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Adoption of silage production practices by dairy farmers in western Maharashtra

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Abstract

The present study was conducted in the Pune, Ahmednagar Satara, and Sangli districts of Western Maharashtra for the assessment of the socio-economic profile, knowledge level, adoption of silage production practices, and constraints faced by dairy farmers. Most of the dairy farmers included in the study were in the middle age group, literate, had medium family size, had dairy farming as a secondary occupation, and fell into the medium milk production category. They were holding small land size and medium herd size. Similarly, most of them had medium experience, medium level of social participation, and extension contact. Almost all the socioeconomic variables studied were at a medium level. Most of the dairy farmers had a medium-level knowledge of silage production and its use. A medium level of adoption (69%) was observed, followed by a low level of adoption (21%) and a high level of adoption (10%) of silage production practices. Overall, the adoption index for all the silage production practices was found to be average (41.55). Land size, herd size, occupation, milk production, annual income, education, social participation, and knowledge level were found to be significantly associated with the adoption of silage production practices. Several constraints for dairy farmers hampered the adoption of silage production and utilization practices. The high cost of the harvester machine, unavailability of storage facilities, lack of knowledge regarding the exact proportion of ingredients used for silage, proper storage of silage, scarcity of fodder crops for silage making, lack of knowledge regarding silage production were the major constraints faced by dairy farmers towards the silage production. Awareness campaigns must be organized to increase the rate of adoption of silage production practices through subject-specific training and demonstrations.

Keywords: Adoption, silage production practices, knowledge level, dairy farmer

Introduction

The livestock sector plays an important role in the rural economy and different livestock species are reared under the crop-livestock integrated farming system. Dairy farming is a significant source of income and employment. The low yield of feed crops in India's farming industry is one of its distinguishing characteristics (Sagar *et al*., 2013) [8]. Silage is a possible alternative to other feed sources in times of fodder shortage. Green grasses that have been squeezed tightly and without oxygen are used to make silage. The most crucial element in the development of dairy and cattle is providing dairy animals with nutrient-rich feed. Silage feeding is possible because to the lack of green fodder throughout the summer and in places with insufficient irrigation facilities. Making silage is a pretty straightforward operation that involves harvesting green feed, compressing it, and then sealing it in an airtight container. (Danner *et al*., 2003) [3]. The fundamental issue with silage production is the wide range in the forage's DM content or nutritional quality. Cattle, primarily dairy cows, eat corn silage as a source of energy and fibre (Borreani and Tobacco, 2010) [2]. If silage is not prepared properly, there may be more waste. Imperfectly prepared silage won't be consumed by animals. Production of high-quality silage is dependent on both controllable and uncontrollable factors (Mahanna and Chase, 2003) [4]. Unexpected climate-related factors, such as the moisture content of the crop at harvest, can have a negative impact on the production and use of silage. Even though ensiling is used in India, there is a dearth of scientific information regarding the methods dairy farmers use to produce and use silage. Finding out what practices dairy farmers have followed about the production and use of silage is crucial. Silage is popular in the western regions of Maharashtra, where several sorts of preparations, including

bunker, tank, silo, and bags, are used based on the silage needs. However, scientific studies on its preparation practices, utilization practices, and constraints faced by dairy farmers and livestock owners were not conducted. The present study aimed to determine the knowledge, and practices followed by dairy farmers towards silage production and utilization in parts of Maharashtra. This study can help in the development of tailor-made strategies to address dairy farmers' overcoming constraints regarding silage production and utilization. Hence, the present study, "Adoption of silage production practices by dairy farmers in western Maharashtra" was undertaken.

Materials and Methods

The study was carried out in the Pune, Satara, Solapur and Ahmednagar districts of western Maharashtra as more number of dairy farmers inhabited in these districts, and milk production besides livestock farming is one of the major occupations of the farmers. The present study utilized an ex-post facto research design. A total of 60 dairy farmers were selected from each district by purposive random sampling. Thus, a total of 240 respondents were selected from these four districts. They were interviewed with the help of a structured interview schedule, keeping in view the objectives of the study. The adoption was measured by developing an adoption schedule. An adoption index was utilized to quantify the adoption level of practices and corresponding rank order was given to each practice. The overall adoption index was calculated by using the adoption index methodology. Collected data will be analyzed using appropriate statistical tools.

Results and Discussion

Socio-economic profile of dairy farmers

Age

The distribution of respondents according to age is presented in Table 1. It was categorized into young, middle, and old age groups. Present findings revealed that the majority of the respondents (70%) were from the middle age group followed by the old age group (17%) and young age group (13%). It was noticed that the middle age group is commonly engaged in dairy farming activities because they manage family responsibilities very well.

Gender

It was observed that (Table 1), most of the respondents were male (96%) only 4% were female respondents. The majority of the dairy farmers being studied are males who organize their dairy business with the help of women.

