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MILK PRODUCTION AND COMPOSITION OF LACTATING BUFFALOES FED RATIONS CONTAINING CORN SILAGE AND/OR FRESH BERSEEM

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ABSTRACT

Twelve lactating buffaloes in the 3rd to the 5th lactation, weighing 550-650 kg, after 8 weeks of calving in complete switch-back design with three treatments, were used in the study. Each group of buffaloes fed one of the three rations (R) consisted of 40 % concentrate feed mixture (CFM) and 20 % rice straw (RS) plus 40 % corn silage (CS, R1) or 40 % fresh berseem (FB, R2) or 20 % CS + 20 % FB (R3). Results showed that digestibility coefficients of dry matter (DM), organic matter (OM), crude protein (CP) and crude fibre (CF) as well as digestible crude protein (DCP) value were significantly ($P < 0.05$) higher, however, the digestibility coefficients of ether extract (EE) and nitrogen free extract (NFE), as well as total digestible nutrients (TDN) value were significantly ($P < 0.05$) lower for R2 compared to R1, while R3 was intermediate without significant differences. Actual and fat corrected milk (FCM; 7 %) yield were nearly similar for different experimental groups. However, buffaloes fed R1 had higher contents of milk fat and lactose, R2 had higher protein, solids-not-fat (SNF) and ash contents and R3 revealed higher total solid (TS) content ($P < 0.05$). The intake of DM was nearly similar for the different experimental groups. However, buffaloes fed R1 recorded significantly ($P < 0.05$) higher TDN intake and those fed R2 had higher DCP intake. Buffaloes fed R3 had the lower amount of DM, R2 and R3 had the lower amount of TDN and R1 had the lower amount of DCP required per one kg of 7 % FCM. Average daily feed cost and feed cost per one kg 7 % FCM were increased significantly ($P < 0.05$) with feeding fresh berseem compared to corn silage. Meantime, total revenue of milk yield was significantly ($P < 0.05$) higher with R3 compared to both R1 and R2. However, net revenue and economic efficiency increased significantly ($P < 0.05$) with corn silage compared to fresh berseem. The concentrations and excretion of macro and micro-elements in milk of buffaloes were significantly ($P < 0.05$) higher in R2 followed by R3, while R1 had the lower values. The concentrations of Ca, phosphorus (P), copper (Cu), Zn and Mn in milk of buffaloes fed corn silage were lower than the normal values.

Key words: lactating buffaloes; corn silage; fresh berseem; digestibility; milk yield and composition; feed conversion, milk minerals

INTRODUCTION

Using such high quality forage for feeding lactating buffaloes formulated balanced rations with adequate protein and energy that reflect on health conditions and enhanced milk production and composition (Mahmoud and Ebeid, 2014). Depending on corn silage as the main source of roughage in rations of lactating cows has an effect on animal productive performance similar to that in cattle depending on berseem hay plus corn silage in its ration (Orabi and Mousa, 2015).

Feeding management practices of the dairy farm can have a major impact on the levels of milk fat and protein concentration in milk. Nutritional strategies that optimize rumen function also maximize milk production and milk components. However, there are several strategies, which producers can use to enhance rumen function and the resulting milk components. However, nutritional

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strategies, which affect milk components, include adequate rumen degradable protein and adequate pounds of forage NDF in the diet especially for early lactation cows (Varga and Ishler, 2007).

Concentration of fat in milk can vary over a range of about 3 % through diet manipulation. In contrast, lactose, minerals, and the other solid contents of milk are not responsive, whereas the protein can vary at 0.6 % (Varga and Ishler, 2007).

Chemical composition of grass and legume are distinctively different. Crude protein (CP) content is generally lower for grass than legume; however, the composition of the crude protein differs. Grass contains more non-protein nitrogen in soluble protein and legumes contain more amino acids or peptides in soluble crude protein (Varga and Ishler, 2007).

A great deal of information has recently become available for better nutrition strategies including covering minerals to livestock, particularly lactating cows (McDowell and Valle, 2000). Minerals are greatly essential for proper metabolic functioning of the animal. A problem arises when the feed intake does not supply enough amount of minerals to meet the animal's requirements. This may occur when the feed is low in minerals, the bioavailability of the minerals is low, or another nutrient is interfering with the ability of the animal to absorb or utilize the minerals (Malmberg *et al*., 2003).

The contents of calcium, phosphorus, sodium, zinc and manganese were deficient in whole plant corn silage, and adding such minerals during feeding corn silage as a basal ration for feeding lactating cows is very necessary (Gaafar, 2009). Feeding of dairy cows with a ration containing 40 % concentrated feed mixture + 40 % corn silage + 20 % rice straw needs using mineral additives, especially for calcium, phosphorus, copper, zinc and manganese. The premix and seaweed additives increased apparent mineral absorption and retention, mineral concentration in hairs, blood plasma and milk (Bassiouni *et al*., 2013).

