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Genetic and Non-Genetic Parameters of First Lactation Milk Yield, Composition and Energy Traits in Karan-Fries Cattle

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ABSTRACT

Records of 1471 Karan-Fries cows from 102 sires with five or more daughters per sire during the period 1989-2013 were used to study genetic and non-genetic parameters for First lactation 305-days or less milk yield (FL305MY- kg), First lactation 305 days or less wet average (FL305WA- kg), Average test day milk yield (ATDMY- kg), Average test day fat percentage (ATDFP-%), Average test day fat yield (ATDFY-g), Fat based energy per kg (FBE/kg-cal) and Fat based energy per first lactation 305 days or less milk yield (FBE/FL305MY–kcal). The non-genetic parameters were analysed by fixed linear model. Heritability and phenotypic/genetic correlations were estimated by paternal half sib correlation method and sire variance and covariance, respectively. Period of calving was significant for all the traits. Season had significant effect on all the traits except ATDFP and FBE. Age group was significant for ATDFP only. The FBE/FL305MY had positive and significant ($P<0.01$) genetic and phenotypic correlations with FL305MY, FL305WA, ATDMY and ATDFY. The positive phenotypic correlation of ATDFP and FBE/kg with composition and energy traits revealed selection for an increased fat percentage will improve the concentrations of other constituents in milk. Higher estimates of heritability, significant genetic and phenotypic correlation between FL305MY and FBE/FL305MY revealed that any of the two traits can be used for genetic evaluation of Karan-Fries bulls when genetic improvement is sought.

Keywords: Lactation traits, Genetic and non-genetic parameters, Milk yield, Karan-Fries cattle

Genetic and non-genetic parameters are important tools for improving quantitative traits by selection. The potential for genetic improvement of a trait largely depends upon genetic variation existing in the population of interest. The genetic variability for a particular trait in a herd or population is measured by heritability estimate of a trait under given environmental conditions. The estimates of genetic and non-genetic parameters are helpful in determining the method of selection to predict direct and correlated response to selection, choosing a breeding system to be adopted for future improvement as well as in the estimation of genetic gains. If genetic correlation between the two traits is high, the selection for one trait would result in an improvement/deterioration for the other trait as a correlated response. The phenotypic correlation is an expression of observed relationship between the phenotypic performance of different traits while the degree of association between genes responsible for the additive variance of different traits is measured through genetic correlation. The genetic correlations give the information that genes affecting one trait also affect the other traits. In India, though the production of milk has increased many fold in last few decades, the relative contribution of milk and other dairy products towards the dietary energy is very less. Milk is a major source of dietary energy, protein and fat, contributing on average 134 kcal of energy/capita per day, 8 g of protein/capita/day and 7.3 g of fat/capita per day (FAOSTAT, 2012). Contribution of livestock to household income ranges widely from 2 % to more than 33 % in a number of developing countries (Pica-Ciamarra *et al.,* 2011). Livestock represents a large and growing employment sector (Smith *et al.,* 2013) and attention to milk constituents will not only increase marketing of milk products but also the nutritional value of the milk. So far, genetic and non-genetic parameters for Fat based energy per kg (FBE/kg-cal) and Fat based energy per first lactation 305 days or less milk yield (FBE/FL305MY- kcal) have not been studied. It is envisaged that this information will be useful for the formulation of future breeding strategy for the genetic improvement of Karan-Fries cattle in India and elsewhere.

MATERIALS AND METHODS

Description of the study area

Karnal is situated at an altitude of 235 to 252 meters (748 feet) above the mean sea level at 29.68°N latitude and 76.98^0E longitude in eastern zone of Haryana which comes under the Trans-Gangetic plain agro climatic zone of India. The climate that prevails is subtropical in nature. The temperature in summer months (April to June) ranges between 24°C — 44°C. Karnal experiences moderate rainfall in the months of July and lasts till September. Winters are extremely cold. The temperature ranges from 4°C to 32°C in winter months (October, November, December and January).

