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Variation in milk constituents during different parity and seasons in Murrah buffaloes

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ABSTRACT

The characteristics of lactation curves and effect of lactation stage, parity and season on milk yield and level of its constituents were investigated in 100 buffaloes varying from parities 1 to 7 at institute farm. Average lactation length overall experimental animals was 323 days. Milk yield,% fat, protein and lactose varied from 4.3 to 9.5 kg, 7.19±0.04 to 8.63±0.07g%, 3.46±0.01 to 3.56 g% and 4.36 to 4.60% respectively. Effect of lactation stage on milk yield, milk fat and lactose content was significant. Milk protein did not vary significantly over the stages of lactation. Lactose increased significantly up to sixth month of lactation, however, change in milk lactose content was not significant thereafter. Milk yield declined significantly during late stage of lactation with a significant concomitant increase in milk fat. Content of milk protein and lactose remained the least variable milk constituents. The study revealed that trend in variation of milk yield and major milk constituents during entire lactation in buffaloes was comparable with cows. Level of milk yield in buffaloes decreased by 9% during hot and humid months due to summer stress and increased by 10.6% during winter in present study. Milk fat level decreased and protein content increased significantly during winter. Milk fat and protein levels were more in advance parities indicating significant effect of parity on milk composition. Data on levels of milk constituents varying over the lactation stages and parities in buffaloes were important phenotype indices for developing genomic selection programme in buffaloes.

Key words: Murrah buffaloes, Milk fat, Peak yield, Protein, Lactose, Season, Stage of lactation

Livestock sector has emerged as a fast growing sub-sector of agriculture in country. It is important to determine the milk production potential of animal and milk composition in lactation curve to improve milk yield and obtain desired quality. Estimates of lactation parameters are useful for assessing the nutritional as well as health status of animals (Dudouet 1982) as under-fed animals have lower proportion of milk components (Egbowon 2004). Also, persistency of lactation is important in judging the production ability of animal. Persistency is a function which is associated with rate of decline in yield, once animal reaches peak milk yield (Appuhamy *et al*. 2007), revealing the production potential of a particular animal. However, stage of lactation and parity of animal and season of calving are some other major factors which influence milk yield and its composition in cattle (Ibeawuchi and Dangut 1996), buffalo (Sekerden Ozel 1999) and goat (Akingbade *et al.* 2003).

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The present study was conducted to generate database on the level of variation in milk yield and different milk constituents during the entire lactation period in Murrah buffaloes which is mandatory phenotype indices to establish phenotype- genotype interactions for future technological interventions as genomic selection for sustainable buffalo breeding.

MATERIALS AND METHODS

Animals and management: Buffaloes (90; first to seventh parity), maintained at the CIRB farm, Hisar, were kept under farm management. Requirement of buffaloes was met through green (*ad lib.)* and concentrate according to milk production. All the experimental animals were offered identical ration to meet production/maintenance requirement to negate the feeding effect on milk production. The animals had free access to water throughout the day.

Sample collection and analysis: Milk samples were collected from individual animals at weekly interval during evening.

Dams were allowed to nurse calf briefly for stimulating milk let down. Dams were hand-milked and 100 ml milk was collected covering all the four quarters. Milk yield was recorded after complete milking. Ten ml milk sample was subjected to ultrasonic milk analyser for fat, protein, SNF and lactose determination. Lactoscan analysis is done by chemical methods as Gerber – for fat, gravimetric- for SNF, Kjeldahl - for protein determination covered by Lactoscan SLP, software version 60.

Statistical analysis: A multivariate analysis (Johnson and Wichern 2002) of variance was performed to observe pair wise mean differences in milk yield and composition over different sources of variation i.e. seasons, parity and stage of lactation throughout the lactation period i.e. early (first 90d), mid (91 to 180 d) and late (181 to 280 d) lactation using Duncan multiple range test. Test of significance among the means of milk yield and milk constituents with respect to seasons, parity and lactation stages was studied as per the MANOVA test criteria and 'F' approximation Analysis.

RESULTS AND DISCUSSION

Estimates of milk yield and its composition were determined in 100 multi-parous buffaloes, varying from first to seventh parities over winter, summer and autumn seasons. Average lactation length was determined as 323 days in experimental animals. The trend in milk yield in buffaloes during the entire lactation is shown in Fig. 1.

Lactation: The average milk yield over the entire lactation in 100 lactating animals, allocated to different parities from parity 1 to 7 over 3 seasons, winter, summer and autumn was determined as 7.38±1.9 kg. Average lactation length in these animals was 323 days. Milk yield was as high as 16.1kg/day during early lactation (first 12 weeks), receding up to 4.06 kg/day during late lactation (59th week). Average peak milk yield was recorded as 10.21 kg per day at stage of 6.1±3.3 wks, ranging from 6.2 kg during 5–8 weeks to 16.1 kg during 8–13 weeks of lactation in animals under study. Duration of peak yield persistency was more than 10 weeks in 13%, 6–10 weeks in 45% and less than 5 weeks in 40% of the study group animals. Data on persistency of peak yield indicated appreciable genetic potential of production in study animals (Fig. 1).

