



Utility of first lactation fat energy corrected milk yield as a trait for genetic evaluation of Mehsana buffalo bulls using various sire evaluation methods

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ABSTRACT

India being a vegetarian country, milk is the major source of dietary bio-energy, but majority of animals are routinely being evaluated on the basis of their milk producing ability. The present study was aimed to come up with a sire evaluation methodology based on first lactation Fat Energy Corrected Milk Yield (FBE) in order to obtain an accurate and unbiased estimate of breeding value of Mehsana buffalo bulls and ranking them on the basis of their daughter's performance for future herd improvement. Data for the present study included 7825 she buffaloes in their first lactations, extended over a period of 25 years (1989 to 2013), from field progeny testing programme of Dudhsagar Research and Development Association (DURDA), Dudhsagar Dairy, Mehsana, Gujarat. The data were classified into different subclasses based on period, season, cluster and age at first calving group. The average breeding values of Mehsana buffalo bulls evaluated for FBE by least squares method (LSM), best linear unbiased prediction sire model (BLUP-SM) and best linear unbiased prediction animal model (BLUP-AM) methods were 1215.89, 1185.7 and 1185.7 kcal, respectively. BLUP-AM method had lowest error variance as compared to LSM and BLUP-SM methods of sire evaluation. This indicated that BLUP-AM was most efficient method.

Key words: BLUP-AM, BLUP-SM, Energy corrected milk yield, LSM

Livestock sector is an important sub sector of the agriculture of Indian economy. The buffalo require a relatively low level of inputs, thrive on low-quality crop residues (Resali 2000), forms the backbone of India's dairy industry, considered as the 'bearer cheque' of the rural flock, and known as India's milking machine (Balain 1999). The world buffalo population is estimated to be approximately 194.29 million (Hamid *et al.* 2017) out of which India possesses 108.7 million head which contribute about 55.95% of the world's buffalo population. India continues to be the largest producer of milk in world. Milk production in India, which was around 17–22 million tonnes in the 1960s, has increased to 176.3 million tonnes in 2017–18. Similarly, per capita availability of milk has increased from 307 g in 2013–14 to 375 g in 2017–18 (DAHD 2018).

According to World Health Organization, protein energy malnutrition (PEM) refers to "an imbalance between the supply of protein and energy and the body's demand for them to ensure optimal growth and function" (Bhutia 2014).

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It is seen that food unavailability, inadequate purchasing power or inappropriate utilization at household level contributes to food insecurity (FAO 2013). Though, the per capita food production increased by 75% in the past two decades, ironically this has not reflected in nutrition and food energy insecurity, which still remains high (Chand and Jumrani 2013). The practice of vegetarianism in India is the highest in the world. In India, a substantial proportion (35%) of the population are vegetarians (Shridhar *et al.* 2014), while 61.80% population of the Gujarat is vegetarian (SRS 2014). For such population, milk is a major source of dietary energy, protein and fat, contributing on an average 134 kcal of energy/capita per day, 8 g of protein/capita/day and 7.3 g of fat/capita per day (Tyagi *et al.* 2017). The growth of any country is depending on the availability of healthy human resource. In India, though the production of milk has increased many folds in last few decades, the relative contribution of milk and other dairy products towards the dietary energy is very less. Considering potential of milk to mitigate bio-energy insecurity, attempt was made to utilise first lactation fat energy corrected milk yield as a trait for evaluation of Mehsana buffalo bulls so, that energy production potential of bulls can be assessed.

In the past, augmentation of lactation milk yield has been emphasised through increase in the productivity of dairy animals. Huttman *et al.* (2009) opined that the energy balance should be included into future animal breeding

programs. Keeping in view the above fact, present study considered first lactation Fat Energy Corrected Milk Yield (FBE) exclusively based on average test day fat yield (ATDFY). The heritability of ATDFY is higher and therefore, it is equally likely that inheritance of FBE will be more than that of the inheritance of milk yield. There is dearth of report available regarding the sire evaluation in terms of milk energy produced by them. Moreover, importance of sire evaluation based on FBE is greater when price determining factor for milk is fat yield and not solely the total milk volume. The generated information will be useful in optimising the future breeding programmes for genetic improvement of the Mehsana buffalo.

