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# Sensory characterization of vegetarian pizza by using quantitative descriptive analysis

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**Abstract:** Consumption of vegetarian pizza is increasing worldwide for increasing popularity towards vegetarian diets. However, a proper description of sensorial attributes of vegetarian pizza is still not available in the existing scientific literature. Such characterization provides inevitable information for product's evaluation and process improvement. Therefore, the present study was undertaken to objectively characterize the sensory attributes of vegetarian pizza using statistical tools. A descriptive score card comprising all the possible sensory attributes of pizza was drafted and finalized by group discussion with sensory evaluation experts. Thirty six pizza samples were collected from different Indian cities. Sensory evaluation was done using Quantitative Descriptive Analysis (QDA) and significant ( $p < 0.05$ ) difference among the market samples was observed. Principal Component Analysis (PC) revealed five principal components (PC) which accounted for 93% variation in the sensory data viz., (1) cohesiveness of crust/cooking intensity/free moisture of cheese, (2) firmness/crispiness/type of crust, (3) cohesiveness/thickness of cheese, (4) chewiness, and (5) overall acceptability.

**Keywords:** Pizza, Principal Component Analysis (PCA), Sensory Evaluation, Quantitative Descriptive Analysis (QDA),

## Introduction

Pizza is world's most popular baked products and it can be defined as a plain bread leavened through chemicals or yeast (Redl et al. 2003), with pizza toppings consist primarily of tomato products and cheese, with ingredients such as, meat, onions, or peppers garnished on the top to provide variety. In pizza preparation, dough is formed into the shape of a pizza crust and thereafter dried in a convection or micro-wave oven. After the addition of pizza toppings, i.e., sauce and cheese and any additional ingredients, the whole mass is baked in a micro-wave or convection oven for predetermined time and temperature, the crust remains crisp throughout the baking process. On an average, this topping comprises about 45% of the weight of the finished pizza and rest 55% is the bread like crust. For the purpose of pizza topping, *pasta filata* variety of cheese is widely used across the world (Locci et al. 2008). The pizza market in India is worth above 1500 crores and is developing at a rate of 26% throughout the previous 5 years (Anonymous 2013). As indicated by Pizza Power (2013), a state of industry report, USA, Brazil, Russia, China and India are seen as developing pizza markets of the world. The sales of pizza have expanded from \$28 billion in 2000 to over \$35 billion in 2010 and it keeps on rising in USA (Nickle and Pehrsson 2013).

To produce a food product which could meet the expectations of consumer, it is very crucial to characterize the optimum sensory attributes of the particular product since it may prove to be a driving force for consumer acceptance and demand (Desai et al. 2013). Quantitative descriptive analysis (QDA) approach has been recognized as a tool for measurement and optimization of sensory attributes of various food products (Stone and Sidel 1998). The main principal of QDA is to impart adequate training to panelists who can measure the product attributes to obtain the quantitative description of that product which could be further analyzed statistically. In QDA approach, the key organoleptic attributes of the product are found out along with their appropriate intensity scales specific to that product. For this purpose, panelists work together in a focused group and by discussion among themselves they identify such attributes (Chapman et al. 2001). Terminologies defining the major sensorial attributes are generated by panelists, the

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resulting descriptions are important for profiling of sensory attributes and the analysis is efficiently utilized in modeling the predictions of consumer acceptability. Further, sensory evaluation sessions are conducted for panelists to identify and score product attributes. Results obtained by QDA can be analyzed statistically and then represented graphically.

PCA is a multivariate technique of extracting structure from a correlation matrix. The scores of various dependent variables obtained by descriptive analysis technique are subjected to further analysis in this technique to reduce the set of dependent variables (attributes) to a smaller set of underlying variables which are known as factors, based on the patterns of correlation among the original dependent variables (Lawless and Heymann 1998). PCA extract a new variable called a principal component for group of correlated original attributes. Further, second and third group are identified with derivation of factors for each, based on residual variance. PCA provides factor loadings which are represented as correlation of attributes with new dimensions and factor scores as values of products on new dimensions. Factor loadings are essential for interpretation of dimensions and the factor scores illustrate the relative positions among the products in a map (Jolliffe 2005). The results obtained by PCA has some fates such as profiling of specific product characteristic, comparing and contrasting similar products based on imperative attributes to consumers and thus increasing market share by making changes in product characteristics. Combination of QDA and PCA has been used to characterize sensorial attributes of many food products with great degree of success, such as ultra-pasteurized milk (Chapman et al. 2001), Cheddar cheese (Young et al. 2004), chocolate milk (Thompson et al. 2004), soy milk (Keast and Lau 2006), whey and soy proteins (Drake et al. 2007), fermented food products (Ghosh and Chattopadhyay 2012), labneh (Kaaki et al. 2012), yoghurt (Desai et al. 2013) and *doda burfi* (Chawla et al. 2014) and *cham cham* (an indigenous *channa* based dairy product) (Puri et al. 2016).

Owing to the fact that a major portion of Indian population is vegetarian, the consumption of vegetarian pizza is increasing and the trend is moving towards more and more appreciation of its sensorial attributes, as eating of pizza is becoming more common (De Vita et al. 2016). However a proper product description in terms of sensorial attributes of vegetarian pizza is still not available in the existing scientific literatures. Hence, the objective of this study was to identify lexicons with their definitions which could characterize the sensory attributes of vegetarian pizza using QDA and PCA. The information so obtained will be useful for understanding the most important sensory attributes of vegetarian pizza. Such information is crucial for optimizing the production process at commercial scale for preparation of vegetarian pizza having most desirable sensory attributes.

## Materials and Methods

### Origin of the samples

A total of thirty six samples of vegetarian pizza were collected from nine different prominent pizza manufacturer shops (four times from each shop) located in four cities of north India *viz.*, Delhi, Chandigarh, Patiala and Karnal. As a few different varieties of vegetarian pizza were available, the most popular variety (Farm Fresh pizza) having similarity in style and types of toppings used was selected from each shop. The pizza toppings used in farm fresh pizza consisted primarily of mozzarella cheese, tomato sauce, onion, capsicum and tomato and black olive slices. Freshly prepared and packaged samples were procured from the individual shops and were packed in insulated containers (maintained at  $30\pm 1^\circ\text{C}$ ). The packed samples were brought to the laboratory in about 3-4 hours time. Immediately after the samples were received, they were reheated to serving temperature ( $50\pm 2^\circ\text{C}$ ) by microwave oven (100% power level for 2 minutes) and presented for sensory evaluation to the trained sensory panelists.

### Experimental conditions of the sample

Sensory evaluation was carried out in sensory evaluation laboratory of Dairy Technology Division. During the evaluation period, temperature of  $24\pm 2^\circ\text{C}$ , 60-62% relative humidity and lightness intensity of 110 candle foot was maintained. For each evaluation, one quarter of a full pizza ( $50\pm 2$  grams) of sample was presented at  $50\pm 2^\circ\text{C}$  temperature to the panelists seated in individual booths. Each sample was served monadically with deionised water.

Ten trained sensory evaluation panelists, constituted from the faculty of Dairy Technology Division, National Dairy Research Institute, Karnal, India, developed the attribute terms for sensory evaluation of vegetarian pizza samples using QDA methodology (Chawla et al. 2014). The judges had previous experience in sensory evaluation of dairy products and were selected based upon their ability to detect the off-flavors in mozzarella cheese.

The ballot development for sensory evaluation was accomplished in six working sessions (each session of 1 hour). After the terminology development phase, the panelists were trained for the evaluation of pizza for a period of 2 months in 24 sessions of 1 hour each. The training consisted of evaluating surface characteristics of mozzarella cheese as described in Chel et al. (2009).

### Sensory analyses

Factorial design was used for sensory evaluation of pizza samples, with sample\*judge matrix in three different sessions. Each session comprised of three parts in which 7-8 sensory attributes were evaluated. The descriptive terms for each major

sensory attribute category were developed by discussion, followed by consensus among the trained panel members. Similar approach has been reported by Puri et al. (2016) to generate sensory vocabulary. List of different descriptors (vocabulary) so finalized are provided in Table 1. Attributes were quantified with a linear intensity rating scale score card in which scale was from 0 to 10; where 0 = attribute not detected and 10 = attribute extremely strong (Chapman et al. 2001).

The main descriptors that were chosen to include in a score card used for sensory evaluation were six attributes for crust characteristics evaluation *viz.*, firmness, crispness, cohesiveness, moisture absorption, pull-apart and type of crust. Two attributes for evaluation of topping characteristics *viz.*, cooking intensity and amount of topping were used. For determining surface colour attributes, two attributes *viz.*, blister colour and opaqueness; for surface consistency evaluation, the five descriptors free oil, free moisture, blister coverage, skinning and flow-off crust were used. For evaluation of melted cheese characteristics, three attributes *viz.*, hardness, cohesiveness and chewiness were chosen. For evaluation of

stretch characteristics three attributes *viz.*, strand length, thickness and force to stretch were used.

### Statistical analyses

The data were analyzed using IBM SPSS Statistics 20.0. Scores from ten panelists were used for descriptive statistical analysis. Analysis of variance (ANOVA) and Tukey test were employed for post hoc multiple comparisons so as to analyze the descriptive data to determine whether the means were different significantly or not. PCA was applied to the means of all the attributes using factor analysis technique. The analysis extracted the most significant variables with minimum loss of information. A combination of Kaiser's criterion *i.e.*, (eigen value >1) and the principal components that accounted for minimum 70 % of the variance in the data set was applied to retain the number of final factors from the initial ones (Lawless and Heymann 1998). To facilitate interpretation of the results, the factors were orthogonally rotated (which leads to uncorrelated factors) by using the 'Varimax' method (Massart et al. 1988).

**Table 1** Descriptors with definition used to explain the desirable quality parameters of Pizza

Descriptors	Definition
<b>Crust Characteristics</b>	
Firmness	Force required to compress and cut the sample using incisors
Crispness	The force by which the pizza sample shatter upon mastication
Cohesiveness	Degree to which mass hold together due to inter particle bonding
Moisture absorption	Amount of saliva absorbed by the pizza sample before swallowing
Pull-apart	Force required to separate a bite size with teeth and fingers from rest of the specimen
Type	Thinness or thickness of the crust.
<b>Topping Characteristics</b>	
Cooking intensity	Intensity of cooked flavor for cheese and vegetables
Amount	Quantity of Cheese and vegetables on pizza
<b>Surface Colour</b>	
Blister colour	The intensity of the brown hue on the blisters.
Opaqueness	The degree of opacity of the melted cheese.
<b>Surface Consistency</b>	
Free oil	The amount of free oil on surface of pizza.
Free moisture	The amount of free moisture on the surface.
Blister coverage	The amount of the surface covered by blisters.
Skinning	Extent of layer formation on top surface of melted cheese.
Flow-off crust	The quantity the cheese melted off the crust
<b>Melted Cheese Texture Characteristics</b>	
Hardness	The force required to bite through the sample using molars.
Cohesiveness	Degree to which the cheese tends to binds together during mastication.
Chewiness	The total amount of energy required to masticate the sample to a state ready for swallowing.
<b>Stretch Characteristics</b>	
Strand length	How far the mozzarella cheese strand elongates before it breaks.
Thickness	The width of the melted cheese strand.
Force to stretch	The energy required to pull a strand.
Overall Acceptability	The total sensory likeness and dislikeness of the product based on all the sensorial attributes tested.

## Results and Discussion

### Descriptive analysis

For sensory evaluation of samples, some specific terms were generated by discussing with the trained panel members, which were used as basic for QDA. After a consensus discussion among the panelists, list of different descriptors were finalized. Descriptive vocabulary generated by the panelists to describe the sensory attributes of pizza is presented in Table 1. Mean panelist ratings of overall quality of market samples of vegetarian pizza and attribute intensities for crust characteristics, surface colour, surface consistency, topping characteristics and melted cheese characteristics for samples of nine shops are listed in Table 2.

### ANOVA and Post-hoc test

Analysis of variance was carried out on mean sensory scores of pizza samples collected from nine different shops (Table 2). All the studied attributes varied significantly ( $p < 0.05$ ) among the nine shops with the fact that some samples have overlapping qualities, however no such significant difference ( $p < 0.05$ ) was obtained among the sensory results of panelists and for interaction effect between the panelist and shop. For the characteristic “firmness of crust”, the sample P6 differed significantly ( $p < 0.05$ ) from P5, P8 and P9 samples. Firmness of the sample P6 was highly acceptable because it was neither too soft nor too hard so that it could be easily cut and compressed during mastication. Except samples P5, P8 and P9, all other samples did not differ significantly from P6. “Crispiness” of P6 sample was significantly ( $p < 0.05$ ) different from P2, P3, P4, P5, P7 and P9 and rest of the sample had similar crispiness as the sample P6. The difference in crispiness among samples was probably due to the excessive loss of moisture from the crust during baking. There was significant difference ( $p < 0.05$ ) in “cohesiveness of crust” among the samples P5, P6 and P9. Similarly, “moisture absorption” of P4 sample differed significantly ( $p < 0.05$ ) from P8 and P9. This variation in moisture absorption of pizza crust perceived by the sensory panelists may be due to the salivary flow difference of the individual panelists. de Delahaye et al (2005) reported differences in moisture absorption capacity of pizza for differences in their moisture content in crust. “Pull-apart” of sample P6 and P9 differed significantly ( $P < 0.05$ ) from all other samples. This may be due to the differences in textural characteristics of the pizza crust as well as difference in surface hardening that occurred at the bottom surface of crust during baking. “Type of crust” reflects the extent of thinness or thickness of the crust. Sample P6 obtained highest sensory scores because the thickness was found to be optimum by the judges and the score differed significantly ( $P < 0.05$ ) from all other samples. Crust thickness of sample P9 was highest and differed significantly ( $P < 0.05$ ) from sample P1, P3, P6, P7 and P8.

In topping characteristics, sample P9 was significantly different ( $P < 0.05$ ) from all other samples as it was highly baked and possessed intensely brown surface and sample P6 differed significantly in cooking intensity from P1, P3, P5 and P9. The reason for this difference could be the higher baking temperature (280°C) or longer baking time (6 min) during pizza making. Sample P9 contained significantly ( $P < 0.05$ ) higher amount of pizza cheese and vegetables as compared to all other samples. The higher amount of pizza cheese and vegetables in sample P9 might be due to this particular shop added higher amounts of these ingredients to produce a better quality pizza than other rival shops.

Variation in surface colour of sample P9 varied significantly ( $P < 0.5$ ) from all other samples and the scores of this sample were higher as compared to other samples. It was probably because of the optimum baking of this sample. Blister colour of sample P9 was highly rated by the sensory panelists. Browning of blister to this extent was much liked by the judges. “Opacity” of sample P9 differed significantly ( $P < 0.5$ ) from sample P6. It was observed probably because in melted cheese, the temperature and amount of fat mainly influences the opacity and it differed due to fat content of the cheese varied. Opacity is temperature dependent and it reduces upon the cooking and cooling of cheese due to the fat coalescence which leads cheese to appear more translucent (Chen et al. 2009). Hence, probably the sample P7 and P9 either contained less fat and/or baked at higher intensity.

Surface consistency of samples differed significantly ( $P < 0.5$ ) for different shops. Presence of free oil on the surface of this sample was excessively high (more than 3 milliliters of oil from the surface of each sample presented to the panelist) which rendered it unfavorable to the judges. “Free moisture” of sample P9 varied significantly ( $P < 0.05$ ) from all other samples and sample P5 differ significantly from P6. “Blister coverage” greatly influences the consumer for purchasing pizza. Sample P9 was significantly ( $P < 0.5$ ) differed from all other samples in this attribute. “Skinning” of sample P9 was also significantly ( $P < 0.5$ ) different from all the samples. Skinning mainly depends upon the age of the cheese used, its composition, oven type and baking conditions used. “Flow of crust” of the sample P1 differed significantly ( $P < 0.5$ ) from all the other samples. It might be due to higher amount of shredded cheese on the pizza base that would flow from the base to the outer sides during baking.

Melted cheese characteristics of sample P8 differ significantly ( $P < 0.5$ ) from P1 and the sample P9 varied significantly ( $P < 0.5$ ) from all other samples. Hardness of cheese is mainly due to the higher amount of protein content in cheese (Chen et al. 2009). “Cohesiveness of cheese” of sample P1, P4 and P7 differed significantly ( $P < 0.5$ ) from P8. It is the ability to hold cheese mass together after chewing. “Chewiness” of sample P1 was significantly ( $P < 0.5$ ) different from sample P3, P4, P5, P6, P8 and P9. Variation in cheese stretch characteristics of sample P1 differed significantly ( $P < 0.05$ ) from sample P3, P4, P6, P7 and P8.

**Table 3** Varimax rotated principal component factor loading for pizza attributes

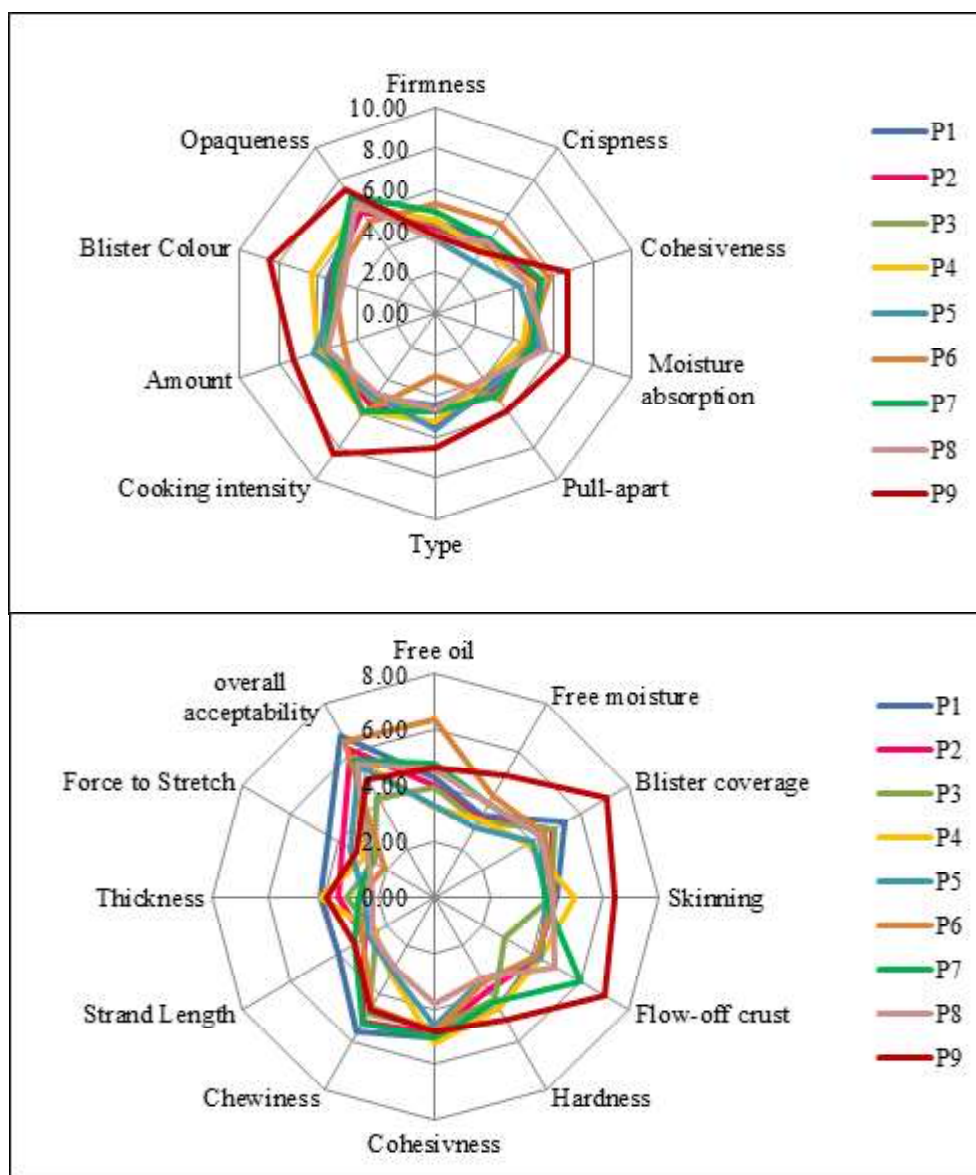
Attributes	P1	P2	P3	P4	P5	P6	P7	P8	P9
Firmness	4.46 <sup>abc</sup> ± 0.8	4.19 <sup>abc</sup> ± 0.5	4.40 <sup>abc</sup> ± 0.2	4.56 <sup>abc</sup> ± 0.4	3.59 <sup>a</sup> ± 0.2	5.31 <sup>a</sup> ± 0.2	4.94 <sup>ab</sup> ± 0.2	3.60 <sup>d</sup> ± 0.3	3.80 <sup>cd</sup> ± 0.2
Crispness	4.41 <sup>abc</sup> ± 0.9	4.12 <sup>bc</sup> ± 0.2	3.98 <sup>bc</sup> ± 0.3	3.80 <sup>bcd</sup> ± 0.2	3.06 <sup>d</sup> ± 0.3	5.26 <sup>a</sup> ± 0.3	4.38 <sup>bc</sup> ± 0.4	4.27 <sup>bc</sup> ± 0.2	3.68 <sup>bcd</sup> ± 0.2
Cohesiveness of crust	4.88 <sup>cd</sup> ± 0.4	5.25 <sup>bc</sup> ± 0.2	4.78 <sup>cd</sup> ± 0.2	4.89 <sup>bcd</sup> ± 0.2	4.31 <sup>d</sup> ± 0.3	5.77 <sup>b</sup> ± 0.3	5.44 <sup>bc</sup> ± 0.3	4.71 <sup>cd</sup> ± 0.3	6.70 <sup>a</sup> ± 0.3
Moisture absorption	5.15 <sup>bc</sup> ± 0.1	5.04 <sup>cd</sup> ± 0.3	4.70 <sup>cd</sup> ± 0.2	4.43 <sup>d</sup> ± 0.1	5.27 <sup>bc</sup> ± 0.3	4.67 <sup>cd</sup> ± 0.3	4.89 <sup>cd</sup> ± 0.3	5.55 <sup>b</sup> ± 0.1	6.67 <sup>b</sup> ± 0.2
Pull-apart	4.33 <sup>cd</sup> ± 0.1	4.57 <sup>bcd</sup> ± 0.1	3.97 <sup>d</sup> ± 0.2	4.06 <sup>cd</sup> ± 0.2	4.48 <sup>bcd</sup> ± 0.3	5.21 <sup>ab</sup> ± 0.3	4.8 <sup>bc</sup> ± 0.3	3.99 <sup>d</sup> ± 0.4	5.82 <sup>a</sup> ± 0.2
Type	4.45 <sup>b</sup> ± 0.8	5.44 <sup>ab</sup> ± 0.2	4.78 <sup>b</sup> ± 0.5	5.20 <sup>ab</sup> ± 0.4	5.63 <sup>ab</sup> ± 0.2	2.97 <sup>c</sup> ± 0.5	4.71 <sup>b</sup> ± 0.2	4.66 <sup>b</sup> ± 0.1	6.47 <sup>b</sup> ± 0.3
Cooking intensity	5.00 <sup>cd</sup> ± 0.5	5.43 <sup>bcd</sup> ± 0.3	5.12 <sup>cd</sup> ± 0.4	5.88 <sup>bc</sup> ± 0.3	4.91 <sup>cd</sup> ± 0.2	6.05 <sup>b</sup> ± 0.4	5.92 <sup>bc</sup> ± 0.2	4.74 <sup>d</sup> ± 0.2	8.39 <sup>a</sup> ± 0.3
Amount	5.79 <sup>bc</sup> ± 0.4	5.59 <sup>bc</sup> ± 0.4	5.70 <sup>bc</sup> ± 0.2	6.07 <sup>b</sup> ± 0.2	6.26 <sup>ab</sup> ± 0.1	4.79 <sup>c</sup> ± 0.6	5.53 <sup>bc</sup> ± 0.4	5.53 <sup>bc</sup> ± 0.1	7.21 <sup>a</sup> ± 0.2
Bilister colour	5.48 <sup>bcd</sup> ± 0.4	5.33 <sup>bcd</sup> ± 0.4	5.09 <sup>cd</sup> ± 0.5	6.30 <sup>b</sup> ± 0.2	4.84 <sup>d</sup> ± 0.2	5.24 <sup>bcd</sup> ± 0.2	5.22 <sup>cd</sup> ± 0.3	4.71 <sup>d</sup> ± 0.1	8.44 <sup>a</sup> ± 0.2
Opacity	6.47 <sup>ab</sup> ± 0.3	6.17 <sup>ab</sup> ± 0.5	6.68 <sup>ab</sup> ± 0.7	6.38 <sup>ab</sup> ± 0.1	6.81 <sup>ab</sup> ± 0.5	5.49 <sup>b</sup> ± 0.4	7.03 <sup>a</sup> ± 0.2	6.58 <sup>ab</sup> ± 0.5	7.38 <sup>a</sup> ± 0.2
Free oil	4.30 <sup>bc</sup> ± 0.4	4.04 <sup>bc</sup> ± 0.6	3.96 <sup>bc</sup> ± 0.1	3.21 <sup>c</sup> ± 0.3	3.28 <sup>c</sup> ± 0.2	6.40 <sup>a</sup> ± 0.4	4.78 <sup>b</sup> ± 0.5	4.61 <sup>b</sup> ± 0.3	4.68 <sup>b</sup> ± 0.2
Free moisture	3.35 <sup>bcd</sup> ± 0.2	3.21 <sup>cd</sup> ± 0.1	3.17 <sup>cd</sup> ± 0.2	3.25 <sup>bcd</sup> ± 0.5	2.85 <sup>d</sup> ± 0.2	4.18 <sup>b</sup> ± 0.3	3.89 <sup>bcd</sup> ± 0.3	3.84 <sup>bcd</sup> ± 0.4	5.08 <sup>a</sup> ± 0.3
Bilister coverage	5.37 <sup>b</sup> ± 0.4	4.89 <sup>bc</sup> ± 0.3	4.93 <sup>bc</sup> ± 0.3	3.82 <sup>d</sup> ± 0.3	4.01 <sup>cd</sup> ± 0.1	4.57 <sup>bcd</sup> ± 0.3	4.39 <sup>bcd</sup> ± 0.5	4.41 <sup>bcd</sup> ± 0.4	7.13 <sup>a</sup> ± 0.2
Skimming	4.35 <sup>bc</sup> ± 0.3	4.16 <sup>bc</sup> ± 0.4	4.15 <sup>bc</sup> ± 0.1	5.00 <sup>b</sup> ± 0.2	3.98 <sup>c</sup> ± 0.2	4.32 <sup>bc</sup> ± 0.4	3.96 <sup>c</sup> ± 0.3	4.23 <sup>bc</sup> ± 0.5	6.41 <sup>a</sup> ± 0.1
Flow-off crust	4.24 <sup>c</sup> ± 0.2	4.26 <sup>c</sup> ± 0.2	2.88 <sup>d</sup> ± 0.3	4.35 <sup>bc</sup> ± 0.1	4.39 <sup>bc</sup> ± 0.1	4.21 <sup>c</sup> ± 0.8	5.99 <sup>b</sup> ± 0.3	4.99 <sup>bc</sup> ± 0.2	6.99 <sup>a</sup> ± 0.2
Hardness	4.57 <sup>ab</sup> ± 0.2	3.80 <sup>bc</sup> ± 0.1	4.23 <sup>abc</sup> ± 0.2	4.57 <sup>ac</sup> ± 0.4	3.43 <sup>bc</sup> ± 0.1	3.50 <sup>bc</sup> ± 0.4	4.28 <sup>abc</sup> ± 0.4	3.35 <sup>c</sup> ± 0.5	5.09 <sup>a</sup> ± 0.6
Cohesiveness of cheese	5.01 <sup>a</sup> ± 0.3	4.93 <sup>ab</sup> ± 0.1	4.70 <sup>ab</sup> ± 0.6	5.25 <sup>a</sup> ± 0.2	4.58 <sup>ab</sup> ± 0.3	4.81 <sup>ab</sup> ± 0.4	5.04 <sup>a</sup> ± 0.3	3.85 <sup>b</sup> ± 0.4	4.86 <sup>ab</sup> ± 0.3
Chewiness	5.57 <sup>a</sup> ± 0.3	5.15 <sup>ab</sup> ± 0.3	4.81 <sup>bc</sup> ± 0.3	3.18 <sup>d</sup> ± 0.3	3.07 <sup>d</sup> ± 0.5	4.54 <sup>bc</sup> ± 0.5	5.23 <sup>ab</sup> ± 0.3	2.87 <sup>d</sup> ± 0.2	4.64 <sup>bc</sup> ± 0.5
Strand Length	3.99 <sup>a</sup> ± 0.7	2.90 <sup>ab</sup> ± 0.3	2.46 <sup>b</sup> ± 0.3	2.50 <sup>b</sup> ± 0.2	2.77 <sup>b</sup> ± 0.3	3.03 <sup>ab</sup> ± 0.9	3.37 <sup>ab</sup> ± 0.6	2.59 <sup>b</sup> ± 0.2	3.35 <sup>ab</sup> ± 0.3
Thickness	4.11 <sup>a</sup> ± 0.6	3.45 <sup>ab</sup> ± 0.3	3.19 <sup>ab</sup> ± 0.3	4.09 <sup>a</sup> ± 0.2	2.54 <sup>bc</sup> ± 0.5	2.76 <sup>bc</sup> ± 0.8	2.79 <sup>bc</sup> ± 0.6	2.25 <sup>c</sup> ± 0.3	3.90 <sup>ab</sup> ± 0.7
Force to stretch	4.38 <sup>a</sup> ± 0.6	3.87 <sup>ab</sup> ± 0.2	2.54 <sup>bc</sup> ± 0.3	2.89 <sup>bc</sup> ± 0.6	3.47 <sup>abc</sup> ± 0.6	2.11 <sup>c</sup> ± 0.6	2.69 <sup>bc</sup> ± 0.6	2.72 <sup>bc</sup> ± 0.3	3.22 <sup>abc</sup> ± 0.5

Means (least square) sensory score of shops of nine groups (Mean ± SE)

ANOVA and Tukey post hoc test was applied to descriptive sensory score data to obtain difference in mean

<sup>abcd</sup> Values in row followed by different superscripts differ significantly (P<0.05)

**Fig. 1** Sensory profile of market samples of pizza from nine different pizza shops. Individual attributes are positioned like the spokes of a wheel around a center (zero, or not detected) point, with the spokes representing attributes intensity scales, with higher (more intense) values radiating outwards. (a) For crust and topping characteristics and surface colour; (b) for surface consistency, melted cheese texture characteristics, stretch characteristics and overall acceptability



Spider plots were created by plotting average intensity scores on a corresponding scale and then joining the points (Stone and Sidel 1998). Fig 1a and 1b shows attributes of the market samples of pizza from nine different pizza shops. This plot illustrates that “blister colour” and “cooking intensity” of sample P9 was maximum, which is not-desirable and lowest in P8 sample. It could also be seen that amount of cheese and vegetables was maximum in sample P9 followed by P5 and P4 and lowest in sample P6 and rest of the samples differed non-significantly. Crispiness was maximum of the sample P6 and lowest in sample P5 and other samples possessed no significant difference in this attribute. Crust type of sample P6 obtained minimum scores indicating it was a thinner sample and the sample P5 had thicker crust as compared to all other samples. It could also be observed that blister coverage of sample P9 was maximum and lowest in sample P5. Presence of free oil was maximum on sample P6 and lowest in P5.

#### Principal Components Analysis (PCA)

To eliminate descriptor redundancies and to simplify the data, PCA is used for transformation of original dependent variable into uncorrelated dimensions. PCA was applied to the mean attribute ratings listed in Table 2 to simplify the interpretation of data from 22 attributes measured on nine samples. To obtain specific knowledge about factors having critical importance among the sensorial descriptors, PCs were extracted based on maximum variance values. Among the PCs extracted, five PCs having eigen values  $> 1$  (Kaiser criterion) explaining 93.05% of the total variance in the data set were taken for further analysis. The results revealed that on the basis of eigenvector loadings, first PC with eigen value of 9.03 was able to explain 41.07 % of the total variation whereas second PC with an eigen value 5.31 explained 24.14 % of the variation and both the PC's (PC1 and

**Table 3** Varimax rotated principal component factor loading for pizza attributes

Attributes	PC1	PC2	PC3	PC4	PC5
Firmness	-0.026	-0.872*	0.407	0.146	-0.087
Crispness	0.143	-0.922*	-0.081	0.203	0.091
Cohesiveness of crust	0.923*	-0.171	0.217	0.174	-0.088
Moisture absorption	0.732	0.568	-0.281	0.183	0.102
Pull-apart	0.879	-0.119	0.066	0.168	0.078
Type	0.239	0.912*	0.182	-0.039	-0.050
Cooking intensity	0.911*	0.097	0.347	-0.005	-0.153
Amount	0.415	0.861	0.264	-0.018	-0.045
Blister Colour	0.797	0.332	0.487	-0.032	-0.055
Opaqueness	0.294	0.776	-0.013	0.269	-0.269
Free oil	0.518	-0.765	-0.305	0.210	0.008
Free moisture	0.964*	-0.137	-0.083	0.092	-0.109
Blister coverage	0.734	0.287	0.138	0.485	-0.036
Skinning	0.809	0.340	0.377	-0.142	-0.062
Flow-off crust	0.822	0.254	-0.074	0.048	0.148
Hardness	0.415	0.303	0.740	0.304	-0.128
Cohesiveness of cheese	0.035	-0.160	0.915*	0.136	0.102
Chewiness	0.117	-0.284	0.354	0.856*	0.041
Strand Length	0.331	-0.076	0.178	0.683	0.552
Thickness	0.160	0.204	0.882*	0.150	0.200
Force to Stretch	-0.177	0.519	0.228	0.387	0.683
overall acceptability	-0.079	-0.480	0.069	-0.010	0.863*
Variance explained <sup>1</sup>	41.06%	24.14%	14.65%	8.53%	4.66%

Five PC were extracted by applying PCA on the mean values of descriptive sensory scores

\*Number marked \* are believed to be most important

<sup>1</sup>Refers to percent variance explained

**Table 4** Factor score for market sample of pizza

Attributes	PC1	PC2	PC3	PC4	PC5
	Cohesiveness of crust/ cooking intensity/free moisture	Firmness/ crispness/type	Cohesiveness of cheese/thickness	Chewiness	Overall acceptability
P1	-0.50904	0.03169	0.61255	1.4601	1.53707
P2	-0.41749	0.07137	0.21155	0.26761	0.72221
P3	-0.99354	0.10602	0.19663	0.74424	-2.1434
P4	-0.41089	0.09189	1.69587	-1.81258	-0.01943
P5	-0.74093	1.14554	-0.77625	-0.65089	0.45535
P6	0.64693	-2.26353	-0.305	-0.49351	0.12578
P7	0.12101	-0.51726	-0.05251	0.89735	-0.4364
P8	-0.02582	0.23087	-1.9564	-0.6532	0.07764
P9	2.32977	1.10342	0.37356	0.24088	-0.31882
Variance explained	41.061	24.147	14.650	8.531	4.658

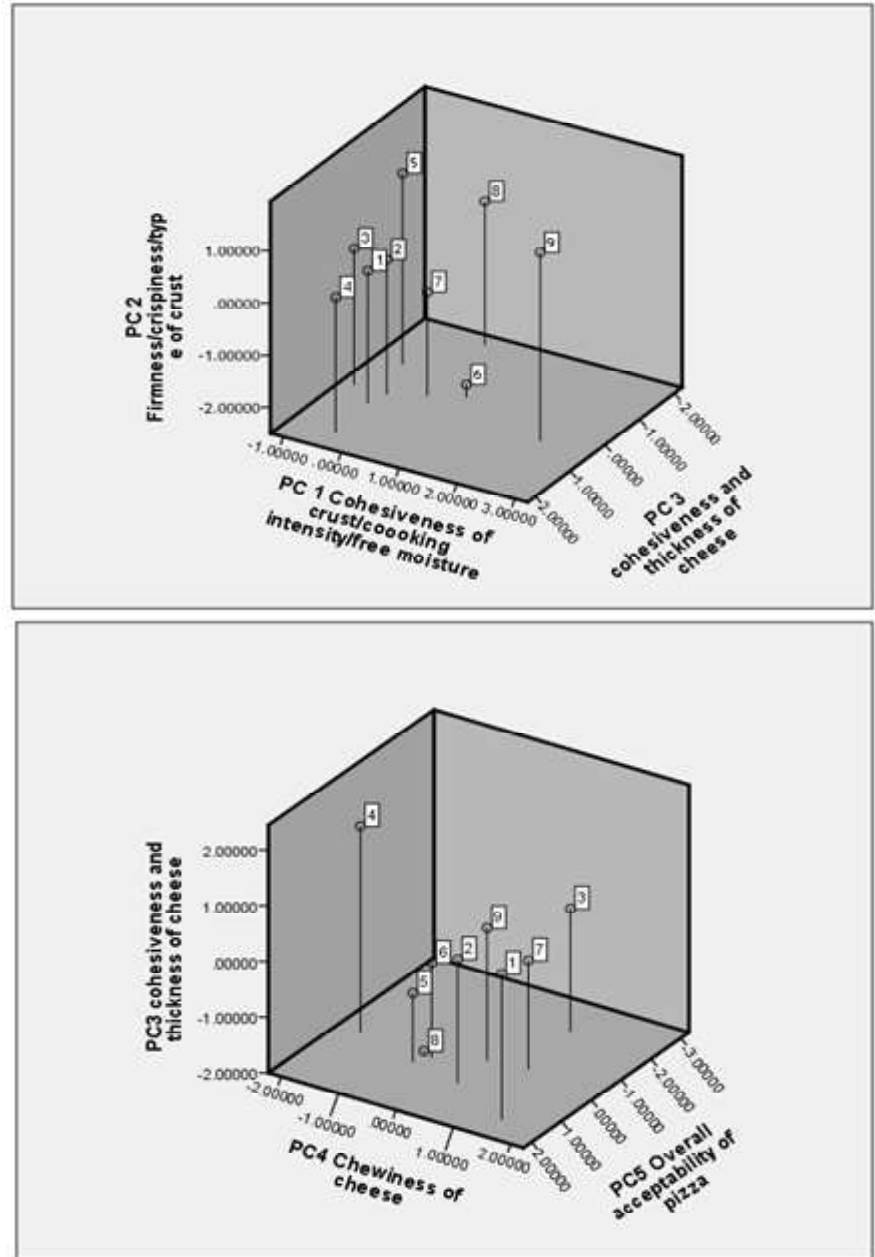
Factors scores were generated by applying PCA on descriptive sensory score data

<sup>1</sup>Refers to percent variance explained

PC2) explained 65.20 % of the total variation. Third PC with eigen value of 3.22 was able to explain 14.65 % variation, fourth PC having eigen value of 1.88 explained 8.53 % variability and

fifth PC with eigen value of 1.03 was able to explain 4.66 % variability. For closer alignment with original variables, PCs were

**Fig. 2** Three-dimensional plot showing factors scores of market samples of pizza of Varimax rotated PC axes (a) PC1, PC2, PC3 and (b) PC3, PC4, PC5. Lables: Pizza shop codes (1-9)



rotated using Varimax rotation method (Lawless and Heymann 1998). Rotation of variables resulted in factor loadings which represented correlation between PC and the original attribute. High factor loading values marked with asterisk were of chief importance. As shown in Table 3, absolute value of factor loadings corresponding to each sensory attribute decides the relation between principal component and that specific sensory attribute. PC1 was found to be entirely related to the “cohesiveness of crust”, “cooking intensity” and “free moisture” as the loadings had maximum absolute values. More than one variable can be explained with the help of one principal component as suggested by Chapman et al. (2001). PC2 had large loadings for “firmness”, “crispiness” and “type of crust”.

PC3 was largely related to “cohesiveness of cheese” and “thickness of cheese strand” while PC4 was found to be influenced by “chewiness” and PC5 was found to be related to “overall acceptability”.

For positioning or specifying the location of all the samples in three dimensional space, Varimax rotated PC factor score values (Table 4) can be utilized (Coxon 1982). Hence, with the help of three dimensional graphs the position of different samples of pizza along five PC generated were correlated (Fig. 2a and 2b). Products that were comparatively similar were found in close proximity to each other on the graph space, samples with significant difference were found far apart (Jolliffe 2005). It can

be observed from Table 4 that sample group P6, P7 and P9 were shown to have positive factor score values from 0.121 to 2.330 for “cohesiveness of crust”, “cooking intensity” and “free moisture” as compared to all other group samples as shown by negative factor score values from -0.026 to -0.994, signifying that samples P6, P7 and P9 were not preferred by sensory panelists due to high surface moisture on cheese and more cohesive crust and also for higher cooking intensity of the sample P9. “Firmness”, “crispiness” and “type” of P1, P2, P3, P4 and P8 groups was found more desirable as compared to P5, P6, P7 and P9 market samples P5 (1.146) and P9 (1.103) had higher score while P6 (-2.264) and P7 (-0.517) had very low scores which could be observed by higher and smaller spike height on graph, respectively. At the same time scores for “cohesiveness of cheese” and “thickness” of samples from group P1 (0.613), P2 (0.212), P3 (0.197), P9 (0.374) and P4 (1.696) were found higher as compared to P5, P6, P7 and P8 groups as represented by taller spikes height shown in the Fig 2a. Factor scores for “chewiness” of sample P1, P2, P3, P7 and P9 were higher, sample P1 (1.460) and P7 (0.897) had highest factor scores among them as shown in Fig. 2b. Overall acceptability of sample P1 (1.537) had higher factor score and samples P2, P5, P6 and P8 also had higher positive factor scores as compared to sample P3, P4, P7 and P9 which were found to have negative factor scores signifying that samples from these groups were found undesirable to sensory panel members.

