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RESEARCH PAPER

Review and Research Agenda on Horticulture Supply Chain

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ABSTRACT

The objective and purpose of this research paper are to provide a list of prospective research areas to revamp the supply chain of horticulture products as a relevant research topic and for the same we conducted an extensive review of the available literature in the domain. We performed a detailed review of academic articles, published in reputed peer-reviewed international journals, in the domains of horticulture products (fruits and vegetables, flowers, nuts and seeds, herbs, medicinal plants, sprouts, seaweeds, mushrooms, algae, and non-food crops like grass, ornamental trees, and plants) and its supply chain management. An extensive review has been developed to emphasize the need for alignment among the key aspects of horticulture products and its supply chain, the links between supply chain processes and strategy. We have taken a final sample of 70 articles published from 1994 to 2018 for the knowledge base of this research. A Literature survey in this respect indicates that most of the research has been conducted in the field of products having longer life cycles than the products having shorter life cycles like perishable (horticulture products) products. The scope of the research is to study the various levels and distinct forms of horticulture products' supply chain. The results provide evidence about the journals, show the publication pattern over time, the research methodology adopted, and the content elements of horticulture products' supply chain. The research findings apply to a large extent for managerial decisions. There is huge research scope available in the area of the horticulture supply chain as only limited research has been done in this field. This research work and future researches in this field would be helpful for managers, decision-makers, students as well as academicians. After extensive review and synthesis, important findings from the existing literature, critical review, and challenges have been derived to highlight how horticulture products and its supply chain should be best matched to its production and logistics processes.

KEYWORDS: *Fruits and vegetables; Horticulture products; Horticulture supply chain; Managing perishables; Research agenda; Review.*

1. Introduction

Horticulture, a branch of agriculture, deal with the art, science, technology, and business of growing fruits and vegetables, flowers, plants and herbs, medicinal plants, seeds and nuts, sprouts, mushrooms, seaweeds, algae and non-food crops like grass, ornamental plants, and trees. Horticultural crops are defined as crops that are not industrial crops or staple cereals but are mainly eaten for interest and flavor of food for flexible consumption-based on quality, price, and supply. A horticultural crop includes vegetables, fruits, spices, flowers, plantation crops, medicinal plants, and aromatic plants.

The main problem in India is to manage the perishability in the horticulture supply chain as more than half of vegetables and fruits produced end up rotting as waste while arriving into the market for sale and this is the main hindrance for India to become among leading producers of horticulture products. A few more reasons are poor pre and post-harvest methods of storage, warehousing, and logistics from point of production to sale. The key issues related to Agri-logistics for the development of the cold chain industry are limited financial capabilities of the logistics service providers or transporters, non-standard pricing practices, lack of scientific material handling methods, high prices, and

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limited choices for the customers. (Data extracted from FFFI-Freight forward Federation of India).

In our review process, we have found researchers' interest in the domain of managing supply chains of vegetables and fruits, sweet cherry, papaya, pineapple, peach, guava, apples and pears, soybeans, groundnuts, carrot, mushroom, date, oil palm, fresh flowers, leafy greens, microgreens, and sprouts. Indian fruit and vegetable (F&V) sectors have a glorious past as well as a promising future. India is one of the leading producers of vegetables and fruit. It shows that the vegetable and fruit sector in India contributes significantly to the GDP and help the country to prosper. This sector created a lot of employment opportunities and also helped a lot to improve the socio-economic status of the Indian farmers in the urban as well as rural areas. Sweet cherry found to be one of the most popular fruits because of its abundant nutrients, good taste, bioactive components, phenolic compounds, anthocyanins, and including vitamin C. but it is highly perishable product because of its high respiration rate, rapid softening process (at room temperature- 27 °C) that causes the weight loss, changes in color, changes of nutrients and browning.

Papaya , the Caricaceae family and is native to Central America and southern Mexico, primarily in Guatemala. In now a day, papaya is mainly grown in tropical and subtropical regions of the world, as papaya cultivation got spread over other continents just after the Spanish colonization of the Americas. Leading papaya producing countries are Mexico, Brazil, India, Nigeria, and Indonesia. The pineapple [1], is one of the star fruit in the international fruit sector having a much faster growth than others in the fruit sector. Pineapples can be exported and processed fresh in pineapple pulp, canned pineapple, and juices. Peach, belongs to the Rosaceae family, is one of the most economical fruits and a typical climacteric stone fruit. The leading countries in peach production are China, Italy, Spain, Greece, and the USA. China is the top producer of peach with the largest area planted peaches across the globe. Peach cultivars are of six groups in this study, based on shape, texture, and skin hair characters as sweet, crispy, yellow-fleshed, honey, nectarine, and flat [2]. Honey Peach is the world-popular among them due to its high marketing value in recent years.

Guava, belongs to the Myrtaceae family, native to Mexico, is a tropical plant. It is available throughout South America, Europe, Asia, and Africa. Now, it is one of the most cultivated fruit crops in almost all tropical and subtropical countries, also referred to as "super-fruit" due to its high antioxidant capacity and contains a large number of minerals and vitamins. Guava contains biologically active secondary compounds such as triterpenoids, flavonoids, and others. Guava contains a high concentration of vitamin C and is highly perishable of having a shelf life of approximately two days (at room temperature - 27 °C). So, it is consumed usually as fresh or processed one that includes squash, pulp, puree, nectar, canned slices, paste, syrup, and juices into various commercial products. Out of all these, the juice is economically important due to its high nutritional values. Apples and pears are highly perishable goods due to quality loss concerning time. So, the inherent perishability of these fruits confines the possibilities of commercialization and processing to an optimum portion of the time. Controlled atmosphere storage or cold chains have been established along the entire Supply Chain, to extend the marketable periods in this regard.

