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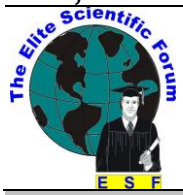


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**RESEARCH ARTICLE**

# Effects of Feeding Frequency and Fodder Particle Size on the Production Performance of Lactating Cows

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**ABSTRACT**

The variation in feeding frequency and fodder particle size affects the production of lactating animals by altering the rumen ecology. The present study was aimed to investigate the effect of different fodder particle sizes and feeding frequencies on the production performance and milk composition in lactating cows. Sahiwal breed cows (n=15) having uniform age and milk yield were selected and randomly divided in 5 equal groups. Two fodder sizes, $C_1$ (20 mm) and $C_2$ (40 mm) were offered to animals with two feeding frequencies, $F_1$ (twice daily) and $F_2$ (thrice daily). Five different treatments were allotted accordingly; $T_1 = C_1F_1$, $T_2 = C_1F_2$, $T_3 = C_2F_1$, $T_4 = C_2F_2$ and $T_5$ (control) given whole fodder once daily. The study lasted for 13 weeks with the first week to acclimatize the experimental animals with feeding routine. Results showed that in group T4, the dry matter intake (11.04±0.05kg) and milk yield (6.30±0.06 kg) were significantly higher ($P<0.05$) as compared to other groups while milk fat (4.67±0.05%) and total solids (12.14±0.094%) were significantly higher ($P<0.05$) in T3 when compared with other groups. Similarly, T5 showed significantly higher values of solid not fat (7.62±0.046) than other groups. On the other hand, milk protein percentage showed a non-significant ($P>0.05$) difference among all treatment groups. It was concluded that fodder particle size and the feeding frequency showed a significant effect on production performance and milk composition parameters in lactating Sahiwal cows.

## INTRODUCTION

Livestock plays a key role in the national economy of Pakistan. Livestock sector contributes about 60.5% of the value of agriculture and nearly 11.2% to the national gross domestic product. Out of total 201.9 million heads of livestock, large ruminants constitute 87.8 million which provide 57.87 million tonnes of milk, 2.28 million tonnes of beef and 17.43 billion numbers of hides. Nearly 8 million families are directly or indirectly involved in raising and keeping livestock as a source of their livelihood. Such families are generating 35% of their total income from livestock sector (Anonymous, 2019). It has been reported that the feeding frequency and particle size of fodder stimulates the production of lactating animals by affecting the microflora of the rumen. Upon feeding twice or thrice daily, the rumen micro-organisms have a short period of time to digest large amounts of feed, causing initial fall in microbial activity due to dilution effect of the feed and saliva. Further, it might then be followed by an increase in the ratio of acetic to propionic acid in case where the diet is rich in rapidly fermentable carbohydrates (Macmillan et al., 2017; Bach et al., 2006; French and Kennelly, 1990). Dry matter intake (DMI), rumination activity and rumen fermentation are affected by ration particle size while it has a positive impact on the capacity of the ration to congregate the animal's fiber requirement (Ramirez et al., 2016; Anonymous, 2001). Previous studies revealed the effect of feeding frequency and particle size of different forage and concentrates on milk composition, milk yield (MY) and milk quality in different dairy breeds (Jiang et al., 2018; Miller-Cushon and DeVries 2017; Esmaeili et al., 2016). A moderate increase in the particle size of diets can considerably elevate DMI, MY and milk fat (MF) percentage (Kahyani et al., 2013). The physical form of the diet is an important

determinant of its nutritive value affecting feed intake and rumination, dry matter, energy intakes, rumen function, digestive efficiency and production in addition to composition of milk that ultimately affects the health of the cow (Kmicikewycz and Heinrichs, 2015; Allen, 1997). In Pakistan, most of the farmers are still raising their animals on conventional *ad libitum* feeding pattern. Some dairymen feed their animals once daily, while some offer the feed twice a day. Feeding pattern in terms of feeding frequency and fodder particle size for dairy animals has yet to be standardized. Keeping in view, this study was carried out to determine the influence of different feeding frequencies and fodder particle sizes on milk yield and composition in lactating Sahiwal cows.

