Indian J Dairy Sci 79(2): 192-200
https://doi.org/10.33785/IJDS.2026.v79i02.013

RESEARCH ARTICLE

Dairy farmers' knowledge and practices in silage-making *Vis-a-Vis* assessment of silage quality and silo structures at field level in Punjab (India)

Kajalpreet Kaur[1] , Jaswinder Singh[1], Jaspal Singh Hundal[2], Akshita Chadda[1](✉), Rajesh Kasrija[1] and Paviter Kaur[3]

Received: 12 June 2025 / Accepted: 10 November 2025 / Published online: 23 April 2026

Abstract: This research examines the knowledge and practices of dairy farmers regarding silage production, along with the silage quality and silo structures in the Punjab (India). Data on knowledge, practices, and silo structures were collected from 385 silage-making farmers, selected through multistage sampling techniques across the state using a pre-tested and structured interview schedule. A total of 100 silage samples were examined for quality characteristics and Flieg score, and 18 samples were tested for mycotoxin levels. The results highlighted that 52.72% of farmers had a medium level of knowledge and practice score. The majority of farmers prepared silage on their own (84.42%), lined the bottom of the silo with tarpaulin, straw, or both (85.5%), covered the silo from the top immediately after compaction (74.03%), fed the silage round the year (81.56%), removed silage from the silo manually on a daily basis (84.94%), and were unaware about silage additives (79.74%). The knowledge-practice score was positively correlated ($p < 0.01$) with herd size ($r = 0.185$), milk production ($r = 0.159$), land owned ($r = 0.125$), and training attended ($r = 0.626$). The average dry matter, pH, crude protein, lactic acid, and ammonia nitrogen were 29.52±1.30%, 4.34±0.94, 9.36±0.88%, 4.34±0.58%, and 9.82±2.3%, respectively. The average Flieg score of silage was 90.58±36.82, indicating good quality. The mean mycotoxin level was 18.49±16.0 ppb (range 2.10 - 50). The majority of respondents (n=275) had pit silos while the rest of the 110 farmers had stacked silos. The average dimensions (length x breadth x depth) of the silo were 59.07 x 17.74 x 3.08 feet. Around 21% of participants reported challenges in silage-making, while 28% faced issues with silage feeding. The research identified the areas of silage production that require greater attention from researchers and extension service agencies to enhance the knowledge and practices of dairy farmers.

Keywords: Dairy farmers, Knowledge, Practice, Silage quality, Silos

[1]Department of Veterinary and Animal Husbandry Extension Education,
[2]Department of Animal Nutrition
[3]Department of Veterinary Microbiology
Guru Angad Dev Veterinary and Animal Sciences University (GADVASU), Ludhiana, India

(✉)Email: akshitachadda@gadvasu.in

Introduction

Green fodder being the natural feed for animals, economical source of nutrients and other mutlifacet benefits become the inseparable portion of the dairy industry. Owing to small holding, different cultivation practices, daily cutting and chopping, labour demanding, non uniform availaility of quality fodder throughout the year, conservation of fodder through silage and hay is generally recommended. The anerobically fermented and acidic product from the fodder crops is known as silage (Wilkinson 1990). Maize is a highly nutritious non leguminous fodder crop for silage production due to its high yield, stable nutritional profile, and high sugar content (Karnatam et al. 2023). Good quality silage has a pH of 3.8-4.2, pleasant colour, aroma, and smell, while foul odour, blackish colour indicates poor quality.

India - the largest producer of milk globally, with output increasing by 3.83% from 222.07 million tonnes in 2021–2022 to 230.58 million tonnes in 2022–2023 (BAHS 2023). This remarkable rise demonstrates the nation's commanding lead in the world dairy industry. However, consistent supply of quality feed is required for the long-term viability and affordability of livestock production, which are necessary to maintain this increase. However, there are notable seasonal and geographical variations in the supply of high-quality fodder in India, which poses continuous difficulties for the dairy enterprise. Punjab, with a bovine population of 65 lakhs is producing14.30 million tonnes of milk annually (BAHS 2023). In Punjab, different types of fodder viz maize, barley, pearl millet, lucerne, berseem, sorghum, oats are available to the animals in different seasons. Due to many quoted benefits (Kumar et al. 2019; Khaleduzzaman et al. 2010), dairy farmers of Punjab are now shifting from fresh fodder feeding to silage feeding. Different strata of dairy farmers are using different practices in making the silage across the state. Knowing these variances may make it easier to pinpoint effective practices for

enhancing silage production and highlight areas where extension services may make improvements (Ponnusamy et al. 2019). The present study was thus planned with the objectives to explore the knowledge and practice of dairy farmers regarding conservation of green fodder as silage and to evaluate the quality parameters of silage prepared at farm level.

