



## A critical control points based approach for reduction of mastitis incidence in dairy farms of Karnataka

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### ABSTRACT

Hazard analysis critical control points (HACCP) based system is mainly a risk based preventive approach developed to increase food safety assurance level from farm. This program deals with control factors affecting the process and product. A semi-structured questionnaire was administered to 101 farmers in the adopted villages, covering 134 crossbred dairy cows. The baseline data indicated that based on California Mastitis Test (CMT) the incidence of clinical and subclinical mastitis in crossbred cow was 8.21 and 44.78% respectively. The risk factors associated with the incidence of mastitis were parity, level of milk yield, udder hygiene, udder shape, teat length, teat-tip-to-ground distance, animal housing conditions, milking management, post-milking time taken by the animal for lying down, a long gap in tail hair clipping. CCPs identified and developed plan may be suitable for customized and implementation on small-holder dairy farms. This is a logical, effective and systemic approach for control of incidence of mastitis, improve the udder health status and milk quality.

**Keywords:** Critical control points, Identification, Mastitis, Management

Dairy production contributes significantly to livelihood security of small, marginal and landless labour, in Indian rural setting. Even though, we are global leaders in bovine population and milk production, the quality of milk produced in our country is a major concern. In most cases, milk has high bacterial load and somatic cell count, making our milk and milk products unaccepted for export to many countries. Worldwide, consumer awareness about safety of milk and dairy products has increased. Safety of milk has to be an integral part of production process from farm to consumer. Mastitis is a serious problem causing a significant negative impact on the viability and productivity in dairy farms, milk quality, and animal welfare. In spite of all technological advances, globally mastitis still continues to be one of the challenges for most dairy farmers. Mastitis is caused by a wide spectrum of pathogens and it poses the major challenge to address it effectively. There are many factors that contribute to repeated incidence of mastitis in animals, especially in Indian context. Some of them are herd factors, environmental factors, milking management etc.

Hazard analysis critical control point (HACCP) is a management system of control based on principles of prevention (Corlett and Pierson 1992). This can be used for farm management, as it is farm-specific, low labour intensive, based on risk management and prevention, and links farm management with milk quality. Implementation of HACCP system on dairy farms can bring in a lower

somatic cell and bacterial count in milk, and reduce monthly veterinary expenses. Under field conditions, adoption of effective mastitis control programmes could not be achieved, even after intensive efforts by various stakeholders. Effectiveness of Critical Control Points (CCPs) protocols for mastitis control in small-holder dairy production system has not been explored fully. A study was conducted to identify, develop, implement and evaluate CCPs based approach to control mastitis incidence in small-holder dairy farm, in the adopted villages of Farmer FIRST project.

### MATERIALS AND METHODS

*Study design:* An innovative CCPs based approach used to control mastitis incidence could be applied as udder health status improvement tool in small-holder Indian dairy farm. HACCP principles, as developed by Codex Alimentarius Commission (CAC) were applied to control mastitis incidence in a systemic manner ensuring that all relevant stage, activities or process in dairy farm were taken into account. In brief, this involves multiple steps, like assembling multi-disciplinary team, identification of hazards and risk and subsequent identification of CCPs. For each CCP, appropriate critical limit, monitoring action and verification procedures were considered. For selection of CCPs, data were recorded from farms, and statistical analysis was performed using IBM SPSS20 software. CCPs were identified by the association between the dependent variables, cow mastitis status (0, negative and 1, positive) and with that of independent variables. The significant

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difference emerged out with chi-square ( $\chi^2$ ) analysis were subjected for bivariate logistic regression (odds ratio and P value given). Occurrence of mastitis (Sub-clinical and clinical) was considered as outcome variable. Finally, CCPs were confirmed with application of decision tree earlier developed by the CAC and bivariate logistic regression was used to verify risk factors identified. The point, step or procedure identified has to be associated with hazard, must be measurable or observable and standard and tolerance limits has to be defined.

Present study was conducted in Lakshmidivipura and Thimmajannahalli villages in Doddaballapur Taluk of Bengaluru Rural District, Karnataka, India. A semi-structured questionnaire was used to collect data from 101 farmers covering 134 crossbred dairy cows (Holstein Friesian and Jersey). Information regarding milking practices, farm management, distribution of work and responsibilities related to this, hygiene, knowledge about mastitis, and associated disease problems were obtained. The cow level factors included breed, lactation (age, parity, and stage of lactation), and milk yield. Herd-level factors assessed were herd size, herd management system, use of bedding material, milking practice (hand/ machine) and method of milking (full hand, knuckling, and striping), frequency of milking, time of milking, cleaning and drying method of udder, pre- and post-milking teat dipping, hygiene of animal shed, milking order of mastitis cow, dry cow therapy, calving care, and treatment and/or culling of chronically infected animal. With respect to hygiene farm, udder, leg and thigh hygiene also monitored. All the farmers followed hand milking. Milking was done twice daily. Baseline data for the same parameters were collected before the start of the study. Milch animals (220) were screened for clinical and subclinical mastitis, using CMT kit, EC and Draminski Mastitis Detector. Post screening, 134 animals, which showed symptoms of mastitis, were selected for the study.