## MATERIALS AND METHODS

### Experimental animals

Fifteen cows of Sahiwal breed, approximately at the same age, lactation stage and almost the same MY and body weight were selected from the herd maintained at Livestock Experimental Station, (LES) Khizerabad, Sargodha-Pakistan.

### Experimental design

The experimental animals were randomly divided into 5 groups comprising three animals in each group. Five different treatments were assigned to each group viz. $T_1$, $T_2$, $T_3$, $T_4$ and $T_5$, described as $T_1$=Fodder with small particle size (20 mm) fed twice daily ($C_1F_1$), $T_2$=Fodder with small particle size (20 mm) fed thrice daily ($C_1F_2$), $T_3$=Fodder with large particle size (40 mm) fed twice daily ($C_2F_1$), $T_4$=Fodder with large particle size (40 mm) fed thrice daily ($C_2F_2$) and $T_5$=Whole (un-chopped) fodder fed once daily (control group). Residual fodder was weighed from all the individual experimental animals next day, one hour before the start of next regimen to determine the fodder consumption. The concentrate ration having 13.86% crude protein and 65% total digestible nutrients was given according to their milk production, i.e. 1 kg concentrate was given per 2.50 kg milk produced as practiced on LES Khizerabad, Sargodha. Fresh and clean water was provided 2-3 times a day. Other management practices were consistent for all the animals. The study period lasted for 13 weeks with the first week as acclimatization period.

### Milk and fodder analysis

Cows were milked 2 times a day and MY was recorded. While, weekly milk analysis for major milk constituents and proximate analysis of green fodder samples was performed using methods as described previously (AOAC, 1990).

### Statistical analysis

The data on daily feed consumption, daily milk yield, weekly milk analysis and proximate analysis of green fodder samples were collected and subjected to statistical analysis employing completely randomized design using Minitab (2000).

## RESULTS

### Dry Matter Intake (DMI)

Results of the present study revealed that different treatments have significant effect on DMI (Table 1). Among different groups, DMI was significantly higher ($P<0.05$) in treatment group $T_4$ followed by $T_3$ and $T_1$. Data showed that DMI was higher with large fodder (40 mm) particle size than the treatments given small (20 mm) sized fodder particles (Table 2).

### Milk Yield (MY)

The results showed that different treatments also have a significant effect on MY of experimental animals (Table 1). The highest MY (6.30±0.06 kg) was observed in $T_4$. All other treatments, $T_1$ (6.08±0.07 kg), $T_5$ (6.07±0.09 kg), $T_2$ (5.94±0.11 kg) and $T_3$ (5.87±0.10 kg) showed a significant difference with $T_4$, while showed non-significant differences among themselves (Table 2). The results revealed significant ($p<0.05$) effect of feeding three times daily on milk production in cows. There was a significant ($p<0.05$) influence of interaction between the frequency of feeding and fodder particle size on MY.

### Milk Fat (MF)

Fat contents of milk were significantly ($P<0.05$) affected by different treatments (Table 1). Analysis of the milk samples showed that highest MF contents were present in the milk of animals which were offered fodder with large sized particle twice a day ($T_3$) with a mean value of 4.67±0.05% followed by $T_1$ with a mean value of 4.48±0.12% and $T_5$ with mean value of 4.31±0.07%. Lowest fat contents were recorded in the milk of animals from $T_4$ (4.16±0.05%) (Table 2).

### Milk Protein (MP)

It is evident from Table 1 that protein contents of milk did not vary significantly between treatments ($P>0.05$). However, maximum protein contents were observed in the $T_2$ with a mean value of 3.18±0.06%. Protein contents of $T_3$ and $T_5$ were 3.15±0.07 and 3.12±0.06%, respectively. Lower protein contents were observed in $T_1$ and $T_4$ with mean values of 3.02±0.12 and 3.05±0.05%, respectively (Table 2).