The objective of the present study was to investigate the effect of feeding rations containing corn silage and/or fresh berseem on feed intake, digestibility, milk yield and composition, mineral content in milk, feed conversion and economic efficiency of lactating buffaloes.

MATERIAL AND METHODS

The current work was carried out at private farm, Kafr El-Sheikh Province, North Delta, Egypt during the period from February to April 2018.

Experimental animals

Twelve lactating buffaloes at the 3rd to the 5th lactation, weighing 550-650 kg after 8 weeks of calving in complete switch-back design with three treatments, R1, R2 and R3 with three successive experimental periods were used. Each period consisted of 28 days and the first 14 days were considered as transition period followed by 14 days of the tested period, as described by Lucas (1956). Animals were divided into two blocks, each block contained 2 animals per each treatment as follows:

Three treatments (complete design):

	Block I	Block 2
Period 1	R1 R2 R3	R1 R2 R3
Period 2	R2 R3 R1	R3 R1 R2
Period 3	R1 R2 R3	R1 R2 R3

Lactating buffaloes were individually fed to cover the recommended requirements according to Kearl (1982). Rations were recalculated every week based on milk yield and body weight of animals.

Experimental rations and the management

Each group of buffaloes fed one of the three rations consisted of 40 % concentrate feed mixture (CFM) and 20 % rice straw (RS) plus 40 % corn silage (CS, R1) or 40 % fresh berseem (FB, R2) or 20 % CS + 20 % FB (R3). Concentrate feed mixture was given two times daily at 8 a.m. and 4 p.m., rice straw was offered two times at 9 a.m. and 5 p.m., while corn silage and fresh berseem were offered at 10 a.m. Buffaloes were watered three times daily at 7, 12 a.m. and 6 p.m. Chemical composition of feedstuffs and experimental rations are presented in Table (1).

Table 1. Chemical composition of feedstuffs and experimental rations

Item	Feedstuffs				Experimental rations		
	CFM**	CS	FB	RS	R1	R2	R3
Dry matter, %	90.45	27.72	16.3	89.96	65.26	60.69	62.98
Composition of DM, %							
Organic matter	91.20	92.84	87.45	83.62	90.34	88.18	89.26
Crude protein	16.46	8.14	15.87	2.78	10.40	13.49	11.94
Crude fiber	11.82	24.73	27.15	34.89	21.60	22.57	22.08
Ether extract	3.26	2.58	2.34	1.19	2.57	2.48	2.53
Nitrogen free extract	59.66	57.39	42.09	44.76	55.77	49.65	52.71
Ash	8.80	7.16	12.55	16.38	9.66	11.82	10.74

*CFM: concentrate feed mixture, CS: corn silage, FB: fresh berseem, RS: rice straw, R1: ration 1, R2: ration 2 and R3: ration 3.
**CFM was consisted of 35 % undecorticated cottonseed cake, 5 % linseed cake, 25 % ground yellow corn grains, 20 % wheat bran, 10 % rice bran, 3 % molasses, 1 % limestone and 1 % common salt.

Digestibility trials

Three digestibility trials were carried out during the 2nd period of feeding trial using the experimental buffaloes (four animals in each group) to determine nutrient digestibility coefficients and feeding values of the experimental rations using acid insoluble ash (AIA) as a natural marker (Van Keulen and Young, 1977). The samples of concentrate feed mixture, corn silage and rice straw were taken three times at the beginning, middle and the end of the collection period. Faeces samples were taken from the rectum of each cow twice daily at 12 h intervals during the collection period (7 days). Samples of feedstuffs and faeces were analysed according to A.O.A.C. (1995). The quantity of faeces was calculated from the equation given by Schneider and Flatt (1975) as follows:

Faeces DM (kg) = [DM intake (kg) x (100 – DM digestibility %)]/100

The urine samples were taken from each cow twice daily at 12 h intervals during the collection period (7 days) by clitoral stimulation after the vaginal area was washed with warm water and the urine volume was determined from the equation stated by Nennich *et al*. (2006) as follows:

Urine excretion ($kg.day^{-1}$) = (MUN × 0.563) + 17.1

Where, MUN was milk urea nitrogen and determined from the equation of Nousiainen *et al*. (2004) as follows: MUN ($mg.l^{-1}$) = -14.2 + 0.17 × dietary CP content ($g.kg^{-1}$ dry matter).