**Sample analysis:** Quarter milk samples were directly (DSSC) and indirectly screened for somatic cell count level by means of California Mastitis Test (CMT) as described by Quinn *et al.* (1999) and Electrical Conductivity (EC). Milk samples from all quarters were collected after few strips of milk sample were discarded from each quarter. Milk (2–4 ml) from separate quarter was drawn into corresponding cup of testing paddle. Milk were tested according to standard procedure and graded from 0, 1, 2, 3 and 4 which indicate healthy, trace, weak, distinct and strong positive respectively and were scored based on the gel formation. Mastitis was therefore defined at cow level if one or more quarters were CMT positive. The results of milk electrical resistance measured with the Draminski Mastitis Detector and were interpreted with Draminski Mastitis Detector (Source: [www.draminski.com](http://www.draminski.com)) for diagnosis of subclinical mastitis. If the difference between the highest unit quarter and rest of the three quarter units lesser than 50 units, then it indicates that all quarters are unaffected while more than 50 indicates affected. Somatic cell counting (SCC) is a direct and accurate method in dairy

animal. DCC (DeLaval cell counter) is a rapid method and easily transportable to farm. Pooled milk from individual cow quarter used for SCC. The results are displayed within 30 to 45 sec. In the direct test, milk SCC with  $200 \times 10^3$  cells/ml was used as a cut off value to differentiate the unaffected from affected cows.

## RESULTS AND DISCUSSION

**Overall incidence of mastitis in crossbred cattle:** In the present study, indirect tests (CMT and EC) and direct test (SCC) used to study incidence of mastitis. Taking into consideration CMT, EC, and SCC test, the overall incidence of mastitis in crossbred dairy cattle at cow and herd level was 63.18% and 68.31%, respectively. CMT result showed that the overall incidence of clinical and subclinical mastitis in crossbred cow was 8.21 and 44.78%, respectively. The overall herd level mastitis was 68.3%.

Table 1. Overall incidence of mastitis (%) in crossbred dairy cattle

Test	Cow (n=134)		Herd (n=101)	
	Uninfected	Infected	Uninfected	Infected
CMT	47.01 (63)	52.99 (71)	40.6 (41)	59.4 (60)
EC	28.4 (38)	71.6 (96)	23.8 (24)	76.2 (77)
SCC	35.1 (47)	64.9 (87)	30.7 (31)	69.3 (70)
Overall	36.82	63.18	31.69	68.31

Figures in parenthesis indicate the number of observations. \*Pre-determined cut-off value of  $200 \times 10^3$  cells/ml was used to differentiate the uninfected from infected (SCM) cattle using individual cow pooled milk samples.

**Host-level risk factors associated with incidence of mastitis:** The host level risk factors associated with mastitis incidence are given in Table 2. The incidence of mastitis in Jersey and HF crossbred cattle on the total 134 crossbred dairy cattle the incidence of mastitis was observed to be higher in HF crossbreds (55.2%) compared to Jersey (38.9%) crossbreds. The incidence of mastitis was higher in the >8 years (66.7%) followed by the age groups 5–8 years (59.7%) and < 5 years (39.2%). Overall incidence of mastitis was significantly ( $P < 0.05$ ) higher in parity >5 followed by the parity 3–4 and <3 was 76.5%, 62.7% 39.4%, respectively. In the early stage of lactation-the incidence of mastitis found non-significantly higher (56.2%) followed by late lactation (52.9%) and mid-lactation (47.7%). In the present study, lactating animals were divided into two groups according to their level of milk production (test day milk yield), viz. low yielding (<10 litres) and high yielding (>10 litres). The overall incidence of mastitis was higher with >10 litres (59.6%), compared to < 10 litres (34.4%) of milk yield. Incidence of subclinical mastitis was higher in animals with high yielding animals (>10 litres) compared to low yielding animals. In the present study, the incidence of mastitis was higher in the BCS above 3 (55.2%) compared to BSC less than 3 (51.3%). Overall incidence of mastitis was higher in the dairy animals with previous history (61%) compared to no history (40.4%) of mastitis.