### Solids-Not-Fat (SNF)

Treatments had significant impact on SNF (%) in milk (Table 1). Maximum (7.62±0.04%) and minimum (7.40±0.03%) values were obtained in $T_5$ and $T_1$, respectively. SNF value of 7.58±0.04% was observed in $T_4$ that did not differ statistically ($P>0.05$) with $T_5$ and $T_3$ having mean values of 7.62±0.04 and 7.49±0.05%, respectively. A statistically significant difference ($P<0.05$) was found between $T_1$ and $T_5$ (Table 2).

**Table 1: Analysis of variance (ANOVA) table of all parameters**

| Source of variation | Degrees of freedom | F-value | | | | | |
|---|---|---|---|---|---|---|---|
| | | DMI | MY | MF | MP | SNF | TS |
| Treatment | 4 | 384.65** | 5.16** | 7.17** | 1.26NS | 5.47** | 5.37** |
| Weeks | 11 | 1658.66** | 12.20** | $0.86^{NS}$ | 8.93** | 3.15** | 2.16* |
| Treatment x weeks | 44 | 31.36** | $1.04^{NS}$ | $0.09^{NS}$ | 2.06** | $o.86^{NS}$ | $0.76^{NS}$ |
| Error | 120 | | | | | | |
| Total | 179 | | | | | | |

NS = Non-Significant (P>0.05); * = Significant (P<0.05); ** = Highly Significant (P<0.01); DMI= Dry matter intake; MY= Milk yield; MF = Milk fat; MP= Milk protein; SNF= Solids-not-fat; TS= Total solids

**Table 2: Mean values of various parameters in different treatments**

| Parameters | Treatments | | | | |
|---|---|---|---|---|---|
| | $T_1$ | $T_2$ | $T_3$ | $T_4$ | $T_5$ |
| DMI (kg) | $10.70\pm0.10^{b}$ | $10.64\pm0.07^{d}$ | $10.71\pm0.09^{b}$ | $11.04\pm0.05^{a}$ | $10.67\pm0.11^{c}$ |
| MY (kg) | $6.08\pm0.07^{b}$ | $5.94\pm0.11^{b}$ | $5.87\pm0.10^{b}$ | $6.30\pm0.06^{a}$ | $6.07\pm0.09^{b}$ |
| MF (%) | $4.48\pm0.12^{ab}$ | $4.19\pm0.05^{c}$ | $4.67\pm0.05^{a}$ | $4.16\pm0.05^{c}$ | $4.31\pm0.07^{bc}$ |
| MP (%) | $3.02\pm0.123^{a}$ | $3.18\pm0.063^{a}$ | $3.15\pm0.078^{a}$ | $3.05\pm0.059^{a}$ | $3.12\pm0.060^{a}$ |
| SNF (%) | $7.40\pm0.039^{c}$ | $7.41\pm0.045^{c}$ | $7.49\pm0.055^{bc}$ | $7.58\pm0.043^{ab}$ | $7.62\pm0.046^{a}$ |
| TS (%) | $11.95\pm0.088^{a}$ | $11.66\pm0.075^{b}$ | $12.14\pm0.094^{a}$ | $11.70\pm0.065^{b}$ | $11.97\pm0.111^{a}$ |

$T_1$ = fodder of small particle size fed twice daily, $T_2$ = fodder of small particle size fed thrice daily, $T_3$ = fodder of large particle size fed twice daily, $T_4$ = fodder of large particle size fed thrice daily, $T_5$ = un-chopped fodder fed once daily Means sharing similar letter in a row or in a column are statistically non-significant (P>0.05); DMI= Dry matter intake; MY= Milk yield; MF = Milk fat; MP= Milk protein; SNF= Solids-not-fat; TS= Total solids

**Total Solids (TS)**

Analysis of variance revealed that TS contents of milk were significantly affected by the treatments (Table 1). Maximum TS were observed in $T_3$ with the mean value of 12.14±0.09% followed by $T_5$ (11.9±70.11%) and $T_1$ (11.95±0.08%).