MATERIALS AND METHODS

Source of data and general management practices: The first lactation monthly test-day milk yield data of Mehsana buffaloes calved between the years 1989 and 2013 at the farms located in the field progeny testing areas of Dudhsagar Research and Development Association (DURDA) were used. Dudhsagar Research and Development Association (DURDA) is actively engaged with the genetic improvement of buffaloes and cows. The Mehsana District Co-operative Milk Producers' Union Limited, with the help of National Dairy Development Board, Anand, is carrying out field progeny testing programme through DURDA in Mehsana buffaloes since 1985. Geographically, the farms are located in Mehsana District (area of over 4500 km²) in Gujarat, which is situated at the cross point of 23.40° N latitude and 72.30° E longitude, at an altitude of 265 m above mean sea level. The climate of region is tropical and semi-arid maximum temperature recorded is 45°C and minimum is 15°C. Average rainfall in the district is around 668 mm and rainy season lasts for approximately 45 days. Data of field progeny testing was available in the form of monthly test day milk yield (TDY). Ten test day monthly milk yield records taken at 6th days in milk yield (TDY1), 36 (TDY2), 66 (TDY3),.....276 (TDY10) of first lactation. Only those animals were considered which produced milk for at least 100 days, and more than 500 kg. There was plenty of green and dry fodder available in the area throughout the year. Concentrates were fed in wet, boiled and raw forms. Majority of the farmers had separate houses for their animals. *Kachcha* and *Pakka* types of houses with optimum ventilation with both open and close type of sheds were commonly used for keeping the animals. The buffaloes were milked twice a day at almost equal intervals by hand milking.

Field progeny testing methodology: The programme covers around 74 villages on an average each having 300–400 she buffaloes. About 1500 inseminations per bull (Procured from the native breeding tract and selected on the basis of their dam's best milk yield) were carried out by the village level inseminators, over a period of about two years so as to get the progenies born across different seasons and locations. The mates were identified by ear tagging at the time of first insemination. The details of insemination, pregnancy diagnosis, calving and lactation recorded by

village level inseminators and the livestock supervisors, were subjected to analysis on monthly basis. The lactation records for each test day milk yield (morning and evening) were taken at the farmer's door by milk recorders.

Calculation of first lactation total milk yield: Total first lactation milk yield were calculated as per the procedure suggested by the International Committee for Animal Recording (ICAR 2014) where, partial production from calving to first milk recording, partial production during all milk recordings and partial production from last milk recording to drying-off day were given their due weight age. First lactation fat energy corrected milk yield of Mehsana buffaloes was estimated as per Tripathy *et al.* (2017):

$$\text{FBE/ kg (cal)} = \{ \text{ATDFB (Average test day fat percent)} \times 9.23 \times 1000 \} / 103$$

where, the value 9.23 is the calories of heat evolved by the complete combustion of 1 g butter fat.

The data available for the study were grouped into cluster, periods, seasons and age at first calving groups. A total of 4665 livestock keepers from 74 villages, were clustered into 3 groups based on geographical location. The duration of 25 years was classified in to 5 periods each of 5 years. Each year of calving was further classified into 2 seasons (least calving season: January to June and most calving season: July to December) considering the seasonality of reproduction in buffaloes. Further, age at first calving of Mehsana buffaloes were classified into 3 groups using mean and 1 standard deviation of AFC in the population (Group I: 677–1100 days, Group II: 1101–1678 days and Group II: 1679–2522). Only the sires having records on at least 30 or more daughters were included in the present study.

Statistical analysis: Genetic evaluation of Mehsana buffalo bulls were carried out by least-squares method, Best Linear Unbiased Prediction – Sire Model (BLUP-SM) and Best Linear Unbiased Prediction – Animal Model (BLUP-AM) in which sires were treated as random effect and the other non-genetic factors (cluster, season, period and age at first calving group) were taken as fixed effects. The study was aimed to come up with a sire evaluation methodology based on FBE in order to obtain an accurate and unbiased estimate of breeding value of Mehsana buffalo bulls and ranking them on the basis of their daughter's performance for future herd improvement. The least-Squares analysis of variance (Harvey 1990) followed by Duncan's Multiple Range Test (DMRT) as modified by Kramer (1957) was used to assess the effect of various non-genetic factors used in the study. The data were adjusted for significant non-genetic factors before estimating the genetic parameters and breeding values. Paternal half sib correlation method (Becker 1975) was used to estimate the heritability of the traits.