Soybeans, one of the most important commercial commodities in the global market, Brazil is the leading producer of Soybeans and it constitutes one of the primary agriculture crops in Brazil, represents around 49% of the total land area used for grain cultivation. Groundnuts , semi-perishable, can be stored for longer periods if temperature, pod or kernel moisture, and humidity are controlled and optimized. Deviations will lead to losses either in storage or at milling from optimum conditions of storage. Major storage problems include infestation by rodents, toxigenic molds, and insects, suboptimal weather for groundnut. The primary storage pest is groundnut bruchid, Caryedon serratus (Olivier) for unshelled groundnuts throughout Central and West Africa and in many parts of Asia. Carrot quality has been determined by the genomic constitution in terms of nutrients and by seasonal impacts and production systems. Post-harvest quality losses in carrot appear as mechanical impacts with the function of time, and storage conditions. The Average shelf-life of carrot is 5–10 days in general.

Mushroom quality, mainly comprises of stipe length, color, and cap opening. Consumers at continental Europe prefer white mushrooms with a short stipe and a closed hat. The fresh mushroom cap color is white and the mushroom that is exposed to high temperatures is having darkens color, one of the non-oil export products of Iran, plays an important role in the Iranian economy. Each component of the date, like flesh, leaf, stone, etc. can be beneficial for the food supply chain if properly processed. The ripening

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process of date consists of four stages; Kimri, Khalal, Rotab, and Tamar. Dates at the Khalal stage that is sweet, with low astringency and a low amount of tannin are ready to market as fresh fruit. Oil palm [3], originated at the West African coast, approximately 95% of existing plantations are situated in a latitude range of North and South of the Equator in the world, restricted to some countries in Latin America, sub-Saharan Africa, and Southeast Asia. Palm oil is the highest yield of vegetable oil, extraordinary oil and overall biomass productivity known among cultivated plants due to its adaptability to the wet tropics. Indonesia and Malaysia are accountable for around 86% of the global palm oil supply, ranked them, I, and III largest global producers of vegetable oils respectively.

Fresh flowers [4], are perishable products, with interesting and unique global supply chain management. The production of roses in Columbia and Ecuador is primarily for the US market, and the production in Uganda and Kenya is mainly for the European market. Some countries are specialized in high-value products, for example, orchids from Singapore and roses from the Netherlands. Leafy greens, are the important sources of vitamins and minerals, antioxidants, and dietary fibers. Microgreens, are distinct from sprouts even though both are greens and consumed in an immature state. Microgreens are having a broad range of leaf color, shape, variety, and strong flavor-enhancing properties than sprouts. Sprouts are grown in dark and moisture saturated conditions than microgreens. Microgreens contain lower nitrate content, higher amounts of phyto-nutrients, and minerals than their mature leaf counterparts. Greenhouse growers, urban and semi-urban farmers have invested in their production due to the appeal of microgreens to consumers due to its high price market and comparatively short production cycle.

Fresh horticultural produce is highly perishable, continues to lose water due to respiration and transpiration process, and remain metabolically active after harvesting. Due to this reason, shelf-life of fresh produce turns into a race against the time to maintain quality and to reduce food loss for growers, processors, and retailers. Water loss in fresh produce is associated with economic loss due to shriveling of the product as it causes a decline in saleable mass. Moisture loss in the fresh produce can accumulate on the product surface. It causes defects in the external appearance of the product as well as spoilage microorganisms, which leads to flavor loss and quality deterioration. Hence, it is important to eliminate moisture condensation to prevent the growth of spoilage causing microorganisms and maintain quality. Temperature modification and control of the atmosphere are the important factors to extend the shelf life of fresh produce. Hence, the goals of post-harvest technology are to reduce losses and maintain freshness quality in the post-harvest value chain of fresh horticultural produce.

2. Review of Literature

Food packaging [5] through bio-nano and edible and composite films was developed by extrusion followed by thermo molding. In this study, Corn starch was used as a carbohydrate polymer, glycerol was used as a plasticizer, and several nano-clays were used as nano-fillers. Fruits and vegetables [6] are presented as a source of phytochemicals and nutritional compounds. Lactic acid bacteria (LAB) fermentation is used in common for fermented vegetable or fruit products (part of various diets worldwide) that produces changes in types of bioactive compounds as well as profiles both. The Molecules like short-chain fatty acids, bioactive peptides, poly-saccharides are generated; anti-nutritional compounds, as well as sugar content, are decreased; the phenolic compounds converted to added biological value into molecules that lead to pre-biotic and pro-biotic potential supply, bioavailability and bio-accessibility improvement of food components, results in the modifications of health-related properties of food. Quality of sweet cherry and self-life extension [7] by using the ginseng extract (GSE) coatings the guar gum (GG). Quality (decay percentage, weight loss, and firmness), nutrient components (titratable acid, total soluble solids, total phenols, ascorbic acid, anthocyanins), respiration rate, and malondialdehyde evaluations are performed. The Result showed that coatings developed through the method extended shelf life of sweet cherries for about 8 days. Post-harvest losses (PHL) in the tomato supply chain [8], in Zimbabwe, was aimed to study at identifying in farmers' context characteristics, quality control and logistics activities that are related with the generation of PHL. Cluster analysis results in three clusters of farmers, grouping based on quality control and logistics-related activities and similarities on context vulnerability. A framework has been developed for intervention strategies to support the tomato farmers' development as a step-wise improvement of quality control and logistics practices to advance tomato supply chains and to reduce PHL in these chains.

A multi-sensor managed traceability system was developed and evaluated for the honey peach

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export chain. HACCP and traceability both are considered as an effective tool for the improvement of quality control and transparency in the export chain. A traceability system, with HACCP based quality control and integrated multi-sensors, was developed on a real-time basis to monitor the identified traceable information and to provide the quality control and evaluation decision. This system was validated and evaluated at the honey peach export chain from China to Singapore. Quality maintenance [9] of fresh-cut ready to fry potato sticks was addressed through the effect of storage time, nitrogen fertilization rate, LBG (locust bean gum) based edible coating, and packaging film and assessed through monitoring firmness and color, bioactive components content, and microbiological parameters. Results indicated the need for management of nitrogen fertilization to point out the excess nitrogen fertilization levels and to obtain the high-quality fresh cut ready to fry potato sticks.

