

Addressing the impact of COVID-19 on dairy value chains: evidence from Punjab, India

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The COVID-19 pandemic has adversely affected dairy farmers with the demand shrinking due to income losses of the consumers, disruptions in the supply chains reducing supply, raising costs and increasing wastage. The present study examined such disruptions in Punjab, India, with the primary survey covering dairy farmers, intermediaries, consumers and other stakeholders in the dairy industry. The results reveal a significant fall in farmgate milk prices, disruption in transporting milk within the supply chains, labour shortages, rise in production costs and lack of operating capital. The demand for milk and milk products declined sharply during the pandemic. To dispose of the excess milk supply, dairy farmers turned to localized value chains catering directly to consumer households. Approximately half of the farmers lost almost one-third of their income from processed milk products like ghee and butter. The dairy farmers agreed to strengthen the dairy value chains through better integration of the stakeholders. The inability of the farmers to quickly shift to digital platforms for sales of milk and milk products during the pandemic calls for special capacity-building efforts.

Keywords: COVID-19 pandemic, dairy sector, digital platforms, disruptions, value chain management.

THE rapid spread of the COVID-19 pandemic has disrupted supply chains in the dairy sector across the globe. The pandemic is expected to stay longer with significant bearing on the sizeable stakeholders in the dairy sector as they face challenges such as shifts in supply and demand. This supply and demand mismatch was created by an abrupt supply change, from dairy farmers at the village level to large cooperatives. On the demand side, many producers and cooperatives were left without a market to sell their products. The pandemic has heavily affected the dairy industry through decreased farmgate milk prices, disruptions and difficulties moving milk within the supply chains, worker shortages, increased production costs and lack of operating costs¹⁻⁵. Hussain *et al.*⁶ witnessed a 7.5% shortage of dry feed intake. More than one-third of the farms faced a problem of feed shortage and drug unavailability, which hampered the daily milk production at the farm level – the hike in prices of cattle feed and dry fodder also affected dairy produc-

tion during the pandemic². Secondly, the crisis led to a decline in milk procurement prices, which could be attributed to the destruction of demand in the hotels, restaurants and catering sectors. In contrast, a surge was witnessed in skimmed milk powder (SMP) prices^{6,7}.

The dairy sector is an important sub-sector of Indian agriculture, contributing 28.6% to the gross agricultural value added, and providing livelihood and employment to about 6 million people in the country⁸. In the past three decades, the pace of production growth of the dairy sector has continuously outperformed, in value terms, the rate of production growth. Therefore, this sector has become indispensable for the faster growth of the rural economy. In India, the dairy sector is dominated by an informal milk distribution system, dealing with 80% of the total milk surplus, unlike advanced countries where 90% of the produced milk is distributed through formal organized channels. Punjab has the country's highest per capita milk availability (1181 g per day). The monthly income of households earned from agriculture in Punjab is around INR 16,020, which is more than the national average of INR 8059, wherein the livestock sector has contributed the second maximum share of agricultural household income⁹. However, the rapid spread of the COVID-19 pandemic has disrupted the supply chain in the state's dairy sector, and new market channels have emerged in organized and unorganized sectors of the dairy industry at a regional level. However, it is less clear in the recently published literature on how to assess initial initiatives by dairy farmers, processors and consumers, and implement such approaches. But the study cannot ignore the current crisis in the dairy sector as the pandemic has caused a considerable disconnect among all the actors involved in value chain management (VCM), eventually led to a change in consumption pattern, and this disconnect also caused a significant difference in the behaviour of dairy consumers in the short supply chain. In this context, the present study deals with VCM in the dairy sector, highlighting how each and all stakeholders enhance overall profitability by adding value. A holistic understanding of the impact would help draw appropriate policies and revival strategies in a short-term crisis.