Materials and Methods

Ethical Statement and study area

The study was carried out from Feburary 2024 to December 2024 in the Punjab state (latitude 30°4' N and longitude 75°5' E) of India and in accordance with Declaration of Helsinki and national guidelines ensuring voluntary participation, informed consent, anonymity, and data confidentiality. The state comprised of 22 districts and two rivers namely Sutlej and Beas divide the state into three regions as Majha (above Beas River), Malwa (below Sutlez river) and Doaba (between Beas and Sutlez rivers), which were diverse in their dialect as well as in farming practices.

Sample size determination

The related information was collected from the 385 silage making farmers through structured interview schedule by personal interview method. The sample size of 385 was calculated using online software (*https://www.statulator.com/SampleSize/ss1P.html*) based upon 50% response distribution, 5% margin of error and 95% confidence interval. The respondents were selected using multistage sampling technique in which 50% of the total districts (n=11, 3 from Majha and 4 from each Malwa and Doaba regions) and 44 villages (four villages/district) and 8-10 farmers per village was covered to collect the required number of samples. The inclusion criteria of respondents comprised of minimum 18 years of age, knowledge of Punjabi language and involved in silage making process.

Development of interview schedule and piloting

A well-structured interview schedule was developed after a comprehensive review of litrature and in discussion with the experts of the university. It comprised of open ended, close ended and binary questions exploring respondents on existing knowledge on fodder and silage, field practices adopted in making silage, benefits of silage feeding and challenges in silage making and feeding. The interview schedule was divided into five sections namely i) characterization of respondents, ii) knowledge about fodder and silage, iii) practices related to the conservation of green fodder as silage, iv) benefits and challanges in silage and v) evaluation of silo structure.

The interview schedule so developed was piolted among 40 silage making farmers to assess the clarity, validity and ambiguity of cotent if any. Accordingly, two questions were modified and one question was omitted to improvise the schedule for the ease of respondents. Data from this pretesting study were excluded from the main study. This improvised interview schedule was then used for data collection from respondents.

The practices and knowledge level were assessed through construction of 15 statements and the scores were calculated using 1 for each correct answer and 0 for each incorrect answer. The total knowledge and practices (KP) score for each respondent was computed by sum of their individual scores and were categorized accordingly as low (Mean- S.D), medium (between low and high) and high (Mean +S. D). Silo structure and dimesnions were practically measured using standarized measuring tape.

Silage quality estimation

A total of 100 samples (32 samples from Malwa, 30 from Majha and 38 from Doaba region) were collected one from every 3rd or 4th farmer surveyed. Approximately, 2 kg of silage sample was collected from different deep spots (W pattern) from the face of the silo for silage quality analysis. All the samples were properly mixed and stored in clean air tight bags and were stored in deep freezeer till further processing. Beside colour and smell, DM (Oven method), pH (digital pH Meter), crude protein (Kjeldahl method), lactic acid (colorimetric method) and ammoniacal nitrogen (Kjeldahl method) were estimated using standard protocols. Further, Fleig Point (FP) was also calculated (Dong et al. 2017) using following equation

$$FP = 220 + (2 \times DM\% \quad 15) \quad 40 \times pH$$

Higher scores indicate better quality. Fleig's index categorizes silage into five quality levels: very inferior (<20), inferior (21-40) medium (41-60), good (61-80), and very good (81-100). Further 18 samples (6 samples taken from each of the three regions) were analysed for mycotoxin level using HPLC.

Statistical analysis

Data were tabulated, coded and analyzed using software like MS excel as well as statistical package for the social science (SPSS). Descriptive statistics which included frequencies, percentages, and means were performed for continuous/categorical variables. Analysis of variances (ANOVA) followed by Tukey's HSD Test were performed to compare the quality parameters of silage across the three regions of Punjab.

Results and Discussion

Characterization of respondents

Majority of respondents were male (97.14%), above 36 years of age (88.57%), educated up to higher secondary and above (67.79%), 63.12% of families have a family size of 5 or more. and were practicing dairy farming as their main occupation (64.94%).

Additionally, 52.47% respondents had more than 30 adult animals and Around 15% of farmers had 11–20 adult animals, while 5% of farmers had 21–30 adult animals. Most of the farmers (89.87%) had of more than six years of experience and were producing 200 litres of milk/day at their farm. 15% respondents owned >25 acres of land while 42.34% owned between 10-25 acres of land. Interestingly majority of the respondnets (84.68%) did not attend any training on dairy or silage making.

