

Knowledge, attitude, and practices of dairy farmers in Punjab, India

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Abstract – The objective of this work was to identify the persisting challenges and lucrative strengths of dairy farming in Punjab. The primary data were collected from farmers through interviews. The desensitized data were subjected to statistical analyses. The results revealed that the dairy farmers of the state prefer buffalo over cattle and that the preferred breeds of cattle and buffalo are the Holstein-Friesian crossbred (65.82%) and Murrah (81.42%), respectively. Livestock insurance is insignificant (0.32%) because of the lack of awareness of the farmers. In addition, the size of the grazing facility (13.39%) has been shrunken due to the cultivation of seasonal crops. More than half of the farmers (57.64%) sell milk to Punjab State Cooperative Milk Producers' Federation Limited (MILKFED), a major milk cooperative. Furthermore, 56.22 and 19.84% of the farmers use animal excreta for manure and fuel purposes, respectively. Of the interviewed farmers, 69.45% specified that the major problem in dairy farming are lower profits due to the low milk price and high production costs. The main stumbling blocks for the dairy farming business in the state of Punjab are: inadequate facilities for dairy farmers, high cost of feed and fodder, low economic gains, loan outsourcing, and inadequate veterinary services. For the dairy industry to thrive in the state, the identified problems need to be addressed immediately by the government through farmer-oriented programs and policies to help make dairy farming a profitable business.

Index terms: dairy farmers, doubling farmers' income, knowledge-attitude-practice, MILKFED, milk production, Punjab.

Conhecimento, ações e práticas de criadores de gado leiteiro em Punjab, Índia

Resumo – O objetivo deste trabalho foi identificar os desafios contínuos e os pontos lucrativos da pecuária leiteira em Punjab. Os dados primários foram coletados por meio de entrevistas com os criadores. Os dados dessensibilizados foram submetidos a análises estatísticas. Os resultados mostraram que os criadores de gado leiteiro do estado

Core ideas

- The foundation of any farming business is the knowledge, attitude, and practices of the farmers associated with it.
- Many progressive dairy farmers in the Punjab state of India have taken this business to a new height.
- Through online and in-person interviews, dairy farmers from Punjab provide their input for progressing dairy farming.
- The views of the farmers from Punjab about dairy farming in the state are the central theme of the manuscript.
- The difference between the farming practices in India and the USA are discussed briefly.

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preferem búfalo a gado e que as raças de gado e búfalo preferidas são o cruzamento Holstein-Friesian (65,82%) e Murrah (81,42%), respectivamente. O seguro pecuário é insignificante (0,32%) devido à falta de conhecimento dos criadores. Além disso, o tamanho da área de pastagem (13,39%) foi reduzido em razão do cultivo de culturas sazonais. Mais da metade dos criadores (57,64%) vendem leite para a Punjab State Cooperative Milk Producers' Federation Limited (MILKFED), uma grande cooperativa de criadores de gado leiteiro. Além disso, 56,22 e 19,84% dos criadores utilizam os excrementos dos animais como esterco ou combustível, respectivamente. Dos criadores entrevistados, 69,45% especificaram que o principal problema da pecuária leiteira são os baixos lucros devido ao baixo preço do leite e aos altos custos de produção. Os maiores obstáculos para a pecuária leiteira no estado de Punjab são: instalações precárias para os criadores, altos custos de alimento e forragem, baixos lucros, empréstimos terceirizados e serviços veterinários inadequados. Para a indústria da pecuária leiteira crescer no estado, os problemas identificados precisam ser enfrentados imediatamente pelo governo por meio de programas e políticas voltados aos fazendeiros, para ajudar a transformar a pecuária leiteira em uma atividade lucrativa.

Termos para indexação: criadores de gado leiteiro, dobrar os lucros dos criadores, conhecimento-ações-práticas, MILKFED, produção de leite, Punjab.

INTRODUCTION

Dairy farming is a booming industry globally, among which India stands out as a major milk producer, with the largest bovine population worldwide. In India, dairy farming is now being practiced on commercial lines by several farmers in Punjab and other states such as Haryana, Gujarat, and Tamil Nadu (Rathod & Dixit, 2020).

Since the Harappa Mohenjo-Daro civilization, the Punjab province of undivided India has been a pioneer in agrarian economy, with a remarkable progress in the consolidation of agriculture and animal husbandry, as shown by the sophisticated machinery used by animal farmers to ensure a higher livestock productivity (Kulke & Rothermund, 2016).

In the state of Punjab, although 23% of the farmers are marginal (< 0.01 hectare land) and have livestock as their major occupation according to the data of the 70th round of key indicators of agricultural households (India, 2013), milk production was about 11.85 million tons in 2017–2018 (Athare et al., 2019). In this scenario, animal husbandry, especially dairying, has become an important secondary source of income for rural families, providing employment to many people, especially marginal and commercial farmers in the state (Dev, 2012).

The agro-dairy industry and agripreneurship in India, however, are hindered by a number of existing and persistent problems, as pointed out by extension workers and researchers (Bairwa et al., 2014). Some of the identified problems are: growing population leading to an expanding urbanization, climate changes, lifestyle changes, high prices of concentrate mixture, no remuneration for milk, feed and fodder shortage, no input for the production and enrichment of green fodder, and lack of concentrates and mineral mixtures in the villages (Rathod et al., 2011), as well as the inadequate facilities and weak economic conditions of marginal farmers (Dabas et al., 2004). Other major concerns of dairy farmers include drops in production and milk production costs (Hermansen, 2003).

The objective of this work was to identify the persisting challenges and strengths of dairy farming in the state of Punjab.

METHODOLOGY

Primary data collection

For the study, farmers distributed all over Punjab were interviewed from March 2017 to June 2019, aiming to identify the main challenges faced by them when practicing animal husbandry in the state and how to improve dairy farming practices (Mukhopadhyay et al., 2020), in order to increase their profits. Each of the participating farmers provided verbal consent for data analysis and publication without disclosing their personal information.

In total, 654 responses were collected through the three types of interviews described in Table 1.

Table 1. Three types of interviews for the collection of data from dairy farmers in Punjab, India.

SN	Type of interview	Total
1	Door-to-door interview	236
2	Interview of farmers visiting the <i>Pashu Palan Mela</i> animal husbandry fair at Guru Angad Dev Veterinary and Animal Sciences University, in Ludhiana, Punjab	315
3	Online interview through the distribution of a questionnaire	103

The asked questions covered six different categories, indicated in Table 2.

Table 2. Broad categories of the questions asked based on the areas of livestock farming in Punjab, India.

SN	Category
1	Basic information of the farmer (education, caste, loan, landholding, and primary occupation)
2	Animal breeding
3	Nutritional and management practices
4	Common diseases, treatment, and vaccination
5	Production and earning from dairy farming
6	Suggestions of the respondent farmers to improve the dairy sector

Quality check and processing of the primary data

The primary data were checked, and the responses of 19 farmers were discarded since the information given by them was almost void for most of the questions. The desensitized data (with all personal information of the farmers deleted) of the remaining 635 responses were used for statistical analyses, considering three types of independent variables: binomial, “yes” or “no” answer; categorical, more than two discrete groups such as age groups and education level; and continuous, milk yield per day and cost of feed.

