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APPLICATION ARTICLE

Investigating the barriers to growth in the Indian food processing sector

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Abstract

The Indian food processing sector (IFPS) has a tremendous capability for growth that can improve the socio-economic conditions of the rural masses. The performance of this sector is lagging behind substantially when compared to other developing nations. This study aims to identify growth barriers at different supply chain (SC) stages in the IFPS. Delphi analysis is performed to find out the barriers in the IFPS. Eighteen growth barriers have been found through expert opinion and extensive literature review spanning across three supply chain tiers: farm level, distribution level, and the consumer level. Further, to prioritize and identify the relative importance of various barriers, the analytic hierarchy process is employed. The results show that the top growth barriers in IFPS are—*the lack of standardization and quality in the processed food, rain-dependent farming, and the high cost of cold chain facilities*. The novel contribution of this study lies in capturing the intricacies of growth barriers in IFPS in an integrated manner across different SC tiers. Interactions between the identified drivers are important to both practitioners and researchers in understanding and driving process, quality, and technology improvements. Finally, the results also throw light on prioritized areas of concern that can be a game-changer for policymakers in India and other developing nations.

Keywords Food supply chain · Growth barriers · Indian food processing sector · Analytic hierarchy process · Delphi analysis

Abbreviations

AHP	Analytic hierarchy process
CII	Confederation of Indian Industry
CII-FACE	The CII Jubilant Bhartia Food and Agriculture Centre of Excellence

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USA	United States of America
IFPS	Indian food processing sector
GDP	Gross domestic product
FL	Farm-level
DL	Distribution-level
CL	Consumer-level
MCDM	Multiple-criteria decision modeling
RFID	Radio-frequency identification
CI	Consistency index
CR	Consistency ratio
RI	Random consistency index
DEMATEL	Decision-making trial and evaluation laboratory
ISM	Interpretive structural modeling
SEM	Structural equation modeling
SIDBI	Small industries development bank of India
FSSAI	Food safety and standards authority of India
APMC	Agricultural Produce Market Committees
GOI	Government of India
NABARD	National Bank for Agriculture and Rural Development

1 Introduction

India is ranked first in the production of milk, banana, papaya, mango, ginger, pulses, and buffalo meat globally. However, the overall processing level of perishable products stands just at 10% [10], which significantly limits the processing capability when compared to other nations such as the USA (80%), France (70%), and Thailand (30%). Despite having the advantage of favorable agri-climatic conditions, the Indian food processing sector (IFPS) lags compared to global food processing supply chains in terms of overall productivity. For instance, exports of processed food as a percentage of GDP stand at 2% for India [4], which is easily noticeable when compared to Brazil (4%), Argentina (7%), and Thailand (9%).

Moreover, the supply chain (SC) gaps and losses are perhaps the biggest challenges faced by the IFPS. Losses occur in the IFPS at multiple levels, such as farm, distribution, and consumer levels. According to Shankar et al. [42], this has emerged as a severe global challenge as around 40–50% of the world's root crops, fruits, and vegetables are destroyed before consumption. The food processing industry can play a vital role by reducing food losses, productivity improvements, and increasing the shelf life of their products [31]. This can be accomplished by involving all supply chain stakeholders and optimizing the supply chain from beginning to end, resulting in a win–win outcome for all parties involved [13, 14].

The food processing sector is generally divided into two broad areas: processed food and value-added processed food [36, 52]. The first category deals with milk, flour, rice, spices, pulses, vegetables, fruits, and salt that are sold in either packed or unpacked condition. These products have short to medium shelf life depending upon the storage and weather conditions at different supply chain

stages. There are multiple challenges, such as wastage and contamination in this category, especially with the sold products without packing. The second category contains processed food products such as jams, juices, pickles, processed vegetables and fruits, dairy, poultry, and chocolates. These food products are generally processed using natural and artificial food preservatives before packing and having a long shelf life.

IFPS in itself has a significant growth perspective and tremendous scope for socio-economic development in terms of value addition, trade boost, employment opportunities, and food wastage reduction [9, 22, 52]. The exports of the processed agriculture commodity provide a better return and increase the farmers' income and living standards. Due to its paramount importance, the IFPS has been identified as one of the vital sectors under the 'Make in India' initiative launched by India's Government in 2014. Although there is still a long way to capture untapped opportunities in IFPS, that is not possible without identifying and addressing the barriers to the growth of IFPS [5, 30].