The least-squares method (Harvey 1979) was used to estimate the breeding value of bulls. The model used in the analysis was

$$y_{ij} = \mu + S_i + e_{ij}$$

where y_{ij} , observation on j^{th} progeny of i^{th} sire; μ , population

mean; S_i , effect of i^{th} sire; e_{ij} , random error assumed to be normally and independently distributed with zero mean and constant variance NID $(0, \sigma_e^2)$.

Index (I) of i^{th} sire was estimated by following formula:

$$I = \mu + S_i$$

where I, Index of i^{th} sire; μ , population mean; sire least squares constant of i^{th} sire.

The breeding value of sire was estimated by best linear unbiased prediction (BLUP) method as given by Henderson (1975). In BLUP sire model (BLUP-SM), where (co)variance components were estimated by best linear unbiased prediction animal model (BLUP) in WOMBAT genetic analysis tool (Meyer 2007). The model used in the analysis was

$$y_{ijk} = Xb_i + Zs_j + e_{ijk}$$

where y_{ijk} , vector of observations; X, incidence matrix for fixed effects with dimension $(n \times p)$; Z, incidence matrix for random sire effect with dimension $(n \times q)$; b_i , vector of fixed effects with dimension $(p \times 1)$; S_j , vector of sire effect with dimension $(q \times 1)$ and e_{ijk} , vector of random residual effects with dimension $(n \times 1)$ with mean zero and variance $(0, \sigma_e^2)$. It was assumed that the expectations (E) of the variables are, $E(y) = Xb$; $E(s) = E(e) = 0$; $Var(s) = A\sigma_s^2$; $Var(e) = I\sigma_e^2$ and $Var(y) = ZAZ' \sigma_s^2 + R$.

From the above the mixed model equation developed as follows:

$$\begin{pmatrix} X'X & X'Z \\ Z'X & Z'Z + A^{-1}\alpha \end{pmatrix} \begin{pmatrix} \hat{b} \\ \hat{a} \end{pmatrix} = \begin{pmatrix} X'y \\ Z'y \end{pmatrix} \text{ where, } \alpha = \frac{\sigma_e^2}{\sigma_s^2} = \frac{(4-h^2)}{h^2}$$

and A is the numerator relationship matrix (NRM) of all the animals, which has nonzero off-diagonals only for the animal's parents, progeny, and mates. The elements of A can contain additive genetic effects, non-additive genetic effects, maternal effects, and permanent environmental effects. In BLUP-AM, the single trait animal model was considered for estimation of breeding values using WOMBAT software (Meyer, 2007) as

$$y_{ijk} = Xb_i + Zs_j + e_{ijk}$$

where y_{ijk} , vector of observations; b_i , vector of observation of fixed effects; a_j , vector of additive genetic effect (Random animal effect); X, design matrix/ Incidence matrix of fixed effect; Z, design matrix/ Incidence matrix of random effect and e_{ijk} , vector of residual errors with $E(y) = Xb$. Further, $E(s) = E(e) = 0$; $Var(a) = A\sigma_a^2$; $Var(e) = I\sigma_e^2 = R$, and $Cov(a, e) = 0$, so that $Var(y) = ZGZ' + R$, A is a numerator relationship matrix.

From above the Mixed Model Equation (MME) obtained was

$$\begin{pmatrix} X'X & X'Z \\ Z'X & Z'Z + A^{-1}\alpha \end{pmatrix} \begin{pmatrix} \hat{b} \\ \hat{a} \end{pmatrix} = \begin{pmatrix} X'y \\ Z'y \end{pmatrix}$$

where, $\alpha = \sigma_e^2/\sigma_a^2$ similar to sire model but $\sigma_a^2 = \sigma_e^2/0.25$.

The sires were ranked as per their breeding value for first lactation FBE. The effectiveness of sire evaluation

methods was judged by using various criteria, viz. within sire variance or error variance and rank correlations. The method with the lowest error variance was considered as most efficient method. Spearman's rank correlations between the ranks were estimated based on breeding values of sires derived by different methods. Higher rank correlation between the sire evaluation methods indicated higher degree of similarity of ranking by two methods.