Statistical analyses

The data were subjected to statistical analyses based on the type of input data: one-way frequency table for discrete data sets and basic statistics for continuous data, in order to study the effect of the evaluated parameters, including education, caste, land ownership, outstanding loans, and animal vaccination. The data were analyzed using the Systat, v.13, software (Systat Software Inc., San Jose, CA, USA) and the R programming environment (R Core Team, 2021). A Venn diagram was drawn using an online tool available at Bioinformatics & Evolutionary Genomics (2023).

RESULTS AND DISCUSSION

Of the 635 interviewed farmers, 623 (98.11%) belong to the state of Punjab and only 12 (1.89%) were from adjoining districts of neighboring states who were visiting the animal husbandry fair at Guru Angad Dev Veterinary and Animal Sciences University. In total, 631 (99.37%) of the respondents were male and only 4 (0.630%) were female. The participating farmers were distributed in the following casts: general caste (92.28%), other backward classes (6.61%), and scheduled caste (1.10%). The age groups of the farmers were the following: up to 24 years (12.60%), 25–34 years (30.71%), 35–49 years (30.55%), and 50 years and above (26.14%). The respondents were distributed

according to their educational level, as follows: uneducated (21.42%), passed Class 10 (33.86%), passed Class 12 (27.72%), graduate (16.54%), and postgraduate (0.47%). The primary source of income of 98.74% of farmers was agriculture, and only 1.26% of the farmers (eight in total) stated that dairy farming was their main source of livelihood.

Response to general questions

The applied questionnaire contained 34 general questions pertaining to the first five broad categories listed in Table 2: 1. basic information of the farmer; 2. animal breeding; 3. nutritional and management practices; 4. common diseases, treatment, and vaccination; and 5. production and earning from dairy farming. A brief summary of the main problems faced by the farmers is presented before the sixth category, in which the respondent farmers gave suggestions on how to improve the dairy industry.

The answers (“yes” or “no”) of the farmers are shown in Table 3 and discussed posteriorly after presenting their breed preferences.

Table 3. Response of the farmers indicating their practices and preferences for dairy farming in the state of Punjab, India^(*).

SN	Question	Yes	No
1	Is dairy farming the main occupation of the farmer?	82a (12.91%)	553b (87.09%)
2	Has the farmer received training in animal husbandry?	41a (6.46%)	594b (93.54%)
3	Are there toilet facilities in the farmer’s house?	625a (98.43%)	10b (1.58%)
4	Does the farmer own a <i>Kisan</i> credit card?	52a (8.19%)	583b (91.81%)
5	Does the farmer have the Mahatma Gandhi National Rural Employment Guarantee Act job card?	0 (0%)	635b (100%)
6	Are the animals insured by the farmer?	2a (0.32%)	633b (99.69%)
7	Does the farmer use commercial feed for the animals?	460a (72.44%)	175b (27.56%)
8	Does the farmer use green fodder for the animals?	604a (95.12%)	31b (4.88%)
9	Does the farmer cultivate green fodder for the animals?	515a (81.1%)	120b (18.9%)
10	Does the farmer use azolla to feed the dairy animals?	13a (2.05%)	622b (97.95%)
11	Does the farmer cultivate azolla for the animals?	2a (0.32%)	633b (99.69%)
12	Does the farmer offer salt/vitamins/minerals to the animals?	245a (38.58%)	390b (61.41%)
13	Does the farmer vaccinate the animals against foot-and-mouth disease?	526a (82.83%)	109b (17.17%)
14	Does the farmer vaccinate the animals against hemorrhagic septicemia?	547a (86.14%)	88b (13.86%)
15	Does the farmer vaccinate the animals against brucellosis?	502a (79.06%)	133b (20.95%)
16	Does the farmer vaccinate the animals against Theileria?	354a (55.75%)	281b (44.25%)
17	Does the farmer vaccinate the animals against black quarter?	414a (65.2%)	221b (34.8%)
18	Does the farmer deworm the animals regularly?	507a (79.84%)	128b (20.16%)
19	Are the sick animals quarantined?	117a (18.43%)	518b (81.58%)
20	Is the farmer already using disease diagnosis kit(s)?	8a (1.26%)	627b (98.74%)
21	Does the farmer consult a veterinarian regarding animal breeding?	219a (34.49%)	416b (65.51%)
22	Does/has the farmer keep/kept indigenous breeds of cattle?	91a (14.33%)	544b (85.67%)
23	Does the farmer want to keep indigenous breeds of cattle?	131a (20.63%)	504b (79.37%)
24	Does the farmer own a bull?	63a (9.92%)	572b (90.08%)
25	Are the diseased animals treated by a veterinarian?	590a (92.91%)	45b (7.09%)
26	Does the farmer allow natural service for female cattle/buffalo?	73a (11.5%)	562b (88.5%)
27	Does the farmer keep records on the animals (pedigree, production, feed, purchase/sale, etc.)?	111a (17.48%)	524b (82.52%)
28	Does the farmer maintain records of artificial insemination services?	67a (10.55%)	568b (89.45%)
29	Does the farmer want to use a mobile app to record data?	437a (68.82%)	198b (31.18%)
30	Does the farmer sell milk?	534a (84.09%)	101b (15.91%)
31	Does the farmer analyze milk production and sale data?	494a (77.8%)	141b (22.21%)
32	Does the farmer produce butter out of milk?	59a (9.29%)	576b (90.71%)
33	Does the farmer produce clarified butter (ghee) from milk?	56a (8.82%)	579b (91.18%)
34	Does the farmer want to adopt dairy farming as a primary occupation?	100a (15.75%)	535b (84.25%)

^(*)Different letters between two levels of an effect indicate a significant difference ($p < 0.05$).

The survey showed that 493 (77.63%) of the participating farmers owned cattle, whereas 551 (86.77%) owned buffalo (Table 4). However, for most of the farmers, cattle or buffalo rearing is only a supplementation to their main occupation. The trend of preferring buffalo over cattle in the state is in alignment with the 19th livestock census (Punjab, 2012).

Table 4. Number and percentage of farmers raising cattle and buffalo based on the size of their farms.

Farm size	Cattle*	Buffalo*
No dairy animal ⁽¹⁾	142 (22.36%)	84 (13.22%)
Micro-dairy (1–3) ⁽²⁾	309 (48.66%)	270 (42.52%)
Small dairy (4–10) ⁽²⁾	140 (22.05%)	246 (38.74%)
Medium-sized dairy (11–49) ⁽²⁾	39 (6.14%)	33 (5.19%)
Large dairy (above 50) ⁽²⁾	5 (0.79%)	2 (0.32%)
Total number of farmers	493 (77.63%)	551 (87.77%)

⁽¹⁾For more details, please see Figure 1. ⁽²⁾Values between parentheses indicate the size of the dairy farm in terms of the number of animals maintained. *Value obtained for Pearson’s chi-squared test, at $p < 0.05$, for the size of the cattle and buffalo farms, separately.

