Indian Journal of Agricultural Sciences **94** (3-S1): 018–025, March-S1 2024/Article
https://doi.org/10.56093/ijas.v94i3.148596

Perceived constraints in agro-processing in unorganized agri-businesses: Learning from Trans-Gangetic Plains

RENU BALAKRISHNAN[1], SANDEEP MANN[1], ARVIND KUMAR[2], ASHISH SANTOSH MURAI[3]*, RAJIV SHARMA[1], SACHIN MITTAL[4] and MANDEEP SINGH[1]

ICAR-Central Institute of Post-Harvest Engineering and Technology, Ludhiana, Punjab 141 004, India

Received: 16 February 2024; Accepted: 13 March 2024

ABSTRACT

Agro-processing within the production catchment has the potential to enhance farmers' income, reducing post-harvest losses, and generating rural employment in India. A study was carried out during 2019–22 to identify the constraints impacting performance of agro-processing units being run by the unorganized sector in Trans-Gangetic Plains. A total of 60 current and 60 potential agro-processing farmers were undertaken using simple random technique to carry out the study. A combination of quantitative and qualitative approaches were used in collecting data. Data were analyzed using Friedman's, Nemenyi's and Kruskal-Wallis's tests. Study highlighted the issues that current agro-processors encounter, various constraits including high interest rates, inadequate storage, few marketing avenues, slow information access, and expensive equipment maintenance. Further, the challenges faced by aspiring agro-processors were information deficits, marketing and high operating expenses. The insights suggest measures to promote the adoption of post-harvest technologies among stakeholders.

Keywords: Adoption, Agro-processing, Agri-business, Constraints, Post-harvest technology

The primary sector, with agriculture at its core, plays a central role in India's economy. Amidst the COVID-19 pandemic, the proportion of workers in the sector rose to 46.5% of the working population in 2020–2021. While contributing 21.7% to the nation's GDP (GoI 2021), the agriculture and allied sector accounts for a substantial 20.19% of gross value added (GVA), surpassing the global average of 6.4% (MoSPI 2021). Over the past 6 years, Indian agriculture has demonstrated a consistent annual growth rate of 4.6% (MoF 2023). Despite the challenges posed by the pandemic in 2021–22, the growth rate achieved was 3.9% (MoF 2022). India's agricultural prowess is evident through its global dominance in milk, cashews and tea commodities. India has achieved a status as a net exporter of various products, including fish, buffalo meat, rice (especially Basmati), and spices, despite importing goods like vegetable oils and pulses. Notably, agricultural exports reached a record of US $50.2 billion in 2021–2022, marking an 18% increase over the previous year (APEDA 2022).

Notwithstanding these successes, agriculture still faces a variety of obstacles like climate change, fragmented lands, inefficient mechanization, low productivity, disguised unemployment, growing production prices, and substantial water use. Besides, rising per capita income, land reorganization and population growth pose new concerns. Furthermore, considerable losses during production and post-harvest handling diminish its total technical efficiency. Harvest and post-harvest losses for major crops in the nation are 3.89–5.92% for cereals; 5.65–6.74% for pulses; 2.87–7.51% for oilseeds; 6.02–15.05% for fruits; 4.82–11.61% for vegetables; 4.86–8.76% for fish; 2.34–5.63% for meat; and 0.87% for milk (NABCON 2022). Despite a notable decline in post-harvest losses of agricultural goods over time, the estimated total financial loss for 2022 was ₹1527.90 billion, up from ₹926.51 billion in 2015 (NABCON 2022, Jha *et al.* 2015). The post-harvest losses in Indian agriculture can be attributed to a combination of systemic and infrastructural challenges. Notably, just 49% of oilseeds, 78% of wheat and 92% of paddy are processed, with a sizable amount occurring at an organized level (Deloitte 2021). The unorganized food processing sector employed about 5.11 million labourers in 2015–16 (NSSO 2018) with a 14.18% contribution to the total employment in the unregistered manufacturing sector (GoI 2022).

