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MILK PRODUCTION AND COMPOSITION IN BUFFALOES FED ON SILAGE AND GREEN FODDER OF MAIZE (*ZEA MAYS* L.)

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ABSTRACT

Background Profitable dairy business requires optimum feed supply for economic returns. Fodder availability is limited by harsh climatic conditions both in winter (December-January) and summer (May-June). Conservation of surplus fodder in the form of silage is therefore essential during peak season for lean season.

Methodology Six milking buffaloes of *Nili Ravi* breed were divided in 2 groups under randomized complete block design, and fed with maize silage (MS) and maize fodder (MF) for sixty days during 3 lactation years to evaluate their effect on milk yield and composition.

Results Dry matter intake (DMI), solid-not-fat (SNF), milk pH and acidity were not affected by the dietary treatments during the first two years ($p \leq 0.05$). However, DMI during the third year and the average DMI of three years was higher ($p \leq 0.05$) in group fed on maize silage. Milk production, butter fat, protein and total soluble solids (TSS) were higher in the group fed with maize silage during the first year, and a similar trend was observed for the second and third year and on overall basis. Presence of higher neutral detergent fiber (NDF) and acid detergent fiber (ADF) level of fresh maize fodder might be the cause of lower intake in MF group and longer digestion time resulted in less ingestive activity, less milk yield with lower concentration of milk constituents.

Conclusion Buffaloes fed on MS group showed higher DMI, better milk production with more butter fat, SNF, TSS and higher protein due to better digestion and ingestive activity, availability of more nutrients and better fiber digestion of silage as compared to fresh fodder.

INTRODUCTION

Milk is an integral part of human diet for all age groups and considered as complete diet. The population of Pakistan is increasing at the rate of 3% and the milk requirement of ever increasing population necessitates an increase in milk production, livestock population and fodder production (GOP 2015). Adequate supply of food to masses require increased cultivation of cereals and cash crops and consequently decrease in area under fodder cultivation. Increase in turn out, profit margins, milk quantity and effective reproduction of dairy animals need appropriate supply of nutrients in ample amount. Requirement is variable for different animal species, breeds and classes in both qualitative as well as quantitative terms among and within forage crops (Chaudhary et al. 2012). The estimated area under fodder crops in the province of Punjab, Pakistan is 2.7 million hectares, which is about 14-16% of the total cultivated cropped area with annual fodder production of 57 million tons, giving a nationwide average of 21.1 tons per hectare (Bhatti 2001; Bilal et al. 2001).

Fodder in green form makes an indispensable part of diet for dairy animals and its availability round the year is prerequisite for the production and economic returns from the successful dairy business (Brar et al. 2016). Maize is a leading fodder with excellent nutritional value after legume green fodders

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(Chaudhary et al. 2014). In developing countries like Pakistan, fodder crops play an essential role in the agricultural economy by giving cost effective source of feed for dairy animals. The price of milk mainly depends upon the nutrient value of fodder fed to dairy animals and thus feeding animals with sufficient green forage considerably lowers the cost of milk production than concentrates (Chaudhary et al. 2014). Available nutrients are easy to digest from lush green palatable fodders as compared to concentrate and livestock like these to satisfy their hunger (Chaudhary et al. 2012). These are cheapest source of protein, carbohydrates, vitamins and minerals. Maize in green form is highly acceptable to animals as it is free from anti-nutritional factors, supply protein and minerals in adequate amount with excellent palatability and digestibility. Milch animals require 40 kg green fodder day^{-1} for optimum milk production (Chaudhary et al. 2014). However, the main trouble limiting the production of livestock and dairy animals in Pakistan is the non-availability of good quality fodder in ample quantity (Sarwar et al. 2002) round the year. Due to different climactic factors, the season for the active fodder growth is limited in the country. In winter and summer season, harsh environment negatively affects the supply of green fodder to animals (Brar et al. 2016), and ultimately affects their productive performance (Rasool et al. 1996). In developing countries because of ever growing human need for food, only limited cultivated land can be allocated to fodder production. Moreover, in our region, low per acre fodder yield and fodder scarcity periods, one is during summer months and second in the winter months, further aggravates the situation (Sarwar et al. 2002).