Pectinaceous matter hydrolysis in the guava juice [10] was investigated in this study through Hill Equation modeling for enzymatic treatment of guava juice. The rate of the enzymatic reaction and the degree of pectinaceous matter hydrolysis has been determined and results showed the increase in the degree of hydrolysis for each enzyme concentration with time. Post-harvest loss (PHL) and quality deterioration of horticultural crops [11] was assessed in Ethiopia. Weather and climate conditions, handling and harvesting techniques, storage, packaging, transportation, dust from the cement factory, market condition, pest animals, and disease are recorded as major causes for post-harvest loss (PHL). This study identified that post-harvest loss (PHL) was recorded highest for tomato than mango and coffee and 20%-50% loss was recorded in from marketing to consumption in these commodities. Horticulture supply chain performance [12] was addressed by identifying and determining the supply chain performance of each actor. In the first stage, planning elements have been identified along with process, supply, delivery, and returns. In the second stage in-depth identification conducted on the first stage. Fruit pulp temperature history monitoring [13] was addressed throughout the cold chain through simulation of an artificial fruit that is composed out of a thin plastic shell, filled with the mixture having same thermal properties as of real fruit that mimics the shape, size, color, and surface texture of the fruit inside the cargo at a higher spatial resolution. Bio mimetic approach is used to match the thermal response of simulated fruit as real fruit as close as possible. The simulated artificial fruit was used for monitoring fruit pulp in cold stores, pre-cooling facilities, refrigerated containers, and ripening facilities. Detection of salmonella in vegetables [14] was demonstrated in fresh leafy green vegetables in irrigation water through the applicability of an ELIME (Enzyme-Linked Immuno Magnetic Electrochemical) assay by comparison with ISO culture method and Real-Time PCR (RT-PCR). Environmental impacts of the production of pisco [15] of six wineries were assessed through LCA (life cycle assessment) in Peru to identify the hotspots of the system and to propose improvement actions including the vinification /distillation, viticulture, and bottling stages.

Post-harvest losses (PHL) in vegetables and fruits [16] were identified through fourteen critical factors and modeled interpretive structural modeling (ISM) approach to establish an interrelationship between defined factors in the Indian context in two parts wherein inputs from the experts of academia and field experts were considered. Optimization of fresh food logistics [17] for a Chilean apple supply chain has been presented optimization models with three kinds of decisions in horticulture that are purchasing, transporting, and warehousing fresh produce. In this study, a purchasing model, storage model, and integrated model for fresh produce have been proposed to give a joint solution for purchasing, transporting, and warehousing. Post-harvest loss (PHL) in the sweet potato value chain [18] is mapped for quantifying the degree of losses and to establish the links between distinct value chain constraints, food losses, and limitations. Shelf life issues at distribution, handling, and harvest at farm level were identified as vulnerable hot-spots for post-harvest losses of the sweet potato. Post-harvest quality of organic fruits [19] has been discussed in this study through various parameters like post-harvest storage performance, physicochemical properties, microbiological, nutritional, and sensory quality. This study illustrated those nutritional properties and physic-chemical those are related to the contents of antioxidants, phenolics and vitamins that are higher in organic fruits. The better taste of organic products is consumer's perception due to halo effect of the label of organic food. This study attributed to different fertilization systems that are used in organic and conventional managed soils. The Study addressed that high levels of nitrates and pesticide residues in conventionally grown fruits are of major concern. Resource efficiency [20] has been evaluated by a hypothetical sugar beet leaf

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processing supply chain by comparing various supply chain options. Resource efficiency is dominated by the amount of effectively used leaf material in the process. This study has discussed soil quality, transportation load, efficiency, energy use, and equipment scale.

Fresh vegetables and fruit quality [21] were defined through various factors configuring quality in the pre-harvest period in the horticultural supply chain. Factors discussed in the study are biofortification, optimization of production inputs, optimized controlled stress conditions, application of harvest maturity indices, and redirection of horticultural breeding. RFID traceability [22] for the kiwifruit supply chain was formulated using MOINLP (multi-objective integer non-linear programming model). A new approach PPO (Plant Pollinator Optimization Algorithm) has been implemented and performed in comparison to NSGA-II (Non-dominated Sorting Genetic Algorithm-II), a well-known approach.

Sustainability issues in a centralized cut flower supply chain [23] were addressed by developing a new replenishment policy for the deteriorating items. A model has been developed considering transportation cost, inventory cost, the social and environmental impact of using various transportation vehicles that create greenhouse gas as well as pollution. In this study, variables that are considered are partial back-order ratio, end-customer demand, deterioration rate at in-stock inventory, deterioration during transportation, quantity discount prices, backorders, transportation route option, uncertain demand, and holding cost that resulted in inventory policy with best transportation routes and vehicles. Pome fruit industry supply chain optimization model [24] was formulated through multi-period mixed-integer linear programming for medium-term planning of pear and apple supply chain. The Lexicographic method is used to solve mathematical model for multi-objective optimization to analyze face of changes in processing, storage, and transportation capacities.

Storage temperature optimization in leafy greens supply chain [25] is considered through the growth of pathogens, microbial safety, cost of refrigeration, and sensory quality parameter by using NLP (nonlinear programming). Interactive GUI (graphical user interface) was developed in MATLAB. Temperature prediction of fruit in the refrigerated container [26], strawberry shipping container has been investigated in different refrigeration failure scenarios, compared with three data estimation tools capacitive and trigging heat transfer, and artificial neural networks for food safety improvement. Benefits and adaptation of private standards [27] in horticultural export chains were analyzed in terms of labor, and influencing employment conditions in processing, production, and export companies with special reference to Peru. The study concluded that to reinforce the respect of labor laws, national labor standards are most effective tool in this scenario.