The motivation for this study is that the current state of research in IFPS is staggered and focused on individual SC tiers, as seen in the previous studies. This study identifies the growth barriers in IFPS across various SC tiers. To the best of the authors' knowledge, the novel contribution of this study lies in capturing the intricacies of growth barriers across different SC tiers, namely—farm level, distribution level, and the consumer level. The research questions of this study are as follows.

RQ1: What are the barriers to growth in the Indian Food Processing Sector (IFPS)?
RQ2: What is the relative priority and importance of the identified growth barriers?

Delphi analysis has been performed to find out the barriers in the IFPS. The Analytic hierarchy process (AHP) is then deployed to prioritize these barriers in the IFPS. In the end, policy-level interventions and the interplay of important barriers for researchers and practitioners are analyzed. In summary, the major contributions of the research work are as follows:

i. The present research work uncovers possible growth barriers in the Indian food processing sector through the Delphi technique.
ii. The ranking and relative importance of the identified barriers is determined using the Analytic hierarchy process (AHP).
iii. This research work presents significant insights for researchers, practitioners, and policymakers.

The rest of the article is organized as follows. Section 2 presents the literature review, and Sect. 3 presents the model development. Section 4 discusses the steps involved in applying the Delphi analysis and AHP. The results are summarized in Sect. 5. The work is concluded, and future research directions are also presented in the last section.

2 Literature review

Some important literature related to the Indian food processing sector is discussed in this section. Murthy and Yogesh (2014) identified the challenges and opportunities in the IFPS. Earlier, Singh et al. [49] also identified the issues and challenges in the IFPS and examined the hurdle in the path of IFPS growth. Recently, Persis et al. [32] assessed the impact of circular economy in the food processing industries. As per the study's findings, ethical practices and the internet of things should be encouraged to increase sustainability in food processing. It improves the decision-making in the supply chain and enhances efficiency. Babu et al. [6] spread the awareness required for starting the food processing business and current initiatives and policies in the food processing sector by the Indian government. As per the findings, there is a need to provide training for developing the food processing industries. Das and Biswas [12] explored the role of the food processing sector in the Indian economy and presented the role of IFPS in the future.

Some authors discussed the current issue related to IFPS, like Thulasiraman et al. [50], raised the issues in the food processing sector in pandemic situations like COVID-19 and how to manage the short supply of food in case of a pandemic. The proper balance between food processing industries and the food supply chain can help in achieving sustainability. During lockdown in case of a pandemic situation, it is challenging to provide the raw material for the food processing industries. Similarly, chitrakar et al. [8] identified the role of information technologies in managing food processing industries during a pandemic situation.

Shelly and Kaur [43] assessed the role of IFPS in economic growth and employment. They also suggested that an increase in foreign direct investment, global competitiveness, and export promotion is required to develop the IFPS. Singh et al. [48] presented factors that affect dairy processing. Ali (2007) [3] has analyzed the barriers in the meat processing industry. Reddy and Bantilan [39] have discussed issues that decrease the efficiency of groundnut processing. Sharma et al. [41] examined the problems associated with the dairy green supply chain management industry. To capture the vast issues and contextual complexity in agricultural food supply chains, researchers also using various multiple-criteria decision modeling (MCDM) approaches.

3 Model development

The conceptual model for growth barriers in the IFPS is extracted from the existing research studies, added expert opinion, and expert validation. The barriers have been extracted by keeping the broader focus on increasing the productivity and product shelf life supported by efficient food processing that aims to minimize food wastage at various supply chain stages. In particular, short shelf-life agriculture/animal produce (perishable items like fruits, vegetables, dairy products, etc.) and long shelf-life produce (wheat, rice, pulses, etc.) are considered for the study.

The food processing sector is affected by various demand-side factors such as rapid urbanization, changing food habits, and rising demand for frozen food that should be healthy and nutritious. Cleanliness, freshness, flavor, ease of cooking, and taste are other essential product characteristics that play an important part in consumers' purchase decisions [20]. On the supply side, the food industry has to address multiple challenges to minimize food wastage like proper traceability, packaging, cold chain, transportation, etc. Eco-innovation should be adopted to reduce food and packaging waste [46]. Proper traceability is required to monitor the live food condition along the supply chain, such as temperature, humidity, etc., to avoid food spoilage [11]. Studies in the logistics sector, such as Prajapati et al. [33], also throw light on this issue from a transportation perspective.