At green stage, maize contains soluble sugars and protein in ample amount which make it ideal for the production of silage (Chaudhary et al. 2014). During the time of peak fodder growth season, conservation of the surplus fodder as silage may resolve the fodder deficiency under lean season (Brar et al. 2016). Silage from maize has become best replacement of green maize fodder and main component in feed of milch animals (Khan et al. 2015; Heuzé et al. 2017). Preparation of silage is one of the best processes for conservation of fodder (Schukking 1994). In tropical countries and generally in Pakistan, conservation of fodder into silage making is not a common process among the dairy farming community. Fermentation properties of tropical fodder silages and their feeding standards have not been recognized. The quality of fodder may be preserved by silage making and also preservation of surplus fodder makes the land free for subsequent cultivation (Bolsen et al. 1996; Chaudhary et al. 2014).

Dry wheat straw is generally utilized as feedstuff for animals throughout the country. Roughages provide very limited nutrients and wheat straw supply cellulosic carbohydrates and has potential to be used in combination with green forages as well as concentrates (Chaudhary et al. 2012). Present study was designed for evaluating the effect of green maize fodder or maize silage and wheat straw on milk production and composition in buffaloes.

MATERIALS AND METHODS

Experiment was conducted at the Dairy Farm of Fodder Research Institute, Sargodha. Six *Nili Ravi* buffaloes were selected and randomly divided into two groups under randomized complete block design (RCBD). Group-I was fed on maize silage (MS) plus wheat straw while, group-II was fed on fresh maize fodder (MF) plus wheat straw. The diets were fed at *ad–libitum* basis and fresh drinking water was made available round the clock. Animals were fed experimental diets for sixty days during the first lactation period and procedure was repeated for two subsequent lactation years. Individual feeding was practiced and daily feed intake per animal was recorded. Milking was done twice a day (at 6:00 h and 18:00 h) and record was maintained. The milk samples were collected to evaluate milk fat, protein, solid-not-fat (SNF), total soluble solids (TSS), pH and acidity at the end of trial during each year.

Chemical analysis of feed

Dry matter, ash content, crude protein content of wheat straw, maize fodder and maize silage were determined using methods described in AOAC (1990). Neutral detergent fiber (NDF) and acid detergent fiber (ADF) contents were determined as described by Van Soest et al. (1991).

Chemical analysis of milk

Fat contents were determined by Gerber method as described by Kirk and Sawyer (1991). Acidity, pH**,** TSS and protein were determined by Kjeldahl's method following AOAC (1990). SNF content was calculated by difference using Harding (1995) formula:

$$\text{SNF content (\%)} = \text{TSS (\%)} - \text{Fat (\%)}$$

Statistical analysis

The data collected for each parameter was subjected to analysis of variance using multivariate analysis in General Linear Model option of Statistix® 8.1.

RESULTS AND DISCUSSION

Feed quality

Determination of nutritional quality of feed is essential to provide information and insight for adequate substitution or supplementation (Chaudhary et al. 2012). Maturity stage of plant is an important determinant of forage quality. Quality of maize fodder is ideal when grains are at milky stage. Advancing maturation affects the forage quality; fiber content increases, NDF and protein content decreases, leading to less intake by animal and also lower digestibility. Quality of maize silage is best at milky stage of grain as at this stage maximum nutrients have been accumulated and are in easily accessible form. Chaudhary et al. (2012) studied the effect of different maturity stages on silage quality of maize and found that at milky grain stage, dry matter content was 21%, crude protein 7% and net energy of lactation 0.67 Mcal/lb. Composition of silage in current study was slightly different because of higher dry matter (33.10%), protein content (8.40%) and maturity stage of fodder for silage is between milky and overripe stage. Fresh green maize fodder showed more dry matter, NDF and ADF while less protein and ash content. Wheat straw exhibited significantly higher dry matter, NDF and ADF while, lowest crude protein and ash contents (Table 1).