Furthermore, the obtained data show that every respondent maintains at least 1 animal (buffalo or cattle), whereas about 10% of the farmers have ventured into dairy farming with more than 10 animals (Table 4).

In addition, out of the 635 participants, 409 farmers reared both cattle and buffalo in their dairy farms, 142 owned only buffalo, and the remaining 84 owned only cattle (Figure 1).

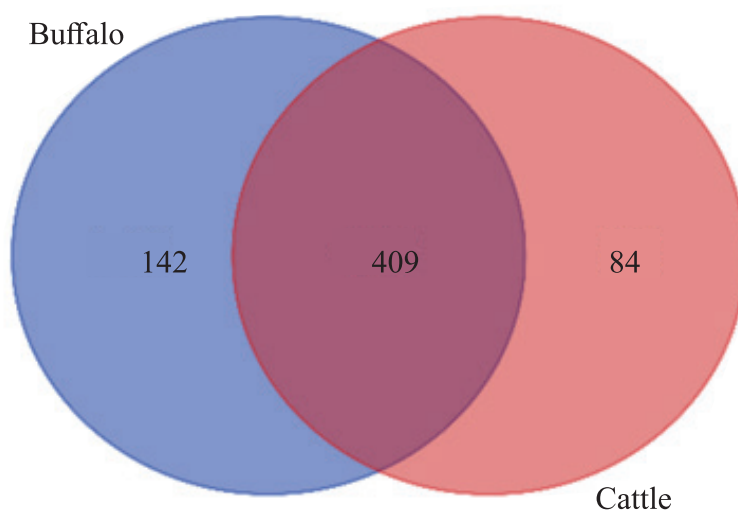


Figure 1. Venn diagram showing the number of farmers maintaining only cattle, only buffalo, and both cattle and buffalo in the state of Punjab, India.

It is possible that the farmers are preferring buffaloes over cattle because of the associated advantages of the former, such as a better feed conversion efficiency, sustainability even on poor feed and forage quality, higher returns from milk (buffalo milk across breeds has more than 8% fat, which is valued in milk in India), milk with a better nutritive value (higher amounts of solids-not-fat, including sugar, protein, vitamins, and calcium), a higher number of productive years in comparison

with crossbred cows, a better adaptability to harsh environments, and a higher disease resistance than crossbred cows (Balhara et al., 2017; Deka et al., 2020; Kumar et al., 2021).

Regarding the most preferred breeds, 65.82% of the farmers prefer Holstein-Frisian crosses over Jersey (9.76%) and Zebu Sahiwal (2.05%) crosses (Figure 2). In addition, a total of 131 (20.63%) farmers expressed interest in maintaining indigenous breeds of livestock over crossbred cattle.

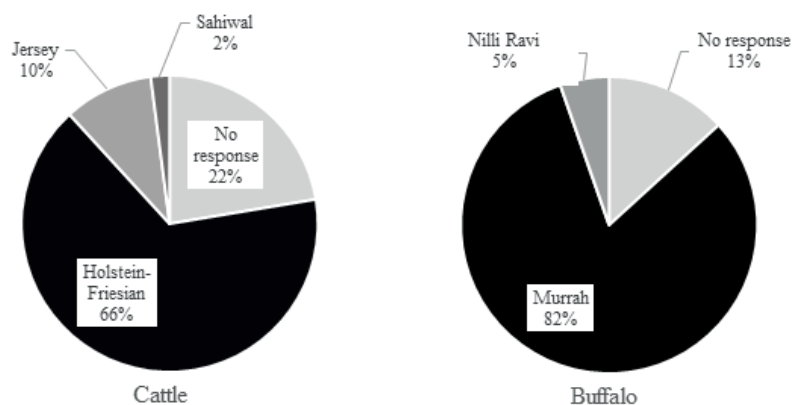


Figure 2. Preferred cattle and buffalo breeds among dairy farmers in Punjab, India.

Murrah is the most preferred breed of buffalo, which could be due to its high butterfat content (~ 7.0%) and high average milk yield (~ 6.8 kg per day), providing a higher turnover to the farmers (Mohali, 2014).

Basic information of the farmer

The basic information of the dairy farmers directly influences their stances on: livestock insurance (i), training on animal husbandry (ii), training on animal farming (iii), venturing into dairy farming (iv), and size of dairy farm compared with landholding (v), in addition to indicating their economic status (vi).

i. Stance of the farmers on livestock insurance:

The dairy farmers in Punjab, by and large, are not aware of the importance of insuring their animals. Of the respondents, only two farmers (0.32% of the total participants) have insured their livestock. According to the collected data, both of these farmers received training in animal husbandry, maintained a low number of cattle and buffalo (four and three, respectively), and vaccinated their animals regularly. Therefore, animal husbandry training has had an impact on the *modus operandi* of their dairy farm.

A similar result was observed by Ministry of Agriculture & Farmer Welfare of the government of India in the response to un-starred question no. 2827 (India, 2018), which indicated that, in 2014–2015, about 50,000 animals were insured, but that, from 2015–2017, not a single animal was insured in Punjab. In the state, the number of farmers benefiting from livestock insurance was only 5,685 in 2014. One of the main reasons for these low numbers is that animal insurance is optional, differently from the government-sponsored crop insurance, *Pradhan Mantri Fasal Bima Yojana* (2019), which is compulsory for loanee farmers and deducted by banks from the farmer's credit card (*Kisan credit*

card). Furthermore, the banks are not involved in livestock insurance, and most animal farmers do not know how to purchase it. Therefore, for an increased livestock insurance, the banks in India should be directed by the regulating body to make animal insurance compulsory for all dairy farmers that apply for the *Kisan* credit card (Pradhan Mantri Fasal Bima Yojana, 2019), which would allow of farmers to have more knowledge on the subject, showing the need for a government-sponsored livestock insurance.

ii. Animal husbandry training and related awareness:

About 41 (6.46%) of the farmers attended animal husbandry training programs for dairy practices in Punjab (Table 3).

Regarding the awareness of the farmers, more than 86% of the respondents cover the annual vaccination of their livestock against one or more diseases, such as foot-and-mouth disease, brucellosis, hemorrhagic septicemia, Theileria, and black quarter. Moreover, 507 (79.84%) farmers also adopt regular deworming programs for their livestock (Table 3). This result can be mostly attributed to the diligent work of the Department of Animal Husbandry of the state and to the general awareness of the farmer.

Of the participating farmers, only 11.49% adopt natural services over artificial insemination (Table 3), which could be due to the widespread artificial-insemination network and the efforts of field veterinarians and para-veterinarians.

iii. Impact of educational qualification on receiving training on animal farming:

The analysis of the available data, according to the chi-squared test at $p < 0.01$, shows that the less educated farmers require more training (Table 5). Therefore, educational qualification has a significant impact on the understanding of the farmer of the importance of receiving relevant training in their field, considering that 136 (21.42%) of the respondent farmers are uneducated, others are educated at least up to class 10, and 108 (17%) have graduate and postgraduate degrees.