Knowledge of respondents about green fodder and silage

All farmers acknowledged the necessity of green fodder for dairy animals. Beside the natural feed and providing the sense of fullness to dairy animals, green fodder improves milk production, milk fat, digestibility and overall health and reproductive status of the animal (Table 1).

Quote: According to some respondents, the inclusion of green fodder in the diet enhances animal growth and body weight and helps lower the incidence of retained placenta.

Most of the farmers were found unaware about the right quantity of green fodder required for an adult animal. The general thumb rule is to give 10% of body weight however in present study it varied from 5 to >20 kg/animal/day. Non availability of green fodder round the year was the major reason quoted (84%) for

Table 1: Knowledge of respondents about green fodder

Particulars	Category	Frequency (n=385)	Percentage
Advantages of green fodder	Increases milk production	173	44.9
	Improves digestibility	92	23.9
	Increases milk fat	72	18.7
	Green fodder keeps animals full and satisfied.	26	6.8
	Improves the overall health	22	5.7
Daily amount of green fodder provided per adult animal	5-10kgs	13	3.38
	>10-15kgs	118	30.65
	>15-20kgs	173	44.94
	>20kgs	81	21.04
Do you know about leguminous fodder crops (e.g., Lucerne, Cowpea) and non-leguminous fodder crops (e.g., Maize, Sorghum)?	Yes	240	62.34
	No	145	37.66
	Don't know	145	37.66
Knowledge about name of leguminous fodder crops	Matar	125	32.47
	Beans	88	22.86
	Green grams	11	2.86
	Masoor	9	2.34
	Mustard	7	1.81
	Don't know	145	37.66
Knowledge about name of non-leguminous fodder crops	Wheat	26	6.75
	Berseem	106	27.53
	Lucerne	80	20.78
	Barley	19	4.94
	Sorghum	9	2.34
Differences between leguminous fodder crops and non-leguminous fodder crops	Yes	18	4.68
	No	367	95.32
Knowledge about the toxic factors present in fodder crops	Yes	13	3.38
	No	372	96.62
Do you have round-the-year availability of fodder crops (e.g., Maize, Lucerne, Sorghum, Cowpea)?	Yes	60	15.58
	No	325	84.42
During which months do you experience scarcity of fodder crops	No scarcity	60	15.58
	Scarcity between March-April	87	22.60
	Scarcity between April-July	221	57.40
	Scarcity between November-January	17	4.42

less offering, further scarcity of green fodder majorly prevails between March and July months of the year. Interestingly, on asking "Do you know leguminous and non-leguminous fodder crop"62% respondents quoted yes but nearly all (95%) were not able to tell the difference between these two.

Majority of the farmers (79.22%) stated that silage can be made from non-leguminous crops, followed by 5.97% and 14.81% mentioned that silage can be made from leguminous crops and both non leguminous crops as well as leguminous crops respectively. The optimum dry matter required in fodder crop to be ensiled should be 30-35%, but majority of respondents (78%) were unaware about it as well as for dry matter content of silage. Majority respondents revealed that for making silage the chop length of fodder crop should be > 2-3 cm (72%) and minimum days need for silage making varied between 41 and 50 (86%). The desired colour of good quality silage is greenish yellow but surprisingly 13% respondents quoted dark brown colour. Additionally, 15% respondents quoted sweet odour as desirable against the lactic acid/vinegar odour indicating their ignorance on the topic. Majority farmers were found unaware about the prominent acid (lactic acid) in the silage as well as optimum pH of the silage (Table 2)

About acquisition of silage related information and knowledge, a significant 65.19% of farmers gained their knowledge from progressive farmers followed by 15.06% from veterinary university, 17.14% from Agriculture University and 2.60% from Farmer outreach centre. According to NSSO (2005), farmers acquire a significant portion of their knowledge from other farmers.

When asked about additives used in making silage, 79.74% (n=307) farmers were unaware of any additives while only 20.26% (n=78) were familiar with the additives used in silage production. Additionally, fenugreek (0.77%), sodium bicarbonate (1.55%), soybean cake (1.81%), molasses (4.41%), and salt (11.68%) were mentioned as additives.