Feed intake

Mean values for feed intake showed significant ($p \leq 0.05$) differences for dry matter intake (DMI) of silage and fodder ranging from 8.24 (fodder) to 11.85 kg (silage). Feed intake in terms of DMI was higher in buffaloes nourished with maize silage (10.78 kg) as compared to those animals fed on fresh green maize fodder (9.51 kg). Year effect was also significant ($p \leq 0.05$) (Table 2). Highest mean for DMI was observed during 3rd year (12.44 kg) which is statistically at par with mean from 2nd year (11.72 kg) while, lowest mean during 1st year of study (9.28 kg). The interaction between dietry treatments and year exhibited remarkable impact on DMI (Figure 1), milk quantity (Figure 2) and composition (Figure 3, 4, 5 and 6). The highest mean value for treatment*year interaction for DMI was recorded for MS group during 3rd year while, minimum in MF group in 1st year (Figure 1). On an average, 1 kg extra dry matter consumption in the form of maize silage resulted in 1.11 liters overall increase in milk production. Consumption of maize silage was higher than fresh green maize fodder which is in line with Anwar et al. (1991) who noted more consumption of sorghum silage than sorghum fodder. The findings of current study are in agreement with Anwar at el. (1991) who found 8.49 and 8.29 kg mean values, respectively for sorghum silage and fodder in *Nili Ravi* buffalo. Quality of fodder is preserved in silage and hence it is equally nutritious and as good for livestock as fodder itself. In silage, fodder becomes more palatable as hard stems become soft, easily digestible from and anti-nutritional factors are destroyed or reduced in amount (Chaudhary et al. 2014). Kaiser et al. (2004) found 0.9 and 0.6 kg additional milk kg^{-1} silage dry matter, respectively during early and late lactation in cows.

Milk quantity

Both feed type and years showed significant ($p \leq 0.05$) impact on quantity of milk produced. Average milk production varied from 8.10 to 8.93 L animal^{-1} day^{-1} with overall average of 8.39 L animal^{-1} day^{-1} in buffaloes fed with fresh green maize fodder (40-45 kg day^{-1}). While, in buffaloes with silage feeding, average milk yield animal^{-1} day^{-1} was ranged from 9.50 to 10.0 L with a mean value of 9.80 L. The mean for milk quantity in present study is higher than Anwar et al. (1991) who reported 7.47 kg milk in animal fed on sorghum silage and 7.28 kg in buffalo fed on sorghum fodder. Mean yield of milk was increased 16.81% when maize fodder as animal feed was replaced with maize silage. Maximum milk production was recorded in 2nd year while, minimum in 1st year. Maximum milk production was noted in 2nd year of study in MS fed buffalo group under combined influence of treatment * year while, response of interaction on milk production was minimum in MF during 1st year (Figure 2). The current study showed increasing trend in rate of milk production by substituting fodder with silage which is similar to previous findings (15.5%) by Brar et al. (2016). Supplementation of feed by replacing pasture or fodder with high quality silage (Phillips, 1988; McDonald et al. 2000) or sorghum silage increased the milk production (Anwar et al. 1991) while, Chamberlain and Wilkinson (1996) recorded increased milk yield with silage in Holstein Friesian cow at different lactation stages.

Milk composition

Butter fat content

Feed type and year significantly ($p \leq 0.05$) influenced the butter fat content in buffalo milk. Average milk fat content varied between 7.28 and 7.72% for silage and fodder during different years. Values for fat content were substantially higher (7.51%) in animal fed on silage as compared to those nourished with fresh green maize fodder (7.34%). Maximum value of mean for butter fat was noted in milk samples

Table 1 Chemical composition of different feeds

Parameters	Maize silage	Maize fodder	Wheat straw
Dry matter (%)	33.10	37.00	93.00
Crude protein content (%)	8.40	7.70	3.32
Neutral detergent fiber (%)	36.70	44.00	78.58
Acid detergent fiber (%)	20.70	24.30	50.60
Ash content (%)	8.90	8.60	8.50

Table 2 Effect of maize silage or fresh maize fodder and year on milk production and composition of *Nili Ravi* buffaloes during three lactations

Parameters	Dietary treatments	Years			Mean
		1	2	3	
	MS	9.31	11.18	11.85	10.78a
Dry matter intake (kg day^{-1})	MF	8.24	10.26	10.02	9.51b
	Mean	**9.28b**	**11.72a**	**12.44a**	**20.29**
	MS	9.50	10.0	9.90	9.80a
Milk production (L day^{-1})	MF	8.10	8.93	8.13	8.39b
	Mean	**8.80b**	**9.47a**	**9.02b**	**18.19**
	MS	7.34	7.72	7.47	7.51a
Milk fat (%)	MF	7.28	7.42	7.31	7.34b
	Mean	**7.31c**	**7.57a**	**7.39b**	**14.85**
	MS	4.92	4.73	4.98	4.88a
Milk protein (%)	MF	4.23	4.25	4.29	4.26b
	Mean	**4.58a**	**4.49b**	**4.63a**	**9.13**
	MS	7.90	8.20	8.01	8.04a
Solid-not-fat (%)	MF	7.25	7.37	7.21	7.28b
	Mean	**7.58b**	**7.79a**	**7.61ab**	**15.31**
	MS	15.24	15.60	15.42	15.42a
Total soluble solids (%)	MF	14.53	14.81	14.5	14.61b
	Mean	**14.89b**	**15.21a**	**14.96b**	**30.03**
	MS	6.12	6.32	6.12	6.19
Milk pH	MF	6.11	6.30	6.30	6.24
	Mean	**6.12**	**6.31**	**6.21**	**12.42**
	MS	0.20	0.19	0.21	0.20
Milk acidity (%)	MF	0.18	0.18	0.18	0.18
	Mean	**0.19**	**0.19**	**0.20**	**0.38**

