International Journal of

Dairy Science

ISSN 1811-9743

Academic
Journals Inc.

www.academicjournals.com

International Journal of Dairy Science 2 (4): 321-329, 2007
ISSN 1811-9743

Effect of By-Pass Cement Dust Supplementation Level to Diets on the Productive Performance of Lactating Buffaloes

[1]M.E.H. Shalabi, [2]S.M. Kholif and [3]M.M. Khorshed
[1]Central Metallurgical Research and Development Institute (CMRDI), Egypt
[2]Department of Dairy Science, National Research Centre, Dokki, Cairo, Egypt
[3]Department of Animal Production, Faculty of Agriculture,
Ain Shams University, Cairo, Egypt

Abstract: Fifteen lactating buffaloes after seven days post-parturition were divided randomly into three groups (of 5 animals each) to study the effect of adding By-Pass Cement Dust (BCD) level to the buffalo's diets on the coefficients of nutrient digestibility and milk yield and composition using complete random block design experiment with 90 days period. The control group was given a basic diet consisting of (60% Concentrate Feed Mixture (CFM): 20% berseem clover: 20% rice straw), the second and third groups were fed the control ration plus 7.5 and 15 g/head/day BCD, respectively. The CFM for each animal was offered individually once daily at 8.00 am, while berseem clover and rice straw were offered at 10.00 am. Individual milk samples were collected every two weeks of the experimental period for chemical analysis. After 4 h of the morning meal, grab samples and blood serum samples were collected in the last day every month for chemical analysis. Nutrients digestibility coefficient of organic matter, crude protein and crude fiber were significantly higher with animals fed low level followed by high level of BCD and then control. Also, dry matter, ether extract and nitrogen free extract digestibilities followed the same trend while the effects of treatments failed to be significant. Supplementation of low level of BCD to buffaloes rations increased yields of milk ($p<0.05$), 4% FCM ($p>0.05$) and milk constituents ($p>0.05$) compared with other treatments. Milk fat, protein and lactose contents were insignificantly increased with animals fed BCD compared with control. While, total solids, ash and solids not fat contents were not differed among treatments. Milk P, Mg and K contents were significantly higher with animals fed BCD compared with control. Feed efficiency as Milk yield/dry matter intake (DMI) ($p<0.05$) and FCM/DMI ($p>0.05$) were higher for animals fed BCD than that fed control. Blood serum total protein, urea and glucose were higher ($p<0.05$) in animals fed on low BCD supplemented rations, while, other blood serum parameters were not affected by treatments. Also, blood serum Ca, Na and Fe were significantly higher in animals fed on low BCD supplemented rations compared with control. It could be concluded that low BCD supplementation (7.5/head/day) to diets improved nutrients digestibility coefficients, milk yield and milk constituents than other treatments.

Key words: By-Pass Cement dust (BCD), digestibility, milk, blood serum, buffaloes

INTRODUCTION

Late stages of gestation and early lactation contribute to changes in both Ca and P metabolism (Liesegang *et al*., 2000). Increased bone resorption occurs because of skeletal mineralization of the fetus in late gestation and milk production during early lactation (Brommage and DeLuca, 1985; Fukuda and Iida, 1993). Milk production requires an available supply of P and bone resorption was estimated to

Corresponding Author: S.M. Kholif, Department of Dairy Science, National Research Centre, Dokki, Cairo, Egypt

supply 500-600 g of P during the first few weeks of lactation (Wu *et al*., 2000). A large portion of P mobilized from bone tissue may be a direct consequence of Ca mobilization for Ca homeostasis in early lactation (Horst, 1986; Wu *et al*., 2000). It is hypothesized that feeding a prepartum ration to supply between 30 and 35 g of P/cow daily for multiparous Holstein cows is sufficient to meet periparturient requirements without adverse effects on metabolism or early lactation performance (Peterson *et al*., 2005). Overfeeding of P is costly and increases the risk of environmental damage through eutrophication of lakes and streams (Rotz *et al*., 2002). Once the P requirements of the cow are met, most excess dietary P is excreted in the manure, primarily in the feces (Wu *et al*., 2000, 2001). The term micro-or trace minerals refers to those specific elements that are present in small amounts in the diet and are needed in small amounts by the body (Segerson *et al*., 1977; Corah, 1996). Due to this definition, trace minerals are sometimes ignored or overlooked. Nevertheless, they participate in a wide range of body functions, most of them as components of important enzymatic systems that involve immune, metabolic and reproductive functions (Graham, 1991; Ferguson, 1996; NRC, 2001).