Materials and methods

The study draws on the primary data collected through personal interviews. For the selection of dairy farmers, the

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Table 1. Selection of dairy farmer

District	Block	Village		Sample size
Amritsar	Ajnala	Abu Said	Bhure Gill	51
	Verka	Miran Kot Kalan	Pandori Waraich	31
Ludhiana	Ludhiana I	Baliewal	Satyana	48
	Machiwara	Chakki	Manewal	39
Total sample size				169

Table 2. Summary statistics of selected dairy farmers in Punjab

Particulars	Average
Age (yrs)	39.9
Years of schooling (no.)	6.66
Family size (no.)	5.20
Monthly income (INR)	30,053.5

study chose Amritsar and Ludhiana, the highest milk-producing districts in Punjab. In the subsequent stage, two blocks were selected from each selected district. At the final stage of sampling, there were 51 and 31 dairy farmers from Ajnala and Verka blocks of Amritsar district, and 48 and 39 dairy farmers from Ludhiana-I and Machiwara blocks of Ludhiana districts respectively (Table 1). Information regarding various aspects like the social status of dairy farmers and details of their landholdings, changes in input and expenditure patterns of dairy farming during the lockdown, effect on milk production, its management to create value of dairy products, suggestions thereof, etc. was collected from selected dairy farmers.

Additionally, the COVID-19 crisis caused significant changes in the behaviour of dairy consumers in the short supply chain; they started using SMP due to fear of the spreading pandemic. Hence, the study has focused on organized retailing platforms to observe consumer behaviour. For this study, 25 consumers were selected each from Ludhiana and Amritsar city. Hence, the study ensures considerable coverage with two districts, four blocks, eight villages and two metro cities. Data on consumers' perceptions to assess the impact of the lockdown on availability, consumption of newly emerged products like SMP, prices, and preferred platforms for buying and selling dairy products during the lockdown were collected. Further, a sample of ten market officials from Verka were approached to study the whole market scenario of dairy products during the pandemic. The total sample size of the study comprised 169 dairy farmers, 50 consumers and market officials.

The study also examined the factors affecting the income of dairy farmers. Further, the study divided the farmers into three distinct income groups (low, medium and high) to know the impact across different income groups. Six separate regressions were run to find the factors affecting income changes and distribution for each income group in the two specified time periods.

The model used in the study is as follows:

$$Y_i = a_0 + \sum_{i=1}^n b_i x_i + u_i,$$

where Y is the monthly income of the farmer (₹), x_i are independent variables in the study and u_i is the error term.

Variable description	Type of variable
Income (Rs/month)	Continuous
Access to market	Yes = 1, No = 0
Lifting of milk	Yes = 1, No = 0
Value chain initiatives	Yes = 1, No = 0

Results and discussion

Basic household profile

It is essential to understand the basic profile of the sample dairy farmers to assess the representatives of the sample farmers. Among sample dairy farmers, the average age was 39 years (Table 2). Education is another important indicator influencing the farmers' managerial and technical ability. It is evident from Table 2 that the educational score of farmers was 6.66 schooling years, indicating that majority of the dairy farmers were illiterate or had basic primary education.

Implications of the pandemic on the dairy sector

Table 3 summarizes how dairy farmers were affected by the lockdown. During the pandemic, dairy farmers were affected from both the input and output sides. More than 50% of farmers agreed to the availability of cattle feed, green fodder, concentrates and artificial insemination during the pandemic. In this study, 30% of the farmers faced labour availability problems during the pandemic, while only 17% faced this problem before the pandemic. Lockdown had important consequences on the labour supply¹⁰ and resulted in a massive reverse migration from the northwestern states of Haryana and Punjab, with estimates suggesting that approximately one million labourers had returned to their home states with little chance of returning soon¹¹.

Table 3. Severity of problems during the COVID-19 pandemic in Punjab, India

Particulars	Severity of problems (%)	
	Before the pandemic	During the pandemic
Variable inputs		
Cattle feed	5.9	68.6
Green fodder	1.8	66.9
Concentrates	1.8	51.5
Artificial insemination	3.0	44.4
Dry fodder	–	35.5
Medicine and healthcare	5.9	34.3
Labour	17.2	30.2
Logistics	10.1	56.8
Fuel and lubricants	2.4	10.1
Repair and maintenance	7.1	53.8
Credit and reliefs	4.7	71.0
Marketing issues		
Effect on demand	–	47.8
Problem of price change	5.9	82.8
Effect on lifting	4.1	75.7
Effect on the smooth functioning of the milk collection centre	0.6	38.46

Table 4. Farmers' perspective on the prices of milk and milk products during the pandemic

Particular	No change	Less than 10%	10–20%	20–30%	Greater than 30%
Milk	15.9	18.9	62.7	2.4	–
Ghee	31.9	5.3	11.2	2.4	49.1
Butter	40.8	3.5	10.6	1.8	47.2

No. of respondents in %.