Buffalo milking and milk samples

Individual morning and evening milk yield of lactating buffaloes were recorded daily and corrected for 7 % fat content (FCM) using the formula of 7 % FCM = 0.265 x milk yield (kg) + 10.5 x fat yield (kg) as stated by Raafat and Saleh (1962). Milk samples from consecutive evening and morning milking were taken at the 4th week of each period and mixed in proportion to yield. Milk fat, protein, lactose and total solids were determined using Milko-Scan (133B Foss Electric).

Preparation of samples for mineral determination

Wet ashing is primarily used in the preparation of milk samples for subsequent analysis of specific minerals according to (A.O.A.C., 1995). It breaks down and removes the organic matrix surrounding the mineral so that they are left in an aqueous solution. A quantity of 0.5 gram from the samples of feedstuffs and 1 ml from milk were wet ashing. Sample put in a flask with added 10 ml of pure sulfuric acid and then heated with added some drops of hydrogen peroxide. Heating is continued until the organic matter is completely digested, leaving only the mineral oxides. After that it was diluted to 100 ml by distilled water and kept in clean bottles for mineral determination. Mineral excretion in milk was calculated from the milk yield and the concentrations of minerals in milk of cows and buffaloes.

Mineral determination

- Calcium was determined according to the method of Baron and Bell (1957).
- Magnesium, copper, zinc, manganese and iron were determined by Atomic Absorption Spectrophotometer (G.B.C. Avanta).
- Phosphorus was determined by hydroquinone reagent using Spectrophotometer (Jenway 6305 UV/vis. Spectrophotometer).
- Sodium and potassium were determined by Flame Photometer (EEL).

Feed conversion

Feed conversion was calculated as the quantities of DM, TDN and DCP (kg) required to produce one kg 7 % FCM.

Economic efficiency

Economic efficiency of milk production was estimated and expressed as average daily feed cost, cost of 1 kg 7 % FCM, output of milk yield and the ratio between the output of milk yield and feed cost. The prices of one ton were 4500 LE for concentrate feed mixture, 600 LE for corn silage, 550 LE for fresh berseem and 425 LE for rice straw and one kg 7 % FCM was 10 LE according to the prices of 2018. (Ed. Note: 1 Egyptian Pound equals 0.053 Euro; exchange rate on June 4 2019.)

Statistical analysis

The data were analysed using general linear model procedure adapted by IBM SPSS Statistics (2014) for user's guide with one-way ANOVA. Significant differences in the mean values among dietary treatments were analysed by Duncan's test set at the level of significance P < 0.05 (Duncan, 1955).

RESULTS AND DISCUSSION

Nutrient digestibility and feeding values

Digestibility coefficients and feeding values of the experimental rations are shown in Table (2). The digestibility coefficients of dry matter (DM), organic matter (OM), crude protein (CP) and crude fibre (CF) were significantly (P < 0.05) higher for R2 compared to R1, while R3 was intermediate without significant differences. However, the digestibility coefficients of ether extract (EE) and nitrogen free extract (NFE) were significantly (P < 0.05) higher for R1 compared to R2, while R3 was intermediate without significant differences.

In general the higher digestibility values obtained for most nutrients in all tested rations may be attributed to the effect of feeding such high quality forage (berseem or corn silage) which provided stimulatory factors to cellulolytic bacteria and other rumen bacteria. These factors resulted in some changes in the digestive function, which lead to increase in the availability and utilization of nutrients in the rumen and could have a significant impact on digestion and nutritive values of experimental rations.

Table 2. Nutrient digestibility coefficients and feeding values of experimental rations

Item	Experimental rations			MSE
	R1	R2	R3	
Digestibility coefficients, %				
DM	67.24^{b}	69.48^{a}	68.35^{ab}	0.56
OM	68.54^{b}	70.65^{a}	69.41^{ab}	0.55
CP	68.49^{b}	71.93^{a}	70.15^{ab}	0.69
CF	67.64^{b}	69.60^{a}	68.00^{ab}	0.55
EE	82.02^{a}	78.94^{b}	80.56^{ab}	0.70
NFE	72.50^{a}	68.54^{b}	70.62^{ab}	0.75
Feeding values, %				
TDN	66.91^{a}	63.85^{b}	65.20^{ab}	0.62
DCP	7.12^{b}	9.70^{a}	8.38^{ab}	0.39

$^{a, b}$ Values in the same row with different superscripts differ significantly (P < 0.05).