Standardization and Normalisation of data

The records of Karan-Fries cows of known pedigree and with normal lactation were included in the present study. The normal lactation was considered as a period of milk production by a cow for at least 100 days, the milk production in lactation was recorded a minimum of 500 kg and the cows calved and dried under normal physiological conditions. Out of 1471 Karan-Fries cows, Information of 158 Karan-Fries cows were not considered for this study due to various reasons like abortion, still birth and other reproductive problems.

Data source

Data on records of 1471 Karan-Fries cows from 102 sires, spread over a period of 25 years (1989-2013), maintained at ICAR-National Dairy Research Institute, Karnal were analyzed for first lactation traits viz; First lactation 305-day milk yield (FL305MY-kg), First lactation 305 days or less wet average (FL305 WA-kg), Average test day milk yield (ATDMY-kg), Average test day fat percentage (ATDFP-%), Average test day fat yield (ATDFY-g), Fat based energy per kg (FBE/kg-cal) and Fat based energy per first lactation 305 days or less milk yield (FBE/FL305MY-kcal). Sires having five or more progeny were evaluated on the basis of first lactation records. The study was classified into eight periods viz; 1(1989-1991); 2(1992-1994); 3(1995-1997); 4(1998-2000); 5(2001-2003); 6(2004-2006); 7(2007-2009) and 8(2010-2013). Each year was sub-classified into four seasons, depending on prevalent meteorological factors, feed and fodder availability as recorded in CSSRI, Karnal (Singh, 1983). Age at first calving of Karan-Fries cows was classified into three age groups using mean and one standard deviation after normalizing the distribution of AFC in the population as 1{≤ 865 (206)}; 2{865-1184 (903)} and 3{≥ 1184 (190)}.

Statistical analysis

The effect of non-genetic factors on normalised production traits were studied by least-squares analysis for non-orthogonal data, using fixed linear model (Harvey, 1990). The following models were used with assumptions that different components being fitted into the model were independent and additive. The model for First lactation traits was considered as:

$$Y_{ijkl} = \mu + P_i + S_j + (AG)_k + e_{ijkl}$$

where, Y_{ijklm} = observation on l^{th} cow in k^{th} age group of first calving, calved in j^{th} season and i^{th} period of calving; μ = overall mean; P_i = fixed effect of i^{th} period of calving (1 to 8); S_j = fixed effect of j^{th} season of calving (1 to 4); $(AG)_k$ = fixed effect of k^{th} age group of animals at first calving (1 to 3) and e_{ijklm} = random error ~ NID $(0, \sigma^2_e)$.

Paternal half sib correlation method (Becker, 1975) was used to estimate the heritability of first lactation traits using the following model:

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

Where, Y_{ij} = Observation of the j^{th} progeny of i^{th} sire; μ = Overall mean; S_i = Effect of i^{th} sire and e_{ij} = Random error NID (0, σ^2e). The S_i and e_{ij} are assumed to be independent of each other.

Genetic correlation (r_g) was estimated as:

$$r_{g\ (xy)} = \frac{COVs_{XY}}{\sqrt{\sigma^2_{s\ (x)}\ \sigma^2_{s\ (y)}}}$$

where, $COVs_{xy}$ = Sire component of covariance between traits X and Y and σ^2_S = Sire component of variance for traits X and Y, respectively.

Phenotypic correlation was estimated as:

$$r_{p\ (xy)} = \frac{COV\ s_{\ (XY)} + COVe_{\ (XY)}}{\sqrt{[\sigma^2_{S\ (X)} + \sigma^2_{e(X)}][\sigma^2_{S(Y)} + \sigma^2_{e(Y)}]}}$$

where, $COVs_{(xy)}$ = Sire component of covariance for traits X and Y and $\sigma^2_{e(X)}$ and $\sigma^2_{e(Y)}$ = Error component of variance for traits X and Y. The statistical significance of correlation was tested by the t-test as given by (Snedecor and Cochran, 1967). First lactation energy corrected milk of Karan-Fries cows was estimated by using standard practices as suggested by (Overmann and Sanmann, 1926) as follows:

Fat Based Energy per kg (cal) (FBE/kg) = (ATDFP × 9.23) × 1000 /103 where, the value 9.23 is the calories of heat evolved by the complete combustion of one gram butter fat.