Practices of respondents regarding silage making

All dairy farmers surveyed reported using maize for silage production, primarily because of its high carbohydrate and energy content, beneficial nutrient profile, and excellent fermentability and high ensilability (Allen et al. 2003; Karnatam et al. 2023). All farmers were using private varities of maize and were found harvesting maize with movable harvestror with chop length of 2-3 cm (73%) but at different stage like milking stage (64%), flowering stage (24%) and in between these two stages. Previously, Brar et al. (2017) evalauted different varities of maize for silage making and found P-1844 as superior one along with low ammonical nitrogen and aflatoxin level. Smaller fodder chop size ensures proper compaction, anarobic condition, fermentation

Table 2: Knowledge about silage

Particulars	Category	Frequency	Percentage
Optimum dry matter required in fodder	Don't know	299	77.66
	25-30DM %	23	5.97
	>30-35DM%	51	13.25
	>35DM%	12	3.12
Chop length of fodder crop	1-2cm	105	27.27
	>2-3	280	72.73
Minimum days required to make silage	<40 days	36	9.35
	41-50 days	330	85.71
	>50 days	19	4.94
Optimum dry matter content of silage	Don't know	299	77.66
	25-28DM%	23	5.97
	>28-31DM%	51	13.25
	>31-34DM%	12	3.12
Colour of silage	Greenish yellow	191	49.61
	Greenish brown	146	37.92
	Dark brown	48	12.47
Odour of silage	Vinegar	322	83.64
	Sweet	58	15.06
	No smell	5	1.30
Prominent acid in silage	Don't know	328	85.19
	Lactic acid	44	11.43
	Butyric acid	13	3.38
pH of silage	Don't know	326	84.68
	3-4	21	5.45
	>4-5	38	9.87

Table 3: Practice of farmers for the conservation of green fodder as silage

Particulars	Category	Frequency	Percentage
Varieties of fodder crop used for making silage	Private Firm1	367	95.32
	Private Firm 2	10	2.60
	Private Firm 3	8	2.08
Chop size of fodder crops	1-2cm	105	27.27
	>2-3cm	280	72.73
Silage preparation	Self + labour	325	84.42
	Hired professionals	60	15.58
	Don't hire	325	84.42
Charges paid to experts (such as fodder specialists or silage technicians)	3000-4000 Rs/acre	15	3.90
	4001-5000 Rs/acre	30	7.79
	5001-6000 Rs/acre	15	3.90
Stage of crop used for making silage	Milking	248	64.42
	Flowering	91	23.64
	Between milking and flowering	46	11.95
Days taken from harvesting crop to covering the silo	4 to 5	99	25.71
	>5 to 7	265	8.83
	>7	21	5.45
Covering of pit	Immediately	285	74.03
	Next day	100	25.97
Covering of silage after removal on daily basis	Covering after daily removal	308	80.00
	Don't cover daily	77	20.00
Prevention of soil contamination from the bottom as well as from sides of silo	(Tarpaulin) Tarpal / polythene	158	41.04
	Straw	56	14.55
	Both	115	29.87
	Nothing	56	14.55
Monitoring the quality of silage	Visual smell/taste	370	96.10
	Lab test	15	3.90
	Other	0	0
Period of feeding of silage	Round the year	314	81.56
	Scarcity period	71	18.44
Removal of silage manually or with machinery	Manual	327	84.94
	Mechanical	58	15.06
Feeding silage to all animals	Yes	364	94.55
	No	21	5.45
Feeding of fungal infested silage	Yes	42	10.91
	No	343	89.09
Testing of fungal infestation in silage	Yes	46	11.95
	No	339	88.05
Feeding of silage	As such	281	72.99
	Mixing with straw	73	18.96
	Mixing concentrate and straw	31	8.05
Quantity of fodder used to make silage	Less than 500qts	38	9.87
	500-1000qts	74	19.22
	>1000qts	273	70.91
Quantity removed from silo everyday	Less than 10qts	31	8.05
	10-15qts	65	16.88
	15-20qts	87	22.60
	>20qts	202	52.47
Acres of fodder ensiled	1-3acres	38	9.87
	>3-5acres	74	19.22
	>5-7acres	219	56.88
	>7acres	54	14.03
Additives used in preparation of silage	Yes	26	6.75
	No	359	93.25

quality and stability (Neumann et al. 2007) while longer chop length resulted in less grain being cracked which ultimately end up in dung (Bernardes and DoRego 2014). Only 16% farmers in present study were found hiring professional services at the rate varied between Rs 3000 and Rs 6000 per acre for making silage. It took 5-7 days from harvesting crop to covering the silo for majority of farmers (68.83%) and around 26% reported 4-5 days. Earlier, (Brar et al. 2017) quoted that farmer took 1-3 days to fill the pit. All dairy farmers surveyed, utilized mechanical mean i.e. tractors to press chopped fodder for silage production to exclude maximum air. Silo should be covered immediately after pressing to exclude maximum air for anaerobic condition, majority farmers (74.03%) in the present study were found doing the same while 25.97% reported to cover the silo on next day.