Innovation strategies [28] in raspberry farming has been discussed through LCA (life cycle assessment) and s-LCA (social life cycle assessment) under specific consistency requirements by selecting two scenarios, with and without innovation and then combined with a cause-effect chain. Post-harvest losses due to gray mold [29], incited by Botrytis cinerea, was addressed on fruit crops. This pathogen is controlled by an integrated management program of "post-harvest gray mold control" having a combination of pre and post-harvest practices, including the use of biocontrol agents, conventional fungicides, natural antimicrobials, disinfecting agents, and physical treatments. Apple dehydration plant performance [30] evaluated by efficiency analysis through Data Envelopment Analysis (DEA) of a plant of the dried apple in Chile, considered both discretionary and non-discretionary variables. The result indicated that the model (without non-discretionary variables) leads to higher efficiency.

Micro-scale vegetable production [31], discussed in pre-harvest and post-harvest in microgreens. In this study pre-harvest factors are considered as fertilization, species selection, bio-fortification, growth, and lighting stage in terms of crop quality and physiology. Post-harvest applications and handling were discussed through atmospheric composition, temperature, packaging, and lighting technology that influence microbial safety and the self-life of micro-greens. [32] formulated the Internet of Things (IoT) based monitoring framework for the in-transit freshness of fruit e-commerce deliveries and proposed an approach based two-stage scenario to assess the freshness of the in-transit fruits. In the first stage, a scenario construction method was developed by using the learning by doing mechanism to obtain the most appropriate delivery environment; and in the second stage, the scenario analysis method integrated with the interval comparison technique to assess in-transit fruit freshness.

Operations research models [33] for fresh fruit supply chain was reviewed and it concluded some significant new problems facing in the industry such as lack of holistic approaches to design and management of fresh fruit supply chain; and indicated some future research directions.

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Similarly, raw material procurement issues [34] in the agro-industry supply chain was addressed in fruit processing industries in Indonesia. Most processing industries used the contract system in procurement to reduce the risk of a large amount of raw material required for production. The resource of raw material and its continuity were identified as strong factors in the procurement of raw materials for fruit processing industries.

Role of cooperatives [35] was investigated in food quality and safety management practices implemented on the farms in the fresh produce chain through four cooperatives case studies to consider the percentage of contractual sales and the different size of farms through FSMS (food safety management systems) in Belgium and the Netherlands. Data has been collected through semi-structured interviews of quality assurance managers of these cooperative firms. Evolution of moisture and transpiration [36] was addressed in packaged fresh horticultural produce, provided an evaluation on the application of integrative mathematical modeling to describe the water relations for packaging design and also discussed various adverse effects of transpiration on shelf-life and post-harvest quality of FFV (fresh fruit and vegetables).

A stochastic optimization model [37] has been presented in major spatial and temporal components for soybean complex and tested using data from a large trade of soybean supply chain in Brazil based on parameters of purchase and sale prices, volumes of demand, and crop failure rate. Supply chain performance [38] of fresh vegetables has been evaluated through the combinations of SCOR and AHP models in Indonesia. The behavior of customers in flower field [39] were analyzed regarding pricing mechanism of the flowers, where the payment is made in an honor box. Moral appeals and legal threats in pricing were discussed in which people make their decision regarding prices of flowers, and observed a switch to more expensive flowers.

Information needs and sharing strategies [40] aimed at study among vegetable farmers and vendors to build a center of agricultural information regarding marketing and production information of vegetables in China. The findings disclosed the differences between the vegetable farmers and vendors for their willingness to join such centers regarding preferred information sources, information needs, and sharing strategies to enhance the efficiency and effectiveness of food security in the existing vegetable supply chain. The Logistics system model [41] has been developed for the tomato commodities supply chain using a discrete event simulation approach, where a simulation model occurs with a change of status from the points of discrete-time through the case. This study proposed four models of logistics system to provide a positive effect on the decision accuracy that sheds effect on logistic expenses, logistic achievements, and farmer productivity.

Groundnut crop storage [42] demonstrated the efficacy of triple-layer PICS (Purdue Improved Crop Storage) bags over cloth bags, comprised of two inner high-density polyethylene bags and an outer woven polypropylene bag to protect pods from damage by bruchids, quality deterioration, and afla toxin contamination. Early diagnosis of microbial contamination [43] of vegetable soup has been experimented by an electronic nose EOS507C, based on four metal oxide sensors array to test the artificial contamination by Escherichia coli and Entero bacterhormaechei over two experimental campaigns to a large dataset of 584 samples. This study resulted in an ideal industrial screening system having sensitivity, specificity, operational simplicity, early diagnosis, cost-effectiveness, and reproducibility.

Societal, institutional challenges and sustainability issues [44] that influence innovation and investment decisions of MSE (micro and small enterprise) of palm oil smallholders in Malaysia discussed has also been in this study. An automatic sorting system [45] for Date fruits comprised of capturing and illumination unit, conveying unit, and sorting unit were addressed in this study through an index, based on color features to detect Date samples. Risk assessment for virological hazards associated with fresh lettuce [46] based on the Codex Alimentarius framework was carried out in a leafy green production. This study provided an example to monitor and control the food-borne viruses to assess one vertical production enterprise. It is resulted to the fit for purpose guidance sheet to prevent the contamination of leafy green vegetables, by viruses.