Education

The educational status of dairy farmers is expressed in Table 4.3 which revealed that most of the dairy farmers attended secondary school level of education (42%), followed by higher secondary school (36%), schooling up to primary level (10%), graduation (09%) and illiterate (3%). According to the study's findings, respondents were accessible to schooling and recognized its importance in the decision-making process. This level of literacy could be attributed to the study areas' positive social and educational environments, as well as their awareness of the importance and need for education in life.

Occupation

The distribution of the respondents according to occupation is presented in Table 1, which revealed that most of the dairy farmers (78.75%) chose dairy farming as a subsidiary occupation followed by dairy farming as a main occupation (21.25%). Dairy farming is a traditional source of income in the study area, usually done alongside agricultural farming, and is regarded as a significant additional source of income. The vast majority of the farmers in this study agreed on the same pattern.

Family size

The distribution of the respondents according to their family size is presented in Table 1. Results showed that maximum number of respondents (71%) had medium family size followed by small family size (25%) and large family size (4%). A large percentage of respondents in the study area have a medium family size, which could be due to the fact that a significant number of respondents reside with their close family members. The medium family size greatly helped them in their dairy endeavors.

Annual Income

Categorization of dairy farmers' annual income was done through mean and standard deviation. Results (Table 1) revealed that the majority of dairy farmers belonged to the medium annual income group 1, 51,782 to 7,41,133 (89%), high annual income group, (4%) and low annual income group (7%). Because of the fertile land and good irrigation, as well as the economically sound subsidiary business, the study area is considered highly developed.

Land size

The distribution of the respondents according to land size is presented in Table 1. The majority of the respondents (40%) had small land size followed by semi-medium land size (30%), marginal (20.41%), medium land sizes (8.33%), and landless (1.25%) categories. The size of landholdings may be decreasing due to land division over generations and changes in family integrity, as well as land use for industrial and private sector large-scale projects.

Herd size

From Table 1, it was observed that most of the respondents (85%) had medium herd size followed by small herd size (8%) and large herd size (7%). It was noticed that dairy farmers possessed an average of 4-18 dairy animals for dairy farming as a source of additional income generation in addition to agriculture.

Experience in dairy farming

It was noted that most of the respondents had a medium level of experience (57%) followed by a high level of experience (30%) and a low level of experience (13%) in dairy farming. Since the majority of the respondents were in the middle age range, the age group directly relates to the respondents' experiences.

Milk production

The distribution of respondents according to milk production of the dairy farmers were presented in Table 1. Results indicated that the maximum number of respondents

belonged to the medium category of milk production (79%) followed by the high category (13%) and the low category (8%) of milk production. These findings could be attributed to the fact that most of the farmers were having a medium herd size of 4-18 animals.

Social participation

The social participation of dairy farmers were presented in Table 1. Present findings revealed that the majority of respondents (73%) had a medium level of social contact followed by a low level of social contact (27%). The majority of them were found to be Panchayat Samitee and Gram Panchayat members, then milk cooperative societies. Several groups/societies exist to meet the demands of dairy farming, including prompt financial aid. As a result, the majority of respondents join them as members to receive these benefits.

Extension contact

Extension contact was categorized as low, medium, and high levels. Table 1 showed that the majority of the dairy farmers (53.33%) had a medium level of extension contact followed by a low level of extension contact (46.66%). No one is having a high level of extension contact. Most dairy farmers contacted friends, progressive dairy farmers and relatives for information, and they also used social media.

The majority of socio-economic variables were not included in any of the earlier studies conducted in India. Despite the fact that very rare researchers revealed the study results. According to Sharma *et al.* (2021) [9], the adoption of better fodder technologies and practices is significantly influenced by factors such as education level, standard livestock unit, animal breed type, off-farm revenue activities, farm size, and access to training, loans, and markets. Moreover, Singh (2022) [10] found that smallholder dairy farmers' adoption of silage-making is low and heavily reliant on the farmers' education, farming background, financial situation, and access to extension services. The way that technologies are adopted is significantly influenced by socioeconomic factors.

