Quality and safety assessment of goat milk collected from different regions of Mathura city

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Received: 15 July 2020 / Accepted: 12 September 2020 / Published online: 27 December 2020
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Abstract: The present study was carried out for quality and safety assessment of goat milk from five different regions of Mathura city viz. Holigate, Sadar, Aurangabad, Chungi and Township. The milk samples were collected from dairy shops, vendors and milk producers and evaluated on the basis of various organoleptic tests, physico-chemical properties, proximate estimation and microbiological studies following the standard procedures. Among organoleptic tests, Chungi (70%) and Township (90%) samples had clearer appearance than the other area. All sample collected from township is white in color. Regarding texture/consistency of milk, the sample procured from T having normal consistency and normal odor. The COB test was positive in 20 and 10% samples of H and S areas only. There was no significant difference in temperature, pH and titrable acidity of milk of different areas. However, the specific gravity showed significant ($P<0.05$) difference among milk samples from different regions. The specific gravity of S area samples was significantly ($P<0.05$) higher than H, C and T areas. The temperature, pH and specific gravity were lower however titrable acidity was higher than normal prescribed range in all milk samples. There was significant ($P<0.05$) difference for all proximate

parameters except fat content. The moisture contents of H, C and T were significantly ($P<0.05$) higher but the SNF was lower than in S area. The protein percent of H region samples was significantly ($P<0.05$) lower than of other regions. The ash content of S region was significantly ($P<0.05$) higher than of C region, whereas total solid content of S region was significantly ($P<0.05$) higher than H, C and T region. The mean total solid content of A was comparable to C, H, T and S region. Although proximate parameters of goat milk deviated from normal prescribed range but all samples were negative for adulteration eg. preservatives, neutralizers and others adulterants. There was no significant difference in DMC, SPC, *Coliform* count and *Staphylococcus* count of milk samples collected from different regions however all samples had higher microbial load than the prescribed limit.

Keywords: Adulteration, Goat milk, Organoleptic test, Preservative, Quality assessment

Introduction

Goats are supposed to be the first farm animal to be domesticated and known as poor men's cow because they have never been intensively farmed, that is why they are healthy, rarely suffer from mastitis. Being second largest in goat population, India also has some of the great milch breeds like Jamunapari, Beetal, Surti, Barbari. Goat milk is having better digestibility, alkalinity, buffering capacity and certain therapeutic values in medicine and human nutrition in comparison to cow's or human milk (Haenlein, 2014; Park, 1989; Park, 1994). It is responsible for production of several antimicrobial substances like bacteriocin and goat milk microbiota is also considered a good source of novel bacteriogenic *Lactic acid* bacteria (LAB) strains that can be exploited as an alternative for use as bio preservative in food (Perin, 2014). The milk of small ruminants such as goats is of particular economic interest in the developing countries. The production of this type of milk has to be a useful strategy to overcome the problems of under nutrition (Haenlein, 1984). It is easier to digest than cow's milk and may have certain therapeutic value (Haenlein, 2004). The major differences between goat's and cow's milk because of different proportions of the different kinds of casein, and also to the different structure and size of fat globules and protein micelles (Tziboula, 2003). All these

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differences could lead to the milk behaving differently during processing that could affect the final quality of goat's milk dairy products (Vargas, 2008). The efficient utilization of goat milk provides an opportunity to diversify the dairy market since it allows us to develop added value to the fermented products with particular characteristics compared to cow's milk.

Goat milk has similar properties to human milk it contains vitamin content just like human milk except lower content of folic acid, vitamin C and inositol (Le-Jaouen, 1981). Goat's milk contains vitamins, minerals, trace elements, electrolytes, enzymes, proteins, and fatty acids that are easily assimilated by the body. Therefore awareness about advantage of consumption of goat's milk should be popularized so that production and utilization of goat's milk could be enhanced (Kumar, 2012). Goat's milk shows therapeutic virtues for individuals with certain dietetic problems, thus physicians have traditionally recommended goat's milk for infant and others allergic to cow milk. The research was done to assess the quality and safety parameters of market milk of goat milk because goat milk is very important to the health of human especially to the children and adolescent people because goat milk having easily digestible macro and micronutrient. Goat milk has better fat and protein digestibility and assimilation ability, along with this it also has higher mineral and vitamins composition which make it less allergic than other milk (Goswami et al. 2017). Despite of this fact, the problem of milk deficiency escalates due to minimum availability of resources of land, labour, capital, inadequate cooling facilities, insufficient feeding of animals etc. As population is rising day by day there is increased pressure on the land resources, availability of land for cultivation of food crops and fodder crops. All these factors contributed to certain malpractices. Milk adulteration is the most dangerous and hazardous practices in developing countries like India. Several factors like adulteration, presence of antibiotic, insecticides and pesticides residues and seasonal changes affect the physico-chemical properties and composition of milk (Bashir et al. 2013). By taking all these points into consideration, the present study was carried out to assess the safety and quality parameters of goat milk with respect to physico-chemical properties, adulteration and microbiological quality in Mathura city.