RESULTS AND DISCUSSION

Total first lactation FBE in Mehsana buffaloes was estimated to be 1222.41 ± 5.19 kcal with the coefficient of variation of 24.6%. Comparison of mean by DMRT revealed that first lactation fat based FBE is greatly influenced ($P \leq 0.01$) by period and season of calving, cluster of calving and different age group at first calving. The genetic parameter (heritability) estimate for the trait was obtained to be 0.12 ± 0.02 , which was significantly ($P \leq 0.01$) different from zero.

Breeding value estimates for first lactation FBE: The average expected breeding value of Mehsana buffalo bulls for first lactation FBE by least squares method was 1215.89 kcal. The highest estimate of the breeding value from this method was 1453.16 kcal (19.51% higher than the average breeding value) while the lowest was 1070.96 kcal. As many as 63 sires (approximately 45%) out of 140 sires were having breeding values more than the average expected breeding value.

The average expected breeding value for first lactation FBE in Mehsana buffalo bulls by BLUP-SM was 1185.7 kcal, which ranges from 1421.06 kcal (19.84% higher than the average breeding value) to 1039.35 kcal. Out of total 140 sires under evaluation, 63 sires (approximately 45%) had breeding value above than the overall average breeding value. Similarly, the average expected breeding value of Mehsana buffalo bulls for first lactation FBE by BLUP-AM was again same as of BLUP-SM (1185.7 kcal) but the highest and lowest breeding values from this method were obtained to be 1472.75 kcal (24.20% higher than the average breeding value) and 978.94 kcal, respectively. The difference of 493.81 kcal between highest and lowest breeding values by this method was comparatively much higher than those observed in other methods of sire evaluation used in the present study. As many as 70 sires (50%) out of 140 sires were found with breeding values more than the average expected breeding value.

Effectiveness of various sire evaluation methods: The relative efficiencies for both the methods LSM and BLUP-SM were observed to be 78% when compared with BLUP-AM (Table 1).

Rank correlation coefficients were employed for determining the relative accuracy of a method with respect to the most efficient method (Table 2). The values of rank correlation coefficients of both LSM and BLUP-SM with most efficient BLUP-AM method were 0.94 (Table 3).

Sire evaluation is one of the most important aspects of dairy animal genetic improvement programme.

Table 1. Relative efficiencies of different sire evaluation methods for first lactation FBE in Mehsana buffaloes

Trait	Method	Error variance	Relative efficiency (%)
First lactation FBE	LSM	538662578	78.337
	BLUP-SM	538667000	78.336
	BLUP-AM	421974000	100

Table 2. Rank correlations between breeding values of Mehsana buffalo bulls for first lactation FBE by different methods

Method	LSM	BLUP-SM	BLUP-AM
LSM	1	0.998**	0.940**
BLUP-SM		1	0.940**
BLUP-AM			1

**Significant at (P<0.01).

Traditionally, it involves the estimation of breeding value of the bulls on the basis of first lactation 305-days milk yield of their daughters with a rationale to minimise generation interval. A new approach to evaluate the Mehsana buffalo sires on the basis of first lactation FBE was used in the present study.

Total first lactation FBE in Mehsana buffaloes was much higher than those reported by Tripathy (2015) in Sahiwal (776.14±17.58 kcal) and Tripathy *et al.* (2017) in crossbred cattle (1176.77±10.58 kcal). The moderate estimate of heritability indicates adequacy of additive genetic variance for affecting the selection to genetic improvement of the trait. Variation in first lactation FBE during different periods, season, and cluster of calving may be attributed to the

different management practices as well as different feed and fodder availability due to varying climatic conditions. The finding further substantiates the importance of buffaloes in country like India for nutritional energy security.

The expected breeding value of Mehsana buffalo bulls for first lactation FBE by least squares method and BLUP-SM in the present study was higher than those reported by Tripathy (2015) in Karan Fries and Sahiwal cattle. Effectiveness of various sire evaluation methods were determined by taking two parameters namely, efficiency and relative accuracy with respect to most efficient method. The sire evaluation method which has minimum error variance was considered to be the most efficient and was taken as the base for estimation of efficiency of other methods.