MS and MF indicate the buffaloes fed maize silage and fresh maize fodder, respectively. Means sharing different superscripts differ significantly ($p \leq 0.05$).

during 2nd year (7.57%) while, minimum during 1st year (7.31%). But 1.0 kg extra dry matter intake from silage resulted in 1.82% increase in fat content of milk obtained from buffaloes fed on maize silage. Mean interaction score for milk fat content was significantly higher in buffaloes nourished with maize silage during 2nd year and lowest in those fed on green maize fodder in 1st year (Figure 3). The results for butter fat of buffalo milk in current study are higher and in contradiction than those reported by Anwar et al. (1991) who reported 5.08% for sorghum silage which is non-significant with mean for fodder (5.74%). These differences can be attributed to difference in nutritional quality of silage and fodder as maize is used in present study while, sorghum by Anwar et al. (1991).

Solid-not-fat content of milk

The effect of dietary treatments, feeding year and their interaction was significant on SNF content of milk. Milk solids other than fat ranged from 7.21 to 8.20% in milk samples from animals receiving different dietary treatments during different study years. SNF content was substantially higher in milk obtained from milking of buffaloes fed on maize silage (8.04%) as compared to milk from fresh maize fodder (7.28%) fed buffaloes. Among feeding years, maximum SNF content (7.79%) of milk was recorded during 2nd year and minimum in milk from 1st year of study (7.58%). Significantly higher SNF mean value