This study was conducted to evaluate the effects of supplementation level of BCD-as high source of calcium, phosphorous, sodium and iron contents-to rations on the productive performance of lactating buffaloes.

MATERIALS AND METHODS

This study was conducted at the Experimental Farm in Shalakan, Faculty of Agriculture, Ain Shams University and Dairy Science Department, National Research Center, Dokki, Giza, Egypt, during 2005.

By-Pass Cement Dust

By pass Cement Dust was obtained from National Cement Company (El-Tabbin, Helwan, Egypt). X-ray analysis of by-pass cement dust is shown in Fig. 1, from this figure it was shown the main fraction components of BCD are calcite (calcium carbonate ($CaCO_3$)), quartz (SiO_2), sodium chloride (NaCl).

Animals and Diets

Fifteen lactating buffaloes after seven days of parturition were divided randomly into three groups (of 5 animals each)-according to milk production and lactation season-to study the effect of supplementation level of BCD to buffalo's rations on nutrient digestibility coefficients, blood serum parameters and milk yield and composition using complete random block design experiment with 90 days period. Experimental rations were control (60% Concentrate Feed Mixture (CFM): 20%

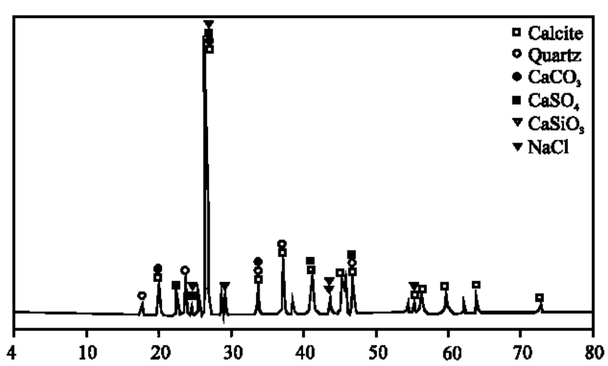

Fig. 1: X-ray analysis of by-pass cement dust

Table 1: Chemical composition of dietary ingredients (% DM basis)

Items	CFM	RS	BC	BCD
Dry matter	91.29	93.39	90.35	--
Organic matter	89.89	86.77	87.90	--
Ash	10.11	13.23	12.10	--
Crude protein	14.15	3.96	12.80	--
Ether extract	4.05	4.55	2.50	--
Crude Fiber (CF)	15.33	35.50	28.20	--
Nitrogen free extract	56.36	42.76	44.40	--
Minerals composition				
CaO	0.632	0.31	1.52	44.24
P_2O_5	0.836	0.10	0.26	6.35
MgO	0.409	0.14	0.30	1.45
Na_2O	0.0002	0.0002	0.004	2.00
K_2O	0.044	0.12	0.01	3.50
Fe_2O_3	1.256	1.55	2.53	1.92

CFM: Concentrate Feed Mixture, RS: Rice Straw, BC: Berseem Clover, BCD: By-pass Cement Dust

berseem clover: 20% rice straw), treatment I (control ration plus 7.5 g/head/day BCD) and treatment II (control ration plus 15 g/head/day BCD). The CFM was consisted of 35% yellow corn, 25% wheat bran, 22% decorticated cotton seed meal, 15% rice bran, 1.5% ground limestone and 1.5% common salt. The chemical composition of ingredients is showed in Table 1. The offered feeds were assessed to cover the requirements for each animal (ARC, 1965). The CFM for each animal was offered individually once daily at 8.00 am, while berseem clover and rice straw were offered at 10.00 am and 4.00 pm. Dry matter intake was measured during the last refusals of the previous day. Clean water was available to animals at all times.