Table 5. Number and percent of farmers who received training on animal husbandry and their level of education.

Level of education	Trained	Untrained	Total
Uneducated	133 (97.79%)	3 (2.21%)	136 (21.42%)
Passed Class 10	206 (95.81%)	9 (4.12%)	215 (33.86%)
Passed Class 12	155 (88.06%)	21 (11.94%)	176 (17.72%)
Graduate	98 (93.33%)	7 (6.67%)	105 (16.54%)
Postgraduate	2 (66.60%)	1 (33.30%)	3 (0.47%)
Total	594 (93.54%)	41 (6.46%)	(100.00%)

iv. Acceptability of young farmers to venture into dairy farming:

Rather than conventional agriculture, dairy farming can provide, up to some extent, income to marginal and small-scale farmers. The farmers who are considering dairy farming after completing their education is equally distributed over the age groups ranging from 24–34 and 35–49 years. Sharma et al. (1994) and Gopi et al. (2017) observed that, in general, young farmers are believed to be more efficient than older ones due to the crucial role of education. In addition, of the dairy farmers, 26.14% belong to the older age group, 61.25% to the middle-age group, and only 12.5% to the young-age group. According to Roy (2013), older and younger farmers are losing interest in agriculture farming, while dairy farming is becoming quite popular among animal farmers due to its higher profits (Roy, 2013).

v. Size of the dairy farms compared with the farmer's landholding:

Although farmers with no landholding also have dairy animals, those with average landholdings maintain the highest number of dairy animals (Table 6). However, the farmers with the largest landholdings (above 16 acres) majorly depend on commercial agricultural farming as an income source and, therefore, have less interest in dairy animals or farming.

Table 6. Average farm size (number of cattle and buffaloes maintained) \pm standard error of the mean compared with the landholding of the animal farmer⁽¹⁾.

Landholding	Cows	Buffaloes
No landholding	3.57A \pm 0.88 (n=70)	3.79ac \pm 0.41 (n=70)
Up to 5 acres	4.69A \pm 1.42 (n=254)	3.07a \pm 0.19 (n=254)
6–15 acres	4.84A \pm 0.62 (n=226)	5.23b \pm 0.47 (n=226)
16–70 acres	2.81A \pm 0.42 (n=85)	4.68bc \pm 0.42 (n=85)

⁽¹⁾Means followed by equal letters, uppercase in the columns, do not differ significantly for number of cows. Different letters indicate a significant difference ($p < 0.05$) between landholding size and the number of buffaloes maintained.

vi. Socioeconomic status of the participating farmers:

Most of the respondent farmers, except 10, stated that there are toilet facilities in their households (Table 7). This is likely a result of the impact of the countrywide sanitation program, *Swachh Bharat* mission, on the personal hygiene of the population.

Table 7. Comparison of the educational qualification of the farmer with the availability or not to a toilet facility in their home (number and percent of farmers).

Educational qualification	Available ⁽¹⁾	Not available	Total
Uneducated	132 (20.78%)	4 (0.63%)	136 (21.42%)
Passed Class 10	213 (33.54%)	2 (0.32%)	215 (33.86%)
Passed Class 12	175 (27.55%)	1 (0.16%)	176 (27.72%)
Graduate	102 (16.06%)	3 (0.47%)	105 (16.54%)
Postgraduate	3 (0.47%)	0 (0.00%)	3 (0.47%)
Total	625 (98.42%)	10 (1.57%)	635 (100.00%)

⁽¹⁾Nonsignificant by the chi-squared test at $p > 0.05$.

1. Animal breeding

The prime target of animal breeding is to select parent animals with a high genetic worth, which would ensure an improved production, reproduction, disease resistance, and resilience to climate change in the progenies. In this category of questions, participants were asked about the adoption of biotechnological techniques for breeding purposes (i), their general awareness about breeding (ii), selection criteria for purchasing an animal (iii), and the reason to keep indigenous cattle at their farms (iv).

i. Awareness about using biotechnological techniques:

The dairy farmers interviewed in Punjab are currently adopting high-level biotechnological techniques for the genetic improvement of their livestock. According to the present study, 9.29% of farmers use exotic semen, 1.58% use the embryo transfer technique, and 0.47% use embryo sexing and cloning.

ii. Awareness about breeding:

More than one-third of the participants stated that they usually seek expert opinions when selecting germplasm prior to breeding their dairy animals. However, this is not the case for 65.51% of the farmers.

iii. Selection criteria for purchasing an animal:

As a criteria to purchase animals, 34.80% of the farmers opt for better breeds, 14.96% for a better production, and 3.94% for both factors.

iv. Reason to keep indigenous cows at their dairy farms:

Although there could be several reasons to maintain indigenous cows in dairy farms, the obtained results indicate that some farmers believe that indigenous cows are more climate-resilient (3.31%), have better milk quality regarding solids-not-fat and fat contents (4.25%), show a better disease resistance (3.78%), and are ethically good to keep (4.57%) due to the religious beliefs across the state (Figure 3). Contrastingly, 8.98% of farmers highlighted that indigenous cows produce less milk than crossbreeds. However, the majority of the farmers did not answer this question, perhaps because of their lower preference for indigenous cattle breeds.

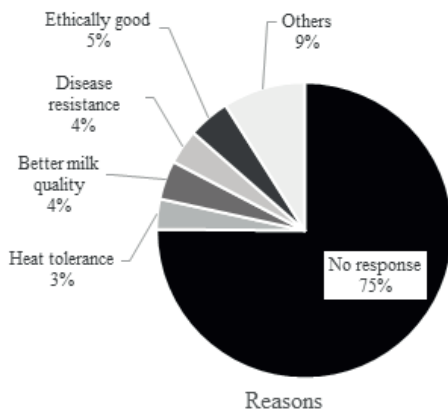


Figure 3. Major reasons for maintaining indigenous dairy cows according to the dairy farmers interviewed in the state of Punjab, India.

2. Nutritional and management practices

The nutritional regime directly affects animal growth rate, production capacity, and health status, especially considering that many diseases occur due to under- or overfeeding. Therefore, feeding is key to a profitable and sustainable farming, maintaining an acceptable performance of neonatal, growing, breeding, pregnant, lactating, and dry animals.