Table 1: Socio-economic profile of dairy farmers N=240

Sr. No	Category	Frequency	Percentage (%)
Age			
1	Young age (< 37 years)	31	13.00
2	Middle age (37- 47 years)	169	70.00
3	Old age (> 47 years)	40	17.00
Gender			
1	Male	231	96.00
2	Female	09	04.00
Education			
1	Illiterate	08	03.00
2	Primary	23	10.00
3	Secondary	101	42.00
4	Higher secondary	86	36.00
5	Graduation	22	09.00
Occupation			
1	Main	51	21.25
2	Subsidiary	189	78.75
Family size			
1	Small family size (1-4 members)	59	25.00
2	Medium family size (5-7 members)	171	71.00
3	Large family size (>7 members)	10	04.00
Annual Income			
1	Low (Up to Rs.1,51,782)	16	07.00
2	Medium (Rs.1,51,782 to 7,41,133)	213	89.00
3	High (Above Rs.7,41,133)	11	04.00
Land size			
1	Landless	03	01.25
2	Marginal	49	20.41
3	Small	96	40.00
4	Semi-medium	72	30.00
5	Medium	20	8.33
6	Large	00	00
Herd size			
1	Small (up to 4 animals)	19	08.00
2	Medium (4-18 animals)	204	85.00
3	Large (above 18 animals)	17	07.00
Experience in dairy farming			
1	Low (< 7 years)	31	13.00
2	Medium (7 - 23 years)	138	57.00
3	High (> 23 years)	71	30.00
Milk production			
1	Low (Up to 26 liters)	19	08.00

2	Medium (26 - 124 liters)	190	79.00
3	High (Above 124 liters)	31	13.00
	Social participation		
1	Low (up to 2)	65	27.00
2	Medium (2 to 4)	175	73.00
3	High (more than 4)	00	00
	Extension contact		
1	Low (Up to 0.02)	56	46.66
2	Medium (0.024 to 1.02)	64	53.33
3	High (More than 1.02)	00	00

Knowledge level of dairy farmers towards silage production and utilization practices

The knowledge level of dairy farmers towards silage production practices was evaluated in terms of basic and essential parameters and represented in Table 2. Results indicated that a higher percentage of dairy farmers fall under the medium level of knowledge category (69%) followed by low (22%) and high (9%) level of knowledge category. It was observed that a lack of subject-specific training programs, average social connections, and average information could all be contributing factors to a medium level of knowledge.

Table 2: Distribution of dairy farmers according to their knowledge level N = 240

Sr. No.	Categories	Frequency	Percentage (%)
1	Low (up to 28)	53	22.00
2	Medium (28 to 39)	166	69.00
3	High (above 39)	21	09.00

Distribution of dairy farmers according to their knowledge level towards silage production and utilization practices

As stated in Table 3, it was observed that majority of the dairy farmers had complete knowledge on silage feeding in scarcity period (81.00%), followed by pressing of chopped fodder while preparing silage (80.00%), feeding of silage is beneficial for milk production in dairy animals (74%), chopping size of the crops and thickness of stem (66.00%), crops used for preparation of silage and methods used for silage making (58%), bacterial culture used for silage production (57%), steps in silage making (56%), method of feeding of silage to dairy animals (56%), method of covering or sealing of silo pit or silo bag (54%), percentage of moisture of fodder crop used for silage (53%), after opening silage in silo pit, method to cover or seal of silo pit or silo bag again (52%), selection of fodder crop in early flowering stage (51%), required time period for silage (49.58%), duration of silage storage (49%), meaning of silage (48%), types of silo used for storage of silage (48%), method of opening of silo pit after preparation of silage (48%), growth of fungus in silage (37%), and colour of good silage (35%).

Uppermost partial knowledge was recorded in terms of the percentage of urea, jaggary, water and salt used in silage production (65%), followed by pH of silage (61%), odor or smell of silage (60%) and color of good silage (60%), growth of fungus in silage (55%), required time period for silage (50%) and meaning of silage (47%). Half percentage of the respondents don't know the types of silo used for the storage of silage followed by the pH of silage (20%), odour or smell of silage (15%), Percentage of urea, jaggery, water, and salt used in silage production (8%), and fungus growth on silage (8%).

Overall, the findings showed that most dairy farmers had a medium-level degree of understanding on the production and use of silage. We must place emphasis on the organization of trainings and awareness campaigns to advance understanding about the production and use of silage. Comparable findings were noted by Narain *et al.* (2016) [5]. They studied the adoption of fodder production and conservation technology in Bundelkhand, Uttar Pradesh, India, and concluded that the respondents had the highest knowledge about leguminous and non-leguminous fodder followed by fodder requirement and cropping scheme preparation based on the number of animals and importance of different roughages for animal health. The lowest adoption was found for the items for which there was the lowest knowledge level.