Upon closer inspection of the existing literature and expert opinion, the barriers are divided into the farm, distribution, and consumer levels. Key issues found at the farm level are *low yield, inadequate quality of food produce, conventional farming methods, rain-dependent farming, lack of proper logistics and the handling facilities at the farm, insufficient cold storage facilities near the farm, unaffordable modernization, high advertising cost, and, improper grading*. Next, at the distribution level, barriers in the food processing sector were found out to be *the high cost of modern transportation facilities, high cost of the cold chain, inadequate information technology and communication support, high cost of packaging, limited market support, lack of government support and poor coordination between farmers and food processor*. At the consumer level, the barriers found are *lack of awareness, lack of standardization, and quality in processed food and conventional food habits*. The complete list of the critical barriers, along with their descriptions, is shown in Table 1. The Delphi technique is a well-known and widely used technique. The steps of the Delphi technique has summarized in the next section in brief.

The existing literature and experts' opinion suggested that more research is needed in the Indian food processing sector. This work aims to fill some of the existing research gaps by finding critical barriers in the Indian food processing sector (IFPS). The Delphi technique is used to capture the expert opinion. The conceptual model is shown in Fig. 1. Further, the analytic hierarchy process (AHP) ranks and identifies the relative importance among various barriers.

4 Research methodology

This research paper uses the Delphi analysis and the AHP technique to achieve the research objectives. Steps involved in the Delphi analysis and AHP are given below:

4.1 Delphi analysis

The RAND Corporation developed the Delphi analysis technique in 1950 [27]. It is a judgemental technique. In this technique group of experts discuss the problem and come with a common opinion for decision making. It is advantageous when there is inadequate theoretical development (Bouzon et al., 2016). Various researchers and

Table 1 Growth barriers of the Indian food processing sector

Barrier	Description	Key research works
Farm-level		
Low yield and inadequate quality of food produce (FL1)	The low yield of farm produce is a problem for food processing industries. Poor quality of agriculture commodity at farm reduces the input for processing industries	Kumar et al. [25], Mahapatra and Mahanty [26], Gardas et al. [17], Joshi et al. [21], Dora et al. [16]
Conventional methods of farming (FL2)	The traditional way of agriculture reduces the yield at the farm level. Farmers are unaware of new technologies, machines, techniques, and the high quality of seeds	Kumar et al. [25], Mahapatra and Mahanty[26], Dharni and Sharma [15], Bag and Anand [5], Kumar and Basu [24]
Rain dependent farming (FL3)	Unpredictable weather decreases the output of farm produce. Sometimes a significant amount of agricultural produce becomes waste because of uneven rainfall and change in rainfall patterns	Kumar et al. [25], Raut et al. [38], Rao et al. [37]
Lack of proper logistics and handling facilities at the farm (FL4)	A significant amount of perishable food will waste due to inadequate transportation and handling facilities at the farm level	Gardas et al. [17], Sidhh et al. [45], Accorsi et al. [1], Dharni and Sharma [15], Mangla et al. [28]
Lack of proper cold chain facilities near the farm (FL5)	Large amounts of agricultural commodities/products are turning waste because of the cold chain facility	Gardas et al. [17], Sidhh et al. [45], Accorsi et al. [1], Dharni and Sharma [15]
Unaffordable modernization (FL6)	The cost of modernization is high for the food processor. It is unaffordable to small-scale industries, and large enterprises are not interested in the small-sized market	Gardas et al. [17] Sidhh et al. [45]
High advertising cost (FL7)	Large industries can advertise their product, but small enterprises cannot promote their processed product through various media because of the high cost of advertising	Kumar et al. [25], expert opinion
Improper grading and sorting (FL8)	Lack of proper food inspection for quality, freshness, size, shape, and market value	Expert opinion

Table 1 (continued)