Table 2. Host level risk factors associated with the incidence of mastitis in crossbred dairy cattle (%)

Variable	Uninfected	Infected
<i>Breed</i>		
HF (116)	44.8 (52)	55.2 (64)
Jersey (18)	61.1 (11)	38.9 (7)
<i>Age (year)</i>		
≤5 (51)	60.8 (31)	39.2 (20)
>5–8 (62)	40.3 (25)	59.7 (37)
>8 (21)	33.3 (7)	66.7 (14)
<i>Parity</i>		
<2 (66)	60.6 (40)	39.4 (26)
>3–4 (51)	37.2 (19)	62.7 (32)
>5 (17)	23.5 (4)	76.5 (13)
<i>Stage of lactation</i>		
Early	43.8 (32)	56.2 (41)
Mid	52.3 (23)	47.7 (21)
Late	47.1 (8)	52.9 (9)
<i>Level of milk production</i>		
<10 litre (35)	65.7 (23)	34.3 (12)
>10 litre (99)	40.4 (40)	59.6 (59)
<i>Previous history of mastitis</i>		
No (52)	59.6 (31)	40.4 (31)
Yes (82)	39.0 (32)	61.0 (50)
<i>Body condition score (BCS)</i>		
<3 (76)	48.7 (37)	51.3 (39)
>3 (58)	44.8 (26)	55.2 (32)

Figures in parenthesis indicate the number of observations.

*Environment level factors associated with incidence of mastitis in crossbred dairy cattle:* The incidence of mastitis was higher in animals maintained under poor housing conditions (82.1%) compared to good housing conditions (45.3%). Overall incidence of mastitis was higher in dairy animals kept in the animal shed with damaged floor condition (81.2%) followed by partially damaged (59.2%) and undamaged floor (42%). The incidence of mastitis was

Table 3. Environment level factors associated with the incidence of mastitis in crossbred dairy cattle (%)

Variable	Uninfected	Infected
<i>Condition of the animal house</i>		
Good (106)	54.7 (58)	45.3 (48)
Poor (28)	17.9 (5)	82.1 (23)
<i>Floor condition</i>		
Undamaged (69)	58.0 (40)	42.0 (29)
Partially damaged (49)	40.8 (20)	59.2 (29)
Damaged (16)	18.8 (3)	81.2 (13)
<i>Drainage facility</i>		
Good (60)	63.3 (38)	36.7 (22)
Poor (45)	40.0 (18)	60.0 (27)
Absence (29)	24.1 (7)	75.9 (22)

Figures in parenthesis indicate the number of observations.

higher in animals maintained in the animal house which had no proper drainage facility (75.9%) followed by poor drainage (60.0%) and good drainage (36.7%).

*Farm management level risk factors associated with incidence of mastitis:* Incidence of mastitis was higher in animals maintained in sheds with once a day cleaning (62.7%) compared to more than once a day cleaning schedule (46.98%). The incidence of mastitis was significantly higher in the dairy animals maintained under the animal house where chemical agents were used for cleaning (21.4%) compared to the usage of only water (56.7%). Similarly, incidence of mastitis was higher in crossbred cows maintained in animal sheds where fly control measures were absent (61.5%) compared to the application of fly control measures (31.6%). A few dairy farmers were making smoke by using the leaves of neem (*Azadirachta indica*) as a fly repellent. The overall incidence of mastitis was higher in the cows with no tail switch trimming (68.8%) followed by a long gap (>6 months) (61.1%) and less than 6 months (39.7%). The overall incidence of mastitis was significantly higher in cows where the standing of a cow after milking was not followed (64.8%) as compared to cows standing for at least 30–45 min after milking (30.4%).

*Milking level risk factors associated with incidence of mastitis:* In the study villages, all animals were hand milked and stripping (52.98%) followed by knuckling (47.02%) methods of milking were adopted by the dairy farmers. All dairy cattle management activities were carried out by the women, however, milking responsibility was shared by both spouses. In the study area, none of the farmers followed the pre- and post-milking teat dip, cotton towel to dry udder and hand.