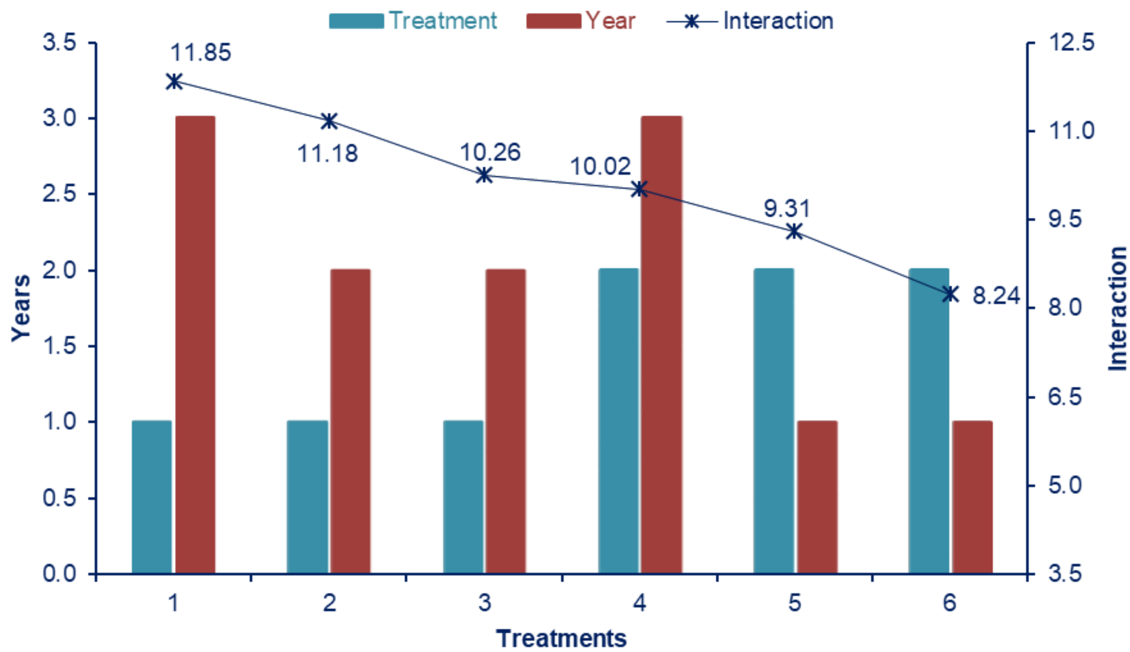
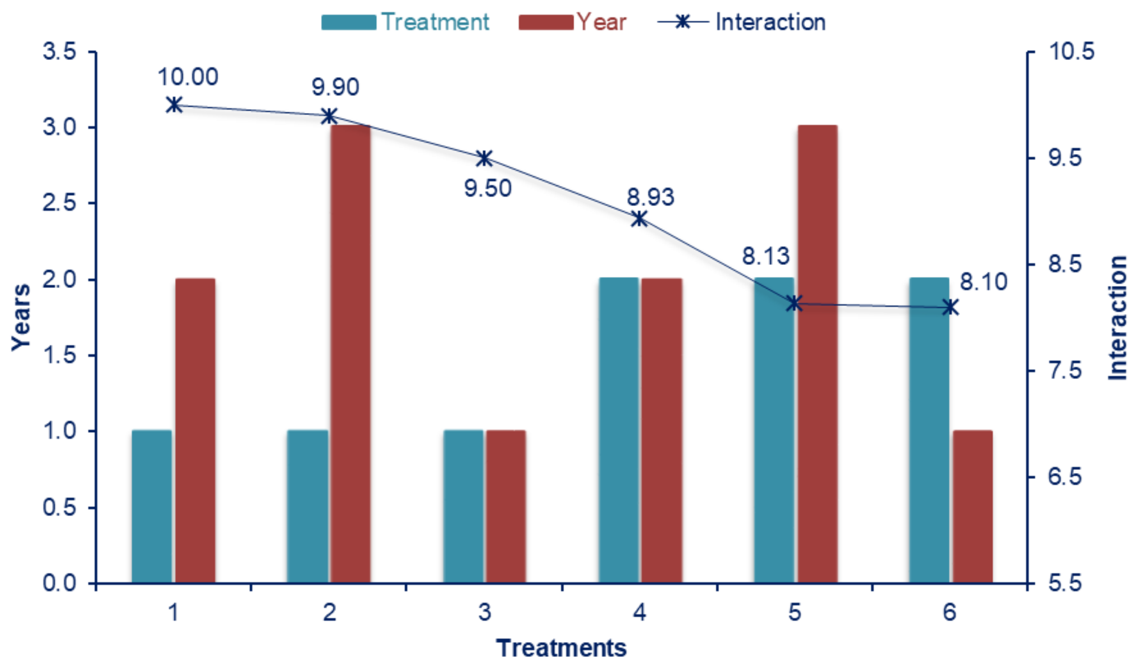


Figure 1 Effect of dietary treatments and year interaction on dry matter intake by buffaloes