[1]ICAR-Central Institute of Post-Harvest Engineering and Technology, Ludhiana, Punjab; [2]Indian Council of Agricultural Research, New Delhi; [3]ICAR-Agricultural Technology Application Research Institute, Ludhiana, Punjab; [4]Food Safety and Standards Authority of India, Eastern Regional Office, Kolkata.
*Corresponding author email: ashish.murai@icar.gov.in

Though government has been trying its level hard with different policies and programmes to encourage the expansion of this industry, there seems to be differences in the processing levels, and therefore potential of unorganized sector is yet to be harnessed. In this backdrop, present study was carried out with two objectives: (i) to identify and prioritize key challenges faced by both current and potential agro-processors, and (ii) to formulate strategic recommendations for increasing processing and value addition in the production area.

MATERIALS AND METHODS

The focus of this study was the unorganized agro-processing units which were individually owned businesses with less than 10 workers involved in secondary processing activities such as milling, flour/powder production, and oil expulsion. Sangrur, Rupnagar and Ludhiana districts of Punjab, widely cultivating food grains and oilseeds, were purposively selected in this study (2019–22) to represent three distinct sub-agroclimatic zones of the Trans-Gangetic Plain region. The predominant crops that are processed by local units in this region include paddy, wheat, maize, rapeseed and mustard, pigeonpea, chickpea, and greengram. The active agro-processors were selected from a comprehensive list collected from the All India Co-ordinated Research Project on Post-Harvest Engineering Technology coordinating center at Ludhiana and Punjab Agricultural University, Ludhiana, which has played a key role in establishing agro-processing units in the region. The prospective agro-processors were chosen from a comprehensive list of farmers obtained from the corresponding district's Krishi Vigyan Kendra, who had contacted these organizations seeking information about secondary agro-processing. Based on simple random sampling, 20 respondents were drawn from each group within each of the three districts. Thus, 60 current and 60 potential agro-processor farmers made up the total sample size of 120 for this study. Interview schedule was developed and pilot tested to ensure consistency and the applicability of the information. Following this, face-to-face qualitative interviews were carried out with the selected respondents.

Technical proficiency, infrastructure, financing, market, and equipment limitations were the primary categories of constraints for active agro-processors. Six statements representing each category were chosen using Edward's (1969) criteria and assessed using Likert's (1932) five-point summated rating system. The obstacles were defined as the degree to which they affect the profitable functioning of agro-processing facilities to several important factors such as infrastructure, finance, market, equipment, and technical ability. Thirty participants, distinct from the sample, but representing the population assessed the scale's applicability before its administration to the target population. The validity of the scale was established by employing the jury's opinion. The Split Half and Cronbach's alpha coefficient techniques (1951) ensured the scale's internal consistency. The observed coefficient of internal consistency (Spearman's rho) was 0.760, while the Cronbach's alpha coefficient was 0.871. The instrument to measure the constraints faced by potential agro-processors contained 18 items, scored using the same reliability techniques. The obtained Spearman rho (0.720) and Cronbach alpha (0.767) coefficients were found to be acceptable according to established criteria (Nunnaly 1978, Churchill and Brown 2006).

Three focused group discussions were conducted with the experts in post-harvest management and value addition for identifying strategies for the promotion of agro-processing. The experts meticulously examined the results of the study and responded to the question "How can we transform the unorganized agro-processing business into a sustainable and innovative enterprise by effectively tackling the existing challenges?". Each expert's statements were meticulously recorded, and a thorough content analysis of their discussions was conducted. For efficient analysis, a table was prepared by assigning proper codes to each inputs. Consequently, frequently used terms were noted, and key themes were derived and focused coding was used to further improve the recommendations by merging the coding categories identified in the first step. Further, it enabled the researcher to draw insightful parallels between the various discussions. Based on the analysis, the devised strategies were presented before all the experts who participated in the discussion to convey the outcome of the conversations.

Statistical analysis: The Kruskal-Wallis one-way ANOVA was used to compare major constraint dimensions, and Freidman's test to assess intra-dimension differences. Nemenyi's method was applied to identify significant differences between constraints and grouped them into homogeneous categories (Siegel and Castellan 1988). Statistical Package for the Social Sciences (SPSS 25.0) was applied to analyze the data.