Table 3: Distribution of dairy farmers according to their knowledge level towards silage production and utilization practices N=240

Sr. No	Statements	Knowledge level					
		Complete		Partial		No	
		F	%	F	%	F	%
1	Meaning of silage	116	48	111	47	13	05
2	Crops used for the preparation of silage	140	58	90	38	10	04
3	Methods of silage making	139	58	89	37	12	05
4	Steps in silage making	135	56	98	41	07	03
5	pH of silage	46	19	147	61	47	20
6	Odour or smell of silage	59	25	144	60	37	15
7	Types of silo used for storage of silage	115	48	114	47	11	50
8	Percentage of moisture of crop used for silage	127	53	106	44	07	03
9	Bacterial culture (powder)used for silage production	138	57	95	40	07	03
10	Chopping size of the crops and thickness of the stem	158	66	77	32	05	02
11	Percentage of urea, Jaggary, water, and salt used in silage production	63	27	157	65	20	08
12	Selection of fodder crop in the early flowering stage	122	51	111	46	07	03

13	Duration of silage storage	118	49	108	45	14	06
14	Required time period for Silage	119	49	120	50	01	0.42
15	Method of the opening of silo pit after preparation of the silage	116	48	113	47	11	05
16	Method of the feeding of silage to dairy animals	135	56	96	40	09	04
17	Method of covering or sealing of the silo pit or silo bag	130	54	103	43	07	03
18	After opening the silage in the silo pit, a method to cover or seal it again	125	52	108	45	07	03
19	Colour of good silage	85	35	144	60	11	05
20	Growth of fungus in silage	89	37	133	55	18	08
21	Silage feeding is beneficial for milk production in dairy animals	178	74	55	23	07	03
22	Silage feeding will be helpful in a scarcity period	194	81	37	15	09	04
23	Pressing of chopped fodder while preparing silage	193	80	40	17	07	03

Silage production practices adopted by dairy farmers

The adoption of silage production practices has been studied as a dependent variable and results were presented in Table 4. Results depicted that a medium level of adoption (69%) was observed in most of the dairy farmers followed by a low level of adoption (21%) and a high level of adoption (10%). Every respondent prepares silage in accordance with the number of animals in the herd. Due to their unawareness of several aspects of silage production practices, the majority of respondents were categorized under a medium level of adoption. Similar results were observed by Narain *et al.* (2016) [5], who came to the conclusion that the items with the lowest adoption were those for which there was the lowest knowledge level. High adoption rates coincided with high knowledge levels. To enable farmers to acquire and utilize technologies for fodder production and conservation, it is, therefore, necessary to first educate them on better fodder utilization techniques. Reyes (2019) [7] evaluated the determinants of silage adoption in animal production units in the dry tropics of northwest Mexico and found that the probability of silage adoption by the farmers surveyed was 13.4%. The likelihood of adopting the practice of silage was higher among the farmers who had the most agricultural land and education. Thus, alternative methods like equipment leasing or the direct sale of silage gained through producer organizations should be looked for in order to expand the use of this technique among producers with limited resources. The farmers must be encouraged to adopt silage production and other technological innovations in the area of cattle feeding through the development of differentiated support and technology transfer strategies for various types of producers.

Slightly comparable results were revealed by Reiber *et al.* (2009) [6] wherein they noted that silage adoption has so far been low in the tropics, particularly under smallholder conditions. Innovation and adoption processes of silage technologies were promoted in drought-constrained areas of Honduras using a flexible, site-specific and participatory research and extension approach. They stated that when targeting the production system's needs and farmer demands, silage promotion can lead to significant adoption, including at the smallholder level, in the tropics.

Table 4: Silage production practices adopted by dairy farmers

Sr. No.	Category	Frequency	Percentage
1	Low (up to 43)	51	21.00
2	Medium (43 to 60)	165	69.00
3	High (above 60)	24	10.00

Practice-wise adoption of different silage-making practices

The adoption of different silage production and utilization practices was represented in the Table 5.

Method used for silage production

Table 5 represent the practices adopted by dairy farmers regarding the method used for silage production. Results revealed that the majority of the dairy farmers (88%) used bag silos and none of the respondents follow bamboo silos in the study area. Less than half of the respondents (33%) follow pit silo -underground storage without construction or with construction followed by bunker silo (19%). Tower silos and drum silos are adopted by less percentage of respondents. The findings indicated that respondents preferred the affordable bag silo over all other options because of its handiness, convenience in movability, due to less requirement of storage space, and ease of packaging. Likewise, some dairy farmers are nowadays using readymade balloon silage. It was noted that some of the farmers in the study area prepared bag silos and sold them to other farmers. Reiber *et al.* (2009) [6] found comparable results that little bag silage (LBS) is viewed as a low-cost ideal alternative for resource-poor smallholders to relieve dry-season feed shortages.

Preference of crops for silage making

The distribution of dairy farmers according to the preference of crops for silage making was presented in Table 5. From the results, it was observed that among cereal crops maize was a highly preferred crop (98%) for silage making due to its availability followed by jowar/sorghum and sugarcane tops. Among grasses, elephant grass (22%) was somewhat preferred for silage-making. None of the farmers used pulses for silage making as well as Rhodes, Sudan, and ruzi grasses in the study area. Similar results were noted in a study on silage production and consumption on dairy farms in Brazil, Bernardes and Rego (2014) [1] found that maize was the most often cultivated crop for silage. The other species that were frequently cited were sugarcane, sorghum, and tropical grasses. Parallel findings were observed by Wendling and Filho's (2018) [11] wherein they noted that milk production is heavily reliant on maize silage, even in pasture production systems. Even if they don't employ technical criteria for the production and supply of silage to dairy cows, farmers appear to rely primarily on maize silage to ensure the annual availability of feed and enhance milk production.