Analysis of Feed Samples

Samples of ingredients and rations were analyzed for DM, ash, CF and Ether Extract (EE) according to methods of AOAC (1995). While, organic matter and Nitrogen-Free Extract (NFE) was calculated. Calcium, potassium, magnesium, iron and sodium were analyzed by using atomic absorption spectrophotometer (IL-5-12) according to Jackson (1958). While, inorganic phosphorous was determined by calorimetric method by using kits according to Troug and Meyer (1939).

Digestibility Trial

Simultaneously three digestibility trials were carried out on all animals of each treatment of feeding trail and repeated each 30 days of the experimental period. Grab sample method was used and silica as internal marker was applied for determining the digestibility. After 4 h of the morning meal, feces grab samples were collected individually from each animal for three successive days. Solution of 10% H_2SO_4 were added to the representative samples then dried in oven at 70°C for 24 h. The dried feces samples from each animal were mixed and stored at 18°C for chemical analysis. The digestibility coefficient was calculated according to the following formula according to (Gallup *et al*., 1945; Forbes and Garrigus, 1948).

$$\text{Digestibility \%} = 100 - \left[100 \times \frac{\text{\% indicator in feed}}{\text{\% indicator in feces}} \times \frac{\text{\% nutrient in feces}}{\text{\% nutrient in feed}}\right]$$

Sampling and Analysis of Milk

Individually milk samples were collected every two weeks of the experimental period (90 days). The buffaloes were hand milked (twice/day), milk yield was recorded and pH of milk was determined (Ling, 1963). Milk samples were also, analyzed for fat, Total Solids (TS), Total Protein (TP) and ash (Ling, 1963), however, lactose was colorimetric determined according to Barnett and Abd El-Tawab (1957). Solids-Not-Fat (SNF) was calculated by difference.

Sampling and Analysis of Blood Serum

Blood samples were collected from the jugular vein of each animals at the last day of each period after 4 h post morning feeding. The collected blood samples were centrifuged at 4000 r.p.m./20 min. to separate the serum. The obtained serum was stored at 18°C till it was analyzed. Serum total protein was determined as described by Armstrong and Carr (1964), albumin (Doumas *et al*., 1971), urea (Patton and Crouch, 1977), glucose (Siest *et al*., 1981) and serum GOT and GPT (Reitman and Frankel, 1957). Globulin and albumin/globulin ratio were calculated.

Statistical Analysis

Data obtained from this study were statistically analyzed according to procedures outlined by Snedecor and Cochran (1982). The procedure was complete random block design for milk, blood and digestibility data using the general linear model procedure:

$$Y_{ijk} = \mu + R_i + T_k + e_{ijk}$$

Where Y_{ijk} is the parameter under analysis of the ijk goat, μ is the overall mean, R_i is the effect due to the lactation period on the parameter under analysis, T_k is the effect due to treatment on the parameter under analysis, e_{ijk} is the experimental error for ijk on the observation.

The Duncan's multiple range test was used to test the significance between means (Duncan, 1955).

RESULTS AND DISCUSSION

Dry Matter Intake

Dry matter intake did not differed among treatments, being 15.14, 15.08 and 14.85 kg/head/day in control, low and high BCD, respectively (Table 2). The animals of BCD treated group consumed lower ($p>0.05$) amount of dry matter than control animals. Calcium, phosphorous and iron intake were increased significantly ($p<0.05$) with increasing BCD level in the buffaloes diets. These results may be due to high concentrations of calcium, phosphorous and iron in the BCD. While, magnesium, sodium and potassium intake were slightly increased with adding BCD. The P content of the recommended diet corresponded closely to what the National Research Council (NRC, 2001) considers to be the requirement for lactating cows with milk production slightly lower to that of buffaloes used in this experiment. Our results suggest that the true digestibility and availability of P in feeds or BCD is lower than the value of 70% used by NRC (2001).