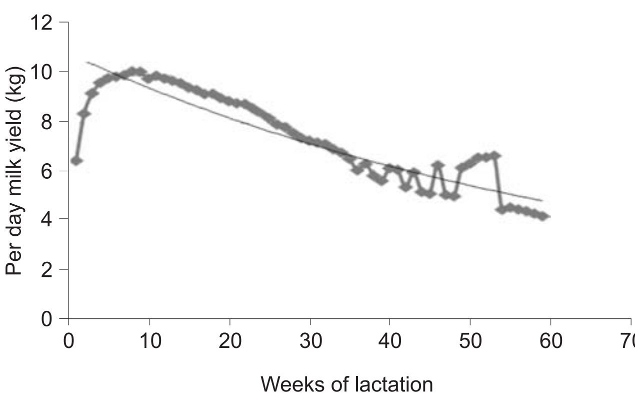

Fig. 1. Average milk yield (kg) at different lactation stages in Murrah buffaloes.

Stage of lactation vis a vis milk yield and composition: Composition of milk is the result of various biological reactions which in turn are affected by environment, feed intake and physiological status of animals (Neville *et al*. 2001). It directs traffic of substrates from the blood circulation to the mammary tissues under the control of various physiological factors and genetic make-up of an animal (Khan *et al*. 2008). Further, the physiological status of animal is governed by nexus of hypothalamus and pituitary endocrinology, affected by environment (Anila Mushtaq and Qureshi 2009). Spectrum of variation in milk composition, which expectedly is originated from difference in genetic make-up within species was studied in a group of 100 buffaloes. Present study revealed that changes in milk composition occur during the first few weeks of lactation. Data on overall mean±SE on milk yield and its composition over the lactation is presented in Table 1.

Milk fat increased significantly (P< 0.05) from 7.19±0.04 to 8.63±0.07g% during first trimester to fifth trimester of lactation. Total milk protein level was determined as 3.56±0.0 g% during first trimester of lactation. Milk protein level decreased to 3.468±0.007 g% third trimester of lactation. Difference in milk fat and protein between early and late months of production was significant (P<0.05). Milk fat content increased with a concomitant decrease in milk yield during advance lactation. This study indicated that lactation stage significantly (P<0.05) affected the milk yield (Table 1). Advance lactation is associated with reduction in milk yield and a concomitant decrease in milk protein and lactose due to an increase in unit volume of milk.

Milk lactose varied between 4.36 to 4.60%, with a significant (P<0.05) increase during last trimester of lactation.

Table 1. Variation in milk yield and composition during lactation in Murrah buffaloes

Milk yield and constituents	1–12 wks	13–24 wks	25–36 wks	37–48 wks	>48 wks
Mean ± SE (n)					
Per day yield (kg) (100)	9.41 ±0.07	9.01± 0.06	7.09±0.06	5.35± 0.09	4.36±0.19
Fat g % (98)	7.19 ±0.04	7.52±0.04	7.82±0.03	8.30±0.04	8.62±0.07
Protein g % (96)	3.56±0.01	3.52±0.01*	3.4±0.01^{ac}	3.48±0.01$^{\dagger c}$	3.47±0.02$^{*\dagger a}$
Lactose (100)	4.51±0.01^{gh}	4.48±0.01$^{f\ i\mu}$	4.46±0.01$^{a\mu}$	4.51±0.02$^{\dagger hi}$	4.55±0.02$^{a\dagger g\ f}$

Differences in mean±SE values with common superscript alphabets are nonsignificant (P< 0.05).

Table 2. Effect of season on milk composition in Murrah buffaloes

Sources	Milk constituents			
	Milk yield	Fat %	Protein %	Lactose
(Jan-April) Winter (09)	8.921±0.064	7.383±0.032	3.533±0.373†	4.484±0.298
(May-Aug) Summer (13)	7.332±0.068	7.944±0.033	3.439±0.239	4.434±0.360
(Sept-Dec) Normal (80)	7.927±0.084	7.572±0.037	3.553±0.258†	4.544±0.298

Difference in mean±Std. Error with common superscript alphabets are nonsignificant (P<0.05).

Lactose synthesis reportedly draws water into milk and are highly correlated, which probably maintains secretion rates of lactose and water nearly constant throughout lactation (Pollott 2004).