About 34% of farmers reported a problem with timely access to medicine and healthcare during the pandemic. Including veterinary services in the list of 'essential services' by the Central Government ensured continuous emergency services in the animal husbandry and veterinary sectors, particularly in cases of emergent animal health issues¹². This was also observed during the study period, as more than 50% of the farmers mentioned that artificial insemination was not a severe problem. There was a mobility restriction to stem the spread of COVID-19 during the lockdown period, and people were strictly advised to stay in their homes. Approximately 57% of respondents reported that they were unaffected by the lack of fuel and lubricants during the pandemic. It is well known that rural credit is essential to increase the farmers' income and welfare. To address the damage caused by lockdown restrictions, the Central Government announced short-term measures like an interest subvention scheme (subsidy on the interest rate) on farm loans along with a three-month loan moratorium¹³. According to 71% of farmers, the timely availability of credit significantly impacted dairy farming.

Table 3 presents the problems of milk production, marketing, lifting and impact on prices. The demand for milk had decreased due to the closure of nearby sweet shops, hotels and tea shops. It was tough for dairies to handle excess

milk supply on the one hand and a significant concurrent drop in demand for milk and milk products on the other¹⁴. About 48% of farmers reported that the reduced demand for milk and milk products during the COVID-19 lockdown had harmed milk producers. Punjab has one of the most robust networks of milk procurement by organized sector players. However, 83% of farmers reported drastic changes in milk prices during the lockdown, and were forced to dispose of their milk at a price lower than the cost of production. According to 76% of dairy farmers, some milk plants accepted milk from them in deferred payment conditions, while others had a weekly milk holiday (no milk collection on that day). However, 38% of farmers agreed that the milk collection centres generally operated during the lockdown.

Farmers' perspectives about the prices of milk and milk products

Table 4 shows the magnitude of price change for milk and milk products such as ghee and butter. Most farmers were adversely affected by the decrease in milk prices. In the case of fresh milk, 62% of farmers reported that milk prices had been reduced by up to 20%, while 19% of farmers received less than 10% of the price than the normal

Table 5. Descriptive statistics of variables used in regression analysis

Variables			Income groups		
			Low	Medium	High
Income (Rs/month)	Pre-COVID	Mean	7,593	29,938	64,498
		Minimum	2,340	10,335	53,460
		Maximum	9,870	53,280	94,140
	During lockdown	SD	2,384	13,859	10,380
		Mean	7,929	30,419	65,854
		Minimum	2,700	10,725	56,340
	Maximum	10,290	54,780	96,300	
	SD	2,456	14,055	10,424	
	Access to market (N*)	Pre-COVID	No	8	18
	Pre-COVID	Yes	28	82	27
		During lockdown	No	24	64
	During lockdown	Yes	12	33	8
		Milk lifting (N*)	Pre-COVID	No	9
	Pre-COVID	Yes	27	86	26
		During lockdown	No	23	44
	During lockdown	Yes	13	53	18
		Value chain initiatives (N*)	Pre-COVID	No	30
	Pre-COVID	Yes	6	3	7
		During lockdown	No	18	49
	During lockdown	Yes	18	48	19

*Number of farmers.

Table 6. Impact of the COVID-19 pandemic on the income of dairy farmers in Punjab

Parameters	Low-income group		Medium-income group		High-income group	
	Pre-COVID	During lockdown	Pre-COVID	During lockdown	Pre-COVID	During lockdown
Intercept	3,505.97*** (726.47)	6,742.63*** (632.03)	8,547.83*** (1,370.37)	26,288.85*** (1,861.38)	54,149.01*** (792.80)	58,701.53*** (826.13)
Access to market	3,710.32*** (869.83)	240.60 (1,614.39)	11,567.48*** (1,893.86)	-12,165.40*** (4,121.31)	3,090.99*** (792.80)	14,509.94** (4,141.15)
Milk lifting	1,568.75 (987.91)	-703.77 (1,336.78)	13,709.67*** (2,476.35)	5,194.60 (3,789.71)	8,789.90** (2,444.47)	193.17 (2,103.13)
Value-chain initiatives	147.95 (321.57)	2,720.45** (753.40)	3,807.02 (5,988.11)	10,974.49*** (3,082.83)	2,740.94 (3,748.23)	6,882.26** (1,941.46)
N	36	39	100	97	35	35
R ²	0.70	0.24	0.34	0.11	0.21	0.67

Figures in parentheses indicate standard error. *,**,*** indicates significance at 10%, 5% and 1% respectively.

situation. According to the price change scenario for ghee and butter, approximately 50% of farmers lost more than 30% of their dairy income derived from ghee and butter.