Barrier	Description	Key research works
Distribution-level		
High cost of modern transportation facilities (DL1)	Because of the high transportation cost or unavailability of transportation, food turns waste at the distribution level. It is not distributed to the market/mandis, decreasing the input to the food processing system	Gardas et al. [17], Sidhh et al. [45], Accorsi et al. [1], Shukla and Jharkharia [44], Kumar et al. [25], Prajapati et al. [34]
High cost of cold chain facilities and low return (DL2)	The high cost of the cold storage facility at the distribution level increases the waste and subsequently affects food processing	Gardas et al. [17], Sidhh et al. [45], Accorsi et al. [1], Shukla and Jharkharia [44], Viswanadham [51]
Inadequate IT support and communication (DL3)	Sensors, the Internet of Things, and RFID increase the performance of the supply chain and helps in monitoring the product, and these devices helpful in decision making. Inadequate support in this regard is a key barrier	Singh and Sahu [47], Kumar et al. [25], Dandage et al. [11], Singh et al. [49], Kasso et al. 23
Poor coordination between farmer and food processing units (DL4)	Proper coordination between farmers and food processors is required to decrease waste. A large number of intermediaries in the food supply chain reduce the coordination among the players	Gokarn and Kuthambalayan [19], Kumar et al. [25]
High cost of packaging (DL5)	The high cost of packaging to the food processor increases the value of the final product. It discourages the sales of the final product after processing	Simms et al. [46], Expert opinion
Limited domestic market (DL6)	A limited domestic market exists because of the low-income level of the people. They cannot buy high-cost processed products	Expert opinion
Lack of government support (DL7)	The government should provide more financial support to develop the necessary infrastructure, technology, and skill	Gardas et al. [17], Sidhh et al. [45], Viswanadham [51], Bag and Anand [5], Mangla et al. [28]

Table 1 (continued)

Barrier	Description	Key research works
Consumer-level		
Conventional food habits (CL1)	Traditionally Indians buy fresh food as compared to packed/processed/preserved food. High processing costs make the processed food unaffordable to Low-income people	Gupta [20], Expert opinion
Lack of standardization and quality in processed food (CL2)	People are not getting value for money because of the poor quality of processed food in most cases	Balaji and Arshinder [7], Dandage et al. [11], Viswanadham [51], Sidhh et al. [45]
Lack of awareness (CL3)	Low awareness about nutritional value in the processed food	Bag and Anand [5], Expert opinion

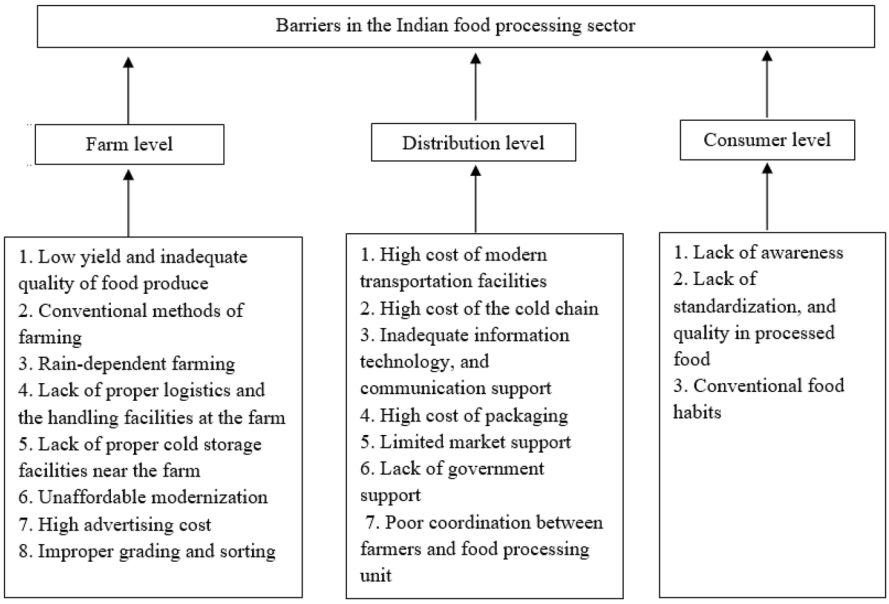

Fig. 1 The conceptual model for barriers in the Indian food processing sector

practitioners widely use it for analyzing complex decision problems. In this method, decision-making depends upon human judgment. The steps involved in this paper for the Delphi technique are (see, Akkermans et al. [2]).

i. Identification of the research problem and questionnaire design to analyse the problem.
ii. Search for experts related to the research problem to be analyzed. The experts are approached and asked for information related to the issues in the questionnaire format.
iii. Experts give some ideas and possible solutions about the barriers in the Indian food process sector.
iv. Responses are collected from each expert. Received responses are reviewed and analyzed with the proper feedback.
v. The expert is contacted again, and the process is repeated until the consent of all experts is reached. Finalize the barriers after the consent of all the experts'. Finalized growth barriers are shown in Table 1.