Fat based energy per first lactation 305 days or less milk yield (kcal) (FBE/FL305MY) = (FBE/kg) × (FL305MY)

RESULTS AND DISCUSSION

Non-genetic parameters

Average, analysis of variance (ANOVA) of first lactation traits are presented in Tables 1 and 2.

First lactation 305 days or less milk yield in Karan-Fries cattle

Average FL305MY was estimated as 3121.80 ± 26.80 kg with coefficient of variation as 31.05 %. The result agreed with Divya (2012) and Singh (2014) who observed almost similar estimate. However, the present estimate was lower than the report of Kokate (2009) but was higher than the result of (Nehra, 2011). Overall least-squares mean of FL305MY was estimated as 3136.58 ± 35.26. Period of calving had significant effect (p<0.01) on FL305MY (Fig. 1). Similar result was found by (Kokate, 2009). Season of calving had significant effect (p<0.05) on FL305MY (Fig. 1) and was observed by Kokate (2009) and (Nehra, 2011).

Table 1: Mean, standard error and coefficients of variation of first lactation traits of Karan-Fries cattle

Trait	N	Mean± SE	CV (%)
FL305MY (kg)	1308	3121.80± 26.80	31.05
FL305W. A (kg)	1308	10.77± 0.08	26.59
ATDMY (kg)	1308	10.94± 0.08	27.64
ATDFP	1308	4.20± 0.01	8.18
ATDFY (g)	1308	446.74± 3.62	29.27
FBE/kg (cal)	1308	376.22± 0.85	8.18
FBE/FL305MY (kcal)	1308	1176.77± 10.58	32.52

SE= Standard error; CV= Coefficient of variation

FL305MY=First lactation 305-days or less milk yield, FL305WA=First lactation 305 days or less wet average, ATDMY=Average test day milk yield, ATDFP=Average test day fat percentage, ATDFY=Average test day fat yield, FBE/kg=Fat based energy per kg and FBE/FL305MY=Fat based energy per first lactation 305 days or less milk yield (kcal).

Table 2: Analysis of variance (M.S Values) of First lactation traits in Karan-Fries cattle

Sources of variation	FL305MY	FL305WA	ATDMY	ATDFP	ATDFY	FBE/kg	FBE/FL305MY
Period (7)	206770.70**	29.84**	25.60**	0.52**	42696.72**	4269.36**	309596.11**
Season (3)	2273314.60*	27.62**	25.09*	0.06	39946.21*	421.82	325136.53**
Age group (2)	1851643.83	35.84	40.09	0.16**	41959.59	1426.06	157828.56
Residual (1284)	723648.36	6.11	7.12	0.03	12604.26	798.15	105251.88

** P<0.01; * P<0.05

Non-significant effect of season of calving was observed by Divya (2012) and Singh (2014). Age group had no significant effect on FL305MY. Nehra (2011) and Divya (2012) also reported similar findings, whereas significant effect of age group was reported by (Singh, 2014).

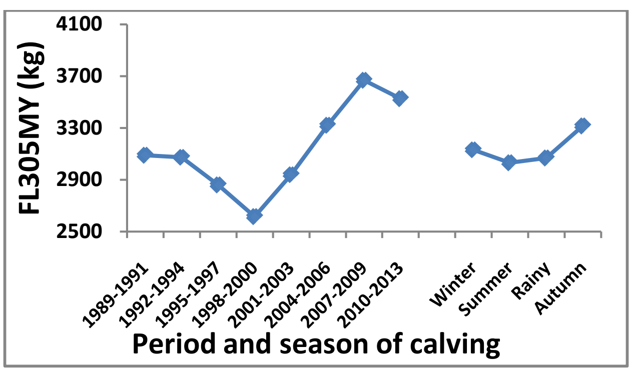

Fig. 1: Period and season wise variation of FL305MY

First lactation 305 wet average in Karan-Fries cattle

FL305WA was estimated as 10.77 ± 0.08 kg with coefficient of variation as 26.59 %. The present estimate is in agreement to the value reported by (Dash, 2014). Higher estimate than the present study was reported by (Sarkar *et al.,* 2006). Overall least-squares mean for FL305WA was estimated as 10.78 ± 0.10 kg. Period and season of calving had significant effect (p<0.01) whereas, age group had no significant effect on FL305WA (Fig. 2). Significant effect of period of calving was reported by (Tadesse *et al.,* 2003). Similarly, significant effect of season of calving was reported by (Missanjo *et al.,* 2010). Non-significant effect of season of calving was reported by (Shubhalakshmi *et al.,* 2009). Non-significant effect of age group was reported by (Singh, 1995).