## Conclusion

It could be concluded from the study that the sensorial attributes of vegetarian pizza samples could be properly defined using 21 descriptors and Principal Component Analysis identified nine prime descriptors (cohesiveness, cooking intensity, free moisture, firmness, crispness and type of crust, cohesiveness, thickness, chewiness) governed much of the variation of sensory attributes of vegetarian pizza. Hence, these attributes may be given prime importance while developing the product technology for industrial scale production.

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## Descriptive sensory profiling of *thandai* using principal component analysis

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**Abstract:** *Thandai* being nutrient crammed pabulum is relished as a traditional milk-based beverage in India. Being indigenous drink, international and national level research work and the literature pertaining to the same is not available. Thus, the present study was undertaken to investigate and characterize the sensory attributes of commercially available *thandai* using Quantitative Descriptive Analysis (QDA) and Principal Component Analysis (PCA). QDA revealed statistically significant ( $p < 0.05$ ) difference in sensory attributes of *thandai* amongst the market samples. PCA identified three significant principal components that accounted for 93.01 per cent of the variation in the sensory data. Correlation matrix revealed many linear relationships between independent terms of sensory attributes.

**Keywords:** Milk beverage; 100-point scale; Principal component analysis; Quantitative descriptive analysis.

### Introduction

The ancient philosopher has espoused the basic senses of human- sight, hearing, smell, taste and touch as “the windows of the soul.” Sensory properties of products are absolutely necessary for the development of the product and can generally be described using terms defined within the categories of appearance, flavor and texture. *Thandai*, a traditional milk-based

beverage is easily digestible, highly refreshing, thirst quenching, appetizing and nutritionally far superior to many synthetic and aerated drinks. Being prepared from a combination of fruits and nuts with food additives, a proper blend of these is of utmost importance to bestow a peculiar sensory characteristic to the milk. The characterization of product is an important criterion to evaluate the product precisely and specifically. As the sensory quality is driving force for consumer acceptance and consequently demand laden (Desai et al. 2013), present study was undertaken to investigate and characterize the quality of commercially available *thandai* in terms of sensory attributes. The need to develop appropriate sensory characteristics that are product sensitive and specific has emerged in the recent years as the dairy and food industry has grown from the concept of “eat what we produce” to “produce what you want to eat”. The application of statistical tools specifically QDA and PCA to develop these terminologies has been successfully employed in the recent years to characterize the sensory attributes of many food products.

Quantitative descriptive analysis (QDA) has been known as a tool for measurement and optimization of the aesthetically and measurable parameters of various products (Stone and Sidel, 1998). Descriptive sensory analysis of any product requires a descriptive technique and lexicon to describe the sensory properties in detail (Chawla et al. 2014). The principle involved in the QDA is highly dependent on the ability of the panelists to give reproducible results to yield quantitative product description which further can be evaluated statistically (Murray et al. 2001). Piggott and Hunter (1999), and Basker (1988) described screening tests and measures to monitor the performance of panelists for selection in panel. The critical part for any QDA is the scale usage and training of the panelists. Drake and Civille (2003), and Meilgard et al. (2007) reviewed these specifics and suggested that a panel or group of individuals to be employed for descriptive sensory analysis to obtain consistent results.

Principal component analysis (PCA) is a multi-variable analysis statistical tool (Martinez et al. 1998), widely used and involves reducing the original dependent variables (attributes) into a lower number of orthogonal (uncorrelated) synthesized variables

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(factors) based on pattern of correlation among the original variables (Lawless and Heymann, 1998). The application of PCA to the data obtained by QDA can be successfully employed to profile specific product characteristics, comparing and contrasting similar products based on attributes crucial of importance for sensory recognition and thus holding its promising position by altering product characteristics. Many researchers have employed the applications of QDA and PCA for the characterization of many food dairy products *viz.*, ultra-pasteurized milk, cheddar cheese, chocolate and soy flavored milk (Chapman et al. 2001; Young et al. 2004; Thompson et al. 2004; Keast and Lau, 2006), fermented food products like yoghurt (Desai et al. 2013; Ghosh and Chattopadhyay, 2012), labneh (Kaaki et al. 2012), and Indian delicacies like *Doda burfi* (Chawla et al. 2014) and *Cham-Cham* (Puri et al. 2016). In light of the above, considering the degree of success of QDA and PCA to descriptively illustrate the sensory attributes of food products, present study was envisaged to characterize the quality of commercially available *thandai* in terms of sensory attributes with the help of QDA and PCA as a statistical tool.

## Materials and Methods

### Market survey

Five best renowned commercial samples of *thandai* concentrate, in liquid form, were procured from the domestic market. Choosing the market samples was based on the brand image and consequent their sales in the market. Therefore, the brands chosen for the study were procured and coded for further analysis. For uniform product quality, homogenized toned milk was used for reconstitution studies, collected, and standardized to desired fat and SNF content, from the Experimental Dairy plant, College of Dairy Science and Technology for the preparation of *thandai* from market samples.

### Preparation of Thandai from commercial samples (as directed by manufacturer on the label)

All the samples were reconstituted as per the procedure mentioned on the label, adding ice-chilled milk and decoction in requisite amounts. Careful instructions were taken into account while reconstitution as mentioned by the manufacturer.

### Sensory evaluation

The sensory evaluation of the product was carried out by a panel of nine trained faculty members (n= 9) from Dairy Technology Department, working at College of Dairy Science and Technology, Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana, India. The attribute terms adjudicating and characterizing procedures were developed using flavor profile methodology (Keane, 1992). The work done on sensory lexicons by Adhikari et al. (2011), Puri et al. (2016), Chawla et al. (2014), Civile et al. (2010), and Drake et al. (2010) was thoroughly studied

to choose wide range of descriptive attributes, highly regarded for *thandai*. A descriptive language was developed for various attributes of *thandai* with the identified lexicon (Table 1). A total of 17 descriptors were selected under 4 heads. These four heads included color and appearance, flavor, mouthfeel and overall acceptability. Attributes were quantified with an intensity scale of 100 and analyzed using the procedure adopted by Chawla et al. (2014). After the screening of identifiable attributes and suitable terminology, the panelists were briefed and trained to accurately judge the characteristics of the product accordingly. The training period was continued until all the panelists grasped adequate knowledge to differentiate the intensity rates of each characteristic. An approximate sample size of 25 ml was presented to the panelists for its evaluation at its best, keeping in view of judging all the attributes in a precise manner. To achieve reproducible sensory results, random coded samples were served to the panelists with a maximum of two samples served at a time with a temperature of 5°C (in closed cups to ease shaking of contents), and lukewarm water as a white between the different samples. Sensory analysis was performed thrice to eradicate any source of unbiases in the results. All of these triplicate formulations were served on different days to avoid misapprehensions. The environment of test performance was kept pleasant to minimize human errors during sensory analysis.

### Statistical analysis

The data were analyzed with statistical analysis system (SAS) version 9.3.8 (SAS Inc., Cary, NC, USA). One-way analysis of variance (ANOVA) was performed on the descriptive data obtained during the present investigation for difference in means. Duncan's multiple range test was employed to evaluate statistically significant differences in mean values. Further, the mean scores of all 17 descriptors from descriptive analysis of commercial samples of *thandai* was subjected to Principal component analysis (PCA) using XL stat 32-bit software to have in depth understanding of the components of prime importance, maximum positive loadings and their interaction with other attributes in *thandai*.

## Results and Discussion

### Descriptive sensory analysis

Descriptive language for various attributes of *thandai* with the identified lexicon in presented in (Table 1). Puri et al. (2016) showed that the sensorial attributes of *Cham-Cham*, *Doda burfi* and greek yogurt differed with each other except few attributes and thus the need to develop the product specific lexicons to optimally describe the sensory attributes. Similarly, the sensory attributes of *thandai* differs from these products as depicted in Table 1, except for cooked flavor, and thus justifies the need to develop lexicons specific to *thandai*. The lexicon for *thandai* employed in PCA was figured out by finding its most significant

characteristic features by a panel of trained sensory panelists. The attributes were distributed carefully under the main heads such as colour, consistency, sweetness and flavour. Mean sensory scores of market samples of *thandai* for colour and appearance, flavor, mouthfeel and overall acceptability can be fetched from the figure indicating spikes on spider/ radar web (Fig. 1). These plots were used for the graphical representation of the data generated by QDA methodology by plotting average intensity values on corresponding scale and then joining the points to create a visual profile or “fingerprint” of product attributes (Stone and Sidel, 1998) as these plots are often used for the graphical depiction of the data generated by QDA methodology (Murray et al. 2001). PCA not only helps in identifying underlying attributes of acceptance but also provides a means to check adulteration in many cases (Baquiran et al., 2019). Fig. 1 represents graphic representation of the data for five commercial samples of *thandai* in the form of spider web with a branch or spoke from a central point for each attribute. As presented by peaks and loops, sweetness was maximum in case

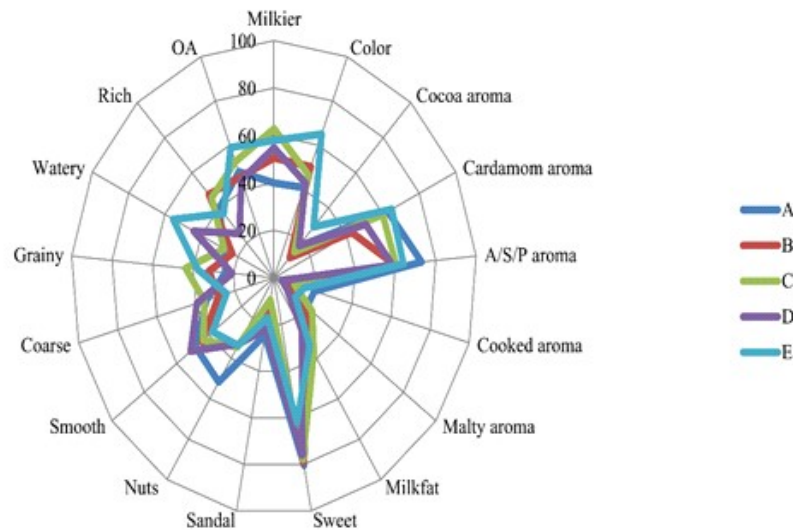
of sample A and lowest in sample E. Similarly, score for watery consistency was highest for sample E and lowest for sample B. Indistinguishable work has been performed earlier in ultra-pasteurized milk (Chapman et al. 2001), commercial lebneh samples (strained yoghurt) (Kaaki et al. 2012), *Cham-Cham* (Puri et al. 2016) and (Singh et al. 2019), where authors represented the descriptive sensory scores of panelists in pictorial form by creating spider plots.

The maximum score for milkier appearance and light brown to pistachio green colour was obtained with sample C (62.85) and E (65.0), respectively. Though, the colour and appearance scores were non-significant ( $p \geq 0.05$ ), these attributes influence food appreciation and quality. The average scores for cocoa, cardamom, almond/saffron/pistachio, cooked, malty, sweet, and sandal and aroma from milk fat and combination of nuts ranged from 11.57-29.0, 42.85-64.85, 58.57-73.0, 4.14-20.71, 8.0-23.57, 62.14-80.42, 9.42-24.57, 26.14-37.28 and 32.85-51.71, respectively. Statistically, non-significant difference ( $p \geq 0.05$ ) was observed

**Table 1** Sensory lexicon developed for *thandai*

Attribute name	Attribute Definition
Milkier Appearance	Having the appearance of milk, whitish, cloudy fluid which can mask other colours and flavours if present in extreme
Colour (Light brown to Pistachio green)	The intensity of colour from light brown to pistachio green
Cocoa aroma	Aromatics that specifically arises from complex biochemical and chemical reactions during the postharvest processing of raw cocoa beans
Cardamom aroma	Aromatics associated with cardamom
Almond/Saffron/Pistachio (A/S/P) aroma	Aroma that arises either due to almonds, saffron, pistachio or a combination thereof
Cooked aroma	Varies in intensity from sweet, pleasant, with slight sulfurous or custard notes, to caramelized or cabbage-like, which may be objectionable. Generally, arises from over cooking/roasting of nuts and milk.
Malty aroma	Malt-like aroma or taste is characteristic of uncooked or roasted grain (including roasted corn, barley or wheat), malt extract
Milk fat	Fat contributed by milk provides a characteristic aroma to the product
Sweet	Sweetness is the most recognized functional property of sugar; intensity depends on amount of sugar added and perceived by taste receptors present on tongue throughout mouth
Sandal	Aromatics associated with sandalwood from trees in genus <i>Santalum</i>
Combination of several nuts	A light, brown, slightly musty and nutty aroma contributed by various nuts infused into the product
Smooth mouth feel	It is the absence of any particles, lumps and bumps in the product.
Coarse mouth feel	Signifies rough mouth feel. The coarseness in the product is resultant of ingredients added and are particularly large in size
Presence of grainy particulates	The extent to which the product is composed of distinguishable pieces or grains of nuts.
Watery consistency	Overly flowing consistency, lacks adequate consistency
Rich mouth feel	Sufficient amount of milk fat, creamy mouth feel
Overall Acceptability	Adequate to satisfy a need, requirement, or standard

**Fig. 1** Descriptive sensory profile of market samples of *thandai* on 100-point scale



**Table 2** Contribution of the variables in factor loadings for sensory analysis of *thandai* employing all attributes

	F1	F2	F3	F4
Milkier	5.74	0.94	8.35	18.30
Colour	12.65	0.73	0.31	8.71
Cocoa aroma	5.63	12.55	0.16	0.16
Cardamom aroma	3.00	3.87	8.77	20.20
A/S/P aroma	0.33	2.18	20.60	0.27
Cooked aroma	0.58	2.18	19.96	1.11
Malty aroma	0.11	12.07	9.10	1.51
Milk fat	5.16	11.35	2.31	0.12
Sweet	10.01	6.02	0.63	0.65
Sandal	3.94	13.34	1.78	0.70
Nuts	2.99	0.63	18.24	0.02
Smooth	14.00	0.24	0.53	2.36
Coarse	8.56	0.00	0.76	33.19
Grainy	9.63	5.80	0.11	5.55
Watery	3.75	13.23	2.29	0.36
Rich	1.07	14.15	4.47	3.93
OA	12.86	0.72	1.64	2.86

Values in bold correspond for each variable to the factor for which the squared cosine is the largest

in the sensory scores of the mentioned attributes except cooked and sweet aroma amongst the five commercial samples of *thandai*. The cooked aroma of sample B and D was observed close to nil with sensory scores of 5.0 and 4.14, respectively. The highest sensory scores for cooked aroma were observed for sample A and were significant ( $p \leq 0.05$ ) w. r. t. sample B and D while non-significant w. r. t. sample C and E. The sweetness scores of sample A was found definite with an average score of 80.42 whereas, in sample E sweetness was found close to moderate

range with an average score of 62.14 and was significant ( $p \leq 0.05$ ) with respect to each other.

Furthermore, the descriptors under mouth feel terminology, were smooth, coarse, grainy/ presence of particulates, watery and rich with their average scores as 37.85-51.42, 24.28-39.42, 20.71-43.71, 22.85-55.42, 25.28-47.57, respectively. The non-significant ( $p \geq 0.05$ ) difference was observed for all the attributes excluding watery

mouth feel. The watery mouth feel scores of sample B and E were significant ( $p \leq 0.05$ ) while non-significant ( $p \geq 0.05$ ) in relation to other commercial samples of *thandai*. The effectiveness of sensory procedure involved in this study can be computed using thorough evaluation of average sensory scores of milk fat aroma, watery mouthfeel and rich mouthfeel. Rich mouthfeel is closely linked with milk fat. Also, the taste, smell, mouth feel, and hedonic properties of fat all contribute to the popular concept of fat “taste” (Drewnowski, 1997). The overall acceptability scores ranged from 44.28-59.0 and were non-significant ( $p \geq 0.05$ ). The maximum sensory scores for overall acceptability were observed with sample E (59.0) while sample D shows the minimum scores with an average of 44.28.

**Principal Component Analysis**

PCA was performed on the 17 attributes measured from five commercial samples of *thandai* to simplify the interpretation of data obtained during QDA methodology. PCs were extracted on maximum variance values to acquire specific knowledge about primeval factors having critical importance among the sensorial descriptors (Puri et al. 2016). The PCA distinguished and segregated brands on the basis of sensory characteristics. The statistical parameters pertaining to the PCA for attributes pertaining to color and appearance, flavor, mouth feel and overall acceptability have been presented in Table 2. The non-redundant terms indicated by PCA clearly differentiated *thandai*. In order to clarify groups of sensory characteristics of *thandai*, factor analysis was applied on the matrix of different sensory attributes. Similarly, distinct and highly reproducible patterns were also reported in soft drinks analysed by Zhang and Suslick (2007). On the basis of the eigen values, PCA distinguished and segregated different sensory attributes and the variables with eigen values over one was taken to explain the total variance. PCA differentiated samples with same characteristics in few quadrants while others with different characteristics remained segregated. Similar results were observed in case of fruit juices with different concentrations of acai (Sabbe et al. 2009) where juices with same characteristics combined in few quadrants while others with different characteristics remained segregated and other products like *Doda burfi* (Chawla et al. 2014), *Cham-Cham* (Puri et al. 2016) and fermented milk products (Ghosh and Chattopadhyay, 2012).

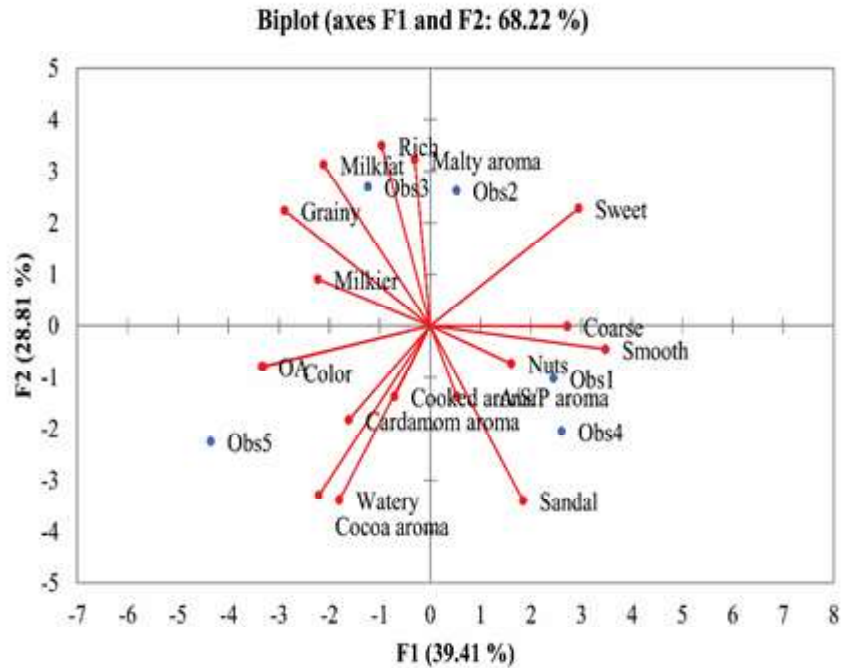
It was clear from the on the basis of eigen vector loadings, four PC’s with an eigen value of 6.7, 4.89, 4.21 and 1.19 were able to explain 39.41%, 28.81%, 24.79% and 6.99% of total variation, respectively. The cumulative variance explained by PC1 and PC2 was 68.22% while 100% of the total variance was explained by cumulating variance of all four PC’s i.e. PC1, PC2, PC3 and PC4. The two PC’s explaining 68.22% of total variation was bi-plotted to study the characteristics that are positively and negatively correlated and also to study the degree of correlation among the attributes. It is evident from the Fig.2 that in PC1, among all the attributes pertaining, sweetness and coarse mouth feel were

**Table 3** Correlation matrix of various variables using Principal Component Analysis (PCA)

Variables	Milkier	Colour	Cocoa aroma	Cardamom	A/S/P aroma	Cooked aroma	Malty aroma	Milk-fat	Sweet	Sandal	Nuts	Smooth	Coarse	Grainy	Watery	Rich	OA
Milkier	1	0.448	0.184	0.052	-0.741	-0.439	-0.086	0.358	-0.447	-0.697	-0.842	-0.457	-0.072	0.692	0.352	-0.013	0.465
Colour		1	0.690	0.267	-0.163	0.100	-0.181	0.352	-0.904	-0.322	-0.475	-0.908	-0.878	0.548	0.628	0.109	0.801
Cocoa			1	0.687	0.238	0.456	-0.494	-0.196	-0.911	0.336	-0.067	-0.514	-0.450	0.092	0.916	-0.462	0.747
Cardamom				1	0.615	0.844	0.146	0.147	-0.461	0.243	0.401	-0.396	-0.139	0.296	0.418	-0.084	0.748
A/S/P					1	0.926	0.306	-0.042	0.091	0.600	0.941	0.030	-0.089	-0.243	-0.105	0.105	0.159
Cooked						1	0.349	0.162	-0.178	0.404	0.772	-0.272	-0.239	0.076	0.084	0.154	0.506
Malty							1	0.822	0.460	-0.508	0.368	-0.237	-0.094	0.556	-0.760	0.903	0.122
Milkfat								1	-0.022	-0.823	-0.121	-0.690	-0.479	0.901	-0.400	0.905	0.494
Sweet									1	0.019	0.413	0.725	0.645	-0.335	-0.893	0.284	-0.803
Sandal										1	0.613	0.529	0.286	-0.848	0.302	-0.672	-0.269
Nuts											1	0.319	0.174	-0.397	0.357	0.118	-0.155
Smooth												1	0.866	-0.803	-0.341	-0.451	-0.887
Coarse													1	-0.461	-0.281	-0.419	-0.634
Grainy														1	-0.031	0.633	0.711
Watery															1	-0.685	0.547
Rich																1	0.166
OA																	1

Values in bold correspond for each variable to the factor for which the squared cosine is the largest

**Fig.2** Biplots from 1<sup>st</sup> and 2<sup>nd</sup> principal components of PCA



positively loaded, whereas sandal aroma, almond/saffron/pistachio aroma, and smooth mouthfeel were in negative correlation. Similarly, in PC2 major sensory attributes like milk fat, milkier appearance, richness and granularity were positively loaded, whereas watery, cocoa, and cooked aroma was negatively correlated. The degree of difference or similarity between two attributes is proportional to the distance between the location of any two attributes (Chawla et al. 2014).

Factor analysis revealed, component 1 positively and significantly loaded with milkier (5.74), color (12.65), sweet (10.01), smooth (14.00), coarse (8.56), grainy (9.63) and overall acceptability (12.86). Similarly, cocoa aroma, malt aroma, milk fat, sandal, watery and rich were found positive in component 2 with values 12.55, 12.07, 11.35, 13.34, 13.23 and 14.15 (Table 2). The characteristics of prime importance were found loaded in sample C whereas cocoa aroma, watery mouth feel was dominating characters in sample E and were less desired by consumers. Sweetness, the identifying and important attribute was found highest in sample B.

Correlation matrix (Table 3) revealed many expected correlations and was conducted to check if linear relationships existed between individual terms of sensory attributes. Milkier appearance was positively correlated with almond/saffron/pistachio aroma as more of nuts and distinct flavors can mask milkier appearance. Grainy mouth feel was positively correlated with overall acceptability whereas smoothness was negatively correlated with overall acceptability, this provides evidence that panelists liked more granulated product. The same holds true as well, *thandai* being a traditional household preparation people relish coarse particles in this drink to chew in their mouth. The

**Table 4** Enhanced contribution of variables in factor pattern loadings for sensory analysis of *thandai* omitting attributes of null importance

Sensory attribute	F1	F2
Colour	15.69	0.10
Cocoa aroma	8.63	18.57
Cardamom aroma	5.83	9.94
A/S/P aroma	0.011	8.15
Milk fat	6.15	18.27
Sweet	13.15	6.24
Nuts	2.17	4.43
Smooth	17.83	1.14
Grainy	11.46	10.77
Rich	1.21	21.42
OA	17.86	0.93

color showed a positive degree of correlation with cocoa aroma and overall acceptability. A positive correlation was observed for cardamom aroma and cocoa aroma with overall acceptability as well as between milk fat and richness and also between milk fat and graininess (Table 3). These results suggest that high grainy and rich mouth feel, good color and cardamom aroma necessarily drive the consumer liking.

Considering presence of variables with non-significant contributions, few variables like malt, cooked, and sandal aroma, along with coarse, and watery mouthfeel were removed from data set and it did not result in a loss of explained variability by PCA, suggesting that these aroma and mouth feel terms could be safely removed from the sensory language without a loss of product differentiation (Table 4). The results obtained after factor analysis

validated the same hence the attributes were omitted from the analysis and data was reanalyzed depicting PC1 and PC2 explaining 47.50 and 26.08% of the variation, respectively. The three PC's were able to explain 95.57 per cent of the total variation. However, the wide variability among different sensory attributes could be attributed to difference in manufacturing practices, varying ingredient quantity and quality and the processing techniques of the final product.

## Conclusions

The demand to develop consumer specific products has caused the researchers to develop sensory lexicons pertaining to that particular product. *Thandai* being an indigenous drink carries none of the literature available either of the international or national level. Therefore, this necessitates the need to characterize the sensory attributes of commercially available *thandai* using quantitative descriptive analysis (QDA) and principal component analysis (PCA). The five commercial samples of *thandai* showed a wide variation with respect to sensory lexicons defined for *thandai*. Among the five samples surveyed, sample C showed maximum positive loadings and scoring for sensory attributes. Attributes such as milk fat, richness, grainy, and milkier were identified as key attributes by PCA. Hence, these attributes may be regarded as prime sensory quality indicators in *thandai* and may be used for the development of the product.

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# A Comparative study on the S- values of cow and buffalo ghee calculated using equations specified in ISO (17678) method of determining the milk fat purity by gas chromatographic analysis of triglycerides

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**Abstract:** Cow and buffalo ghee samples were prepared from the milk collected from the locations in eastern, western, southern, and northern parts of the country. Ghee prepared so was subjected to triglyceride analysis using gas-liquid chromatography and S- limits were calculated using the equations specified in the ISO method. All the five S- limits, as specified in the standard for cow milk, got deviated on both the lower and upper side of the limits in the case of the cow as well as buffalo ghee samples of all four regions. Buffalo ghee samples were found to have a higher upper S- total (ST) limit ranging from 109.34 to 118.21 in the samples from all four regions, whereas lower value was slightly less (94.06 to 94.59) than the lower range specified in the standard for buffalo ghee samples from eastern, northern and southern region samples. A similar trend was observed in the case of s- limit (S4) specified for the detection of Palm oil and beef tallow. In cow ghee also the S- values showed a trend of deviation from the standard.

**Keywords:** Ghee, cow, buffalo, ISO, triglycerides, S- values

## Introduction

Ghee is one of the very important constituents of the India Dairy products basket. As per the definition Milk fat, ghee, butter oil, anhydrous milk fat and anhydrous butter oil are fatty products

derived exclusively from milk or products obtained from milk, or both, by means of processes which result in almost total removal of water and milk solids-not-fat. Ghee has especially developed flavor and physical structure as a result of its method of manufacturing (FSSR, 2019). It is generally prepared by clarifying cream/ butter at 110 – 130°C, wherein butter is obtained either from cream or from curd (traditional practice). Ghee is a very popular dairy product in the South Asian region (India, Bhutan, Sri Lanka, and Nepal) and is the second-largest dairy product (~28%) consumed in India (GAIN, 2014). It has been suggested that the combined butter and ghee production in India will rise to 6.1 MMT against 5.8 MMT last year, indicating a strong consumption demand (GAIN, 2020). According to a report, the Indian ghee market reached a value of Indian rupees 2,273 billion in 2019 and is expected to reach a value of Indian rupees 4,653 billion by 2024 (IMARC, 2020). India's Export of Dairy products was 51,421.85 MT to the world for the worth of Rs. 1,341.03 Crores/ 186.71 USD Millions during the year 2019-20 (APEDA, 2020). The most common types of ghee available in the Indian subcontinent are cow ghee and ghee. International Organization for Standardization has specified a reference method (ISO, 2019) to ensure the purity of only cow milk fat based upon the profiling of triglycerides with 24- 54 carbons (C24-C54) using Gas-liquid chromatography and thereby calculating standard – values (S-values) for the cow milk fat. The detection of different vegetable oils and animal fats in cow milk fat is represented by S-limits (S2, S3, S4 and S5). The ISO/IDF reference values for cow milk fat are ST: 95.68 – 104.32; S2: 98.05 – 101.95; S3: 99.42 – 100.58; S4: 95.90 – 104.10; S5: 97.96 – 102.4.

The scope of the above said method has already mentioned a likelihood of obtaining the false-positive result in fat obtained from bovine milk other than cow's milk. Note 3 of the method also stated that sometimes false positive results reporting for milk from certain Asian regions. This was attributed to special feeding practices such as the feeding of a high proportion of vegetable oils, serious underfeeding (ISO, 2019). Literature also suggested that the presence of phospholipids overlaps with the short-chain triglycerides and might distort the results (Precht 1992). During heating, especially after most of the moisture has

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evaporated, antioxidants are produced from phospholipids, which in turn are believed to be absorbed by the fat (Tamime, 2009). Literature also suggested that there is a variation in the interval of concentration i.e. range of triglycerides in the cow milk fat of various countries (Tolentino et al. 2007). Reports also suggested that goat milk fat did not show a bimodal distribution of triglycerides unlike cow milk fat and maximum values were reported for triglycerides C38 and C40 (Tolentino et al. 2015). Therefore, there is a possibility that the said standard may not be applicable as such to anhydrous milk fat extracted from buffalo milk and also the ghee which is prepared by heat clarifying the butter at a higher temperature like 110- 130°C. There are only limited reports available on the S- values of ghee (Amrutha Kala, 2013; Kala et al. 2016; Sharma et al. 2018). Hence, the present work was carried out to investigate the deviation in S- limits of cow and buffalo ghee. The results obtained will be useful in checking the suitability of the standard (ISO, 2019) to check the purity of cow and buffalo ghee. This will also be helpful in filling the knowledge gap in the S- limits of buffalo ghee.

## Materials and Methods

Milk collection and preparation of ghee samples: To prepare ghee, milk samples were collected from four regions of the country viz, Karnal (Northern), Bengaluru (Southern), Mehsana (Western) and Patna (Eastern). Samples from Northern region (Karnal District) were collected on monthly basis (eight months), whereas, samples were collected after every two months from other regions. These samples were brought to the laboratory at NDRI- Karnal in frozen state. Samples were then thawed and warmed to 40°C and cream was separated using mechanical cream separator. Cream obtained was then heated on a direct flame in a stainless steel vessel and clarified into ghee with continuous stirring at a temperature of 120°C/flash. Ghee was then filtered through muslin (6-8 folds) cloth followed by further filtration using Whatman No.4 filter paper. These samples were then subjected to triglyceride (TG) analysis.

### Triglyceride mix, Tristearin, and Anhydrous milk fat standards

Standard triglyceride mix (CRM18811) consisting of Tricaprylin, Tricaprin, Trilaurin, Trimyrstin, Tripalmitin, and standard anhydrous milk fat (BCR-519) were procured from Sigma - Aldrich Co, 3050 Spruce Street (St Louis, MO 63103, USA 314-771-5765). These standards were used to calibrate the GLC conditions.

### Gas Chromatographic (GLC) analysis of triglycerides

Triglyceride analysis of ghee samples was carried out as per the method specified for triglyceride analysis of the cow milk fat (ISO 17678: 2010). Shimadzu 2010 plus machine (Kyoto, Japan), with GC solution software and CP7532 CP-SimDist Ultimetall capillary column (5 m X 0.53 mm X 0.17 µm) was used

## Calculations of S- limits

S- limits for the pure ghee samples were calculated by substituting the respective triglyceride values in the equations specified in ISO 17678 standard method (ISO 2019)

## Statistical analysis

Mean and the standard deviation was calculated using Graphpad Prism 5 software. Upper and lower limits were calculated as per the method described by Kroemer, 2006 for widely scattered data. The following equation was used to calculate the upper and lower limit of S- values:

$$p_{max} = m + (k_{max} * S)$$

$$p_{min} = m + (k_{min} * S)$$

where

m= mean value

S= standard deviation

k= factor selected from the Table, which is positive sign for above mean and negative for below mean.

One- way ANOVA was performed using Graph pad Prism 5 software and two- way ANOVA by SPSS, to check the significant differences in S- values of cow and buffalo ghee as well as regional variations.

## Results and Discussion

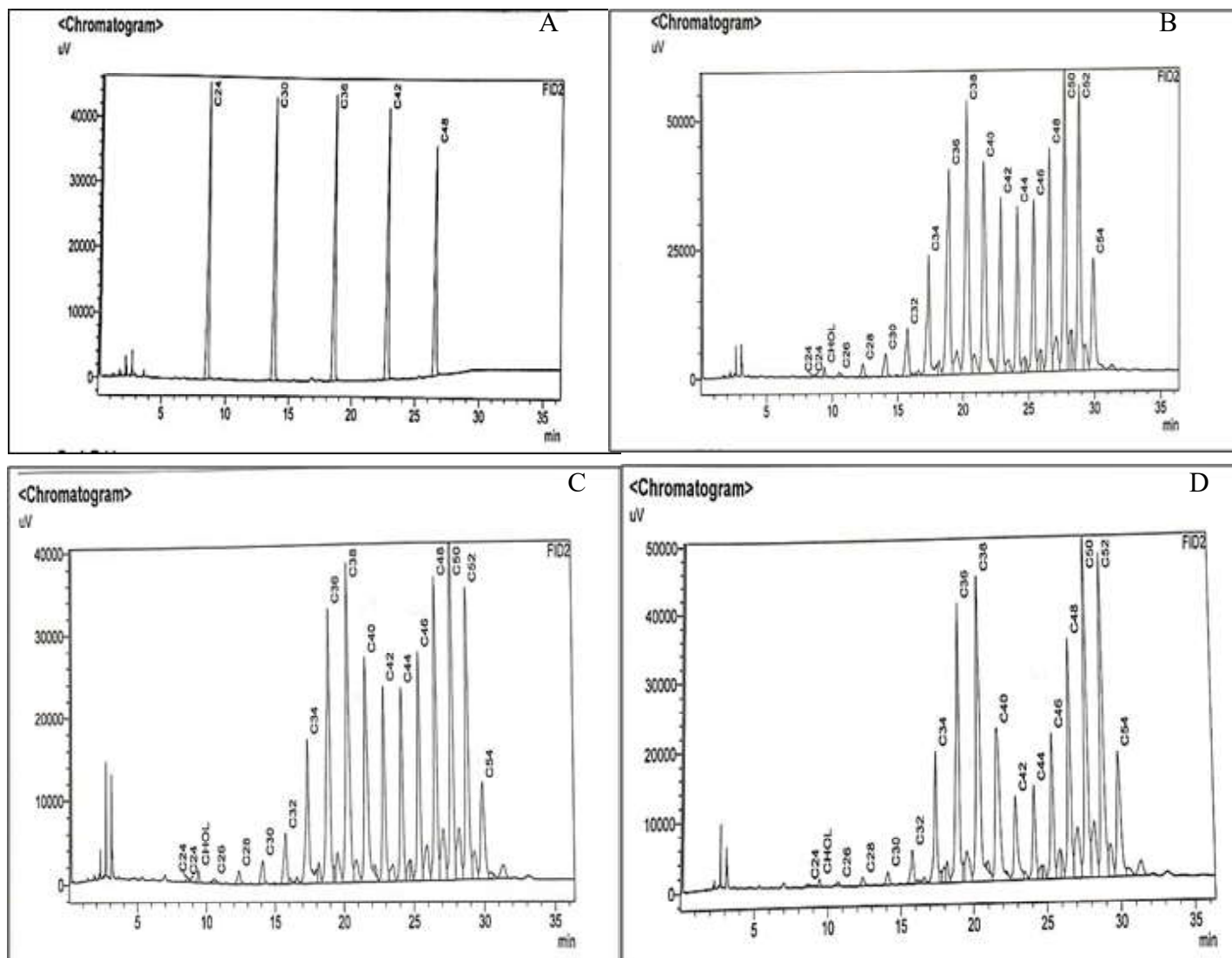
### Standardization of GLC conditions

Conditions of GLC were standardized as per the requirements of the ISO methodology, that baseline drift should be minimum, no splitting of peaks, response factors close to 1.0 and not higher than 1.250. It is evident from the chromatograms (Figure 1) that all the standard triglycerides in the standard mix (CRM18811) have been separated distinctly and drift in the baseline is also negligible. Similarly, in the case of standard anhydrous milk fat (BCR-519), the baseline is stable and peaks of all major triglycerides are also clear without any splitting (Figure 1). Similarly, in the chromatograms of pure cow and buffalo ghee (Figure 1), the baseline is stable and peaks of all major triglycerides are well resolved. Response factors calculated using standard anhydrous milk fat (BCR-519) were also in the range of 0.92-1.1 for different triglycerides having carbon numbers C24- C54. These results demonstrated that the GLC machine's conditions were as desired to have accurate triglyceride analysis of ghee samples.

### Regional variation in the S- limits of ghee

#### Cow ghee

S- total (ST) represents the S- limit for total milk fat. It is evident from the data (Table 1) that the upper limit of ST in the case of



**Fig. 1** Chromatograms of Triglyceride in (A) Standard triglyceride mix (CRM1881) (B) Anhydrous milk fat (BCR-519) (C) Cow ghee (D) Buffalo ghee

northern cow ghee samples was within the upper limit (104.32) specified in the standard, whereas in other regions the observed upper limit was more than the upper limit specified in the ISO/IDF standard of cow milk fat. Similarly, the lower limit for ST observed in eastern, northern, and southern regions was less than the standard lower limit (95.68) specified for cow milk fat (ISO, 2019). Only the western region’s samples could meet the lower limit. The perusal of the data (Table 2) also revealed that the ST of cow ghee from the western region was significantly ( $p < 0.05$ ) different from the ST of other regions.

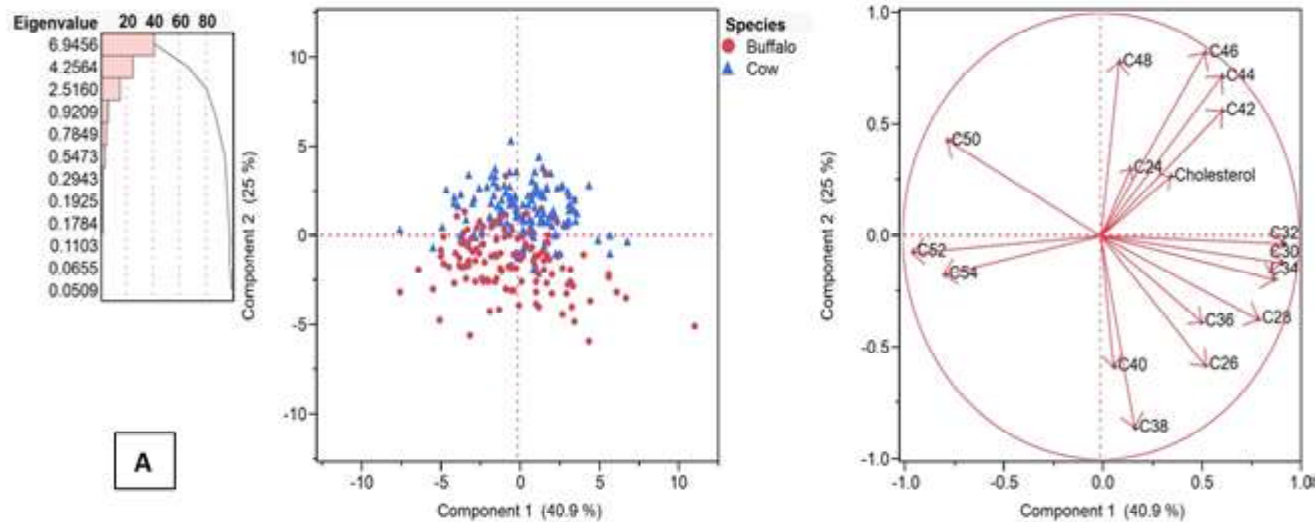
S-limits for the detection of Soybean, sunflower, olive, rapeseed, linseed, wheat germ, maize germ, cottonseed, fish oil in ghee is represented by (S2). For pure milk fat the S2 should be 98.05 – 101.95 as per the standard specified for cow milk fat (ISO, 2019). If the values obtained in the tested milk fat samples are not within

the range, then those samples are considered to be adulterated with the above said oils/ fats. It is evident from the range of S2 (Table 1) observed in the tested samples of cow ghee from different regions that some samples had S2 lower than the specified standard, whereas some had more than the specified in the standard. A perusal of the data (Table 2) also revealed that samples from the eastern and western regions had significantly ( $< 0.05$ ) different S2 than the samples from eastern and western regions.