The answers of the respondent farmers showed a preference for homemade feeds (i) and highlighted their main grazing and farming practices (ii).

i. Preference of homemade feeds over branded ones:

The interviewed dairy farmers were very selective in choosing the feed for their livestock. Of the 460 (72.44%) farmers who offer feed to their livestock, 325 (51.18%) opt for homemade feeds due to their cost effectiveness, whereas 186 (29.29%) prefer ready-made or branded feeds. Verka is the most preferred (11.5%) feed brand, followed by Marigold (1.89%) and Kargil (1.42%), probably because it is considered reliable among farmers and is readily available through cooperative milk societies even in remote areas of Punjab. The underlying reasons for the farmers preferring homemade feed could be the lower costs and the better used raw materials for its production.

ii. Grazing practices and water source for farming practices:

Bovine grazing is not popular among farmers in Punjab, as evidenced by the present study. Only 85 (13.39%) farmers allow their dairy animals to graze (Figure 4), while 498 (78.43%) and 26 (4.09%) have no grazing facility around the barns or improved sheds, respectively.

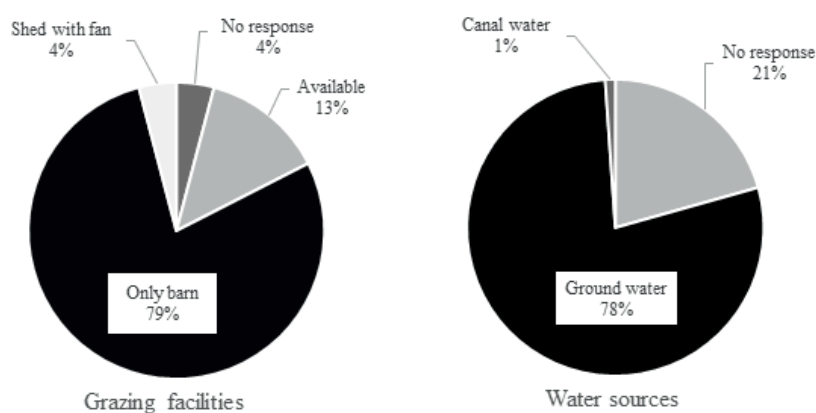


Figure 4. Availability of grazing facilities for animals and water source for farming practices in dairy farms in Punjab, India.

These results could be related to the fact that, in Punjab, the farmer's annual income is dependent on agriculture practices, meaning that seasonal crops are cultivated throughout the year, minimizing the availability of land for grazing and forestation purposes (Agarwal, 2018). Another cause for this could be the increase of in-barn feeding due to the higher number of permanent animal houses established by 80.63% of farmers, compared with the 15.75 who still have temporary animal houses. In addition, during the offseason, there is a shortage of green fodder, which could be tackled if the farmers enrolled in the *Gramin Bhandaran Yojana* program for rural stockpiling sponsored by the Indian government. The objective of this program is to provide an area for the storage of green fodder for future use in all associated facilities in rural areas, helping the farmers to promote, standardize, and control the quality of various agricultural products and grains, consequently improving their marketability (Pradhanmantri Gramin Bhandaran Yojana, 2019).

In the state of Punjab, the primary agricultural practices depend on underground water, which is also used for dairy farming. A total of 497 (78.27%) farmers stated that they use underground water for dairy farming, whereas only 7 (1.10%) use canal water (Figure 3). It should be noted that, in Punjab, there is currently no public authority to regulate canal and groundwater use. However, this is important since farmers have energy subsidies for farming, leading to an excessive use of groundwater. In 1970–1971, Punjab had 1.92 lakh tube wells, which increased to 14.14 lakh by 2015–2016, causing a reduction of 6 to 22 m in the groundwater level (Khanna, 2018).

3. Common diseases, treatment, and vaccination

Livestock diseases decrease the profitability of any farm, directly affecting animal welfare, food security, and human health due to the risk of zoonotic diseases. However, improved animal husbandry practices and timely clinical interventions (such as controlling the entry to farm lots, quarantining sick animals, the judicious use of antibiotics, routine vaccination, (Bose & Kumar, 2024), the evaluation of ethno-therapeutic options, and vector control) can reduce disease occurrence, highlighting the importance of the role of veterinarians (i).

i. Role of field veterinarians in vaccination and disease treatment:

The collected data revealed that most farmers (72.91%) only consult veterinarians and not veterinary assistants or quacks, only 2 (0.32%) consult both veterinarians and veterinary assistants, and 35 (5.51%) do not consult either veterinarians or veterinary assistants when their animals are diseased. Worryingly, 135 (21.26%) farmers stated that they consult only the veterinary assistant and not the veterinarian, which could be due to several factors, including the unavailability of veterinarians nearby and the lower cost of consulting only the veterinary assistant. In this scenario, it is important to raise the awareness of the farmers about the possible losses and consequences of consulting only quacks.

4. Production and earning from dairy farming

The production and marketing of milk products are the cornerstone for success in dairy farming, which is why, in the present study, the participants were asked to whom they are selling their milk products (i), in addition to how they are using animal excreta (ii).

i. Punjab State Cooperative Milk Producers' Federation Limited (MILKFED):

MILKFED is the major milk cooperative in the state of Punjab, whose objective is to carry activities to promote the production, processing, and marketing of milk in order to create a remunerative milk market for milk producers at their doorstep, resulting in quality milk and products for the consumers (Kaur & Singla, 2023). The results of the present study indicate that 57.64% of the interviewed farmers sell milk to MILKFED, 16.54% do not sell milk due to household consumption, 14.80% sell milk to private unions, and 9.29% sell milk to local people. According to the response of the farmers, 77.79% of them analyze the contents of the milk before selling it (Vijay et al., 2021).

ii. Animal excreta – a basic bio-manure for farmers:

In the present study, 357 (56.22%) farmers use animal excreta as manure in their fields, 126 (19.84%) use excreta to make dung cake for fuel purposes, 85 (13.39%) use excreta for more than one purpose, 31 (4.88%) do not use excreta for any purpose, 30 (4.72%) use excreta for biogas production,

and 6 (0.95%) use excreta for other purposes. Interestingly, despite the large use of animal excreta as bio-manure in the state, farmers are still excessively applying artificial fertilizers to their fields (Kaushal & Prashar, 2021). Moreover, the high use of excreta for dung-cake fuel purposes is an indicative that the farmers might not have knowledge of the various subsidy programs carried out by the central and state governments for the establishment of biogas plants depending on landholding size (Entrepreneurship opportunities in the biogas sector, 2018).

Main problems faced by the interviewed dairy farmers in Punjab

According to the survey, although 15.75% of farmers would like to adopt dairy farming as a primary occupation, for most of them, it is a secondary business, either because agriculture has been their main and sole source of income for generations or because of the lower profits of dairy farming due to the low milk prices. According to the online report of Down To Earth (Sushima, 2018), in 2017, the selling price of milk was between ₹ 30–32 per liter, decreasing to ₹ 20–22 per liter in following year, indicating a current loss of ₹ 10 per liter.

The selling price of milk is influenced by several factors, including the price of green fodder for animal feed, which increases the cost of milk production and varies depending on temperature, water availability, and land use. In Punjab, fodder for dairy cattle is affected by extreme variations in temperature and a severe reduction in underground water levels since 1998 due to an annual rainfall lower than normal (700 mm) (Khanna, 2018). In addition, the demand for irrigation water (4.45 million hectare meters) is significantly higher than the total water available for irrigation (3.04 million hectare meters), which is worsened by the daily overuse of underground water for irrigation purposes in various parts of Punjab (Kumar et al., 2018). On top of that, the prices of fodder and the investment in its cultivation keep rising, while the prices of milk stay fixed.