Data in the Table 2 show that R1 had significantly ($P < 0.05$) higher total digestible nutrient (TDN) value (66.91 %), followed by R3 (65.20 %), while R2 had significantly lower value (63.85 %). On the other hand, R2 had significantly ($P < 0.05$) higher digestible crude protein (DCP) value (9.70 %) followed by R3 (8.38 %), while R1 had significantly ($P < 0.05$) lower value (7.12 %). Higher TDN value of R1 may be due to the higher NFE content of corn silage than berseem. On the other hand, higher DCP value of R2 might be attributed to higher CP content of berseem than corn silage, as shown in Table 1. Generally, the present feeding values are mainly associated with the chemical composition and proportion of the experimental feedstuffs, in particular of berseem and corn silage. These results are in agreement with those obtained by El-Ready (2000), El-Aidy (2003) and Khalafalla *et al*. (2007), who found a higher digestibility of all nutrients for cows or buffaloe fed rations contained corn silage, berseem or corn silage and berseem along concentrate feed mixture.

Milk yield and composition

The effect of feeding tested rations on the actual and 7 % FCM yield of the experimental lactating buffaloes is shown in Table 3. The results showed no significant differences in both actual and 7 % FCM yield among the different experimental groups. Moreover, feeding experimental buffalo's rations contained either corn silage (R1) or fresh berseem (R2) or both tested forages (R3) did not affect these parameters. In addition, these results revealed that the requirements of buffaloes in the experimental groups were met by given formulated rations. Moreover, all experimental buffaloes, fed these tested rations, achieved and maintained higher milk production as a result of the feeding such high quality forage along with CFM in proper amounts and proportions. Similar results were found by El-Ready (2000), who reported that milk yield of dairy cows increased with feeding corn silage and fresh berseem. El-Aidy (2003) found that milk yield of buffaloes was not significantly affected by the partial replacement of berseem by corn silage.

In addition, there were significant ($P < 0.05$) differences in milk composition among animals fed tested rations. Feeding of corn silage in R1 significantly ($P < 0.05$) increased the content of milk fat and lactose compared to the feeding of fresh berseem in R2, while R3 showed the intermediate values with insignificant differences. Meantime, the buffaloes fed fresh berseem (R2) had significantly ($P < 0.05$) higher protein, solids-not-fat and ash contents compared with the feeding corn silage (R1) and R3 was intermediate without significant differences. On the other hand, R3 revealed significantly ($P < 0.05$) higher total solid content followed by R1, while R2 had the lower value. The high fat content of milk produced by the buffaloes fed R1 and R3 may be related to the inclusion of high energy corn silage in these two rations, while the lower content of milk produced by feeding fresh berseem in R2 may be attributed to the lower energy content. Milk fat depression can be alleviated within 7 to 21 days by changing the diet of the cow. Milk protein changes may take 3 to 6 weeks or longer if the problem has been going on for a long period (Grainger and Goddard, 2007). Balanced rations for lactating cows should contain at least 40 to 45 percent of ration dry matter from forage. This may be changed by addition of corn silage to the ration and the level of high fibre by-product feeds in the ration. Low forage intake can cause a major reduction in the fat content of milk due to low fibre levels (Mentin and Cook, 2006). Several potential reasons for low forage intake are inadequate forage feeding, poor quality forage and low neutral detergent fibre (NDF) content in forage, that was cut at a very immature stage or late in the fall stage (Bauman and Griinari, 2003). Target a forage NDF intake of 0.9 % of body weight daily. Although low forage diets increase milk protein production, this strategy is not recommended. The low forage levels contribute to acidosis and laminitis; it does not promote good health for the rumen of the cow in a long run. Protein and fat content also can be changed due to the physical form of forage being fed. Much of this is related to ration sorting and failure to provide a consistent diet throughout the day. Coarsely chopped silage and dry hay are the most common causes of sorting. At the extreme, very finely ground diets negatively affect rumen metabolism and depress fat and protein production. Monitoring ration particle size should be done to ensure that adequate effective fibre must be provided and total mixed rations (TMRs) must be mixed properly and distributed evenly to all cows (Dixon and Ernst, 2001). Forage quality can severely impact the amount of energy are being provided

Table 3. Milk yield and composition of buffaloes fed experimental rations

Item	Experimental rations			MSE
	R1	R2	R3	
Milk yield, kg.day^{-1}				
Actual milk	9.64	9.82	9.75	0.07
7 % FCM	9.60	9.39	9.56	0.11
Milk composition, %				
Fat	6.96^{a}	6.58^{b}	6.81^{ab}	0.07
Protein	3.42^{b}	3.75^{a}	3.64^{ab}	0.05
Lactose	5.25^{a}	5.04^{b}	5.16^{ab}	0.05
Solids not fat	9.75^{b}	10.03^{a}	9.97^{a}	0.08
Total solids	16.71^{ab}	16.61^{b}	16.78^{a}	0.11
Ash	1.08^{b}	1.24^{a}	1.17^{ab}	0.02

$^{a, b}$ Values in the same row with different superscripts differ significantly (P < 0.05).

in a ration. Therefore, in addition to doing forage test when new forages are harvested and fed consider having the laboratory to do digestibility measure of the forage as well. It can provide additional information that might shed light on whether lowered milk fat is due to highly fermentable carbohydrates in the ration or inadequate energy provided to the cows stemming from low forage quality. Improvement in nitrogen efficiency may affect milk components.

