post-harvest losses, promoting the benefits of processed strawberry products through digital marketing and educational programs, collaborating with research centers and company executives to promote processing innovation for strawberries. Additional studies on value addition and sustainable processing may open up new avenues for the strawberry processing sector. India will become a major player in the global strawberry processing business as a result of increased government investment, expedited regulatory approvals, and improved market connections.

9. References

1. Almalki FA, Alsamhi SH, Sahal R, Hassan J, Hawbani A, Rajput NS, *et al*. Green IoT for eco-friendly and sustainable smart cities: future directions and opportunities. Mobile Networks and Applications. 2023;28(1):178-202.
2. Balan H, Melnychenko A, Sergiyenko V, Enakiev Y, Domuschi D. Improvement of technology in the cultivation of strawberries hybrid Soraya F1 during a vegetative trial. In: BIO Web of Conferences; c2024. Vol. 122, p. 01024. EDP Sciences.
3. Basu SK, Thomas JE, Acharya SN, *et al*. Prospects for growth in global nutraceutical and functional food markets: a Canadian perspective. Aust J Basic Appl Sci. 2007;1(4):637-649.
4. Bhat R, Geppert J, Funken E, Stamminger R, *et al*. Consumers' perceptions and preference for strawberries: A case study from Germany. Int J Fruit Sci. 2015;15(4):405-424.
5. Chaves A, Zaritzky N, *et al*. Cooling and freezing of fruits and fruit products. In: Fruit Preservation: Novel and Conventional Technologies. 2018. p. 127-180.
6. Chemat F, Rombaut N, Meullemiestre A, Turk M, Perino S, Fabiano-Tixier AS, *et al*. Review of green food processing techniques. Preservation, transformation, and extraction. Innov Food Sci Emerg Technol. 2017;41:357-377.
7. Chen W, Xie C, He Q, Sun J, Bai W, *et al*. Improvement in color expression and antioxidant