Of the interviewed farmers, 95.12% are using green fodder as animal feed and 81.10% are cultivating green fodder in their own land. However, since the production of green fodder requires a high investment in seeds, whose prices are high and for which the farmers have less subsidy, several farmers opt for other types of feed, i.e., 29.29% for ready-made feed and 51.18% for homemade feeds.

In addition to a low or lack of profit (69.45%), the other main problems identified by the respondent farmers were the occurrence of multiple diseases among their animals (10.24%) and a low milk productivity (8.66%), as shown in Table 8.

Table 8. Main issues/challenges faced by dairy farmers in Punjab, India.

Main issue faced by the farmer	Number (percent)*
Almost no profits from dairy farming	441 (69.45%)
Losses due to disease occurrence	72 (10.72%)
Low production leading to losses	55 (8.66%)
Low production and diseases	1 (0.16%)
Low production, diseases, and lower profit	4 (0.63%)
Low production and lower profit	2 (0.32%)
Others	2 (0.32%)

*based on n=577 out of 635 responses received.

The low profits cited by the dairy farmers could be attributed to several reasons, such as low milk selling prices, high costs of feed and fodder, low milk production, and livestock without nutritional supplements.

Considering the selling prices of milk, the majority of the farmers (57.64%) are selling milk to MILKFED, which pays between ₹ 20–27 per liter for cow milk and ₹ 30–45 per liter for buffalo milk on the basis of milk fat (%) content; although quite low, these prices are directly proportional to the net productivity of milk. In this scenario, improved breeding and nutrition are two important pillars for increasing milk productivity. However, as previously discussed, 65.51% of the dairy farmers are not seeking the opinion of veterinarians and veterinary assistants while choosing a breed for artificial insemination and planning the nutritional regime of their animals, which is important considering that 61.41% of the farmers do not provide any salt, minerals, and multi-vitamins to their livestock.

5. Suggestions of the respondent farmers to improve the dairy sector

In the present study, 1,199 suggestions were recorded, being ranked according to their percent (Table 9). Although each farmer was allowed to give up to 3 suggestions, 59 respondents did not give any at all, 113 gave only 1 suggestion, 303 gave 2 suggestions, and 160 gave 3.

Table 9. Percent and rank of the suggestions given by the interviewed dairy farmers to solve the problems faced by them in Punjab, India.

SN	Suggestion	Percent	Rank
1	Increase the minimum market price for milk	24.88	I
2	Waive off loan	11.39	II
3	Transform dairy farming into a profitable business	7.66	III
4	Provide training for dairy farmers	3.68	IV
5	Make feed prices nominal	3.31	V
6	Government support to farmers for dairy farming	2.63	VI
7	Availability of on-time treatment in veterinary hospitals	1.89	VII
8	Availability of better germplasm	1.68	VIII
9	Ban of adulterated milk	1.47	IX
10	Improvement of breeding policies	1.37	X
11	No more taxes on agriculture	0.68	XI
12	Proper vaccination cover for animals	0.58	XII
13	Government subsidy for dairy farmers (none is provided)	0.53	XIII
14	Availability of veterinarians	0.26	XIV
15	Control of mastitis	0.26	XV
16	Resolve animal infertility problems	0.26	XVI
17	Availability of free animal insurance	0.26	XVII
18	Establishment of dairy collection centers in rural areas	0.11	XVIII
19	Others	0.05	XIX

According to the survey, the main problem faced by the dairy farmers in Punjab is the lack of increase in the minimum price stipulated for milk, as also reported by Jayalaxmi et al. (1997), Sharma et al. (2000), Maity & Sidhu (2001), Podikunju et al. (2001), Dabas et al. (2004), and Rathod et al. (2011). For comparison, Numbeo (2023) shows the varying milk prices from one country to another (Table 10).

Table 10. Comparison of milk price per liter in major developing and developed countries.

SN	Country	Regional price of milk per liter	Price of milk per liter in USD	Price of milk per liter in INR (1 USD = 71 INR)
1	India	₹ 40	\$ 0.56	40.0
2	China	¥15	\$ 0.14	9.94
3	Bangladesh	₳ 81	\$ 0.96	68.16
4	Sri Lanka	₨ 210	\$ 1.16	82.36
5	Pakistan	Rs. 140	\$ 0.89	63.19
6	South Africa	R 13	\$ 0.88	62.48
7	United States of America	\$1.20	\$ 1.20	85.20
8	Canada	\$2.87	\$ 2.17	154.07
9	Australia	\$1.20	\$ 0.81	57.51
10	Denmark	kr 11	\$ 1.12	79.52

In addition, most of the interviewed dairy farmers attribute their low economic gains to these low milk prices, which is in agreement with Jayalaxmi et al. (1997).

Other major concerns of the respondent farmers are: making dairy farming a profitable business and waiving off loans, as also observed by Maity & Sidhu (2001), considering the high construction costs when building a farm (Sharma et al., 2000); and the high feed prices, in alignment with Rathod et al. (2011), highlighting the need to educate farmers about the enrichment of fodder and the preparation of a balanced and economical feed. Podikunju et al. (2001) and Dabas et al. (2004) found similar results regarding the problems related to veterinary health care practices, also raised by the farmers.

Considering the aforementioned problems, government initiatives should be undertaken to increase the marketing of dairy products from rural Indian dairy farmers. Several initiatives are floated around every year to transform agriculture and dairy farming into a profitable business, as the program for traditional agriculture development, *Paramparagat Krishi Vikas Yojna*, in which the government aims to promote organic farming in the country, benefiting enrolled farmers with 50,000 per acre during three years (India, 2021).

The government of India has also announced various programs and policies to help improve the economic status of the farmers, covering their income and social security (PMINDIA, 2014). For example, the *Pradhan Mantri Kisan Samman Nidhi* policy, launched in 2018, will benefit farmers, as well as rural and field workers, who have holdings of up to 2 acres, with ₹ 6,000 each year, which will be transferred directly into their bank accounts (Akhtar, 2024). This movement is important, particularly in the state of Punjab, where a suicide trend is observed among indebted farmers (Sangwan, 2017).

In the dairy field, the government should also take steps to implement the same sale mode as that of the pan-Indian electronic trading portal, National Agriculture Market (e-NAM), where agricultural products are sold directly online, encouraging dairy farmers to sell their dairy products online in order to increase their income and offer their products for the best prices. This is interesting especially since 70% of the milk produced in the country is produced by small and marginal farmers (Kumar et al., 2005) and, in recent decades, the demand for organic milk and dairy products has substantially increased (Maji et al., 2017). In view of that, innovative ideas, such as the *Ksheera Samruddhi* model adopted in Kerala, in which produced milk is packed and quality milk is delivered at the doorstep of consumers in many nearby areas (Sreeram & Gupta, 2016), can help farmers to promote organic milk production and marketing.