An Expert System (ES) [47], using Fuzzy Logic, based on the Persian lime production cycle has been developed to predict orchard yield and fruit quality that involve an inference engine, presented If-Then type rules in the study. It is developed to help the farmers to boost production yield and fruit quality as well as to provide a better synchronization with export companies. Decontamination by ultrasound application [48] in fresh fruits and vegetables was discussed in this study by addressing mechanisms, effects, and principles of ultrasound, as a sanitization

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technology on fresh fruits and vegetables. Value chain [49] of Malaysian horticulture produce was also addressed in this study and proposed a conceptual framework for investigating the effect of relationship marketing towards the functions and roles of intermediaries that contributed to the smallholder business performance and the firm's performance.

The Rapid expansion of oil palm [50] in Brazilian Amazon has presented great potential for influencing the development of this region and provided an updated picture of the palm oil sector and its opportunities, challenges and prospects in Brazil, and the use of palm oil as biodiesel. The Shelf life of sweet cherries [51] was discussed through review of critical factors like mold growth, loss of firmness, stem discoloration, color and flavor, and desiccation and also to find out that cultivar, harvest time, cooling practices, packaging, and material handling, influence the shelf life of cherries. This study resulted in the development of packaging with active packaging principles, modified atmosphere packaging to maintain the optimal quality of cherries.

Supply chain [52] of perishable fruits and vegetables was investigated through a simulation system dynamic model to study the relationships and behaviors within the supply chain and to determine the impact of demand, supply and price over it. This study developed a multi-objective model to identify the import quota policy of fruits and vegetables for the Tehran Municipality Organization to consider multiple objectives as price markup, factors of pricing, and price variation. Different control methods to control and reduce the post-harvest diseases [53] during papaya storage were reviewed, that affected fruit quality like Wax combined with fungicides and heat, antagonistic microorganisms, natural compounds (plant derivatives, chitosan), application of irradiation, etc.

Subjective risk judgments [54] for food safety hazards were examined to the discrepancies in perceived risk related with vegetables in domestic urban markets in Nairobi, through developing a conceptual model for risk perceptions of a multidimensional construct to promote food safety, to improve policies, to present the opportunities for change, and to reduce risky food handling in the supply chain. Sustainable lifestyles [55] concerning food systems was investigated through a case of sustainable food self-provisioning in Poland and Czechia, and presented evidence to social and environmentally beneficial practices and explored the motivations that derived from a range of feelings about family and friends, food, quality, and capability.

Postponement [56] was evaluated to improve the soluble coffee supply chain performance by significant cost savings through delay in the packaging and labeling processes until the actual orders are known from retailers. These cost savings include reduction of safety stock, cycle stock, and obsolete stock that are unsold after promotional events. Nutritional bioactive compounds and technological aspects [57] of minor fruits (blackberry, egg-fruit, atemoya, Brazilian guava bacuri, star fruit, sweetsop, cactus pear, feijoa, breadfruit, the fruit of wolf, jackfruit, jaboticaba, lychee, rose apple, marolo, and mangaba) grown in Brazil, were addressed in this study that are used to manufacture the handicraft products like jellies and sweets produced in small-scale, available in free markets, and without safe operational procedures. This study presented empirical evidence to address the unsuccessful food traceability system [58], TAFT (Taiwan Agriculture and Food Traceability program) of fruit and vegetable farmers from a national survey in Taiwan.

MAP (Modified Atmosphere Packaging) technology [59] of minimally processed fresh produce (fruits and vegetables) was discussed through the usage of Oxygen, CO2, and N2 in MAP and usage of other gases like sulfur dioxide, nitrous, and nitric oxides, chlorine, ethylene, propylene oxide, and ozone were also investigated as these gases are not applied commercially due to safety, cost, regulatory reasons in MAP. Private social standards, and global value chains in a labor organization [60] were examined by exploring different opportunities and challenges in East African cut flower industries and revealed that the retailer driven chains offer more space for labor organizations than the traditional cut flower value chains. Key drivers of change [Vagneron et al., 2009] were examined through geographic and organizational changes in the fresh pineapple sector over the last 50 years in Costa Rica.

Carrot quality [61] through non-invasive spectro-photometric sensing was investigated from harvest to consumption to test the sugar contents, a major component of carrot taste by applying partial least squares regression with percentage SECV (Standard Error of Cross-Validation) for glucose, sucrose, and fructose. A feasibility study [62] was carried out to evaluate TTI (Time Temperature Integrators) as a quality indicator of mushroom as a case and measured for both constant and variable temperature profiles by using a spectrophotometer. The kinetic parameters were determined by using three different modeling approaches of the loss of

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mushroom quality, ranges from simple linear kinetics to mechanistic models, which are much more complex. Traceability implementation [63] was developed through an analytical framework and four case studies of vegetable firms were used to analyze the factors for buyer-supplier relationships, and their influences on traceability of raw materials in the vegetable industry in Spain.

The realistic planning model [64] was applied to estimate the fruit processing capacity of the packaging plant and to establish the future sales policies within the fresh fruit (apples and pears) supply chain in Argentina. Pricing dynamics [65] was explained through the factors like market structure changes, marketing channels, promotional impacts, pricing techniques, the price versus value, and retail responses to supply changes, that contributed to the price formation process, at several levels of fresh fruits and vegetables in the US. Concentrations of naturally occurring radionuclide [66] was reviewed in the fruits and vegetables (fruit, leafy vegetables, bean, root, and rice) and their derived products (coffee, sugar, wheat flour, manioc flour, pasta, and cornflour) at Rio de Janeiro City, out of which the highest contribution to radionuclide intake noticed from wheat flour, bean, carrot, manioc flour, rice, potato, and tomato consumption. Applications of electronics and computers [67], including quality management, quality monitoring, environmental control and storage, inventory control, grading systems, and product management were reviewed to illustrate the current state as well as future predictions in post-harvest technology to improve longer storage life, product quality, and product safety.