The relative efficiencies of various sire evaluation methods along with their error variances for first lactation FBE are presented in Table 1. It was observed that BLUP-AM method had lowest error variance for first lactation FBE as compared to other methods of sire evaluation. This indicated that BLUP-AM method was most efficient method. The relative efficiencies for both the methods LSM and BLUP-SM were observed to be 78%. Similar results were obtained by Chaudhari *et al.* (2018) in Mehsana buffaloes for FL305MY, where he concluded that BLUP-AM is more efficient than Simple Daughter average, Least Squares, BLUP-AM and BLUP-SM methods. Similar finding was also reported by Sun *et al.* (2009) in Danish Holstein cows and Singh *et al.* (2014) in Murrah buffaloes for FL305MY.

The estimates of rank correlation between BV of sires by all the methods were highly significant (P≤0.01). This indicates that the two methods; LSM and BLUP-SM are expected to give similar ranking to sires which are fairly

Table 3. Breeding values of top 20 ranking sires for first lactation FBE by different methods

Rank	LSM		BLUP-SM		BLUP-AM	
	LBV	SIRE	SBV	SIRE	ABV	SIRE
1	1453.17	66	1421.06	66	1472.76	168
2	1424.03	168	1387.11	168	1444.36	66
3	1400.23	163	1363.61	163	1428.34	163
4	1365.18	134	1332.13	134	1409.03	134
5	1362.45	86	1330.36	86	1360.28	187
6	1350.98	59	1319.03	59	1337.01	86
7	1340.5	149	1306.89	149	1335.8	149
8	1319.01	99	1287.35	99	1335.69	152
9	1305.23	183	1270.1	183	1332.63	183
10	1300.68	152	1269.3	77	1320.35	59
11	1300.48	154	1267.26	152	1318.57	99
12	1298.56	77	1266.97	154	1311.97	154
13	1296.16	63	1264.79	63	1307.1	160
14	1294.3	139	1261.6	139	1298.39	177
15	1294.27	187	1259.57	187	1288.88	162
16	1288.61	127	1258.94	57	1288.06	57
17	1288.38	131	1256.22	127	1282.28	29
18	1287.74	57	1255.59	131	1281.3	159
19	1283.25	122	1250.92	122	1281.28	176
20	1282.34	160	1250.65	97	1274.44	139

accurate as of the most efficient method (BLUP-AM). The present findings of very high and positive correlations between ranking of different sire evaluation methods was in agreement with the reports for FL305MY, of Chaudhari *et al.* (2018) in Mehsana buffaloes, Singh *et al.* (2014), Chaudhari *et al.* (2015) and Kumar *et al.* (2015) in Murrah buffaloes.

Although average estimates of breeding value for BLUP-SM and BLUP-AM was approximately same, the range of the same estimated by BLUP-AM was much higher. This is due to the fact that the BLUP-AM considers the entire relationship matrix available in the pedigree whereas, BLUP-SM only considers the relationship of animals with sires.

In conclusion, BLUP-AM method was relatively more efficient, accurate and stable with lowest genetic variation than other methods of sire evaluation. Use of this model is, therefore, recommended for genetic evaluation of Mehsana buffalo bulls.