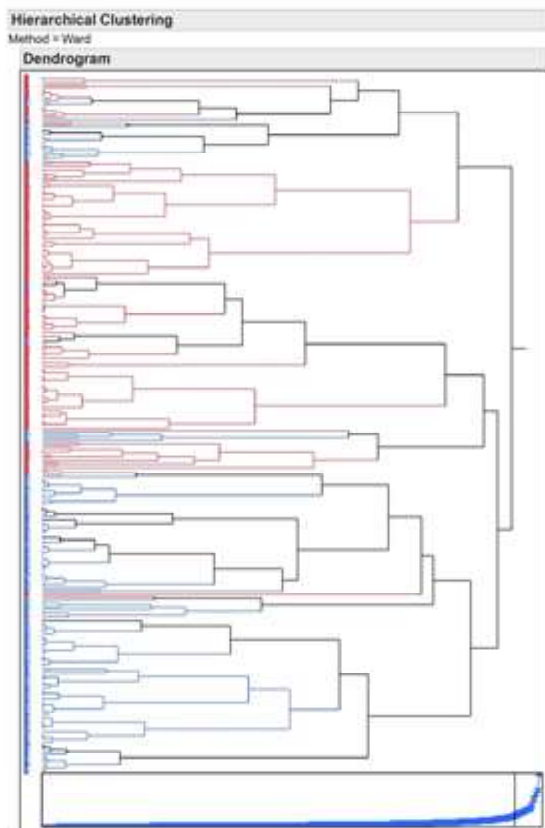
S-limits for the detection of Coconut and palm kernel fat in cow milk fat is represented by (S3). For pure cow milk fat, the S3 should be 99.42 – 100.58 as per the standard specified for cow milk fat (ISO, 2019). It is visible from the data (Table 1) barring samples from the northern region in all other regions the lower values observed were slightly less than the lower limit specified

Principal Components: on Correlations

Summary Plots



A



B

**Fig. 2** Scores and loading plots of PCA model for triglycerides of Cow and Buffalo ghee (A) Dendrogram showing separate clusters of cow (blue) buffalo (red) ghee (B)

in the standard. Similarly, except for the western region, the upper values observed were slightly higher than the upper limit specified in the standard. This again indicated that the limits observed in the present study were not the same as specified in the standard for cow milk fat. Average values (Table 2) revealed that the samples from the western region had significant ( $p < 0.05$ ) difference from the S3 values of other regions.

S-limits for the detection of palm oil and beef tallow in cow milk fat are represented by (S4). For pure cow milk fat the S4 should be 95.90 – 104.10 as per the standard specified for cow milk fat (ISO, 2019). It is evident from the data (Table 1) except for western region samples, the lower limit observed in the cow ghee samples was lower than the value specified in the standard. On the contrary, the observed upper limit in the samples of the eastern, western, and southern regions was higher than the upper limit specified in the said standard (ISO, 2019). In the case of northern region samples, the observed upper value was within the upper limit specified in the standard. On account of S4 also it can be inferred that the values determined in the present study were not following the range specified in the standard for cow milk fat. The regional difference was significant as evident in the data presented in Table 2.

S-limits for the detection of lard in cow milk fat are represented by (S5). For pure cow milk fat, the S5 should be 97.96 – 102.4 as per the standard specified for cow milk fat (ISO, 2019). In the present study, it was observed that cow ghee samples of eastern and southern regions had observed lower range values slightly less than the lower limit specified in the standard. On the contrary, the samples from northern and southern regions also showed upper values higher than the upper limit specified in the standard. S5 also indicated clearly that the range obtained in the present study was showing a deviation from the limits specified in the standard of pure cow milk fat. A perusal of the data on the basis of average S5 values of cow ghee from different regions it was found that there was a significant ( $< 0.05$ ) difference in the S5 of cow ghee samples of eastern and southern regions.

This can be attributed to the fact that in countries like India, wherein organized dairy farming is still not fully developed and milk is poured into the pool by a variety of farmers including the poor, and marginal. At the same time, there is regional diversity with respect to the feed/ fodder and breeds of cattle, which might be the factor contributing to such differences among the cow ghee samples from different regions as well as deviation from the standard (ISO, 2019) specified for cow milk fat.

### **Buffalo ghee**

S-limits have not been specified for buffalo milk fat in the standard (ISO, 2010 & 2019). Therefore it is difficult to compare the findings of the present investigation with reference to any standard. However, it was observed that the profile of buffalo ghee with

reference to the major triglycerides was akin to the triglyceride profile of cow ghee. The only difference was that the concentration of some of the triglycerides (C34, C36, C38, C52, and C54) was higher in buffalo ghee and some of the triglycerides (C42, C44, C46, C48) were less than their concentration in cow ghee. Therefore, the concentration value of these triglycerides was substituted in the different equations, and S- values were determined. It is evident from the data (Table 1) that in all four regions the variation in the upper range for (ST) as determined in the present investigation was higher (109.34 – 118.21). It is evident from the ST data that both lower and upper limits were higher than the values observed in cow ghee samples in the present investigation. The observed variation may be attributed to the species difference in the fatty acids composition of milk fat. Similarly, the lower range also varied from 94.06 – 96.83.

On perusal of the average ST values (Table 2), it was inferred that barring samples from the western region there was a significant ( $< 0.05$ ) difference in the ST- values of Cow and buffalo ghee samples. This could be attributed to the variation in the triglyceride concentration of cow and buffalo ghee as the literature suggests that buffalo and cow ghee has different saturated fatty acids (SFA) profiles (Carolina and Luis Fernando, 2020). Similarly, other researchers also reported a variation in the triglyceride containing different carbon numbers from C24- C54 (Smidy et al. 2012; Hazra et al. 2017; Sharma et al. 2018 and Amrutha Kala, 2013) in the milk fat of different species.

In the case of S2 (Table 1) the range in different regions varied between 96.12 to 103.27. On comparing the average (Table 2) it was observed that the regional difference was not significant. However, the difference in the S2 of cow and buffalo ghee samples was statistically significant ( $p < 0.05$ ) in the southern region.

The lower and upper S3 limits (Table 1) varied between 97.75 to 99.26 and 100.78 to 101.35, respectively. It is also evident from the data (Table 2) that there were a regional difference in the S3, eastern and northern samples were found to have statistically ( $p < 0.05$ ) higher values than the samples of western and southern regions. On perusal of the data, it was also observed that cow ghee samples from the southern region had significantly ( $p < 0.05$ ) higher S3 than the buffalo ghee samples of the same region.

The lower and upper S4 limits of buffalo ghee from different regions (Table 1) varied between 95.60 to 99.58 and 110.60 to 117.37, respectively. It is evident from the data depicted in Table 2 that there was a significant ( $p < 0.05$ ) difference in the average S4 of buffalo ghee among the different regions. Northern region samples of buffalo ghee were found to have statistically lower average S4 than the samples of the western and southern region.

Similarly, the lower and upper S5 values in buffalo ghee samples from different regions varied from 94.47 to 97.11 and 101.01 to 104.81, respectively. The perusal of the average values (Table 2)

**Table 1** Range of S- values in pure Ghee from different regions

S- limits	Type of ghee	Eastern (E)	Western (W)	Northern (N)	Southern (S)	No of samples analyzed			
						E	W	N	S
ST	Cow	91.59-105.24	97.27-105.93	90.60-102.36	93.00-106.34	36	40	50	24
	Buffalo	94.30-110.10	96.83-112.37	94.06-109.34	94.59-118.21	32	39	32	19
S2	Cow	96.28-102.53	97.17-101.77	95.42-100.48	92.82-103.08	36	40	50	24
	Buffalo	96.39-102.09	97.20-102.70	96.12-101.52	96.23-103.27	32	39	32	19
S3	Cow	99.21-101.36	99.15-100.19	99.79-101.41	99.16-101.24	36	40	50	24
	Buffalo	98.90-101.30	98.60-100.78	99.26-101.34	97.75-101.35	32	39	32	19
S4	Cow	92.53-106.37	97.32-106.48	92.22-102.80	89.53-107.25	36	40	50	24
	Buffalo	95.65-112.35	99.58-114.32	95.60-110.60	96.23-117.37	32	39	32	19
S5	Cow	97.03-102.31	98.16-101.84	98.36-102.84	96.52-105.88	36	40	50	24
	Buffalo	97.11-101.01	96.75-101.13	96.77-101.81	94.47-104.81	32	39	32	19

ST-S- total; S2-Soybean, sunflower, olive, rape seed, linseed, wheat germ, maize germ, cotton seed, fish oil; S3- Coconut and palm kernel fat; S4- Palm oil and beef tallow; S5- Lard

(ISO/IDF Reference values for cow milk fat: ST: 95.68 – 104.32; S2: 98.05 – 101.95; S3: 99.42 – 100.58; S4: 95.90 – 104.10; S5: 97.96 – 102.4)

**Table 2** S- values (Average  $\pm$  SD) in pure Ghee from different regions

S- limits	Type of ghee	Eastern (E)	Western (W)	Northern (N)	Southern (S)	No of samples analyzed			
						E	W	N	S
ST	Cow	98.42 $\pm$ 5.33 <sup>aA</sup>	101.6 $\pm$ 3.38 <sup>bA</sup>	96.48 $\pm$ 4.59 <sup>aA</sup>	99.67 $\pm$ 5.21 <sup>aA</sup>	36	40	50	24
	Buffalo	102.2 $\pm$ 6.17 <sup>aB</sup>	104.6 $\pm$ 6.07 <sup>abA</sup>	101.7 $\pm$ 5.97 <sup>aB</sup>	106.4 $\pm$ 9.23 <sup>bB</sup>	32	39	32	19
S2	Cow	99.41 $\pm$ 2.44 <sup>aA</sup>	99.47 $\pm$ 1.8 <sup>aA</sup>	97.95 $\pm$ 1.99 <sup>bA</sup>	97.95 $\pm$ 4.02 <sup>bA</sup>	36	40	50	24
	Buffalo	99.24 $\pm$ 2.23 <sup>aA</sup>	99.95 $\pm$ 2.15 <sup>aA</sup>	98.82 $\pm$ 2.11 <sup>aA</sup>	99.75 $\pm$ 2.75 <sup>aB</sup>	32	39	32	19
S3	Cow	100.2 $\pm$ 0.91 <sup>aA</sup>	99.67 $\pm$ 0.41 <sup>bA</sup>	100.6 $\pm$ 0.63 <sup>cA</sup>	100.2 $\pm$ 0.81 <sup>acA</sup>	36	40	50	24
	Buffalo	100.1 $\pm$ 0.94 <sup>aA</sup>	99.69 $\pm$ 0.85 <sup>bA</sup>	100.3 $\pm$ 0.81 <sup>aA</sup>	99.55 $\pm$ 1.41 <sup>bB</sup>	32	39	32	19
S4	Cow	99.45 $\pm$ 5.41 <sup>abA</sup>	101.9 $\pm$ 3.56 <sup>aA</sup>	97.51 $\pm$ 4.13 <sup>bA</sup>	98.39 $\pm$ 6.92 <sup>bA</sup>	36	40	50	24
	Buffalo	104.0 $\pm$ 6.5 <sup>abB</sup>	106.5 $\pm$ 5.76 <sup>aB</sup>	103.1 $\pm$ 5.86 <sup>bB</sup>	106.8 $\pm$ 8.27 <sup>aB</sup>	32	39	32	19
S5	Cow	99.67 $\pm$ 2.06 <sup>aA</sup>	100.00 $\pm$ 1.44 <sup>abA</sup>	100.60 $\pm$ 1.75 <sup>abA</sup>	101.20 $\pm$ 3.66 <sup>bA</sup>	36	40	50	24
	Buffalo	99.06 $\pm$ 1.52 <sup>aA</sup>	98.94 $\pm$ 1.71 <sup>aA</sup>	99.29 $\pm$ 1.97 <sup>aB</sup>	99.64 $\pm$ 4.04 <sup>aB</sup>	32	39	32	19

<sup>a, b</sup> means within a row and <sup>AB</sup> means with in a Colum with different superscripts are significantly different (p<0.05) from each other

ST-S- total; S2-Soybean, sunflower, olive, rape seed, linseed, wheat germ, maize germ, cotton seed, fish oil; S3- Coconut and palm kernel fat; S4- Palm oil and beef tallow; S5- Lard

(ISO/IDF Reference values for cow milk fat: ST: 95.68 – 104.32; S2: 98.05 – 101.95; S3: 99.42 – 100.58; S4: 95.90 – 104.10; S5: 97.96 – 102.4)

revealed that there was no significant difference between these values on account of regional variations in the sample of buffalo ghee.

However, the difference in cow and buffalo ghee samples was evident in S5 also irrespective of the region. These differences between cow and buffalo ghee S- limits can be attributed to the variation in the concentration of certain triglyceride moieties. The said justification is further supported by the PCA analysis of the triglyceride data of both the ghee types (Fig 2A&B) carried out in the present investigation. The loading plot of the PCA of triglycerides composition (Figure 2A) showed that the majority of the cow and buffalo ghee samples were distinct from each

other in terms of triglycerides having 26, 28, 36, 42, 44, 46, and 50 acyl carbons. It is also evident from the dendrogram (Figure 2B) that majority of the cow and buffalo ghee samples were clustered into two separate hierarchical clusters barring a few samples overlapping with each other. Findings akin to the present investigation that cow ghee contained a higher amount of TG C42 to C54 and buffalo ghee had more C26 to C36 were also reported earlier (Amrutha Kala, 2013). It has been reported that triglyceride content varies among different species and also in different breeds of the same animal species (Fontecha et al. 1998). This further confirmed that cow and buffalo ghee have dissimilarities based on certain triglycerides, which could be

attributed to differences in fatty acid concentration in the two fats. Hence it can be concluded that cow and buffalo ghee are two distinct types of ghee and the standard specified for cow milk fat cannot be applied to buffalo milk fat.

A perusal of the data (Table 2) revealed that the average S- values of cow ghee samples were within the limits of the standard specified for cow milk fat (ISO, 2019). This led to an interesting extrapolation of the findings that there is a likelihood that the cow ghee which is produced commercially by the Dairy industry shall meet the S- limits specified in the standard of cow milk fat (ISO, 2019). The very reason for the above mentioned observation is that the milk is procured by the Dairy processing plants from the large area of their milk collection chain which nullifies the deviations arising from the milk of individual farmers or a particular milk route.

However, in the case of buffalo ghee the average S- total and S4, were on the higher side of the limits and even more than the upper limits in western and southern buffalo ghee samples. This led to the observation that there is a definite need to develop a separate standard for buffalo ghee.

## Conclusions

Cow and buffalo ghee were found to have different concentrations of certain triglycerides. These variations led to the differences between the S- values of cow and buffalo ghee. Though the average S- values of cow ghee were within the limits of the standard but S- limits had a deviation from the S- limits of cow milk fat specified in the standard (ISO, 2019). Buffalo ghee showed a greater deviation in all the S- limits. Even the average S- total and S4- (Palm oil and beef tallow) in buffalo ghee was higher than the upper limit specified for these in cow milk fat standard. Regional differences were also found in both cow and buffalo ghee samples. On the basis of this limited study, there seems to be a need to develop a standard of S- limits for buffalo ghee and relook into the standard of cow ghee of Indian origin. This could be achieved by collecting the milk samples throughout year from the organized dairy farms and stakeholders in the dairy supply chain from the length and breadth of India and thereby preparing the ghee samples from such milk and analyzing the samples. The setting up the S-values breed-wise is also one of the challenging task. This will only be possible by the concerted efforts of the Dairy Industry and Academia.

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# Process optimization of fortified sweetened milk kefir

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**Abstract:** Kefir is an acidic-alcoholic fermented milk product. Regular consumption of kefir is helpful in relieving intestinal disorders, reducing flatulence, and creating healthier digestive system. An attempt was made to optimise the process to produce fortified sweetened milk kefir. Kefir was prepared using kefir grains with sugar (6, 8 and 10%), fibres (inulin, oat, and soya, each 3%) and stabilizer (0.1% pectin). Addition of 6% sugar showed significantly ( $p < 0.05$ ) higher body and texture scores with no significant ( $p > 0.05$ ) difference in flavour, colour and appearance when compared to kefir made with 8 and 10% sugar. Similarly, overall acceptability was highest in kefir made with 6% sugar. Firmness in kefir was highest made with 6% sugar, followed by 8 and then 10% sugar. Among the three fibers, addition of 3% inulin showed significantly ( $p < 0.05$ ) better sensory attributes when compared to kefir added with soya and oat fibre. Acidity of inulin added kefir was lowest among soya and oat fibre added kefirs which was optimum. Kefir prepared with soya fibre showed significantly ( $p < 0.05$ ) higher acidity than other two samples. No significant ( $p > 0.05$ ) difference was observed in pH among all kefir samples. Firmness and consistency increased significantly ( $p < 0.05$ ) with the addition of inulin. An acceptable quality fortified sweetened milk kefir can be prepared with 0.1% pectin, 6% sugar and 3% inulin as dietary fibre for improved health benefit.

**Keywords:** Colour, Dietary fibre, Flavour, Health benefit, Sweetened milk kefir

## Introduction

Kefir is a fermented milk product prepared by incubating milk with either kefir grains (a group of microorganisms held together by a polysaccharide framework i.e., Kefiran) or kefir starter culture (Satir and Guzel-Seydim, 2016). Kefir differs from other fermented milk products in a way that is not a simple consequence of the metabolic action of a single microbial species but a blended microflora i.e., 66% bacilli, 16% streptococci, and 18% yeasts (Farnworth, 2003). Enthusiasm has evolved for the development, production, and utilization of kefir since its beginning, owing to its immense therapeutic benefits on the immune system, the gastrointestinal system and the digestion of cholesterol (Tamai et al. 1996). Moreover, anti-cancer, anti-bacterial and anti-fungal properties have been exhibited *in vitro*, animals or human models (De Moreno de LeBlanc et al. 2007). Additionally, kefir cultures can be linked to promote food safety by restraining coliforms and several pathogens (Van Wyk et al. 2011).

As kefir has a slightly acidic taste, yeasty and tangy flavour, sweetening of kefir will make the taste milder, improve flavour and overall acceptability which will be more relished by the Indian populace. In eastern part of India, *dahi* is used as *mistidoi/dahi* by adding sweetener such as jaggery which lends a caramelized flavour and colour to the *dahi*. Sweetening will make the kefir a product like *mistidahi*. Cool sweet milk kefir will be a thirst quenching and refreshing product with prickly sensation. Sweetness of the kefir will provide an exotic enrichment to the taste buds. Yet, no attempt has been made so far to prepare sweetened milk kefir and to evaluate the microbial behaviour of kefir grains in the presence of sugar.

Milk and most milk products are devoid of dietary fibre, but there is a growing awareness among consumers about the physiological benefits of fibre fortified milk products. Dietary fibres impart some basic functional characteristics like water holding capacity, viscosity, water swelling capacity, fat binding capacity, antioxidant properties etc. (Elleuch et al. 2011) and improving sensory characteristics and shelf- life of the product. Various published reports have demonstrated that there are numerous therapeutic benefits related with the consumption of dietary fibre, including lower risk of heart diseases, diabetes,

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obesity, and a few types of malignancy (Mann and Cummings 2009). Addition of inulin has shown that it can attenuate the cholesterol in blood plasma (Roberfroid, 2005) and improves calcium, magnesium, and iron absorption (Bosscher et al. 2003). Addition of oat fibres is linked with depletion of post-prandial blood glucose and insulin responses (Wood et al. 1994), higher transport of bile acids towards lower portions of the gut and higher discharges of bile acids (Dongowski et al. 2005) or reduction of serum cholesterol levels (Hecker et al. 1998). Yogurt fortified with soya is advantageous in reducing cholesterol levels (Crouse et al. 1999), blood pressure and to alleviate indications of menopause and osteoporosis (Messina et al. 2004). To know the beneficial effects of kefir consumption, an attempt was made to optimize the process for preparation of fortified sweetened milk kefir.

## Materials and Methods

### Raw materials and ingredients

Fresh whole and skim milk were procured from the Experimental Dairy Plant of ICAR- National Dairy Research Institute, Bengaluru (India). Kefir grains were obtained from U.S. Food grade High methoxy pectin obtained from M/s Hi Media laboratories Pvt. Ltd. Refined crystalline cane sugar from local market, Dietary soya fibre (*Fimbrim*® from M/s Solae Company, U.S.), oat fibre (*Vitacel*® HF- 600® from M/s J. Rettenmair and Sohne GmbH, Germany) and inulin (from M/s DKSH India Pvt. Ltd., Bangalore, India) were procured.

### Activation of kefir grains

Kefir grains were activated according to the technique adopted by Angulo et al. (1993). Following each incubation, straining of the fermented product was done through nylon sieve (mesh size: 1/20 inch) to retrieve the kefir grains which were then washed with sterile distilled water prior to next inoculation. This process was repeated 4-5 times until the desirable kefir flavour was achieved.

### Preparation of fortified sweetened milk kefir

Fresh raw milk was standardized to 3% fat, preheated at 50-60°C and homogenized in two stage (first stage- 2500 psi, second stage- 500 psi) homogenizer. All the additives were added on milk basis into the milk after homogenization and before final heat treatment. During optimization process, first pectin (0.1%) and sugar (6, 8 and 10%) were mixed and then added to standardized milk followed by addition of fibres (inulin, oat, and soya fibre). Milk was heated to 90-92°C for 10 minutes with intermittent stirring followed by cooling (28-30°C) and filtration to remove any coagulated particles. Kefir grains were inoculated to the milk at a level of 4 g/L of milk and incubated at 30°C for about 20-24 h in B.O.D incubator till the titratable acidity had reached to 1% lactic acid. The product was thoroughly stirred and sieved through nylon sieve (mesh size: 1/

20 inch). After retrieving the kefir grains, the products were then filled in polypropylene cups and kept for maturation for 24 h at 6-8°C. Thereafter, the product was stored in the refrigerator.

### Sensory evaluation

Sensorial assessment of the milk kefir was carried out by an expert panel of minimum five judges to judge the kefir samples on a 9-point hedonic scale (9=like extremely; 1=dislike extremely) at room temperature. Duo-trio tests were used to determine a candidate's ability to detect differences among similar products with different ingredients for selection of Judges.

### Physico-chemical analysis

#### pH

The pH of kefir samples was measured directly by inserting the electrode into the sample followed by recording of reading.

#### Titratable acidity

The acidity of kefir samples was measured as per the method of AOAC947.05 (2012) for milk. The sample was well mixed, and 10 g of sample was taken in a beaker. Phenolphthalein indicator of 2-3 drops was added and titrated against 0.1 N NaOH till the first appearance of faint pink colour. The acidity was expressed as % lactic acid by weight.

#### Textural analysis

Textural properties such as firmness, consistency, index of viscosity and stickiness were determined using TA-XT Plus Texture Analyser (Stable Microsystems, UK) with P/25 cylindrical probe. At 6-8°C, textural properties of kefir samples were measured using 200 ml kefir in a 250 ml beaker. The probe travelled at a speed of 1.0 mm/s up to 10 mm distance into the kefir sample from the surface and then returned to the original position generating force-time curve. The positive peak of the curve gave firmness (Newton), the negative peak gave stickiness (Newton), the area of positive peak gave consistency (Newton-second) and the area of negative peak gave index of viscosity (Newton-second).

#### Statistical analysis

The data were subjected to analysis of variance (ANOVA) using IBM SPSS statistics 23 software. Results of triplicate trials were used for statistical analysis.

## Results and Discussion

### Effect of sugar addition on sensory attributes of milk kefir

All sugar (6, 8 and 10%) added kefir samples scored higher for flavour as compared to control (Fig. 1 a). The most notable

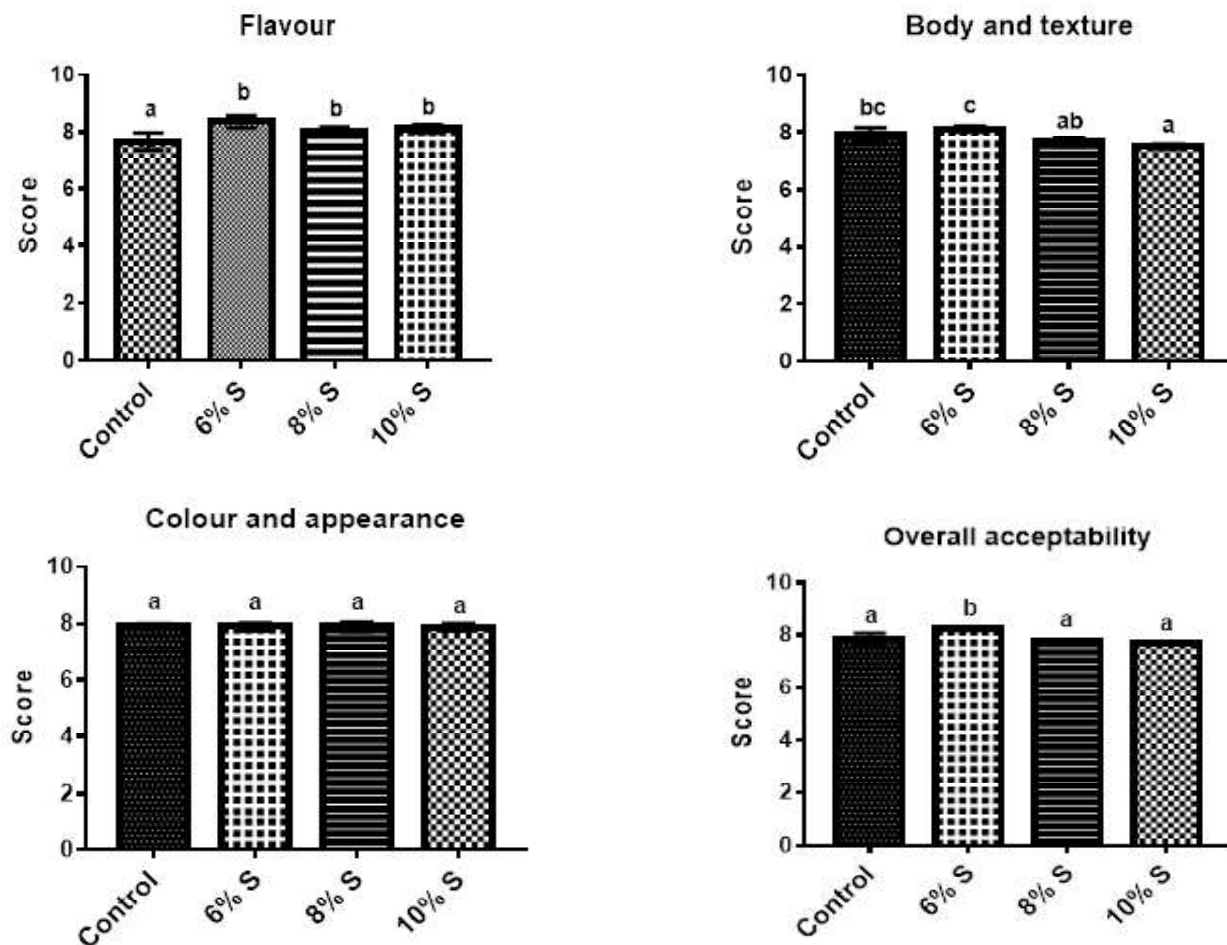


Fig. 1 Effect of sugar addition on sensory attributes of milk kefir

function of sugar in food is its sweet taste. Sweet taste serves as a sensory cue for source of pleasure. Body and texture score of kefir with 6% sugar was significantly ( $p < 0.05$ ) higher than other three kefir samples (Fig. 1 b). Sugar affected the physical characteristics of kefir to a significant degree. It provided solids which impacted the mouthfeel and texture of kefir as reported by Spillane (2006) for many fermented products. No significant ( $p > 0.05$ ) difference was observed in colour and appearance among all kefir (Fig. 1 c). Overall acceptability score was maximum for kefir with 6% sugar followed by control, 8 and 10% sugar added kefir, respectively (Fig. 1 d). Akter et al. (2010) evaluated the different levels of sugar (8, 10, 12 and 14%) on qualitative characteristics of *mistidahi* (Sweet Yoghurt) and found that 10 and 12% sugar levels obtained more organoleptic score than those of 8 and 14%. So, the concentration of sugar affects the characteristics of the final fermented product - higher amount is detrimental to lactic acid bacteria and lower one does not change the original sour flavour. Similarly, in the present study an optimum 6% sugar produced the best kefir when compared to control, 8% and 10% sugar.

#### Effect of sugar addition on pH and acidity of milk kefir

No significant ( $p > 0.05$ ) difference in pH and acidity was observed between the control and 6% sugar added kefir. Whereas kefir with 8 and 10% sugar showed significantly ( $p < 0.05$ ) lower acidity and higher pH than the control and kefir with 6% sugar (Table 1), making them less preferred to other kefir samples. Sugar acts as a substrate for lactic acid bacteria and yeast species in kefir grains and is responsible for development of acidity during the fermentation. The amount of acidity present depends upon the concentration of sugar and incubation time. Yeasts are recognized in playing a key role in the preparation of fermented dairy products, where they provide essential growth nutrients such as amino acids and vitamins, alter pH, secrete ethanol, and produce  $CO_2$  (Farnworth, 2003). Hence, lower acidity was observed in 8 and 10% sugar added kefir. Ghosh and Rajorhia (1990) also found similar results in *mistidahi* and stated that higher concentration of sugar showed inhibitory effect in the *mistidahi*. The activity of the *Lactobacillus* cultures was greatly affected with the increase in sucrose concentration which alters morphology by elongating and distorting the cell.

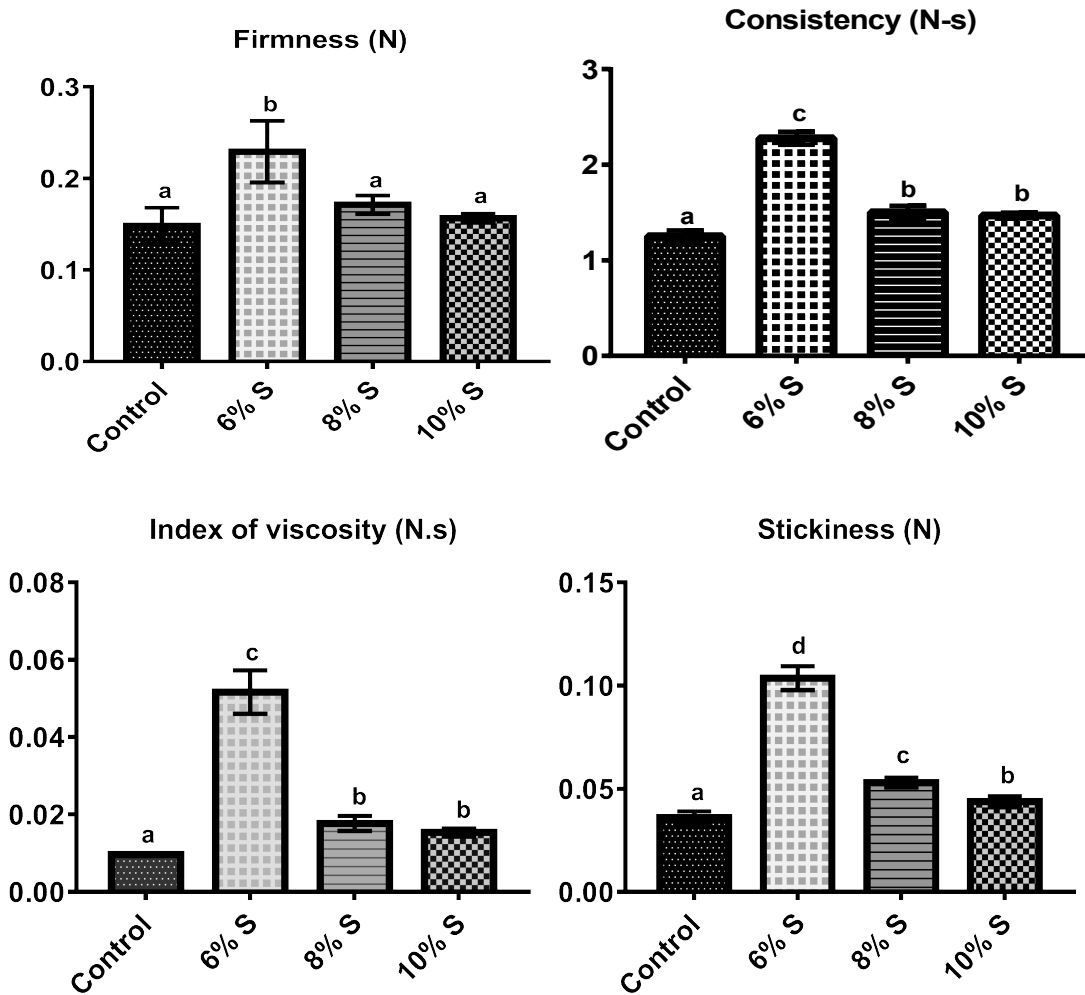


Fig. 2 Effect of sugar addition on textural properties of milk kefir

#### Effect of sugar addition on textural properties of milk kefir

Firmness was significantly ( $p < 0.05$ ) higher for kefir with 6% sugar as compared to other kefir samples (Fig. 2 a). Kefir with 6% sugar showed highest firmness, followed by 8 and 10% sugar added kefir and then control kefir (Fig. 2 a). Kefir with 6% sugar showed the highest consistency among all kefir samples. Kefir with 8 and 10% sugar showed significantly ( $p < 0.05$ ) higher consistency as compared to control kefir (Fig. 2 b). Similarly, kefir with 6% sugar exhibited significantly ( $p < 0.05$ ) higher index of viscosity among the four types of kefir (Fig. 2 c). Stickiness was the highest in kefir with 6% sugar, followed by with 8, 10% sugar and control, respectively (Fig. 2 d). Textural properties of kefir were improved with the addition of sugar due to increase total solids content in sweetened milk kefir as compared to control. However, kefir with 8 and 10% sugar showed lower textural properties which may be due to higher  $\text{CO}_2$  production in the kefir. Whey pockets and gas holes were observed with increasing sugar content in kefir. Since kefir added with 6% sugar showed the best sensorial attributes,

optimum pH and acidity and better textural properties, it was selected for further optimization of dietary fibre.

#### Effect of dietary fibres incorporation on sensory attributes of sweetened milk kefir

The effects of dietary fibre incorporation on the sensory attributes of kefir are displayed in Fig. 3. Six percent sugar was added in all samples. Control sample was added with sugar but without dietary fibre. Significantly ( $p < 0.05$ ) higher flavour was observed in inulin added kefir among four samples (Fig. 3 a). Soya fibre added kefir showed significantly ( $p < 0.05$ ) lower flavour than other kefirs (Fig. 3 a). The body and texture of kefir with inulin was the highest among all kefirs (Fig. 3 b). Inulin added kefir and control kefir showed no significant ( $p > 0.05$ ) difference in colour and appearance (Fig. 3 c). Whereas oat fibre added kefir showed significantly ( $p < 0.05$ ) inferior colour and appearance when compared to control but significantly ( $p < 0.05$ ) better than soya fibre added kefir (Fig. 3 c). Overall acceptability of inulin added

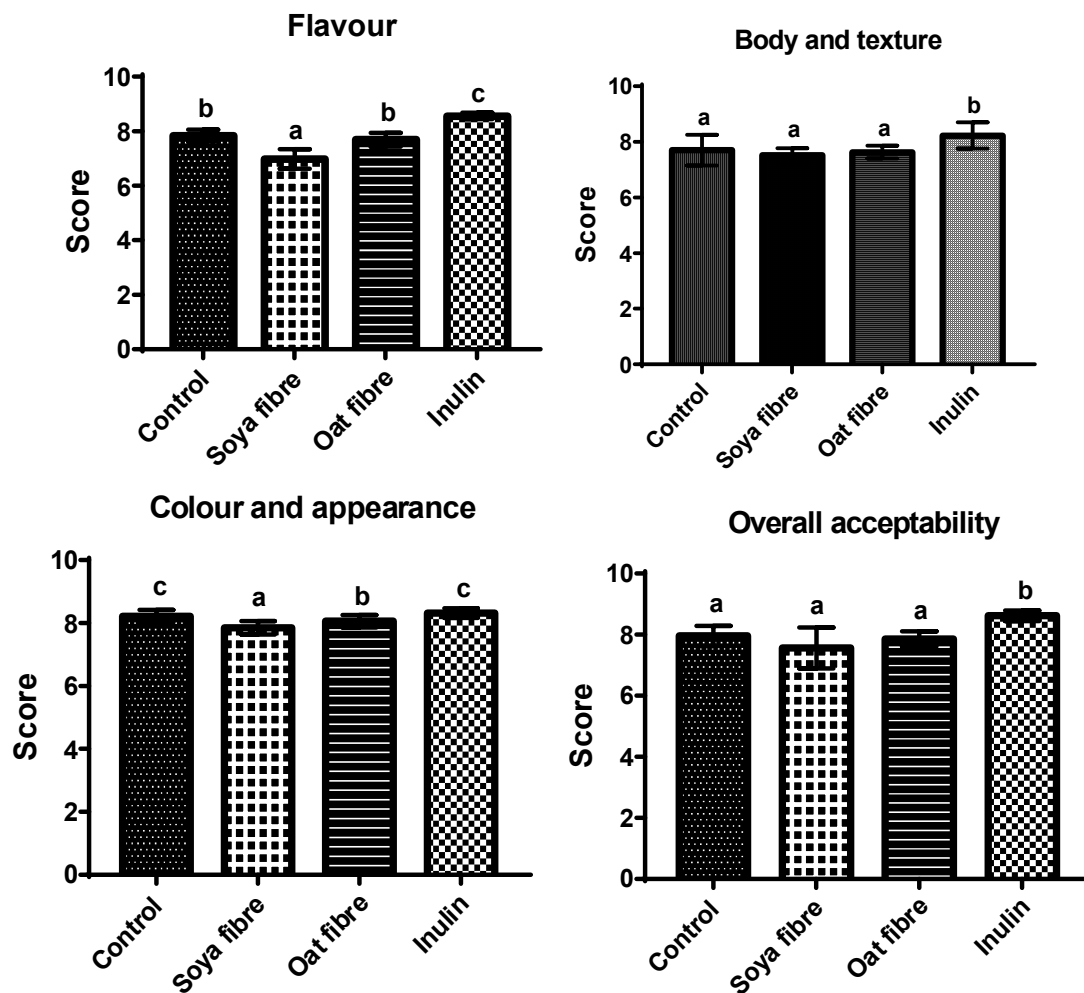


Fig. 3 Effect of dietary fibres incorporation on sensory attributes of sweetened milk kefir

Table 1 Effect of sugar addition on acidity and pH of milk kefir

Attributes	Control	6% Sugar	8 % Sugar	10 % Sugar
Acidity	1.13 ± 0.01 <sup>b</sup>	1.07 ± 0.05 <sup>b</sup>	0.98 ± 0.02 <sup>a</sup>	0.99 ± 0.01 <sup>a</sup>
pH	4.43 ± 0.01 <sup>a</sup>	4.44 ± 0.01 <sup>a</sup>	4.49 ± 0.03 <sup>b</sup>	4.48 ± 0.02 <sup>b</sup>

Mean ± S.D; means with different superscripts in a row differ significantly (p<0.05) (n=3)

kefir was maximum followed by control and then kefir added with oat and soya fibre, respectively (Fig. 3 d). The better sensory attributes of inulin added kefir might be because of additional sweetening effect of inulin which might have masked the acidic taste of kefir and improved the flavour (Allgeyer et al. 2010). No significant (p>0.05) difference was found in terms of taste and consistency when inulin was added to kefir made with skim milk powder (Glibowski and Kowalska 2012). Similarly, Ertekin and Guzel- Seydim (2010) found that odour and taste of kefir samples were indifferent with or without inulin. Loss of flavour, colour and appearance in soya milk kefir fortified with soya fibre was also reported by Baú, et al. (2014). Although soya fibre is relatively

soluble as compared to oat fibre, but sensory attributes were least in kefir added with soya fibre. The lower sensory attributes of kefir with oat fibre were due to settling of fibres at the bottom of container during incubation which resulted in an unacceptable appearance.