Fugure 2 Effect of dietary treatments and year interaction on production of milk

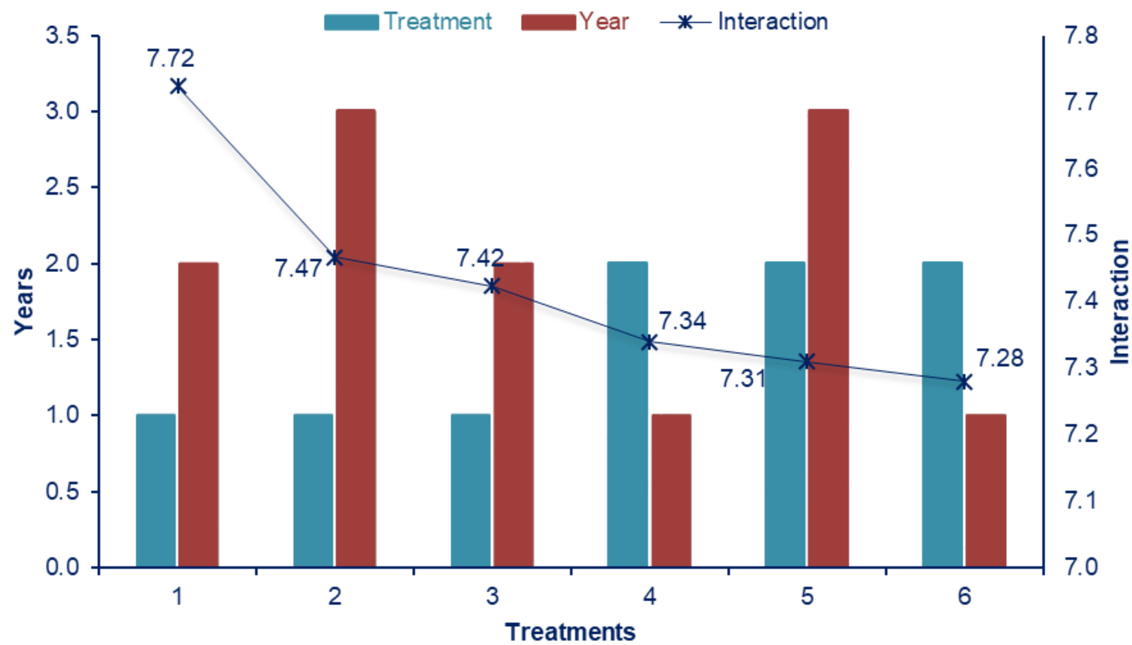


Figure 3 Effect of dietary treatments and year interaction on fat content of milk

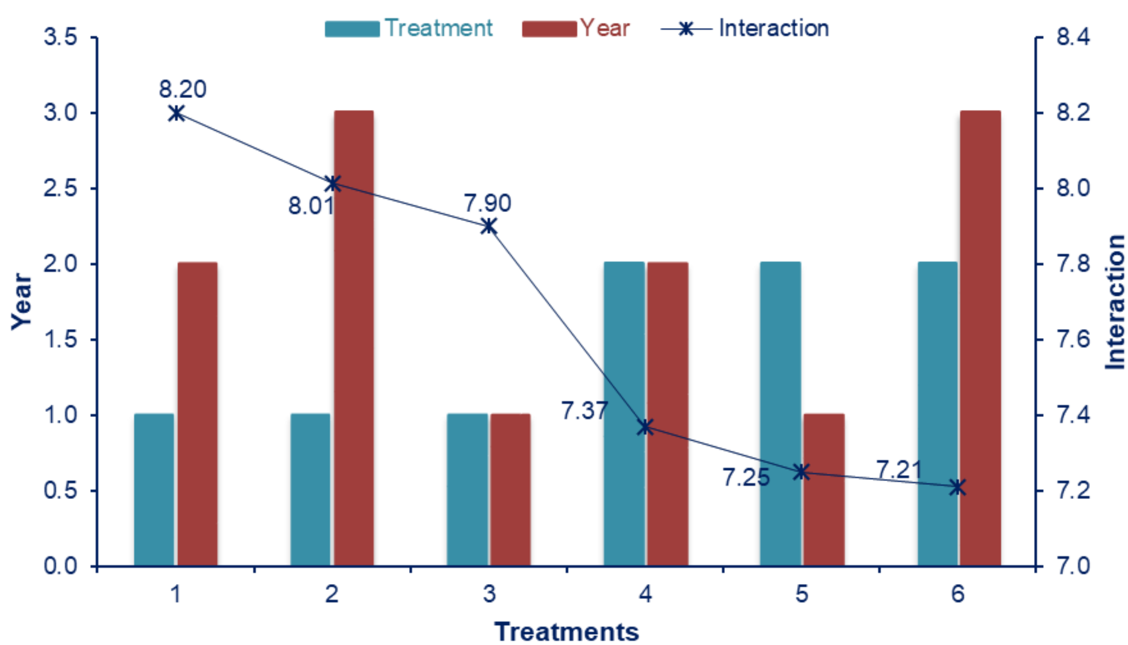


Figure 4 Effect of dietary treatments and year interaction on solid-not-fat (SNF) of milk

for treatment * year interaction was noted during 2nd lactation year in MS fed buffaloes while, minimum interaction impact for SNF content of milk was observed in MF group in 3rd year (Figure 4). Replacing green maize fodder with maize silage resulted in an increase of 8.22% in SNF content of milk per kg of silage. Anwar et al. (1991) revealed non-significant ($p \leq 0.05$) differences in SNF content of milk from *Nili Ravi* buffalo fed on sorghum silage fodder and mean values were 9.35% for silage and 9.50% for fresh fodder. However, mean values in current study are slightly lower which might be due to difference in composition of feed as maize is used in present study and sorghum by Anwar et al. (1991).