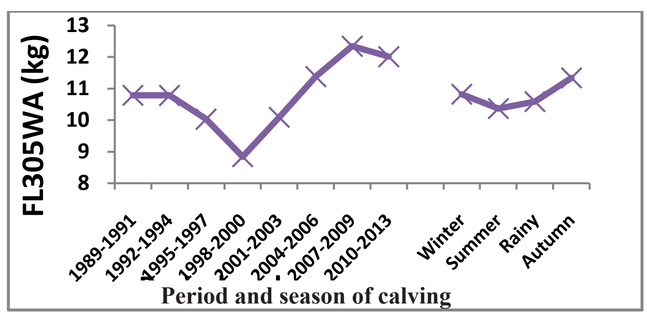

Fig. 2: Period and season wise variation of FL305WA

Average test day milk yield in Karan-Fries cattle

ATDMY was estimated as 10.94 ± 0.08 kg with coefficient of variation as 27.64 % and was almost in agreement to the value 11.19 ± 0.70 found by (Sarkar *et al.,* 2006). Higher estimates than the present study in Holstein Friesian cattle was reported by (Rekik *et al.,* 2009). Overall least-squares mean for ATDMYwas estimated as 11.01 ± 0.10 kg. Period (p<0.01) and season (p<0.05) of calving had significant effect on ATDMY (Fig. 3). Age group effect was non-significant. Mishra (2001) reported significant effect of period and season of calving on ATDMY in Karan-Fries cattle.

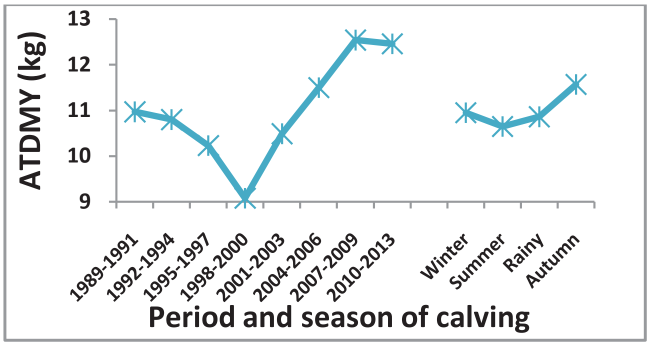

Fig. 3: Period and season wise variation of ATDMY

Average test day fat percentage in Karan-Fries cattle

ATDFP was estimated as 4.20 ± 0.01 % with coefficient of variation as 8.18 %. Lower estimate of Average lactational fat percentage was reported by Mishra (2001) and Sarkar *et al.* (2006) in Karan-Fries and Radhika *et al.* (2012) in HF crossbred cattle. Overall least-squares mean for ATDFP was estimated as 4.18 ± 0.007. Period of calving and age group had highly significant effect ($p<0.01$) whereas, season of calving was non-significant on ATDFP (Figure 4). The literature pertaining to the effect of non-genetic factors on ATDFP in Karan-Fries cattle are not available. Significant effect of age of calving in HF cattle was reported by Akhandpratap-verma *et al.* (2014) and season of calving in various breeds of cattle were reported by Missanjo *et al.* (2010) and (Nyamushambaa *et al.,* 2013). Non- significant effect of age of calving on lactational fat percentage in HF was observed by (Djemali and Berger, 1992).