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REFERENCES

- Balain D S. 1999. In flow and out flow of buffalo germplasm resources and their global contribution. Invited papers presented in short course on "characterization and conservation of domesticated livestock and poultry resources". 10- 19 May. National Bureau of Animal Genetic Resources (ICAR), Karnal.
- Becker W A. 1975. *Manual of Quantitative Genetics*. 3rd ed. Washington State University, Pullman, Washington.
- Bhutia D T. 2014. Protein energy malnutrition in India: The plight of our under five children. *Journal of Family Medicine and Primary Care* **3**(1): 63–67.
- Chand R and Jumrani J. 2013. Food security and under-nourishment in India: Assessment of alternative norms and the income effect. *Indian Journal of Agricultural Economics* **68**(1): 39–53.
- Chaudhari P N, Upadhyay M R, Patel A C, Patel S B and Rank D N. 2015. A comparison of different methods of sire evaluation for production and reproduction traits of Murrah graded buffaloes. *Indian Journal of Dairy Science* **68**(3): 259–65.
- Chaudhari J D, Gupta J P, Pandey D P, Shah R R, Prajapati B M, Parmar G A, Prajapati M N, Patel P A, Prajapati K B and Prajapati B H. 2018. Effectiveness of various sire evaluation methods in ranking Mehsana bulls based on FL305MY and TMY under field progeny testing programme. *Indian Journal of Animal Sciences* **88**(12): 1419–21.
- DAHD. 2018. Annual Report 2017–18. Department of Animal Husbandry, Dairying & Fisheries, Ministry of Agriculture & Farmers Welfare, Government of India, New Delhi.
- FAO. 2013. Hunger portal 2013. [Accessed 2018 March 19]. Available from: <http://www.fao.org/docrep/018/i3434e/i3434e00.htm/>.
- Hamid M A, Zaman M A, Rahman A and Hossain K M. 2017. Buffalo genetic resources and their conservation in Bangladesh. *Research Journal of Veterinary Sciences* **10**: 1–13.
- Harvey W R. 1979. Accuracy of simplified regressed least-squares (SRLS) vs. BLUP method for ranking sires. *Indian Journal of Animal Genetics and Breeding* **1**(1): 7–19.
- Harvey W R. 1990. User's Guide for LSMLWM and MIXMDL PC-2 version. Mixed Model Least-Squares and Maximum Likelihood Computer Programme. 4255. Mumford Drive, Columbus, Ohio 43220, USA.
- Henderson C R. 1975. Best linear unbiased prediction under a selection model. *Biometrics* **31**(2): 423–47.
- Hüttmann H, Stamer E, Junge W, Thaller G and Kalm E. 2009. Analysis of feed intake and energy balance of high-yielding first lactating Holstein cows with fixed and random regression models. *Animal* **3**(2): 181–88.
- ICAR. 2014. International Committee for Animal Recording International Agreement of Recording Practices. The General Assembly held in Berlin, Germany.
- Kramer C R. 1957. Extension of multiple range tests to group correlated means. *Biometrics* **13**: 13–18.
- Kumar V, Chakravaty A K, Patil C S, Shivahre P R and Gupta A K. 2015. Comparison among different conventional methods of sire evaluation in Murrah buffalo. *Indian Journal of Animal Sciences* **85**(6): 670–73.
- Meyer K. 2007. WOMBAT—A tool for mixed model analyses in quantitative genetics by restricted maximum likelihood (REML). *Journal of Zhejiang University Science (Biomedical & Biotechnology)* **8**(11): 815–21.
- Resali D P. 2000. Recent trends in buffalo production in Nepal: A review. Bulletin of the FAO Inter-Regional cooperative Research Network on Buffalo. *Europe-Near Estate* **14**: 6–10.
- Shridhar K, Dhillon P K, Bowen L, Kinra S, Bharathi A V, Prabhakaran D, Reddy K S and Ebrahim S. 2014. The association between a vegetarian diet and cardiovascular disease (CVD) risk factors in India: The Indian migration study. *PLoS ONE* **9**(10): e110586.
- Singh M, Singh A, Gupta A K, Chakravarty A K, Prakash V, Singh A and Sahoo S. 2014. Relative effectiveness of best linear unbiased prediction—animal model vis-à-vis other sire evaluation methods for genetic evaluation of Murrah sires. *Indian Journal of Dairy Science* **67**(6): 510–14.
- SRS. 2014. Sample Registration System (SRS) baseline survey 2014. Published by the Registrar General of India [accessed 2018 March 19]. http://www.censusindia.gov.in/vital_statistics/BASELINE%20TABLES07062016.pdf.
- Sun C, Madsen P, Nielsen U S, Zhang Y, Lund M S and Su G. 2009. Comparison between a sire model and an animal model for genetic evaluation of fertility traits in Danish Holstein population. *Journal of Dairy Science* **92**: 4063–71.
- Tripathy S. 2015. Genetic evaluation of Sahiwal and Karan-fries bulls for first lactation energy corrected milk production and productivity. M.V.Sc Thesis. National Dairy Research Institute, Karnal.
- Tripathy S, Chakravarty A, Mir M, Singh A, Jamuna V and Lathika S. 2017. Genetic and non-genetic parameters of first lactation milk yield, composition and energy traits in Karan-Fries cattle. *Journal of Animal Research* **7**(1): 49–57.
- Tyagi S, Kumar Y and Panwar D. 2017. Determination of fat and protein contents of khoa and chhana based sweets. *International Journal of Applied Current Research* **1**(1): 1–10.
- Tripathy S, Chakravarty A, Mir M, Singh A, Jamuna V and Lathika S. 2017. Genetic and non-genetic parameters of first lactation milk yield, composition and energy traits in Karan-Fries cattle. *Journal of Animal Research* **7**(1): 49–57.