**Effect of dietary fibres incorporation on pH and acidity of sweetened milk kefir**

Soya fibre added kefir showed significantly (p<0.05) higher acidity as compared to other samples. No significant (p>0.05) difference was observed in pH among all types of kefir (Table 2). Typically,

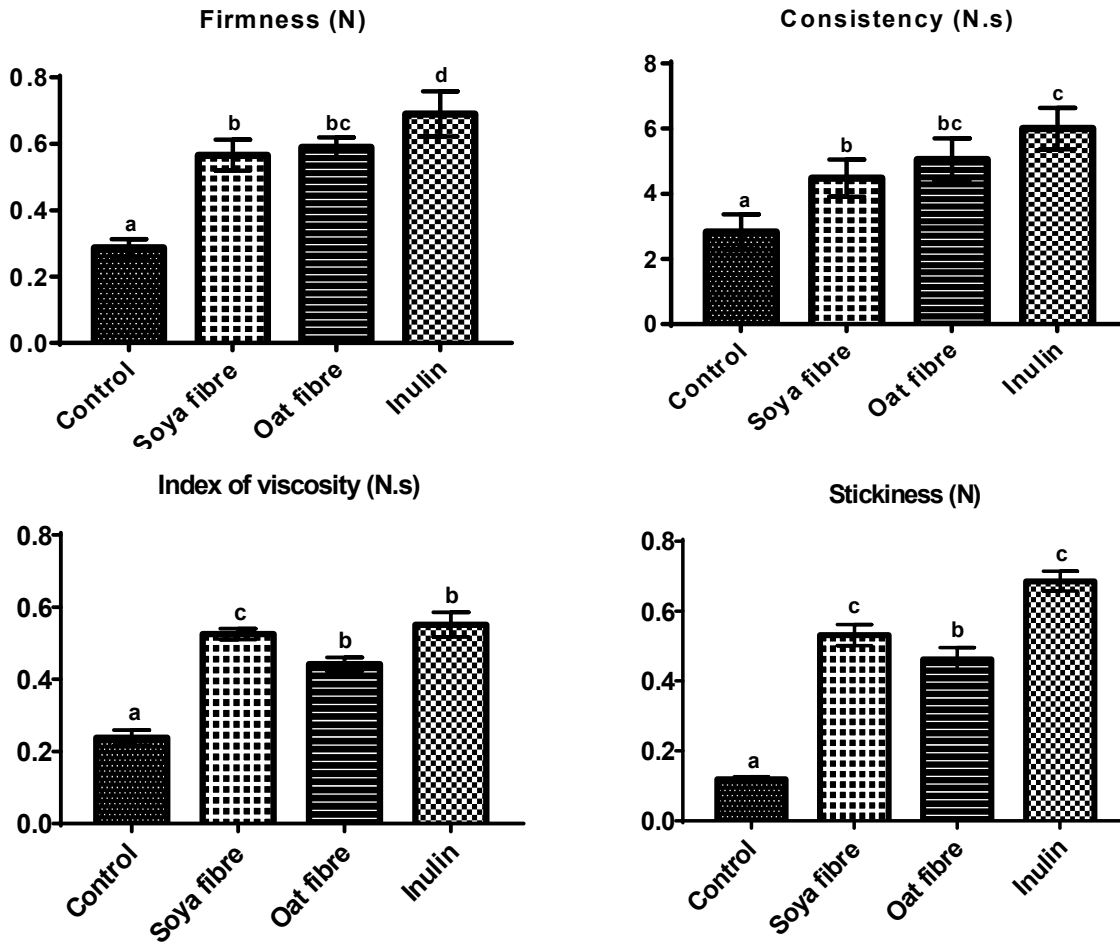


Fig. 4 Effect of dietary fibres incorporation on textural properties of sweetened milk kefir

Table 2 Effect of dietary fibres incorporation on acidity and pH of sweetened milk kefir

Attributes	Control kefir (6%S)	Soya fibre	Oat fibre	Inulin
Acidity	1.07 ± 0.12 <sup>a</sup>	1.21 ± 0.03 <sup>c</sup>	1.12 ± 0.06 <sup>ab</sup>	1.09 ± 0.03 <sup>ab</sup>
pH	4.45 ± 0.04 <sup>a</sup>	4.34 ± 0.12 <sup>a</sup>	4.42 ± 0.04 <sup>a</sup>	4.44 ± 0.02 <sup>a</sup>

Mean ± S.D; means with different superscripts in a row differ significantly ( $p < 0.05$ ) ( $n=3$ )

pH of kefirs made in dairy industry ranged between pH 4.3 and 4.4, and similar pH values were observed in the present study, where addition of different fibers did not affect pH and acidity significantly ( $p > 0.05$ ) except that higher acidity in soya fiber added kefir was observed. Baú et al. (2014) in the study with soya milk kefir prepared with soya fibre (3% w/w) showed higher acidity and lower pH as compared to kefir without soya fibre and they concluded that some fibre may stimulate the metabolism of the kefir grains resulting in higher acidity. Ertekin and Guzel-Seydim (2010) studied the effect of 2% inulin on physicochemical properties of kefir and pH was found to be between 4.29 and 4.40. They concluded that neither high performance nor native inulin did affect the pH changes in kefirs significantly ( $p > 0.05$ ). Although in the present study, there were no significant ( $p > 0.05$ ) differences in pH and acidity of different fibre added kefirs, but kefir added

with inulin showed optimum pH and acidity and obtained better sensorial and textural properties.

#### Effect of dietary fibre incorporation on textural properties of sweetened milk kefir

Firmness was significantly ( $p < 0.05$ ) increased after addition of inulin in the preparation of kefir (Fig. 4 a). It was highest for inulin added kefir, followed by oat and soya fibre added kefir and then control kefir (Fig. 4 a). Consistency was significantly ( $p < 0.05$ ) better in inulin added kefir (Fig. 4 b). Kefir added with soya and oat fibre also showed significantly ( $p < 0.05$ ) higher consistency than control kefir (Fig. 4 b). It was witnessed that index of viscosity of inulin added kefir was maximum among the four samples (Fig. 4 c). Similarly, stickiness of kefir was enhanced after inulin

addition as compared to control kefir (Fig. 4 d). Soluble fibers like inulin formed viscous gel and modified the product textural properties. Sendra et al. (2010) have also reported increased firmness and viscosity in fermented milk products with the addition of different fibres. In the present study inulin added kefir showed significantly ( $p < 0.05$ ) higher textural properties as compared to control, oat and soya fibre added kefir which may be ascribed to stable gel formation being soluble fibre as compared to relatively less soluble oat and soya fibre which subsequently settled in the bottom. Moreover, the increased viscosity in inulin added kefir may be attributed due to increased total solids content and due to the higher molecular weight of inulin (Buriti et al. 2010). Increased production of polysaccharide due to the prebiotic effect of inulin must have also indirectly decreased the syneresis, increased the viscosity and firmness during the product storage (Jolly et al. 2002).

## Conclusions

An attempt was made to develop fibre fortified sweetened milk kefir as a potential healthy alternative to *mistidohi* and yogurt. Sensory evaluation of developed sweetened milk kefir revealed that addition of 6% sugar made its taste more palatable which was liked by the taste of the Indian populace. Inulin addition of 3% improved the textural properties of sweetened kefir and contributed to its acceptance. An acceptable quality fortified sweetened milk kefir can be prepared with 0.1% pectin, 6% sugar and 3% Inulin fortification.

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## Formulation and quality evaluation of (*Pennisetum glaucum* incorporated) value-added paneer by Response Surface Methodology

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**Abstract:** Paneer is a South Asian variety of soft cheese. It is rich in protein but deficient in fibre. Efforts were initiated to prepare a fibre rich paneer by addition of pearl millet flour (*Pennisetum glaucum*). For the formulation of value-added product, 10 samples variation were developed including standard, (88.96 to 100 mL) cow's milk (CM) and pearl millet flour (PMF) (0.17 to 5.82 g). The experiment was designed by Central Composite Rotatable Design to optimize the CM, and PMF concentration for the development of value-added product with dietary fibre, and to evaluate proximal, textural and sensory characteristics of the product. For optimization, the levels of incorporation of CM and PMF were taken as variables whereas overall acceptability (OAA) as response. The optimum level of CM and PMF obtained using numerical optimization was found to be 95:3. PMF incorporated paneer had high carbohydrate (3.72g), protein (16.95g) and fibre (0.66g) content but low in fat (17.08g). Texture analysis reported higher hardness, chewiness and adhesiveness for formulations developed by addition of >4 g millet flour. Sensory scored revealed that paneer with 90 mL CM and 1g of PMF (V<sub>1</sub>) and 92.5 mL CM and 3g of PMF (V<sub>2</sub>) had highest overall acceptability (8.50 to 8.60). Therefore it was

concluded that the incorporation of PMF for the formulation of value-added paneer was a great success and furthermore it will be helpful for developing value-added dairy products for the developing countries.

**Keywords:** Cow's milk, Dietary fibre, Paneer, Pearl millet flour

### Introduction

India has witnessed a remarkable growth in milk production during the last few decades due to the success of the Operation Flood Programme, which is one of the world's largest and successful integrated dairy development programs initiated in 1970's (Khan et al. 2014). Cow's milk plays an important role in human nutrition since milk is one of the primary sources of nutrients in diets. Paneer is a variety of soft cheese obtained by acid and heat coagulation of milk. It is a non-fermented, non-renneted, non-melting, and unripened type of cheese. It is an indigenous milk product obtained through acid coagulation of heated milk and subsequent removal of whey. Paneer is a rich source of protein available at lower cost and form an important source of animal protein for vegetarians. Biological value of protein in paneer ranges from 80-86 (Shrivastava et al. 2017).

According to FSSAI (2011), paneer shall not contain more than 70.0% moisture and <50.0% milk fat (dry matter). Good quality paneer is characterized by marble white colour, mildly acidic taste, nutty flavour and spongy body according to FSSAI (PFA 2010). Paneer contains 50-60% of moisture, 23-25% fat, 17-18% protein 2-2.5% lactose and 1.5-2.0% minerals (Kumar et al. 2011). It is also a good source of fat-soluble vitamins A and D according to Bureau of Indian Standard (BIS 1983).

Millets are major food sources for millions of people, especially those who live in hot, dry areas of the world. Millets are comes under *Poaceae* family, and classified as-maize, sorghum, and Coax (Job's tears) under the grass sub-family, *Panicoidae* (Yang et al. 2012). They are grown mostly in marginal areas under agricultural conditions in which major cereals fail to give substantial yields (Adekunle, 2012). Millets are important foods in many underdeveloped countries due to their ability to grow under adverse weather conditions like limited rainfall. In contrast,

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millet is the major source of energy and protein for millions of people in Africa. It has been reported that millet has many nutritional and medical functions like- hypoglycaemic, cardio protective, colon cancer anticipatory and prebiotic actions (Obilana et al. 2002).

Millet is a drought resistant crop and can be stored for a long time without insect damage (Adekunle et al. 2012); hence, it can be important during famine. There are many varieties of millets. The four major types are Pearl millet (*Pennisetum glaucum*), which comprises 40% of the world production, Foxtail millet (*Setaria italica*) (Obalana et al. 2002), Proso millet or white millet (*Panicum miliaceum*), and Finger Millet (*Eleusine coracana*).

Pearl millet (*Pennisetum glaucum*) has been chosen for this study because it is the most widely grown type of millet. It can tolerate difficult climatic conditions such as drought, low soil fertility and high temperature, and can also grow in areas where other cereal crops, such as maize (*Zea mays*) or wheat (*Triticum aestivum*), would not survive. Pearl millet grain is highly nutritious, with 8–19% protein, low starch, high fibre (11.3g/100 g), high amount of antioxidant and micronutrient concentrations (iron, calcium and zinc) than rice, wheat, maize and sorghum (Lestienne et al. 2005; Sade, 2009; Yadav et al. 2014).

A considerable amount of literature has already identified the need for the formulation of value-added paneer like- designer paneer made up of ragi and wheat (Narayanan, 2014), cottage cheese or paneer prepared with coconut, millet, soy milk and pulses (Azeez et al. 2016) and fermented rice milk paneer (Amini et al. 2019). But in the present study for the formulation of value-added product pearl millet is used with milk because, over the last three decades the consumption of group 1 (unprocessed/ minimally processed) and group 2 (processed culinary ingredients) foods has been replaced by group 3 ultra-processed food products, which is deficient in fibre. On the other hand, fibre used to play key role in our diet because of its expedient effect on hyperlipidaemia, hyperglycaemia, constipation, colon cancer, and obesity (Srilakshmi, 2012).

**Table 1** Experimental model for the product

Treatments	Cow's Milk (mL)	Pearl millet flour (g)
Standard	100	-
Variation 1(V <sub>1</sub> )	90	1
Variation 2(V <sub>2</sub> )	95	1
Variation 3(V <sub>3</sub> )	90	5
Variation 4(V <sub>4</sub> )	95	5
Variation 5(V <sub>5</sub> )	88.96	3
Variation 6(V <sub>6</sub> )	96.03	3
Variation 7(V <sub>7</sub> )	92.5	0.17
Variation 8(V <sub>8</sub> )	92.5	5.82
Variation 9(V <sub>9</sub> )	92.5	3

Therefore, the study was aimed to formulate a value-added paneer with high nutritional value. Hence the present study investigation was under taken with objectives of optimize the formulation of fibre rich paneer using Response Surface Methodology. Moreover, the effect of incorporation on proximal, textural and sensory parameters of the formulated value-added paneer samples was also estimated.

## Materials and Methods

### Materials

Pearl millet has been selected as a sample because it has high protein, and fibre content as well as long shelf life. Pearl millet was collected from Jaisuriya shop (Salem), milk from Avin milk store (Periyar University), and lemon from local market of Salem, Tamil Nadu.

### Processing of pearl millet

Pearl millet seeds (1kg) were stored and thoroughly washed using warm (65°C) water. It was sun dried at 45 - 48°C for 10 days and milled by using locally fabricated attrition mill. The powdered samples were passed through sieve (125mm) in order to obtain fine pearl millet flour and, stored in a plastic container at room temperature.

### Optimization of value-added paneer using Response Surface Methodology (RSM)

ACCRD analysis was used to optimize and evaluate the effect of two variables (Cow's milk and pearl millet flour) on response (OAA). Based on previous preliminary experiments, the variable ranges were determined and presented with their coded and actual values in Table 1. The proportion of milk and flour was expressed as a fraction of the mixture and for each treatment combination, the sum of the components proportion was  $\leq$  to 100; where -

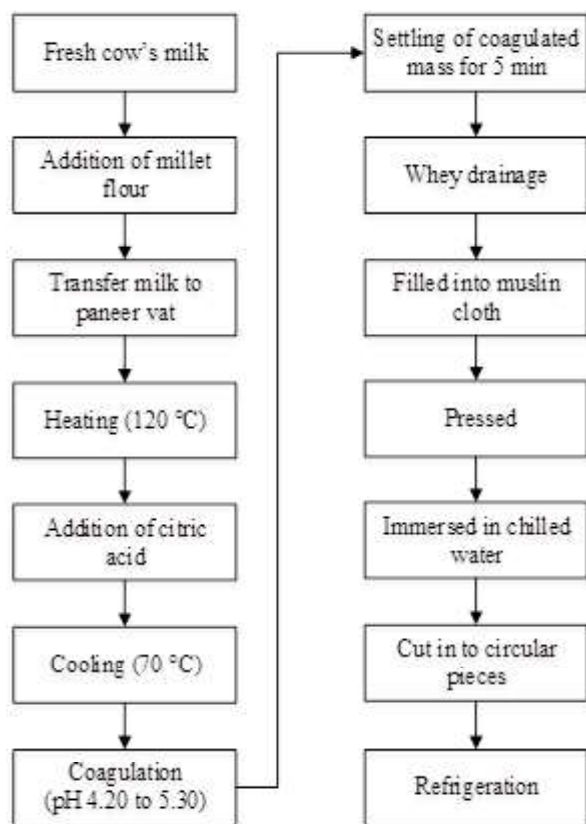
$$(x_i = x_1 + x_2 < 100\%)$$

### Standardization and optimization of value-added paneer procedure

Value-added paneer was prepared by mixing pearl millet flour with fresh milk and 10 composite samples were prepared in which one treatment was control, and 9 samples variation were mixed at different ratio as given in Table 1.

### Procedure for making value-added paneers

Cow's milk was filtered and transferred to stainless steel pan. Pearl millet flour was added with the fresh milk and heated to 120°C to control contamination from millet, and harmful bacterial growth, then subsequently cooled to 70°C. Coagulation of milk was performed by adding citric acid solution and then coagulated



**Fig. 1** Flow chart for preparation of value-added paneers

mass was allowed to settle for 5 minutes. Then whey was drained, curd collected and filled in to muslin cloth to facilitate the expulsion of whey. The muslin cloth with the coagulated mass was pressed. Then the pressed mass was immersed in the chilled water. Then the obtained paneer samples were sliced in to pieces (Fig. 1).

**Proximate analysis of value-added paneers**

Nutrient analysis was performed for carbohydrate, protein, fat, and fibre (soluble and insoluble) of the samples. Carbohydrate, protein, and fat were determined according to the method of AOAC (2000). Soluble, insoluble, and total fibre content were calculated according to the AOAC (2016) 993.19, 991.42, 991.43.

(Total carbohydrate (g): = 100-weight in grams × [protein + fat + water + ash + alcohol] in 100 g of food)

**Texture analysis of value-added paneers**

**Table 2** Predicted optimization of process parameters by desirability approach

Process Parameters	Target	Experimental Design		Optimum values
Cow's Milk	In range	90	100	95
Pearl Millet	In range	1	5	3
Responses				
OAA	Maximum	6	9	9

The texture profile of value added paneers were performed using Perten Instruments TVT 6700 texture analyser. The instrument was fitted with a 35 mm cylinder probe (P/35). Samples were tested after a period of exactly 10 min had elapsed following cooking (Bourne, 1978). Measurements were performed at room temperature (~28°C). Calibration settings used were the 5 kg load cell with a return trigger path at 15 mm. The measurement mode settings for double cycle compression (pre-test, test and post-test) were set to a speed of 1.0 mm/sec; trigger type at auto-10 g; and data rate: 200 pps, based on force-time curves of the Texture Profile Analysis and the graphs obtained were analysed for hardness, springiness, stickiness, cohesiveness, chewiness, and adhesiveness.

**Sensory evaluation of value-added paneers**

Value-added paneer samples were subjected to sensory evaluation using 9-point hedonic scale (1=dislike and 9= like extremely). Sensory attributes were evaluated by 10 panel members of six replications colour, appearance, texture, flavour, taste, and overall acceptability.

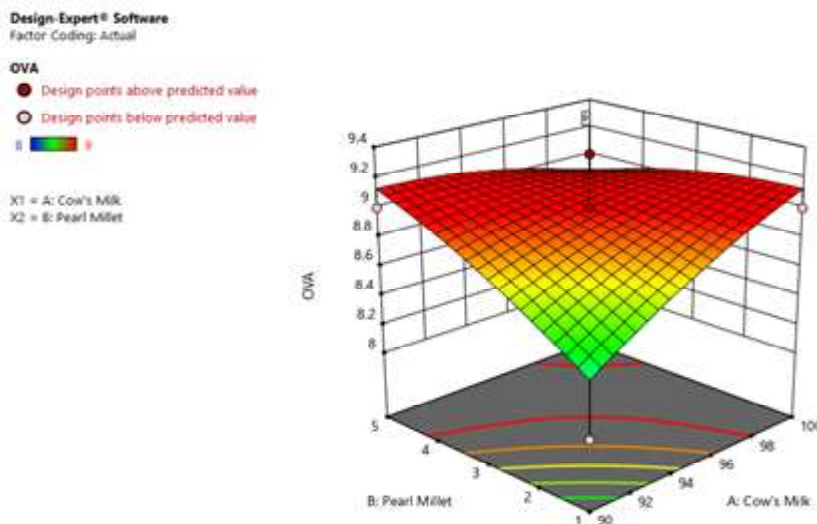
**Statistical analysis of value-added paneers**

The data obtained in the experiment was analysed statistically for the test of significance using complete randomized design and randomized block design for one-way analysis of variants. The data acquired from various experiments were recorded as mean ± standard deviation (SD). To determine the level of significance critical difference (CD) was calculated between the treatment means. The data was analysed by using SPSS software package and MS Excel 2010.

**Results and Discussion**

Predicted optimization was performed for sensory attribute and overall acceptability by imposing desirability constraints. Table 2 shows that constraints were imposed for paneer with better sensory attributes, and desirable value of both independent and dependent variables. The maximum score that can be achieved with the desirable value of overall acceptability scores was 9. On the basis of these calculations good millet incorporated paneer could be made when the milk: pearl millet ratio is 95:3. The effect of overall acceptability scores varied from 6 to 9 (like slightly to like extremely). Fig.2 shows that with increase in cow's milk and pearl millet there was an upsurge in sensory score of overall acceptability, and then slight diminution in further increase in

**Fig.2** Response surface of cow's milk and pearl millet flour for the development of value added product



**Table 3** Effects of cow's milk and pearl millet flour on overall acceptability of paneer using Responses Surface Methodology

Source	Sum of Squares	Mean Square	F-value
Model	0.5481	0.1096	2.05
A-Cow's Milk(CM)	0.1250	0.1250	2.33
B-Pearl Millet(PM)	0.1250	0.1250	2.33
AB	0.2500	0.2500	4.67
A <sup>2</sup>	0.0272	0.0272	0.5072
B <sup>2</sup>	0.0272	0.0272	0.5072
Residual	0.3750	0.0536	
Lack of Fit	0.3750	0.1250	
R <sup>2</sup>	0.59		
Adjusted R <sup>2</sup>	0.30		
Predicted R <sup>2</sup>	-1.88		

Values are the mean  $\pm$  Standard Deviation (SD) value are determined with a range of  $p < 0.05$

variations. Same result was reported by Gull et al. (2015) in their work optimization of millet supplemented pasta.

Effect of milk and pearl millet flour on sensory score of overall acceptability could be described by the following equation:

$$\begin{aligned} \text{(Overall acceptability)} = & +9.00 + 0.1250 \text{ Cow's milk} + 0.12 \text{ Pearl} \\ & \text{millet} - 0.2500 \text{ Cow's milk} \times \text{Pearl millet} - 0.0625 \text{ Cow's milk}^2 \\ & - 0.06 \text{ Pearl millet}^2 \end{aligned} \quad (1)$$

R<sup>2</sup> was found to be 0.59 (Table 3), indicating that 59 % of the variability in the response could be explained by the model. The "Predicted R-Squared" of -1.88 is in reasonable agreement with the "Adjusted R-Squared" of 0.30.

$$\begin{aligned} \text{(Overall acceptability)} = & - 23.39 + 0.57 \text{ Cow's milk} + 2.53 \text{ Pearl millet} \\ & - 0.025 \text{ Cow's milk} \times \text{Pearl millet} - 0.002 \text{ Cow's milk}^2 \\ & - 0.015 \text{ Pearl millet}^2 \end{aligned} \quad (2)$$

### Proximate analysis of value-added paneers

Table 4 displays that total fibre content was high in V<sub>8</sub> (0.66  $\pm$  0.01) with milk and millet flour ratio (92.5:5.8). The high fibre content might be related to the addition of pearl millet flour. Similar results are also reported by Singh et al. (2019), in the nutritional evaluation of laddoo prepared with pearl millet.

Comparing with standard, carbohydrate (3.72  $\pm$  0.02 g), and protein (16.95  $\pm$  0.03 g) content were high in V<sub>8</sub>. Whereas, fat content was high in standard associating with other variables (18.72  $\pm$  0.51 g). Relating the obtained figures of nutritional profile, (+1.88 g) raised in carbohydrate, and (+ 2.4 g) of protein might be due to the presence of carbohydrate and protein in millet flour. These results are in agreement with Murthy et al. (2016) and, Kumar et al. (2018), while they worked on complementary food prepared from malted wheat and foxtail millet and, pearl millet based spread. In associating with standard V<sub>9</sub>, has low fat content (-1.64g) it might be due to the incorporation of millet flour (3 g) in milk (92.5 mL)

also reported by Shivakumar et al. (2014) in millet based paneer kheer work.

**Texture analysis of value-added paneers**

Measured textural parameters of value-added paneer samples were given in Table 5. The value of hardness ranges in V<sub>1</sub>-V<sub>9</sub> was about 2.30 to 13.87N, springiness 0.66 to 0.93 mm, stickiness -0.40 to -0.13 N, cohesiveness 0.89 to 1.20, chewiness 1.97 to 10.94 N and adhesiveness 0.03 to 0.22 J.

**Hardness and chewiness**

Hardness is most commonly evaluated characteristics while determining paneer texture. Chewiness is the energy required to masticating a solid food product to make it ready to eat for swallowing. V<sub>8</sub> has (13.87 N) maximum hardness and chewiness (10.94 N). It could be related to the presence of millet flour, as inclusion rate >4 used to increase hardness and chewiness, also agreed by Jain et al. (2009) in the study of textural properties analysis of soy paneer.

**Springiness**

Springiness is the rate and extent to which a deformed material goes back to its original condition after the force has removed. Springiness was high in V<sub>1</sub> (0.93 mm) and low in V<sub>3</sub> (0.66 mm). This was also might be related to incorporation of millet flour. Inclusion rate > 4 used to decrease springiness, also discussed by Uprit et al. (2004) in their study textural analysis of soy fortified paneer.

**Stickiness and adhesiveness**

Stickiness and adhesiveness is distinct as the force necessary to overcome the attractive forces between surface of the product and the surface of the material. V<sub>8</sub> (score -0.13 N, 0.22 J) has high stickiness and adhesiveness with incorporation rate of (5.8 g PMF). Whereas, V<sub>7</sub> (score -40 N, 0.04 J) has low stickiness and adhesiveness comparing to standard with incorporation rate of (0.017 g PMF). Increased rate of stickiness and adhesiveness might be due to the adhesive nature of millet flour as reported by Dharmaraj et al. (2012) in their work physicochemical and textural characteristics of expended finger millet.

**Cohesiveness**

**Table 4** Proximate analysis of value-added paneers<sup>1</sup>

Sample	Fibre (g)			Carbohydrate	Protein	Fat
Milk:Millet	Soluble	Insoluble	Total	(g)	(g)	(g)
Standard	-	-	-	1.84±0.62	14.55±0.57	18.72±0.51
V <sub>1</sub> (90:1)	0.09±0.02	0.02±0.02	0.11±0.01	1.92±0.03	14.74±0.03	18.23±0.02
V <sub>2</sub> (95:1)	0.09±0.02	0.02±0.02	0.11±0.01	2.09±0.13	14.95±0.03	18.23±0.06
V <sub>3</sub> (90:5)	0.45±0.03	0.11±0.02	0.56±0.04	2.61±0.08	15.12±0.09	18.04±0.04
V <sub>4</sub> (95:5)	0.45±0.03	0.11±0.06	0.56±0.04	3.07±0.03	15.85±0.01	17.63±0.01
V <sub>5</sub> (88.9:3)	0.27±0.01	0.07±0.03	0.34±0.04	3.05±0.03	15.36±0.02	17.86±0.05
V <sub>6</sub> (96.03:3)	0.27±0.01	0.07±0.03	0.34±0.04	3.13±0.01	15.51±0.02	17.76±0.02
V <sub>7</sub> (92.5:0.17)	0.01±0.01	0.003±0.002	0.01±0.02	2.94±0.02	15.24±0.03	17.94±0.02
V <sub>8</sub> (92.5:5.8)	0.53±0.01	0.13±0.01	0.66±0.01	3.72±0.02	16.95±0.03	17.41±0.01
V <sub>9</sub> (92.5:3)	0.27±0.01	0.07±0.03	0.34±0.04	3.45±0.04	16.14±0.11	17.08±0.02

<sup>1</sup> Values are the mean ± Standard Deviation

**Table 5** Textural characteristics of value added paneers<sup>1</sup>

Products	Hardness	Springiness	Stickiness	Cohesiveness	Chewiness	Adhesiveness
Milk:Millet	(N)	(mm)	(N)		(N)	(J)
Standard	2.30±0.01	0.76±0.02	-0.35±0.03	1.0±0.12	6.66±0.03	0.03±0.05
V <sub>1</sub> (90:1)	4.91±0.87	0.93±0.07	-0.24±0.00	1.16±0.24	5.32±1.6	0.05±0.02
V <sub>2</sub> (95:1)	2.45±1.25	0.78±0.33	-0.20±0.31	0.961±0.06	1.97±1.4	0.10±0.80
V <sub>3</sub> (90:5)	4.76±0.66	0.66±0.29	-0.17±0.04	1.20±0.04	3.72±1.5	0.11±0.18
V <sub>4</sub> (95:5)	4.01±0.79	0.92±0.09	-0.13±0.01	0.91±0.01	3.28±0.41	0.07±0.08
V <sub>5</sub> (88.9:3)	7.90±3.43	0.80±0.16	-0.19±0.05	0.89±0.01	5.25±1.8	0.07±0.06
V <sub>6</sub> (96.03:3)	4.93±1.04	0.78±0.28	-0.36±0.24	1.00±0.17	3.74±1.3	0.05±0.04
V <sub>7</sub> (92.5:0.17)	5.39±0.60	0.74±0.10	-0.40±0.01	0.94±0.00	3.78±0.72	0.04±0.12
V <sub>8</sub> (92.5:5.8)	13.87±4.22	0.71±0.04	-0.13±0.01	1.14±0.22	10.94±1.9	0.22±0.05
V <sub>9</sub> (92.5:3)	7.66±0.43	0.71±0.18	-0.22±0.01	1.04±0.17	5.92±2.6	0.07±0.31

<sup>1</sup>Values are the mean ± Standard Deviation (SD) of 6 determinants with a range of p<0.05

**Table 6** Mean organoleptic scores of developed value-added paneers with pearl millet<sup>1</sup>

Variations Milk:Millet	Colour	Appearance	Texture	Flavour	Taste	Overall Acceptability
Standard	8.80±0.42 <sup>ab</sup>	8.70±0.48 <sup>2b</sup>	8.70±0.67 <sup>c</sup>	8.30±0.48 <sup>e</sup>	8.30±0.48 <sup>e</sup>	8.40±0.51 <sup>b</sup>
V <sub>1</sub> (90:1)	8.10±0.73 <sup>ab</sup>	8.00±0.66 <sup>a</sup>	8.10±0.56 <sup>abcd</sup>	7.20±0.78 <sup>ab</sup>	7.20±0.78 <sup>ab</sup>	8.00±0.66 <sup>ab</sup>
V <sub>2</sub> (95:1)	8.00±1.05 <sup>a</sup>	8.00±1.05 <sup>a</sup>	8.50±0.52 <sup>cd</sup>	7.70±0.48 <sup>bc</sup>	7.70±0.48 <sup>bc</sup>	8.60±0.51 <sup>b</sup>
V <sub>3</sub> (90:5)	7.40±0.96 <sup>a</sup>	7.40±0.96 <sup>a</sup>	7.70±0.67 <sup>ab</sup>	7.70±0.67 <sup>ab</sup>	6.90±0.31 <sup>a</sup>	7.80±0.63 <sup>a</sup>
V <sub>4</sub> (95:5)	7.40±0.51 <sup>a</sup>	7.40±0.51 <sup>a</sup>	7.90±0.73 <sup>abc</sup>	7.40±0.84 <sup>ab</sup>	7.30±0.67 <sup>ab</sup>	7.90±0.73 <sup>ab</sup>
V <sub>5</sub> (88.9:3)	7.60±0.84 <sup>a</sup>	7.60±0.84 <sup>a</sup>	7.40±0.69 <sup>a</sup>	7.50±0.52 <sup>ab</sup>	7.50±0.52 <sup>ab</sup>	8.10±0.73 <sup>ab</sup>
V <sub>6</sub> (96.03:3)	7.60±0.84 <sup>a</sup>	7.60±0.84 <sup>a</sup>	8.00±0.94 <sup>abcd</sup>	7.80±0.42 <sup>bcd</sup>	7.70±0.48 <sup>bc</sup>	8.00±0.66 <sup>ab</sup>
V <sub>7</sub> (92.5:0.17)	8.20±0.63 <sup>ab</sup>	8.20±0.63 <sup>a</sup>	8.20±0.78 <sup>bcd</sup>	8.40±0.69 <sup>de</sup>	8.40±0.69 <sup>cde</sup>	8.00±0.94 <sup>ab</sup>
V <sub>8</sub> (92.5:5.8)	7.60±0.84 <sup>a</sup>	7.60±0.84 <sup>a</sup>	8.00±0.81 <sup>abcd</sup>	7.20±0.91 <sup>ab</sup>	7.20±0.91 <sup>ab</sup>	7.80±0.91 <sup>a</sup>
V <sub>9</sub> (92.5:3)	7.90±0.87 <sup>a</sup>	7.90±0.87 <sup>a</sup>	8.40±0.69 <sup>bcd</sup>	8.80±0.91 <sup>bcd</sup>	8.80±0.91 <sup>bcd</sup>	8.50±0.52 <sup>ab</sup>
F-value	2.710 <sup>*</sup>	2.364 <sup>*</sup>	2.527 <sup>*</sup>	7.0738 <sup>**</sup>	7.708 <sup>**</sup>	2.051 <sup>*</sup>

<sup>1</sup>Values are the mean ± Standard Deviation (SD) of 6 determinants. The values are determined using Duncan's Multiple Range Test (p<0.05).

\*\* - Highly Significant (P ≤ 0.01), \* - Significant (0.01 < P ≤ 0.05), NS – Not Significant (P > 0.05)

Which is well-defined as the extent to which a material can be deformed before its rupture depends upon the strength of internal bond. V<sub>3</sub> (1.20) has maximum cohesiveness and V<sub>5</sub> (0.89) minimum. In general cohesiveness used to increase as a result of addition of high proportion of millet flour or long time storage condition. As explained by Shrivastav et al. (2010) in textural analysis of paneer with pressure and superheated steam.

### Sensory evaluation of value-added paneers

As mentioned in Table 6, with regards to the attribute colour and appearance, all the 9 variables differs significantly with standard, it's might be due to the addition of millet flour (0.17- 5.8 g of PMF). Same result also reported by Solanki et al. (2018) in their work preparation of millet kheer. Textural characteristics did not define any significant difference between V<sub>2</sub> (score 8.50) (95 mL CM and 1 g PMF), and V<sub>9</sub> (score 8.40) (92.5 mL CM and 3 g of PMF) with standard because of minimal inclusion rate of PMF (1 to 3 g), but they use to differ significantly with other variables. In flavour and taste aspects, V<sub>7</sub> did not vary significantly from standard with an inclusion rate of 0.17 PMF. But V<sub>9</sub> (8.80) differ significantly in association with control, it's might due to the presence of (3 g) of PMF, same result was reported by Mannuramath et al. (2015) in their work little millet incorporated functional bread.

The overall acceptability score did not differ significantly with standard for the paneers prepared with 95 mL CM and 1 g PMF (V<sub>2</sub>) and 92.5 mL CM and 3 g PMF (V<sub>9</sub>) and found to be satisfactory by the panellist. This shows that millet flour incorporation improved the sensory quality of paneer sample up to 3 g level, but further increase led to reduction of sensory score. These results are comparable with Singh et al. (2017) in the study preparation of mint paneer.

### Conclusions

According to the result of the study it is concluded that Response Surface Methodology was effective in the formulation of value added Product with 95 mL cow's milk and 3 g pearl millet flour. Incorporation rate (>5 PMF) used to improve nutritional quality especially for fibre and protein however, overall acceptability decreased. Therefore, the value-added product with a ratio of cow's milk and pearl millet flour 90:1 (V<sub>2</sub>) and 92.5:3 (V<sub>3</sub>) found to be accepted by sensory panellists. Current study has suggested that inclusion of millet flour (>4) increased hardness, chewiness and adhesiveness of the product. After improving the nutritional quality V<sub>9</sub> reported good fibre (0.34g) and protein (6.14g) content along with the overall acceptability. Therefore, with a certain outcome the attempt to formulate a value added product with fibre has been successfully attained. Further studies are recommended on shelf life and effect of packaging on the value-added product.

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# Efficiency of imputing missing genotypes by INDUSCHIP v2 in HF Crossbred cattle

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**Abstract:** INDUSCHIP- an Illumina platform based custom made genotyping chip was designed with 45K polymorphic markers for Indian cattle breeds and 8K base SNPs of Illumina BovineLD chip to genotype indigenous and crossbred cattle in India. Current study was undertaken to assess the genotype imputation efficiency of INDUSCHIP v2 microarray in HF crossbred cattle and compare its efficiency of imputation with that of GGP-35K microarray. HD genotyping data of total 869 cattle from 14 indicine breeds, 2 crossbred (HF and Jersey crossbred) and 2 exotic breeds (HF, Jersey) were used for this study. Post quality control, only 846 animals and 449955 SNPs remained for imputation study. Only 23.65% of 35339 SNPs in GGP-35K chip are found to be common with INDUSCHIP v2 SNP panel. Imputation was carried out with the help of Beagle 5.0 software using subset of both INDUSCHIP v2 and GGP-35K SNP panels. The study revealed higher average concordance rate (CR) and squared correlation ( $DR^2$ ) for INDUSCHIP v2 as compared to GGP-35K in crossbred HF population.

**Keywords:** Genotype Imputation, HF Crossbred cattle, INDUSCHIP, Single Nucleotide Polymorphism

## Introduction

Identification of polymorphic variants (SNPs) across the genome, development of high throughput genotyping and sequencing techniques has led to the generation of massive amount of genomic information on large number of individuals. In Livestock, these genomic information is mainly used for breeding purpose, known as Genomic selection (GS), where, superior individuals are selected for breeding at the very young age on the basis of Genomic enhanced Breeding values (GEBV), computed as a linear function of evenly spaced DNA markers (SNP) spread across the genome and their associated genotypes (Meuwissen et al. 2016). Genomic information from dense SNP chips provides an opportunity to increase rate of genetic progress in the breeding programs if a sufficient number of markers and animals with phenotypes are genotyped. More number of markers means greater linkage disequilibrium between SNPs and more chances of capturing genomic variation. However, several studies indicated that increase in SNP density, after a certain threshold, does not seem to improve the quality of realized genomic relationship in any significant way (Su et al. 2012, Chang et al. 2019).

Since, genotyping with HD SNP panels are expensive, it limits the number of animals to be genotyped. Hence, in practice, people preferred cost effective alternative called genotype imputation, which allows inference of the missing marker genotypes from individuals genotyped with low or medium density (LD) panels by using information from reference population genotyped with high-density panels (Carvalho et al. 2014). This not only makes it possible to increase the genomic information and predict missing genotypes (Marchini and Howie, 2010) but to reduce genotyping costs and intensify genomic selection (Ventura et al. 2014) by genotyping more number of animals and combine data from different breeds (Larmer et al. 2014).

To implement genomic selection in India for indicus breeds and their taurine crosses, a medium-density customized chip i.e., INDUSCHIP v1 consisting of 45700 SNPs sampled from HD genotype of the mostly four indicus breeds (Gir, Sahiwal, Kankrej and Red Sindhi) and their taurine crosses (HF cross & Jersey cross) have been developed (Mrode et al. 2019). The genotyping

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chip contained around 41000 SNPs from HD data having high MAF (0.25), uniformly distributed across the genome for all the breeds under study with an average distance between two consecutive SNPs around 65 kbps. In addition to the above, 2000 ancestry informative SNPs for above mentioned six breeds, ISAG recommended parentage SNPs and some known open-source genetic markers were also included (Nayee et al. 2017). Subsequently, INDUSCHIP v1 was upgraded to INDUSCHIP v2 (52363 SNPs) incorporating additional 6663 highly polymorphic SNPs (Saha et al. 2020).

Current study was undertaken to assess the genotype imputation efficiency of INDUSCHIP v2 micro array to HD level in Holstein Friesian crossbred (HF CB) population and compare its performance with other commercially available medium density chip i.e., GGP indicus-35K microarray developed by Neogen Geneseek operation on Illumina platform specially designed for indicine cattle.

## Materials and Methods

### Source of data

Total 869 number of Cattle belong to 14 different Indicine breeds (Amritmahal, Deoni, Gir, Hariana, Hallikar, Kankrej, Khillar, Kangayam, Ongole, Red Sindhi, Rathi, Sahiwal, Siri and Tharparkar) and 2 crossbred (HF crossbred-HF CB and Jersey crossbred-JCB) breeds were genotyped with 777K Bovine HD BeadChip (Illumina, Inc., San Diego, CA). The genotype data for 2 taurine breeds, Holstein Friesian (HF) and Jersey, were obtained from Aarhus University, Denmark. The genotype candidates were selected mainly from frozen semen stations in India and certain state run livestock farms maintaining purebred animals of those breeds.

### Data editing

Quality control checks were applied to raw data. SNPs located on autosomes, with call rate >95% and genotyping rate >90% were kept. Further, SNPs with a minor allele frequency (MAF) less than 0.01 and Hardy Weinberg equilibrium having p value less than  $10^{-4}$  were excluded.

After quality control, out of a total of 869 animals of 14 different breeds (multi-breed) and 777962 SNPs, only 846 animals and 449955 SNPs remained for imputation study.

### Retrieval of INDUSCHIP and GGP indicus-35K SNP panels:

50K SNP panel data (52363 SNP) of INDUSCHIP was retrieved from customized INDUSCHIP v2 manifest file (NDDB\_Induschip2\_15061153X355693\_B1.bpm). Around 2949 SNPs, which were present in INDUSCHIP v2 manifest file but was not found to be matching with HD SNPs, thus were excluded from this study. After quality control, finally 49399 SNPs remained,

whose HD genotyping data was extracted as a subset to study the imputation efficiency of INDUSCHIP. Similarly, The SNP panel list of GGP indicus-35K medium density chip was obtained from NAGRP community data repository.

### Creation of test, reference and validation data sets

From this data, randomly 11 HF CB animals were selected at a time to form test groups animals. While remaining animals 835 animals of multiple breed were taken as reference group with HD data obtained after quality control. Five such test groups were created. Subsequently, genotyping information for the INDUSCHIP and GGP indicus 35K SNP panel were retrieved as a subset from HD data for all the five test groups of animals.

Further, in order to study the concordance of imputation for missing genotypes, five validation data sets with HD genotype data for each group of test animals were also created.

A schematic diagram of the experimental design of this imputation study is presented in Figure 1.

### Imputation using INDUSCHIP and GGP indicus-35K SNP panels

Imputation was carried out for 5 test groups of animals using genotyping information of INDUSCHIP v2 SNP panel and GGP indicus-35K SNP panel, respectively. During the study, instead of taking all the 29 autosomes, imputation was carried out for 5 selected autosomes (i.e. Chromosome no.1, 5, 15, 20 and 25) to compare the imputation efficiency.

PLINK (Purcell et al. 2007) software was used for quality control of the data, creation of test, reference and validation data sets as well as for preparing inputs file for Beagle. Imputation was carried out using Beagle 5.0 software (Browning et al. 2018), a population-based imputation program (does not rely on pedigree information) that adopts a stochastic procedure based on a Hidden Markov Monte-Carlo process to infer the probabilities of each haplotype/genotype (Carvalho et al. 2014). Imputation accuracy was assessed in terms of concordance rate i.e. the proportion of alleles or genotypes that are correctly imputed (Weigel et al. 2010) and squared correlation between the estimated allele dose and the true allele dose i.e. dosage  $r^2$  ( $DR^2$ ). The animal wise concordance rate between imputed and actual genotype was estimated using R statistical software and  $DR^2$  values between markers are obtained from Beagle software output.