Majority farmers lined the bottom of silo with tarpauline, straw or both (85.5%), fed the silage round the year (81.56%), removed silage from silo manually on daily basis (84.94%), check quality of silage through visual or smell (96.10%), fed silage to all their animals (94.55%) and were feeding as such (73%) without mixing with straw or concentarte (Table 2). Face management is very important aspect in silage feeding. In the present study 33.51% farmers reported to remove silage vertically, and rest 66.49% reported to remove silage in horizontaly or block cutting method. Further, 80% farmers reported to cover the face after silage removal. Heterogeneously removing silage is reflective of poor silo design (oversized) in relation to the number of animals to be fed (Bernardes and Do Rêgo 2014).

Feed-out around 15cm/day from the bunk face in order to minimize aerobic deterioration resulting in nutrient losses (Pitt and Muck 1993).

Additionally, majority of respondents were using >1000 quintals of fodder for silage making (70.91%), not using any additive in silage (93.25%) and never tested their silage for fungal infestation (88%).

Nearly, 11% farmers in the present study reported to fed fungal infested silage to their animals. Feeding of spoiled and fungal infested silage not only limit the dry matter intake (Whitlock et al. 2000) but also negatively affect the health of the animals (Lindgren et al. 2002) and quality of their products (Tabacco et al. 2009).

Around 7% respondents were found using some additional feed stuffs/additives like salt (3.11%), molasses (1.81%), soybean cake (0.5%), Sodium bicarbonate (0.77%) and Fenugreek (0.51%).

Quote: *As per respondents' perceptions, the addition of fenugreek to silage enhanced its palatability and aroma, resulting in greater feed consumption and better digestive response among animals.*

Addition of salt, molasses, soyabean, and sodium bicarbonate were reported to have variable affect of silage quality or animal performance (McLaughlin et al. 2002; Liu et al. 2020; Regueira et al. 2015; Dawson and Steen 1997). Inclusion of fenugreek in ruminant feed is still a researchable topic as few sudies quote positive affect (Mir and Kumar 2012; Zeng et al. 2024) while other found no or negative effect (Alemu and Doepel 2011).

Quality silage can be prepared without any silage additive by ensuring the correctness of all management steps in the process (Bernardes and Do Rego 2014); however, silage additive depending upon their nature/type can enhance the silage quality through different mode of action. Additives cannot create high-quality silage from poor-quality forage, but they can help convert top-quality forage into excellent silage (Kenilworth and Warwickshire 2012). Additioally, additives minimise DM losses during ensiling and maintain nutrients throughout the fermentation and feed-out phases (Kung et al. 2003).

Theses practices reflect a combination of traditional methods with some gaps in technical knowledge, highlighting the need for extension services and training to promote best practices in silage preparation and quality management.

Evaluation of silo structure

Among all the surveyed dairy farmers, 275 farmers had silo pit, while 110 farmers had a pile or stacked silo, with variations in dimensions as given in Table 4. Stacked silo (ensiling without a structure) is gaining popularity due to low cost, ease of adoption however it is more prone to covering material damage and air exposure and have low density (Savoie and Jofriet 2003). Comprehensive research is necessary to determine its appropriateness in the nation's warm environment. The variation in silo structure was presented in Table 4.

While majority of the respondents (92.73%) had silo in or just around the farm, only 7.27% respondnets had silo outside the farm ranging from 500 m to 3 Km distance (7.27%). Further maority of farmers (85.45%) were found covering the bottom of silo with polythene sheet (41.04%), straw (14.55%) and both (29.87%) respectively.

Benefits and challenges in silage feeding

Silage feeding reported to boosts milk production (34.81%) with higher fat percentage (15.32%), cost effective (16.62%), improved body condition score (13.51%), less time consuming (13.51%) and no repeat breeding problems (6.23%). High energy, a steady and balanced nutritional supply, high-quality fibre, good digestion, and increased management efficiency might all contribute to the advantages mentioned. The most common issue was the difficulty in finding appropriate harvesting equipment, which may reflect limited mechanization access or the high cost of machinery. Fungal contamination was also a concern, likely

caused by delayed pit covering, inadequate compaction, or poor silo maintenance. These findings were in relevance with Owhal (2023). Some respondents cited lack of storage infrastructure and trouble maintaining anaerobic conditions—critical for effective silage fermentation and preservation (Table 5). High-quality silage feeding enhanced animal performance as it guarantees a consistent supply of nutrients; while low-quality silage feeding might present several hazards.