Feed intake

Average daily feed intake by lactating buffaloes is presented in Table 4. The intake of DM was nearly similar for the different experimental groups without significant difference. Although, the buffaloes fed R1 showed significantly (P < 0.05) higher TDN intake compared to those fed R2, the buffaloes fed R3 showed intermediate TDN with insignificant difference. DCP intake was significantly (P < 0.05) higher for R2 followed by R3, while R1 had significantly (P < 0.05) lower DCP intake. These results may be a reflection of the higher TDN content of R1 contained corn silage and higher DCP content of R2 contained fresh berseem (Table 2). Differences in cell wall fibre content (NDF) and fibre chemical structure are likely the reason for the superiority of legume silage. Legumes have a lower concentration of NDF but higher proportions of indigestible NDF and lignin than grasses. Due to lower NDF concentration and higher rate of rumen degradation rate of the digestible NDF in legumes than in grass, legumes have similar *in vitro* organic matter digestibility at much lower level of potentially digestible NDF than grasses (Weisbjerg *et al*., 2008). The intake of TDN by lactating buffaloes was significantly higher with feeding corn silage, however DCP intake was significantly higher with feeding fresh berseem in reflection to their chemical composition and their nutritive values (Mahmoud and Ebeid, 2014).

Feed conversion

Data of feed conversion expressed as DM, TDN and DCP required for producing one kg 7 % FCM are presented in Table 4. The amount of DM required for 1 kg of 7 % FCM was significantly (P < 0.05) lower for ration containing corn silage plus fresh berseem (R3) compared to the other two rations containing corn silage (R1) and fresh berseem (R2). The amount of TDN required for producing 1 kg 7 % FCM was significantly (P < 0.05) higher with feeding R1 compared with both R2 and R3. However, R2 showed significantly (P < 0.05) higher amount of DCP required for producing 1 kg of 7 % FCM followed by R3, while R1 had the lower value. The improvement of feed conversion ratio was reflected in the improvement in nutrient digestibility (Table 2), 7 % FCM yield (Table 3) and feed intake (Table 4). The better feed utilization was obtained at the combination of corn silage

Table 4. Feed intake, feed conversion and economic efficiency of buffaloes fed experimental rations

Item	Experimental rations			MSE
	R1	R2	R3	
Feed intake, kg/head/day				
DM	16.15	16.26	16.29	0.05
TDN	10.80^{a}	10.38^{b}	10.62^{ab}	0.08
DCP	1.15^{c}	1.58^{a}	1.36^{b}	0.06
Feed conversion, kg.kg^{-1} 7 % FCM				
DM	1.76^{a}	1.76^{a}	1.69^{b}	0.02
TDN	1.17^{a}	1.13^{b}	1.10^{b}	0.01
DCP	0.125^{c}	0.171^{a}	0.142^{b}	0.007
Economic efficiency				
Feed cost, LE.day^{-1}	47.65^{c}	55.84^{a}	52.01^{b}	1.21
Feed cost, LE.kg^{-1} 7 % FCM	5.18^{c}	6.05^{a}	5.40^{b}	0.14
Total revenue, LE.day^{-1}	92.01^{b}	92.24^{b}	96.24^{a}	0.97
Net revenue, LE.day^{-1}	44.36^{a}	36.40^{b}	44.23^{a}	1.62
Economic efficiency	1.93^{a}	1.65^{b}	1.85^{a}	0.05

[a, b, c] Values in the same row with different superscripts differ significantly (P < 0.05).

and fresh berseem. These results agreed with those obtained by El-Aidy (2003), who found that lactating buffaloes fed corn silage along with CFM were more efficient concerning the amount of 7 % FCM produced if compared to feeding berseem and CFM. El-Ready (2000) reported that feeding corn silage and fresh berseem improved the feed utilization efficiency in dairy cows. Dairy cows fed ration contained concentrate feed mixture, fresh berseem and corn silage showed the best feed conversion (Gaafar *et al*., 2010).