RESULTS AND DISCUSSION

Socio-economic characteristics of agro-processors and potential agro-processors: The results indicated that middle age group (35–55 years) of agro-processors was predominating in both categories (Table 1). The agro-processors, older than 55 years constituted 26.7%, while only 5% of aspirants fell in this age group since people are often less open to technology and risk after a certain age. All respondents had formal education, with 25% of active and 40% of aspirants being graduates. About 51.7% of aspirants belonged to nuclear families, indicating a situation where fewer family members contribute to income and feel the need for additional income. Most of the agro-processors had semi-medium and medium-sized (2–10 ha) farmland, and all of them had more than 10 years of farming experience. Processing appears to be an emerging field, with 58% of active processors having experience of 10 years or less in the business. While 75% of processors attended training, only 13% of aspirants were exposed to such an exercise pointing towards their lack of information or willingness. Only 20% of the surveyed processors and 28% of aspirants belonged to the low-farm income group.

The study identified four operational models of agro-processing centre (APC), mainly centered around cereals, followed by oilseeds. Pulses were processed in only 8% of APCs, reflecting their limited cultivation in the region. Despite the modest cultivation of spices, 48% of units processed them, driven by consumer demand and the significance of spices in Indian cuisines. Among the APC models, aspirants preferred Model II and III, compatible with the regional cropping system. APCs were predominantly small-scale, with 82% employing fewer than four workers and 53% reporting annual revenues of more than ₹0.849 million, highlighting the economic potential present within the production catchment.

Age, education, experience, family size, income, and farm size influence farmers' decisions to adopt or reject agricultural technologies (Mafimisebi *et al.* 2006, Espinoza-Ortega *et al.* 2007). Education also contributes to motivate farmers to explore alternative revenue streams like agro-processing (Liu *et al.* 2019, Khoza *et al.* 2019). Experienced farmers, particularly middle-aged ones, tend to persist in agro-processing activities, contributing to the industry's sustainability (Zhou and Lele 2022). These factors jointly stress the complex dynamics affecting the agro-processing sector.

Constraints faced by active agro-processors: The results indicated a substantial variation in the impact of constraints (K (observed)=100.943>K (critical value) = 9.488, df = 4, P<0.001). With a mean rank of 204.85, respondents ranked financial limitations as the most severe (Table 2), followed by market-related constraints (201.02). Infrastructure-related limitations had a mean rank of 75.95, which were comparatively milder than that of technical expertise (158.48) and equipment (112.20). Contrastingly, infrastructure limitations have been observed to hinder peri-urban fish processing (Gills *et al.* 2017).

Table 1 Socio-economic characteristics of the active and prospective agro-processors in the Trans-Gangetic plain region

Parameter	Active agro-processor (%)	Potential agro-processor (%)
Age (in years)		
<35	8.3	13.3
35–55	65.0	81.7
>55	26.7	5.0
Education		
Illiterate	0	0
Primary school	3.3	0
Secondary school	26.7	18.3
Higher secondary school	41.7	41.7
College and above	28.3	40.0
Family type		
Nuclear family	36.7	51.7
Joint family	63.3	48.3
Farm size (ha)		
Marginal farmer (<1)	3.3	3.3
Small farmer (1–2)	5.0	10.0
Semi-medium farmer (2–4)	40.0	36.7
Medium farmer (4–10)	48.3	46.7
Large farmer (≥10)	3.3	3.3
Farming experience (years)		
≤10	0	18.3
11–20	30.0	38.33
21–30	30.0	28.3
31–40	21.7	15.0
41–50	15.0	0
>50	3.3	0
Processing experience (years)		
≤10	58.3	-
11–20	36.7	-
>20	5.0	-
Training attended related to processing		
Yes	75.0	13.3
No	25.0	86.7
*Farm income (₹ in Million)**		
Low (<0.298)	20.0	28.3
Medium (0.298–0.377)	26.7	25.0
High (0.378–0.458)	28.3	21.7
Very high (>0.458)	25.0	25.0
*Income from processing (₹ in Million)**		
Low (<0.700)	16.7	-
Medium (0.700–0.849)	30.0	-
High (0.850–0.949)	21.7	-
Very high (>0.949)	31.7	-
Agro-processing center model		
Model I-Cereals	5	13.3
Model II-Cereals and oilseeds	46.7	50.0
Model III- Cereals, oilseeds and spices	40.0	31.7
Model IV- Cereals, pulses, oilseeds and spices	8.3	5.0
Number of employees in the processing unit		
1–3	81.7	-
4–6	15.0	-
7–9	3.3	-

*Classification based on quartile values.