Materials and Methods

The experiments were conducted in Department of Livestock Products Technology, College of Veterinary Sciences and Animal Husbandry, DUVASU, Mathura. Total 50 milk samples of goat were procured from local market/milk vendors etc. from 5 different regions (10 samples from each area) of Mathura i.e. Holigate (H), Sadar (S), Aurangabad (A), Chungi (C) and Township (T). The 250 ml raw milk was collected in sterile plastic bottle from bulk milk container of milk vendors and then put in to the ice box. The chemicals and culture media used in the study were procured from Hi Media Laboratories (P) Ltd, Mumbai and Tulip Diagnostics (P) Ltd., Goa.

Analytical procedure

Platform tests

Under platform test general appearance, odor, color, texture and clot on boiling test was performed (BIS, 2015).

Physico-chemical Properties

Under physico-chemical parameters, pH was determined by using digital pH meter (WTW, Germany, model pH 330i). The temperature of milk samples was taken with the help of a thermometer by immersing the same in the milk (100 ml) contained in measuring cylinder. Specific gravity of milk sample was determined by method of Mahoney (1988). Fresh milk sample was filled sufficiently into a glass cylinder (100 ml capacity) and lactometer was held by the tip and inserted into the milk. The lactometer was allowed to float freely until it reached equilibrium. Then the lactometer reading at the lower meniscus was recorded. The thermometer was inserted immediately into the milk sample and the temperature of the milk was also recorded. The following formula was used to calculate the specific gravity of the milk:

$$\text{Specific gravity} = (\text{CLR}/1000) + 1$$

Where, CLR = corrected lactometer reading at a given temperature, i.e., for every degree F above 60°F, 0.1 was added to the lactometer reading but for every degree F below 60°F, 0.1 was subtracted from the lactometer reading.

Titrateable acidity of the milk sample was determined according to the method of the AOAC (1990). Nine ml of milk sample was pipetted into a beaker and 3 to 5 drops of 1 % phenolphthalein indicator was added to it. The milk sample was then titrated with 0.1N NaOH solution until a light pink color persisted. The titrateable acidity calculated using the following formula and expressed as % lactic acid

$$\text{Titrateable acidity (\%)} = 0.1\text{N NaOH (ml)} \times 0.009 \times 100 / \text{Weight of milk sample}$$

Proximate Estimation

Among the proximate parameters, the fat content was determined by using Gerber's method (APHA, 1985). 10 ml sulphuric acid (H_2SO_4) was poured into butyrometer, after that 10.75 ml of milk sample was slowly added into butyrometer followed by 1 ml of amyl alcohol. The contents of butyrometer were thoroughly mixed and centrifuged at 1100 rpm for 5 minutes. The percent fat was recorded directly from the butyrometer scale.

$$\text{Fat\%} = \text{Upper reading} - \text{Lower reading}$$

The moisture, protein and ash content were evaluated by following AOAC (1995) method. The SNF and Total solids contents were determined by ISI (1960) method.

Determination of preservatives

The qualitative test for preservative addition in milk was evaluated as per ISI (1960).

Boric acid

10 ml of milk was taken in a test tube and 1 ml of conc. hydrochloric acid (HCl) was added and mixed it thoroughly. A strip of turmeric paper was dipped in acidified milk. Appearance of characteristic red colour on the turmeric paper indicated the presence of boric acid or borax ($\text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O}$). The red colour changed to dark blue green on addition of ammonium hydroxide, but reappeared on re-acidification with hydrochloric acid in case of positive samples. However no color change was indication of negative boric acid test.