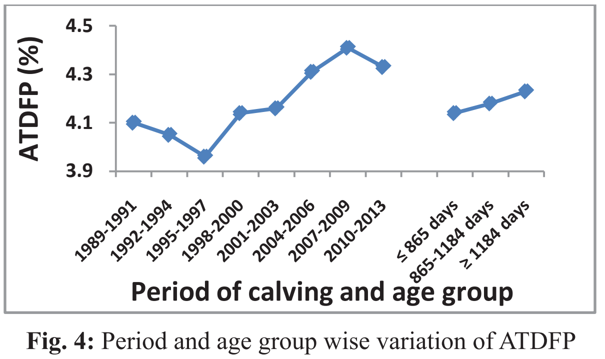

Fig. 4: Period and age group wise variation of ATDFP

Average test day fat yield in Karan-Fries cattle

ATDFY was estimated as 446.74 ± 3.62 g with coefficient of variation as 29.27 %. Harries (2007) reported the average test day fat yield in HF as 600 g. Pereira (2013) reported ATDFY as 400 g in HF crossbred cattle. Overall least-squares mean for ATDFY was estimated as 447.74 ± 4.36 g. Period ($p<0.01$) and season ($p<0.05$) of calving had significant effect (Fig. 5) whereas, age group effect was non-significant on ATDFY. The reports regarding effect of non-genetic factors on ATDFY are not available. Significant effect of period and season of calving on lactational fat yield in HF was reported by (Barbosa *et al.,* 2008).

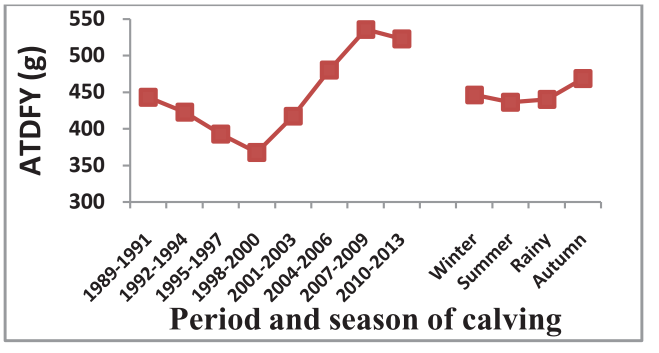

Fig. 5: Period and season wise variation of ATDFY

Fat based energy per kg in Karan-Fries cattle

The average FBE/kg was estimated as 376.22 ± 0.85 cal with coefficient of variation as 8.18 %. Overmann and Sanmann (1926) reported energy values of 582.4 cal per quart. Overall least-squares mean for FBE/kg was estimated as 376.20 ± 1.08 cal. Period of calving had significant ($p<0.01$) effect (Fig. 6) and season of calving and age group effect were non-significant on FBE/kg. The literature pertaining to FBE/kg in Karan-Fries cattle is not available.

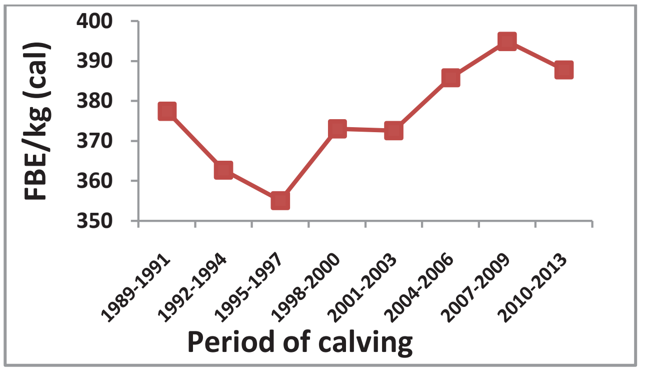

Fig. 6: Period wise variation of FBE/kg

Fat based energy per first lactation 305 days milk yield in Karan-Fries cattle

The average FBE/FL305MY was estimated as 1176.77 ± 10.58 kcal with coefficient of variation as 32.52 %. Overall least-squares mean for FBE/FL305MY was estimated as 1181.71 ± 13.46 kcal. Period and season of calving were highly ($p<0.01$) significant effect (Fig. 7). Age group at first calving was non-significant. The literature pertaining to FBE/FL305MY in Karan-Fries cattle is not available.