4.2 Analytic hierarchy process (AHP)

It is a multi-criteria decision-making (MCDM) technique used for solving a complex problem. Saaty developed AHP in 1980, and AHP is used to model and rank factors in various fields like management, manufacturing, industry, government, engineering, etc. Managers, researchers, and practitioners use it by arranging a

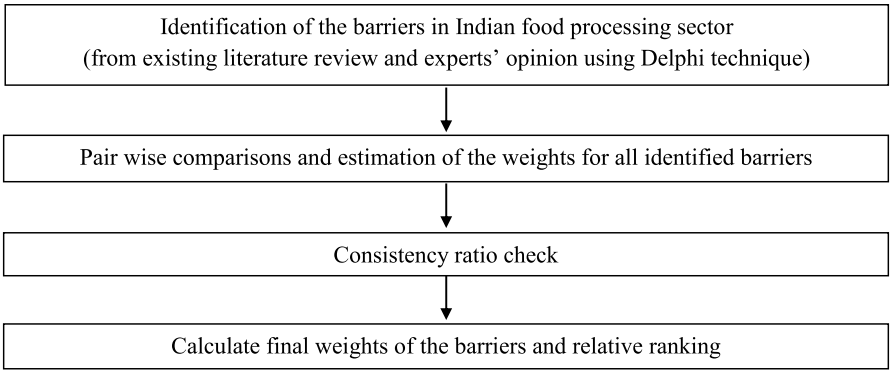

Fig. 2 AHP flowchart

Table 2 Scales in pairwise comparisons [40]

Score	Definition
1	Equal importance of both factors
3	Limited importance of one factor over another
5	Strong importance of one factor over another
7	Very strong importance of one factor over another
9	Extreme importance of one factor over another
2, 4, 6, 8	Intermediate value between two close judgments'

complex problem into a simple hierarchy. This method is simple, easy, and flexible to apply. The flowchart of the AHP method is shown in Fig. 2. A survey has been conducted for the data collection. The responses have been collected from food processors and researchers working in the food processing supply chain domain. The questionnaire consists of three sections. The first section deals with the general information of the respondents and their respective affiliation backgrounds. Section two is designed to select the most suitable barriers and exploring their significance in the Indian food process industries. Section three helps in finding the priority of concern of the growth barriers chosen in the food processing sectors. The expert has validated the final results.

The steps involved in the AHP application are as follows [29, 38].

a. Select the barriers from the extant literature review. Finalize the barriers by taking the experts' opinions from the researcher, practitioner, and field personnel. The scale used for the pairwise comparison is shown in Table 2.
b. Pairwise comparison of the finalized barriers at farm, distribution, and consumer level by the experts are shown in Tables 3, 4 and 5, respectively. In this research work, ten experts (seven food processors & three academicians) were contacted for conducting the study. A final decision-making matrix is formulated after taking ten individual responses in matrix form.

Table 3 Pairwise comparisons of barriers at the farm level

	FL1	FL2	FL3	FL4	FL5	FL6	FL7	FL8
FL1	1	0.25	0.33	0.25	0.20	0.33	2.00	2.00
FL2	4.00	1	0.33	1.0	1.0	0.50	3.00	3.00
FL3	3.00	3.00	1	3.00	2.00	1.00	3.00	3.00
FL4	4.00	1.00	0.33	1	1.00	1.00	4.00	4.00
FL5	5.00	1.00	0.50	1.00	1	3.00	4.00	3.00
FL6	3.00	2.00	1.00	1.00	0.33	1	2.00	2.00
FL7	0.50	0.33	0.33	0.25	0.25	0.50	1	1.00
FL8	0.50	0.33	0.33	0.25	0.33	0.50	1.00	1

Table 4 Pairwise comparisons of barriers at the distribution level

	DL1	DL2	DL3	DL4	DL5	DL6	DL7
DL1	1	1.00	2.00	1.00	3.00	3.00	2.00
DL2	1.00	1	3.00	2.00	3.00	4.00	3.00
DL3	0.50	0.33	1	0.50	3.00	3.00	2.00
DL4	1.00	0.50	2.00	1	3.00	4.00	3.00
DL5	0.33	0.33	0.33	0.33	1	1.00	0.50
DL6	0.33	0.25	0.33	0.25	1.00	1	0.50
DL7	0.50	0.33	0.50	0.33	2.00	2.00	1