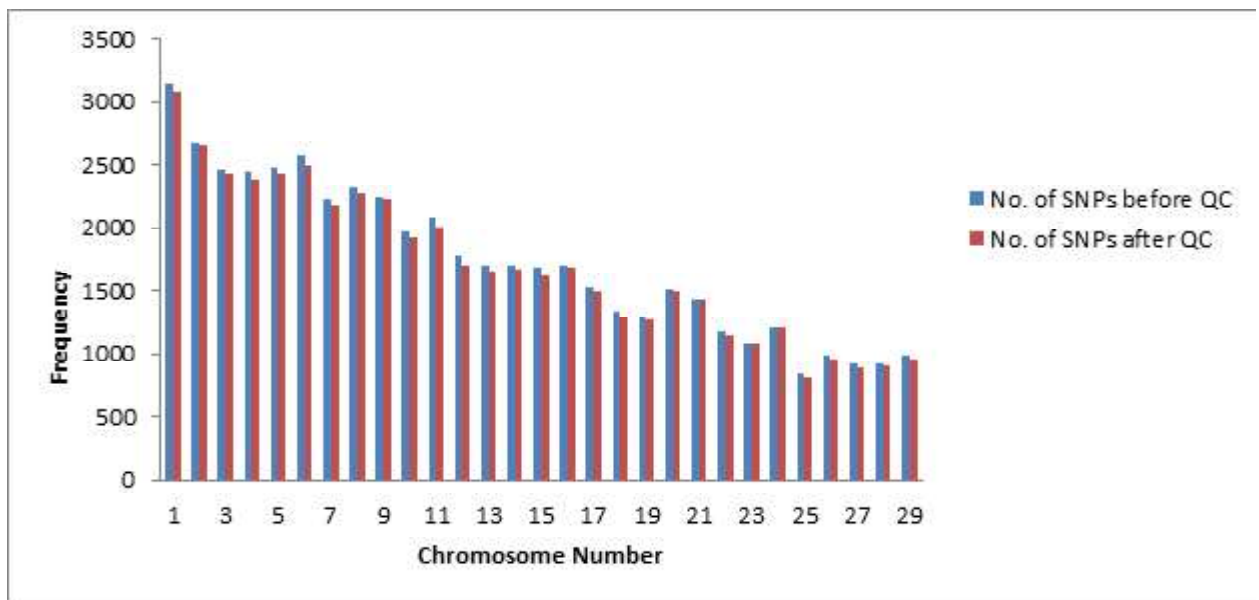
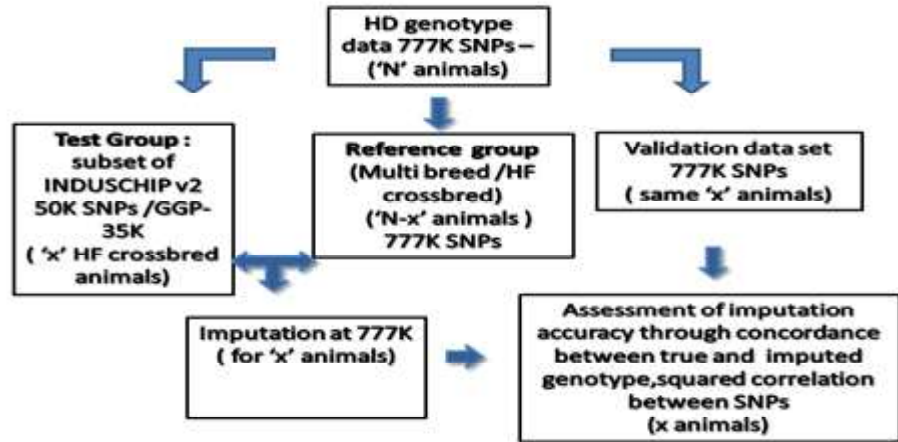
## Results and Discussion

### Characterization of INDUSCHIP v2 SNP chip

#### Number and Distribution of SNPs across autosomes:

For an SNP array to be efficient in genotyping for a particular population, it is important to ensure that the selected SNPs are

**Fig. 1** Schematic Diagram of the experimental design for imputation study



**Fig. 2** Chromosome-wise distribution SNPs in INDUSCHIP v2 before and after quality control

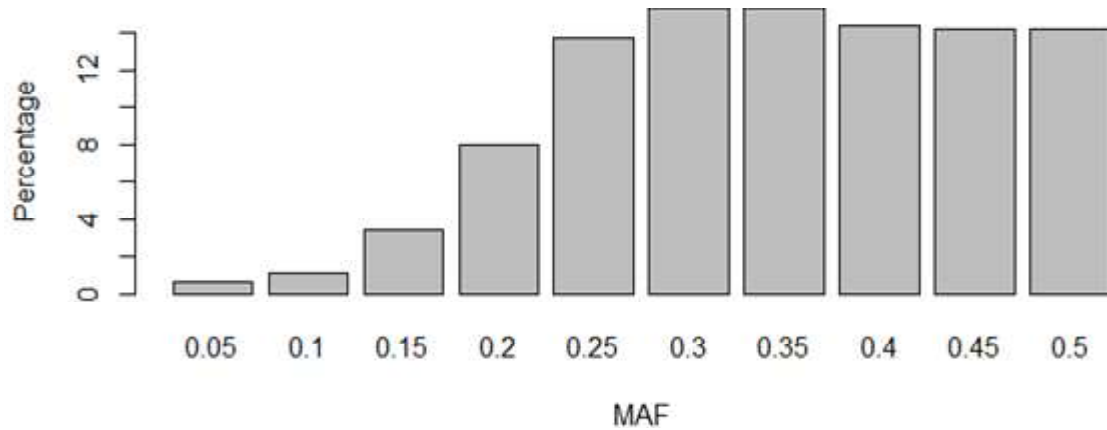
distributed evenly covering the entire genome. INDUSCHIP was designed by selecting a subset of SNPs from Illumina BovineHD genotyping array. INDUSCHIP v2 manifest file revealed that there were altogether 52363 SNPs located in all chromosomes. Out of which only 50436 SNPs are located in 29 autosomes (96.3%). Distribution of SNPs across the autosomes in INDUSCHIP v2 vis-à-vis Illumina Bovine HD chip is presented in Table No.1. The data revealed that on an average 6.8% of the HD SNPs located per autosomes were selected in customized INDUSCHIP v2 microarray.

The average distance between the SNPs was found to be around 49.7 Kb across the autosomes. The maximum distance between SNPs was found in chromosome number 10 (52.52 Kb), while minimum distance (46.79 Kb) was observed in chromosome number 9.

Post quality control (QC), out of a total of 50436 SNPs located in autosomes, only 49399 SNPs remained for imputation study. The autosome wise distribution of SNPs before and after quality control (QC) is presented in Figure 2.

#### Minor allele Frequency

Autosome-wise distribution of minor allele frequencies (MAF) in HFCB population was estimated using PLINK and presented in Table no.2. MAF was classified into three different categories viz. Rare SNPs (MAF > 0 – <0.05), Intermediate SNPs (MAF >= 0.05 – 0.25), and Highly polymorphic SNPs (MAF > 0.25). The distribution of SNPs based on MAF in HFCB population for INDUSCHIP v2 SNP panel indicated that the majority of SNPs (around 73.27%) existing in INDUSCHIP v2 SNP panels are polymorphic having MAF >0.25 (Figure 3).



**Fig. 3** MAF-wise distribution of SNPs (%) in INDUSCHIP v2

**Table 1** Chromosome-wise distribution of SNPs in Illumina Bovine HD chip and INDUSCHIP v2 microarray

Chromosome No.	No. of SNPs in Bovine HD chip	No. of SNPs in INDUSCHIP v2	% SNP in INDUSCHIP v2 compared to Bovine HD chip	Average distance (in KB) between SNPs in INDUSCHIP v2
1	46495	3155	6.8	50.14
2	40056	2677	6.7	51.00
3	35579	2468	6.9	49.15
4	34980	2442	7.0	49.26
5	34842	2483	7.1	48.70
6	35519	2572	7.2	47.11
7	33168	2227	6.7	50.46
8	33529	2320	6.9	48.70
9	31060	2250	7.2	46.79
10	30449	1975	6.5	52.52
11	32015	2078	6.5	51.50
12	26127	1782	6.8	51.00
13	23594	1700	7.2	49.32
14	24780	1697	6.8	49.00
15	24755	1680	6.8	50.53
16	24178	1695	7.0	47.92
17	22266	1522	6.8	49.28
18	19386	1342	6.9	49.05
19	18908	1284	6.8	49.72
20	21490	1508	7.0	47.39
21	21175	1440	6.8	49.67
22	18034	1178	6.5	51.76
23	15215	1091	7.2	47.66
24	18620	1217	6.5	50.95
25	12931	838	6.5	50.92
26	15242	988	6.5	52.21
27	13152	922	7.0	49.18
28	13038	921	7.1	50.13
29	14710	984	6.7	51.31

**Comparison of the efficiency of INDUSCHIP v2 and GGP indicus-35K microarray in imputing missing SNPs in HF crossbred cattle**

Investigation on SNP markers available in GGP indicus-35K chip, respectively, revealed that out of total 35339 SNPs present in GGP indicus-35K chip, only 8361 SNPs are found (23.65 %) to be

**Table 2** Chromosome-wise distribution of MAF in INDUSCHIP v2 microarray

Chromosome No.	Categories of Minor Allele Frequency (MAF)			Grand Total
	>0-0.05	>0.05-0.25	>0.25	
1	14	814	2259	3087
2	34	768	1849	2651
3	21	588	1819	2428
4	14	586	1791	2391
5	21	651	1755	2427
6	13	660	1817	2490
7	14	586	1574	2174
8	20	856	1396	2272
9	5	603	1621	2229
10	5	453	1470	1928
11	5	468	1539	2012
12	10	455	1245	1710
13	9	595	1055	1659
14	18	499	1150	1667
15	9	401	1213	1623
16	8	471	1202	1681
17	12	351	1130	1493
18	6	302	989	1297
19	13	274	988	1275
20	13	375	1104	1492
21	13	394	1026	1433
22	7	236	910	1153
23	2	224	856	1082
24	3	326	877	1206
25	1	165	646	812
26	1	209	754	964
27	3	187	709	899
28	2	190	711	903
29	2	219	740	961
Total	298	12906	36195	49399
%	0.60	26.13	73.27	

common with INDUSCHIP v2 SNP panel. In GGP indicus-35K chip, around 81% of SNPs were found to be polymorphic with  $MAF > 0.25$ .

Imputation was carried out using genotype information at INDUSCHIP v2 SNP panel and GGP indicus-35K SNP panel for 5 chromosomes (i.e. Chromosome no. 1, 10, 15, 20 and 25, respectively) for all the five test group of animals.

The Concordance rate obtained from this study found to vary between 0.971 (Chromosome no.10) to 0.980 (Chromosome No.15) while imputing INDUSCHIP v2 SNP panel to HD level, while the same was varying from 0.961 (Chromosome no.10) to 0.974 (Chromosome No.15) for GGP indicus-35K (Table 3).

Carvalho et al. (2014), while imputing GGP20Ki and GGP75Ki panel to HD panel in Nellore animals, observed concordance rate of 97 and 99%, respectively.

The average  $DR^2$  found to vary between 0.892-0.922 in INDUSCHIP v2, while it was 0.888-0.913 in GGP indicus-35K (Table 4).

The present study revealed that selected SNPs in customized INDUSCHIP v2, which was specifically designed for genotyping of indicine breeds and their crosses, were distributed uniformly covering the entire genome. Distribution of SNPs in INDUSCHIP v2 is found to be similar to the distribution of SNPs in other Bovine SNP chips like Illumina 50K and GeneSeek 75K (Mutukumalli et al. 2009).

The majority of the SNPs with high MAF ( $>0.25$ ) across the autosomes, indicated existence of considerable heterozygosity in crossbred population and INDUSCHIP v2 appeared to be effective in capturing variability in the crossbred population. Malik et al. 2018 in his study using high throughput genotyping-by-sequencing (GBS) markers found that the MAF within the

**Table 3** Average concordance rate of INDUSCHIP v2 and GGP indicus-35K in HFCB cattle

Group	INDUSCHIP v2					GGP indicus-35K				
	Chr1	Chr5	Chr10	Chr15	Chr25	Chr1	Chr5	Chr10	Chr15	Chr25
Test -1	0.986	0.984	0.970	0.987	0.978	0.983	0.977	0.958	0.984	0.969
Test -2	0.975	0.984	0.977	0.986	0.982	0.968	0.977	0.970	0.982	0.974
Test -3	0.982	0.980	0.968	0.975	0.980	0.977	0.972	0.958	0.966	0.976
Test -4	0.968	0.968	0.970	0.972	0.965	0.953	0.957	0.960	0.970	0.956
Test -5	0.971	0.968	0.971	0.975	0.969	0.963	0.956	0.960	0.968	0.956
Average	0.977	0.977	0.971	0.98	0.975	0.969	0.968	0.961	0.974	0.966

**Table 4** Average DR<sup>2</sup> of INDUSCHIP v2 and GGP indicus-35K in HFCB cattle

Group	INDUSCHIP v2					GGP indicus-35K				
	Chr1	Chr5	Chr10	Chr15	Chr25	Chr1	Chr5	Chr10	Chr15	Chr25
Test -1	0.920	0.926	0.893	0.933	0.890	0.916	0.919	0.887	0.931	0.877
Test -2	0.900	0.923	0.918	0.930	0.908	0.897	0.916	0.915	0.922	0.898
Test -3	0.924	0.921	0.907	0.910	0.909	0.918	0.913	0.897	0.905	0.901
Test -4	0.892	0.906	0.902	0.918	0.877	0.883	0.886	0.897	0.895	0.896
Test -5	0.892	0.906	0.902	0.918	0.877	0.881	0.890	0.891	0.914	0.868
Average	0.906	0.916	0.904	0.922	0.892	0.899	0.905	0.897	0.913	0.888

Indian cattle varied from 0.103 (in Ongole cattle) to 0.177 (in Siri cattle), whereas the Holstein cattle had the lowest value of 0.089. Chagunda et al. 2018 reported average minor allele frequency of 0.29, 0.23, 0.18 and 0.13 for Holstein, Jersey, N'Dama and Gir cattle, respectively.

Comparing imputation efficiency between INDUSCHIP v2 and GGP indicus-35K expressed in terms of average concordance rate as well as squared correlation estimate (DR<sup>2</sup>) between Imputed and actual genotypes revealed marginally better performance of INDUSCHIP v2 over GGP indicus-35K chip in Indian HF crossbred population. It may be attributed due to the fact that design of INDUSCHIP v2 chip was based on Indigenous breeds and its crosses (Nayee et al. 2017), while the SNP panels for GGP indicus-35K chip were selected from Australian Brahman, Droughtmaster, Guzerath, Gyr, Nellore, Santa Gertrudis, and tropical composite (Ferraz et al. 2018).

## Conclusions

From the present study it can be concluded that the current version of customized INDUSCHIP micro array i.e. INDUSCHIP v2 was quite efficient in imputation at HD level, hence can be effectively used for genotyping and subsequent analysis. However, with the passage of time, as more and more number animals of different breeds spread across the country are genotyped and incorporated in reference population, it would be possible to improve its imputation efficiency further through expanding reference population and incorporating more informative SNPs for the Indian cattle population in future versions of INDUSCHIP micro array. Further, it may also lead to development of low density (LD) microarray with around 10000

informative SNPs and make genotyping facility available to the common dairy farmers at affordable cost.

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RESEARCH ARTICLE

# Effect of area specific mineral mixture supplementation on milk production, biochemical and blood mineral status of Black Bengal goats

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**Abstract:** This study was conducted to find out the effect of area-specific mineral mixture (ASMM) supplementation on production performances, the biochemical and mineral profile of Black Bengal does during the peripartum period. For this purpose, 20 pregnant does were made into two groups according to the bodyweight viz., Control-T<sub>0</sub> (n=10) and Treatment-T<sub>1</sub> (n=10) and supplemented with 0 and 6 g of ASMM/animal/day, respectively starting from 3 months before the expected date of parturition to till the onset of the first post-partum estrus. Overall mean milk fat, total ash, total solids, solids not fat, milk crude protein and milk yield, blood glucose, non-esterified fatty acids,  $\alpha$ -amino nitrogen, phosphorus and serum glutamic pyruvic transaminase concentration were not affected by ASMM supplementation. The overall mean of serum glutamic oxaloacetic transaminase, calcium, copper, and zinc concentration in control (T<sub>0</sub>) and treatment (T<sub>1</sub>) groups were 127.05±1.27 vs. 132.73±1.26 IU/L, 7.83±0.08 vs. 8.19±0.08 mg/dl, 0.66±0.02 vs. 0.94±0.02 ppm, 0.69±0.01 vs. 0.97 ± 0.02 ppm, respectively and the values were higher in supplemented groups. More studies need to be conducted involving the use of ASMM supplementation to see its effect on the performance of goats.

**Keywords:** Area-specific mineral mixture, Biochemical, Goat, Minerals, Milk parameters

## Introduction

Goats (*Capra hircus*) are reared by farmers for purposes like meat, milk, hides, hair and dung. Black Bengal (*Capra hircus bengalensis*) breed of goat is mostly reared in the eastern and north-eastern region of India. Black Bengal goat is a smaller in body size but highly prolific and meat-type breed of goat and it has many desirable productive traits like early sexual maturity i.e. 6-8 months of age. Nutritional status affects the production potential and reproductive performance of farm animals. More often goats are generally malnourished, particularly with regards to micronutrients. There are twenty-two mineral elements which are very much essential for the health and production of animals (Sharma et al. 2009). Micro-minerals supplementation is required as most of the roughages, greens, concentrates are deficient in trace mineral elements. Ghosh et al. (2013) reported six minerals namely Ca, P, Zn, Cu Co, Mn are deficient in lower Gangetic part of West Bengal. But till now, the impacts of area specific mineral mixture (ASMM) on production performance of Black Bengal goat have not been studied. Concept of the area a specific mineral mixture is a new approach of low input and high output for the end-users. There is an abundant opportunity for exploiting the idea of ASMM for adjusting the deficiency of minerals to obtain the optimal production potential of animals to improve the economy of farmers.

## Materials and Methods

### Experimental animals

This study was approved by the Institutional Ethics Committee of ICAR-National Dairy Research Institute, India. Twenty numbers of Black Bengal does of 1<sup>st</sup> parity maintained at ERS-IVRI, Kalyani farm was selected and divided randomly into 2 groups of 10 animals each based on their body weight viz., control (T<sub>0</sub>) and treatment (T<sub>1</sub>). Control animals were managed under complete grazing with supplementation of concentrate @300 g/head/day starting from three months before parturition until the appearance of the first post-partum estrus. The animals in the treatment group were fed the same diets as in control group except supplemented with ASMM @ 6 g/head/day. This area

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specific mineral mixture was prepared (Table 1) as per Ghosh et al. (2013).

### Chemical analysis of feeds

Proximate composition of feeds and fodders was analysed as per AOAC (2005) and cell wall constituents were estimated as per Van Soest et al. (1991). One g representative samples of feeds and fodders fed to goats were taken and tri-acid digestion ( $\text{HNO}_3$ :  $\text{HClO}_4$ :  $\text{H}_2\text{SO}_4$  in ratio 3: 2: 1) was done for 1 to 2 h until the solution was clear. The samples were filtered with Whatman 42 filter paper. Then, a sufficient amount of deionized water was added to make the final volume up to 100 ml and samples were analysed by using AAS (Agilent-200 model). Plasma minerals were also analysed.

### Analysis of blood parameters

Blood samples were collected at the weekly intervals from the jugular vein into heparinised tubes (20 IU heparin/ml of blood) and centrifuged at 3000 rpm for 30 min at 4°C and plasma was separated and kept in the labelled storage vials of 5 ml capacity and stored at -20°C till analysis. For determination of plasma NEFA, copper soap extraction methods modified by Shipe et al. (1980) was followed. Blood  $\alpha$ -amino nitrogen concentration was estimated as per Goodwin (1970). Blood glucose was estimated using commercially available glucose test kit (GOD-POD Method, Span Cogent Diagnostics Ltd., India Product no# 93DP100-74). Alanine amino transaminase (ALT) and aspartate aminotransferase (AST) were estimated by 2, 4-DNPH (Reitman and Frankel Method) using a commercial kit (Span Diagnostics Ltd., India). Blood calcium was estimated using a commercially available calcium kit (Span Diagnostics Ltd., India; product no. 87L S100-60).

### Estimation of milk composition

Milk samples were collected on day3 after parturition and then fortnightly till first postpartum heat. Complete milking was done, milk was collected aseptically in the clean and sterile sampling bottles. The milking was done in the morning and evening on the days of sample collection to assess the milk production. 10 ml of milk sample was preserved separately for total protein estimation while, the remaining portion was used for fat, solid-not fat, total solids and ash estimation.

Milk fat was estimated as per Gerber, (1892), the fat percentage was read directly by especially a calibrated butyrometer. For the estimation of milk total solids, 10 g of milk sample was taken in pre-weighted silica crucible placed at 80°C in the hot air oven for overnight. Next day sample with crucible was weighed. Total solids and SNF contents were estimated by the difference. For estimation of milk total ash dry sample with silica, crucible was ashed at 550°C in a muffle furnace for 3 h and total ash was estimated by the difference in weight after ashing of dried sample.

The total nitrogen was estimated (AOAC 2005). Total nitrogen content was multiplied by 6.38 to get milk protein value.

### Statistical analysis

Different statistical designs were considered to the analysis of data as per Snedecor and Cochran (1994) and analysis was carried out through the SPSS v16.

## Results and Discussion

### Mineral status of feeds

The average concentration of calcium (Ca), phosphorus (P) copper (Cu) and zinc (Zn) in green fodder were 0.25%,0.38%,7.98 ppm, and 44.46 ppm, respectively with corresponding values of 0.25%,0.24%,7.53 ppm, and 38.75 ppm, in concentrate mixture (Table 2). The fodders were deficient in P. The lower P level could be attributed to low pH of the soil (Singh et al. 2011) and the ionic acidity of soil might be induced the formation of a complex with iron and thereby lowered the availability of inorganic P. The critical concentration of Zn for feeds and fodder is 30 ppm (McDowell et al. 1983). Panda et al. (2016) reported content of Mn, Cu and Zn in different feed and fodder varied between 17.14-54.29, 4.55-38.90 and 17.51-47.78 ppm, respectively in the western undulating region of Orissa. Das et al. (2003) reported the feed and fodder available for animal feeds in hill zone region West Bengal were a good source of Cu (17.97-38.73 ppm) moderate source of Ca (0.26-89%) and Zn (31.91-57-35 ppm) and a poor source of P (0.14-17%). Samanta and Samanta (2002) studied in the coastal saline zone of West Bengal and noticed, the available feeds and fodder were sufficient in Ca, Cu and Zn but deficient in P concentration. Similar findings have been reported earlier from the north-eastern part of India (Chander Datt and Aruna Chhabra 2005, Hegde et al. 2016, 2018).

### Effect of the area-specific mineral mixture (ASMM) on milk yield and composition

The milk yield and composition were similar in two groups indicating that ASMM supplementation has no significant effect on these variables Table 3. Singh et al. (2016), Wu et al. (2000), Sharma et al. (2002), Rabiee et al. (2010) and Begum et al. (2010) reported non-significant ( $P>0.05$ ) effect of feeding ASMM on milk components such as protein, fat and SNF of milk on. This

**Table 1** Mineral composition of area specific mineral mixture

Minerals	Quantity (g)
Calcium	25.96
Phosphorus	20.08
Zinc	0.529
Copper	0.258
Cobalt	0.027
Manganese	0.011

**Table 2** Chemical composition (% DM basis) and mineral status of concentrate and green fodder

Attributes	Concentrate mixture	Green fodder
Dry matter (%)	93.9±0.12	17.13±2.33
Organic matter (%)	93.72±0.07	86.81±0.63
Crude protein (%)	18.94±0.60	12.82±1.73
Ether extract (%)	4.51±0.10	2.66±0.27
Total ash (%)	6.28±0.07	12.92±0.62
Acid Insoluble ash (%)	1.77±0.06	3.36±0.28
Neutral detergent fiber (%)	32.54±1.67	57.6±5.65
Acid detergent fiber (%)	11.20±1.98	35.91±4.08
Calcium (%)	0.25	0.25
Phosphorus (%)	0.24	0.38
Copper (ppm)	7.53	7.98
Zinc (ppm)	38.75	44.46

**Table 3** Effect of ASMM on milk yield and milk composition

Attributes	Control (T <sub>0</sub> )	Treatment (T <sub>1</sub> )	P
Milk fat (%)	5.74±0.03	5.86±0.04	>0.05
Total solids (%)	15.16±0.19	15.23±0.15	>0.05
Total ash (%)	0.78±0.01	0.80±0.01	>0.05
Solid not fat (%)	8.64±0.02	8.71±0.03	>0.05
Crude protein (%)	3.63±0.04	3.67±0.05	>0.05
Milk yield (g/day)	281.49±19.91	312.43±16.20	>0.05

finding also supported by Singh et al. (2016), Tiwari et al. (2013), Sahoo et al. (2017) and Nocek et al. (2006) who found the non-significant difference improvement in overall milk yields of control and area specific mineral mixture supplemented group. Singh et al. (2020) reported after introducing (50g) mineral mixture in the feed, average milk yield, fat and SNF content increased by 6.2, 5.3 and 1.8%, respectively, while milk yield increased by 0.49 L/day/animal.

#### Effect of ASMM on blood parameters

Non-esterified fatty acids (NEFA) and  $\alpha$ -amino nitrogen (AAN) values differed non-significantly ( $P < 0.05$ ; Table 4) among groups at different time intervals. NEFA is produced due to the adipose tissue breakdown of fat in response to negative energy status. These circulating NEFAs are absorbed and metabolized for energy. The concentration of NEFA directly reflects the amount of adipose tissue breakdown. Clinical experience suggests serum NEFA concentrations are more sensitive to energy balance changes compared with body condition scoring in growing situations (Van Saun, 2000). Blood  $\alpha$ -amino nitrogen indicates protein synthesis status of the animal, but here, the results indicate sufficient protein ration was provided in both groups. Hornick et al. (1996, 1998) reported plasma  $\alpha$ -amino nitrogen increases during growth. Mondal and Prakash (2003) reported plasma  $\alpha$ -amino nitrogen concentration increases, as the buffalo's age increases. Godara et al. (2015) reported no significant difference ( $P > 0.05$ ) in AAN levels between treatment and control

group when supplemented with an area specific mineral mixture in black Bengal goats.

Blood glucose level was also similar in both the control and ASMM supplemented groups. Similar to our result, Ashry et al. (2012) and Behera et al. (2012) reported that feeding mineral mixture did not have any significant effect on blood glucose concentration. Contrary to our result, Godara et al. (2015) reported a significant difference ( $P < 0.05$ ) in glucose levels between treatment and control group when supplemented with area specific mineral mixture in black Bengal goats.

#### Effect of area-specific mineral mixture on serum enzymes

The plasma ALT level was similar in two treatment groups, however, plasma AST level was higher ( $P < 0.05$ ; Table 4) group T1 but its concentration was within the normal value. Similar to our results, Godara et al. (2015) reported a significant difference ( $P < 0.05$ ) in AST levels between treatment and control group when supplemented with area specific mineral mixture in black Bengal goats. Sharma et al. (2011) and Exton (1980) also observed that AST and ALT level was higher in mineral supplemented group as compared with the control group. Pandey et al. (2018) and Chaudhary and Patel (2019) observed no significant change in on serum AST concentration due to supplementation of either commercial or ASMM.

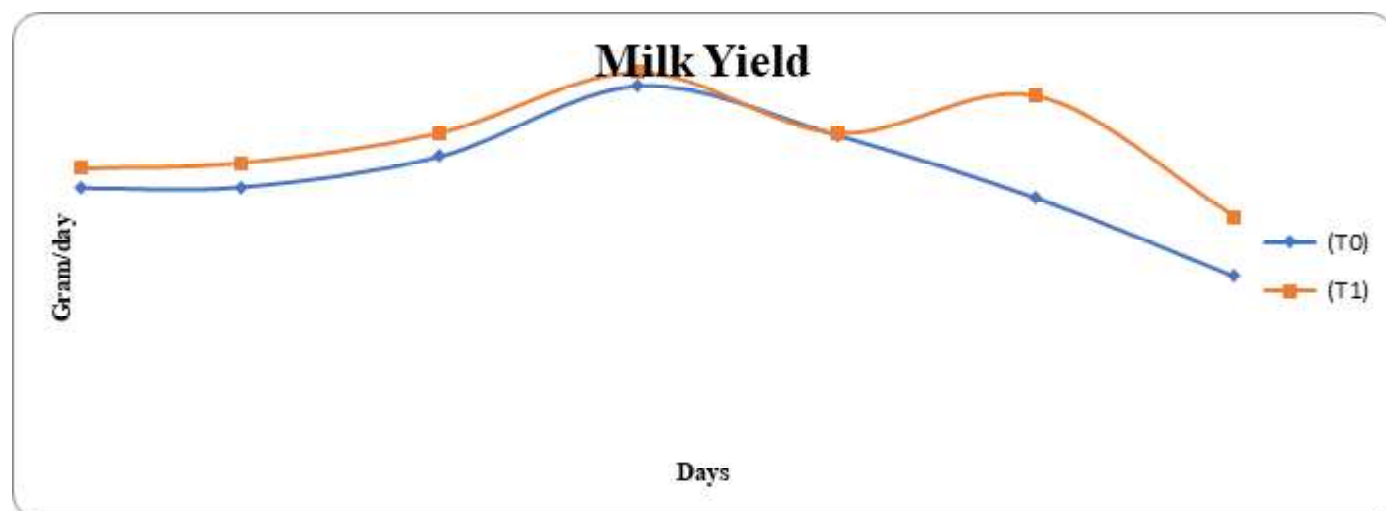


Fig. 1 Effect of ASSM on milk yield of Black Bengal does

Table 4 Effect of supplementation of ASSM on different blood parameters

Attributes	Control (T <sub>0</sub> )	Treatment (T <sub>1</sub> )	P
NEFA (μmol/L)	0.28±0.02	0.26±0.02	>0.05
α-amino nitrogen (mg/dl)	37.74±0.77	39.89±1.07	>0.05
Glucose (g/dl)	53.26±1.33	55.70±1.43	>0.05
ALT (IU/L)	29.73±0.74	30.92±0.55	>0.05
AST (IU/L)	127.05±1.27 <sup>b</sup>	132.73±1.26 <sup>a</sup>	<0.05
Calcium (mg/dL)	7.83±0.08 <sup>b</sup>	8.19±0.08 <sup>a</sup>	<0.05
Phosphorus (mg/dL)	4.72±0.17	4.96±0.21	>0.05
Copper (ppm)	0.66±0.02 <sup>b</sup>	0.94±0.02 <sup>a</sup>	<0.05
Zinc (ppm)	0.69±0.01 <sup>b</sup>	0.97±0.02 <sup>a</sup>	<0.05

a.b values bearing different superscripts in column differ significantly ( $P<0.05$ ) from each other

#### Effect of area-specific mineral mixture on plasma mineral profile

The overall mean value Ca was higher ( $P<0.05$ ) in the T1 group (Table 4). This might be because, vitamin D in the intestinal mucosa as 1, 25-dihydroxycholecalciferol acted by the opening of Ca channel and facilitates Ca uptake and transfer with the help of Ca binding protein (Hurwitz, 1990). Phosphorus concentration was found to be similar in both groups. The overall mean of copper (Cu) and zinc (Zn) differed significantly ( $P<0.05$ ; Table 4) between the groups due to supplementation of ASSM which contains these minerals. Similar results were supported by other workers (Upadhyay, 2004; Chaudhary and Patel 2019; Niaz et al. 2017; Agrawalla et al. 2017 and Samanta et al. 2005).

#### Conclusions

It is concluded that supplementation of area-specific mineral mixture significantly improved the Ca, Zn and Cu concentration in plasma of Black Bengal does. Though supplementation of ASSM did not have significant improvement in milk production and its composition, more studies need to be carried out to see

the effect of supplementation of the area-specific mineral mixture on the overall performance of goats.

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# Marketed surplus and milk marketing channels in Madhya Pradesh: Implications for dairy farmers and traders

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**Abstract:** The study has addressed the issue associated with the alternative milk market chains and their implications on dairy farmers and traders. The study was conducted by collecting data from 80 producer households along with 28 market intermediaries involved in the marketing of milk from producers to end consumers in the study area. The study revealed that the overall marketed surplus of milk in the study area was found to be 74.77 per cent and was highest for large category households. Out of the total marketed surplus, 79.78 per cent of milk was disposed of through unorganized sector while only 20.22 per cent was available to organized sector in the study area. Among the existing milk marketing agencies in the area, milk vendors were dominating and collecting a major share of raw milk from the producers. Among the various milk marketing channels involving intermediaries, producer's share in consumer's rupees as well as marketing efficiency, was found to be highest in channel-d! (producer-halwai-consumer) in the study area. The findings from the study suggest that producers should dispose of their milk through those channels in which minimum marketing agencies were involved and traditional milk sector should be addressed in a constructive manner due to their dominance in milk marketing in the state.

**Keywords:** Milk, Marketing agencies, Marketed surplus, Marketing efficiency

## Introduction

Milk production in India has been increased three-fold between 1970 and 2019 which represents a sustained growth for meeting the growing demand of milk, but the dominance of traditional marketing channels has not been affected. Marketing is as critical to better performance in dairying as dairy farming itself. The importance of marketing farm produces has been realized long ago. This fact has been supported by the report of the National Commission on Agriculture, 1976 which emphasized that it is not enough to produce a crop or an animal product but it must be satisfactorily marketed. Out of the total milk production in India, 48 per cent is consumed at the producer level while 52 per cent is available for non-producers. Out of this total marketed surplus, 40 per cent of the milk sold is handled by the organized sector while the remaining 60 per cent by the unorganized sector (GOI, 2018).

Madhya Pradesh is 3<sup>rd</sup> highest milk producing state (15.91 million tonnes) and ranks sixth in terms of per capita milk availability (538 g/cap/day) in India (NDDDB, 2019). Milch animals are owned by the farmers who are located in a widely dispersed rural area and this large group of scattered farmers cannot be covered by the milk co-operative societies. Consequently, traditional milk marketing is dominating in the state. A study carried out by Sharma (2012) in Malwa region of Madhya Pradesh reported that 80-85 per cent of the marketed surplus is disposed of through traditional milk marketing channels, while only 15-20 per cent is available to milk co-operatives in the area. These traditional and informal milk marketing chains often provide the main outlet for smallholder dairy producers and major source of fresh milk supply for consumers. They have been playing a pivotal role in linking growing demand among consumers with increased production from producers. The emergence of modern milk marketing chains is posing stiff competition for the existence of traditional milk market agents. However, the basic structure of milk production and marketing is not likely to change significantly in the near future and therefore, the dominance of traditional milk market

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chains will continue to persist in spite of the rapid growth of the organized and formal milk marketing chains.

Keeping the above points into consideration, the present study was undertaken to determine the marketed surplus of milk and analyze the marketing efficiency of various milk marketing channels for disposal of milk in study area.

## Material and Methods

### Study area

Madhya Pradesh consists of 11 Agro-Climatic Zones, from which two zones, namely, Malwa (Western) and Kymore (Eastern) were purposively selected. Malwa region being very much advance in livestock farming, accounted for about 22.18 per cent of the bovine population of the state. It is having the largest crossbred (37.05 per cent) and buffalo (25.83 per cent) population of the state and contributes the highest share (23.18 per cent) to the states total milk production (GOI, 2019). On the other hand, the Kymore plateau is considered to be one of the backward regions in livestock farming in the state, contributing 8.17 per cent to the state's milk production. This region has the largest population of indigenous cattle (15.25 per cent) but their productivity was very low (0.5 to 1.5 litres/animal/day).

### Sampling

Multi-stage random sampling technique was adopted for the selection of districts, tehsils and villages. One district from each zone i.e., Dewas district from Malwa plateau and Panna district from Kymore plateau was selected randomly. One block from each district i.e., Khategaon block from Dewas district and Powai block from Panna district was randomly selected. From each block, two villages were randomly selected i.e., Kharda and Jiyagaon from khategaon while Bolai and Krishngarh from Powai. A predetermined sample of 80 milk producers, 10 milk vendors, 08 creameries, 05 halwais and 05 contractors were drawn randomly from the four villages.

### Selection of sample households

A predetermined sample of 80 producer households was drawn randomly from all four villages. The selected households were post stratified into three categories based on milch animals viz., small (1.39-2.94 SAU), medium (2.95-4.70 SAU) and large (4.71-8.95 SAU) using Cumulative Square Root Frequency Method. Thus, the 80 households were distributed as 42 (52.50 per cent) in small herd size category, 26 (32.50 per cent) in medium and 12 (15 per cent) in large herd size category.

### Selection of milk marketing agencies

Both the organized (modern) and unorganized (traditional) sectors of milk marketing were functioning in the districts. The description of the milk marketing agencies is given below:

#### *Milk vendors*

A milk vendor collects milk from milk producers and sells it to the consumers or to the other milk marketing functionaries.

#### *Creameries*

They collect milk from milk producers and sell it to the direct consumer in the form of raw milk or milk products.

#### *Contractors*

Milk contractor collects milk from milk vendor or other milk marketing agencies and sells it to the customers as per the demand.

#### *Halwais*

Halwai collects the milk from either producer directly or from different milk marketing agencies and sell it to the consumers in the form of milk or milk products like sweets.

The information was collected by personal interview from the above intermediaries on average quantities of milk purchased by them each day from the producers at various prices and sold either to the consumers or the contractors at different prices. Information was also collected on various aspects like investment on vehicle and types of equipments along with their expected life, fuel cost, labour cost and other miscellaneous cost, time spent in milk collection, distance travelled by them per day for milk collection and distribution etc.

### Analytical framework

#### Marketed surplus

Marketed surplus is that part of the produce which is brought to the market for sale by the producer after retaining some quantity for his family consumption. The total milk produced by all the milch animals in the sampled unit was reckoned as milk production for that unit. The quantity of milk which is retained by the sampled unit for consumption as liquid milk or by conversion into different products has been taken as its total consumption, while the quantity of milk and milk products which is left over after meeting his consumption need will be available for marketing which is called marketed surplus of that sampled unit.

Marketed surplus of milk = Total milk production – Total milk consumption

### Disposal pattern of marketed surplus of milk

The disposal of milk consists of the retention of liquid milk and conversion of milk into different milk products at the household level and the remaining part out of total milk production that is available for sale as liquid milk in the market.

The information regarding the quantity of milk consumed at home and the agency to whom the milk was sold, i.e., co-operative societies, private dairies, milk vendor, processor or directly to the consumer along with average price realized were collected and analyzed for different categories of households.

### Marketing efficiency of milk marketing channel

It involves the mapping of various agencies involved in the production and consumption of milk and milk products in the study area. They can be categorized into direct and indirect channels. In direct channel, milk and milk products are directly sold to consumers, while indirect channel involves a number of intermediaries to make available milk and milk products to the end consumers.

### Cost components of milk marketing agencies

The expenditure on various items was classified according to their fixed and variable expenditure.

**Fixed cost:** Fixed costs include interest on fixed capital and depreciation on vehicles and equipments. Cost of durable assets (depreciation) can be accounted for by using the Capital Recovery Cost (CRC) Method.

The CRC method is defined as the annual payment that will repay the cost of fixed input over the useful life of input and provide an economic rate of return on investment. The interest on fixed capital does not need to be accounted separately when CRC approach is followed.

The formula for estimation of CRC is:

$$R = Z \left[ \frac{\{(1+r)^n \times r\}}{\{(1+r)^n - 1\}} \right]$$

Where,

- R= Capital recovery cost
- Z= Initial value of the capital asset
- r = Current interest rate
- n = Useful life of the assets/animals

**Variable cost:** it consists of:

### Raw milk cost

To estimate the raw milk cost, the quantity of raw milk purchased by each agency was multiplied by their prices paid.

### Fuel cost

Fuel cost included expenses on petrol for the vehicle, wood and match box.

### Electricity cost

Electricity was used for running electric equipments like fan, light, refrigerator, etc.

### Labour used in business

Wage prevailing in the area was taken as labour cost and calculated by taking into consideration the time spent on different activities of milk marketing.

### Miscellaneous cost

Miscellaneous cost included the cost of repair of equipments and vehicles, cost of gunny bags, cost of chemicals used for making milk products, cost of small glassware etc.

### Marketing efficiency

For calculation of marketing efficiency, information on milk marketing channels, cost and returns of various marketing agencies, producers' share in consumer rupees and price spread was collected and analyzed using the method suggested by Acharya and Agrawal (2009).

### Price spread

The economic efficiency of marketing system is generally measured in terms of the price spread of an agricultural commodity. The smaller the price spread; the greater will be the efficiency of a marketing system.

$$P_s = P_c - P_f$$

Where,

- $P_s$  = Price Spread
- $P_c$  = Consumer's Price
- $P_f$  = Producer's Price

### Producer's share in consumer's rupee

It is the price received by the farmers and expressed as a percentage of the price paid by the consumer.

$$P_s = \frac{P_f}{P_c} \times 100$$

Where,

$P_s$  = Producer's share in consumer's rupee  
 $P_f$  = Producer's price  
 $P_c$  = Consumer's Price

### Marketing efficiency

Marketing efficiency was calculated by using formula as given below.

$$\text{MME} = \frac{\text{FP}}{\text{MC} + \text{MM}}$$

Where,

MME = Modified measure of marketing efficiency

FP = Price received by the producer

MC = Marketing Cost

MM = Marketing margins

## Results and Discussion

### Marketed surplus of milk

The average production and marketed surplus of milk per day was worked out for different categories of households and are presented in the Table 1.