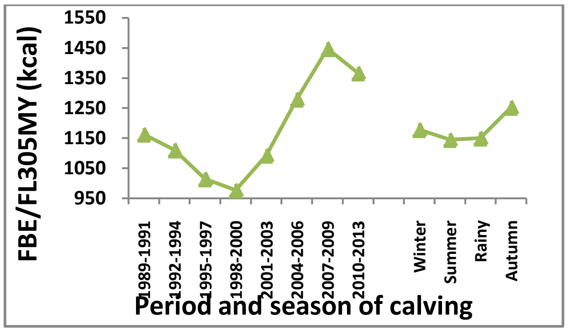

Fig. 7: Period and season wise variation of FBE/FL305MY

In the first four periods i.e., 1889-1991, the mean of all first lactation traits was decreasing but thereafter showed an increasing trend which indicates that management of animals were improved significantly from 2001-2003 in the herd. This may be due to the fact that silage based feeding system was replaced by a more efficient energy based feeding system from December, 2003 in the herd. Autumn season of calving had the most significant effect on FL305MY, FL305WA, ATDMY, ATDFY and FBE/FL305MY. The increase may be due to more favourable temperature and digestible feeds available in autumn season. Rehman *et al.* (2008) observed autumn calvers having highest first lactation 305-day milk yield in Sahiwal cows. Bahashwan *et al.* (2014) observed significant ($p < 0.05$) effect of autumn season of calving on daily milk yield in Dhofari cow's. The reason behind increase in ATDFP with increase in age at first calving may be cows maturing and calving at a higher age genetically, will have optimum body weight/condition and well developed reproductive system, such cows are likely to perform better for first lactation traits. Pirlo *et al.* (2000) observed positive effect of age at first calving on fat percentage in Italian Holsteins. Nilforooshan *et al.* (2004) observed that by reducing age at first calving in iranian Holsteins had a negative effect on milk fat. There are negative effects of lower and higher values of AFC on longevity and milk yield characteristics Simerl *et al.* (1992) however, reducing age at first calving is an effective method for dairy farmers to decrease payments and allow an earlier return on investment.

Table 3: Heritability (diagonal), genetic (below) and phenotypic (above diagonal) correlation of First lactation traits in Karan-Fries cattle

TRAIT	FL305MY	FL305WA	ATDMY	ATDFP	ATDFY	FBE/kg	FBE/FL305MY
FL305MY	**0.49 ± 0.09**	0.935** ±0.01	0.86** ± 0.01	-0.08 ± 0.03	0.82**± 0.02	-0.04 ± 0.03	0.97** ± 0.01
FL305WA	0.96** ± 0.06	**0.51 ± 0.10**	0.91**± 0.01	-0.087± 0.03	0.86** ± 0.01	-0.04± 0.03	0.91**± 0.01
ATDMY	0.99** ± 0.02	0.10 ± 1.00	**0.35 ± 0.08**	-0.09± 0.03	0.96** ± 0.01	-0.04 ± 0.03	0.86** ± 0.02
ATDFP	0.152 ± 0.18	0.013 ± 0.90	0.056 ± 0.19	**0.291 ± 0.08**	0.075 ± 0.03	0.62**± 0.02	0.07± 0.03
ATDFY	0.97**± 0.02	0.18 ± 0.08	0.96** ± 0.06	0.179 ± 0.19	**0.34 ± 0.08**	NE	0.86** ± 0.01
FBE/kg	0.21± 0.33	0.24 ± 0.38	0.11 ± 0.38	0.95** ± 0.02	0.09 ± 0.36	**0.47 ± 0.26**	0.23 ± 0.05
FBE/FL305MY	0.95** ± 0.02	0.93**± 0.009	0.98** ± 0.02	0.22 ± 0.17	0.92** ± 0.02	NE	**0.51± 0.10**

** P≤ 0.01

Genetic parameters

The heritability, genetic and phenotypic correlations of first lactation traits of Karan-Fries cattle are presented in Table 3.