Nutrients Digestibility Coefficient

Nutrients digestibility coefficient as affected by experimental treatments are shown in Table 3. Organic matter, crude protein and crude fiber digestibilities were highly increased ($p<0.05$) with

Table 2: Nutrients and minerals intake of lactating buffaloes fed on experimental rations

Items	Control	Low BCD	High BCD	±SE
No. of animals	5.00	5.00	5.00	
Live body weight (kg)	569.70	570.00	572.70	0.077
Dry matter intake (kg/h/day)	15.14	15.08	14.85	0.048
From CFM	9.86	9.80	9.74	0.046
From BC	2.35	2.31	2.18	0.051
From RS	2.93	2.97	2.93	0.042
Calculated minerals intake (mg/100 g)				
CaO	0.754[c]	1.089[b]	1.424[a]	0.237
P_2O_5	0.610[b]	0.658[ab]	0.709[a]	0.035
MgO	0.346	0.357	0.369	0.008
Na_2O	0.049	0.065	0.081	0.009
K_2O	1.548	1.581	1.614	0.019
Fe_2O_3	0.0009[c]	0.0152[b]	0.0295[a]	0.008

a, b, c means with different superscripts are significantly different ($p<0.05$)

Table 3: Nutrients digestibility coefficients of lactating buffaloes fed on experimental rations

Items	Control	Low BCD	High BCD	±SE
Dry matter	53.36	54.32	53.46	0.567
Organic matter	57.32^{b}	61.02^{a}	56.35^{ab}	2.240
Crude protein	59.98^{b}	62.35^{a}	60.36^{a}	3.290
Ether extract	59.98	60.25	58.25	0.944
Crude fiber	52.36^{b}	56.21^{a}	52.56^{ab}	1.979
Nitrogen free extract	50.35	53.86	52.58	1.910

Each value is mean of 27 samples for 9 animals. a, b, c means with different superscripts are significantly different ($p<0.05$)

Table 4: Milk yield and composition and feed efficiency of lactating buffaloes fed on experimental rations

Items	Control	Low BCD	High BCD	±SE
Yields (Kg d^{-1}):				
Milk	7.97^{b}	8.19^{a}	8.09^{b}	0.056
4% FCM	10.68	11.18	10.95	0.145
Milk composition yield (g day^{-1})				
Fat	499.7	526.6	514.5	7.788
Total solids	1268.0	1258.8	1300.1	12.530
Solids not fat	767.5	786.2	784.7	6.006
Protein	330.8	343.9	336.9	3.789
Lactose	318.8	359.5	355.9	13.020
Ash	66.9	70.3	70.5	1.169
Milk composition (%)				
Fat	6.27	6.43	6.36	0.097
Total solids	15.91	15.37	16.07	0.107
Solids not fat	9.63	9.60	9.70	0.057
Protein	4.15	4.20	4.16	0.044
Casein nitrogen (mg dL^{-1})	513.10	525.40	520.50	4.379
Lactose	4.00	4.39	4.40	0.050
Ash	0.839	0.858	0.872	0.023
pH	6.93	6.96	6.92	0.014
Minerals (mg dL^{-1})				
Ca	14.89	14.21	13.03	1.836
P	8.80^{B}	26.00^{A}	24.80^{A}	3.123
Na	1.16^{b}	1.31^{a}	1.29^{a}	0.476
K	16.41	17.68	16.17	1.245
Mg	3.12^{b}	7.01^{a}	6.22^{a}	3.996
Fe	0.16	0.15	0.17	0.906
Feed efficiency				
Milk yield/DMI	0.526^{b}	0.609^{a}	0.578^{a}	0.042
FCM yield/DMI	0.757	0.796	0.762	0.026

Each value is mean of 54 samples for 9 animals. A,B,C and a,b,c means with different superscripts are significantly different ($p<0.01$) and ($p<0.05$)

animals fed ration supplemented with low level of BCD followed by high level of BCD and then control. The same trend is true for milk yield ($p<0.05$) and yields of fat and milk composition as g/d percentage ($p>0.05$) (Table 4) or blood serum albumin, P, K and Mg ($p>0.05$) (Table 5). Also, digestibility of dry matter, ether extract and nitrogen free extract were followed the same trend, however, the effect of treatments failed to be significant. This improvements of nutrients digestibility may be due to the availability of minerals in the rumen lead to the increase of the numbers of rumen total viable bacteria and cellulolytic bacteria with animals fed BCD. In total, the addition of low BCD level resulted a good nutrients digestibility coefficient while, the high level of BCD resulted a negative results.