CONCLUSIONS

Considering the answers of the interviewed farmers, the main stumbling blocks for dairy farming in the state of Punjab, India, are: inadequate facilities, high feed and fodder costs, low economic gains, major loan outsourcing, and inadequate veterinary services. To allow of the dairy industry to thrive in the state, the identified problems need to be addressed immediately by the government through farmer-oriented programs and policies to help make dairy farming a profitable business and to increase the net profits of the farmers, also guaranteeing their social security. This way, dairy farming can be an alternative source of income for a debt-ridden state, reducing the suicide trend among farmers by allowing of their recovery from an economic setback.

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REFERENCES

- AGARWAL, A. Forest cover: Punjab tops from below; Haryana second. **Punjab News Express**, Jan. 14 2018. Available at: <<http://punjabnewsexpress.com/oped/news/forest-cover-punjab-tops-from-below-haryana-second-71373.aspx>>. Accessed on: Oct. 13 2019.
- AKHTAR, J. **The Impact of Pradhan Mantri Kisan Samman Nidhi Scheme on the Farm Income of Beneficiaries in Uttar Pradesh**. 2024. Available at: <<https://desagri.gov.in/wp-content/uploads/2024/04/2022-23-The-Impact-of-PM-KISAN-Scheme-on-the-Farm-Income-of-Beneficiaries-in-Uttar-Pradesh.pdf>>. Accessed on: July 22 2024.
- ATHARE, P.G.; VERMA, A.; MALHOTRA, R.; SENDHIL, R. Economics of milk production in Pune district of Maharashtra: a comparative analysis. **Indian Journal of Dairy Science**, v.72, p.652-658, 2019. DOI: <https://doi.org/10.33785/IJDS.2019.v72i06.011>.
- BAIRWA, S.L.; LAKRA, K.; KUSHWAHA, S.; MEENA, L.K.; KUMAR, P. Agripreneurship development as a tool to upliftment of agriculture. **International Journal of Scientific and Research Publications**, v.4, p.1-4, 2014.
- BALHARA, A.K.; NAYAN, V.; DEY, A.; SINGH, K.P.; DAHIYA, S.S.; SINGH, I. Climate change and buffalo farming in major milk-producing states of India – present status and need for addressing concerns. **Indian Journal of Animal Sciences**, v.87, p.403-411, 2017. DOI: <https://doi.org/10.56093/ijans.v87i4.69476>.
- BIOINFORMATICS & EVOLUTIONARY GENOMICS. **Calculate and draw custom Venn diagrams**. Available at: <<http://bioinformatics.psb.ugent.be/webtools/Venn/>>. Accessed on: Dec. 23 2023.
- BOSE, B.; KUMAR, S.S. Dairy Farmers’ Awareness of Vector-Borne Zoonotic Diseases: A Pilot Study. **Vector-Borne and Zoonotic Diseases**, 2024. Ahead of Print. DOI: <https://doi.org/10.1089/vbz.2023.0132>.
- DABAS, Y.P.S.; BARDHAN, D.; SHABEENA, M. Constraints in the adoption of dairy technology by rural women in Tarai area of Uttaranchal. **Indian Dairyman**, v.56, p.25-28, 2004.
- DEKA, R.P.; MAGNUSSON, U.; GRACE, D.; SHOME, R.; LINDAHL, J.F. Knowledge and practices of dairy farmers relating to brucellosis in urban, peri-urban and rural areas of Assam and Bihar, India. **Infection Ecology & Epidemiology**, v.10, art.1769531, 2020. DOI: <https://doi.org/10.1080/20008686.2020.1769531>.
- DEV, S.M. **Small farmers in India: challenges and opportunities**. Mumbai: Indira Gandhi Institute of Development Research, 2012. Available at: <<http://www.indiaenvironmentportal.org.in/files/file/Small%20Farmers%20in%20India.pdf>>. Accessed on: Oct. 20 2019.
- ENTREPRENEURSHIP opportunities in the biogas sector. 2018. Available at: <<http://www.energynext.in/2018/05/entrepreneurship-opportunities-in-biogas-sector/>>. Accessed on: Oct. 13 2019.
- GOPI, R.; NARMATHA, N.; SAKTHIVEL, K.M.; UMA, V.; JOTHILAKSHMI, M. Socio-economic characteristics and its relationship with information seeking pattern of dairy farmers in Tamilnadu, India. **Asian Journal of Dairy and Food Research**, v.36, p.16-20, 2017. DOI: <https://doi.org/10.18805/ajdf.v36i01.7454>.