Formalin

10 ml of milk was taken in a test tube. One or two drops of ferric chloride (FeCl_3) was added in it and mixed properly. After sufficient mixing 5 ml of conc. sulphuric acid (H_2SO_4) was poured from side wall of the test tube. Formation of brown color precipitate was the indication of negative formalin test.

Hydrogen peroxide

5 ml of fresh milk was taken in a test tube, an equal volume of sample milk was added, then two drops of 2 % of para-phenylenediamine reagent was added and mixed it well. Blue color developed in the presence of H_2O_2 , whereas pure milk sample remained white in color.

Determination of Neutralizer

Carbonate/Bicarbonate

The addition of carbonate / bicarbonate in milk was evaluated as per (Ayub et al. 2007) 5 ml of milk with equal volume of 95% alcohol was taken in a test tube. A few drops of 0.1% (w/v) alcoholic solution of rosolic acid was added. If alkali was present a rose red colour appeared whereas brownish color was observed in pure milk.

Determination of Adulterants

Cane sugar

As per ISI (1960), 15 ml of milk sample was taken in a test tube and 1 ml of conc. hydrochloric acid was added. Then 0.1 gm of Resorcinol reagent was added and mixed. The tube was placed in boiling water bath for 5 min. and observed the colour change. Appearance of deep red colour indicated the presence of sucrose and there was no change in colour in pure milk samples.

Starch

As per ISI (1960), 3 ml of milk sample was taken in a test tube. The milk was boiled over the flame, then allowed to cool the sample at room temperature. 1-2 drops of iodine solution was added to the test tube. Development of blue colour indicated the presence of starch which disappeared when sample was boiled and reappeared on cooling. If the test was negative for starch there was no change in colour of milk.

Detection of urea

As per ISI (1960), 5 ml of milk was taken in a test tube and ½ teaspoon of soyabean or arhar powder was added then mixed the content thoroughly by shaking the test tube. A red litmus paper was dipped in it after 5 min. and removed it after 30 sec. A change in colour from red to blue indicated the presence of urea in the milk.

Microbiological parameters

The Direct microscopic count (DMC), standard plate count (SPC), *Coliform* count and *staphylococcus* count was determined as per the procedure described in APHA (1984).

Statistical analysis

Total 50 samples were taken from whole Mathura city, where 10 samples were taken from each area ($10 \times 5 = 50$). Therefore, sample size was 10 ($n=10$) in each area. The data generated from various trials under each experiment were pooled and analyzed by statistical method of one way-ANOVA and $\text{Mean} \pm \text{S.E}$ using SPSS Statistics 20.0 software package developed as per the procedure of Snedecor and Cochran (1994) and means were compared by using Duncan's multiple range test (Duncan, 1995).

Results and Discussion

Platform tests

The results for platform tests are presented in table 1. The milk samples collected from H, S, A and C were 50, 50, 60 and 70 % clear in appearance respectively, however T area had 90% clear milk samples. Out of total, 40, 50, 40, 30 and 10% goat milk samples from H, S, A, C and T respectively had visible dirt. H had 10% samples with foreign matter, however foreign matter was not seen in any sample of S, A, C and T areas. T had more clear samples than other areas because consumers were procuring the goat milk directly from the milk producers and there was no involvement of vendors, however H samples were collected by milk vendors and middlemen. The visible dirt and foreign matter in milk might be due to ill maintenance of herd and unhygienic milking of goats. Out of total milk samples, 70, 80, 90 and 90 samples were of pure white color whereas 20, 20, 10 and 10 % samples had light yellow color in H, S, A and C respectively. 10% samples of H area were

pale yellow in color. The samples collected from T were 100% white in color. There was no dark yellow color in any milk sample. The variations in color of goat milk samples collected from five different regions of Mathura city might be because of variation in feed, breed and lactation period.