Economic efficiency

Results of economic efficiency shown in Table 4 revealed that both average daily feed cost and feed cost per 1 kg of 7 % FCM were significantly (P < 0.05) higher with feeding fresh berseem (R2) followed by feeding corn silage plus fresh berseem (R3), while feeding corn silage (R1) showed the lowest values. Meantime, total revenue of milk yield was significantly (P < 0.05) higher with R3 compared to both R1 and R2. Moreover, buffaloes fed both R1 and R3 had significantly (P < 0.05) higher net revenue and economic efficiency compared to those fed R2. These results agreed with those obtained by El-Aidy (2003), who found that lactating buffaloes fed corn silage along with CFM were more efficient economically compared to the feeding berseem and CFM. El-Ready (2000) reported that feeding corn silage and fresh berseem improved efficiency in dairy cows. Dairy cows fed ration contained concentrate feed mixture, fresh berseem and corn silage showed the best economic efficiency (Gaafar *et al*., 2010).

Mineral content of feedstuffs and experimental rations

Mineral contents of the experimental feedstuffs and experimental rations are presented in Table 5. The data revealed that the contents of Ca, K, Zn, Mn and Fe were higher in fresh berseem, while the contents of P, Mg, Na and Cu were higher in concentrate feed mixture. However, the lower contents of all mineral were detected in corn silage and rice straw. Fresh berseem, as legume, was rich in Ca content. Gaafar (2009) found that the contents of all minerals (Ca, P, Mg, Na, K, Cu, Zn, Mn and Fe) were higher in concentrate feed mixture compared to corn silage. Bassiouni *et al*. (2013) reported the low contents of calcium, phosphorus, magnesium, sodium, copper, zinc and manganese in corn silage and also the low contents of calcium, phosphorus, magnesium, potassium, copper and zinc in rice straw. Alfalfa has almost twice the ash content of corn silage (NRC, 2001). Maize silage has low concentrations of calcium, magnesium, sodium and phosphorus. Feeding maize silage can exacerbate mineral deficiencies because magnesium and calcium already present in pasture diets. As a general rule, when maize silage makes up 25 % or more of a lactating cow diet, mineral supplementation is recommended. Depending on the individual farm, phosphorus supplementation may also be required. Requirements for trace minerals are similar when feeding maize silage or grazing pasture. A trace element supplementation or animal treatment programme should be routine 1 month before calving and 4 months after calving. Supplying the cow's requirements in copper, selenium, cobalt, iodine and zinc will cost approximately 4 cents per cow per day (Kolver *et al*., 2001).

The contents of all minerals were higher in R2 contained fresh berseem than in R1 contained corn silage, while mineral content in R3 was intermediate between R1 and R2. Mineral calculation of experimental rations showed that the contents of calcium, phosphorus, copper, zinc and manganese in R1 as well as phosphorus, copper and zinc in R3 were lower than the recommended requirements for dairy cows being 0.60, 0.40 %, 10, 40 and 40 ppm, respectively (NRC, 2001). Gaafar (2009) found that feeding growing calves with a ration containing corn silage needs mineral additives. Bassiouni *et al*. (2013) reported that feeding dairy cows with a ration containing 40 % concentrate feed mixture + 40 % corn silage + 20 % rice straw requires mineral additives, especially for calcium, phosphorus, copper, zinc and manganese.

Dietary mineral balance

Mineral balance in buffaloes fed experimental rations was presented in Table 6. The intake of macro- and micro- minerals was significantly higher ($P < 0.05$) with feeding R2 contained fresh berseem compared to R1 contained corn silage, whereas R3 was intermediate between them with significant differences. The higher increase was detected in Ca, medium increase was found in Na, K, Zn and Mn, low-medium increases in Mg and low increase in P and Cu. These increases might be attributed to the higher mineral content in fresh berseem compared to corn silage as well as in R2 compared to R1 (Table 5). The excretion in faeces and urine as well as the absorption and retention of all minerals increased significantly ($P < 0.05$) with increasing dietary mineral intake, which R2 showed significantly ($P < 0.05$) highest values followed by R3, whereas R1 showed lowest values. These results agreed with those obtained by Gaafar (2009), who found that dietary mineral intake, excretion, absorption and retention by growing Friesian calves decreased with increasing the level of corn silage in the rations. Bassiouni *et al*. (2013) reported that apparent absorption and retention of minerals by dairy cows increased with increasing mineral intake by seaweed and premix supplementation.