Milk Yield and Composition

Data of milk and milk constituent yields of the experimental buffaloes are summarized in Table 4. Milk yield ($p<0.05$) and 4% FCM ($p>0.05$) were higher in low level followed by high level of BCD supplemented groups than buffaloes receiving control. The higher milk yield with the animals fed low level of BCD supplemented ration might be attributed to the positive effect of BCD on the digestibility of organic matter and its nutrients as shown in Table 3. Lopez *et al*. (2004) and Peterson *et al*. (2005) were reported that high P supplementation to lactating cows diet was not affected milk yield. As an impact of the increased milk yield, daily fat, protein, lactose, solids not fat and ash yields were insignificantly higher in groups received low level of BCD than that received other treatments. While, milk total solids yield was slightly decreased with animals fed the low level of BCD compared with animals fed other rations.

Data of milk composition are also summarized in Table 4. Milk protein content was higher ($p>0.05$) in T_2 (low level of BCD) than other treatments. Milk casein nitrogen was increased with animals fed ration added with BCD compared with control animal. Calcium and phosphorous were involved in casein synthesis in the mammary gland which led to the increase of milk protein with animals fed ration supplemented with low level of BCD. Supplementation of BCD increased ($p>0.05$) milk lactose content, these results probably attributed to the higher ($p<0.05$) of crude fiber digestibility (Table 3) and blood serum glucose ($p<0.05$) and albumin ($p>0.05$) concentration of animals fed low level of BCD supplemented ration as shown in Table 5. It led to an increase in milk lactose synthesis and consequently milk production being increase. Milk fat content was insignificantly increased with low level of BCD treated groups compared with control. However, milk total solids, solids not fat and ash contents and milk pH values were not differ among treatments.

Milk composition was not affected by dietary Ca and P contents. There is no evidence in the literature suggesting that fat content of milk is influenced by feeding Ca and P in excess of NRC (2001) requirements. There have been reports of reduced protein content of milk with low dietary P (De Boer *et al*., 1981; Call *et al*., 1987; Wu and Satter, 2000), but the majority of studies (Valk and Sebek, 1999; Wu *et al*., 2000, 2001) have shown no difference in concentration of milk protein due to dietary P content. Since Ca and P are part of the casein micelle (Jenness, 1985), blood serum Ca and P concentrations could influence milk protein content.

Milk P was increased ($p<0.01$) while, milk Ca was slightly decreased with animals fed BCD compared with control. In the preset study, milk Ca concentration was lower than that of Gowenlock *et al*. (1988) who suggested that milk Ca concentration ranged from 160 to 1600 m gL^{-1} for normal animal growth. This results indicate the higher P absorption than Ca from blood to mammary gland for milk protein synthesis. Calcium has a very close inter-relationship with P and vitamin D. Optimum animal performance is linked closely with Ca and P level in the diet (Hegsted, 1973). The homeostatic mechanism of animals tends to protect against the absorption of excessive quantities of the elements, thus eliminating extra through faeces (Table 6). This may be due to its relationship between Ca and other nutrients, especially P; the feeding of excessive levels of Ca for an extended period of time may have detrimental effects on animal performance.

Milk Mg and Na were significantly higher ($p<0.05$) with animals fed BCD than control. However, milk Fe and K were not affected by treatments. Results obtained here are in harmony with those found by Gowenlock *et al*. (1988) who reported that milk K and Fe concentrations ranged from 350-700 and 0.5-3.0 m gL^{-1}, respectively, for normal animal growth. Excessive level of K may interfere with the uptake of other minerals, including Mg and P. The absorption of Fe is facilitated by the presence of vitamin C and Ca (Ashraf *et al*., 2006).

Generally, feed efficiency calculated as milk yield/DMI ($p<0.05$) and 4% FCM/DMI ($p>0.05$) were improved with animals fed BCD supplemented ration compared with control.