Table 5 Pairwise comparisons of barriers at the consumer level

	CL1	CL2	CL3
CL1	1	0.25	1.00
CL2	4.00	1	3.00
CL3	1.00	0.33	1

c. Determine the weights and ranking of all the factors and subfactors. Weights, global ranking, and local ranking of all the factors and subfactors are shown in Table 7.
d. Determination of consistency index (CI) for assessing the consistency in expert judgment by using the relation:

$$\mathrm{CI} = \frac{\lambda_{\max} - n}{n - 1}$$

where, $\lambda_{\max}$ is the maximum eigenvalue of the matrix, and n is the number of factors/barriers.

e. Next, find the value of consistency ratio (CR), which is calculated as CI/RI, where RI is the random consistency index. The above expression calculates the value of

CI, and the RI value depends upon n. RI corresponding to the value of n is shown in Table 6.

f. If the final value of CR is less than 0.1, then results are acceptable means judgments are consistent. If CR is more than 0.1, then repeat the procedure. CR value in the case of farm-level barriers is 0.062. Similarly, the CR value for the distribution and consumer levels was 0.02 and 0.01, respectively. Hence, our results are acceptable.

5 Results and discussions

The novel contribution of this paper is two-prong: first, identification of the barriers, and second, ranking of identified barriers. Eighteen barriers have been identified in the IFPS through extant literature and Delphi analysis. Out of these, eight are at the farm level, seven at the distribution level, and three at the consumer level. The ranking of these barriers is obtained by using the AHP method. The pairwise evaluation matrix for the identified main barriers and the specific factors is constructed to determine their priority or ranking. The final relative weights and ranking of all the factors and subfactors in the IFPS are summarized in Table 7.

Relative weights for all sub-factors have been calculated (see Table 7). Further, for estimating the global weights, each main factor's relative weights are multiplied with its corresponding subfactor weight. For example, for calculating the global weight of subfactor (FL1), factor weight (FL) is multiplied by the corresponding sub factor's relative weight ($0.493 \times 0.056 = 0.0276$). Local ranking of subfactors in the particular level (farm, distribution, consumer) based on the relative weights of the subfactors and global ranking has been done based on the sub-factors global weights. The global ranking is the ranking of all the sub-factors based on the global weights. This procedure is already explained in Sect. 4.2 in detail.

Among the main factors, the ranking identified in decreasing order of the relative weights is as follows: farm level (0.493), distribution level (0.311), and consumer level (0.196). This indicates that efforts towards addressing the challenges at the farm level should be the first priority, followed by distribution and consumer levels, respectively. The decreasing order of top five barriers at the farm level factors is *rain-dependent farming (FL3 0.239), lack of proper cold storage facilities near the farm (FL5 0.188), lack of proper logistics and handling facilities near the farm (FL4 0.150), unaffordable modernization (FL6 0.141), and conventional methods of farming (FL2 0.131)* (refer to Table 7).

Table 6 Random consistency indices (Alonso and Lamata, 2006)

n	1	2	3	4	5	6	7	13	14	15	16
RI	0	0	0.5245	0.8815	1.1086	1.2479	1.3417	1.5551	1.5713	1.5838	1.5978

Table 7 Final relative weights and ranking of factors and sub-factors in the Indian food processing sector

Main factors	Factors weight	Sub factors (barriers)	Relative weights	Local ranking	Global weights	Global ranking
Farm level (FL)	0.493	Low yield and inadequate quality of food produce (FL1)	0.056	6	0.0276	13
		Conventional methods of farming (FL2)	0.131	5	0.064	7
		Rain dependent farming (FL3)	0.239	1	0.117	2
		Lack of proper logistics and handling facilities near the farm (FL4)	0.150	3	0.073	5
		Lack of proper cold storage facilities near the farm (FL5)	0.188	2	0.092	3
		Unaffordable Modernization (FL6)	0.141	4	0.069	6
		High advertising cost (FL7)	0.047	8	0.0231	16
		Improper grading and sorting (FL8)	0.048	7	0.0236	15
Distribution level (DL)	0.311	High cost of modern transportation facilities (DL1)	0.201	3	0.0625	9
		High cost of cold chain facilities and low return (DL2)	0.267	1	0.0830	4
		Inadequate IT support and communication (DL3)	0.130	4	0.0404	10
		Poor coordination between farmer and food processing units (DL4)	0.202	2	0.0628	8
		High cost of packaging (DL5)	0.059	6	0.0183	17
		Limited domestic market (DL6)	0.053	7	0.0164	18
		Lack of government support (DL7)	0.088	5	0.0273	14
Consumer level (CL)	0.196	Conventional food habits (CL1)	0.174	3	0.0341	12
		Lack of standardization and quality in processed food (CL2)	0.634	1	0.1242	1
		Lack of awareness (CL3)	0.192	2	0.0376	11