Selection criteria of fodder crops for silage making

Table 5 showed the adoption of practices regarding the selection criteria of fodder crops for silage making by dairy farmers. More than fifty percent of the dairy farmers were aware of regarding crops should be harvested between flowering and milk stage and they should have a thick stem (75%), moisture content of the fodder crop should not exceed 65% for efficient silage making (60%), judging the moisture content of the fodder crop, squeezing the stem in our palm for checking moisture percentage (51%), and moisture content in the fodder crop if high then the crop should be dried at least 3 to 4 hours before transporting to the silage pit (42%). These results indicated that farmers were well aware of the selection criteria of fodder crops for silage production.

Ingredients used for silage preparation (per ton)

Results regarding the adoption of ingredients used for silage preparation was shown in Table 5. Results indicated that most of the farmers use bacterial culture powder (53%) for the preparation of silage due to its easy availability and affordability in the study area. Average respondents used other ingredients for the preparation of silage. Small dairy farmers were observed using urea, salt, Jaggary, and other ingredients for silage preparation. However, large-scale dairy farmers typically use bacterial culture for silage preparation

Preparation of silage

Practices adopted by dairy farmers towards the preparation of silage are presented in Table 5. Results revealed that most of the respondents fully adopted the practices regarding the preparation of silage *viz.*, fodder should be chopped into small pieces of 1- 2 inches with the help of a chaff cutter (73%), Prepared fodder chaff should be spread and sprayed the mixture of the Jaggary, salt, urea, mineral mixture and/or the bacterial culture into a silage bag or silo pit properly (68%), chaff is plunged into a silo pit it should be properly spread and compactly packed either by hammering or machine pressing by manually peddling on the surface or by using bullock or tractor (66%), care should be taken that no air will remain inside the silo pit (64%), the process should continue till the silo pit is filled compactly (64%) and proper sealing of silo pit or silo bag by polythene/ plastic bag/ mud (63%). The results showed that in the study area, most of the farmers were well-informed about silage preparation techniques because most of the farmers regularly make silage on their farms.

Parallel findings noted by Bernardes and Rego (2014) wherein they conducted a study on silage production and use on Brazilian dairy farms, they found that the majority of farmers covered their silos with earth and double-sided plastic film (black on white). Nonetheless, over a fifth of all farmers continue to use black plastic.

Categorization of silage by touch

The adoption of practices according to the categorization of silage by touch was evaluated and presented in Table 5. The majority of farmers, according to the results, were fully aware of the classification of silage based on various practices, including tightly squeezing the silage in one's hand, saying that the silage was good or that the moisture content was high or low based on the dripping of water from one's hand, silage breaking into small pieces, and silage breaking into two pieces slowly. It was seen that they consistently use these methods when making silage.

Categorization of silage by smell

Table 5 shows the classification of silage by smell that dairy farmers have used. The majority of respondents only partially implemented the methods, while only a tiny minority of dairy producers fully accepted the silage classification by smell practices.

Categorization of silage by taste

The practice of adoption of categorization of silage by taste was evaluated and represented in Table 5. The majority of farmers did not use silage categorization by taste, and the adoption rate was very low. The reason for this could be a lack of awareness among respondents.

Categorization of silage by colour

As shown in Table 5, the adoption of practices regarding the categorization of silage by colour was evaluated. According to the findings, the majority of dairy farmers only partially adopted the practices for silage categorization by colour. The main reason for the low adoption of these practices is a lack of awareness among respondents.

Categorization of silage by pH

Results of the adoption of practices for the categorization of silage by pH were represented in Table 5. The majority of dairy producers have only partially adopted the silage classification procedures based on pH analysis. It was found that while large-scale dairy farmers were aware of these methods, small-scale dairy farmers were not, and hence the adoption was only partially made.

4.11 Method of silage feeding to dairy animals

The adoption of the silage-feeding approach for dairy animals was shown in Table 5. Most dairy producers (62%) fully adopted the practice of feeding 4 kg of silage per week together with green fodder, while 84% of respondents adopted the practice of giving 15-20 kg per week after one week. Similar results were observed by Wendling and Filho (2018) [11], who found that overall, production systems and the amount of silage produced and fed to cows do not adhere to technical standards. As a result, silage yield and use could be enhanced by adopting methods for more effectively allocating crop inputs.

Duration for use of silage after preparation

The adoption of practices regarding the duration for use of silage after preparation is shown in Table 5. After six months of planning, the majority of responders (84%) started using silage, according to the results. After a year of preparation, some farmers (37%) were seen to partially adopt the practice of using silage. Very few respondents used silage for longer than a year in their practices.

