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Review Article

GENETIC AND NON-GENETIC FACTORS AFFECTING MILK COMPOSITION IN DAIRY COWS

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ABSTRACT
Milk constituents such as fat, protein, SNF, lactose, total solids and casein %, especially β-casein A1 and A2 have so far received little attention in breed improvement programmes. Genetic and non-genetic factors play a significant effect on the variations of milk yield and their components. The nutritive value of the milk is based on its components. Nowadays, milk pricing system is also based on the percentage of milk composition, mainly fat, Snf, TS, A1 and A2 beta-casein. Indigenous dairy cattle breeds are higher in milk composition traits.

KEYWORDS: Milk, constituents, genetic, non-genetic and betacasein.

INTRODUCTION

The composition of milk from dairy cows is of major interest to milk producers, processors and consumers because of its health related issues and also market demand. It directly affects the economy of milk production as well as economic condition of these dairy farmers. The composition of milk has received little attention in breeding programs. To change the composition of milk, it requires knowledge of the relative influence of genetic and environmental factors affecting milk constituents traits. However, there is less information on the effects of breed/species, stage of lactation, parity, period/year, season of calving, dry period, body condition score, body weight, pregnancy, service period, heat stress, lamness, milking temperament, sex of calf born and sire on milk composition traits. This can be achieved by an in-depth investigation of all factors affecting the milk composition in a holistic manner. Since, the information of milk composition is scanty on genetic and non-genetic factors influencing milk constituents traits in Indian dairy cattle especially in tharparkar . The present review is therefore, an attempt to analyse the factors influencing milk constituents traits in tharparkar cows and other dairy cattle breeds.

Milk Composition

Milk is composed of water, proteins, amino acids, vitamins, lipids, fatty acids and minerals. It contains the essential nutrients needed for growth and development of human kind well as for the neonates animals. Studies on indigenous cows (Zebu type) have revealed that A1 allele is more frequent in exotic cattle (A1 milk) while Indian native dairy cows have only A2 allele and hence are a source for safe milk (Mishra *et al*., 2009). Indian milk breeds of cows (Red Sindhi, Sahiwal, Tharparkar, Gir and Rathi) produce 100% A2 milk whereas foreign breeds (HF and Jersey produces around 60 % A1 milk (NBAGR, 2011). Ng-Kwai-Hang and Grosclaude, 2002 reported that A1 β-casein is absent in the milk of pure Asian and African Cattle. So, our indigenous cows produce A2 milk.

TABLE1. Milk Composition in dairy cows

Breeds of cattle	Fat%	Protein%	Casein%	SNF%	Lactose%	TS%	Reference
Tharparkar	4.37 ±0.20	3.92±0.05	-	10.13 ±0.12	5.35 ±0.08	14.22 ±0.25	Sarkar *et al*., 2006
-do-	-	-	-	-	-	13.53 ± 0.08	Patel, 1994
-do-	-	-	-	-	-	13.53 ±0.08	Sharma *et al*., 1983
-do-	-	4.9 ± 0.01	-	9.1 ±0.01	-	-	Lal *et al*., 1984
Karan Fries	3.91 ±0.14	3.58 ±0.04	-	9.78 ±0.09	5.39 ±0.5	13.69 ±:0.7	Sarkar *et al*.,2006
Karan Fries	4.02 ± 0.02	3.35 ± 0.03	2.68 ± 0.02	-	-	-	Misra and Joshi, 2009
Sahiwal	4.23 ±0.18	3.60 ±0.05	-	9.77 ±0.11	5.38 ±0.07	13.99 ±0.23	Sarkar *et al*.,2006
Assam native cattle	5.34 ±0.06	3.04 ±0.03	-	8.54 ±0.03	-	13.88 ±0.07	Kayastha *et al*., 2008

Importance of milk constituents

Many studies have been carried out to determine the composition of milk, its nutritional value and many have proved that, despite the negative perception milk receives, there is a wide range of health benefits that are associated with milk components (Knowles *et al*., 2006). Milk calcium is essential for healthy bones and teeth and helps prevent hypertension. Selenium is an important component of the immune and antioxidant system in humans. Presence of several bioactive components and essential amino and fatty acids (FA) in milk, makes milk to have higher biological value than meat. Omega-3 FA is associated with prevention of cardiovascular diseases, cancers and other diseases. The β-casein composition of the protein fraction has become of special interest recently because of a possible relationship between β-casein genotype and the health of populations of consumers (Keith Woodford, 2007; Mishra *et al*., 2009; Sodhi *et al*., 2013). A1 milk is responsible for many human disorders like Type 1 diabetes, autism and heart diseases but A2 milk does not cause such type of illnesses (Keith Woodford, 2007; Mishra *et al*., 2009; Sodhi *et al*., 2001), a higher incidence of diabetes (Elliott *et al*., 1999). A1-β casein is also associated with coronary heart disease (McLachlan, 2001). Presence of these qualities in milk, it has become an important part of daily diet (Schonfeldt *et al*., 2012).