Impact of the COVID-19 pandemic on the income of dairy farmers

Various factors like feed and fodder cost, labour hours and veterinary charges affect the income of dairy farmers, but in this study the focus was on the impact of the COVID-19 pandemic on the income of dairy farmers due to supply-chain disruptions. So, in this direction, we have taken income as a dependent variable and access to the market, milk lifting and value-chain initiatives as independent variables (Table 5). For a better interpretation of the results and to draw a

valid conclusion about the impact of the COVID-19 pandemic on the income of dairy farmers, they have been categorized into three income groups, viz. low, medium and high on the basis of mean–SD estimation method (detailed in the methodology).

To study the impact of COVID-19 on the income of dairy farmers in Punjab, the log–lin regression model was used. For a better explanation of the results, dairy farmers were categorized into three different income groups, viz. low, medium and high (Table 6). In the case of low-income groups, access to the market during the pre-COVID period was positive and significant which indicates that the markets were easily accessible to all low-income dairy farmers. However, during the lockdown period, access to the market was positive but insignificant as the lockdown imposed restrictions on the movement from city to city.

Similarly, in the case of milk lifting and value-chain initiatives, the coefficients were positive but not significant during the pre-COVID period, as none of the farmers who belonged to the low-income group had taken any initiative to do the value addition of milk at his/her level. During the lockdown phase, the negative and non-significant coefficient of milk lifting indicates that it was affected to some extent.

In the medium-income group, the variables like access to the market and milk lifting were positive and significant during the pre-COVID phase, while none of the farmers had taken any initiatives for the value addition of milk. However, during the lockdown phase, although access to the market was negative but significant, the value-chain initiatives were positive and significant. It is worth mentioning that during the pre-COVID period, about 100 dairy farmers were in the category of the medium-income group but during the lockdown phase, this number reduced to 97 as three farmers had shifted from the medium to low-income group. It indicates that COVID-19 has severely affected the income of the farmers. Similar results were observed for the high-income group of farmers.

Farm-level initiatives during the pandemic

Milk is a perishable commodity with a strong supply chain in India dominated by a cooperative production and distribution structure¹⁴. Long-distance food-supply chains have been hit the hardest during the pandemic^{15,16}. Dairy farmers introduced several initiatives to address the issue of excess (unsold) milk during the lockdown to avoid potential losses. Most of the farmers (45%) preferred to manage their milk at the household level, as the avenues for milk sale declined for the existing dairy farmers due to the closure of major commercial ventures, i.e. tea stalls, sweet shops and sudden closure of milk procurement operations by the private milk traders. The dairy farmers managed their milk by converting it into processed form, i.e. ghee, butter and curd which have longer shelf life. The reason behind increase in the consumption of curd has been highlighted in a study conducted by Govindaraj *et al.*¹⁷, which concluded that curd consumption had drastically increased as the number of family members had increased due to reverse migration to rural areas. However, increase in curd consumption could be partially attributed to extreme hot weather conditions during

the summer. A study by Nayantara¹⁸ found that the excess amount of milk produced by dairy farmers could be consumed either in processed or fresh form. In this way, the dairy farmers managed the excess milk at their level. About 25% of farmers who processed excess milk for value-added products like ghee, butter and curd had started their own dairy unit (Table 7). The Punjab State Cooperative Milk Producer’s Federation assured dairy farmers by marketing value-added products; 23% of the farmers joined the cooperative society. On-line sales of dairy products was made by only 6% of the farmers.

Before collecting farmers’ perceptions, we identified those farmers (about 84%) who considered that VCM practices could be used to enhance their income from dairy farming (Figure 1) and collected the data (Table 7).

Farmers’ perceptions regarding VCM

Next, we provide insights into the possibility of the upgradation of value chains and linking the farmers with them. The linkages of farmers with upgraded value chains will help in increasing their income. It will also help increase the dairy sector in Punjab. Before the recommendations for upgradation, dairy farmers’ perceptions of strengthening VCM through collective actions were recorded in this study.