From the above results, it is clear that farm factors are the influential critical factors and need urgent attention from the decision-makers and policymakers to reduce losses at the farm level supply chain. Farm-level is the initial level in the food supply chain. It is also called a post-harvest stage. If the supply chain reduces the losses at this stage, more raw materials would be available to the food process industries. It will further contribute towards increasing the productivity of processing industries. After the farming stage, farm produce goes to the distribution stage. The top five barriers in the decreasing order of the distribution process are *high cost of cold chain facilities and low return (DL2 0.267), Poor coordination between farmer and food processing units (DL4 0.202), High cost of modern transportation facilities (DL1 0.201), Inadequate IT support and communication (DL3 0.130), lack of government support (DL7 0.088).*

Around 10% of the perishable items are using cold storage facilities in India at the distribution stage. Cold storage and warehouse facilities are required to reduce wastage and maintain agricultural product quality [1]. Cold storage should be at the accessible route and ensure proper transportation facilities near the cold chain facility. It should also be a nearby processing unit to minimize lead time. Our results suggest that the direct linkage between them is still a major problem. Government and non-government organizations should spread information and help to establish the links between farmers and processing units. Once these links are established, the next step should be to make unorganized farmers join hands through cooperative societies (e.g., Amul) to harness the economies of scale. All players should exchange information for better decision-making [35]. Gardas et al. [18] suggested that if the food processing industries purchase raw material from the farmer directly, it will reduce the intermediaries. This will enhance farmers' income as well as the profitability of the processor. The other two barriers in distribution are the high cost of packaging (DL5) and the limited domestic market (DL6).

The last stage in the IFPS is the consumer level. Ultimately, a food processor earns a profit when the consumer likes it. We find that critical barriers at this stage are *lack of standardization and quality in processed food (CL2 0.634), lack of awareness (CL3 0.192), and conventional food habits (CL1 0.174).* Traditionally Indian people buy fresh food as compared to packed/processed/preserved food. High processing cost makes processed food unaffordable to low-income people, and sometimes people are not getting value for money because of the poor quality of processed food. However, with the ever-increasing young population in metro cities, the demand for quality processed food is ever-increasing. The results suggest that the critical factor among all three barriers in this stage is the lack of standardization and quality in processed food. Once this is taken care of, the other two barriers will start to weaken down gradually. Hence, the study strongly suggests that food processors should focus their resources in this direction with urgency.

The top five barriers out of eighteen barriers as per global ranking in the Indian food processing sector are as follows (refer to Table 7): *Lack of standardization and quality in processed food (CL2), Rain dependent farming (FL3), Lack of proper cold storage facilities near the farm (FL5), High cost of cold chain facilities and low return (DL2), Lack of proper logistics and handling facilities near the farm (FL4).* Three barriers out of the top five barriers belong to the farm-level

factors. These factors are the influential critical factors and need urgent attention from the decision-makers and policymakers to reduce losses at the farm level in the Indian food supply chain. Some other reasons for the slow growth in the IFPS are that most people cannot afford processed food because of the low-income level, fresh produce preferences compared to packaged food, and most of the people are not yet visiting a supermarket. However, all of these barriers were not investigated together; hence their relative importance was unexplored so far, which is one of the key contributions of this paper.

Among the top ten barriers in the overall global ranking, the contribution of the farm-level barriers, distribution level barriers, and consumer level barriers is 50%, 40%, and 10%, respectively. While the contribution of the consumer-level barriers seems the lowest, it is to be noted that one of the factors in the consumer level—Lack of standardization and quality in processed food-is the top-most factor among all eighteen identified factors. Hence, we reiterate that food processors should give quality assurance prime importance. This can be successfully pursued by focusing efforts towards total quality management and lean practices, which produce significant improvements across different sectors [13, 14]. Further, at the farm level, the government should support small farmers. This can be done by providing them subsidies, finance to purchase modern equipment, banking facility, and investments in installing small food processing units at the farm. Awareness about the benefits of the small food processing units of agriculture produces and provides back-end support to farmers should be prioritized in this segment. Recently, Lok Sabha (Parliament of India) passed The Farmers' Produce Trade and Commerce (Promotion and Facilitation) Bill, 2020, and The Farmers' (Empowerment and Protection) Agreement of Price Assurance and Farm Services Bill, 2020 helps the IFPS by providing the direct link to the farmers and industries.