Control of crown rot of banana through mini wet-pack over fungicide-impregnated pads, which is less error-prone, was discussed in the Windward Islands. Several regional R&D activities were also presented that include physical methods, cultural methods, natural chemicals, mode of fungicide application, and biological control towards improved crown rot control. A case of Mozambican cashew nuts was discussed for the country and commodity-specific factors that revealed its weaknesses and also presented the major constraints on cashew nuts processing that are political rather than economical or technical. Case of technological development, through two types of paths, transaction cost-minimizing path, and production cost-minimizing path was discussed in the Danish fruit and vegetable industry to optimize the performance of products as well as processing technology.

A case of the Dutch flower auctions was discussed in terms of the agriculture industry and specific nature of the goods that deal with highly fragile and perishable produce and where the quality is based on the perception of consumers and also revealed the use of electronic markets, as a strategic response to the auction of flowers and pot plants in the world marketplace. Horticultural import growth was carried out to identify main sources of change through decomposition analysis of horticultural trade flows in horticultural imports, (EC (Electric Conductivity) is a meaningful indicator of soil salinity, water quality, and fertilizer concentration) from different LDC (Least developed countries) regions. Sources of change are associated with the relative openness to the EC market, international competitiveness, the degree of trade preference, and EC global import growth.

3. Research Agenda & Issues Addressed

In recent years the highest attention with the highest frequency on sample papers reviewed has been given to manage horticulture products supply chain as horticulture products are considered as perishable products due to having a shorter life cycle. Apart from managing the horticulture supply chain, we have found some research papers on vegetable and fruit supply chain, sustainable supply chain, shelf life, post-harvest decay, leafy green vegetables, fresh fruits, and vegetables with the highest frequency. Figure I represented key research agenda addressed in the domain vs. frequency of research papers.

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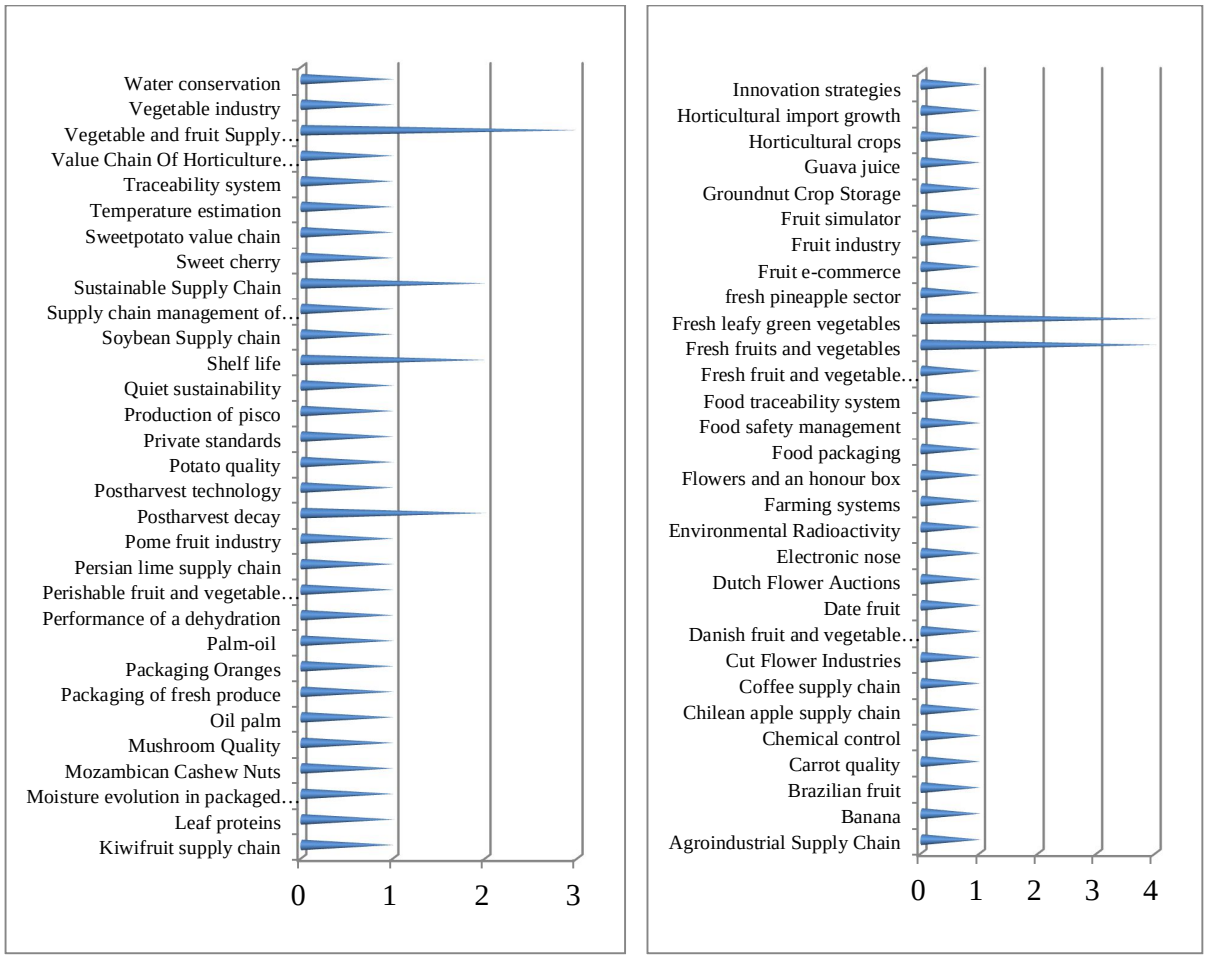

Fig. 1. Key research agenda vs. frequency of research paper reviewed

We have reviewed 116 research papers in the domain of horticulture products and horticulture supply chain. A final sample of 70 articles published from a decade (1994 to 2018) constituted the knowledge base of the study. We have found research papers on various research issues as listed below.