Farmers’ perceptions to strengthen VCM

The dairy farmers adopted various initiatives to strengthen the value chain in the challenging period of lockdown restrictions. According to 55% of farmers, value-chain practices can be strengthened by collaborating with different stakeholders, increasing purchasing power (33%) in a dairy enterprise (Table 8). Further, 23% of farmers considered providing technical knowledge regarding the value chain of milk and milk products adequate. In contrast, 8% of farmers mentioned that providing incentives to promote the value chain helps sustain the income during the study period. However, 16% of farmers considered that no initiative helped strengthen the value chain during the disruptions in Punjab.

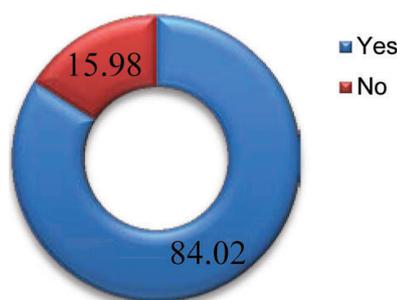


Figure 1. Perception of dairy farmers to strengthen the value chain management.

Table 7. Initiatives taken by dairy farmers regarding value chain management during the pandemic

Initiatives taken	Respondents (%)
Adopt an on-line mode for the sale of dairy products	6.8
Join as member of a cooperative society	22.7
Start own dairy	25.0
Management at the household level	45.5

Source: Authors’ estimation.

Insights of dairy farmers about the participation of the Government in strengthening VCM

Table 9 presents the various Government initiatives in the dairy sector to boost the value chain during the pandemic in Punjab, with multiple responses. Ninety-nine per cent of farmers (167 sampled) considered that the Government assisted them and prevented losses due to value-chain disruptions. The Government of Punjab had launched a scheme to provide a 40% subsidy on machines. The provision of subsidized dairy equipment to boost dairy farming was the most promising initiative, according to 89% of farmers, followed by providing incentives for milk processing and value addition (45%). According to 36% of farmers, the exemption of good and services tax on livestock feed helped reduce the cost of milk production, enabling them to increase their profit in dairy farming, followed by initiating chilling centres at the village level to collect and store the milk in bulk quantity (32%). Farmers had faced numerous challenges because of the COVID-19 lockdown restrictions; 27% mentioned that the Punjab Agricultural University uses social media to advise farmers, followed by timely access to extension services to transfer to technology at the farm level (20%).

Consumers' perspectives on changes in the dairy sector during the pandemic

This study also included different consumers residing in the cities, viz. Amritsar and Ludhiana. The average age of the consumer was 32.1 years (Table 10). The average family size was 4.26 members, with a monthly income of Rs

25,628. Regarding educational status, most respondents (about 62%) had studied up to the secondary level. About one-fifth of the consumers had studied up to the graduate level, while only 8% had postgraduate degrees.

Table 11 shows the frequency of visits of consumers to retail stores during the pre-COVID and lockdown periods. Interestingly, about 25 consumers visited the retail stores two days a week during the pre-COVID period, while during the lockdown period the visit was reduced by 50% compared to the pre-COVID period. About seven consumers visited the retail stores daily during the pre-COVID period, while this situation changed during the lockdown period, with the number being only one consumer. The number of consumers visiting the retail stores three days a week was the same during the COVID and pre-COVID periods. Regarding access to the supermarkets and availability of dairy products at the consumers' doorsteps, nearly one-fifth of the respondents reported a lack of paneer during the lockdown period. In the case of curd, the proportion was 40%. It is interesting to note that more than one half of the consumers reported the lack of availability of SMP during the lockdown period. At the same time, more than one-fourth of the respondents did not get SMP from the nearby markets during the said period.

Table 12 shows the consumers' perceptions towards changes in the dairy sector during the pandemic. More than 75% of the consumers observed no change in the prices of dairy products. However, at the time of the lockdown, about 70% of the consumers observed that the prices of dairy products had increased by more than 20%, while one-fifth of the respondents observed that the prices varied in the range of 10–20%. Let us now consider the purchasing behaviour of the consumers. It is pertinent to mention that before the lockdown period, only 8% of the consumers

Table 8. Perceptions of dairy farmers to strengthen value chains in dairy farming

Particular	Percentage
Synergy between different stakeholders	55.63
More purchasing power to sustain value chains	33.80
Access technical knowledge	23.94
Incentives on value additions	7.75
Incentives through SFAC	3.52

SFAC, Small farmers' agri-business consortium. Multiple responses; $N = 142$.