Table 2 Major dimensions of constraints faced by agro-processors and multiple pairwise comparisons

Dimensions of constraints	Mean rank	Groups*		
Infrastructure	75.95	A		
Equipment	112.20	A	B	
Technical and capacity building	158.48		B	
Market	201.02			C
Financial	204.85			C

*Mean rank with the same letters is not significantly different from each other.

Friedman's two-way ANOVA was used to comprehensively examine the limitations of each main dimension (Table 3). Of the constraints related to financing, the higher interest rate of the credit (4.14) and the unavailability of credit itself (3.98) emerged as the most important challenges. The constraint related to the elevated initial capital investments was recognized as moderately severe (3.73). Besides, increased initial investment resulted in a longer payback period (3.81) and an increase in variable costs from operating a unit to full capacity (3.61). Conversely, the higher expense of employing skilled workers was seen as a less significant limitation (1.73). The agro-processing business depends heavily on finance and major obstacles to financing are either lack of credit or higher interest rates for credit. Particularly for smallholders, the paucity of funding disrupts business and makes expansion challenging (Sekyi *et al.* 2020).

The next significant constraints emerged were the absence of suitable marketing channels (3.97) and inadequate knowledge about effective marketing strategies (3.91). Moderately severe was the constraint of price risk and uncertainty (3.89), and relatively less severe was the lack of demand for the product (3.42), as the processing was aligned with local consumers' preferences. Additionally, processors faced competition (1.98) from larger market participants and comparable units. Localized marketing strategies can limit growth potential (Ferris *et al.* 2014, Ayuba and Kazeem 2015). Focusing on important aspects of market dynamics such as price volatility, uncertainty, and employment of effective risk management techniques (Serra *et al.* 2011) is crucial in inflecting the profitability aspects.

Within the spectrum of technical competency related constraints, the pivotal aspects that came to the forefront, were the absence of timely information about the latest processing technologies, followed by inadequate training programmes. Moreover, keeping a steady supply of raw materials throughout the year emerged as a significant difficulty because of the seasonality of agricultural production. Certain processors experienced challenges in maintaining consistent product quality throughout the year (2.183). This was due to fluctuations in raw material quality resulting from variations in crop varieties, moisture content, insect pest attacks, etc. Timely information transmission, extensive training programmes, and cooperative activities for knowledge sharing are recognized to be necessary (Meena *et al.* 2009, Ghanghas *et al.* 2017). Moreover, policymakers can consider initiatives to support the year-round production of key crops and investigate alternatives to storage and preservation facilities (Lambert 2001).

The Friedman test result revealed substantial disparities in the severity of equipment-related constraints. The cost of repairing and maintaining such equipment was notably high (4.83), often due to a lack of available qualified personnel in rural or small-town settings (4.57). The existing machinery was deemed unfriendly to farmers (3.43), incompatible with local conditions (3.33), and locally unavailable (3.32). Respondents also emphasized the necessity of developing small-capacity, multi-commodity processing equipment (1.53). Equipment constraints are imperative in the agro-processing industry as emphasized by Kachru (2010). Consequently, high repair and maintenance costs, unsuitability to local conditions, and unavailability of low-capacity, multi-product processing equipment were found to be the major hurdles in agro-processing (Dixit *et al.* 2010, Weldegiorges 2015). Likewise, it is very important to ensure the readiness of experienced technicians for machine repair and maintenance (Kumar *et al.* 2016).

The test statistics for infrastructure-related constraints highlighted the lack of facilities for storing both raw materials and processed products within the production catchment as the most prominent constraint, with a mean rank of 4.00. Established units also encountered hurdles in expanding their operations due to constrained space (3.91) and unreliable electricity supply (3.76), particularly during extreme weather seasons. Meanwhile, waste and dust management to maintain hygienic (3.69) around the unit, as well as inadequate road and transportation facilities (3.61), were considered moderately severe constraints. Notably, some processors indicated inadequate packaging facilities and a lack of knowledge about appropriate packaging materials (2.03) as constraints. This aspect also stood out in the multiple-pair comparison of constraints. Infrastructure-related constraints are significant blockades for agricultural processing units (Chodavarapu *et al.* 2016). Along with the issues of storage, power supply, transportation, limitations related to packaging options and the lack of knowledge about suitable packaging materials must be addressed (Gulati *et al.* 2017).