Milk protein remained lower towards advancing lactation contrary to the earlier findings of Auldist *et al*. (1998) showing that the concentration of total protein, fat, casein and whey protein increases during the advancing lactation in pasture fed dairy cows. In fact, milk protein and lactose content showed association with increase or decrease in milk yield in contrast with the milk fat content, suggesting that milk fat synthesis is independent of milk yield. Therefore, its content varies per unit volume of milk. Fat content varies maximum as it is dependent on dietary regimen and its concentration is lactation stage defined milk volume while content of minerals and lactose is least variable. Heritability of milk fat and protein content is reportedly higher (0.50) than milk yield (0.30), leaving a little scope for non genetic factors to affect milk composition (Bath *et al*. 1985). Significant genetic contribution towards milk protein content was identified in Murrah buffaloes (Sikka *et al.* 2004).

Seasons and milk yield and composition: The effect of season of calving on milk yield is confounded by breed, stage of lactation and environment. Milk yield was estimated as 8.921±0.064, 7.3324±0.068 and 7.9276±0.0845 kg during winter (January to April), hot and humid (May to August) and autumn (September to December) seasons of the year, respectively, with an overall estimated milk yield level of 8.060±0.072 kg. Level of milk yield decreased by 9% during hot and humid months due to summer stress and increased by 10.6% during winter in buffaloes.

An increase of 8% was reported in milk production in cows calving during October to February than in cows calving during summer. Ambient temperature variation during the seasonal changes from winter to summer and vice-versa is likely due to an interaction between day light and ambient temperature. Milk production declines when environmental temperature exceeds. The reduction in milk yield is largely due to drop in feed intake. This effect is pronounced in high producing animals than low producers. These seasonal effects were circumvented by many workers by suitably changes in feeding and shelter management of the dairy cow reportedly. The effect of season on milk yield (kg) was found to be significant (P<0.05).

Table 3. Variation in milk yield (kg) over different parity in Murrah buffaloes

Parity	No. Animals (n)	Av. milk per day (kg) mean±Std. error
1	25	7.602±0.028[c]
2	26	8.482±0.089[†a]
3	14	8.018±0.116[†]
4	18	8.288±0.103[a]
5	11	7.873±0.133 [be]
6	04	7.853±0.238 [bcd]
7	02	7.413±0.253[dec]
Grand mean		7.932±0.144

Difference in mean±Std. Error with common superscript alphabets are nonsignificant (P<0.05).

Data on fat % showed higher fat content with a concomitant decrease in milk yield in buffaloes. Fat % decreases to minimum level during winter, i.e. 7.38±0.03g% compared with 7.94±0.03g% during summer-humid months. A decreasing trend in fat % associated with increased milk yield suggests there is a decrease in per unit volume of milk increase, especially, during winter and vice-versa during summer and hot-humid months which reflected into a negative relation between fat and milk yield. A significant (P< 0.05) increase in milk may also probably explain water retention in body and lesser energy dissipation through oxidative respiratory cycle, which leaves acetate to be channelized into fat synthesis pathways in winter improving production causing no winter stress in these animals. Milk protein level was 3.4±0.24 g% and 3.55±0.20 g%, respectively, in calving during summer, winter- autumn seasons. This seasonal difference is significant (P< 0.05). Lowering in milk protein and lactose during summer stress with a concomitant low milk yield is obvious in this study (Table 2). Seasonal variation in buffalo milk constituents was significant (P< 0.05).

Average values of milk fat, solids-not-fat (SNF), protein, and lactose percentages were recorded as 7.65±0.05, 9.36±0.02, 3.81±0.02, and 4.83±0.01, respectively, by Dubey *et al.* (1998). All traits of milk composition differed significantly among months of lactation.

Effect of parity on milk yield and composition: Average milk yield of buffaloes with parity varying over the parities

Table 4. Effect of parity on milk composition in Murrah buffaloes

Parity	n	Av. fat %	Av. protein %	Av. lactose %
1	25	7.35 ± 0.07^{e}	$3.51 \pm 0.01^{a\dagger}$	4.47 ± 0.01^{b}
2	26	7.76 ± 0.05^{a}	$3.51 \pm 0.01^{\ddagger\dagger}$	4.51 ± 0.01^{e}
3	14	7.60 ± 0.05^{bd}	$3.48 \pm 0.01^{b\dagger}$	4.46 ± 0.01^{abcd}
4	18	7.51 ± 0.04^{cd}	$3.51 \pm 0.08^{\pm\dagger}$	4.48 ± 0.01^{db}
5	11	7.98 ± 0.05	$3.51 \pm 0.01^{\dagger}$	4.52 ± 0.01^{f}
6	04	7.66 ± 0.09^{abc}	$3.56 \pm 0.03^{\dagger f}$	4.48 ± 0.02^{cb}
7	02	7.14 ± 0.12^{e}	$3.53 \pm 0.02^{f\ddagger\pm ab}$	4.46 ± 0.03^{abcdef}

Differences in mean±SE values with common superscript alphabets are nonsignificant (P< 0.05).