As evident from the Table 1 that the overall average milk production was 9.85 litres per day which varied from 5.73 litres in case of small category to 20.04 litres in case of large category households. A perusal at the table indicates that consumption had direct relation with the family size i.e., consumption was increasing with the increase in family size. The overall average marketed surplus was 7.36 litres per day which is highest for large category (16.33 litres/day) followed by medium category. The overall proportion of marketed surplus of milk to total milk was 74.77 per cent and was highest for large category households i.e., 81.50 per cent followed by medium (75.88 per cent) and small category households (66.65 per cent). Both in relative as well as in absolute terms, production and marketed surplus increased with the increase in the herd size implying positive relationship between production and marketed surplus of milk. These findings are similar to that reported by many authors (Yogi et al. 2007; Sharma, 2012; Meena and Tiwari, 2015).

### Disposal pattern of marketed surplus of milk

It was observed that both organized and unorganized agencies were operational in the study area. The organized sector consists of milk co-operative societies while unorganized sector mainly comprises of milk vendors, creameries, halwais, consumers etc.

The study revealed that out of the total marketed surplus of milk i.e., 589 litres, large proportion of milk was disposed of through the unorganized sector (79.78 per cent) while only 20.22 per cent was sold through organized sector. Among the various intermediaries present in unorganized sector, 34.18 per cent and

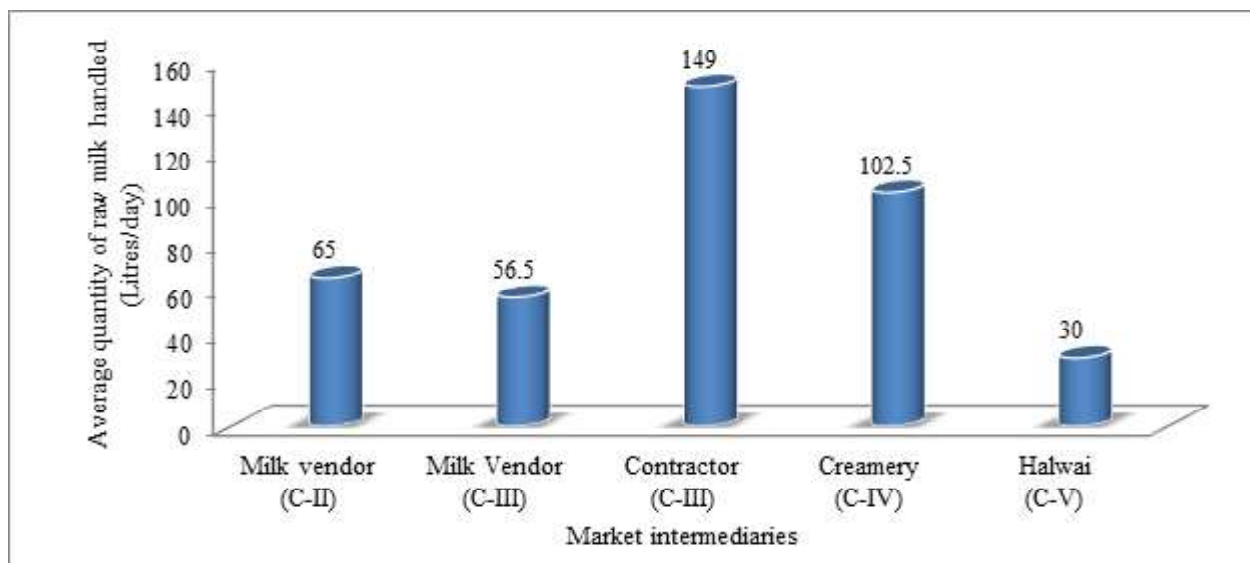
**Table 1** Average milk production, consumption and marketed surplus of milk across the herd size category

Particulars	Small	Medium	Large	Overall
Average milk production (litres/day)	5.73	11.80	20.04	9.85
Family size (No.)	6.43	6.72	7.01	6.62
Average milk consumption (litres/day)	1.92	2.85	3.67	2.48
Average marketed surplus (litres/day)	3.82	8.95	16.33	7.36
Marketed surplus as percent of total production	66.65	75.88	81.50	74.77

**Table 2.** Disposal of milk to different milk marketing agencies across herd size category (Litres/day)

Sl. No.	Milk marketing channels	Small	Medium	Large	Overall
I	Unorganized sector				
1	Directly to consumers (C-I)	10.95(6.83)	18.20(7.82)	10.28(5.24)	39.43(6.69)
2	Milk vendor (C-II)	56.18(35.02)	79.65(34.22)	65.55(33.44)	201.38(34.18)
3	Milk vendor (C-III)	30.17(18.81)	40.37(17.34)	31.67(16.16)	102.21(17.35)
4	Creamery (C-IV)	25.14(15.67)	32.41(13.92)	47.66(24.32)	105.21(17.86)
5	Halwai (C-V)	8.72(5.44)	7.28(3.13)	5.79(2.95)	21.79(3.70)
	Total	131.16(81.77)	177.91(76.44)	160.95(82.12)	470.02(79.78)
II	Organized sector				
1	Milk cooperative societies	29.24(18.23)	54.84(23.56)	35.05(17.88)	119.13(20.22)
	Overall Total	160.40(100.00)	232.75(100.00)	196.00(100.00)	589.15(100.00)

Figures in parentheses indicate percentage to the overall total



**Fig. 1** Average quantity of raw milk handled by various market intermediaries

17.35 per cent of the milk was disposed off through milk vendor who directly sell milk to consumers and to the contractor, respectively. About 6.69 per cent of the total milk marketed by producers was disposed off directly to consumers of the same area. Thus, milk vendors were found to be the dominating agency in procuring milk from producers in the study area. These findings are in accordance with Sharma (2012) in Malwa zone of Madhya Pradesh. The co-operatives were getting their highest proportion of marketed surplus of milk from medium category households (23.56 per cent) in both relative and absolute terms followed by small category. The possible reason for channelizing higher proportion of milk by medium and small farmers towards cooperative societies may be due to better price, input supply like cattle feed, fodder and veterinary care etc. The requirement of halwais in the area was less and therefore mainly fulfilled by small and medium farmers.

**Marketing efficiency of different milk marketing channels**

An efficient marketing system is an effective agent of change and an important means of raising the income level of the producer farmers vis-a-vis level of consumer satisfaction. In the present study, a complete chain of traditional milk marketing has been studied right from the milk producers to the consumer as well as various intermediaries involved in marketing of milk in different channels in the study area. Traditional milk marketing in the present study refers to the informal sector, whereas the modern milk marketing is the concept referred to the formal sector.

**Milk marketing channels**

The marketing channels which were found to be active in the study area are:

1. Producer – Village Co-operative Societies – District Milk Union - Retailer - Consumer
2. Producer - Milk Vendor - Consumer
3. Producer - Milk Vendor - Contractor – Consumer
4. Producer - Creameries - Consumer
5. Producer - Halwai - Consumer
6. Producer – Consumer

In the study area, mainly six channels were found working. But, the investment pattern of intermediaries, cost and returns of marketing agencies and marketing efficiency was worked out only for the traditional milk marketing channels as they were having the dominant share in procuring milk sold by producers in the study area as confirmed by earlier study conducted by Sharma (2012) in Madhya Pradesh. Many other authors in different states also reported the same findings viz., (Singh, 2016; Singh, 2013; Yogi et al. 2007; Vedmurthy and Chauhan, 2005).

- Channel-I: Producer – Consumer
- Channel-II: Producer - Milk Vendor - Consumer
- Channel-III: Producer - Milk Vendor - Contractor – Consumer
- Channel-IV: Producer - Creameries - Consumer
- Channel-V: Producer - Halwai – Consumer

### Average quantity of raw milk handled

Marketing agencies who are interviewed for data collection were also collecting milk from other villages besides the sample households in the study area.

On an average, creameries in channel-IV handled 102.5 litres/day, milk vendor in channel-II handled 65 litres/day, milk vendor in channel-III handled 56.5 litres/day, halwais in channel-V handled 30 litres/day and contractor in channel-III handled the maximum amount of milk among all intermediaries i.e., 149 litres/day.

### Investment pattern of market intermediaries

Investment of any dairy business activities depends upon the scale of operation, initial or working capital, types of business (as milk vendor, milk contractors, creameries, halwais etc.), size of business, equipments used etc. Keeping these facts in view, marketing agencies decides their own investment pattern as per the scale of operation. Table 3 shows the average initial investment by the various marketing functionaries.

**Table 3** Average initial investments by marketing agencies (Rs. /Agency)

Sl. No.	Particulars	Investment on			Total
		Building	Vehicle	Equipment	
1	Milk vendor(Channel-II)	-	54,750(87.95)	7,800(12.05)	62,550(100.00)
2	Milk vendor(Channel-III)	-	49,666.67(89.09)	6,083.33(10.91)	55,750(100.00)
3	Contractor(Channel-III)	-	2,82,500(94.84)	15,375(5.16)	2,97,875(100.00)
4	Creameries(Channel-IV)	-	52,650(55.32)	42,525*(44.68)	95,175(100.00)
5	Halwai(Channel-V)	63,750(85.33)	8,875(11.88)	2,087.5(2.79)	74,712.5(100.00)

Figures in parentheses indicate percentage to row total \*furniture and refrigerator included

**Table 4** Costs incurred by different milk marketing agencies (Rs. /litres)

Particulars	Milk Vendor (C-II)	Milk Vendor (C-III)	Contractor (C-III)	Creameries (C-IV)	Halwai (C-V)
	Fixed cost				
CRC on building	-	-	-	-	0.70
CRC on vehicle	0.07	0.07	0.18	0.06	0.05
CRC on equipment	0.04	0.04	0.06	0.22	0.05
Total fixed cost	0.12	0.11	0.25	0.29	0.80
	Variable cost				
Milk cost	36.93	33.07	38.90	37.24	39.63
Fuel cost	2.22	1.53	3.10	2.85	2.54
Electricity cost	0.00	0.00	0.00	0.19	0.14
Labor cost	2.98	2.07	2.88	3.61	1.49
Miscellaneous cost	0.03	0.03	0.03	0.04	0.04
Total variable cost	42.15	36.70	44.92	43.94	43.84
Total Variable Cost excluding Milk Cost	5.23	3.63	6.02	6.69	4.21
Total marketing cost excluding milk cost	5.34	3.74	6.26	6.98	5.01
Total milk marketing cost	42.27	36.81	45.16	44.22	44.64
Consumer's price ( <sup>1</sup> /litre)	47.36	38.90	47.73	48.53	48.13
Margin or returns	5.09	2.09	2.57	4.30	3.49

**Investment in the business of Creameries**

Creameries collect raw milk from the milk producers and supply it to the end consumers. Out of total investment made by them, 55.32 per cent of it was made on vehicle while 44.68 per cent was incurred on equipments (Table 3). These results are in conformity with the similar study conducted by (Singh, 2013).

**Investment in the business of Halwais**

Halwais present in the study area used to collect milk from the producers and supply it either in raw form or in processed form to the consumers. On an average, they invest 85.33 per cent of their total investment on building while 11.88 per cent and 2.79 per cent was invested on vehicle and equipments.

**Cost and returns of milk marketing agencies**

Cost and returns depends on the types of marketing agencies involved in the marketing of milk. Table 4 indicates the cost and returns of various milk marketing agencies.

**Milk vendor**

Milk vendor in Channel-II handled on an average 65 litres of milk per day. They incurred total marketing cost of Rs. 5.34 per litre in channel-II. Out of the total marketing cost excluding milk cost, fixed and variable cost were observed to be 2.25 per cent and 97.75 per cent, respectively. They had spent total milk marketing cost including milk cost of Rs. 42.27 per litre and obtained returns of Rs. 5.09 per litre in channel-II (Table 4).

On the other hand, milk vendor in Channel-III handled incurred total marketing cost excluding milk cost to be of Rs. 3.74 per litres since they did not dispose-of milk directly to consumer. The share of variable cost was found to be highest (97.50 per cent). The returns to milk vendors in channel-III were found to be Rs. 2.09 per litre.

**Contractor**

They collect milk from milk vendor (Channel-III) and supply it to consumers. They incurred total marketing cost of Rs. 6.26 per litre of milk among which the variable cost has highest share i.e., 96.01 per cent. The margin of milk contractor was found to be 1 2.57 per litre in channel-III (Table 4).

**Creameries**

Almost all the creameries were running on rented shops in the study area. In channel-IV, they incurred total marketing cost of Rs. 6.98 per litre. Out of these, 4.15 per cent was worked out to be fixed cost while 95.85 per cent was variable cost. The returns of creameries were worked out to be Rs. 4.30 per litre (Table 4).

**Halwais**

Halwais had well established shops in the study area either on rent or owned. They incurred total marketing cost of Rs. 5.01 per litre of milk. Out of the total marketing cost, they incurred Rs. 0.80 per litre on fixed assets while variable cost was found to be Rs. 4.21 per litre. They had obtained returns of Rs.3.49 per litre in channel-d!

**Producer’s share in consumer’s rupee**

Table 5 indicates that in channel-I, producer was selling milk directly to the consumer so complete amount of consumer’s price was received by the producers. Hence, producer’s share in consumer’s rupee was 100 per cent. In channel-II, producer’s share was 77.96 per cent while milk vendor accounts for 22.04 per cent. In channel-III, the producer’s share in consumer’s rupee was lowest among all the channels i.e., 69.28 per cent. In channel-IV, producer was getting 76.75 per cent of the price paid by the consumer while creameries accounts for 23.25 per cent. Producer’s share was 82.34 per cent while halwai was having only 17.66 per cent of price paid by consumer in channel-d!. Hence, Producer’s share in consumer’s rupee was observed to be highest in case of channel-V (82.34 per cent) after the channel-I (100%).

**Table 5** Share of producer and various agencies in consumer’s price in different milk marketing channels

Agencies	Channel-I	Channel-II	Various Milk Channel-III	Marketing Channel-IV	Channel Channel-V
Producer’s share	40.52(100.00)	36.93(77.96)	33.07(69.28)	37.24(76.75)	39.63(82.34)
Milk vendor		10.44(22.04)			
Milk vendor			5.83(12.22)		
Contractor			8.83(18.50)		
Creameries				11.28(23.25)	
Halwai					8.50(17.66)
Consumer’s price (Rs.)	40.52 (100.00)	47.36 (100.00)	47.73 (100.00)	48.53 (100.00)	48.13 (100.00)

Figures in parentheses indicate percentage of consumer’s price (column total)

**Table 6** Marketing cost, marketing margin and price spread in different milk marketing channels

Particulars	Marketing		Channel		
	Channel-I	Channel-II	Channel-III	Channel-IV	Channel-V
Net receipt to producer	40.52	36.93	33.07	37.24	39.63
Marketing cost	-	5.34	10.00	6.98	5.01
Marketing margin	-	5.09	4.66	4.30	3.49
Consumer's price	40.52	47.36	47.73	48.53	48.13
Price spread	0	10.44	14.66	11.28	8.50

**Table 7** Marketing efficiency of different milk marketing channels

Channels	Marketing cost + marketing margin	Price received by producer	Marketing efficiency
Channel-I	-	40.52	-
Channel-II	10.44	36.93	3.54
Channel-III	14.66	33.07	2.25
Channel-IV	11.28	37.24	3.30
Channel-V	8.50	39.63	4.66

### Price spread

Table 6 reveals that the price spread was zero in channel-I as it was a direct channel (Producer-Consumer). Price spread was worked out to be lower in case of channel-V i.e., Rs. 8.50 in comparison to channel-a! (Rs. 10.44), channel-IV (Rs. 11.28) and channel-III (Rs. 14.68). Hence, channel-III is the least efficient channel in the study area. In channel-V, the marketing margin was also observed to be less than other channels except for channel-I which is a direct channel. Net receipt to producer is also higher in case of channel-V (Rs. 39.63) as compared to other milk marketing channels (Table 6). Hence, it can be said that milk sold through channel-V (Producer-Halwai-Consumer) which has the smallest price spread was more efficient as compared to other channels in the study area. This is in conformity with the similar findings of many authors (Singh, 2016; Singh, 2013; Yogi et al. 2007; Vedmurthy and Chauhan, 2005).

### Marketing efficiency

Marketing efficiency is essentially the degree of market performance. It can be harnessed to improve the quality of the masses by raising the income level of the farmers as well as consumers satisfaction.

Table 7 revealed that channel-V (4.66) is more efficient than channel-II (3.54) followed by channel-IV (3.30) and channel-III (2.25), respectively. These findings are in agreement with the findings of other authors (Yogi et al. 2007; Vedamurthy and Chauhan, 2005) which indicates that the channels with fewer intermediaries were more efficient.

The marketing efficiency was found to be consistent in the present study in case of channel-V. Halwais paid higher price to the producers in comparison to other market agencies along with

their lowest marketing cost and margin among all the agencies. Channel-II and channel-c! are efficient as compared to channel-III in the study area as they also provide better prices to producer as well as have lower marketing cost as compared to channel-II. In case of channel-III, two agencies were involved i.e. milk vendor and contractor, who collects milk from the producers and supply it to the end consumers. Because of more intermediaries, this channel showed less efficiency as they had higher margins and higher costs of marketing. In addition to this, they paid minimum price to the producers among all the agencies and therefore are less efficient which is found to be consistent with the similar study conducted by (Singh, 2016; Singh 2013).

### Conclusions

The current study indicates that marketed surplus of milk was found to be increasing with the increase in herd size and the traditional milk marketing channels were procuring the major proportion (75-80 per cent) of marketed surplus in the study area. The study suggests that the producers should dispose of their milk through those channels in which minimum marketing agencies were involved which ensure better returns to them along with reasonable price to the consumers. Dominance of traditional milk markets emphasized that they need to be addressed in a constructive manner and the policies should be evolved which would allow informal players to improve their performance including quality control and their integration with the emerging modern milk supply chains in the state. The quality gap can be addressed to a large extent by popularizing training and certification programs for small-scale milk traders and processors.

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## An economic analysis of milk production in Haryana

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**Abstract:** Dairying is an important supplementary enterprise enhancing the livelihood of farmers and hence analyzing its profitability as well as identification of production constraints paves way for policy implications. An attempt was made to determine the costs, returns and constraints involved in milk production at Karnal and Jind districts of Haryana state during 2019-20. Primary data was collected from 120 milk producing households and was subjected to tabular analysis and Garrett's ranking technique. The overall net maintenance cost per animal per day was highest in the case of crossbred cow, followed by buffalo and indigenous cow. The overall cost of milk production was highest for buffalo (Rs. 40.35/litre), followed by crossbred (32.48/litre) and indigenous cow (Rs. 31.88/litre). A major portion in the total variable cost was contributed by the feed and fodder, followed by labour. Net return realized per litre of milk was positive across animal categories, but it was highest in the case of crossbred cow owing to higher productivity as compared to buffalo and indigenous cow. Distant location of artificial insemination centres and high price of concentrates were identified as the major production constraints faced by the farmers. The study advocates for adoption of better scientific breeding and management practices, mobile services for quality semen delivery as well as providing feeds at subsidized price channelizing through Farmer Producer Organizations (FPOs).

**Keywords:** Cost and returns, Capital recovery cost, Garrett ranking, Standard animal units

### Introduction

Indian agriculture is predominantly a crop-livestock based production system and 70 per cent of the population is directly or indirectly engaged in agriculture. Due to pronounced adverse influence of vagaries of climate on crop production, dairy sector has been emerging as a stable source of livelihood and witnessing rapid strides in the recent past. Post launching of Operation Flood in 1970 and other dairy development programs, India emerged as the largest producer and consumer of dairy products in the world. Hence, dairy sector acts as a complementary enterprise to farming sector by providing employment as well as a stable source of income and nutritional requirement of family. Currently, the share of agriculture & allied sector in 'Gross Value Addition' (GVA) is 17.2 per cent, out of which livestock sector alone contributes 4.9 per cent to GVA (National Accounts Statistics, 2019-20). India's agrarian economy has experienced most significant changes over past three-and-half decades due to the extremely impressive performance of dairy sector and continuously rising contribution of livestock sector in the agricultural gross domestic product. The share of livestock in agricultural gross domestic product has risen from 17 per cent to 25.6 per cent between 1970 and 2019 (DAHD&F, 2018-19). India has retained the status of highest milk producer in the world, annual milk production being 187.7 million tonnes, with a per capita availability of 374 gram/day (NDDDB, 2018-19). The annual growth rate in milk production has been estimated around 6 per cent and India holds a share of around 19 per cent in global milk production (DAHD&F, 2018-19). Milk is the ultimate output having economic significance which brings returns to the milk producers. Hence, estimation of the cost and returns of milk production acts as an important economic indicator for assessing the level of profit of dairy enterprise at the producers' level. The objective of the present study is to analyze the costs and returns of milk production across herd size and compare among the breeds viz., indigenous & crossbred cows and buffaloes to know the relative profitability besides analyzing the break-even output (BEO). The analysis of various constraints faced by the dairy farmers can provide useful

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insights to policy makers for prioritizing the research and/or development agenda for dairy sector.

## Materials and Methods

### Selection of study area

Haryana possesses 2.5 per cent of country's total bovine population with growing annual milk production from 66.61 lakh tonnes in 2011-12 to 83.81 lakh tonnes in 2018-19 (Department of Animal Husbandry and Fishery, 2018-19). Haryana is among the top ten milk producing states in India, ranking second in terms of per capita per diem availability of milk (835 grams) against the national average of 374 grams (Department of Animal Husbandry and Fishery, 2018-19). Karnal and Jind districts, being in eastern zone, were selected randomly due to high average bovine density, best breeds of animals, high quality feed management, burgeoning dairy sector as well as existence of both organized and unorganized dairy marketing sectors. Two villages from each district were selected randomly for the study.

### Collection of data

A sample of 120 milk producer households was randomly selected for the study. The primary data was collected from the sample households using conventional survey method & well-structured schedule through personal interview. The data pertaining to socio-economic and demographic particulars of households namely, age, education, family composition, occupation, operational land holding, type of livestock, investment on livestock, machinery and equipments, value of feed, fodder and other miscellaneous expenses, milk production and prices of inputs & outputs *etc.* were collected from the sample respondents. The data obtained from the milk producers were post stratified in to small (2-8 milch animals), medium (9-16 milch animals) and large (17-36 milch animals) herd size categories using the cumulative square root frequency technique with milch animal as the basis of classification. Thus, total 120 producer households were classified as 49 small, 55 medium and 16 large herd sized category households.

### Analytical framework

In order to accomplish the objectives of the study, the data collected from the milk producers were scrutinized, tabulated and analyzed utilizing various analytical tool. Tabular analysis was applied to work out the costs and returns from milk production and Garrett ranking approach was followed for identifying the major constraints faced by the farmers during milk production.

### Cost of milk production

The costs and returns of milk production are important indicators of profitable dairy farming. The total costs involved in milk production comprise fixed costs and variable costs. For estimation

of different costs and return, the following methodology was followed.

### Fixed costs

Fixed costs (FC) are the expenditure incurred by the producer irrespective of the level of production. They don't vary with the output and remain unchanged in the short-run. Various components of fixed costs include depreciation and interest on fixed capital. Capital Recovery Cost (CRC) method was used for estimation of fixed cost. Another fixed cost item *i.e.* interest on fixed capital was not estimated separately as CRC approach was followed.

### Depreciation cost

Depreciation is defined as reduction in the value of fixed assets due to wear and tear, over time, accidental damage and technological obsolescence. Annual depreciation on animals, buildings, machinery and equipments used in dairy farming was included for calculation using CRC method.

The formula for estimation of CRC is given by:

$$R = Z \left[ \frac{(1+r)^n r}{(1+r)^n - 1} \right]$$

Where, **R** is the capital recovery cost, **Z** is the initial value of the capital asset, **r** is the interest rate and **n** is the useful life of the assets.

When the assets were purchased from borrowed capital the actual interest rate charged by the bank was taken as 'r', while in case of owned funds, the rate of interest on term deposit of 1-5 years was taken. The depreciation of milch animals was taken as 10 per cent, 8 per cent and 10 per cent for local cows, crossbred and buffalo with a productive life of 10, 12.5 and 10 years, respectively. The total CRC was then apportioned into individual animal in accordance with Standard Animal Units (SAUs)

### Variable Costs

Variable costs are those costs which are incurred on the variable factors of production. Variable cost items include feed and fodder cost, labour cost, veterinary and miscellaneous expenses. Data on variable expenses were collected from the farmers and annual expenditures were converted to daily expenses. Subsequently, it has been apportioned into standard animal units (SAUs) for standardization followed by comparison.

### Feed and fodder cost

It includes costs of green fodder, dry fodder, concentrates and mineral mixture fed to animals. The cost was estimated as a product of quantity of certain feed/fodder fed to animals and the purchase

price of respective feed. In case of home grown feed/fodder, their farm harvest prices were considered. Where farm harvest prices were not available, imputed value of crop was taken into account as the prevailing price of standing crop in the locality. For calculating cost of the concentrate feed which was prepared at home, weighted prices of ingredients *i.e.* share of each component in the concentrate composition was taken into account. When animal feeds were grass and tree leaves collected from common property resources, its imputed value was accounted for estimation of the feed and fodder cost.

### Labour cost

The information regarding labour requirements for various farm operations and labour cost were collected during the personal interview from the farmers. Labour cost comprises both family labour and hired labour. The cost of hired labour was calculated considering type of work allotted and wages paid, whereas, family labour costs were arrived at on the basis of existing wage rate of permanent farm labour.

### Veterinary and miscellaneous expenses

Veterinary expenses included medicines, doctors' fees, vaccination charges as well as natural and artificial insemination charges. Miscellaneous expenditure included electricity, water charges, expenses on repairing fixed assets, and other related expenses.

### Standard Animal Units (SAUs)

Among the various cost items discussed, the producer incurs certain expenses for the entire herd on the farm. Fixed assets like cattle shed, feed manger, chaff cutter, milk cans and buckets etc. are used collectively by the farmer for all the cattle irrespective of their age and sex. Therefore, for assigning the joint expenditures into per animal basis considering the difference in the regional endowments, age of the animals and animal species as these have different effect on cost structure, the entire herd was converted into SAUs following Sirohi et al. (2015) for the northern region. The standard animal unit for the study area *i.e.* Northern region is given in Table 1.

### Other Cost Concepts

#### Gross Cost

It is the total cost incurred by the producer which was estimated by adding all the cost components including fixed and variable costs.

Gross Cost = Total Fixed Cost + Total Variable Cost

**Net Cost:** The net cost was estimated by deducting the imputed income earned through dung, from the gross cost.

Net Cost = Gross Cost – Value of the Dung

### Cost of milk production

In order to estimate the cost per litre of milk, the net cost per animal per day was divided by average milk of animal per day.

$$\text{Cost per litre of milk (₹/lit)} = \frac{\text{Net Cost Per Animal}}{\text{Avg. Milkyield of animal}}$$

### Gross Returns

Gross returns were obtained by multiplying milk yield of an individual animal with respective prevailing prices in the study area.

Gross Returns: (Milk produced/household /day) \* Price of Milk

### Net Returns

Net return was computed by subtracting net cost from gross returns.

Net Returns = Gross Returns - Net Cost

### Price of Milk

The price of milk differs for different type of milk, *i.e.* buffalo, crossbred cow and local cow milk. Weighted average price of milk was calculated for each household by using the following formula.

$$\text{Weighted Average Price} = \frac{\sum P_i W_i}{\sum W_i}$$

Where,

$P_i$  is price per litre of the  $i^{\text{th}}$  type of milk

$W_i$  is total quantity of  $i^{\text{th}}$  type of milk sold by the household

### Break-even output

Break-even output (BEO) of milk production indicates the quantity of milk a farmer needs to sell to reach at the break-even point *i.e.* point of no profit and no loss. BEO of milk was calculated using the following formula:

$$\text{BEO} = F / (P - V)$$

Where F is the total fixed cost for the product, P is the price per unit of the product and V is the average variable cost of the product (Venkatesh et al. 2012).

### Identification of production constraints

Garrett's ranking technique is widely used to rank the responses collected through survey (Balaganesh and Kumari, 2017; Sendhil et al. 2013). Based on the primary data collected from the sample households, Garrett's ranking technique was used to analyze the constraints faced by the dairy farmers during milk production system. The constraints identified based on literature review were non-remunerative price of milk, low availability of green fodder, high cost of feed, poor quality of concentrates, distance location of semen collection centres, irregularity in payment, non-availability of subsidiary feed, lack of quality inputs and high transportation charges in procurement of inputs (Khoweio et al. 2012). The farmers were asked to rank the factors which were identified as limiting factors for livestock production. These orders of merit were transformed into units of scores by using the following formula.

$$\text{Percentposition} = \frac{100(R_{ij} - 0.50)}{N_j}$$

Where,

$R_{ij}$  is the rank for the  $i^{\text{th}}$  factor by the  $j^{\text{th}}$  individual.

$N_j$  is the number of factor ranked by the  $j^{\text{th}}$  individual.

The per cent position of each rank was converted into scores by referring to the table given by Garrett and Woodworth (1969). Then for each factor the scores of the individual respondents were added together and divided by the total number of respondents for whom scores were added. These mean scores for all the factors were arranged in descending order and the most influencing factors were identified through the ranks assigned.

## Results and Discussion

Analysis of costs and returns of milk production of different category of milch animal is considered to be an important aspect of dairy enterprise as it reflects the productivity and profitability of the enterprise. The results of the study are presented and discussed as follows.

### Costs and returns of milk production from indigenous cows

The overall gross maintenance cost of indigenous cows was estimated to be Rs. 123.76 per day per cow which varied from 108.13 per day for small herd size category to Rs 139.46 per day for large size category (Table 2). The overall total fixed cost was estimated to be Rs. 14.78 per day which contributed for about 11.94 per cent of overall gross cost. The overall total variable cost was found to be Rs. 108.98 per animal per day which estimated to be Rs. 96.34, Rs. 109.11 and Rs. 121.48 for small, medium and large herd size category, respectively and it accounted for about 88.06 per cent of overall gross cost. From the above table, it is clear that the overall feed and fodder cost constituted a major share for about 76.25 per cent of gross cost, followed by labour

cost (8.35 %). The contribution of feed and fodder cost to the gross maintenance cost was highest as compared to other cost components attributed to the higher price of feed and feed fodder in the study region. The labourers were paid on monthly basis which varied from 8000 to 9000 per month *i.e.* around 250 to 300 rupees per day. So, when the labour cost was converted into per animal basis it came out to be very low. The dung value was observed to have an increasing trend across the herd size as the large farmers were selling dung to the nearby biogas plants with a reasonable price; while the small farmers were utilizing dung as fuel in the form of dung cake. The contribution of both fixed and variable costs to the gross cost are found to be in conformity with the earlier studies conducted by Singh and Datta (2016).

Overall cost of milk production per litre was estimated at Rs. 31.88. The per litre cost of milk production was found to decrease with increase in the herd size which might be attributed to economies of scale. The net return obtained from per litre milk in case of all the herd size categories was found to be mildly positive. The overall net return per litre of milk was worked out to be Rs. 1.28 and it varied from Rs. 1.79 for large herd size category to Rs. 1.30 for medium and Rs. 0.73 for small size category. The net return from milk production was found to vary positively with the herd size of the households.

Though the net return obtained in the case of indigenous cow was less as compared to crossbred and buffalo in the study area, but the farmers preferred to rear descript indigenous breeds due to their easy adaptability to local climate, low maintenance cost, high fat content but low productivity (Lal and Chandel, 2016). The result obtained regarding the cost and returns of milk production in case of indigenous cows was found to be in conformity with the earlier study conducted by Lal and Chandel (2016) and Athare et al. (2019). The break-even output (BEO) was found to be increasing across the herd size which varied from 3.61 litre per day in case of small herd size to 5.07 litre per day in case of large herd size category. The overall BEO was estimated to be 4.19 litre per day which was higher than the overall productivity of indigenous cow *i.e.* 3.68 litre per day.

### Costs and returns of milk production from crossbred cows

It can be seen from Table 3 that the overall gross maintenance cost of crossbred cows varied from Rs. 209.47 per day for small herd size category to Rs. 251.44 per day for large herd size category farmers and the overall gross maintenance cost was found to be Rs. 230.16 per day. The overall total fixed cost was estimated to be Rs. 32.08 per day which accounted for about 13.94 per cent of overall gross cost. The overall total variable cost was estimated to be Rs. 198.08 and share of total variable cost in the gross cost was found to be 86.06 per cent. The overall feed and fodder cost constituted a major portion of 71.48 per cent of the gross cost and it varied from Rs. 176.50 (70.19 %) per day in case of large herd size category to Rs. 152.00 (72.57%) per day for small herd

size category. Among the feed and fodder, the concentrates occupied a major share of 29.48 per cent in the gross cost, followed by dry fodder (25.35%) and green fodder (16.64%). This is due to the higher market price of the concentrates in the study area. The overall labour cost was estimated to be Rs.24.58 per day with a share of 10.68 per cent to the gross cost and it was found to be highest for large herd size category (11.16%) and lowest in case of small herd size category (10.03%). The results obtained regarding the per cent share of feed cost and labour cost to the gross maintenance cost was found to be on conformity with earlier research conducted by Lal and Chandel (2016), Vanishree et al. (2018) and Athare et al. (2019).

On the perusal of the cost of milk production, the overall cost of production was estimated to be Rs. 32.48 per litre of milk which varied from Rs. 33.37 for small herd size to Rs. 31.87 for the large herd size category. The cost of milk production was observed to be higher in crossbred cows as compared to indigenous cows due to the higher expenses on feed and fodder in case of crossbred cow. The per litre cost of milk production was found to vary negatively with the herd size. Hence, lowest cost of milk production per litre of milk was estimated in case of large herd size and highest in case of small herd size category due to the economics of scale in dairying. The result regarding the per litre cost of milk production was in accordance with earlier studies conducted by Lal and Chandel (2016) and Acharya and Malhotra (2020).

**Table 1** Standard animal units for Northern region of India

Animals	Indigenous cow	Crossbred cow	Buffalo
Adult male (≥ 3 years)	1.08	1.23	1.25
Adult female (≤ 3 years)	1.00	1.27	1.35
Young stock male (<1 year)	0.39	0.41	0.43
Young stock female (<1 year)	0.39	0.41	0.41
Young stock male (>1 year)	0.54	0.61	0.65
Young stock female (>1 year)	0.46	0.52	0.51
Heifer	0.73	0.78	0.79

**Table 2** Costs and returns of milk production of indigenous cows (Rs./animal/day)

Cost/Returns components	Herd size category			Overall
	Small	Medium	Large	
Total Fixed Cost (TFC)	11.79 (10.90)	14.58 (11.79)	17.98 (12.89)	14.78 (11.94)
Green fodder (F1)	22.08 (20.42)	25.71 (20.79)	26.04 (18.67)	24.61 (19.89)
Dry fodder (F2)	21.97 (20.32)	23.64 (19.11)	27.14 (19.46)	24.25 (19.59)
Concentrate (F3)	42.39 (39.21)	45.34 (36.66)	48.79 (34.99)	45.51 (36.77)
Feed and fodder cost (V1=F1+F2+F3)	86.45 (79.95)	94.69 (76.55)	101.97 (73.12)	94.37 (76.25)
Labour cost (V2)	5.89 (5.45)	10.29 (8.32)	14.82 (10.63)	10.33 (8.35)
Veterinary & Miscellaneous cost (V3)	4.00 (3.70)	4.13 (3.34)	4.69 (3.36)	4.28 (3.46)
Total Variable Cost (TVC=V1+V2+V3)	96.34 (89.10)	109.11 (88.21)	121.48 (87.11)	108.98 (88.06)
Gross Cost (A=TFC+TVC)	108.13 (100.00)	123.70 (100.00)	139.46 (100.00)	123.76 (100.00)
Value of Dung (B)	3.58	5.48	10.83	6.63
Net Cost (C=A-B)	104.55	118.22	128.62	117.13
Price of milk (Rs. /litre)	32.98	33.18	33.30	33.15
Average milk productivity (litre/animal/day) (E)	3.24	3.71	4.08	3.68
Gross Return (D)	106.92	123.05	135.95	121.97
Net Returns (D-C)	2.37	4.83	7.33	4.84
Cost of milk production (Rs /litre) (C/E)	32.25	31.88	31.50	31.88
Net Returns (Rs. /litre) (D/E)	0.73	1.30	1.79	1.28
Average Variable Cost (AVC = TVC/E)	29.72	29.42	29.75	29.63
Break even output (lit) ( TFC/ Price-AVC)	3.61	3.87	5.07	4.19

Figures in parentheses indicate the percentage of gross cost

The overall net return was estimated to be Rs.3.29 per litre of milk and it was found to be positive for all the categories of households. The net return per litre of milk was worked out to be Rs. 2.01, Rs.3.70 and Rs. 4.17 in case of small, medium and large herd size categories, respectively and the net returns from all the three categories of households were found to be varying positively with the herd size. Crossbred milk was basically sold to the milk vendors and dairy processing plants attributed to the higher price of crossbred milk as compared to the milk of indigenous cows which was mostly sold in the neighborhoods. Highest net return obtained in case of large herd size followed by medium and small herd size categories. The result obtained regarding the cost of production and net return per litre of milk was found to be similar with the study conducted by Kumari et al. (2016), Vanishree et al. (2018), Athare et al. (2019) and Acharya and Malhotra (2020). The overall yield obtained in case of crossbred cow was worked out to be 6.82 litre per day which was found to be much higher than the break-even output *i.e.* 4.76 litre per day.

### Costs and returns of milk production of buffaloes

The cost and return of milk production of buffalo is presented in Table 4. The overall gross cost for buffalo milk production was estimated at Rs. 226.58 per day which varied from Rs. 203.89 in

case of small herd size to Rs. 247.26 for large herd size category. The overall total fixed cost and total variable cost for milch buffalo was computed at Rs. 34.79 and Rs. 191.78 per day, respectively.

The share of total fixed cost and total variable cost to the overall gross maintenance cost was found to be 15.36 per cent and 84.64 per cent, respectively. The result obtained was in conformity with earlier studies conducted by Vanishree et al. (2018), Athare et al. (2019) and Acharya and Malhotra (2020). The contribution of overall feed and fodder cost to the gross cost was found to be 70.71 per cent, followed by overall labour cost (9.68%). Among the feed and fodder, the contribution of overall green fodder, dry fodder and concentrates to the gross cost was worked out to be 17.34 per cent, 24.79 per cent and 28.57 per cent, respectively. Highest cost share of concentrates was attributed to their high cost and lowest share of green fodders was due to their high productivity in the study area. Higher cost of production in case of buffaloes was the result of their higher quantity of feed intake as compared to indigenous and crossbred cows.