Constraints perceived by the potential agro-processors: These constraints collectively reflect the factors perceived by aspiring agro-processors as obstacles preventing their entry into the industry. The respondents identified the most pressing constraint (Table 4) as the lack of information about post-harvest technologies, with a mean rank of 12.86. Next in line was the apprehension of finding a market for their processed or value-added products (12.22). Other significant constraints reported were the high cost of operations (12.05), limited knowledge of marketing strategies (11.78), substantial initial investment

Table 3 Severity comparison of constraints faced by agro-processors within each dimension

Dimension	Factor	Mean rank	Groups*
Financial	High labour cost for skilled workers	1.73	A
	High operational cost	3.61	B
	High initial investment	3.73	B
	Longer payback period	3.81	B
	Non-availability of credit	3.98	B
	High rate of interest for credits	4.14	B
	Q (observed)=99.164 >Q (critical value) = 11.070, df=5, *P*<0.001		
Market	Competition from similar units	1.98	A
	Market unavailability/lack of demand	3.42	B
	Lack of market intelligence	3.84	B
	Price risk and uncertainty	3.89	B
	Poor knowledge of marketing strategies	3.91	B
	Lack of appropriate marketing channels	3.97	B
	Q (observed)=69.202 >Q (critical value)=11.070, df=5, *P*<0.001		
Technical and capacity building	Difficulty in maintaining round the year quality of produce	2.18	A
	Non-availability of latest technologies	3.28	B
	Non-availability of trained manpower/labour	3.48	B
	Non-availability of year-round raw material	3.84	B
	Inadequate training programmes	3.99	B
	Lack of timely information related to latest processing technologies	4.22	B
	Q (observed)=55.276>Q (critical value)=11.070, df=5, *P*<0.001		
Equipment	Unavailability of multi-commodity processing equipment	1.53	A
	Non-availability of suitable machinery locally	3.32	B
	Non-suitability of machines to village situations	3.33	B
	Technology developed is not farmer-friendly	3.43	B
	Facility for repair and maintenance of the machinery is not available locally	4.57	C
	High maintenance cost	4.83	C
	Q (observed)=157.713>Q (critical value)=11.070, df=5, *P*<0.001		
Infrastructure	Lack of proper packaging facilities	2.03	A
	Lack of proper roads and transportation facility	3.61	B
	Difficulty in maintaining hygienic conditions around processing unit	3.69	B
	Inadequate supply of power and electricity	3.76	B
	Lack of space and building for processing/ further expansion	3.91	B
	Lack of proper storage structures in the locality/ by own	4.00	B
	Q (observed)=93.959>Q (critical value)=11.070, df=5, *P*<0.001		

*Mean rank with the same letters within the same dimension is not significantly different from each other.

(11.54), extended investment payback periods (11.48), and insufficient training programmes (11.47). Moderately severe constraints included price risk and uncertainty (11.07), scarcity of trained manpower (10.98), lack of year-round raw material availability (10.10), and the absence of suitable marketing channels (9.71). Constraints of lower severity were non-availability of credit (9.52), inadequate market intelligence (9.45), limited motivation (8.03), and high maintenance costs (7.45). Notably, the latter constraints were viewed from the perspective of potential agro-processors who lacked direct experience in operating processing units. Most of the constraints are in line with the comprehensive framework provided by the MoFPI (2018). The results also closely match the findings of the Committee on Doubling Farmers' Incomes (2017).