In the present study, none of the farmers followed the full-hand milking method. The overall incidence of mastitis

Table 4. Management level risk factors associated with the incidence of mastitis in crossbred dairy cattle (%)

Variable	Uninfected	Infected
<i>Frequency of animal house cleaning</i>		
Once a day (51)	37.3 (19)	62.7 (32)
> Once a day (83)	53.02 (44)	46.98 (39)
<i>Chemical used for house cleaning</i>		
Phenol (14)	78.6 (11)	21.4 (3)
Water (120)	43.3 (52)	56.7 (68)
<i>Fly control measures</i>		
Yes	68.4 (26)	31.6 (12)
No	38.5 (37)	61.5 (59)
<i>Tail switch trimming</i>		
< 6 month (68)	60.3 (41)	39.7 (27)
> 6 month (18)	38.9 (7)	61.1 (11)
No trimming (48)	31.2 (15)	68.8 (33)
<i>Post milking standing of cow</i>		
Yes (46)	69.96 (32)	30.4 (14)
No (88)	35.2 (31)	64.8 (57)

on the basis milking method was higher in the knuckling method of milking (71.4%) compared to the stripping (36.6%). The overall incidence of mastitis was higher (65.48%) in cows where milkers did not care for nail trimming compared to regular nail trimming (32.0%). The incidence of mastitis was higher in cows where milkers did not wash their hands (73.3%) followed by usage of water (41.9%) and detergent (8.3%) for hand washing. The incidence of mastitis was higher in cows where milkers did not follow hand drying practice (69.5%) compared to milkers using a towel for hand drying (12.8%). The chi-square analysis revealed that milker's hand drying practice before milking had a significant effect on mastitis. The incidence of mastitis was higher in cows where udder was not washed before milking (62.0%) compared to regular washing of the udder (47.6%). Incidence of mastitis was higher in cows where fore-stripping was not followed (61.4%) compared to cows in which fore-stripping (37.0%) was followed. The findings are in line with Biressaw and Tesfaye (2015).

*Hygiene level variables and the incidence of mastitis in crossbred dairy cattle:* In the present study, incidence of mastitis was higher in dirty farm, udder, thigh and leg was 89.2%, 80.3%, 64.1% and 68.6% respectively, compared to clean. The bivariate logistic regression analysis revealed that the farm and udder hygiene score had a significant effect on the incidence of mastitis.

Many of the risk factors associated with mastitis can be eliminated or reduced by adopting hygienic measures, good management and selecting animals which are less prone to mastitis. The study tried to identify certain managerial risk factors associated with mastitis and develop a suitable

Table 5. Milking management-level risk factors associated with the incidence of mastitis in crossbred dairy cattle (%)

Variable	Uninfected	Infected
<i>Milking method</i>		
Stripping (71)	63.4 (45)	36.6 (26)
Knuckling (63)	28.6 (18)	71.4 (45)
<i>Milkers' nail trimming practice</i>		
Regular	68.0 (34)	32.0 (16)
Irregular	34.52 (29)	65.48 (55)
<i>Milkers' hand wash practice</i>		
Use of detergent (12)	91.7 (11)	8.3 (1)
Use of water (62)	58.1 (36)	41.9 (26)
No handwashing (60)	26.7 (16)	73.3 (60)
<i>Milkers' hand drying practice</i>		
Yes (39)	87.2 (11)	12.8 (1)
No (95)	30.5 (36)	69.5 (26)
<i>Udder wash practice</i>		
Yes (84)	52.4 (44)	47.6 (40)
No (50)	38.0 (19)	62.0 (31)
<i>Fore stripping</i>		
Yes (46)	63.0 (29)	37.0 (17)
No (88)	38.6 (34)	61.4 (54)

Table 6. Hygiene level risk factors associated with the incidence of mastitis in crossbred dairy cattle (%)

Variables	Uninfected	Infected
<i>Farm hygiene score</i>		
Clean (97)	60.8 (59)	39.2 (38)
Dirty (37)	10.8 (4)	89.2 (33)
<i>Udder hygiene score</i>		
Clean (73)	69.9 (51)	30.1 (22)
Dirty (61)	16.7 (12)	80.3 (49)
<i>Leg hygiene score</i>		
Clean (56)	62.5 (35)	37.5 (21)
Dirty (78)	35.9 (28)	64.1 (50)
<i>Thigh hygiene score (THS)</i>		
Clean (83)	56.6 (47)	43.4 (36)
Dirty (51)	31.4 (16)	68.6 (35)

Figure in parenthesis indicate the number of observations  
Identification of Critical Control Points.

critical control points protocol for control of mastitis in crossbred dairy cattle under field conditions. In order to devise the effective programme for the risk factors which affects directly and indirectly incidence of disease severity, understanding of baseline practices at the farms is highly essential. To generate the critical control points protocol for the study areas, significant hazards were arrived at by bivariate logistic regression and cross-referred by applying decision tree developed by *Codex Alimentarius and criteria to identify the most significant CCPs*. For each significant hazard, critical monitoring action and corrective measures were demonstrated to farmers. For this purpose, a framework of Farmer Field Schools was developed.