At a panel discussion with various stakeholders on "Silage: from making to feeding" hosted by Guru Angad Dev Veterinary & Animal Sciences University, a veterinary official disclosed mastitis incidence on a farm that was giving subpar silage. (Video of the panel disussion available on YouTube @ https://www.youtube.com/watch?v=aRXSZLcxDrI. Feeding subpar silage not only deprived the animal from optimum nutrients but also weakens the animal's immune system, which leads to various illnesses including mastitis. Moreover, it was noted that many environmental bacteria that cause mastitis, such as streptococci and enterococci, can withstand the pH drop that occurs during ensiling (Petersson et al. 2011). Consuming these bacteria may result in higher bacterial concentrations in faeces, which might contaminate the udder through the environment. There are other additional variables that might cause mastitis, but discussing them is outside the purview of this paper. Repeat breeding in dairy cows may be caused by inadequate nutrition status with low-quality silage feeding, in addition to other well-cited causes. Low manganese content in corn silage may cause reproductive failure due to manganese deficiency in herds whose diet contains a high percentage of corn silage (Moellers and Riese 1988). Milk can gain a bad smell from the enironment especially when poor quality, is fed (Kalač 2011). Concerns about elevated aflatoxin levels were also noted, which may be due to fungal growth under poorly managed or humid storage conditions. Benfits and challenges of silage feeding have been discussed by many researchers (Albantov 2019; Wilkinson and Muck 2019), but the benefits of silage feeding outweigh the challenges when it is prepared and fed in an exacting and scientific manner. Little over the half of the respondnets (52.72%) had a medium knowledge and Practice (KP) score (between 5.6 and 8.75), while 40.25%

Table 4 Dimensions of silo

Variable Name	Mean	Standard Deviation	Min	Max
Length (feet)	59.07	11.15	32.00	75.00
Breadth (feet)	17.74	5.94	10.00	35.00
Depth (feet)	3.08	2.71	0.00	10.00
Calculated capacity of silo (in quantils)	637.41	497.68	114.09	3947.12

Table 5: Challenges faced during the conservation of silage and silage feeding

Category	Frequency	Percentage
a) Challenges during conservation		
No challenge	305	79.22
Difficulty in finding a harvester	32	8.31
Fungal infection	28	7.27
Unavailability of storage facilities	9	2.34
Difficulty in maintaining anaerobic conditions	6	1.56
Management issues due to changing weather conditions	5	1.30
b) Challenges during silage feeding		
No challenge	277	71.95
Increases the chances of mastitis	40	10.39
Unusual smell in milk	42	10.91
Presence of aflatoxin in milk	14	3.64
Increased repeat breeding/ reproductive problem	10	2.59
Reduction in milk production	2	0.52

Table 6: Descriptive analysis of silage quality parameters (n =100)

Name	Mean	SD	Min.	Q1	Median	Q3	Max.
DM	29.52	1.30	26.25	28.65	29.48	30.35	32.65
pH	4.34	0.93	3.10	3.61	3.99	4.90	7.47
CP	9.36	0.88	6.57	8.69	9.36	9.88	11.37
Lactic acid	4.34	0.58	2.83	4.04	4.30	4.61	6.52
NH_3N	9.82	2.30	5.12	7.96	9.67	11.79	14.70
Fleig Point	90.58	36.82	-34.10	68.40	104.10	116.80	142.80

respondnets had high KP score (>8.75) and rest 7.01% had low KP Score (<5.6). The current findings are consistent with those of Singh et al. (2018). The knowledge- practice score was positively correlated ($p<0.01$) with herd size ($r = 0.185$), milk production ($r = 0.159$), land owned ($r = 0.125$) and training attended ($r = 0.626$) respectively.

Quality analysis of Silage

Descriptive analysis of silage quality parameters was presented in Table 6.

One-way ANOVA revealed that there was a statistically significant difference in mean pH value ($F(2, 97) = 9.06$ ($p = 0.0002$), exist between the three regions of Punjab. Further, there were no statistically significant difference in mean dry matter value ($F(2, 97) = 1.65778$ ($p = 0.195915$), mean crude protein ($F(2, 97) = 0.14349$ ($p = 0.866516$), mean lactic acid ($F(2, 97) = 0.82272$ ($p = 0.442276$), and mean ammoniacal nitrogen ($F(2, 97) = 0.04117$ ($p = 0.959685$). Also, tukey's HSD Test found that the mean pH value was significantly differ between Malwa: Doaba ($p=0.0006$) and Majha: Doaba ($p=0.0049$). However, there was no statistical difference in pH value of silage in Malwa: Majha zones ($p=0.8172$). The mean pH of silage in Doaba area was found highest (4.80) while that of Malwa was 3.99. Overall Mean pH of silage was 4.34, a bit on higher side indicating exposure to air and improper fermentation during ensiling, likewise high average ammonical nitrogen content indicating ensiling too wet or too dry fodder crop. Other parameters were within prescribed standard range (Brar et al. 2017; Brar et al. 2019; Bernardes and Do Rêgo 2014). The average fleig score was 90.58±36.82 indicating good quality silage.