Strategies for promoting agro-processing: Based on the insights gained from the focused group discussion and research, strategies that can be used to promote agricultural processing are Research and development of small machinery; Extension services, training, entrepreneurship development, and technology transfer; Vustom processing centers, farmers' mobilization, and FPO promotion; Infrastructure development, sustainable practices, and policy support; Marketing linkages, branding, export promotion,

Table 4 Severity comparison of various constraints of potential agro-processors

Factor	Mean rank	Group*				
Non-availability of suitable technology locally	2.29	A		C		
Lack of feedback/success stories in media	4.01	A				
Inadequate supply of power and electricity	4.99	A	B			
High maintenance cost	7.45		B	C		
Lack of motivation	8.03		B	C	D	
Lack of market intelligence	9.45			C	D	E
Non-availability of credit	9.52			C	D	E
Lack of appropriate marketing channel	9.71			C	D	E
Non-availability of raw material year-round	10.10			C	D	E
Non-availability of trained manpower/labour	10.98				D	E
Price risk and uncertainty	11.07				D	E
Inadequate training programs	11.47					E
Longer payback period for investment	11.48					E
High initial investment	11.54					E
Less knowledge about marketing strategies	11.78					E
High cost of operations	12.05					E
Inability to find market for value-added produce (lack of demand)	12.22					E
Lack of information related to processing technologies	12.86					E

Q (observed)=369.529>Q (critical value)=27.587, df=17, P<0.001

*Mean rank with the same letters is not significantly different from each other.

and market intelligence; Collaborative platforms, consumer awareness, and quality assurance.

Fostering collaboration between research institutes, industry stakeholders and the private sector is essential for the development of cost-effective small-scale processing machines. Both government and industry should allocate resources to research and development and integrate efforts for improvements in their machinery designs and products (Gulati and Juneja 2020). Likewise, the network of KVK and line departments should collaborate to demonstrate the payback of adopting processing technology. Technical information distribution can be facilitated by collaborations with ICAR. A new generation of agricultural entrepreneurs must be developed concurrently, and this requires the introduction of tailored entrepreneurship development programs that incorporate financial assistance, mentoring, and training. Strengthening, updating and upgrading extension centers, and demonstration facilities plays a key role in showcasing modern processing techniques. This integrated approach provides stakeholders with the skills and knowledge needed for successful developments across the agro-processing sector.

Establishing custom processing centers at the block or village level is the key to strengthening agro-processing at the production catchment. Equipped with processing machinery, these centers can offer farmers affordable access to processing facilities charging reasonable fees based on production volumes. This can be in line with agricultural machinery custom hiring centers (Srinivasarao *et al.* 2013), which have helped mechanize small farms. In addition, encouraging farmers to come together and form cooperatives and Farmer Producer Organizations (FPOs) will help strengthen the agro-processing ecosystem. Moreover, investment is needed in critical areas such as storage, power supply, waste management, transport, and environment-friendly packaging. Simultaneously, efforts must be made to improve the efficiency and scalability of agro-processing facilities, ensuring that they meet the growing demands of industry. Encouraging the adoption of renewable energy sources and supporting research on eco-friendly packaging materials is not only in line with environmental goals but also improves the long-term profitability of the sector. Supporting policies and legal frameworks that complement these initiatives is vital. Infrastructure development and the adoption of innovative practices are must to reduce post-harvest losses and make food more affordable for consumers (Ganguly *et al.* 2017).

A holistic approach is needed to promote strong market linkages between agro-processors, farmer groups, and producer networks. Improving vertical integration will improve overall efficiency and expedite product flow in the agricultural value chain by linking producers, processors and traders. Increasing market appeal through strategic branding, innovative packaging, and rigorous quality assurance initiatives will improve the competitiveness of processed agricultural products. Further, simplification of export procedures and active staging of Indian processed products in the global market will widen the reach of the sector and improve economic prospects. Establishing a centralized system for market information that offers up-to-date market data is also essential for making well-informed decisions. Similarly, the creation of online collaboration platforms is crucial to promote innovation and knowledge exchange in the agro-processing sector. At the same time, consumer education campaigns are needed to educate the public about the benefits of processed agricultural products. Emphasizing factors such as safety, convenience and nutrition can encourage consumer acceptance of these products. Another important consideration is to ensure quality standards at all stages of food production (Ukwuru 2018) i.e. from pre-processing to marketing. Encouraging adherence to these standards and facilitating the certification process through incentives and recognition can improve the overall quality of processed agricultural products. This in turn increases

the confidence of the consumers and strengthens the market position of agro-processing.