Year-wise potential research issues that have been addressed in the literature of the horticulture supply chain are presented here in the following table (Table I).

Tab. 1. Year-wise potential research issues addressed in the horticulture supply chain

Year	Research Issues Addressed- Horticulture Supply Chain
1994	Horticultural import growth
1996	Danish fruit and vegetable industry, Dutch Flower Auctions
1999	Mozambican Cashew Nuts
2000	Control of crown rot of banana
2001	Post-harvest technology
2002	Environmental Radioactivity through naturally occurring radionuclide in vegetables
2004	Fresh fruit and vegetable pricing
2005	Fruit industry
2006	Mushroom Quality, Vegetable industry
2007	Carrot quality
2009	Cut Flower Industries, fresh pineapple sector
2010	Packaging of fresh produce

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2011	Coffee supply chain, Brazilian fruit, Food traceability system
2013	Perishable fruit and vegetable Supply chain, Chemical control, Leafy vegetable supply chain, Quiet sustainability
2014	Persian lime supply chain, Fresh fruits and vegetables, Value Chain Of Horticulture Produce, Oil palm, Shelf life, Water conservation
2015	Soybean Supply chain, Fresh vegetables, Packaging Oranges, Flowers and an honour box, Vegetable supply chain, Supply chain management of tomato commodities, Groundnut Crop Storage, Electronic nose, Palm-oil, Date fruit, Leafy green vegetables
2016	Sustainable Supply Chain, Pome fruit industry, Leafy greens, Temperature estimation, Private standards, Innovation strategies, Post-harvest decay, Performance of a dehydration, Shelf-life, Fruit e-commerce ,Supply chain fresh fruit, Agro industrial Supply Chain, Food safety management, Moisture evolution in packaged fresh horticultural produce
2017	Fruit simulator, Fresh leafy green vegetables, Production of pisco, Vegetable and fruit Supply Chains, Chilean apple supply chain, Sweet potato value chain, Farming systems, Leaf proteins, Fresh fruits and vegetables, Kiwifruit supply chain
2018	Food packaging, Nutritional compounds and phyto chemicals, Quality of sweet cherry, Post-harvest losses, Traceability system, Potato quality, Guava juice, Horticultural crops, Supply Chain Performance

Literature Survey indicated that most of the research in the field of managing horticulture products has been conducted in the last five to six years. A shift has occurred in the research of products having longer life cycles to the products having shorter life cycles like perishable Products (horticulture products). Figure II represented the year-wise number of researches performed in the field of managing horticulture products and their supply chains.

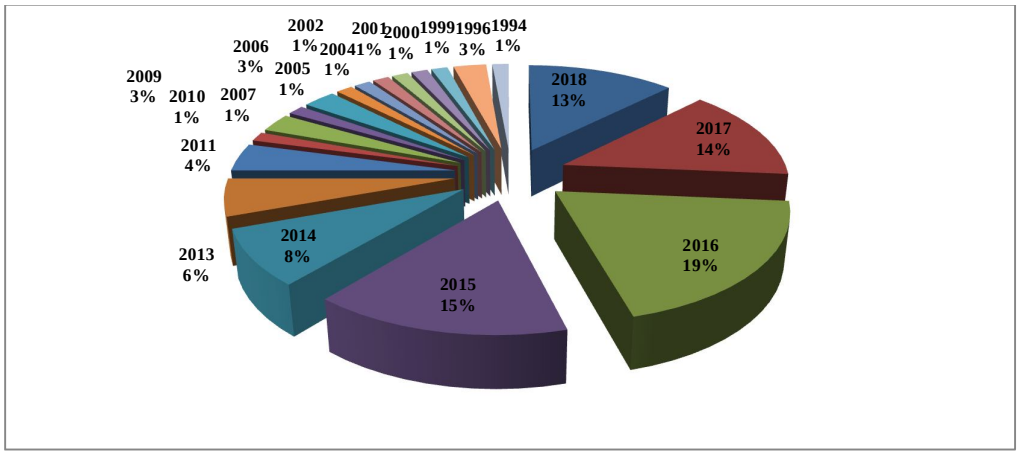

Fig. 2. Year vs. numbers of research issues addressed

We performed an extensive review of academic articles, published in reputed peer-reviewed international journals, mostly in the domain of horticulture products and its supply chain management. Figure III represented the name of peer-reviewed international journal vs. frequency of research articles reviewed in the domain.