Factors affecting milk composition

Milk composition is not constant in dairy cows and is influenced by breed (Sarkar *et al*., 2006; Kayastha *et al*., 2008; Padekar and Bhoite, 2002; Singh *et al*., 2002; Gaur *et al*., 2002; Patel, 1994;) and species differences, parity or lactation order (Lal *et al*., 1984; Sarkar *et al*., 2006; Kayastha *et al*., 2008), age and size of the cow, dietary composition, season (and Sarkar *et al*., 2006; Araora *et al*., 2013; Thomas *et al*., 2015), pregnancy (Mushtaq *et al*., 2009; Gurmessa *et al*., 2012;), Sire (Thomas *et al*., 2009; Hanus *et al*., 2011; Broucek *et al*., 2004; Misra and Joshi, 2004; Ahn et al., 2004; Shavaby, 1988), service period and BCS (Mushtag *et al*., 2009; Dechow *et al*., 2002; Buckley *et al*., 2000b), Dry period (DP) (Pezeshki *et al*., 2008, Santschi *et al*., 2011; Anderson *et al*., 2005; *Rasatani et al*., 2005; Safa *et al*., 2013), lamness, heat stress, behaviour or milking temperament, udder health, locality and stage of lactation (2006; Sarkar *et al*., 2006; Kayastha *et al*., 2008; Arora *et al*.,2013).

The effect of Species/Breed on Milk composition

Effect of breeds (TP, SW, MUH & KF) were reported to be significant for all the traits except lactose % (Sarkar *et al*., 2006). The milk of native cattle of Assam has higher fat (5.34±0.06), SNF (8.54±0.03) and protein content (3.04±0.03) compared to most of the Indian breeds of cattle (Kayastha *et al*., 2008). The lower milk fat % of 4.73±0.39 is seen in Gir cows (Padekar and Bhoite, 2002). Lower fat% is also observed in Deoni cows (Singh *et al*., 2002). SNF % in Milk of Hariana cow is 9.05±0.01 (Kaushik and Tandon, 1979). Higher SNF value (8.5±0.5 %) is also reported in Ongole cows (Gaur *et al.,* 2002). The overall average % of the protein in Hariana cows milk was reported to be 3.33±0.02 % (Kaushik, 1970). Lactose varies greatly among species (Jannes and Solan, 1970). The % of lactose in milk of HFx Native cattle crosses are higher than that of native cattle (Lee, 1977). The mean TS % in Tharparkar cows was reported as 13.53±0.08 (Patel, 1994). The mean TS % in Gir cows was reported as 13.68±0.04 (Padekar and Bhoite, 2002).

The effect of parity on milk composition

There is report that milk fat (4.9 ± 0.02%) and snf (9.1± 0.01%) contents of sahiwal cows attained a peak value in the third lactations and declined thereafter to the minimum (4.8 ± 0.06 % fat and 9.0 ± 0.05 snf) in the 10th (Lal *et al*., 1984). Effect of order of parities was not significant for the milk composition traits and also the TDMY was the highest in 3-5th order of lactation of parity, but the differences were not significant according to Sarkar *et al*., 2006. Variation in all the milk constituents of Assam native cattle due to effect of order of lactation was found to be non significant according to Kayastha *et al*., 2008. Lower fat and snf content are observed at later lactations than earlier lactations (Johnson *et al*., 1961 and Vanschoubroek *et al*. 1964). Fat and SNF are not affected significantly with increasing age of the cows (Arora and Gupta, 1968; Patel *et aI*., 1974). The age of the lactating animal is an important physiological factor affecting the composition of milk (Patel *et aI*., 1974;Sadana *et al*., 1978; Avtar Singh *et al*., 1979). Lactation number of the animal has no significant effect on fat and snf content of tharparkar cow, Red sindhi and Karan swiss cow (Lal *et al*., 1984).

The effect of stage of Lactation on milk composition

Effect of stage of lactation is significant for protein, SNF, lactose, total solid and casein % but not for fat %, although % is higher at later stages of lactation in tharparkar cows (Sarkar *et al*., 2006). Stage of lactation has significant effect on fat, snf and total solids % but non-significant effect on protein% in milk of native cattle of Assam (Kayastha *et al*., 2008). In the early lactation fat and protein decrease and lactose concentration increases, whereas in the late lactation fat and protein increases and lactose decrease (Arora *et al*., 2013).

The effect of pregnancy on milk composition

Pregnancy significantly affects the milk yield but not its composition in crossedbred cow (Mushtaq *et al*., 2009). The snf, protein and lactose contents of the milk were significantly ($p<0.05$) different in pregnancy but fat and ash were not affected in HF crossbred (Gurmessa *et al*., 2012). Pregnancy significantly affected milk as the yield was higher in non-pregnant than pregnant HF crossbred (Gurmessa *et al*., 2012).