Conclusion and policy implications

The agro-processing sector has numerous obstacles because of limited funding, lack of technological expertise, equipment restrictions, and inadequate infrastructure. When taken as a whole, these complex issues impede industrial growth and competitiveness. Reducing interest rates, enhancing credit and encouraging technology use, workforce development, and strategic financial planning are some ways to address financial restrictions. Prompt information releases, extensive training courses and cooperative information-sharing projects will provide agro-processors with the abilities, and know-how required to apply cutting-edge processing technology successfully. The development of locally produced, reasonably priced, and flexible machinery, along with the creation of multi-crop processing facilities and the availability of qualified technicians, can all help to reduce limitations associated with machinery. To ensure the sector's growth and sustainability and to maintain its pivotal position in India's agricultural landscape, it is imperative to handle these intricate and interconnected concerns in an effective, and coordinated manner. Policymakers and industry stakeholders may effectively manage the intricate dynamics of the agro-processing sector, and foster its success, particularly in the post-pandemic era, by implementing targeted policies and interventions that draw on pertinent research insights.

ACKNOWLEDGMENTS

Authors are grateful to the ICAR-Central Institute of Post-Harvest Engineering and Technology for research facilities, respondents for survey participation, and experts for valuable insights.

REFERENCE

APEDA. 2022. India production. Accessed from https://agriexchange.apeda.gov.in/India%20Production/Result_SearchProduct.aspx

Ayuba B and Kazeem O A. 2015. The role of marketing research on the performance of business organizations. *European Journal of Business and Management* **7**(6): 148–57.

Chodavarapu S, Giertz A and Jaeger P. 2016. Agribusiness in South Asia. World Bank.

Churchill G A and Brown T J. 2006. *Basic Marketing Research*. The Dryden Press International, London.

Committee on Doubling Farmers' Income. 2017. Empowering the farmers through extension and knowledge dissemination. Vol. 11. Ministry of Agriculture and Farmers' Welfare, New Delhi.

Cronbach L J. 1951. Coefficient alpha and the internal structure of tests. *Psychometrika* **16**(3): 297–334.

Deloitte. 2021. Study to determine the level of food processing in India. Ministry of Food Processing Industries, Government of India.

Dixit A K, Sharma P C, Nanda S K and Kudos S K A. 2010. Impact of processing technology in hilly region: A study on extraction of apricot kernel oil. *Agricultural Economics Research Review* **23**: 405–10.

Edward A L. 1969. *Techniques of Attitude Scale Construction*. Vakils, Feffer and Simons Pvt. Ltd., Mumbai, India.

Espinoza-Ortega A, Espinosa-Ayala E, Bastida-Lopez J, Castañeda-Martinez T and Arriaga-Jordán C M. 2007. Small-scale dairy farming in the highlands of Central Mexico: Technical, economic and social aspects and their impact on poverty. *Experimental Agriculture* **43**(2): 241–56.

Ferris S, Robbins P, Best R, Seville D, Buxton A, Shriver J and Wei E. 2014. Linking smallholder farmers to markets and the implications for extension and advisory services. MEAS Brief # 4. USAID.

Ganguly K, Gulati A and Braun V J. 2017. Innovations spearheading the next transformations in India's agriculture. ZEF Working Paper Series, No. 159. Center for Development Research (ZEF), University of Bonn, Germany.

Ghanghas B S, Nain M S and Malik J S. 2017. Adoption of post-harvest management practices by vegetable growers in Haryana state. *Indian Journal of Extension Education* **53**(1): 104–10.

Gills R, Sharma J P, Burman R R, Sharma R R and Kar A. 2017. Constraint analysis of fish processing in peri-urban areas of national capital region. *Economic Affairs* **62**(1): 75–81.

GoI. 2021. BRICS *Joint Statistical Publication*, 2021: Brazil, Russia, India, China, South Africa. Ministry of Statistics and Programme Implementation, New Delhi.

GoI. 2022. Economic Survey 2021–22. Ministry of Finance, Department of Economic Affairs, Economic Division, New Delhi.

Gulati A, Roy R and Hussain S. 2017. Getting Punjab agriculture back on high growth path: Sources, drivers and policy lessons. Indian Council for Research on International Economic Relations (ICRIER), New Delhi.

Gulati A and Juneja R. 2020. Farm mechanization in Indian agriculture with focus on tractors. ZEF discussion papers on development policy, No. 297. Center for Development Research (ZEF), University of Bonn, Germany.