- HERMANSEN, J.E. Organic livestock production systems and appropriate development in relation to public expectations. **Livestock Production Science**, v.80, p.3-15, 2003. DOI: [https://doi.org/10.1016/S0301-6226\(02\)00313-5](https://doi.org/10.1016/S0301-6226(02)00313-5).
- INDIA. Ministry of Agriculture and Farmer Welfare. Department of Animal Husbandry, Dairying and Fisheries Lok Sabha. **Unstarred Question n° 2827 to be Answered on 13th March 2018**. 2018. National Livestock Mission. Available at: <http://www.eparlib.nic.in/bitstream/123456789/771781/1/AU2827.pdf>. Accessed on: Oct. 20 2019.
- INDIA. Ministry of Agriculture and Farmers Welfare. **Paramparagat Krishi Vikas Yojana (PKVY): Post Harvest Management Support to encourage Organic Farmers**. 2021. Available at: <https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1739994>. Accessed on: July 22 2024.
- INDIA. Ministry of Statistics and Programme Implementation. **Ministry of Statistics and Programme Implementation report**. 2013. Available at: http://mospi.nic.in/sites/default/files/publication_reports/KI_70_33_19dec14.pdf. Accessed on: Oct. 13 2019.
- JAYALAXMI, G.; SHAILAJA, S.; SOBHANA, G. Constraints experienced by women entrepreneurs. **Journal of Extension Education**, v.8, p.1752-1754, 1997.
- KAUR, M.; SINGLA, N. Formal vs. informal milk marketing channels in Punjab: A comparative economic analysis of dairy cooperative member vis-a-vis non-member milk producers. In: SHERGILL, B.S.; MEHTS, S. (Ed.). **Challenges to Punjab Economy**. London: Routledge India, 2023. p.72-86. DOI: <https://doi.org/10.4324/9781003342304-6>.
- KAUSHAL, L.A.; PRASHAR, A. Agricultural crop residue burning and its environmental impacts and potential causes – case of northwest India. **Journal of Environmental Planning and Management**, v.64, p.464-484, 2021. DOI: <https://doi.org/10.1080/09640568.2020.1767044>.
- KHANNA, R.M. 'Dry' Punjab draws 1.5 times the water that goes in ground. **The Tribune: the voice of people**, Aug. 9 2018. Available at: <https://www.tribuneindia.com/news/punjab/-dry-punjab-draws-1-5-times-the-water-that-goes-in-ground/635178.html>. Accessed on: Aug. 10 2018.
- KULKE, H.; ROTHERMUND, D. **A history of India**. 6th ed. London: Routledge Publishers, 2016. DOI: <https://doi.org/10.4324/9781315628806>.
- KUMAR, N.; SAWANT, S.; MALIK, R.K.; PATIL, G. **Development of an analytical process for the detection of antibiotic residues in milk using bacterial spores as biosensors**. 2005. (Patent Reg # IPR/4.9.1.41 05074114791 del/ 2006).
- KUMAR, N.; SHARMA, G.; LEAHY, E.; SHOME, B.R.; BANDYOPADHYAY, S.; DEKA, R.P.; SHOME, R.; DEY, T.K.; LINDAHL, J.F. Understanding antibiotic usage on small-scale dairy farms in the Indian states of Assam and Haryana using a mixed-methods approach—Outcomes and challenges. **Antibiotics**, v.10, art.1124, 2021. DOI: <https://doi.org/10.3390/antibiotics10091124>.
- KUMAR, R.; VAID, U.; MITTAL, S. Water Crisis: issues and challenges in Punjab. In: SINGH, V.P.; YADAV, S.; YADAVA, R.N. (Ed.). **Water Resources Management: select proceedings of ICWEES-2016**. Singapore: Springer, 2018. p.93-103. (Water Science and Technology Library, v.78). DOI: https://doi.org/10.1007/978-981-10-5711-3_7.
- MAITY, M.; SIDHU, D.S. Adoption of clean milk production and health care practices – a study among dairy farm women. **Journal of Dairying, Foods and Home Sciences**, v.20, p.232-234, 2001.
- MAJI, S.; MEENA, B.S.; PAUL, P.; RUDROJU, V. Prospect of organic dairy farming in India: a review. **Asian Journal of Dairy & Food Research**, v.36, p.1-8, 2017. DOI: <https://doi.org/10.18805/ajdfr.v36i01.7452>.
- MOHALI. Rs 40-lakh-a-year hurrah for the owner of this Murrah! **Hindustan Times**, Feb. 17 2014. Available at: <http://www.hindustantimes.com/punjab/chandigarh/farmer-earns-rs-40-lakh-a-year-from-murrah-bull-semen-sale/article1-1185010.aspx>. Accessed on: Oct. 13 2019.
- MOUTOS, A.; DOXANI, C.; STEFANIDIS, I.; ZINTZARAS, E.; RACHIOTIS, G. Knowledge, attitude and practices (KAP) of ruminant livestock farmers related to zoonotic diseases in Ellassona Municipality, Greece. **European Journal of Investigation in Health, Psychology and Education**, v.12, p.269-280, 2022. DOI: <https://doi.org/10.3390/ejihpe12030019>.
- MUKHOPADHYAY, C.S.; SINGH, K.; KASHAP, N.; SANDHU, Y.; SINGH, S. SWOT analysis to identify important factors influencing dairy farming practices in Punjab. **Agricultural Research Journal**, v.57, 2020. DOI: <https://doi.org/10.5958/2395-146X.2020.00112.X>.
- NUMBEO. **Price Rankings by Country of Milk (regular), (1 liter) (Markets)**. Available at: https://www.numbeo.com/cost-of-living/country_price_rankings?itemId=8. Accessed on: Dec. 23 2023.
- PMINDIA. **Pradhan Mantri Jan Dhan Yojana**. 2014. Available at: https://www.pmindia.gov.in/en/major_initiatives/pradhan-mantri-jan-dhan-yojana/. Accessed on: Oct. 13 2019.
- PODIKUNJU, B.; SHARMA, F.L.; PANWAR, J.S. Constraints encountered by farm women in the management of dairy animals in southern Rajasthan. **Indian Dairyman**, v.53, p.53-57, 2001.
- PRADHAN Mantri Fasal Bima Yojana. **The Economic Times**, 2019. Available at: <https://economictimes.indiatimes.com/hindi/wealth/personal-finance/by-using-these-process-you-can-benefit-from-pmfby/articleshow/64222007.cms?from=mdr>. Accessed on: Oct. 13 2019.

- PRADHANMANTRI Gramin Bhandaran Yojana. 2019. Available at: <<http://pradhanmantri-yojana.in/gramin-bhandaran-yojana-2019-objectives-loan-subsidy-pdf/>>. Accessed on: Oct. 13 2019.
- PUNJAB. Department of Animal Husbandry. **19th Indian livestock census – 2012**. 2012. Available at: <<http://www.husbandrypunjab.org/pages/livestock.htm>>. Accessed on: Oct. 13 2019.
- R CORE TEAM. **R: a language and environment for statistical computing**. Vienna: R Foundation for Statistical Computing, 2021.
- RATHOD, P.K.; DIXIT, S. Precision dairy farming: opportunities and challenges for India. **Indian Journal of Animal Sciences**, v.90, p.1083-1094, 2020. DOI: <https://doi.org/10.56093/ijans.v90i8.109207>.
- RATHOD, P.K.; LANDGE, S.; NIKAM, T.R.; VAJRESHWARI, S. Socio-personal profile and constraints of dairy farmers. **Karnataka Journal of Agricultural Sciences**, v.24, p.619-621, 2011.
- ROY, V.C. Punjab dairy farm model for other states. **Business Standard**, 2013. Available at: <https://www.business-standard.com/article/companies/punjab-dairy-farm-model-for-other-states-112080800051_1.html>. Accessed on: Oct. 13 2019.
- SANGWAN, S.S. Farmers' suicides in Punjab: looking beyond indebtedness. **The Times of India**, 2017. Available at: <<https://timesofindia.indiatimes.com/city/chandigarh/farmers-suicides-in-punjab-looking-beyond-indebtedness/articleshow/60353847.cms>>. Accessed on: Oct. 13 2019.
- SHARMA, N.; DANGI, K.L.; SINGH, S.P. Adoption of improved buffalo husbandry practices in tribal areas of Rajasthan. **Journal of Dairying, Foods and Home Sciences**, v.19, p.114-117, 2000.
- SHARMA, R.K.; PANGHAL, J.S.; MALIK, J.S.; SHEHRAWAT, P.S. Profile of crossbred owners, diseases encountered, and facilities in rural areas for raising crossbreds. **Indian Journal of Dairy Science**, v.47, p.954-958, 1994.
- SREERAM, V.; GUPTA, J. Kaheerasamruddhi – an innovative dairy value chain model from Kerala. **Indian Dairyman**, v.68, p.62-65, 2016.
- VIJAY, D.; BEDI, J.S.; DHAKA, P.; SINGH, R.; SINGH, J.; ARORA, A.K.; GILL, J.P.S. Knowledge, attitude, and practices (KAP) survey among veterinarians, and risk factors relating to antimicrobial use and treatment failure in dairy herds of India. **Antibiotics**, v.10, art.216, 2021. DOI: <https://doi.org/10.3390/antibiotics10020216>.
-