Silage can be contaminated with a variety of mycotoxins, originating from infection of the crop by moulds in the field (Field drived mycotoxin) or from growth of moulds in silage during storage (Ensilage derived mycotoxin) or feeding-out (Face derived mycotoxin). Prevention of mycotoxin contamination of silage requires different strategies (Driehuis 2013). Surprisingly, 50% samples were found to contain mcotoxin level above 20ppb (Average±SD, Min-Max: 18.49 ± 16, 2.10-50). In the present study, 3.64% respondents also showed their conern regarding presence of aflatoxin in milk due to silage feeding. Presence of mycotoxin in silage poses risk not only for livestock health and productivity (Ogunade et al. 2018), but also to consumer health. The level of mycotoxin (aflatoxin) should be well below 20ppb (Thakur et al. 2022).

Silage is regarded as a revolutionary technique in the dairy sector. Dairy producers are using it more and more, either by buying commercial silage bales or by making their own. The region does not currently have a framework in place for quality control and regulation. Poor quality silage may seriously harm the dairy sector. High-quality silage production requires a thorough understanding of the science and processes involved. Establishing a regulatory and quality assurance framework in conjunction with capacity building can give stakeholders more dependability.

Conclusions

Despite the fact that silage is usually well-liked and its advantages are widely acknowledged by dairy farmers, the existence of specific operational and technical gaps emphasises the necessity of focused education and training. The study found that dairy farmers in Punjab still lacked expertise in the fields of silage and fodder. Awareness of fodders, the silage process, the quality of the silage, the construction of the silos, the function of additives, face management, silage testing, and mycotoxin are some important issues that must be addressed at the earliest. The process of silage making should be better understood by farmers through specialised trainings that include hands-on demonstrations. Promoting collaboration between farmers, research institutions, and extension agencies can further enhance knowledge exchange and collective problem-solving, especially through the formation of cooperatives and farmer groups.

Acknowledgements

Authors are grateful to Vice Chancellor, Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana, Punjab, India for providing all necessary facilities and support in conducting this study. The authors are thankful to all the dairy farmers for their cooperation during the entire data collection process.

References

Albantov GP (2019) Advantages and Disadvantages of Maize Silage. In Innovative in Agriculture pp. 160-161

Alemu AW, Doepel L (2011) Fenugreek (Trigonella foenum-graecum L.) as alternative forage for dairy cows. Animal 5(9): 1370-1381

Allen MS, Coors JG, Roth GW 2003 Corn silage. Silage science and technology 42: 547-608

BAHS. Basic Animal Husbandry Statistics. (2023) Department of Animal Husbandry, Dairying and Fisheries. Ministry of Agriculture, Government of India

Bernardes TF, Do Rêgo AC (2014) Study on the practices of silage production and utilization on Brazilian dairy farms. J Dairy Sci 97(3): 1852-1861

Brar NS, Kumar B, Kaur J, Kumar A, Verma HK, Singh R, Singh, P (2019) Qualitative study of corn silage of cattle farms in subtropical conditions of Indo-Gangetic plains. Range Manag Agrofor 40(2): 306-312

Brar NS, Kumar B, Singh P, Kumar A, Singh P (2017) Qualitative assessment of silage prepared at farmer's field in Tarn Taran district of Punjab. Indian J Anim Nutr 34(3): 357–360

Dawson LER, Steen RWJ (1997) The effect of spreading sodium bicarbonate over the surface of grass silage on the intake of grass silages by beef cattle. Anim Feed Sci Technol 67(1): 61-67

Dhand NK, Khatkar MS (2014) *Statulator: An online statistical calculator. Sample size calculator for estimating a single proportion.* Retrieved from http://statulator.com/SampleSize/ss1P.html.

Dong Z, Yuan X, Wen A, Desta ST, Shao T (2017) Effects of calcium propionate on the fermentation quality and aerobic stability of alfalfa silage. Asian-Australas J Anim Sci 30(9): 1278

Driehuis F (2013) Silage and the safety and quality of dairy foods: a review. Agric Food Sci 22(1): 16–34

Kalač P (2011) The effects of silage feeding on some sensory and health attributes of cow's milk: A review. Food Chem 125(2): 307-317

Karnatam KS, Mythri B, Un Nisa W, Sharma H, Meena TK, Rana P, Sandhu S (2023) Silage maize as a potent candidate for sustainable animal husbandry development perspectives and strategies for genetic enhancement. Front Genet 14: 1150132

Kenilworth, Warwickshire (2012) Silage Additives. Dairy Co. Agriculture and Horticulture Development Board, Stoneleigh Park