Table 9. Government involvement in strengthening VCM of the dairy sector in Punjab

Involvement of the Government can help	Percentage
Subsidies on dairy equipment	88.76
Incentives for processing	44.97
Exemption of GST on livestock feed	36.09
Initiating chilling centres in the villages	32.54
Increasing farm advisory services	27.22
Increasing extension services	20.12

Multiple responses; $N = 167$.

Table 10. Socio-economic profile of consumers in this study

Particulars	Average	CV
Age (yrs)	32.11	2.66
Family size (no.)	4.26	2.97
Average monthly income (lakhs, INR)	25,628	2.65
Education	No. of respondents	Percentage
Primary	6	12
Secondary	31	62
Graduate	9	18
Postgraduate	4	8

Table 11. Access to supermarkets and availability of dairy products

Products	Always	Sometimes	Never	Cannot say
Milk	100	–	–	–
Paneer	80	20	–	–
Curd	30	40	–	30
Ghee	76	24	–	–
Skimmed milk powder	4	58	28	10

No. of respondents in %.

Table 12. Consumer behaviour in the dairy sector during the pandemic

Particular	Pre-COVID	During lockdown
Change in prices (%)		
Less than 10	6	4
10–20	–	20
More than 20	–	70
No change	94	6
Changes in purchasing behaviour		
On-line	8	38
Local organized retailing	–	22
Shopkeepers	8	16
Milk vendors	36	30
Local dairies	56	32
Changes in consumption behaviour (%)		
Less than 5	6	2
5–10	–	30
More than 10%	–	54
Cannot say	94	14

No. of respondents in %.

depended upon shopkeepers to meet their demand for groceries and milk products. At the same time, the scenario was reversed during the lockdown period. More than one-third of the consumers met their daily demands from on-line stores. The consumer's approach to the local dairies had changed from 56% in the pre-lockdown period to 32% during the lockdown period. With respect to consumer behaviour regarding the consumption of dairy products, it was observed that about 30% of the consumers had changed their consumption pattern from 5% to 10%. In contrast, more than half of the consumers had changed their consumption behaviour of dairy products by more than 10%. The study has pointed out that the consumption of SMP had increased during the lockdown period would fulfil the daily milk requirement of consumers.

Stakeholders' response to changes in the dairy sector during the pandemic

All the sampled stakeholders like market officials and other skilled personnel in the dairy industry were asked about the performance of the dairy sector during the pandemic. Most opined that the sector had initially faced huge losses due to supply-chain disruptions during the pandemic. However, it was managed with time by adopting dairy value chains at the industry level. Notably, the capacity of SMP manufacturing units had to be increased during the pandemic, as most consumers had shifted to SMP due to fear of the pandemic. With regard to information about the change in prices, almost all the stakeholders observed that the prices had reduced by 30% during the pandemic due to supply-chain disruptions in the dairy sector of Punjab. Undoubtedly, the pandemic affected the dairy sector in the state, but its influence was reduced by adopting different value chains at the industry level.

Conclusion

There have been clear and significant disruptions in the dairy sector caused by the COVID-19 pandemic. Milk supply chains were disrupted at various levels with restrictions on transportation, labour shortages, rising production costs and increased wastage. The demand for milk and milk products dropped during the pandemic, and producers resorted to processing milk at their own level to reduce wastage. The COVID-19 pandemic adversely affected the income of dairy farmers and some of them even fell from medium to low-income category. The Government of Punjab increased procurement through milk cooperatives, and these cooperatives processed raw milk into powdered milk in response to expanded procurement. The stakeholders also demanded the procurement of milk for the midday meal scheme, which could boost the demand for milk and enhance nutritional security of poor children. For the long-term sustainability of the dairy sector, there is a need to encourage product diversification and expand the milk processing capacity in Punjab.

Conflict of interest: The authors declare that there is no conflict of interest.