There were 80, 90 and 90% milk samples with normal consistency in H, S and A areas, however the 100% samples of C and T areas had normal texture. In H, S and A, 20, 10 and 10% samples had watery consistency due to adulteration of water to increase the volume and to mask the light yellow color of milk. There was no sample observed with thick, ropy or slimy consistency. The presence of ropiness or slime in milk is the indication of longer period of storage and microbial load particularly due to *Alkaligenes sp.*

There were 70, 80, 80, 90 and 100% milk samples with normal odor in H, S, A, C and T respectively. There was no milk sample with rancid/oxidized odor in any region due to lower temperature of milk maintained in cans at $18 \pm 2^\circ\text{C}$ and early morning milking of goats. The rancid/oxidized odor of milk is due to fat oxidation due to longer storage and growth of lipolytic microorganisms. H, S, A and C samples had 20, 10, 20, and 10% weedy odor, as well as the sample of H and S had 10% absorbed odor. Weedy odor of samples might be due feeding of concentrate to the animals,

while absorbed odor because of storage of milk in poorly sanitized plastics/metal cans.

Among all samples collected from different regions of Mathura, 20 and 10 were positive for COB in H and S areas, however no milk sample was found positive for COB test in A, C and T areas. Positive COB test shows higher bacterial load and titrable acidity as well as poor quality of milk. Wasiksiri et al. (2010) evaluated the platform test of goat milk samples from Southern Thailand and found that all sample were having white color, good natural smell and no sediment contamination, and 97.7% sample were negative for COB test.

Physico-chemical properties

The results for physic-chemical properties are presented in table 2. There was no significant difference between milk samples for temperature, pH and titrable acidity, however specific gravity value showed significant ($P < 0.05$) difference among milk samples from different regions. The temperature of all milk samples was lower than normal range ($36-38^\circ\text{C}$) which might be due to storage of milk at lower temperature in cool cans. The variation in temperature of milk also might be due to certain factors like collection time, season and chilling of milk before sale. The normal pH of freshly drawn goat milk have been reported to range

Table1 Platform tests of raw milk of goat collected from different regions of Mathura

Parameter	Holigate (H)	Sadar (S)	Aurangabad (A)	Chungi (C)	Township (T)					
	General appearance									
	No.	%	No.	%	No.	%	No.	%	No.	%
Clear	5	50	5	50	6	60	7	70	9	90
Visible dirt	4	40	5	50	4	40	3	30	1	10
Foreign matter	1	10	0	0	0	0	0	0	0	0
	Color									
White	7	70	8	80	9	90	9	90	10	100
Light yellow	2	20	2	20	1	10	1	10	0	0
Pale yellow	1	10	0	0	0	0	0	0	0	0
Dark yellow	0	0	0	0	0	0	0	0	0	0
	Texture									
Normal	8	80	9	90	9	90	10	100	10	100
Watery	2	20	1	10	1	10	0	0	0	0
Thick	0	0	0	0	0	0	0	0	0	0
Ropy	0	0	0	0	0	0	0	0	0	0
Slimy	0	0	0	0	0	0	0	0	0	0
	Odor									
Normal	7	70	8	80	8	80	9	90	10	100
Rancid/oxidized	0	0	0	0	0	0	0	0	0	0
Weedy	2	20	1	10	2	20	1	10	0	0
Absorbed	1	10	1	10	0	0	0	0	0	0
	COB test									
Positive	2	20	1	10	0	0	0	0	0	0
Negative	8	80	9	90	10	100	10	100	10	100

between 6.4-6.9 (Kumar et al. 2012) however in present study, all milk samples had lower pH than the described earlier. The possible reason of lower pH might be the production of lactic acid resulting from fermentation of lactose due to time gap between milking and sale. There was significant ($P<0.05$) difference in specific gravity of milk samples from different regions. The specific gravity of S samples was significantly ($P<0.05$) higher than H, C and T, whereas no significant difference was observed between H, C and T. The samples of A had comparable specific gravity with samples of H, C and T as well as S. The normal range of specific gravity of goat milk is 1.023-1.030 (Kumar et al. 2012). All milk samples had lower range than described value which might due to adulteration of milk with water and variation in breed and feeds.

The normal range of TA of goat milk is 0.17-0.19 (Sawaya et al. 1984). The titrable acidity of all milk samples were within the

normal range, however S milk samples had slightly higher titrable acidity than normal range. The possible reason behind this finding might be the procurement of goat's milk from vendors. The vendors brought the milk from far areas in cool cans and the long time storage of milk at around 18-20°C might cause production of lactic acid by fermentable microorganisms resulting into higher titrable acidity.