The overall cost of production per litre of milk was estimated to be Rs.40.35. The net return per litre of milk production was positive for all the herd size categories. The net return was found to be Rs. 1.82, Rs. 3.48 and Rs. 4.06 per litre of milk for small, medium and large herd size categories, respectively. The overall net return per litre of milk was worked out to be Rs. 3.12 which was lower

**Table 3** Costs and returns of milk production of crossbred cows (Rs. /animal/day)

Cost/Returns components	Herd size category			Overall
	Small	Medium	Large	
Total Fixed Cost (TFC)	28.76 (13.73)	31.63 (13.78)	35.85 (14.26)	32.08 (13.94)
Green fodder (F1)	35.15 (16.78)	38.94 (16.96)	40.84 (16.24)	38.31 (16.64)
Dry fodder (F2)	51.20 (24.44)	59.73 (26.02)	64.13 (25.51)	58.35 (25.35)
Concentrate (F3)	65.66 (31.35)	66.36 (28.91)	71.52 (28.45)	67.85 (29.48)
Feed and fodder cost (V1=F1+F2+F3)	152.00 (72.57)	165.04 (71.89)	176.50 (70.19)	164.51 (71.48)
Labour cost (V2)	21.00 (10.03)	24.66 (10.74)	28.07 (11.16)	24.58 (10.68)
Veterinary & Miscellaneous cost (V3)	7.71 (3.68)	8.23 (3.59)	11.03 (4.39)	8.99 (3.91)
Total Variable Cost (TVC=V1+V2+V3)	180.71 (86.27)	197.93 (86.22)	215.60 (85.74)	198.08 (86.06)
Gross Cost (A=TFC+TVC)	209.47 (100.00)	229.56 (100.00)	251.44 (100.00)	230.16 (100.00)
Value of Dung (B)	4.04	9.26	13.50	8.93
Net Cost (C=A-B)	205.43	220.31	237.94	221.22
Price of milk (Rs /litre)	35.38	35.91	36.04	35.78
Average milk productivity (litre/animal/day) (E)	6.16	6.84	7.47	6.82
Gross Return (D)	217.79	245.61	269.05	244.15
Net Returns (D-C)	12.36	25.30	31.11	22.93
Cost of milk production (Rs/litre) (C/E)	33.37	32.21	31.87	32.48
Net Returns (Rs /litre) (D/E)	2.01	3.70	4.17	3.29
Average Variable Cost (AVC = TVC/E)	29.35	28.94	28.88	29.04
Break even output (lit) ( TFC/ Price-AVC)	4.77	4.53	5.01	4.76

Figures in parentheses indicate the percentage of gross cost

**Table 4** Costs and returns of milk production of buffalos (Rs. /animal/day)

Cost/Returns components	Herd size category			Overall
	Small	Medium	Large	
Total Fixed Cost (TFC)	31.39 (15.40)	34.11 (14.92)	38.88(15.72)	34.79 (15.36)
Green fodder (F1)	36.81 (18.05)	39.35 (17.22)	41.73(16.88)	39.30 (17.34)
Dry fodder (F2)	50.52 (24.78)	57.19 (25.02)	60.78(24.58)	56.16 (24.79)
Concentrate (F3)	61.11 (29.97)	65.23 (28.54)	67.89 (27.46)	64.74 (28.57)
Feed and fodder cost (V1=F1+F2+F3)	148.45(72.81)	161.78 (70.77)	170.39(68.91)	160.21 (70.71)
labour cost (V2)	17.10 (8.39)	23.43 a (10.25)	25.27(10.22)	21.93 (9.68)
Veterinary & Miscellaneous cost (V3)	6.96 (3.41)	9.26 (4.05)	12.73 (5.15)	9.65 (4.26)
Total Variable Cost (TVC=V1+V2+V3)	172.50 (84.60)	194.47 (85.08)	208.38(84.28)	191.78 (84.64)
Gross Cost (A=TFC+TVC)	203.89(100.00)	228.58 (100.00)	247.26(100.00)	226.58 (100.00)
Value of Dung (B)	6.03	11.18	15.80	11.00
Net Cost (C=A-B)	197.86	217.40	231.47	215.58
Price of milk (Rs. /litre)	42.99	43.58	43.84	43.47
Average milk productivity (litre/animal/day) (E)	4.81	5.42	5.82	5.35
Gross Return (D)	206.58	236.28	255.08	232.65
Net Returns (D-C)	8.73	18.87	23.61	17.07
Cost of milk production (Rs. /litre) (C/E)	41.17	40.10	39.79	40.35
Returns (Rs. /litre) (D/E)	1.82	3.48	4.06	3.12
Average Variable Cost (AVC = TVC/E)	35.89	35.87	35.82	35.86
Break even output (lit) ( TFC/ Price-AVC)	4.41	4.42	4.84	4.57

Figures in parentheses indicate the percentage of gross cost

than the overall net return of crossbred cow (Rs. 3.29) in spite of higher marker price of the buffalo milk due to high fat content. It could be due to the lower average productivity of buffalo (5.35lit/animal/day) than the crossbred cows (6.82 lit/animal/day). The low productivity in case of buffaloes was due to poor management practices as well as less accessible veterinary and Artificial Insemination (AI) practices in the study region. The result obtained in respect of the cost of milk production and net return was found to be comparable with the earlier studies conducted by Lal and Chandel (2016) and Kumari et al. (2016). The break-even output in case of buffalo varied from 4.41 litre per day for small herd size to 4.87 litre per day for large herd size category. The overall productivity of buffalo was found to be higher than the overall break even output *i.e.* 4.57 litre per day.

The constraints faced by the dairy farmers in milk production are presented in Table 5. It can be seen that distance location of semen collection centres and high price of concentrates were found to be the major constraints in milk production faced by the farmers with a Garrett mean score of 73.29 and 71.23, respectively. Khoveio et al. (2012) also reported that the low availability of feeds and high market prices of concentrates were the major production constraints in milk production. Poor quality of concentrates and non-availability of subsidized feed were also identified as some of the major constraints faced by the farmers. However, factors like lack of veterinary facilities, high

transportation charges and non-remunerative prices of milk were found to be of least importance. Low availability of green fodder was found to be least important with Garrett mean score of 24.94 due to high fodder yield and availability of green fodders like berseem, cowpea, fodder maize *etc.* in the study area.

## Conclusions

In the present study on economic analysis of milk production, it was found that the overall cost of milk production decreased as the herd size increased, while the overall net returns per litre of milk increased with the herd size. It was highest for crossbred cows (Rs. 3.29) followed by buffalo (Rs.3.12) and indigenous cows (Rs.1.28). It can be concluded that the crossbred cows are economically beneficial for the dairy farmers as their overall per day yield was found to be much higher than the overall break-even output (BEO). However, efforts must be taken to improve the productivity of indigenous cattle by means of proper training programs and facilitation of scientific rearing practices. Moreover, it was also seen that in case of all the animal categories, the net returns varied positively with the herd size. Therefore, it can be concluded that due to rearing of better breeds, adoption of better feeding and management practices, the farmers having large herd size of animals were more benefitted than their counterparts. Hence, efforts should be taken to bridge the knowledge gap of especially small and medium farmers and enabling them to adopt

better rearing practices to obtain higher milk yield and net returns from dairy farming. The study also observed that distant location of semen collection centres and high price of concentrates were the major production constraints faced by the farmers. Steps should be taken to establish new semen collection centres with easy accessibility for the farmers or deliver the quality semen at doorsteps by mobile van as well as making availability of concentrates at subsidized price to the milk producers which can be channelized through Farmer Producer Organizations (FPOs).

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# Knowledge and adoption level of dairy farmers about bovine ectoparasites in the operational area of dairy Vigyan Kendra, Vejalpur, Gujarat (India)

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**Abstract:** The study was carried out to assess the knowledge and adoption level of dairy farmers about bovine ectoparasites in the operational area of Dairy Vigyan Kendra (DVK), Vejalpur, Gujarat (India) during 2019-2020. Using the simple random sampling method, 300 respondents from 30 villages of 10 talukas in the operational area of Dairy Vigyan Kendra, Vejalpur were selected. Majority of dairy farmers (80.33%) reported that their animals were suffering from ticks. An interview schedule was prepared encompassing various aspects of ectoparasites and their control to ascertain the level of knowledge. The majority of dairy farmers had medium level of knowledge (42.33%) and adoption (50.00%) about bovine ectoparasites. Dairy farmers can increase their knowledge about bovine ectoparasites through participation in various extension activities and use of different mass media which might reinforce them to adopt scientific practices regarding control of bovine ectoparasites.

**Keywords:** Adoption, Dairy farmers, Ectoparasite, Knowledge

## Introduction

Ectoparasites are having economic significance on three points (1) direct losses from their bite and annoyance, worries, and psychological disturbances produced during the act of biting

and feeding, (2) diseases they transmit, and (3) expenditure incurred for their control (Narladkar, 2018). The global loss due to ticks and tick borne diseases (TTBDs) was estimated to be between US\$ 13.9 and 18.7 billion annually (De Castro, 1997) while in India the cost of controlling TTBDs has been estimated as US\$ 498.7 million/annum (Minjauw and McLeod, 2003).

The diseases spread by ticks are a major constraint to animal productivity while causing morbidity and mortality in both animals and humans. A number of tick species have been recognised since long as vectors of lethal pathogens, viz. Crimean-Congo haemorrhagic fever virus (CCHFV), Kyasanur forest disease virus (KFDV), Babesia spp, Theileria, Rickettsia conorii, Anaplasma marginale, etc. and the damages caused by them are well-recognised (Ghosh and Nagar, 2014). Hence the knowledge and adoption by dairy farmers about ectoparasites and its control measures would help to make better planning for profitable dairy husbandry.

## Materials and Methods

Study was conducted among the dairy farmers in operational area of Dairy Vigyan Kendra (DVK), Vejalpur. Eleven talukas are under operational jurisdiction of DVK. Out of eleven, seven talukas (Godhra, Shehera, Morva (Hadaf), Jambughoda, Ghoghamba, Halol, and Kalol) are under Panchmahals district and four talukas (Santrampur, Khanpur, Kadana and Lunawada) are under Mahisagar district. Total ten talukas of operational area of DVK were selected randomly for the study. Three villages were selected randomly from each taluka and 10 dairy farmers were selected randomly from each village, thus making the total sample of 300 dairy farmers. A standardized, well-structured pre-tested interview schedule was prepared in light of the objectives in consultation with department of veterinary parasitology and veterinary experts. The data were collected through personal interview method. Knowledge score card was developed by assigning one score to each correct response and zero score to each incorrect response. The score of "2" was assigned to those respondents who adopt the particular practice fully. The partial adoption of practice was given "1" score while "0" score was given to those respondents who do not adopt the particular practice. Adoption is a decision to make full use of an innovation

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as the best course of action available. If the practice adopted was fairly close to the recommendation, it was viewed as partially adopted. Partial adoption is common, at least for some practices. Respondents were categorized into low, medium, and high categories for knowledge level, adoption level, milk production, social participation, extension participation and mass media exposure variables with help of cumulative square root of frequency (CSRFB) method suggested by Dalenius and Hodges (1959). SPSS 21 (IBM, USA) was used to process the collected data.

## Results and Discussion

The complete profile of dairy farmers comprising of different personal and socio-economical characteristics is depicted in Table 1. In the study area, more than half of the dairy farmers were

female (58.33), middle aged group (50.66%), and literate (65.00%). Similar result was reported by Jadav and Raval (2019). Vast majority of dairy farmers (92.34%) had kept buffalo followed by crossbred cow (50.00%) and indigenous cow (22.00%). Results indicated that dairy farmers (45.67%) had kept two milch animals in their dairy farm followed by one or no milch animal (38.33%) and three or more than three milch animals (16.00%). There were 45.00 per cent dairy farmers' animals, which produced less than 9 litres of milk per day. Majority of dairy farmers had medium level of social participation (56.00%), extension participation (42.33%) and mass media exposure (43.67%). The probable reason could be that majority of dairy farmers had registered in milk co-operative society to get the benefit of AMUL pattern having strong network of animal husbandry services like veterinary service, extension activities etc.

**Table 1** Profile of dairy farmers

(n = 300)

Sr. No.	Profile of dairy farmers	Total	
		Frequency	Percentage
1	Sex		
i	Male	125	41.67
ii	Female	175	58.33
2	Age		
i	Young ( Up to 35 years)	71	23.67
ii	Middle aged (36–50 Years)	152	50.66
iii	Old (>50 Years)	77	25.67
3	Education		
i	Illiterate	105	35.00
ii	Primary education	75	25.00
iii	Secondary education	69	23.00
iv	Higher secondary	34	11.33
v	Graduate and above	17	05.67
4	Experience in dairy farming		
i	Low (Up to 10 years)	93	31.00
ii	Medium (11-20 years)	98	32.67
iii	High (>20 years)	109	36.33
5	Land holding		
i	Landless farmers	4	01.33
ii	Marginal farmer (Up to 1.00 hectare)	174	58.00
iii	Small farmer (1.01 to 2.00 hectares)	90	30.00
iv	Medium farmer (2.01 to 4.00 hectares)	23	07.67
v	Large farmer (Above 4.00 hectares)	9	03.00
6	Herd Composition		
i	Indigenous cow	7	02.33
ii	Crossbred cow	14	04.66
iii	Buffalo	113	37.67
iv	Indigenous cow + Crossbred cow	2	00.67
v	Indigenous cow + Buffalo	30	10.00
vi	Crossbred cow + Buffalo	107	35.67
vii	Indigenous + Crossbred cow + Buffalo	27	09.00
7	Herd Size		
i	Small (Up to 3 animals)	111	37.00

ii	Medium (4-6 animals)	112	37.33
iii	Large (>6 animals)	77	25.67
8	Milch animal		
i	Low (d <sup>1</sup> milch animal)	115	38.33
ii	Medium (2 milch animals)	137	45.67
iii	High (e <sup>3</sup> milch animals)	48	16.00
9	Milk Production/ Day/ Farmer		
i	Low (<9 litres)	135	45.00
ii	Medium (9-21 litres)	110	36.67
iii	High (>21 litres)	55	18.33
10	Social participation		
i	Low (<0.41)	78	26.00
ii	Medium (0.41-2.09)	168	56.00
iii	High (>2.09)	54	18.00
11	Extension participation		
i	Low (<2.07)	100	33.33
ii	Medium (2.07-4.24)	127	42.33
iii	High (>4.24)	73	24.34
12	Mass media exposure		
i	Low (<0.59)	104	34.67
ii	Medium (0.59-2.11)	131	43.67
iii	High (>2.11)	65	21.66

(-) indicate the wrong question asked to respondents.

Two-fifth dairy farmers (39.67%) had knowledge about the difference between endoparasite and ectoparasite in operational area of DVK (Table 2). There were 92.00 per cent dairy farmers who had knowledge that ticks coming under ectoparasite followed by flies (84.00%), lice (76.33%), mosquito (70.33%) and mites/mange (63.67%). There were 98.00 per cent of dairy farmers who knew that ectoparasite can be susceptible to buffalo followed by cow (94.67%), dog & cat (48.00%), sheep & goat (32.00%), horse (19.67%) and camel (16.00%).

Regarding the transmission of bovine ectoparasite, 68.00 per cent of dairy farmers believed that bovine ectoparasite infestation can be transmitted to human. Majority of dairy farmers (83.67%) believed that ectoparasite infestation can be transmitted from animal to animal. It is seen in the table 2 that more than one-third (37.67%) of dairy farmers had knowledge that ingestion of contaminated milk is unable to transmit ectoparasite infestation to human and vice versa. Dairy farmer had knowledge about ectoparasite infestation of animals can be transmitted through bite of arthropods (71.00%) and contact of infected animal's skin (64.67%) to human and vice versa.

When asked about symptoms of animal suffering from ectoparasites infestation, majority of dairy farmers (91.33%) had knowledge that it causes harm to animals by biting and blood sucking followed by intense skin irritation, marked itching and scratching (91.00%), septicemia or toxemia (67.00%) and myiasis (56.00%).

Regarding various diseases transmitted due to ectoparasites, dairy farmers had knowledge that ectoparasite infestation can mechanically transmit tuberculosis (31.33%), typhoid (24.67%), anthrax (21.00%), cholera (12.33%) and crimean-congo haemorrhagic fever (CCHF) (11.67%). There was less than half (47.00%) dairy farmers, who had the knowledge that ectoparasites can transmit trypanosomiasis followed by theileriosis (34.33%) and babesiosis (11.67%). Manimaran and Kamboj (2014) reported that ectoparasites infestation reduced animal production and performance, partly through transmission of arthropod-borne diseases like trypanosomiasis, babesiosis and theileriosis.

Majority of dairy farmers believed that treatment of infested animal by a veterinarian can prevent ectoparasites (92.67%), usage of home remedies like neem oils (59.00%), use of insects preventive net (51.67%), use of CaCO<sub>3</sub> (Calcium carbonate) to control ectoparasites in the animal shed soil (35.00%) and regular bathing of animal (96.00%) followed by various pour-on insecticides or acaricides, which should be used under the guidance of a veterinary doctor (85.33%) and maintain proper distance between the animals to be kept to avoid the transfer of ectoparasites from one animal to another (73.33%).

Majority of dairy farmers' animals were suffering from ticks, which indicates that tick is a burning question in dairy farming (Table 3). Similar result was revealed by Ramzan et al. (2018) and reported that most interviewees (78.30%) knew well that their animals had ticks.

**Table 2** Knowledge of dairy farmers about bovine ectoparasites (n= 300)

Sr.No	Statements	No. (%) of participants
	<b>General Information</b>	
1	Number of respondents knowing the difference between endoparasite and ectoparasites	119 (39.67)
2	Number of respondents who know different types of ectoparasites in dairy animals	
A	Ticks	276 (92.00)
B	Mites / Mange	191 (63.67)
C	Lice	229 (76.33)
D	Flies	252 (84.00)
E	Mosquito	211 (70.33)
F	Dragonflies (-)	155 (51.67)
G	Grasshopper (-)	158 (52.67)
3	Susceptible animals that can have ectoparasites	
A	Cow	284 (94.67)
B	Buffalo	294 (98.00)
C	Dog & Cat	144 (48.00)
D	Sheep & Goat	96 (32.00)
E	Horse	59 (19.67)
F	Camel	48 (16.00)
4	Ectoparasite infestation as a curable condition	230 (76.67)
5	Ectoparasite infestation as treatable	254 (84.67)
	<b>Transmission</b>	
6	Bovine ectoparasite infestation can be transmitted to farmers.	204 (68.00)
7	Ectoparasite infestation can be transmitted from animal to animal.	251 (83.67)
8	Ectoparasite infestation of animals can transmit to man and vice versa through:	
A	Ingestion of contaminated milk (-)	113 (37.67)
B	Contact of infected animal's skin	194 (64.67)
C	Bite of arthropods	213 (71.00)
	<b>Symptoms of animal (Suffering from Ectoparasite infestation)</b>	
9	Ectoparasite infestation causes intense skin irritation, marked itching and scratching	273 (91.00)
10	Ectoparasite infestation causes myiasis	168 (56.00)
11	Ectoparasite cause septicemia or toxaemia	201 (67.00)
12	Ectoparasite causes harm to animals by biting and blood sucking	274 (91.33)
	<b>Various diseases transmitted due to ectoparasites</b>	
13	Ectoparasite infestation mechanically transmit viral and bacterial diseases like:	
A	Crimean-Congo haemorrhagic fever (CCHF)	35 (11.67)
B	Typhoid	74 (24.67)
C	Anthrax	63 (21.00)
D	Cholera	37 (12.33)
E	Tuberculosis	94 (31.33)
14	Ectoparasite transmit certain protozoal and rickettsial organisms which causes diseases like:	
A	Trypanosomosis	141 (47.00)
B	Theileriosis	103 (34.33)
C	Babesiosis	35 (11.67)
	<b>Prevention &amp; Control of ectoparasite infestation</b>	
15	Treatment of infested animal by a veterinarian	278 (92.67)
16	Usage of home remedies like neem oils to prevent ectoparasite effective	177 (59.00)

17	Insects preventive net can control ectoparasites	155 (51.67)
18	CaCO <sub>3</sub> (Calcium carbonate) can be useful to control ectoparasites in the animal shed soil.	105 (35.00)
19	To use various pour-on insecticides or acaricides under the guidance of a veterinary doctor	256 (85.33)
20	Regular bathing of animal is advisable for control of ectoparasites.	288 (96.00)
21	To maintain proper distance between the animals for avoid the transfer of ectoparasites from one animal to another	220 (73.33)

**Table 3** Dairy farmers’ response regarding presence of ticks on their dairy animals (n=300)

Sr.No.	Presence of ticks	Frequency	Percentage
i	Yes	241	80.33
ii	No	59	19.67

**Table 4** Knowledge level of dairy farmers about major components of bovine ectoparasites (n=300)

Sr.No.	Major components	Knowledge level (%)
1	General information	62.08
2	Transmission	64.33
3	Symptoms of animal	76.33
4	Various diseases transmitted due to ectoparasites	21.56
5	Prevention & Control of ectoparasite infestation	70.43

Knowledge level of dairy farmers about major components of bovine ectoparasites (Table 4) revealed that an arrangement of major components of dairy farmers’ knowledge level about bovine ectoparasites as ‘Symptoms of animal Prevention and Control of Ectoparasite infestation, Transmission, General information, Various diseases transmitted due to ectoparasites’ are ordered in decreasing trend. Dairy farmers had least knowledge level (21.56%) about various diseases transmitted due to ectoparasites. This result indicates that extension programmes should put more emphasis on various diseases transmitted due to ectoparasites. Similar result was found by Sarita et al. (2017) and reported that only 42.8 per cent of respondents knew only two harms adverse effects followed by < 2 harms (36.4%) and > 2 harms of ectoparasites (20.8%). There is need of extension programmes to educate the farmers about diseases transmitted through ectoparasites and to reduce the economic loss to the farmers (Ponnusamy et al. 2017).

It is observed in table 5 that majority of dairy farmers (42.33%) had medium level of knowledge about bovine ectoparasites followed by 33.00 and 24.67 per cent of them had high and low level of knowledge of bovine ectoparasites, respectively. Knowledge of herdsmen was not good about ticks and tick-borne diseases in district Multan reported by Ramzan et al. (2018). There was 50.00 per cent dairy farmers had medium adoption of practices regarding control of bovine ectoparasites followed by high adoption (26.67%) and low adoption (23.33%). These findings were not in agreement with results of Ramzan et al. (2018), Kumar (2015) and Yadav et al. (2009) and reported that majority of respondents did not follow any practice to control ecto-parasites.

Adoption of dairy farmers regarding practices associate to control bovine ectoparasites presented in table 6. More than half of dairy farmers (55.00%) had not adopted the practice of treatment of infected animal by a veterinarian. It was found that more than fifty per cent dairy farmers had partially adopted the practice of maintaining the proper distance between the animals to avoid the transfer of ectoparasites from one animal to another (59.33%). Majority of dairy farmers (93.33%) had not adopted insects preventive net followed by calcium carbonate (83.67%) and home remedies like neem oils (62.67%) to prevent & control of bovine ectoparasites (Ponnusamy et al. 2017). More than half (54.33%) of dairy farmers had fully adopted the practice of regular bathing of animals for effective control of ectoparasite. These findings were in agreement with results of Singh (2018) and Malsawmdawngliana and Rahman (2016) and reported that majority of the respondents did nothing to control ectoparasites in animal house

The Pearson correlation analysis was conducted to identify the relationship between factors affecting the knowledge level of dairy farmers about bovine ectoparasite and independent variables. An observation of table 7 shows that ‘r’ computed between knowledge level of dairy farmers about bovine ectoparasite and mass media exposure (0.240), extension participation (0.234), education (0.226), landholding (0.218) and herd size (0.158) were found to be significant at 0.01 level of significance. Social participation (0.137) and milk production (0.134) were found to be significant at 5 per cent. Remaining variables like age and experience in dairy farming were observed to be non-significant relationship. The result shows that the

**Table 5** Overall knowledge and adoption level of dairy farmers about bovine ectoparasites (n= 300)

Sr.No.	Knowledge category	Knowledge category No. (%)	Adoption category	Adoption category No. (%)
1	Low (<19.44)	74 (24.67%)	Low (<2.84)	70 (23.33)
2	Medium (19.44-25.88)	127 (42.33)	Medium (2.84-5.29)	150 (50.00)
3	High (>25.88)	99 (33.00)	High (>5.29)	80 (26.67)

**Table 6** Adoption of dairy farmer regarding practices in control of bovine ectoparasites (n= 300)

Sr.No.	Practices	No. (%) of participants		
		Full adoption	Partial adoption	No adoption
1	Treatment of infested animal by a veterinarian	135(45.00)	0(00.00)	165(55.00)
2	Usage of home remedies like neem oils to prevent ectoparasite effective	34(11.33)	78(26.00)	188(62.67)
3	Use of insects preventive net to control ectoparasites	20(06.67)	0(00.00)	280(93.33)
4	Use of CaCO <sub>3</sub> (Calcium carbonate) to control ectoparasites in the animal shed soil	18(06.00)	31(10.33)	251(83.67)
5	Regular bathing of animals for effective control of ectoparasite	163(54.33)	132(44.00)	5(01.67)
6	Maintaining the proper distance between the animals to avoid the transfer of ectoparasites from one animal to another	77(25.67)	178(59.33)	45(15.00)

**Table 7** Correlation (r) between the profile of dairy farmers with knowledge and adoption of dairy farmer about bovine ectoparasite (n=300)

Sr.No.	Variables	Pearson 'r' value (Knowledge)	Pearson 'r' value (Adoption)
1	Age	0.006 <sup>NS</sup>	-0.065 <sup>NS</sup>
2	Education	0.226 <sup>**</sup>	0.151 <sup>**</sup>
3	Experience in dairy farming	0.088 <sup>NS</sup>	-0.070 <sup>NS</sup>
4	Landholding	0.218 <sup>**</sup>	0.162 <sup>**</sup>
5	Herd size	0.158 <sup>**</sup>	-0.050 <sup>NS</sup>
6	Milk production	0.134 <sup>*</sup>	0.021 <sup>NS</sup>
7	Social participation	0.137 <sup>*</sup>	-0.040 <sup>NS</sup>
8	Extension participation	0.234 <sup>**</sup>	0.106 <sup>NS</sup>
9	Mass media exposure	0.240 <sup>**</sup>	0.235 <sup>**</sup>
10	Knowledge of dairy farmers	-	0.347 <sup>**</sup>

\*\* =Significant at 0.01 level; \* =significant at 0.05 level; NS= non-significant

knowledge level about bovine ectoparasites was significantly increasing with increase in exposure to mass media, participation in extension & social activities, educational level and socio-economic condition of dairy farmer (Ponnusamy et al. 2019).

An observation shows that correlation 'r' computed between adoption of dairy farmer about practices of control of bovine ectoparasites and education (0.151), landholding (0.162) and mass media exposure (0.235) were found to be significant at 1 per cent.

The result shows that the adoption level of dairy farmer about practices of control of bovine ectoparasites had significant increase with increasing their mass media exposure, landholding

and educational level. Mass media exposure might have enhanced the awareness of dairy farmers on different practices of bovine ectoparasites' control. Education of dairy farmer might be useful to understand the advantages of different practices of bovine ectoparasites' control. Landholding represents the economic condition of dairy farmer which may be helpful to bear the extra expenses of adopted practices for controlling bovine ectoparasites.

Correlation between knowledge level and adoption level of dairy farmer (0.347) regarding bovine ectoparasites was found to be significance at 1 per cent. It signifies that adoption level of dairy

farmer about control of bovine ectoparasites would increase with his knowledge level.

## Conclusion

The survey of dairy farmers in Panchmahals and Mahisagar districts of Gujarat indicated that farmers are aware of impact of tick infestation in dairy animals. However, the adoption of control measures was found to be medium, requiring extension interventions. The correlation between 'Knowledge level and adoption level of dairy farmer about control of bovine ectoparasites' with education, landholding and mass media exposure was found to be highly significant.

Ectoparasite control programmes (especially focus on tick control programmes) should be organized by maximum mass media exposure as well as level by providing trainings, awareness programmes and literatures on bovine ectoparasite to the dairy farmers.

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# Understanding the relationship between ICT and knowledge sharing using structural equation modeling: A study from Indian milk co-operatives

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**Abstract:** The objective of this paper is to find out the relationship between information and communication technology (ICT) and knowledge sharing (KS) process in Indian Milk Co-operatives. This study uses a quantitative approach as an instrument to collect data from the questionnaire. A total of 114 samples were collected from two different milk co-operatives in India. The data obtained were analyzed and tested the hypothesis by using structural equation modeling (SEM). The result shows that ICT has a significant influence on KS in respondent milk co-operatives. The results of the study can serve as a guide to managers of the co-operatives in designing and ascertain the direction of ICT for effective KS practices.

**Keywords:** Information and communication technology, Knowledge management, Knowledge sharing, Milk co-operatives, Structural equation modeling

## Introduction

Indian agriculture and allied fields are currently facing various challenges like climate change, declining water availability, degradation of land, shrinking land availability, the high cost of cultivation, environmental degradation, poverty and inaccessibility to modern technology, diminishing the availability of agricultural labor and farmers' reduced interest in agriculture (Kothari and Kameswari, 2019). The National Commission on Farmers has drawn attention to the knowledge deficit that constrains the agricultural productivity, which highlights the failure of public extension system and the inability of extension workers to enrich the farmers with knowledge of new technologies (Kale et al. 2015) that can enable them to be more productive. It has been widely recognized that the transfer of relevant knowledge plays an important role in agriculture growth and its productivity. Transfer of relevant knowledge to small

and marginal farmers can help them to improve their yields and get better market prices (Patil et al. 2011; Kukreja et al. 2013).

Knowledge has become a valuable asset and key resource for improving an organization's performance (Karadsheh et al. 2009). Many organizations are exploring the field of knowledge management (KM) to improve their performance and sustain themselves in the competitive world (Yew Wong, 2005). Knowledge sharing (KS) is considered as the core process of KM since one of the main goals and objectives of KM is to promote the sharing of knowledge (Chua, 2004). It is processed in which sharing of knowledge takes place among individuals and or groups in the organization, thereby promoting learning and creation of new knowledge. Transfer of knowledge can be both in the horizontal and/or vertical directions. Horizontal knowledge transfer takes place between the employees in the organizations and vertical knowledge transfer takes place between organizations.

Information and communication technology (ICT) can make more competitive by providing affordable, relevant, searchable, and up-to-date information service to farmers (Patil et al. 2011). Initiatives of ICTs in the livestock sector had helped the extension professionals an opportunity to produce customized extension material that met the real needs of the farmer. For example, in the livestock sector, Smallholder Dairy Tool Box (SDTB) which has been developed by the International Livestock Research Institute (ILRI) and International Crop Research Institute for Semi-Arid Tropics (ICRISAT). It is an ICT based application which contains simple decision support tools, as well as a broad range of modular information that can be easily accessed and compiled to form customized fact-sheets, or other extension materials, on a wide range of dairy-related topics for the farmers and extension officers (Thirunavukkarasu et al. 2008). Dairy information system kiosks (DISK), an ICT project develop by Anand Milk Union Ltd (AMUL), Gujarat with the support of Indian Institute of Management, Ahmedabad (IIMA). This DISK enables horizontal networking of all milk producing cooperative societies and vertical networking with district-level milk unions and state-level federations with the Internet connectivity. The district dairy portal will assist the transactional and information needs of co-operative staff, members (farmers), and other stakeholders (Rao, 2010).

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In the literature, many authors focused on the importance or impact of ICT in the dairy sector. For example, the advantages of ICT to provide effective delivery of information related to animal health care and production to the end-users. By providing a simplified version of information (related to animal husbandry technology) through cyber extension with text and multi-media in local languages had proven to be a cost-effective and powerful tool in building up the capacities of the farmers (Sasidhar et al. 2006). A study was conducted in Rajasthan, India to measure the attitude of livestock farmers' towards the usage of ICT in extension services as a source of information delivery (Rajoria et al. 2018). There have been very limited studies on the KS process at the organizational level and still fewer on the relationship between ICT and KS at the milk co-operative level in the Indian context. In this paper, we are trying to address this need, i.e., studying the relationship between ICT and the KS process in Indian Milk Co-operatives by using structural equation modeling (SEM) technique.

**Materials and Methods**

The main objective of this study is to understand the effect of ICT on the KS process in milk co-operative

Hypothesis (H1): ICT has a significant and direct effect on knowledge sharing in milk co-operatives.

A quantitative research approach was used to test the research hypothesis. For the quantitative method, we developed a questionnaire using prior measurements corresponding to each variable reported in the literature. Since there are very few studies reported in the literature in the context of Indian agricultural organizations, in general, and Indian milk co-operatives in particular; the parameters used in other kinds of organizations were adopted in this study. The questions in the questionnaires were suitably modified to make them more relevant/appropriate for milk co-operatives.

A set questionnaire was designed and used to determine the relationship between ICT and KS. The questionnaire was developed using earlier measurements corresponding to each variable which was derived from the literature (Siong et al. 2006; Lee et al. 2007). Each variable (related to ICT and KS) was addressed through multiple items in the questionnaire to increase the reliability of responses. Each item was based on a five-point Likert scale from "strongly disagree" to "strongly agree" (Albaum, 1997). Table 1 presents the items used to measure research constructs (ICT and KS).

**Data collection**

Muluknoor Women's Cooperative Dairy located at Karimnagar, Telangana, and Mehsana District Co-operative Milk Producers' Union Ltd located at Mehsana, Gujarat were selected. These

**Table 1** Items used for measuring research constructs

Information and Communication Technology	
ICT1	Our organization has ICT infrastructure (like computer, networks) for managing all kinds of documents on agriculture knowledge
ICT2	ICT infrastructure (like computers, software, networks) are easy to use for uploading, searching and retrieving agriculture knowledge
ICT3	I use ICT tools (like computers, emails, telephones, mobile) to communicate within the organization
ICT4	I routinely utilize ICT tools (like computers, emails, telephones, mobile) to access agriculture knowledge from outside organizations
ICT5	We use ICT tools (like computers, emails, telephones, mobile) for sharing agriculture knowledge with farm communities
ICT6	We use computers for storing agriculture knowledge
ICT7	We use the Internet and Intranet to access agriculture knowledge repository Knowledge Sharing
KS1	Periodical annual reports/success stories are made to share with all organization members
KS2	Periodical meetings/workshops/seminars are held to share best practices, new technology in agriculture
KS3	Farm communities are willing to share their experience and knowledge
KS4	Farm communities are willing to share their experience and knowledge with experts group
KS5	We share our field experience with a peer group in the organization
KS6	We use ICT tools like mobile, audio and video conference, the Internet for sharing agriculture knowledge
KS7	The organization encourages the employee to share their knowledge with peer groups and others
KS8	The organization has resources centers, community hall, and forums for sharing agriculture knowledge
KS9	I believe that sharing agriculture knowledge across groups will yield high benefit

organizations were selected for this study as they exhibited a keen interest in mobilization and disseminating knowledge to the farm communities using ICT. Before running the actual survey in milk co-operatives, the questionnaire had gone through a pilot test, to ensure the objectives of the questionnaire were clear and to ensure content validity.

Unit of analysis in this study were middle-level managers, veterinary doctors, agriculture extension officers, project coordinators, cluster in-charge or supervisor, and field workers/operators. These people were surveyed because they play a key role in agricultural knowledge. These people were positioned at the intersection of both vertical and horizontal flow of knowledge. Therefore, they could synthesize the tacit knowledge of both top (scientist group) and bottom (farmer group) level, convert them into explicit knowledge, and incorporate the same into the organizational knowledge repository. There is no prior personal or formal relationship between researchers and interviewees or the organization as a whole. This allowed for triangulation and also helped to validate data interpretation and findings (Venkitachalam et al. 2014).

The questions were well-structured, understandable and were developed in four languages namely English, Hindi, Gujarati, and Telugu keeping in the mind the geographical locations and the composition of people working in milk co-operatives that were the part of the study.

## Results and Discussion

A total of 114 respondents were covered through the questionnaire from the two co-operatives. Data were collected during their weekly and monthly meetings in the organization. During the meetings, questionnaires were distributed to

participants and they were asked to fill the form. Before filling the form, the objectives of the research and questionnaire were explained to them. Data screening was done to ensure the data were clean and ready for further statistical analyses. During the data screening process, seven respondents were dropped due to unengaged responses. Therefore, the sample size for this study is 107. Table 2 summarizes the demographic profile of respondents. The majority of the respondents have a bachelor's degree (55.1%). From the perspective of designation, 65.4% field in-charges/supervisors, 15.9% program managers, and veterinary doctors, and 2.8% managers. Furthermore, the majority of the respondents (32.7%) had 6-10 years of experience in dairying.

### Reliability and validity test

Reliability and validity tests were performed on 16 items that measure the components of both dependent (KS) and independent variables (ICT). Cronbach's alpha, formula is one of the most commonly used techniques to assess the reliability of the items (Sekaran et al. 2016). It suggests that as a rule of thumb, a Cronbach's alpha value of greater than or equal to 0.7 is required to satisfy the reliability (Hair et al. 2006). Referring to Table 3, this condition has been satisfied for both constructs ICT and KS.

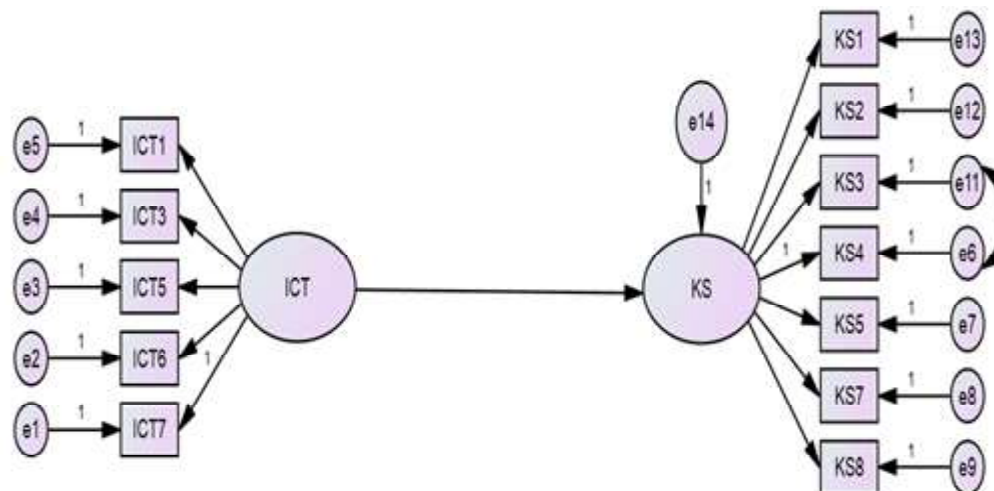
Discriminant validity is used to test construct validity. It has been used because each construct was measured by multiple items. Factor analysis with varimax rotation is used to check discriminant validity.

The Kaiser-Meyer-Olkin (KMO) and Bartlett's measures of sampling adequacy were also computed for comparing the magnitudes of the observed correlation coefficients to the magnitudes of the partial correlation coefficients. The KMO value of greater than 0.5 indicates that factor analysis of the construct was good (Chadha et al. 2014).

**Table 2** Demography profile of respondents

Sample characteristics	Frequency (n=107)	Percent (%)
	Gender	
Male	56	52.3
Female	51	47.7
	Education	
High School	32	29.9
Bachelor Degree	59	55.1
Master's Degree	16	15.0
	Working position of respondents	
Managers	3	2.8
Program managers	17	15.9
Veterinary doctors	17	15.9
Field in-charge/Supervisor	70	65.4
	Experiences of respondents	
0 – 5 years	25	23.4
6 – 10 years	35	32.7
11 – 20 years	33	30.8
Above 20 years	14	13.1

**Fig. 1** Simulation model for the relationship between ICT and KS



**Table 3** Result of reliability and validity

Constructs	No. of items	Indicators	Factor loading	KMO and Bartlett’s test (>=0.5)	Cronbach’s alpha (>=0.7)
ICT	5	ICT1	0.745	0.8	0.789
		ICT3	0.787		
		ICT5	0.700		
		ICT6	0.833		
		ICT7	0.665		
KS	7	KS1	0.682	0.805	0.8
		KS2	0.594		
		KS3	0.692		
		KS4	0.587		
		KS5	0.745		
		KS7	0.680		
		KS8	0.610		

**Table 4** Fitness indexes of the overall model

Name of the Index	Value obtained	Level of Accepted Fit	Results
chi-square value ( $\chi^2/df$ )	2.773	Below 3	Acceptable
CFI	0.901	Very close to 1	Acceptable
GFI	0.924	$\geq 0.90$	Acceptable
AGFI	0.910	$\geq 0.90$	Acceptable

Factor analysis was performed on the 7 items of ICT and 9 items of KS. In the validation process of factor analysis, two items of ICT (ICT2, ICT4) and two items of KS (KS6, KS9) dropped due to poor factor loadings of less than 0.5. Uni-dimensionality is achieved when the items have acceptable factor loading that is 0.5 or higher (Hair et al. 2006). Table 3 summarizes the results of reliability and validity.

**Structural equation modeling (SEM)**

SEM technique has been designed to judge how good a proposed conceptual model can fit the data collected and also to find the structural relationships between the sets of the latent variables. It was adopted to examine the proposed hypothesis on the relationship between ICT, and KS.

The SEM was conducted using Maximum Likelihood Estimation (MLE) procedure. It is one of the most popular methods and is effective when the multivariate normality is used. The final model of the study is illustrated in Figure 1. The curved bi-direction arrow (as shown in Figure 1) represents the covariance or correlation between the indicated pair of measurement errors of the respective items due to redundancy. Therefore, the correlated errors were set to be “free parameter estimates” using the double-headed arrow (Barbara, 2016).

**Overall model fit**

The last step is to test the model fit, i.e. to test how best the collected data set fits the research model. To test this, several indicators were computed by using analysis of a moment

structures (AMOS). The most fundamental measure of overall fit in SEM is the likelihood-ratio chi-square statistics. According to Bagozzi and Yi (1988), a p-value exceeding 0.05 and a normed chi-square value ( $\chi^2/df$ ) that is below 3, are normally considered as acceptable. Comparative fit index (CFI) values close to 1 indicate a very good fit (Hair et al. 2006). Goodness-of-Fit Index (GFI) value greater than or equal to 0.9 indicates good fit and Adjusted Goodness-of-Fit Index (AGFI) value must be greater than or equal to 0.9 (Bagozzi et al. 1988). The developed model has been proved to meet all the requirements and the results are shown in Table 4. Hence, the model was utilized to test the hypothesized relationships among the constructs.

### Testing hypothesis

The results revealed that ICT has a significant and positive effect ( $\beta = 0.35$  at  $p = 0.001$ ) on KS. Therefore  $H_1$  was supported and accepted ( $p = 0.001$ ).

### Conclusions

This paper examined the relationship between knowledge sharing and ICT in Indian agricultural organizations using structural equation modeling method. It found that ICT has a significant and positive effect ( $\beta = 0.35$  at  $p = 0.001$ ) on the knowledge sharing process in the respondent organizations. Respondent organizations are using ICT tools like computers, laptops, and mobile phones for disseminating and sharing agriculture knowledge with the farm communities. The study found that people like managers, veterinary doctors, and program coordinators in milk co-operatives have been using the Internet, emails for sharing knowledge from state and national research institutes, whereas field supervisor, field technical officers had limited access to the Internet, email, etc.

This study might help the managers of the organizations to understand and to find which type of ICT tools and infrastructure are critically required for an effective knowledge sharing process. Because organizations may not manage all modes of knowledge, they might need robust strategies that involve a network of knowledge partners for sharing knowledge.

The easy access to ICT and the low cost of ICT tools have enhanced development and interest in the field of knowledge sharing in agriculture. Rapid development in the field of ICT like the Internet, emails, Web technologies, video-conference, and rapid mobile penetration contribute to the sharing of knowledge within organizations and with farm communities.