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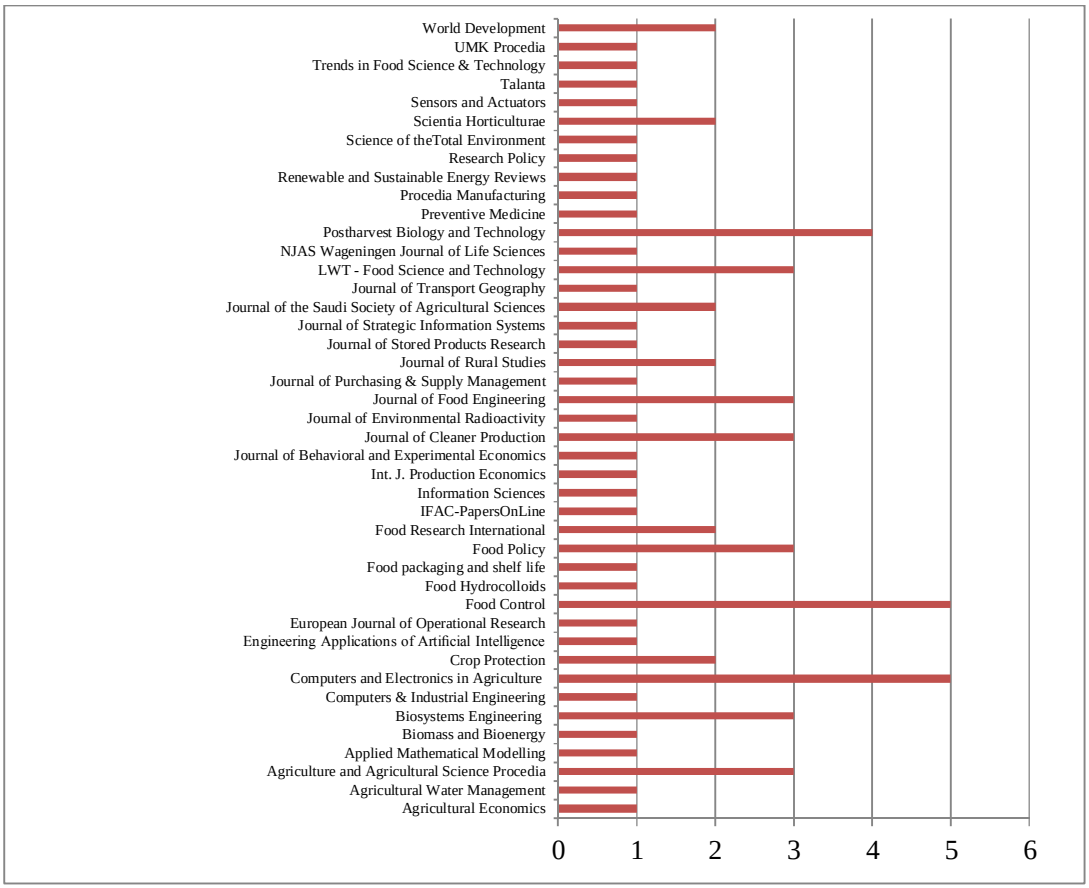

Fig. 3. Name of peer-reviewed journals vs. frequency of research papers reviewed

4. Potential Issues & Future Research Direction

Most of the researchers have been addressed various research issues in the domain related to following areas in Horticulture Supply Chain:

Food packaging, Quality of fruits and vegetables, Pre and Post-harvest technology and losses in supply chain, Horticultural supply chain performance, Fresh leafy green vegetables, Production of pisco, Chilean apple supply chain, Sweet potato value chain, Guava Juice supply chain, Farming systems in production of horticulture, Leaf proteins, Kiwifruit supply chain, Sustainable Supply Chain, Pome fruit industry, Temperature estimation, Private standards, Innovation strategies, Post-harvest decay, Performance of a dehydration, Shelf-life, Fruit e-commerce, Agro industrial Supply Chain, Food safety management, Moisture evolution in packaged fresh horticultural produce, Soybean Supply chain, Packaging Oranges, Flowers Pricing, Supply chain management of tomato commodities, Groundnut Crop Storage, Use of Electronic nose to test artificial contamination in vegetable soup, Palm-oil Production, Date fruit Production, Leafy green vegetables supply chain, Persian lime supply chain, Value Chain Of Horticulture Produce, Water conservation, Perishable fruit and vegetable Supply chain, Chemical control, Coffee supply chain, Brazilian fruit supply chain, Food traceability system, Packaging of fresh produce, Cut Flower Industries, fresh pineapple sector, Carrot quality, Mushroom Quality, Fresh fruit and vegetable pricing, Environmental Radioactivity, Horticultural import growth.

Based on our literature survey, we are recommending a list (Table II) of potential research issues for future researches in the domain of horticulture products supply chain.

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Tab. 2. Future research directions in horticulture supply chain

Self Life and Effect of Temperature on horticulture products.	Logistics and inventory routing for horticulture products
Trade-off among quality, delivery time and cost of horticulture products.	Strategic and environmental issues on horticulture products
Inventory management system for horticulture products	Effect of climate change on horticulture products
Inventory and pricing of horticulture products	Distribution of horticulture products
Extension of shelf life and microbial spoilage in horticulture products	Emerging technologies (Pre and post harvest) for managing horticulture production
Post harvest losses in horticulture products supply chain	Sustainability issues in horticulture products supply chain
Supply chain coordination and integration issues for horticulture products.	Various diseases and health related issues and its impact on horticulture products supply chain.
Horticulture products Supply Chain Performance Measurement	Trends in active and intelligent packaging methods for horticulture products

These are some of the potential research issues that can be addressed in future researches. There have been made many attempts to manage the horticulture products supply chain, but very few attempts, very few guidelines, and literature are available to manage the enlisted research issues.

5. Conclusion & Further Research Ideas

This research is addressed three main questions that are implicitly presented in the title of the study: (1) What does horticulture products supply chain mean? (2) What is known about the horticulture products supply chain? (3) What will come next regarding the horticulture products supply chain? Throughout this paper, we are managed to provide the answers to these questions. First, we identified key research agenda in horticulture products supply chain vs. frequency of research paper (Figure I) by decomposing them into various internal as well as external dimensions. Second, we presented the year-wise number of research issues addressed (Figure II) and the name of peer-reviewed journals vs. frequency of research papers reviewed (Figure III).

Here is a list of further potential research ideas in the domain to adopt as a research topics:

1. Applications of IoT in Horticulture
2. Bioeconomy in Greenhouse Horticulture
3. Horticulture Food Waste Prevention
4. Urban Horticulture and Hydroponics
5. Post Harvest Loss in Horticulture
6. Horticulture Shelf Life Prediction
7. Fresh Vegetable Handling
8. Horticulture Waste Recycling
9. Usage of Sensors for Safety and Quality Assessment
10. Environmental footprint of horticultural products
11. ICT and Social Media Impact on Horticulture Supply Chain
12. Horticultural Products Price Forecasting

The results of an extensive literature review were –potential research issues and future research directions while considering horticulture products supply chain. This study is primarily focused on academic audience; it may also be useful for industry practitioners in the domain that will be able to obtain a comprehensive understanding of the focus of the current research and gaining access to the most representative research areas proposed.

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