Jha S N, Vishwakarma R K, Ahmad T, Rai A and Dixit A K. 2015. Report on Assessment of quantitative harvest and post-harvest losses of major crops and commodities in India. ICAR-All India Coordinated Research Project on Post-Harvest Technology, ICAR-Central Institute of Post-Harvest Engineering and Technology, Ludhiana.

Kachru R P. 2010. Agro-processing industries in India: Growth, status and prospects. *Journal Indonesian Agroindustries* **13**(2): 167–81.

Khoza T M, Senyolo G M, Mmbengwa V M and Soundy P. 2019. Socio-economic factors influencing smallholder farmers' decision to participate in agro-processing industry in Gauteng Province, South Africa. *Cogent Social Sciences* **5**(1): 1664193.

Kumar R, Dixit A K, Kumar A and Singh S. 2016. Agro-processing industries in Haryana: Status, problems and prospects. *Economic Affairs* **61**(4): 707–15.

Lambert I. 2001. Problems and constraints to the development of the agro-processing sector. http://www.uwichill.edu.bb/bnccde/dominica/conference/papers/ Lambert.html

Likert R. 1932. A technique for the measurement of attitudes. *Archives of Psychology* **22**(140): 1–55.

Liu C Y, Lin Y and Feng B. 2019. Migrant entrepreneurship in China: Entrepreneurial transition and firm performance. *Small Business Economics* **52**: 681–96.

Mafimisebi T E, Onyeka U P, Ayinde I A and Ashaolu O F. 2006. Analysis of farmer-specific socio-economic determinants of

adoption of modern livestock management technologies by farmers in southwest Nigeria. *Journal of Food Agriculture and Environment* **4**(1): 183–86.

Meena M S, Kumar A, Singh K M and Meena H R. 2009. Farmers' attitude towards post-harvest issues of horticultural crops. *Indian Research Journal of Extension Education* **9**(3): 15–9.

MoF. 2022. Economic Survey 2021–22. Government of India, New Delhi.

MoF. 2023. Economic Survey 2022–23. Government of India, New Delhi.

MoFPI. 2018. Annual Report 2017–18. Government of India, New Delhi.

MoSPI. 2021. Press note on provisional estimates of annual national income 2020–21 and quarterly estimates of gross domestic product for the fourth quarter (Q4) of 2020–21. Government of India, New Delhi.

NABCONS. 2022. Study to determine post-harvest losses of agri-produces in India. Ministry of Food Processing Industries, Government of India.

NSSO. 2018. Economic characteristics of unincorporated non-agricultural enterprises (excluding construction) in India (NSS Report No. 582). Ministry of Statistics and Programme Implementation, Government of India.

Nunnaly J C. 1978. *Psychometric Theory*. McGraw-Hill, New York.

Sekyi S, Abu B M and Nkegbe P K. 2020. Effects of farm credit access on agricultural commercialization in Ghana: Empirical evidence from the northern Savannah ecological zone. *African Development Review* **32**(2): 150–62.

Serra T, Zilberman D and Gil J. 2011. Price volatility in ethanol markets. *European Review of Agricultural Economics* **38**(2): 259–80.

Siegel S and Castellan N J. 1988. *Nonparametric Statistics for the Behavioral Sciences,* 2nd Edn. McGraw-Hill, New York.

Srinivasarao C, Dixit S, Srinivas I, Reddy B S, Adake R V and Borkar S. 2013. Operationalization of custom hiring centres on farm implements in hundred villages in India. Central Research Institute for Dryland Agriculture, Hyderabad.

Ukwuru M U. 2018. The need for quality control and assurance in local food processing. *Food Science and Nutrition Technology* **3**(1): 1–2.

Weldegiorges Z K. 2015. 'Benefits, constraints and adoption of technologies introduced through the eco-farm project in Ethiopia'. MSc Thesis, Norwegian University of Life Sciences, Norway. Accessed from https://nmbu.brage.unit.no/nmbu-xmlui/handle/11250/2967

Zhou D and Li L. 2022. Farming experience, personal characteristics, and entrepreneurial decisions of urban residents: Empirical evidence from China. *Frontiers in Psychology* **13**: 859936.