For enhancing food safety systems and standards in the food processing sector, industries should adopt good management practices and good hygienic practices. Also, there is a need to provide the skills and training in food technology on the social front. Land acquisition delays and complex government clearance procedures hamper the growth of the food processing sector. The government should provide single window clearance for the food processing projects and relax non-farming land use permits for the food industry. There is an urgent need to provide cheap credit to the food processing sector to create infrastructure like the cold chain infrastructure, logistics, storage facilities, etc., and constitute the task force to examine the working capital requirements.

The raw material of the food processing sector is seasonal and labor-intensive. There is a need to create a risk fund that mitigates the stress in the food processing sector. The research infrastructure, testing facilities, and traceability systems need to be improved, so that safe food reaches the consumers. The initiative should be taken to boost investment in plant and machinery and promote packaging of the product locally to reduce its overall production cost. There is a need to make a national food processing policy to avoid state and center policies' incompatibility. The urgent need to increase start-ups, testing technologies, and innovation in the Indian food processing sector are also evident for practitioners.

The Government of India (GoI) has taken many good initiatives for the development of IFPS. The government announced a start-up India scheme to enhance the credit through banks for start-up ventures to develop the food processing sector and job creation. SIDBI (small industries development bank of India) and NABARD (National Bank for Agriculture and Rural Development) provide funds to the agro-industry, food processing sector, and rural development. These banks are also investing in the capital creation, technological innovation, development, and improvement of the product. Through the skill India mission, the government provides required skills and training to the people working in the food processing sector. The food processing sector is one of the vital thrust sectors among the chosen 25 thrust sectors under the Make in India scheme. The Indian government also created an investor portal to attract investment in the food processing sector. GoI established India's regulatory body, food safety, and standards authority of India (FSSAI) in 2008 to take care of the matters associated with food safety and standard practices in India's food sector. The recent farm bill is aimed to help increase trade by removing intermediaries and putting government taxes outside the Agricultural Produce Market Committees (APMC). It is expected to help in promoting interstate and intrastate business and increase the investment in infrastructure development. Our findings reveal that these policies are the need of the day to improve productivity in IFPS and the Indian agriculture sector. Their proper implementation and execution should be taken on priority by policymakers, researchers, and practitioners.

6 Conclusions and future research directions

India ranks second in the world in terms of the production of agricultural commodities. Still, India has not utilized its full potential and processes just 2% of fruits and vegetables globally. A few researchers have attempted to address this underlying problem by identifying the growth barriers of the IFPS; however, their results stand staggered at different levels. This study is a novel and recent attempt to capture the growth barriers to IFPS in an integrated manner by considering all prime factors together—farm level, distribution level, and consumer level. After the extensive literature review and expert opinion using Delphi analysis in the IFPS, a total of eighteen barriers have been found. Out of these, eight are at the farm level, seven at the distribution level, and three at the consumer level. The barriers are then ranked by using AHP. The results indicate that the top barrier at the farm level is rain-dependent farming (FL3 0.239), and the top barrier at the distribution level is the high cost of cold chain facilities and low return (DL2 0.267). The top critical barrier at the consumer level is the lack of standardization and quality in processed food (CL2 0.634) (Table 7). The study suggests that food processors should prioritize their efforts in this direction to make the supply chain more sustainable. The results are relevant for researchers, practitioners, and policymakers. In the Indian context, more investments are needed in the food processing sector to make it globally competitive, and also, there is a significant gap between food production and processing. In the future, other MCDM techniques such as Decision-making trial and evaluation laboratory (DEMATEL), interpretive structural modeling (ISM), structural equation

modeling (SEM), etc., can also be explored by other researchers. Further, the world is ever-changing, hence after few years, these barriers might evolve with time, and therefore, the avenues of further research in this domain will always exist.

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Data availability Data was collected through surveys and expert interviews by the principal author. The data collection for this research is in concordance with disciplinary norms and expectations of the journal.

Code availability Not applicable for this study.

Declarations

Conflict of interest The authors declare that they have no conflict of interest.

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