1. Qingbin, W., Chang-Quan, L., Yuan-Feng, Z., Anthony, K., Mark, C., Shu-Kun, W. and Lei, H., Impacts of the COVID-19 pandemic on the dairy industry: lessons from China and the United States and policy implications. *J. Integr. Agric.*, 2020, **19**, 2903–2915.
2. Bhandari, G. and Ravishankar, K. M., Implications of COVID-19 for Indian dairy sector. *Food Sci. Rep.*, 2020, **1**, 43–46.
3. BBC News, Coronavirus: why Canada dairy farmers are dumping milk, 4 June 2020; <https://www.bbc.com/news/world-us-canada-5-2192190>
4. Marshall, A., Why farmers are dumping milk, even as people go hungry. WIRED, 23 June 2020; <https://www.wired.com/story/whyfarmers-dumping-milk-people-hungry/> (retrieved 20 January 2022).
5. Das, D., Impact on Indian dairy sector during COVID-19: challenges and opportunities. *Sci. Agric. Allied Sector*, 2020, **2**, 37–42.
6. Hussain, S., Hussain, A., Jeffery, H., Sparagano, Olivier, A. E. and Zia, U. R., Economic and social impacts of COVID-19 on animal welfare and dairy husbandry in central Punjab, Pakistan. *Front. Vet. Sci.*, 2020, **7**, 1–5; doi:10.3389/fvets.2020.589971.
7. Muringatheri, M., Expert calls for adopting market-led scientific interventions to reduce the dairy sector crisis in Kerala. *The Hindu*, 5 May 2021; <https://www.thehindu.com/news/national/kerala/expert-calls-for-adopting-market-led-scientific-interventions-to-reduce-dairy-sector-crisis-in-kerala/article34618043.ece> (retrieved 25 January 2022).
8. Anon., *Agricultural Statistics at a Glance*, Ministry of Agriculture and Farmers Welfare, Government of India, 2019.
9. NABARD, All India Rural Financial Inclusion Survey 2016–17. National Bank for Agriculture and Rural Development, Department of Economic Analysis & Research, Mumbai, 2016.
10. Ceballos, F., Kannan, S. and Kramer, B., Impacts of a national lockdown on smallholder farmers' income and food security: empirical evidence from two states in India. *World Dev.*, 2020, **136**, 50–69; <https://doi.org/10.1016/j.worlddev.2020.105069>.
11. Chaba, A. and Damodara, H., The COVID nudge: labour shortage makes Punjab, Haryana farmers switch from paddy to cotton. *The*

- Indian Express*, 30 April 2020; <https://indianexpress.com/article/india/covid-19-punjab-haryana-farmers-paddy-cotton-6385600/> (retrieved 25 January 2022).
12. GoI, Basics of Animal Husbandry and Statistics, Department of Animal Husbandry, Dairying and Fisheries, Ministry of Animal Husbandry, dairying and Fisheries, Government of India, 2020; <https://dahd.nic.in/sites/default/files/Veterinary%20services%20during%20Covid%2019%20lock%20down%202021.pdf> (retrieved 22 January 2022).
 13. Shukla, S. and Arora, G., The credit burden. *The Indian Express*, 30 August 2020; <https://indianexpress.com/article/opinion/columns/covid-credit-lockdown-demand-supply-chain-farmers-kharif-burden-6576476/> (retrieved 25 January 2022).
 14. Kaur, I. and Singh, K. P., COVID-19 effect: Dairy sector in doldrums. *The Tribune*, 27 April 2020; <https://www.tribuneindia.com/news/features/covid-19-effect-dairy-sector-in-the-doldrums-7-6958> (retrieved 25 January 2022).
 15. Jose, J., Kishore, V. and Bhoi, B. B., COVID-19 impact on food price mark-ups in India. *RBI Bull.*, August 2021; <https://rbidocs.rbi.org.in/rdocs/Bulletin/PDFs/2COVID19IMPACT44A0A468AA-3349B38B94825C61B2FE53.PDF> (retrieved 25 January 2022).
 16. Mahajan, K. and Tomar, S., COVID-19 and supply chain disruption: evidence from food markets in India. *Am. J. Agric. Econ.*, 2021, **103**, 35–52.
 17. Govindaraj G., Shanabhoga, M. B., Swamy, H. M., Nagalingam, M., Shome, B. R. and Rahman, H., Impact of COVID-19 lockdown on various stakeholders associated with dairy food supply chain in Karnataka, India – an evidence based study. *Indian J. Dairy Sci.*, 2022, **75**, 365–375.
 18. Nayantara, N., Karnataka produces a lot of milk, but is racking its brains on what to do with it. *The News Minute*, 2015; <https://www.thenewsminute.com/article/karnataka-produces-lot-milk-racking-its-brains-what-do-it-33023> (retrieved 25 January 2022).
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