Proximate estimation

The results for proximate parameters are presented in table 3. There was a significant ($P<0.05$) difference for all proximate parameters except fat content in goat's milk samples collected from five different regions of Mathura city. The moisture content of H, C and T was significantly ($P<0.05$) higher than S, however there was no significant difference between H, C and T. The moisture content of A was comparable to H, C, T and S.

Table2 Physico-chemical properties (Mean±SE) of raw milk of goat collected from different regions of Mathura

Parameters (%)	Holigate (H)	Sadar (S)	Aurangabad (A)	Chungi (C)	Township (T)	Treatment mean
Moisture	88.42 ^a ±0.36	86.71 ^b ±0.44	87.69 ^{ab} ±0.27	88.51 ^a ±0.17	88.30 ^a ±0.18	87.93±0.16
Fat	3.36±0.10	3.47±0.09	3.59±0.07	3.22±0.08	3.39±0.09	3.40±0.04
SNF	7.79 ^b ±0.31	9.06 ^a ±0.17	8.40 ^{ab} ±0.20	7.95 ^b ±0.13	7.91 ^b ±0.15	8.22±0.11
Protein	2.48 ^b ±0.25	3.14 ^a ±0.06	3.14 ^a ±0.07	3.01 ^a ±0.04	3.01 ^a ±0.06	2.96±0.06
Ash	0.69 ^{ab} ±0.01	0.72 ^a ±0.01	0.71 ^{ab} ±0.01	0.66 ^b ±0.11	0.69 ^{ab} ±0.01	0.70±0.01
Total solids	11.15 ^b ±0.34	12.53 ^a ±0.22	11.99 ^{ab} ±0.26	11.05 ^b ±0.15	11.30 ^b ±0.16	11.60±0.13

Table 3 Proximate estimation (Mean±SE) of raw milk of goat collected from different regions of Mathura

Parameter	Holigate (H)	Sadar (S)	Aurangabad (A)	Chungi (C)	Township (T)	Treatment mean
Temperature	19.72±0.44	19.71±0.42	19.90±0.37	19.02±0.38	19.98±0.23	19.66±0.16
pH	5.62±0.08	5.66±0.038	5.57±0.063	5.67±0.59	5.70±0.081	5.64±0.029
Sp gravity	1.024 ^b ±0.01	1.029 ^a ±0.01	1.027 ^{ab} ±0.01	1.025 ^b ±0.01	1.025 ^b ±0.01	1.026±0.01
Titrable acidity	0.18±0.01	0.20±0.02	0.17±0.15	0.17±0.10	0.19±0.23	0.18±0.08

Table4 Screening of raw milk samples of goat for various preservatives

	Holigate (H)		Sadar(S)		Aurangabad (A)		Chungi (C)		Township (T)	
Preservative	+	-	+	-	+	-	+	-	+	-
Formalin	0	10	0	10	0	10	0	10	0	10
Boric acid	0	10	0	10	0	10	0	10	0	10
Hydrogen peroxide	0	10	0	10	0	10	0	10	0	10

Table5 Screening of raw milk samples of goat for various preservatives

	Holigate (H)		Sadar (S)		Aurangabad(A)		Chungi(C)		Township(T)	
Adulterant	+	-	+	-	+	-	+	-	+	-
Carbonate/ Bicarbonate		0	10	0	10	0	10	0	10	0
Starch	0	10	0	10	0	10	0	10	0	10
Cane sugar	0	10	0	10	0	10	0	10	0	10
Urea	0	10	0	10	0	10	0	10	0	10

Table 6 Microbiological studies (Mean $\pm$ SE) of raw milk of goat collected from different regions of Mathura ($\log_{10}$ cfu/ml)

Parameter	Holigate (H)	Sadar (S)	Aurangabad (A)	Chungi (C)	Township (T)	Treatment mean
DMC	6.692 $\pm$ 0.16	6.719 $\pm$ 0.02	6.716 $\pm$ 0.04	6.755 $\pm$ 0.02	6.707 $\pm$ 0.03	6.718 $\pm$ 0.03
SPC	7.980 $\pm$ 0.20	7.933 $\pm$ 0.19	8.393 $\pm$ 0.19	7.862 $\pm$ 0.22	8.054 $\pm$ 0.16	8.044 $\pm$ 0.08
Coliform count	5.306 $\pm$ 0.15	5.145 $\pm$ 0.17	5.451 $\pm$ 0.19	4.888 $\pm$ 0.21	5.073 $\pm$ 0.22	5.173 $\pm$ 0.08
<i>Staphylococcus</i> count	4.794 $\pm$ 0.13	4.815 $\pm$ 0.16	5.078 $\pm$ 0.14	5.267 $\pm$ 0.25	4.909 $\pm$ 0.20	4.972 $\pm$ 0.08