*Farmer Field Schools for implementing CCP protocol:* Intensive efforts were taken up to identify the critical points and implement CCP protocol developed for the adopted villages. A structured curriculum for imparting knowledge among farmers, regarding importance of cleanliness and seriousness of mastitis along with its economic impact, was developed. A series of 17 classes and workshops were conducted in the field over a period of 3 years. A handful of farmer leaders were identified and trained for spreading the information to the whole village population. Hands-on training was imparted to dairy farmers in the study area to create awareness about good dairy farming practices. During training, farmers were demonstrated step-wise milking procedure and inputs like 'quality milk production kit' was provided to individual farmers. The 'quality milk production kit' included pre- and post-dip solutions with cups, CMT kit, cotton towel, quality milk production charts in English and Kannada (local language), and a diary for record keeping. Follow up was done through locally trained farmer leaders.

*Impact of intervention:* Milk samples were screened for the animals which were undergone CCPs, for identifying any reduction in incidence of mastitis. The intensive efforts of the project team is reflected in the reduction of frequency of incidence of mastitis, reduction in number of milk days loss and reduction in veterinary expenses for treating mastitis (Fig. 1). The cost of intervention was calculated as

Table 7. Summary of critical control points (CCP) for control of mastitis in crossbred dairy cattle

CCP	Hazard	Control measures	Monitoring (Visual)	Verification	Corrective measures
Environment	Floor Drainage	Bedding material (rubber mat), proper drainage	Inspection of farm drainage condition	Recent infection rate, Chronic infection cases, Total bacterial count	Floor and drainage must be constructed for limiting the dirtiness
House and other management	Animal house cleaning	Floor cleaning with using regular tails switch trimming (<6 months)	Visual inspection (house hygiene, fly in the area, standing of an animal)	Earlier and recent infection rate	Cleaning the house floor and equipment with detergent, regular tail switch trimming, providing fresh feed and fodder to the animal
	Fly control				
	Cows switch trimming Post-milking standing of cow				
Milking management	Milkers nails trimming	Regulars milkers nail trimming, hand drying, teat disinfection	Visual inspection of the milking procedure	Recent infection rate, total bacterial count, somatic cell count	Washing and drying of milkers hands, udder preparation and cleanliness while milking, daily use of pre and post-dip use
	Fore-stripping Milkers hand drying before milking				
Hygiene	Udder hygiene Farm hygiene	Maintain proper hygiene of the farm, animal house condition	Farm and udder hygiene score	Earlier and recent incidence cases, bacterial quality of milk	Regular farm manure cleaning, good animal house condition

₹275/animal/ month and the additional returns were calculated as ₹2,175/month/animal.

SUMMARY

The study was planned in two ways, viz. intensive survey using semi-structured questionnaire for baseline information and assessment of risk factors for incidence of mastitis for identification of the Critical Control Points (CCPs). On the basis of identified CCPs, their control measures were developed by a structured process.

Minimizing exposure to unhygienic conditions and improving management were important to controlling udder and teat contamination and thus the physical introduction of microorganism can be prevented. When critical control points at a particular step were decided, critical limits and corrective measures were identified based on team expertise and published literature. In farms under investigation, recommended hygienic procedure included routine use of pre- and post-dip solutions, washing and drying of milker’s hand properly before milking, use of separate cotton towel for udder drying, repairing of housing floor were required or use of rubber mat for flooring and regular maintenance of farm and cow hygiene. Findings of the study are in agreement with earlier study by Cervinkova *et al.* (2003).

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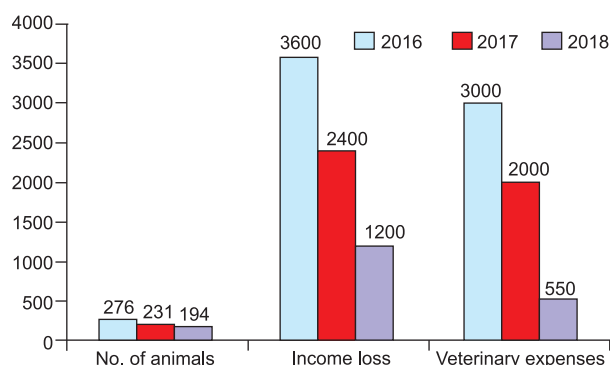


Fig. 1. Impact of interventions on overall incidence of mastitis.

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