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# Challenges and barriers perceived by paravets and veterinarians in delivery of minor- veterinary services at farmers' door- step: An exploratory study in four States of India

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**Abstract:** Delivery of animal health service is unique in India in the term that it is delivered by both paravets and veterinarians and in the complementary and supplementary relationship sometimes, with co-ordination and also independently. Paravets are very low in educational qualification and training, with improper execution of their roles and responsibilities with desired accuracy and accountability. The present study was conceptualized to assess the challenges and barriers in the delivery of minor- veterinary services at farmers' door- step from the perspective of trainers of paravet school (veterinarians) as well as paravet themselves. The research was carried under an exploratory research design, in which a random sampling method was used to reach out to the respondents. Key issues in decision-making regarding livestock extension and veterinary services (based on guidelines issued by DFID) as perceived by veterinarians were identified. Results indicated that lack of information booklets on breeding and management, sub-standardized curriculum and limited skills in diagnosis, lack of regular training programmes, and ethical issues with role obligations were prioritized challenges. Trainers agreed that multiple issues were plaguing delivery of animal health service as obtained RBQ values which were not showing a wide variation. Hence interventions should be planned with a wider focus to resolve these constraints plaguing the delivery of minor veterinary services.

**Keywords:** Animal health service (AHS), Accountability, Barriers, Challenges, DFID, Rank-based quotient (RBQ), Pareto Analysis

## Introduction

The main challenge inefficient delivery of animal health services in India can be stated as shortage of veterinarians (Channappagouda and Sasidhar, 2018; Sasidhar and Reddy, 2013), and lack of adequate skills as well as knowledge among the staff of the State Department of Animal Husbandry (Shubeena et al. 2019). In India, there exists a 49.00 percent gap between veterinarians working at field level against their total requirement (Agrawal et al. 2013). The delivery of animal health services in India has been constrained by a lack of collaboration and coordination among the organizations responsible for the service delivery. Thus, it could be imperative to increase the number of veterinarians, paravets, development of linkages with the State Department of Animal Husbandry and Dairying (Rao et al. 2015). Paravets could be a liaison between farmers, service providers, and professionals upstream. The need is more in private than public due to the expansion of veterinary services in the private sector (Rama *et al.*, 2011). Strengthening of existing mobile veterinary clinics for a wider area coverage of animal health service on demand and encouragement for public-private participation in livestock service delivery could help improve the reach and quality of livestock services (Channappagouda and Sasidhar, 2018).

There exists a need for a paradigmatic shift in the delivery of animal health services by service providers in India that qualification of paravets should be based more on output and outcome of learning rather than relying on input supply only. The curriculum should be standard and harmonized for all the states. There is also an urgent need for monitoring of para-veterinary services for which trained paravets should be registered for their efficient monitoring. More than 100 countries of the world are in process of developing a national qualification framework for paravets. European Qualification framework, ASEAN Qualification Reference Framework, and Southern African Development Community are few examples of it (Barbaruah, 2019). Linking veterinarians with their auxiliary

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(paravets), for veterinarians the coverage of a larger area, increased sales of medicines, better knowledge of the area, better coverage of the area, etc. could be a potential challenge that needs to be addressed. For these para- professional auxiliaries, proper technical assistance, counseling, training, delivery of quality inputs need to be ensured. The regulatory quality should presume that the activities of the paravets should be controlled by veterinary services so that, for example, Paravets whose competencies are inadequate or who provide counterfeit products should be banned from practice. In practice, the veterinary services, in general, do not have the means of exercising this control. The control must be delegated to veterinarians present in the field (Saadi and Isabelle, 2015).

When the distance from state animal health service (AHS) centers to farmer's doorstep increases, the preference of farmers for animal health providers shifted towards private practitioners rather than government service providers. When farmers were in good socio-economic condition with owing a greater number of crossbred cattle, they preferred to avail themselves the animal health services provided by government veterinarians. The farmer having good socio-economic conditions prefer veterinarians over paravets and other animal health delivery channels because they could pay the high transaction cost of veterinarians over paravets (Mirajkar *et al.* 2011). Paravets provide flexible and cost-effective services to resource-poor farmers in marginalized and remote areas which remain untouched by public veterinary services. Keeping this in mind, policy-makers should consider recognizing this pro-poor approach in favor of paravets (Warburton *et al.*, 2011).

## Material and Methods

### Study Area

This study was conducted in four states of India namely, Uttar Pradesh, Haryana, Rajasthan, and Maharashtra. The selection of states for the study was based on the highest bovine population, Milk production, number of paravets schools. States namely, Uttar Pradesh, Rajasthan, and Maharashtra rank first, second and third in terms of the highest bovine population respectively (NDDB, 2015). Haryana ranks second in per capita milk availability (NDDB, 2019) and has progressive growth in dairying. These states show rich prospects in dairying due to high rural households, veterinary hospitals/ polyclinics, and AI done (DAHD& F, 2018). Moreover, all four states belong to different agro-climatic zones, which provide soundness and validity to the study. In which, Haryana from trans- Gangetic plains, Uttar Pradesh from upper- Gangetic plains, Maharashtra from western plateau and hills, and Rajasthan from semi-arid eastern plains were selected for the study. Thus, dairying prosperous states from different agro-climatic zones represent the sampling adequacy. One district from each state was selected purposively constituting a total of four districts for the study. Hisar district

from Haryana state, Mathura district from Uttar Pradesh, Jaipur district from Rajasthan state, and Ahmadnagar district from Maharashtra state were selected (19<sup>th</sup> Livestock Census, 2012). The selection of districts was based on the highest number of paravet schools as compared to other districts of the state.

### Selection of respondents and sampling methods

Paravets and veterinarians (trainers of paravet schools) were surveyed to delineate the challenges and barriers in the delivery of minor- veterinary services by paravets. Those paravets were selected as respondents who have undergone at least 1-month of training for minor veterinary services rather than only trained for AI. They must be delivering their services at the farmer's doorstep for at least 2 years under the guidance/ consultation with veterinarians on a payment basis. Those Paravets were surveyed who were not working under any NGO such as J& K Trust, BAIF, etc. The selection criteria for a trainer of paravet school (veterinarian) was that he/ she should be having at least more than one year of experience in that Paravet School at the time of the investigation. The exploratory research design was used in the study. A random sampling method was used to reach out to the respondents. A pilot study was conducted on a limited scale before interviewing the intended respondents to gain insight and preliminary information, based on which interview schedule could be planned and formulated. The pilot study was conducted in the Karnal district of Haryana by selecting 20 paravets. Based on qualitative inputs provided by respondents, the interview schedule was re-designed and modified accordingly.

### Statistical tools and techniques

Based on focus group discussions, challenges and barriers to inefficient delivery of animal husbandry services by paravets at farmer's doorstep were identified. To prioritize these perceived challenges in the delivery of services from the perspective of paravets themselves, a "rank-based quotient" (RBQ) was used (Sabarathnam, 1988).

$$RBQ = \sum \frac{i = \ln (F_i) (n + 1 - i) \times 100}{N_n}$$

where,

$F_i$  = Frequency of paravets for the  $i^{\text{th}}$  rank of the problem.

$N$  and  $n$  = Number of paravets and the maximum number of ranks given for various challenges by a paravets, respectively.

Pareto analysis technique was followed to delineate the barriers perceived by trainers of paravet schools inefficient delivery of para-veterinary services. In this analysis, it was hypothesized that 20 percent of the factors were causing 80 percent of the problems. This management technique tells whether

by solving a few issues, major bottlenecks could be resolved or not.

## Results and Discussion

### Key issues in decision making for delivery of animal health services as perceived by veterinarians

Various issues such as privatization of animal health service, prospect and provision of cadres vis-à-vis job security, and consultancy role of animal health professionals affect the delivery of animal health service them as well as the selection of animal health service provider by the farmer. For the various types of service (curative, preventive, productive, and diagnostic), it was found that perceived importance given to preventive and productive services by farmers were most potent in affecting their choice for the service provider as perceived by 90.00 and 75.00 percent of farmers respectively for two types of services (Table 1). Thus, the results infer that most farmers have predetermined choices for service providers depending on their compatibility with socio-economic conditions and availability of services. Thus, interventions must attempt to maximize engagement of all socio-economic categories of farmers, paravets, and veterinarians (Hopker *et al.*, 2018). For productive services, such as AI and PD, only 10.00 percent of farmers perceived it as the least potent choice affecting the choice of service provider because AI and PD were normally performed by paravets at their doorstep. However, 75.00 percent of respondents found it as most potent because of the level of satisfaction of farmers towards the productive services and quality of service rendered by service providers. A study conducted by Jain (2016) in the Tonk district of Rajasthan also revealed that 80.00 percent of farmers had medium satisfaction towards the delivery of health services. "Experience of livestock owners in animal husbandry and cultural values of farmer associated with livestock influence their willingness to pay for service" was found least potent by 73.33 and 96.67 percent veterinarians respectively. Delivery of services on integrated aspects as per the extent of crop-livestock interaction was also found least potent by 80.00 percent of veterinarians.

In the context of privatization of services, 81.67 percent of veterinarians perceived that appropriate time would be required for reforms of privatization (Table 1). The finding aligned with reporting of Barbaruah (2017) who revealed that paradigmatic shift should give more reliance on public-private partnership and privatized service delivery to increase accountability and overcome the shortage of veterinarians in India. The possible reason may be that, for sustainable development and coordination for the delivery of service and multi-stakeholder participation, paradigmatic changes require time and effort. Paravets consult veterinarians in case technical complexity and emergency occur at the field level which they could not handle with the prevailing level of knowledge and expertise. Livestock professionals should

work in coordination with farmers, extension professionals to address challenges at the grass-root level. Para-veterinary services had very less focus on extension, outreach, ethical, and miscellaneous roles. About 40.00 percent of veterinarians perceived the least potency of preventive and production-oriented skills of vets in inducing privatization and neglecting other roles. Farmers mostly prefer paravets due to their low overhead and transaction cost, awareness of farmers about overall economic benefits of veterinary treatment over paravets was perceived least potent.

Provision of different paravet and vet cadres has gained recent importance and became a point of debate. It was found that 73.33 percent of veterinarians found the provision of cadre-wise promotion and better remuneration to paravets as the most potent factor. Improving minor veterinary services by relocating unrecognized service providers by providing them suitable identity cards, separate cadres leading to timely promotion and absorption in government services could be very effective (Barbaruah and Samad, 2014). Conflict being indispensable among stakeholders, 60.00 percent of veterinarians perceived a strong need for a sufficient backup mechanism in case conflict between two cadres arises. It was found that 58.33 percent of veterinarians perceived strong need and provision of in-service training of paravets in the supervision of veterinarians. Paravets consult veterinarians in case technical complexity and emergency occur at the field level which they could not handle with the prevailing level of knowledge and expertise. Livestock professionals should work in coordination with farmers, extension professionals to address challenges at the grass-root level. Similar suggestions were proposed by Suvedi *et al.* (2016). Table 1 revealed that addressing the capacity building needs of paravets, addressing the group formation barriers, and regular contact with veterinarians in the dispensary for updating and supervising their skills by working with them were perceived most potent factor in the supervisory role by 60.00, 76.67, and 35.00 percent veterinarians respectively.

### Challenges perceived by paravets in delivery of services for ensuring the satisfaction of farmers in Mathura and Hisar district

Paravets face various types of challenges in the prompt and efficient delivery of animal husbandry services at farmer's doorstep. It was found that lack of information booklets on breeding and management, lack of standardized curriculum and limited skills in diagnosis, lack of regular training programmes to update knowledge and skill and ethical issues with role obligations were challenges perceived in decreasing order of priority by 55, 62.50, 77.50 and 47.50 percent paravets of Mathura district respectively (Table 2). Paravets need suitable training and proper coordination with veterinarians for the effective delivery of their services. In this purview, two levels have been designated for them, namely, Level 5 (minimum 1.5-year training) and Level 3

**Table 1** Distribution of respondents according to key issues in decision making regarding livestock extension and veterinary services as perceived by veterinarians (based on guidelines issued by DFID)

Sl. No.	Key issues in decision making regarding livestock extension and veterinary services	Most Potent	Potent	Least Potent
I.	Choice of farmers for livestock services by vets over paravets			
1.	Kind of service for which farmers prefer to vets over paravets	48 (80.00)	08 (13.33)	04 (06.67)
	Curative			
	Preventive	54 (90.00)	03 (05.00)	03 (05.00)
	Productive	45 (75.00)	09 (15.00)	06 (10.00)
	Diagnostic	52 (86.67)	05 (08.33)	03 (05.00)
2.	Experience of livestock owners in animal husbandry	07 (11.67)	09 (15.00)	44 (73.33)
3.	Delivery of services on integrated aspects as per extent of crop- livestock interaction	05 (08.33)	07 (11.67)	48 (80.00)
4.	Affected by the cultural values of the farmer which affects willingness to pay, thus the choice of service	00 (00.00)	02 (03.33)	58 (96.67)
II.	Privatization of services			
1.	The time required for reforms of privatization.	49 (81.67)	08 (13.33)	03 (05.00)
2.	Adequate business/ marketing skills of the vets to establish their private services.	18 (30.00)	23 (38.33)	19 (31.67)
3.	Sufficient preventive and production-oriented skills of vets (as vets focus on curative services).	15 (25.00)	20 (33.33)	25 (41.67)
4.	Suitable regulation and quality control in policy to give good transactional cost advantage to vets.	22 (36.67)	26 (43.33)	12 (20.00)
5.	Awareness of farmers about overall economic benefits of veterinary treatment over paravets.	14 (28.33)	17 (28.33)	29 (48.37)
III.	Different veterinary and para-veterinary cadres			
1.	Relations among veterinary and para-veterinary cadres should be well defined and farmers should be aware of perceptual differences among service providers.	32 (53.33)	18 (30.00)	10 (16.67)
2.	Sufficient backup mechanism in case conflict between two cadres arises.	36 (60.00)	18 (30.00)	06 (10.00)
3.	Provision of cadre wise promotion and better remuneration to paravets.	44 (73.33)	16 (26.67)	00 (00.00)
4.	The mechanism for working together of two cadres in disease surveillance.	36 (40.00)	18 (32.50)	11 (27.50)
5.	Provision of in-service training of paravets.	35 (58.33)	14 (23.33)	11 (18.34)
IV.	The supervisory role of vets to paravets			
1.	Addressing the capacity-building needs of paravets.	36 (60.00)	24 (40.00)	00 (00.00)
2.	Addressing the group formation barriers and involvement of service providers in forming a suitable framework.	46 (76.67)	12 (20.00)	02 (03.33)
3.	Regular contact with paravets in the dispensary for teaching and supervising their skills by working with them.	21 (35.00)	23 (38.33)	16 (26.67)

(minimum 45 days) as per the Agriculture Skill Council of India under Pradhan Mantri Kaushal Vikas Yojana (PMKVY) (Barbaruah, 2019). The syllabuses have been designed accordingly, but their utilization throughout the country need to be done to do justice with Level 3 training and practice skills of level 5 training. Similarly, paravets of Hisar district also perceived the above challenges as the topmost challenge in service delivery. Irregular and low income of paravets was perceived as a challenge because it hinders the job morale of the paravets. From table 2, it is clear that the frequency of paravets of Hisar district to perceive challenge in terms of a high degree of potency was relatively lower than paravets of Mathura district. It reveals their readiness, motivation, and good infrastructural, situational, and morale of the paravets in the delivery of service.

Prioritization of challenge depends on the awareness about the issue and its attributing factor with due consideration to the potential of that attributing factors to hinder the work. Food safety of animal products due to overuse of antibiotic drugs was such a challenge for which paravets could not recognize the importance, as result 80 percent paravets of Mathura district and 67.50 percent paravets of Hisar district didn't consider it as a potential challenge. Paravets lack sufficient knowledge and awareness about the drug withdrawal period, as a result of which overuse of antibiotics aggravates the pace of the spread of antibiotic resistance leading to inefficiency of drugs to cure diseases (Landers et al., 2012). Paravets maintain their liquid nitrogen reserve for storing the semen straws and thus it was perceived as the least potent challenge by 42.50 and 65.00 percent paravets of Mathura and Hisar district respectively (Table 2). Non- utilization of laboratories for testing, socio-economic issues of farmers affecting the choice of animal health services, and obtaining over-the-counter treatment by farmer were considered as a potent challenge by 60.00, 57.50, and 42.50 percent paravets of Mathura and 52.50, 27.50, and 30.00 percent paravets of Hisar district respectively.

#### **Challenges faced by paravets in delivery of services for ensured satisfaction of farmers in Jaipur and Ahmadnagar district**

The animal health market of India has been facing the problem of the un-organized market scenario, lack of sufficient manpower for delivery of animal health services, and poor veterinary infrastructure. So there exists a huge prospect and responsibility for the para-veterinary sector to deliver their services with high competency (DAHD & F, 2012). Thus it becomes imperative to assess the challenges in the delivery of animal health service to make it proficient and efficient. A perusal of Table 3 revealed that lack of standardized curriculum affecting skills and proficiency of paravets, lack of regular training programmes to update knowledge and skill, and ethical issues with role obligations were challenges perceived in decreasing order of priority by 60.00, 77.50, and 52.50 percent of paravets of Jaipur and 67.50, 80.00, and 60.00 percent paravets of Ahmadnagar district

respectively. Paravets perceived that the socio-economic condition of farmers didn't affect the choice of the service provider to a large extent because 57.50 percent of paravets of Jaipur district and 50.00 percent paravets of Ahmadnagar district perceived it as the least potent challenge (Table 3). As the fee charged towards para-veterinary services was reasonable and fixed to farmers irrespective of any socio-economic condition, paravets also recognized that minor- veterinary services don't have much variation in choice for service providers.

Paravets didn't felt that their job requires any advanced and updated technical knowledge in the minor veterinary services. As a result of which they didn't recognize the importance of contact with research institutes and universities. More research on the training needs of paravets may help in building their capacity building on a national level, it should be focused on more standardized training and their professional credentialing at the regional level (FAO, 2011). Non- utilization of laboratories for testing facilities were perceived as a moderately potent challenge by 42.50 percent of paravets of Jaipur and 50.00 percent of paravets of Ahmadnagar district because they felt that basic knowledge of laboratory and equipment were needed as they have the role to bring the animal samples for testing in the nearby dispensary (Table 3).

#### **Barriers perceived by paravets inefficient delivery of minor veterinary services**

Paravets feel certain barriers either policy-related, workplace, or skill-related barriers which prevent them from working efficiently. Irregular and low income and less preference to paravets as compared to veterinarians by large farmers were barriers responsible for low job morale of the paravets with a rank-based quotient value of 92.29 and 84.38 respectively (Table 4). Paravets revealed that in the year they receive good money during pre-monsoon and pre- wintertime as it was the time of vaccination and deworming schedule. Otherwise, they practice farming for getting continuous and sustained income. Other barriers were the socio-economic condition of farmers affecting choice for AHS provider, inadequate supervision opportunities by vets, and lack of information booklets on breeding and management ranked third, fourth, and fifth with a rank-based quotient value of 79.79, 73.33, and 69.58 respectively. These three barriers could be addressed to some extent if the contact between paravets and veterinarians could be regular and supervision by veterinarians could be ensured. Lack of coordination and updated information to paravets was also perceived as an important barrier because in absence of these two things paravets fail to do justice with judicious use of drugs and play their role in persuading farmers with recent technological advancements such as new kits and technologies. Paravets need coordination with veterinarians and perform duties within the boundary of the minor- veterinary services for which they are not equipped or trained (Venkatramaiah and Ahuja (2012). Paravets lose job morale and

**Table 2** Distribution of respondents according to challenges faced by them in delivery of services for ensuring the satisfaction of farmers in Mathura and Hisar district (as perceived by paravets) (n=80)

Sl. No	Challenges faced by paravets in delivery of services	Mathura (n=40)				Hisar (n=40)				Rank	
		Highly potent	Potent	Not potent	RBQ value	Highly potent	Potent	Not potent	RBQ value		
1.	Lack of coordination and updated information	13 (32.50)	15 (37.50)	12 (30.00)	67.50	IX	12 (30.00)	15 (37.50)	13 (32.50)	65.83	VIII
2.	Outdated tools due to delayed replacement and expensiveness	06 (15.00)	08 (20.00)	26 (65.00)	50.00	XIII	09 (22.50)	09 (22.50)	22 (55.00)	55.83	XII
3.	Lack of information booklets on breeding and management	22 (55.00)	14 (35.00)	04 (10.00)	81.67	III	18 (45.00)	16 (40.00)	06 (15.00)	76.67	IV
4.	Poor contact with research institutes and universities	12 (30.00)	18 (45.00)	10 (25.00)	68.33	VIII	10 (25.00)	17 (42.50)	13 (32.50)	64.17	IX
5.	Non- utilization of laboratories for testing	10 (25.00)	24 (60.00)	06 (15.00)	70.00	VII	12 (30.00)	21 (52.50)	07 (17.50)	70.83	VII
6.	Inadequate supervision by vets	06 (15.00)	12 (30.00)	22 (55.00)	53.33	XII	07 (17.50)	10 (25.00)	23 (57.50)	53.33	XIII
7.	Lack of standardized curriculum & limited skills in diagnosis	25 (62.50)	10 (25.00)	05 (12.50)	83.33	II	28 (70.00)	07 (17.50)	05 (12.50)	85.83	II
8.	Initial over-the counter treatment by farmer	14 (35.00)	17 (42.50)	09 (22.50)	70.83	VI	17 (42.50)	12 (30.00)	11 (27.50)	71.67	VI
9.	Ethical issues and role obligations in service delivery	19 (47.50)	10 (25.00)	11 (27.50)	73.33	V	20 (50.00)	13 (32.50)	07 (17.50)	77.50	III
10.	Irregular availability of Nitrogen when required	06 (15.00)	17 (42.50)	17 (42.50)	57.50	XI	05 (12.50)	09 (22.50)	26 (65.00)	49.17	XV
11.	Less preference to paravets as compared to vets by large farmers	00 (00.00)	08 (20.00)	32 (80.00)	40.00	V	09 (22.50)	10 (25.00)	21 (52.50)	56.67	XI
12.	Irregular and low income	21 (52.50)	13 (32.50)	06 (15.00)	79.17	IV	18 (45.00)	15 (37.50)	07 (17.50)	75.83	V
13.	Lack of regular training programmes to update knowledge and skill	31 (77.50)	09 (22.50)	00 (00.00)	92.50	I	33 (82.50)	07 (17.50)	00 (00.00)	94.17	I
14.	Food safety of animal products due to overuse of antibiotic drugs.	02 (05.00)	06 (15.00)	32 (80.00)	41.67	IV	07 (17.50)	06 (15.00)	27 (67.50)	50.00	XIV
15.	Socio-economic issues of farmers affecting the choice of animal health services.	08 (20.00)	23 (57.50)	09 (22.50)	65.83	X	09 (22.50)	11 (27.50)	20 (50.00)	57.50	X

**Table 3** Distribution of respondents according to challenges faced by them in delivery of services for ensured satisfaction of farmers in Jaipur and Ahmadnagar district (as perceived by paravets) (n=80).

Sl. No.	Challenges faced by paravets in delivery of services	Jaipur (n=40)				Ahmadnagar (n=40)					
		Highly potent	Potent	Not potent	RBQ values	Rank	Highly potent	Potent	Not potent	RBQ value	Rank
1.	Lack of coordination and updated information	15 (37.50)	14 (35.00)	11 (27.50)	70.00	VI	11 (27.50)	13 (32.50)	16 (40.00)	62.50	IX
2.	Outdated tools due to delayed replacement and expensiveness	07 (17.50)	07 (17.50)	26 (65.00)	50.83	XIII	05 (12.50)	06 (15.00)	29 (72.50)	46.67	XV
3.	Lack of information booklets on breeding and management	14 (35.00)	17 (42.50)	09 (22.50)	70.83	V	12 (30.00)	13 (32.50)	15 (37.50)	64.17	VII
4.	Poor contact with research institutes and universities	09 (22.50)	11 (27.50)	20 (50.00)	57.50	X	08 (20.00)	10 (25.00)	22 (55.00)	55.00	XI
5.	Non- utilization of laboratories for testing	13 (32.50)	17 (42.50)	10 (25.00)	69.17	VII	11 (27.50)	20 (50.00)	09 (22.50)	68.33	IV
6.	Inadequate supervision opportunities by vets	12 (30.00)	15 (37.50)	13 (32.50)	65.83	VIII	10 (25.00)	18 (45.00)	12 (30.00)	65.00	VI
7.	Lack of standardized curriculum affecting skills	24 (60.00)	13 (32.50)	03 (07.50)	84.17	II	26 (65.00)	06 (15.00)	08 (20.00)	81.67	III
8.	Initial over-the counter treatment by farmer	14 (35.00)	21 (52.50)	05 (12.50)	74.17	IV	11 (27.50)	14 (35.00)	15 (37.50)	63.33	VIII
9.	Ethical issues and role obligations in service delivery	10 (25.00)	13 (32.50)	17 (42.50)	60.83	IX	12 (30.00)	16 (40.00)	12 (30.00)	66.67	V
10.	Irregular availability of Nitrogen when required	04 (10.00)	05 (12.50)	31 (77.50)	44.17	XIV	06 (15.00)	09 (22.50)	25 (62.50)	50.83	XIII
11.	Less preference to paravets as compared to vets by large farmers	08 (20.00)	09 (22.50)	23 (57.50)	54.17	XI	07 (17.50)	11 (27.50)	22 (55.00)	54.17	XII
12.	Irregular and low income	21 (52.50)	13 (32.50)	06 (15.00)	79.17	III	24 (60.00)	13 (32.50)	03 (07.50)	84.17	II
13.	Lack of regular training programmes to update knowledge and skill	31 (77.50)	05 (12.50)	04 (10.00)	89.17	I	32 (80.00)	08 (20.00)	00 (00.00)	93.33	I
14.	Food safety of animal products due to overuse of antibiotic drugs.	05 (12.50)	05 (12.50)	30 (75.00)	45.83	XV	06 (15.00)	05 (12.50)	29 (72.50)	47.50	XIV
15.	Socio-economic issues of farmers affecting the choice of animal health services.	08 (20.00)	08 (20.00)	24 (60.00)	53.33	XII	09 (22.50)	11 (27.50)	20 (50.00)	57.50	X

**Table 4** Distribution of respondents according to perceived barriers inefficient delivery of para- veterinary services (as perceived by paravets) (n= 160)

Sl. No.	Challenges faced by paravets in delivery of services	Potency			RBQ value	Rank
		High	Medium	Low		
1	Lack of coordination and updated information	56 (27.50)	64 (35.00)	40 (37.50)	70.00	VI
2	Outdated tools due to delayed replacement and expensiveness	27 (16.88)	30 (18.75)	103 (64.37)	50.83	XIII
3	Lack of information booklets on breeding and management	46 (28.75)	82 (51.25)	32 (20.00)	69.58	V
4	Poor contact with research institutes and universities	37 (23.13)	56 (35.00)	67 (41.87)	60.42	IX
5	Non- utilization of laboratories for testing	59 (36.87)	52 (32.50)	49 (30.63)	68.75	VII
6	Inadequate supervision opportunities by vets	65 (40.63)	62 (38.75)	33 (20.62)	73.33	IV
7	Lack of standardized curriculum & limited skills in diagnosis	24 (16.00)	39 (23.38)	97 (60.62)	51.46	XII
8	Initial over-the counter treatment by farmer	41 (25.63)	52 (32.50)	67 (41.87)	61.25	VIII
9	Ethical issues and role obligations in service delivery	35 (21.88)	55 (34.38)	70 (43.74)	59.38	X
10	Irregular availability of liquid nitrogen gas when required	21 (15.00)	40 (22.50)	99 (62.50)	50.42	XIV
11	Less preference to paravets as compared to vets by large farmers	104 (65.00)	37 (23.13)	19 (11.87)	84.38	II
12	Irregular and low income	127 (79.38)	29 (18.13)	04 (02.50)	92.29	I
13	Lack of regular training programmes to update knowledge and skill	34 (21.25)	54 (33.75)	72 (45.00)	58.75	XI
14	Food safety of animal products due to overuse of antibiotic drugs	19 (11.88)	22 (13.75)	119 (74.38)	45.83	XV
15	The socio-economic condition of farmers affecting choice for AHS providers	85 (53.12)	53 (33.13)	22 (13.75)	79.79	III

motivation when they didn't receive money for their efforts because they operate within a very thin margin of income sustainability. Ethical issues and role obligations in service delivery, lack of regular training programmes to update knowledge and skill, and food safety of animal products due to overuse of antibiotic drugs received tenth, eleven, and the fifteenth rank on basis of the weighted mean score.

#### **Pareto analysis and ranking of barriers inefficient delivery of minor veterinary services (as perceived by veterinarians)**

Non- exposure to regular training programmes and lack of sufficient skills and proficiency among paravets were prioritized by trainers as the first and second barrier in delivery of para-veterinary services in terms of potency. These barriers have the highest RBQ values 228.33 and 216.67 respectively) (Table 5). Low, irregular, and seasonal fluctuation in income and socio-economic condition of farmers affecting choice for AHS provider was perceived as a moderate challenge affecting the efficiency and proficiency of paravets in delivery of animal health service. While, veterinarians fail to recognize reward and promotion and dynamic charging by paravets for service rendered to farmers as

a potent challenge. The RBQ values for the above challenges were 183.33 and 178.33, giving second last and last priority to it respectively. Para- veterinary services would proliferate if separate cadres for paravets with timely promotion as well a record of paravets at district level database could be maintained (NAVS, 2018).

The study has also attempted to look at barriers perceived by paravets inefficient delivery of minor veterinary services. Paravets face various constraints in the delivery of prompt and efficient AHS at the farmer's doorstep. To get an overview, a *Pareto analysis* was done for the above issue. According to this analysis, it was hypothesized that 20.00 percent of the factors were causing 80 percent of the problems. This technique could be useful to find out whether by solving a few issues major bottlenecks, prompt and efficient delivery of minor health service could be executed or not. In the present context, it was well evident that cumulatively almost 7 major factors were contributing to 89.74 percent of the constraints, thereby the hypothesis has been disapproved (Figure 1). Hence, interventions should be planned with a wider focus to overcome barriers to inefficient delivery of minor veterinary services. Thus livestock-related

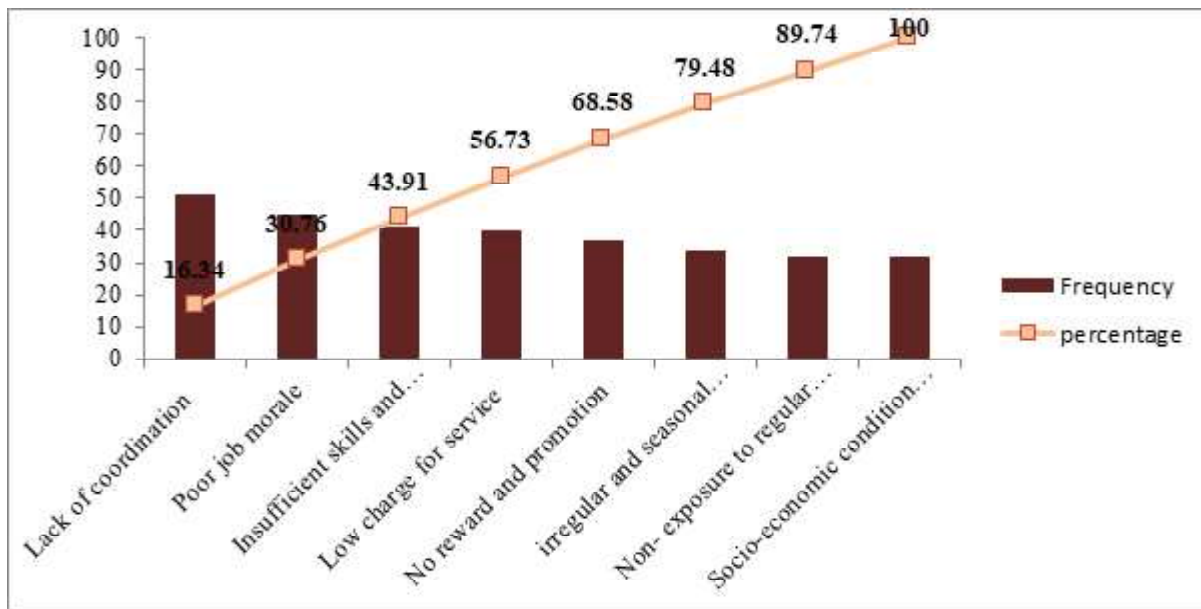


Fig. 1 Pareto Analysis of barriers for paravets inefficient delivery of AHS (in perspective of veterinarians)

Table 5 Distribution of respondents according to barriers perceived by veterinarians inefficient delivery of para- veterinary services (n=60)

Sl.No.	Challenges faced by paravets in delivery of services	Most potent	Potent	Least potent	RBQ values	Ranks
1	Lack of coordination between vets and paravets	19 (31.66)	22 (36.67)	19 (31.67)	200.00	III
2	Poor job morale	18 (30.00)	19 (31.67)	23 (38.33)	191.67	VI
3	Lack of sufficient skills and proficiency	25 (41.67)	20 (33.33)	15 (25.00)	216.67	II
4	Dynamic charging for service rendered to farmers	15 (25.00)	17 (28.33)	28 (46.67)	178.33	VIII
5	No reward and promotion	16 (26.67)	18 (30.00)	26 (43.33)	183.33	VII
6	Low, irregular and seasonal fluctuation in income	18 (30.00)	22 (36.67)	20 (33.33)	196.67	IV
7	Non- exposure to regular training programmes	26 (43.33)	25 (41.67)	9 (15.00)	228.33	I
8	The socio-economic condition of farmers affecting choice for AHS providers	15 (25.00)	27 (45.00)	18 (30.00)	195.00	V

development intervention for animal health service providers could be very effective (Barbuah, 2017). Almost all the veterinarians had agreed that multiple issues were plaguing AHS and hence demand urgent attention from the policymakers. This reasoning was supported by obtained RBQ values which were not showing a wide variation, thus it indicated equal concern about the various barriers by the veterinarian’s inefficient delivery of minor veterinary services. Hence interventions should be planned with a wider focus to resolve these constraints plaguing the delivery of minor veterinary services.

**Conclusions**

Strengthening the para-veterinary services, establish proper coordination with peer animal health service providers, and working under professional guidance and support could be effective in overcoming barriers and challenges in the delivery of minor veterinary services. Updating the existing level of knowledge and skill of paravets through various sources, standardized curriculum regular training programmes, and enhanced skills in diagnosis could help overcome the prioritized challenges. Multiple issues plaguing the delivery of animal health services should be solved using holistic and participatory efforts by involving stakeholders. Hence interventions should be

planned with a wider focus to resolve these constraints plaguing the delivery of minor veterinary services at farmer's doorstep. Overcoming the barriers and challenges along with suitable interventions could increase the accountability and responsibility of paravets to render services with high competency.

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## Pulsed electric field technology - Shelf life extension of milk

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**Abstract:** Application of Pulsed Electric field (PEF) in food processing is one of the innovative non thermal technologies which can be used as an alternative to traditional thermal processing. The nutritional and sensory qualities of the food are altered in thermal processing. As pulsed electric field inactivates microorganisms at ambient temperatures, organoleptic and nutritional properties of the food are retained in liquid foods such as milk, fruit juices. When compared to thermal processing, PEF processing is more energy efficient, as the processing time is only for few seconds. This study investigates the shelf life studies of raw milk processed using PEF technology. The quality control tests were done and physico – chemical parameters were analysed after PEF processing. A mean value of  $26.17 \pm 1.3$  was obtained for shelf life (in days) after PEF processing. The mean values of  $6.58 \pm 0.02$  to  $6.25 \pm 0.02$  and  $0.14 \pm 0.00$  to  $0.18 \pm 0.01$  were obtained for pH and acidity respectively during the 1<sup>st</sup> week to 4<sup>th</sup> week of storage. Pulsed electric field technology has shown positive effects on inactivating pathogenic bacteria and reducing the number of spoilage microorganisms in milk.

**Keywords:** Physico chemical analysis, PEF, Quality Control, ShelfLife,

Consumers are increasingly getting aware of the taste, colour, flavour and nutritional value of the foods they eat. Fresh food contains all the nutrients needed for good health, but because it may not always be possible to obtain fresh food, preservation

becomes necessary (Canovas et al. 1999). Thermal processing has been most commonly used in the food industry to increase shelf life and maintain food safety by inactivating spoilage and pathogenic microorganisms. However, studies have shown that colour, flavour, and nutrients are degraded by heat. Now there is a demand for alternative methods of food preservation. Non thermal methods provide an option because they offer fresh, minimally processed foods with little loss of colour, flavour and nutrients (Asaad and Hilphy, 2012). The use of high intensity pulsed electric fields (PEF) is one of the emerging non thermal processes which accomplishes food preservation with short treatment times (Mercado et al. 1995). PEF technology is not intended to heat food. Rather, it involves the application of a short burst of high voltage to a food placed between two electrodes for only microseconds (Jeyamkondan et al. 1999).

A lab model PEF equipment for liquid food preservation was used to process the milk at room temperature. The independent variables were voltage, distance between electrodes, pulse width and number of pulses. Dependent variables were pH, acidity, and shelf life. The electrodes used were parallel plate circular electrodes made of food grade stainless steel SS304. Raw milk samples were collected aseptically and transported to the lab under refrigerated condition from six different places of Alamathy village. Temperature of all the samples was adjusted to 30°C before PEF treatment. After processing, the samples were stored in glass bottles of 200mL capacity and kept at 5°C.

Quality control tests were conducted after PEF processing. As a platform test, temperature, organoleptic tests were carried out. Temperature was recorded after each trial using highly sensitive thermocouple to check the rise in temperature after processing. Colour and odour were determined using 9 points Hedonic scale rating by 10 selected untrained panellists. A sample volume of 100mL of processed milk sample was given to the panellists to give their ratings in comparison with control.

Chemical tests such as clot on boiling test, pH and total titratable acidity were conducted daily. Five millilitres of sample was taken in a test tube and placed in boiling water bath for five minutes. Appearance of flakes/clots on the walls of the test tube indicated positive for the clot on boiling test. pH was determined with a

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**Table 1** Quality control tests between control and PEF processed samples stored at 5°C(Mean±SE)<sup>@</sup>(N = 6)

Weeks	Sample(milk)	Colour	Odour	pH	Titratable acidity
1 <sup>st</sup> Week	Control	7.67±0.11	7.33±0.16	6.41±0.03	0.16±0.00
	Processed	7.67±0.11 <sup>NS</sup>	7.33±0.16 <sup>NS</sup>	6.58±0.02	0.14±0.00
	t - value	0.00	0.00	4.87**	0.02**

**Table 2** Quality control tests between PEF processed samples during the storage period (Mean±SE)<sup>@</sup>(N = 6)

Weeks	Sample(Milk)	Colour	Odour	pH	Titratable acidity
1 <sup>st</sup> Week	Processed	7.67±0.11 <sup>aA</sup>	7.33±0.16 <sup>aA</sup>	6.58±0.02 <sup>aB</sup>	0.14±0.00 <sup>aA</sup>
2 <sup>nd</sup> Week	Processed	7.65±0.11 <sup>aA</sup>	7.58±0.14 <sup>aA</sup>	6.52±0.03 <sup>aB</sup>	0.14±0.00 <sup>aA</sup>
3 <sup>rd</sup> Week	Processed	7.50±0.11 <sup>aA</sup>	7.65±0.11 <sup>aA</sup>	6.39±0.05 <sup>aA</sup>	0.16±0.00 <sup>aB</sup>
4 <sup>th</sup> Week	Processed	7.58±0.14 <sup>aA</sup>	7.58±0.14 <sup>aA</sup>	6.25±0.02 <sup>bA</sup>	0.18±0.01 <sup>aC</sup>
F - value		0.61 <sup>NS</sup>	0.20 <sup>NS</sup>	6.02**	19.07**

digital pH meter at room temperature. The pH meter was calibrated using pH buffer of 4.0, 7.0 and 9.2. The acidity of milk was estimated by titration method using 0.1N NaOH solution. The titratable acidity was expressed as per cent lactic acid and was determined by titration of a known amount of milk with 0.1 N NaOH using phenolphthalein as indicator.

The data obtained were statistically analysed by one way analysis of variance (ANOVA). The temperature of the milk samples subjected to PEF processing was found to be unchanged. There was no increase in temperature after PEF processing. The colour and odour were determined using 9 points hedonic scale. Table 1 shows the colour and odour values rated in 9 points hedonic scale for control and PEF treated milk samples stored at 5°C. Mean values of 7.67±0.11 and 7.33±0.16 were obtained for colour and odour for control and PEF processed samples during the 1<sup>st</sup> week of storage. It was observed that there was no significant difference ( $p>0.05$ ) in colour and odour. It was also observed from table 2 that there was no significant difference ( $p>0.05$ ) in colour and odour during the storage period of four weeks. Table 1 also shows the pH and titratable acidity of control and PEF processed samples during the 1<sup>st</sup> week of storage. It was observed that the processed samples were highly significant ( $p<0.01$ ) when compared to the control samples after one week. Table 2 shows the pH and titratable acidity of PEF processed samples for 4 weeks stored at 5°C. It was found that there was significant difference ( $p<0.01$ ) in the pH and titratable acidity values between the weeks and decreasing trend in mean values of pH and increasing trend in mean values of titratable acidity were observed during the storage period.

## Conclusion

It was observed that there was no significant difference in colour and odour between the control and PEF processed samples till the first week of storage period. It was also found that there was no significant difference in sensory attributes till 4<sup>th</sup> week during the storage period at 5°C. However, there was significant

difference in pH and titratable acidity. The values of pH and acidity revealed that the shelf life of the PEF processed milk extended to 3 – 4 weeks.

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