Equipment used for silage production

Table 5 represents the adoption of equipment used for silage production. For the production of silage, the majority of dairy farmers fully embraced the use of a chaff cutter, followed by a tractor, silo bags, and sprayer. The dairy

farmers used the harvester machine to some extent. Because farmers mostly relied on tractors for pressing and hand peddling, the adoption of press machines was minimal. In a research on the production and use of silage on dairy farms in Brazil, Bernardes and Rego (2014) [1] found that 40% of farmers still relied on rented machinery or outside contractors. On dairy farms, the pull-type forage harvester accounted for 90.4% of all equipment usage. Only 54.6% of those surveyed said they regularly sharpen their harvesting knives.

Table 5: Practice-wise adoption of different silage-making practices

Sr. No.	Practice-wise adoption	Adoption			Total score	Rank order
		Full	Partial	Never		
1. Method used for silage production						
1	Pit silo underground storage without construction or with construction	79(33%)	63 (26%)	98(41%)	221	II
2	Bunker silo above-ground or below-ground construction	46 (19%)	29(12%)	165 (69%)	121	III
3	Tower silo above ground cylindrical structure	16 (07%)	05 (02%)	219 (91%)	37	IV
4	Bamboo silo	00 (00%)	00 (00%)	240 (100%)	00	VI
5	Drum silo	06 (2%)	14 (6%)	220(92%)	26	V
6	Bag silo	212(88%)	20(08%)	08 (03%)	444	I
7	Other	00(0%)	10(04%)	230 (96%)	10	VII
2. Preference of Crops for Silage Making						
A	Cereal crops					
1	Maize	218(91%)	20(08%)	02(01%)	456	I
2	Jowar/ Sorghum	48(20%)	85(35%)	107(45%)	181	II
3	Pearl millet	04(1.6%)	01(0.4%)	235(98%)	09	VIII
4	Oat	02(01%)	08(03%)	230(96%)	12	VI
5	Sugarcane tops	45(19%)	27(11%)	168(70%)	117	IV
6	Bajra	09(04%)	06(02%)	225(94%)	24	V
B	**Grasses**					
1	Elephant grass (Napier grass)	54(22%)	31(13%)	155(65%)	139	III
2	Guinea grass	00(00%)	12(05%)	228(95%)	12	VI
3	Rhodes grass	00(00%)	00(00%)	240(100%)	00	-
4	Sudan grass	00(00%)	00(00%)	240(100%)	00	-
5	Ruzi grass	00(00%)	00(00%)	240(100%)	00	-
C	**Pulses**					
1	Cowpea	00(00%)	00(00%)	240(100%)	00	-
2	Beans	00(00%)	00(00%)	240(100%)	00	-
3	Lucerne	00(00%)	00(00%)	240(100%)	00	-
4	Berseem	00(00%)	00(00%)	240(100%)	00	-
3. Selection criteria of fodder crops for silage making						
1	Crops should be harvested between flowering and milk stage. It should have thick stem.	179(75%)	56(23%)	05(02%)	414	I
2	The moisture content of the fodder crop should not exceed 65% for efficient silage making	143(60%)	93(38%)	04 (02%)	379	II
3	To judge the moisture content of the fodder crop we can squeeze the stem in our palm after doing so if moisture is retained on the palm, it indicates that the moisture content in the fodders above 65%.	122 (51%)	89 (37%)	29(12%)	333	III
4	If the moisture content in the fodder crop is high then the crop should be dried for at least 3 to 4 hours before transporting it to the silage pit.	101(42%)	104 (43%)	35(15%)	306	IV
4. Ingredients used for silage preparation (per ton)						
1	Urea (1kg)	29 (12%)	90 (40%)	114 (48%)	115	IV
2	Salt (1kg)	48 (20%)	115 (48%)	77 (32%)	211	III
3	Jaggary or Molasses (1kg)	86 (36%)	119 (50%)	35 (14%)	291	II
4	Water (100 Lit)	16 (07%)	72 (30%)	152 (63%)	104	V
5	Mineral mixture (1 kg)	05 (02%)	17 (07%)	218 (91%)	27	VI
6	DCP(Di-Calcium Phosphate)	03 (01%)	20 (08%)	217 (91%)	26	VII
7	LAB (Lactic acid bacteria) / Bacterial culture (powder)	127 (53%)	78 (32%)	35 (15%)	332	I
5. Preparation of silage practices						
1	Fodder should be chopped into small pieces of 1- 2 inches with the help of a chaff cutter.	176 (73%)	58 (24%)	06 (03%)	410	I
2	Prepared fodder chaff should be spread and sprayed the mixture of the Jaggary, salt, urea, mineral mixture and/or the bacterial culture into a silage bag or silo pit properly.	164 (68%)	68 (28%)	08 (04%)	396	II
3	As the chaff is plunged into a silo pit it should be properly spread and compactly packed either by hammering or machine pressing by manually peddling on the surface or by using bullock or tractor	159 (66%)	76 (32%)	05 (02%)	394	III
4	Care should be taken that no air will remain inside the silo pit.	153 (64%)	81 (34%)	06 (02%)	387	V
5	This process should be continued till the silo pit is filled compactly.	154 (64%)	83 (35%)	03 (01%)	391	IV
6	Proper sealing of silo pit or silo bag by Polythene/ Plastic bag/ Mud.	152 (63%)	78 (32%)	10 (05%)	382	VI
6. Categorization of silage by touch						
1	When squeezing the silage tightly in a hand and then opening the hand, if the silage breaks slowly into two, that silage is of good quality.	170 (71%)	62 (26%)	08 (03%)	402	I
2	If the silage breaks into small pieces separately, the silage is deficient in moisture content	133 (55%)	95 (40%)	12 (05%)	362	II
3	If water is dripping, the moisture content of the silage is too high.	132 (55%)	98 (41%)	10 (04%)	362	III
7. Categorization of silage by smell						
1	An Acidic or a sweet-sour pleasant smell indicates good quality.	57 (24%)	121 (50%)	62 (26%)	235	I
2	Manure smell or putrid smell and it is so repugnant that one cannot put the silage near one's	42 (17%)	113(47%)	85 (35%)	197	II