Table 5. Mineral contents of feedstuffs and experimental rations

Element	Feedstuffs				Experimental rations		
	CFM	CS	FB	RS	R1	R2	R3
Macro-element, %							
Calcium (Ca)	0.95	0.25	1.5	0.2	0.52	1.02	0.77
Phosphorus (P)	0.6	0.2	0.35	0.11	0.34	0.40	0.37
Magnesium (Mg)	0.45	0.13	0.35	0.11	0.25	0.34	0.39
Sodium (Na)	0.75	0.12	0.7	0.22	0.39	0.62	0.51
Potassium (K)	1.3	1.1	2.5	0.7	1.10	1.66	1.38
Micro-element, ppm							
Copper (Cu)	12	8	11	5	9.0	10.2	9.6
Zinc (Zn)	40	25	62	20	30.0	44.8	37.4
Manganese (Mn)	45	16	55	50	34.4	50.0	42.2
Iron (Fe)	450	245	470	340	346	436	391

Table 6. Dietary mineral balance in lactating buffaloes fed experimental rations

Element	Ration	Intake	Feces	Urine	Absorption	Retention
Macro-elements, $g.day^{-1}$						
Ca	R1	83.98^c	36.95^c	17.64^c	47.03^c	29.39^c
	R2	165.85^a	76.29^a	33.17^a	89.56^a	56.39^a
	R3	125.46^b	56.46^b	25.72^b	69.00^b	43.28^b
	MSE	12.07	5.81	2.29	6.26	3.98
P	R1	54.91^c	24.16^c	10.98^b	30.75^c	19.77^c
	R2	65.15^a	28.01^a	12.38^a	37.13^a	24.76^a
	R3	60.29^b	26.22^b	11.76^{ab}	34.06^b	22.31^b
	MSE	1.51	0.57	0.21	0.94	0.74
Mg	R1	40.08^c	18.04^c	8.02^c	22.04^c	14.03^c
	R2	55.39^a	25.48^a	11.63^a	29.91^a	18.28^a
	R3	48.88^b	22.24^b	10.02^b	26.64^b	16.62^b
	MSE	2.25	1.09	0.53	1.16	0.63
Na	R1	63.30^c	12.66^c	28.49^c	50.65^c	22.16^c
	R2	101.46^a	21.31^a	46.67^a	80.16^a	33.48^a
	R3	81.47^b	16.70^b	37.07^b	64.77^b	27.70^b
	MSE	5.66	1.28	2.70	4.37	1.68
K	R1	177.65^c	35.53^c	79.94^c	142.12^c	62.18^c
	R2	269.92^a	56.68^a	124.16^a	213.23^a	89.07^a
	R3	224.85^b	46.09^b	102.31^b	178.75^b	76.45^b
	MSE	13.60	3.12	6.52	10.48	3.96
Trace-elements, $mg.day^{-1}$						
Cu	R1	145.35^c	65.41^c	29.07^c	79.94^c	50.87^b
	R2	165.85^a	76.29^a	34.83^a	89.56^a	54.73^a
	R3	156.42^b	71.17^b	32.07^b	85.25^b	53.18^a
	MSE	3.04	1.61	0.85	1.43	0.58
Zn	R1	484.50^c	218.02^c	96.90^c	266.48^c	169.58^c
	R2	728.45^a	335.09^a	152.97^a	393.36^a	240.39^a
	R3	609.37^b	277.26^b	124.92^b	332.11^b	207.19^b
	MSE	35.96	17.27	8.28	18.69	10.42
Mn	R1	555.56^c	250.00^c	111.11^c	305.56^c	194.45^c
	R2	813.00^a	373.98^a	170.73^a	439.02^a	268.29^a
	R3	681.06^b	309.88^b	139.62^b	371.18^b	231.56^b
	MSE	38.10	18.36	8.84	19.74	10.91
Fe	R1	5587.90^c	2514.60^c	1117.60^c	3073.30^c	1955.80^c
	R2	7089.40^a	3261.10^a	1488.80^a	3828.30^a	2339.50^a
	R3	6370.70^b	2898.70^b	1306.00^b	3472.00^b	2166.00^b
	MSE	221.45	110.15	54.80	111.30	56.56

$^{a, b, c}$ Values in the column for each element with different superscripts differ significantly ($P < 0.05$).