Heritability of first lactation traits

The heritability for FL305MY, FL305WA, FBE/kg and BE/FL305MY was high in magnitude viz; 0.49 ± 0.09, 0.51± 0.10, 0.47 ± 0.26 and 0.51 ± 0.10 respectively and thus indicates sufficient additive genetic variance for affecting the selection to improve the traits genetically. Therefore, it is important to consider these traits when recruiting sires for breeding program. The results for FL305MY agreed with Nehra (2011) who observed h^2 estimate of (0.48) in KF cows. The present h^2 estimate was higher than report of Divya (2012), Singh (2013, 2014) who reported values of 0.20, 0.34 and 0.35, respectively. These reports showed that there was wide genetic variation for FL305MY in KF cows. Literature pertaining to heritability estimates of FBE/kg and FBE/FL305MY are not available.

The h^2 estimates for ATDMY, ATDFP and ATDFY were 0.35 ± 0.08, 0.29 ± 0.08 and 0.34 ± 0.08 respectively. The estimates of heritability of these traits reveal genetic factors regulating lesser additive gene action. The present h^2 estimate for ATDFP is in agreement to the value of 0.29 reported by Mishra and Joshi (2004) but lesser than (0.39) h^2 estimate as reported by (Mishra, 2001). Osman *et al.* (2013) reported (0.90) heritability of average test day fat percentage in HF cattle. The literature pertaining to heritability estimates of ATDMY and ATDFY in Karan-Fries cattle are not available. However the heritability estimate (0.21) of lactational fat yield in HF was reported by (Kunaka, 2001). The ATMDY heritability revealed its improvement through accurate recording of the daily milk yield and improvised managemental practices and with its high genetic and phenotypic correlation with ATDFP and ATDFY will result in improvement in all the traits.

Phenotypic correlations

The fat based energy per first lactation 305 days or less milk yield (FBE/FL305MY) had positive and significant (P<0.01) phenotypic correlations with FL305MY, FL305WA, ATDMY, ATDFY and were estimated as 0.972 ± 0.001, 0.914 ± 0.001, 0.862 ± 0.002, 0.861 ± 0.002, respectively whereas, it had low correlation with ATDFP (0.07 ± 0.03). These correlations indicated that higher FL305MY were related with higher FBE/FL305MY on a phenotypic scale. Very high correlations also indicate that sires can be evaluated for milk yield on (FL305MY or FBE/FL305MY) and improvement on one trait could bring a concomitant increase on the other. The ATDFP and FBE/kg had negative phenotypic correlations with FL305MY, FL305WA and ATDMY whereas, positive correlations with the constituent and energy traits. Mishra (2001) reported negative and non-significant phenotypic correlation of lactational fat percentage with other milk yield traits where as the correlation with other milk composition traits were reported positive and statistically significant. The literature reported by Mishra (2001) also suggested that, selection for an increased fat percentage will improve the concentrations of other constituents in milk. Singh (1973) also reported negative phenotypic correlations of fat percentage with first lactation 305 milk yield in Sahiwal cattle.

Genetic correlations

The genetic correlations of FBE/FL305MY with FL305MY, FL305WA, ATDMY and ATDFY were found high and statistically significant (P<0.01) with values 0.95 ± 0.002, 0.93 ± 0.009, 0.98 ± 0.002 and 0.92 ± 0.002 respectively whereas, it had low correlation with ATDFP. The correlation between ATDFP and FBE/kg was high and significant (P<0.01) on both genetic as well as phenotypic scale. The genetic correlations between first lactation traits were significantly high and positive which indicate simultaneous improvement in other traits while selecting any one of them.

CONCLUSION

The effect of period and season of calving and age at first calving on the first lactation traits suggested that traits should be adjusted for non-genetic factors. The genetic and phenotypic correlations between FL305MY and FBE/FL305MY were generally on higher side, suggesting that any of the traits can be used for evaluation of Karan-Fries bulls. The high heritability of FBE/FL305MY showed the importance of including the trait in the selection index when genetic improvement is sought. Effective breeding programs depend on the accuracy of genetic and phenotypic parameter estimates, which include heritability and correlation between traits. In sire evaluation programmes, depending upon the goal of a breeding programme, model with appropriate traits combination should be used.

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