	nose, the quality is poor.					
8. Categorization of silage by taste						
1	If the silage tastes sour and there is no problem in putting it in one's mouth, the quality is good.	78 (32%)	68 (28%)	94 (40%)	224	II
2	If the silage tastes bitter and one cannot put it in one's mouth, the quality is poor.	86 (36%)	73 (30%)	81 (34%)	245	I
9. Categorization of silage by colour						
1	Pale yellow indicates good quality or brownish green and sometimes even golden in colour.	61 (25%)	150 (63%)	29 (12%)	272	I
2	Dark brown or black-bad Quality.	15 (07%)	103 (43%)	122 (50%)	133	II
10. Categorization of silage by pH						
1	Very good silage- 3.5-4.2 Range	69 (29%)	157 (65%)	14 (06%)	295	I
2	Good silage- 4.2-4.5 range	06 (02%)	67(28%)	167(70%)	79	II
3	Fair silage- 4.8 and above	04 (02%)	62 (26%)	174 (72%)	70	III
11. Method of silage feeding to dairy animals						
1	One week -4kg along with green fodder	148 (62%)	65(27%)	27 (11%)	361	I
2	After one week -15 to 20 kg	84 (35%)	34 (14%)	122 (51%)	202	II
12. Duration for use of silage after preparation						
1	Six months	201 (84%)	25 (11%)	14 (05%)	427	I
2	One year	31 (13%)	89 (37%)	120 (50%)	151	II
3	Above one year	14 (06%)	04 (02%)	222 (92%)	32	III
13. Equipment used for silage production						
1	Harvester machine	93(39%)	96 (40%)	51 (21%)	282	V
2	Tractor	181(75%)	46 (19%)	13 (06%)	408	III
3	Chaff cutter	190 (79%)	34 (14%)	16 (07%)	414	II
4	Press machine	34 (14%)	31 (13%)	175 (73%)	99	VI
5	Sprayer	123 (51%)	45 (19%)	72 (30%)	291	IV
6	Silo bags	200 (83%)	25 (10%)	15 (07%)	425	I
7	Other	05 (02%)	02 (0.8%)	233(97.02%)	12	VII

Overall adoption index of silage production practices

The adoption index of silage production practices by dairy farmers is depicted in Table 6. Results revealed in terms of overall adoption practices regarding silage production, preparation of silage obtained more adoption index (81.94), followed by categorization of silage by touch (78.19), selection criteria of fodder crops for silage making (74.58), equipment used for silage production (69.79), method of silage feeding to dairy animals(58.64), categorization of silage by taste (48.85), categorization of silage by colour (42.5), ingredients used for silage preparation (32.91), the duration for use of silage after preparation (32.03), categorization of silage by pH(30.83), the method used for silage production (25.26) and preference of crops for silage making (12.36). As a result of their thorough understanding of the importance of silage, the majority of respondents in the research area fully adopted the practice of silage preparation. According to the findings, overall, the adoption index for all the silage production practices was found to be average (41.55).