Khaleduzzaman ABM, Akbar MA, Shamsuddin M (2010) Low-cost silage technology increases milk production and farmer's income in north-western districts of bangladesh. Successes and Failures with Animal Nutrition Practices and Technologies in Developing Countries 91

Kumar B, Brar NS, Kumar A, Verma HK, Singh R (2019) Nutritious feed for farm animals during lean period: silage and hay-a review. Forage Research 45: 10-22

Kung Jr L, Stokes MR, Lin CJ (2003) Silage additives. Silage Sci Technol 42: 305-360

Lindgren S, E Oldenburg, G Pahlow (2002) Influence of microbes and their metabolites on feed and food quality. Proceedings of the 19th General Meeting of the European Grassland Federation, La Rochelle, France, pp. 503–511

Liu B, Yang Z, Huan H, Gu H, Xu N, Ding C (2020) Impact of molasses and microbial inoculants on fermentation quality, aerobic stability, and bacterial and fungal microbiomes of barley silage. Scientific Reports 10(1): 5342

McLaughlin A M, Erickson PS, Hussey JS, Reid ED, Tanguay JA (2002) NaCl Addition to the Top Layer of Corn Ensiled in Bunker Silos1. Prof Anim Sci 18(1): 90-92

Mir I.A, Kumar R (2012) Effect of feeding fenugreek seeds (Trigonella foenum-graecum) as feed additive on nutrient utilization in goats. Ind J Anim Nutr 29(3): 256-261

Moellers J, Riese R (1988) Nutritional causes of infertility in dairy cows. Vet student 50(2): 89-94

NSSO. National Sample Survey Organisation (2005) Situation assessment survey of farmers: Income, expenditure and product use (NSS 59th Round, Report No. 497). Ministry of Statistics and Programme Implementation, Government of India. https://mospi.gov.in

Neumann M, Mühlbach PRF, Noernberg JL, Ost PR, Lustosa SBC (2007) Effect of particle size and cutting height of corn on the dynamics of the silage fermentation process and feed-out period. Revista Brasileira de Zootecnia 36 : 1602-1613

Ogunade IM, Martinez-Tuppia C, Queiroz OCM, Jiang Y, Drouin P, Wu F, Adesogan AT (2018) Silage review: Mycotoxins in silage: Occurrence, effects, prevention, and mitigation. J Dairy Sci 101(5): 4034-4059

Owhal HU (2023) Adoption of silage production practices by dairy farmers in Western Maharashtra. Dissertation, MAFSU, Nagpur

Patty RL, Cave RA (1938) Pit and trench silos. SDSU Extension Circulars 931

Petersson-Wolfe CS, Masiello S, Hogan JS (2011) The ability of common mastitis-causing pathogens to survive an ensiling period. J dairy Sci 94(10): 5027-5032

Pitt RE, Muck RE (1993) A diffusion model of aerobic deterioration at the exposed face of bunker silos. J Agric Eng Res 55:11-26

Regueira JPS, Pereira OG, Filho SDC V, Ribeiro KG, Garcia R, Cezário AS (2015) Soybean silage in the diet for beef cattle. Acta Sci Anim Sci 37(1): 61-65

Savoie P, Jofriet JC (2003) Silage storage. Silage Sci Technol 42: 405-467

Singh P, Rampal VK, Sidhu SK (2018) Comparative Analysis of Knowledge Level of the Trained and Untrained Dairy Farmers of Punjab. Indian J Econ Dev 14(1a): 502-508

Tabacco E, Piano S, Cavallarin L, Bernardes TF, Borreani, G (2009) Clostridia spore formation during aerobic deterioration of maize and sorghum silages as influenced by Lactobacillus buchneri and *Lactobacillus plantarum* inoculants. J Appl Microbiol 107(5): 1632-1641

Thakur S, Singh RK, De PS, Dey A (2022) Aflatoxins in feeds: Issues and concerns with safe food production. Indian J Anim Health 61(1): 01-13

Whitlock LA, Wistuba T, Siefers MK, Pope RV, Brent BE, Bolsen KK (2000) Effect of level of surface-spoiled silage on the nutritive value of corn silage-based rations. J Dairy Sci 83(Suppl. 1):110. (Abstr.)

Wilkinson JM (1990) Silage UK 6th edition Chalcombe publications, Marlow, UK. pp. 1-166

Wilkinson JM, Muck RE (2019) Ensiling in 2050: Some challenges and opportunities. Grass Forage Sci74(2): 178-187

Zeng X, Chen Y, Li W, Liu S (2024) Application of fenugreek in ruminant feed : implications for methane emissions and productivity. PeerJ 12: e16842