The effect of Sire on milk composition

Significant effect ($p<0.05$) of sire on fat% was seen in crossed bred cattle of Kerala and differences in % of protein, snf and total solids were observed but they were not significantly affected by sire according to Thomas *et al*., 2009. SNF, Casein, Lactose were significantly influenced by sire but not fat in Czech Fleckvieh (CF) breed as reported by Hanus *et al*., 2011. The effect of the sire was significantly expressed in milk production and in the content of fat, proteins, lactose, snf and total solids in Czech cow as reported by Broucek *et al*., 2004. Sire has significant effect on fat, snf, protein and tolal solids in karan Fries cows (Misra and Joshi, 2004). Sire significantly affects all milk fat, protein, lactose and tolal solids in H.F cows (Ahn *et al*., 2004). Sire has no significant effect for lactose %.

The effect of season on milk composition

Milk composition traits were highest in hot humid season but lowest in milk yield as compared to other seasons according to Sarkar *et al*., 2006. The lactose content was less, in winter in comparison to summer where as the protein content was high in winter in comparison to summer as reported by Araora *et al*., 2013. The season had a highly significant influence ($p<0.01$) on milk composition traits of dairy cattle in humid tropics as per Thomas *et al*., 2015.

The effect of DP on milk composition

The cows provided with <20 days DP were best with respect to milk production and beyond this resulted in gradual decline in 305 MY (Stephen Hana, 2014). No significant effects of DP on fat % (Pezeshki *et al*., 2008, Santschi *et al*., 2011). Fat yield is generally unaffected by DP length (Anderson *et al*., 2005). Small increase in fat% of 3.86% and 4.08% was observed following DP of 56d and 28d respectively by *Rasatani et al*., 2005. Protein% is often increased in the lactation following Short DP (Rastani *et al*., 2005; Watters *et al*., 2008, Santschi *et al*., 2011). There is decreased in milk yield but increase in snf, protein and lactose following short DP in HF cows (Safa *et al*., 2013).

The effect of BCS on milk composition

BCS slightly correlated negatively with fat, lactose, SNF and milk yield while positively with protein in crossed bred cattle according to Mushtag *et al*., 2009. Cows that are genetically superior inclined to lose more BCS in early lactation and tend to have higher yields of milk, fat and protein (Dechow *et al*., 2002). Genetically superior milk producing cows tend to have genetically lower BCS throughout lactation (Buckley *et al*., 2000b).

Heritability of milk constituents

The heritability estimates ranged from 0.13 to 0.29 for fat, protein, SNF and total solids; 0.13 to 0.20 for their yields and 0.18 to 0.24 for 305 days or less milk yield and total lactation milk yield in KF according to Misra *et al*., 2004. Highest heritability of fat (0.74%) has been reported in Black and white cows in Netherlands (Korver and Van Avendonk, 1989). Lowest heritability value for fat (0.11±0.15) has been reported in Hariana cows (Kaushik and Tandon, 1979). Highest value of heritability for protein, snf and lactose were reported as 0.76 and 0.83 in HF (Lankamp, 1959). Heritability for protein, snf and lactose were reported as 0.1 in Jersey (Sharma *et al*., 1983).

Genetic correlations of milk constituents

Milk yield was negatively correlated with milk constituent's % but positively correlated with their yields according to Ghosh and Anantakrishnan, 1965. Genetic correlations were negative for milk yield with fat and protein% in Red Sindhi and Sahiwal as reported by Chawla and Mishra, 1976. Genetic correlations (0.75±0.53) between milk yield and fat% was significant but negative in Hariana cows according to Arora *et al*., 1978. The genetic correlation of fat% with protein, snf, TS and lactose% was reported as 0.89, 0.77, 0.97, -0.97, -0.09 and -0.53 respectively; and with their yields as 0.67, 0.30, 0.67 and 0.07, respectively in HF cows. (Sharma *et al*., 1983).Genetic correlation between snf and protein has been reported as 0.79 (Butcher *et al*., 1960).

Phenotypic correlations of milk constituents

Phenotypic correlations were negative for milk yield with fat and protein% in Red Sindhi and Sahiwal as reported by Chawla and Mishra, 1976. The phenotypic correlation of milk yield is negatively correlated with fat, protein, total solids in HF cows (Sharma *et al*., 1983). The phenotypic correlation of fat% in HF cows with protein, snf, TS and lactose were positive as 0.24, 0.38, 0.92 and 0.12 respectively; and with their yield as 0.70, 0.74, 0.87 and 0.72, respectively according to Sharma *et al*., 1983. Phenotypic correlation of snf% with milk yield was -0.20 (Legates, 1960). Positive phenotypic correlation between snf and protein% was calculated as 0.8 by Ketelars, 1956.

CONCLUSION

More attention should be emphasized on milk constituents as a selection criteria in breeding programs to obtain pure, clean and healthy milk and milk products. Such production of good quality milk and dairy products will fetch more returns to their enterprise. It is very essential for the milk producers as well as the consumers to know about the various chemical constituents of the milk they use as milk has many health beneficial components as well as negative aspects too.

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