Table 6: Overall adoption index for silage production practices

Sr. No.	Silage production Practices	Maximum possible Score	Obtained Score	Adoption Index	Rank order
1	Method used for silage production	3360	849	25.26	XII
2	Preference of crops for silage making	7680	950	12.36	XIII
3	Selection criteria of fodder crops for silage making	1920	1432	74.58	III
4	Ingredients used for silage preparation (per ton)	3360	1106	32.91	IX
5	Preparation of silage	2880	2360	81.94	I
6	Categorization of silage by touch	1440	1126	78.19	II
7	Categorization of silage by smell	960	432	45.00	VII
8	Categorization of silage by taste	960	469	48.85	VI
9	Categorization of silage by colour	960	408	42.50	VIII
10	Categorization of silage by PH	1440	444	30.83	X
11	Method of silage feeding to dairy animals	960	563	58.64	V
12	Duration for use of silage after preparation	1920	615	32.03	XI
13	Equipment used for silage production	2880	2010	69.79	IV
	Overall adoption	30720	12764	41.55	

Correlates of silage production practices

The correlation of the coefficient between dependent and independent variables was analyzed and presented in Table 7. Out of twelve independent variables, i.e. land size, herd size, occupation, milk production, annual income, education, social participation, and knowledge level were found to be significantly associated with the adoption of silage production practices. It means these factors will significantly accelerate the rate of adoption of silage production and utilization practices. Similar findings were reported by Singh (2022) [10], who found that smallholder dairy farmers' adoption of silage-making is largely reliant on their degree of education, prior farming experience, financial situation, and access to extension services. The adoption of technologies is greatly influenced by socioeconomic factors as well.

Table 7: Correlates of silage production practices N=240

Sr. No.	Independent Variable	Coefficient correlation (r)
1	Age	-0.0223
2	Family size	-0.0233
3	Land size	0.3015**
4	Herd size	0.4102**
5	Occupation	0.4501**
6	Milk production (lit/day)	0.3584**
7	Annual Income	0.4312**
8	Experience	0.0047
9	Education	0.4107**
10	Social participation	0.2592**
11	Extension contact	0.0856
12	Knowledge level	0.3314**

(** significant at $p<0.01$)

Constraints faced by dairy farmers regarding silage production and utilization practices

The implementation of silage production and usage strategies was hampered by a number of obstacles for dairy farmers. Each constraint was given along with its frequency, percentage, and rank. Rank-wise constraints are showed in Table 8. Results indicated that in cost of the harvester machine is high was the main constraint (81.25%) followed by unavailability of storage facilities (62.5%), lack of knowledge regarding the exact proportion of ingredients used for silage (48.75%), lack of knowledge about proper storage of silage (46.25%), scarcity of fodder crops for silage making (42.5%), lack of knowledge regarding silage production (40.83%), unavailability of land for fodder production (40.00%), high prices of silage culture (37.5%), cost of construction of silo pit or silo bag is high (32.08%), more number of labour required for silage production (31.25%), manage mental issues due to weather condition (25.00%) and difficulty in availability of silage culture (25.00%) was the major constraint faced by the respondent. Similar conclusions were made by Bernardes and Rego (2014) [1], who observed that the primary challenges faced on the farms were a lack of tools, a lack of labour, and weather changes. The main restrictions, according to Reiber *et al.* (2009) [6], were the lack of acceptable and reasonably priced plastic bags, as well as sufficient chopping tools and storage facilities on smallholder farms.

Table 8: Constraints faced by dairy farmers towards silage production and utilization practice

Sr. No.	Constraints	F	%	Rank
1	Lack of knowledge regarding silage production	98	40.83	VI
2	Unavailability of land for fodder production	96	40.00	VII
3	Scarcity of fodder crops for silage making	102	42.50	V
4	Lack of knowledge regarding the exact proportion of ingredients used for silage	117	48.75	III
5	Lack of knowledge about proper storage for Silage	111	46.25	IV
6	Cost of construction of a silo pit /silo bag is High	77	32.08	IX
7	Cost of the harvester machine is high	195	81.25	I
8	Unavailability of storage facilities	150	62.50	II
9	High prices of silage culture	90	37.50	VIII
10	Unable to maintain the anaerobic condition	30	12.50	XIII
11	Managemental issues due to changing weather condition	60	25.00	XI
12	Requirement of labour is more	75	31.25	X
13	Difficulty in the availability of silage culture	60	25.00	XII

Conclusion

The study highlights the importance of silage in enhancing dairy farming in western Maharashtra, particularly in overcoming fodder shortages. Despite the benefits, there is a medium level of adoption and knowledge among dairy farmers regarding silage production. Factors such as age, education, occupation, and herd size influence the adoption and knowledge levels. Most farmers prefer bag silos due to their affordability and convenience. The findings suggest the need for targeted training and awareness programs to improve knowledge and practices related to silage production. Enhanced support and technology transfer strategies are crucial for increasing adoption rates, ensuring dairy farmers can fully leverage silage for better livestock nutrition and productivity. This study serves as a basis for developing tailored interventions to address the constraints faced by dairy farmers in silage production and utilization.

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