(1 to 7) in 100 lactating buffaloes was recorded as given in Table 3. An increase of 10% was recorded in milk production, from first to second lactation animals. Milk production increased with lactation number and maximized during fourth to fifth lactation.

Comparing milk yield over the parities by test of significance of difference using 't- test' revealed that difference in milk yield obtained from buffaloes of parities 2, 3 and 4 is not significant (Table 4) recording highest milk yield through second to fourth parity (8.48±0.09 to 8.01±0.12kg) in these animals. Level milk yield decreased significantly in fifth parity. No significant difference in milk yield of first and seventh parity was recorded. Study corroborates with earlier findings (Agnihotri and Rajkumar 2007) revealing that significant effect of parity on milk yield exists in buffaloes. Bath *et al.* (1985) suggested 20% of the increase in milk production with advancing lactations (age) due to increased body weight and 80% increase is due to the effect of recurring pregnancy in cattle. Sardar *et al.* (1997) and Afzal *et al.* (2007) also reported similar significant effect of parity on milk production in cows. Bajwa *et al.* (2004), Javed (1999), Tahir *et al.* (1989), Deshpande and Sakhare (1984) and Lee and Kim (2006) reported increase in milk yield up to fifth parity and decline thereafter.

Milk yield increased in second lactation onwards and tapers to 7.87±0.13 kg in fifth lactation in present study (Table 3) suggesting that after attaining maturity, further increase in body weight and age affected lactation efficiency, negatively. Therefore, heavier weight and older animals should be culled out from the lactating herd to improve farm productivity.

Agnihotri and Rajkumar (2007) reported a significant effect of parity on milk yield in goat while the changes in total solids, fat, SNF, ash and casein were not significant. However, Pal *et al.* (1996) did not observe the effect of parity on various milk constituents except casein, which was affected due to parity of dam.

No specific trend is ascribed to change in level of milk Fat % (Table 4). Increase in fat is associated with enhanced milk yield with advancing parity up to fifth parity with average increase in milk yield ranging from 8.02±0.12 to 8.48±0.09 kg over second to fourth parity in these animals. However, milk protein increased with parity from 3.51±0.01 g% to 3.56±0.03 g% from parity 1 to 6. Milk protein level does not vary significantly over the parities till sixth parity. Increased protein level was recorded in seventh. High protein in seventh lactation is probably due to reduced milk yield (r = –0.073, P<0.05) resulting in decreased per unit volume protein concentration during advance parities (Table 4). It suggested that protein production level in milk keeps pace with the enhanced milk production levels after fourth parity, hence, it is co-variate with milk synthesis in contrast with fat. Whereas, production of fat is restricted after certain parities, therefore, shows lower g% concentration with increased milk volume. Fat level remains associated with change in milk level during parity 3 and 4, probably, a fat synthesis phase. Correlation (r= –0.098) between milk yield and fat is significant (P< 0.05). Dubey *et al.* (1998) reported highest milk fat content during first parity in buffaloes.

Milk lactose increased in second in parity when compared with late i.e. fifth parity. Increase in the lactose content in second parity is a reflection of more water content available for lactose synthesis due to higher milk yield. Available water content for lactose synthesis reduces in later stage of lactation due to less milk production. Hike in fifth parity is noted possibly due to increased lactose concentration per unit volume of milk where milk yield reduces and so the availability of water for lactose synthesis, therefore, projecting a negative relation between level of milk lactose and milk yield (–0.082, P<0.05) during fifth parity.

Lactose synthesis requires favourable biochemical pathway utilising gluconeogenic pathways linked to protein, fat and SNF. The latter 3 revealed a meaningful correlation with milk yield, r= 0.46, 0.598 and 0.56 (P< 0.05), respectively, with protein, fat and SNF. Analysis of data using MANOVA Test criteria and 'F' approximation revealed that effect of parity, seasons and stage of lactation on milk constituents are independent of one another, therefore, variation in level of constituents in milk is independent of any interactive effect of the 3 main variables of parity, stage of lactation and seasons.

Results from the present study indicated that stage of lactation has an influence on milk yield and its composition. Nutrients in body are channelized to circulation as per the priority of the body functions at any given time (Smith and McNamara 1990). Hormones like leptin etc. stimulate signals influencing hypothalamus, thus regulating appetite, feed intake and body metabolism in favour of milk production. The milk fat composition is also influenced by feed types making different types of substrates available for synthesis of milk. It suggested that desirable composition of milk may be obtained from animals of appropriate physiological/lactation stage and parity fed with special feed ingredients, in the dairy production system.

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