Mineral concentrations in milk

The effect of feeding different rations on mineral concentrations in milk of buffaloes is shown in Table 7. The concentrations of macro-minerals (Ca, P, Mg, Na and K) and micro-minerals (Cu, Zn, Mn and Fe) in milk increased significantly ($P < 0.05$) with increasing dietary mineral intake, absorption and retention. Mineral concentrations

Table 7. Mineral concentrations in milk of buffaloes fed experimental rations

Element	Experimental rations			MSE
	R1	R2	R3	
Macro-mineral, $g.kg^{-1}$				
Ca	1.48^{b}	1.82^{a}	1.60^{ab}	0.08
P	1.00^{b}	1.30^{a}	1.10^{ab}	0.06
Mg	0.21^{b}	0.25^{a}	0.23^{ab}	0.01
Na	0.57^{b}	0.68^{a}	0.61^{ab}	0.03
K	1.58^{b}	1.82^{a}	1.66^{ab}	0.06
Micro-mineral, $mg.kg^{-1}$				
Cu	0.20^{b}	0.26^{a}	0.22^{ab}	0.02
Zn	3.64^{b}	4.16^{a}	3.82^{ab}	0.12
Mn	0.042^{b}	0.053^{a}	0.046^{ab}	0.003
Fe	1.27^{b}	1.43^{a}	1.33^{ab}	0.04

[a, b] Values in the same row with different superscripts differ significantly (P < 0.05).

in milk were significantly higher (P < 0.05) in R2 than in R1, while R3 was intermediate without significant differences. The high significant positive correlations were observed between dietary mineral retention and their concentrations in milk were following: Ca = 0.90, P = 0.85, Mg = 0.80, Na = 0.88, K = 0.85, Cu = 0.86, Zn = 0.89, Mn = 0.85 and Fe = 0.80. The concentrations of Ca and P in milk of buffaloes fed R1 and R3 were lower than the normal values being 1.63 and 1.11 $g.kg^{-1}$, respectively (Soliman, 2005). Bassiouni *et al*. (2013) found that macro and micro-mineral concentration in the milk of cows fed rations containing 40 % corn silage increased with 25 g premix or 50 g seaweed (as a source of minerals) per head per day.

Table 8. Mineral excretion in milk of buffaloes fed experimental rations

Element	Experimental rations			MSE
	R1	R2	R3	
Macro-mineral, $g.kg^{-1}$				
Ca	13.68^{b}	17.56^{a}	15.71^{ab}	0.81
P	9.24^{b}	12.55^{a}	10.80^{ab}	0.62
Mg	1.94^{b}	2.41^{a}	2.23^{ab}	0.11
Na	5.27^{b}	6.56^{a}	5.96^{ab}	0.27
K	14.60^{b}	17.56^{a}	16.27^{ab}	0.61
Micro-mineral, $mg.kg^{-1}$				
Cu	1.85^{b}	2.51^{a}	2.19^{ab}	0.16
Zn	33.63^{b}	40.14^{a}	37.51^{ab}	1.31
Mn	0.39^{b}	0.51^{a}	0.45^{ab}	0.03
Fe	11.73^{b}	13.80^{a}	13.03^{ab}	0.45

[a, b] Values in the same row with different superscripts differ significantly (P < 0.05).

Mineral excretion in milk

The excretion of macro and micro-minerals in milk of buffaloes fed experimental rations is presented in Table 8. The amounts of all mineral excretion in milk were significantly higher ($P < 0.05$) with feeding R2 compared to R1, whereas R3 was intermediate without significant differences. These results illustrate that mineral excretion in milk increased with increasing dietary mineral intake, absorption and retention. Average value and range of mineral excretion in milk as a percentage of mineral retention in the body were high for P - 48.84 % (26.92-69.90 %) and Ca - 36.91% (20.04-51.78 %); medium for Na - 21.35 % (10.67-36.85 %), K - 21.24 % (11.13-35.81 %), Zn - 18.01 % (12.48-27.18 %) and Mg - 13.42 % (7.94-19.26 %); low for Cu - 4.17 % (1.47-7.82 %) and very low for Fe - 0.60 % (0.31-0.89 %) and Mn - 0.19 % (0.10-0.36 %). These results revealed that milk is a good source of calcium, phosphorus, sodium, potassium, zinc and magnesium. Many minerals in milk are associated together in the form of salts, such as calcium phosphate. In milk, approximately 67 % of calcium, 35 % of magnesium, and 44 % of phosphorus are salts bound within the casein micelle and the remainder are soluble in the serum phase. The fact that calcium and phosphorus are associated as salts bound with the protein does not affect the nutritional availability of either calcium or phosphate. Milk contains small amounts of copper, iron, manganese and sodium and is not considered a major source of these minerals in the diet. The concentration of major elements depends on the animal species, method of feeding, lactation stage and health state of the udder (Cashman, 2006).

CONCLUSION

The present results indicated that the use of high quality forage, such as corn silage and fresh berseem for feeding lactating buffaloes formulated balanced rations with adequate protein and energy that reflect enhanced digestibility, feed intake, milk yield and composition, feed conversion and economic efficiency, mineral balance and minerals excretion in milk compared to feeding corn silage or fresh berseem alone.

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