Comparatively lower moisture percent in S samples than other areas could be correlated to higher specific gravity of S areas sample than the samples of other areas. The moisture % of all milk samples showed slightly higher value than the normal range. The normal moisture content of goat milk is 86.5% (De, 1991). It might be due to adulteration of milk with water as well as variation in feeding, nutrition and the climatic conditions. Imran et al. (2008) recorded the moisture content of goat milk collected from local markets of Peshawar in Pakistan as 80.5%.

There was no significant difference in fat content of different milk samples. The fat percent of all samples showed lower value than normal range which might be due to variations in breed, lactation period, feed etc. The normal fat % of goat milk is 3.5 % (De, 1991). Many milk samples of goat's milk were collected directly from milk producers due to availability of less milk from vendors. The price of the goat milk is quite high, further the producer normally uses goat's milk for their own household purposes, therefore there is very less possibility of practicing skimming. The SNF of S region was significantly ($P<0.05$) higher than H, C and T, however there was no significant difference between H, C and T. The SNF content of A was comparable to H, C, T and S. Park (2006) reported the average SNF % of goat's milk to be around 8.9 %. The protein percent of milk of H region was significantly ($P<0.05$) lower than other regions. There was no significant difference between S, A, C and T. All milk samples showed lower of protein content than normal prescribed range. The possible reason behind this might be the rearing of non descript breeds of goats for milk purposes by milk producers in these areas. The normal protein content of goat milk is 3.5% (De, 1991). The ash content of milk of S region was significantly ($P<0.05$) higher than of C region, however samples of H, A and T was comparable with S and C. The variation in ash of goat milk might be caused by several factors such as season, stages of lactation, breed, diet, individual animal and environmental management conditions (Haenlein, 2004). The total solid content of S region milk was significantly ($P<0.05$) higher than that of H, C and T region, however there was no significant difference in between H, C and T region samples. The mean total solid content of A was comparable to C, H T and S. All samples had TS content lower than prescribed normal range. The normal value of TS of goat milk is 13 % (Kumar et al. 1991). Gaddour et al. (2013) observed higher values of pH, total acidity, density, viscosity, protein, fat and ash in goat milk samples of southern Tunisia arid zone.

Preservatives and adulterants

The results for presence of preservatives and adulterants are presented in table 4 and table 5. All milk samples collected from five different regions of Mathura were negative for preservatives' adulteration viz. Formalin, boric acid and hydrogen peroxide. The possible reason behind this might be the use of goat's milk for own household purposes by milk producers and higher price due to medicinal values. All milk samples of goat were negative for any kind of adulteration i.e. neutralizer and others like starch, cane sugar, and urea tested in laboratory.

Microbiological studies

The results for microbiological studies are presented in table 6. There was no significance difference in DMC, SPC, *Coliform* count and *Staphylococcus* count of milk samples collected from different regions. All the samples had higher microbial load than the prescribed limit. It might be due to prolong storage, faulty transportation and handling conditions, infected of udder, unhygienic milking procedure and poor water quality used for cleaning as well as unsterilized equipment. Saad et al. (2013) also reported that higher *Staphylococcus* count (7.5 to 7.4 cfu/ml), and *Coliform* count (7.3 to 7.5 log mpn/ml) in goat milk samples at Cairo and Giza District of Egypt.

Conclusions

Goat milk collected from different dairy shops, vendors and milk producers of different regions of Mathura city were free from any kind of adulteration and preservative addition; however proximate parameters were deviated from the normal range. All milk samples had higher microbial load than the prescribed limit by BIS due to poor hygienic condition and sanitation during milking, handling practices and transportation as well as use of unclean utensils. The consumption of poor quality milk may lead to serious human health problems, so it becomes necessary to implement stringent quality control system and regular check. FSSAI standards should be applied at each and every step starting from farm level to final consumption by producers, sellers and consumers to have wholesome, safe and nutritious milk.

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