activity of strawberry juice fermented with lactic acid bacteria: A phenolic-based research. Food Chem. 2023;X(17):100535.
8. Dague RD, *et al*. Examining the experiences of agricultural growers in Florida in transition to organic agriculture. Northcentral University; c2014.
9. Fischer C. Opportunities for innovation in fruit & vegetable retailing: a value chain approach. In: 19th Annual World Forum and Symposium of the International Food and Agribusiness Association; c2009. Budapest, Hungary.
10. Giampieri F, Alvarez-Suarez JM, Mazzoni L, Romandini S, Bompadre S, Diamanti J, *et al*. The potential impact of strawberry on human health. Nat Prod Res. 2013;27(4-5):448-455.
11. Hassoun A, Kamiloglu S, Garcia Garcia G, Parra-López C, Trollman H, Jagtap S, *et al*. Implementation of relevant fourth industrial revolution innovations across the supply chain of fruits and vegetables: A short update on Traceability 4.0. Food Chem. 2023;409:135303.
12. Inguglia ES, Song Z, Kerry JP, O'Sullivan MG, Hamill RM, *et al*. Addressing clean label trends in commercial meat processing: strategies, challenges, and insights from consumer perspectives. Foods. 2023;12(10):2062.
13. Jayaraman KS, Gupta DD, *et al*. Drying of fruits and vegetables. In: Handbook of Industrial Drying. 2020. p. 643-690. CRC Press.
14. Joshi G, Negi GC, *et al*. Quantification and valuation of forest ecosystem services in the western Himalayan region of India. Int J Biodivers Sci Ecosyst Serv Manag. 2011;7(1):2-11.
15. Khetarpaul N. Food processing and preservation. Daya Books; c2005.
16. Kotwal I. Morphological and molecular characterization of strawberry cultivars under subtropical conditions of Jammu. [Doctoral dissertation]. Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu; c2023.
17. Kumar A, Agrawal S, *et al*. Challenges and opportunities for agri-fresh food supply chain management in India. Comput Electron Agric. 2023;212:108161.
18. Misra NN, Dixit Y, Al-Mallahi A, Bhullar MS, Upadhyay R, Martynenko A, *et al*. IoT, big data, and artificial intelligence in agriculture and the food industry. IEEE Internet Things J. 2020;9(9):6305-6324.
19. Mohammadi N. Recovery, chemical, and bioactivity characterisation of polyphenols from fruits and by-products in food applications: a circular solution toward resilient food systems. [Doctoral dissertation]. University of Limerick; c2024.
20. Obiero L. Sustainable Energy and Water Use for Horticultural Processing by Micro, Small, and Medium Enterprises in Kenya. [Doctoral dissertation]. University of Nairobi; c2022.
21. Palumbo M, Attolico G, Capozzi V, Cozzolino R, Corvino A, de Chiara MLV, *et al*. Emerging postharvest technologies to enhance the shelf-life of fruit and vegetables: an overview. Foods. 2022;11(23):3925.
22. Praveen K. Analytical Study of Operation Greens. [Doctoral dissertation]. Division of Agricultural Extension, ICAR-Indian Agricultural Research Institute, New Delhi; c2023.
23. Priyadarshi R, Jayakumar A, de Souza CK, Rhim JW, Kim JT, *et al*. Advances in strawberry postharvest preservation and packaging: A comprehensive review. Compr Rev Food Sci Food Saf. 2024;23(4):e13417.
24. Ramesh BJ, Swaminathan U, *et al*. Consumer awareness and contemporary policy regulations on artificial food colourants safety in India. Curr Res Nutr Food Sci. 2024, 12(2).
25. Rennie TJ, Sunjka PS, *et al*. Modified atmosphere for storage, transportation, and packaging. In: Novel Postharvest Treatments of Fresh Produce. 2017. p. 433-480. CRC Press.
26. Roussos PA, Triantafillidis A, Kepolas E, Peppas P, Piou A, Zoti M, *et al*. Effects of integrated and organic management on strawberry (cv. Camarosa) plant growth, nutrition, fruit yield, quality, nutraceutical characteristics, and soil fertility status. Horticulturae. 2022;8(2):184.
27. Rubin J, Rubin N. The Great Physician's Rx for Women's Health. Thomas Nelson Inc.; c2006.
28. Samtani JB, Rom CR, Friedrich H, Fennimore SA, Finn CE, Petran A, *et al*. The status and future of the strawberry industry in the United States. HortTechnology. 2019;29(1):11-24.
29. Sansavini S, *et al*. The role of research and technology in shaping a sustainable fruit industry: European advances and prospects. Rev Bras Frutic. 2006;28:550-558.
30. Santos D, Marçal S, Pintado ME, *et al*. Sensory quality and consumer acceptance of foods from agri-food by-products. 2024.
31. Sengar J, Mishra A, Uikey P, *et al*. Value-Added Agri-Processing for Horticultural Crops. Integrated Publications TM; c2023. p. 301.
32. Siddiqui MW, editor. Fresh-Cut Fruits and Vegetables: Technologies and Mechanisms for Safety Control. Academic Press; c2019.
33. Singh S, *et al*. Potential of rice-based food processing industries along Eastern plains of River Ganga. J Disaster Res. 2023;18(7):708-714.
34. Sravani D, Saxena D, *et al*. A mini review on osmotic dehydration of fruits and vegetables. Pharma Innov J. 2021;10:633-639.
35. Verma LR, Joshi VK, *et al*. Post-harvest technology of fruits and vegetables. Postharvest Technol Fruits Veg. 2000;1(1):1-76.
36. Vieira ÉNR, de Oliveira VC, Gomes AT, Lourenço MT, Paiva MJDA, Santos TC, *et al*. Perspectives of high-pressure technology in probiotic food production: a comprehensive review. Food Biosci. 2024;105179.
37. Vitaskos V, Demestichas K, Karetsos S, Costopoulou C, *et al*. Blockchain and Internet of Things technologies for food traceability in olive oil supply chains. Sensors. 2024;24(24):8189.
38. Wani SA, Kour J, Haq RU, Elshikh MS, editors. Fruits and Their Roles in Nutraceuticals and Functional Foods. CRC Press; c2023.
39. Yahia EM, Fonseca JM, Kitinoja L, *et al*. Postharvest losses and waste. In: Postharvest Technology of Perishable Horticultural Commodities. 2019. p. 43-69.