Total soluble solids of milk

The impact of dietary treatment, study year and their interaction were recorded to be significant on total solids content of milk. Average for TSS content of milk varied between 14.50 and 15.60% in milk from buffaloes nourished with silage and fodder during different years. Significantly ($p \leq 0.05$) higher mean values for TSS content were recorded in milk from animals given maize silage (15.42%) than in milk from animals fed with fresh green maize fodder (14.61%). Average of means for feeding years depicted maximum TSS in milk during 2nd year (15.21%) while, minimum in 3rd year (14.96%) which non-significantly ($p \leq 0.05$) differed from TSS of milk from 1st year. Year * dietary treatments interaction mean for TSS of milk was recorded to be maximum in MS group during 2nd milking year while, minimum in milk from buffalo fed on fresh green maize fodder in 3rd year (Figure 5). Total soluble solids content of milk increased 4.37% per kg silage if fresh maize fodder was substituted with maize silage. Differences for TSS values were non-significant ($p \leq 0.05$) in buffaloes nourished with sorghum silage and fodder, and mean TSS was 15.15% for silage and 15.14% for fodder (Anwar et al. 1991). Quality silage supports high production of milk and milk solids at each stage of lactation (Mc Donald et al. 2000).

Milk protein content

The protein content of milk from silage or fodder fed buffaloes was significantly ($p \leq 0.05$) affected by differences in feed composition, study year and interaction of treatments and year. Individual values for protein content varied from 4.23 to 4.98% by feed types during different years under study. Mean of mean values for protein content was significantly greater for milk from animals fed on silage (4.88%) than milk from buffaloes nourished with fresh green maize fodder (4.26%). Maximum mean value for milk protein was recorded during 3rd year (4.63%) which is at par with 1st year (4.58%) while, lowest during 2nd year (4.49%) of study. Mean score in case of protein content of milk for treatment * lactation year interaction was highest in MS group during 3rd year which is statistically at par with mean protein content in same group in 1st year and lowest in milk from MF group boffaloes during 1st year which showed non-significant difference with milk protein from other years (Figure 6). Protein content of milk dramatically increased (11.46%) with every 1.0 kg additional dry matter from maize fodder is replaced with that from maize silage. Anwar et al. (1991) revealed non-significant differences in milk protein from animals fed on sorghum silage and fodder and mean values were 4.67% for sorghum silage and 4.78% for sorghum fodder which supported the findings of current study.

Titratable acidity and pH

The effect of dietary treatments, year and interaction was non-significant on titratable acidity and pH of milk. Thus, replacing fresh green maize fodder with maize silage showed no prominent difference in mean values for pH and acidity of milk. This might be due to greater control of animal body on these quality characters and less or negligible impact of feed and environment prevailing.

CONCLUSION

Dry matter intake, SNF, milk pH and acidity were not affected by the dietary treatment during the first two years ($p \leq 0.05$). However, DMI was higher during 3rd year and three-year average ($p \leq 0.05$) in maize silage fed group. Overall milk production, fat, protein and TSS were higher in group fed on maize silage during all 3 years. Higher DMI in MS group might be related to better digestion leading to more gastric emptying and ingestive activity. However, intake was lower in MF group due to higher NDF and ADF level of fresh maize fodder. Better milk production in MS group might be related to better availability of nutrients from silage than fresh fodder. For silage making, the plants are harvested at optimum nutritional level and thus more nutrients are available to animal. While, in case of fresh fodder, cut and carry system is adopted in which mature fodder may be fed to animals which have more lignin and resulted in poor digestibility. Thus, reduced nutrient utilization might cause poor animal performance as compared to maize silage. Better butter fat in milk from MS group might be related to improved fiber digestion resulting in better acetate to propionate ratio and production in rumen. These are directly involved in de novo milk fat synthesis and hence