## DISCUSSION

Previous studies reported a positive impact of increasing feeding frequency and particle size on DMI in different dairy breeds (Moharrery 2010; Kudrna et al., 2001) which is in line with findings of present study on Sahiwal cows. Contrary to this, some studies also reported reduction in the DMI when there was reduction in the particle length of alfalfa silage (Krause and Combs 2003; Couderc et al. 2006) while other reported non-significant effect on the DMI with respect to corn silage particle length (Onetti et al., 2003; Bal et al., 2000; Clark and Armentano, 1999). This might be correlated with low rumen pH resulting from consumption of diets which had a small particle size of alfalfa, which resulted in sub-acute ruminal acidosis (SARA) and reduced feed intake. However, it has also been reported that a reduction in forage particle size increased DMI of total mixed ration of dairy cattle in early lactation (Jiang et al., 2018; Kononoff and Heinrichs, 2003; Yang et al., 2001). The findings of Mantysaari et al. (2006) were in contrast to our study that less frequent feeding increased the DMI. Results of this study revealed a positive correlation between feeding frequency and MY. These findings were in close conformity with the findings of previous studies (Riva et al., 2013; Gibson, 1984). The probable reason for the increase in MY by increasing feeding frequency could be that rumen microflora had optimum time to digest the feed. On the other hand, when animals are fed once a day, the bulk of feed contained in the rumen not only dilutes the micro-organisms but they also get less period of time to digest the large ingested bulk which results in poor feed utilization and thereby causing a decrease in MY. Leonardi et al. (2004) observed that by reducing the particle length of oats silage increased MY. Esmaieli et al. (2016) reported that variation in fodder particle size is an indicator for predicting bio-physical responses of cows. He also reported a group with medium and coarse particle size of total mixed ration gave higher MF percentage and production yield. Moharrery (2010) reported that increase in MF contents due to increased particle size was greatest for diets that contained long particle forage and concluded that increasing particle length of forages increases the intake of physically effective neutral detergent fiber to a greater extent when forages comprise a larger portion of the diet. Present study was substantiated by the findings of Macmillan et al. (2017). This increase in MF contents could be speculated due to more extensive fiber digestion as a result of increased rumination (Phillips and Rind 2001). In contrast to our findings, Bal et al. (2000) reported that MF percentage did not increase when whole plant corn silage chop length was increased. Results of the present study showed that feeding frequency had no impact on MP level. Krause et al. (2002) also reported that frequency of feeding had no effect on MP. The reason could be that in ruminants bacterial cells are ultimately used as

the major source of amino acids for protein synthesis. Since bacterial cells are an excellent source of protein and their composition is static, it is therefore, expected that nitrogen from fodder will have little effect on the amino acid composition of the milk. Contrasting results have also been reported that cows fed diets containing long-cut corn silage had a higher MP yield compared with cows fed short-cut corn silage (Soita et al., 2005). However, in other studies it has been reported that finely ground particle size resulted in increased MP percentage and protein yield which supports our study (Dhiman et al., 2002; Reis et al., 2001; Yang et al., 2001). The results of present study are similar to the findings of Moharrery (2010) and Krause et al. (2002) who reported that percent SNF amplified with rising forage particle size for diets encompassing elevated moisture corn and reduced with growing forage particle size for diets comprising dried corn but no effect of diet was found on the yield of SNF. The findings of the present study are in agreement with results of a study conducted by Macmillan et al. (2017), who reported that an increased frequency of feeding on various production characteristics was reflected in trends of increasing pounds of total solids daily per cow. Dhali et al. (2005) reported contrary to the results of the present study that feeding of diet comprising of hay, sugar-beet pulp and concentrates two and four times daily had non-significant effects on TS % of milk. It was concluded that fodder particle size and the feeding frequency had a significant effect on milk yield and composition parameters of Sahiwal cow.

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**Authors' Contribution**

AF and ML conceived the idea, designed experimental study. AF conducted the trial. NI, MAA and MIU helped in trial, statistical analysis and manuscript write up. All authors read and approved the final manuscript.

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