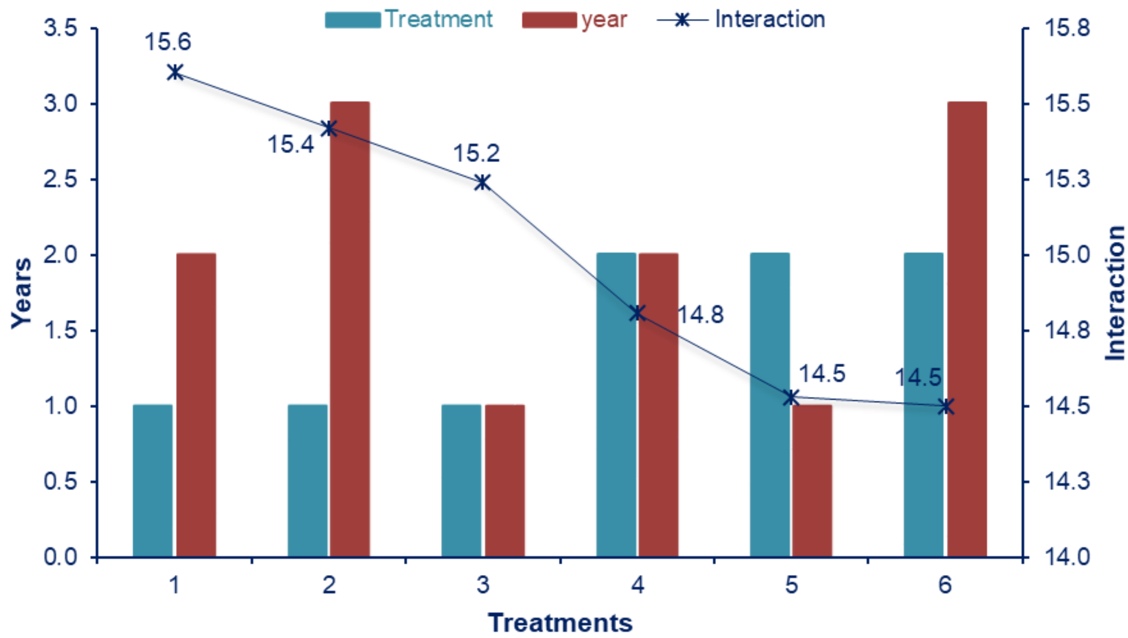


Figure 5 Effect of dietary treatments and year interaction on total soluble solid (TSS) of milk

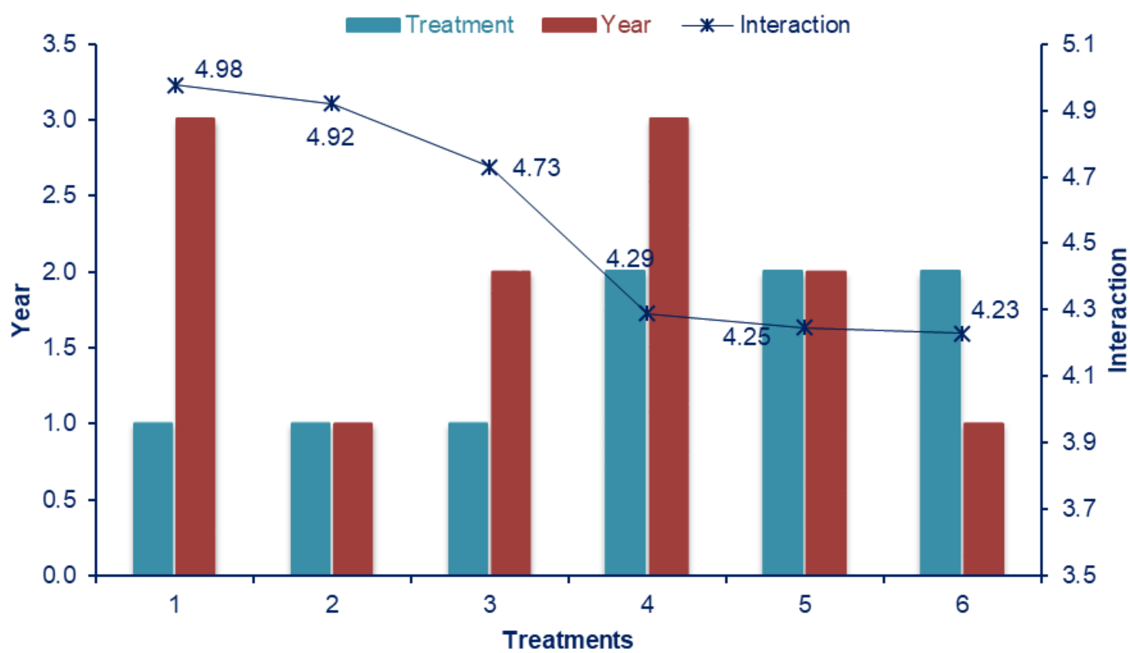


Figure 6 Effect of dietary treatments and year interaction on protein content of milk

higher TSS in MS group are attributed to higher milk fat. Better milk protein in MS group might be the consequence of better microbial colonization and higher microbial protein availability for milk protein synthesis.

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