Blood Serum Metabolites

Data in Table 5 showed no significant differences among different treatments on some blood serum parameters, except urea and glucose values, which were increased ($p<0.05$) with animals fed low level of BCD compared with other treatments. Also, blood serum total protein was higher ($p<0.05$) with animals fed high level of BCD than control. These results may be due to the improvements occurred in metabolic process as a BCD response. Diets containing BCD tend to decrease GOT, GPT and A/G ratio however, concentrations of albumin and globulin were slightly increased with animals fed BCD. Serum glucose had the same trend of milk yield Table 4 which was in accordance with the results of Clark *et al*. (1977) who noted a positive correlation between blood glucose and milk yield.

Blood serum Ca was increased ($p<0.05$), however, concentrations of serum P was decreased with animals fed low level followed by high level of BCD and then control. Our results were lower than that obtained by Gowenlock *et al*. (1988) who noted that blood Ca concentration ranged from 50-150 m gL^{-1} for normal animal growth. Goff (1998) found that blood serum P concentration was within the normal range (4-8 mg dL^{-1}) for adult ruminants. Blood serum sodium and iron concentrations were higher ($p<0.05$) with animals fed BCD than that of control, however, magnesium and potassium were not significantly affected by treatments. Gowenlock *et al*. (1988) reported that blood K and Fe concentrations ranged from 100-250 and 1.5-3.0 mg L^{-1}, respectively, for normal animal growth.

In the present study, high faecal minerals concentrations with animals fed BCD (Table 6) showed that minerals were not absorbed properly due to inefficient metabolic system of the animals having deficiencies of other major elements necessary for proper functioning of the metabolic systems. Faecal Ca, K and Fe concentrations ranged from 2000-6000, 1000-3000 and 200-236 mg L^{-1}, respectively, for normal animal growth (Gowenlock *et al*., 1988). There is no evidence in this experiment that feeding minerals in excess of the NRC (2001) requirement affects the incidence of health problems.

Table 5: Blood serum parameters of lactating buffaloes fed on experimental rations

Items	Control	Low BCD	High BCD	±SE
Total protein (g dL^{-1})	6.85^{b}	7.04^{ab}	7.28^{a}	0.093
Albumin (g dL^{-1})	3.68	3.73	3.67	0.052
Globulin (g dL^{-1})	3.17	3.31	3.39	0.116
A/G ratio	1.19	1.14	1.16	0.072
Urea nitrogen (mg dL^{-1})	48.90^{ab}	51.50^{a}	43.50^{b}	0.145
Glucose (mg dL^{-1})	71.55^{b}	76.50^{a}	72.96^{b}	0.149
GOT units (mL^{-1})	21.88	18.66	23.51	0.205
GPT units (mL^{-1})	15.83	13.80	14.21	0.150
Minerals (mg dL^{-1})				
Ca	27.27^{b}	35.05^{a}	31.29^{ab}	3.311
P	7.69	7.33	6.71	3.146
Na	35.65^{ab}	39.33^{a}	30.48^{b}	2.454
K	17.33	18.13	15.07	1.642
Mg	0.307	0.32	0.352	0.314
Fe	0.136^{b}	0.163^{a}	0.16^{a}	0.983

Each value is mean of 27 samples for 9 animals. a,b,c means with different superscripts are significantly different ($p<0.05$)

Table 6: Minerals concentrations (mg dL^{-1}) of faeces of lactating buffaloes fed on experimental rations

Items	Control	Low BCD	High BCD	±SE
Ca	138.60^{b}	246.50^{a}	273.7^{a}	31.68
P	188.70^{b}	324.10^{a}	355.2^{a}	26.13
Na	28.96^{b}	39.57^{a}	41.46^{a}	10.40
K	16.01^{b}	18.83^{b}	22.88^{a}	7.34
Mg	3.43^{b}	3.61^{a}	3.61^{a}	2.56
Fe	26.59^{b}	30.33^{a}	34.44^{a}	9.35

Each value is mean of 27 samples for 9 animals. a,b,c means with different superscripts are significantly different ($p<0.05$)

CONCLUSIONS

It could be concluded that supplementing buffaloes' ration with 7.5 g/head/day of By-pass Cement Dust (BCD) was improved nutrients digestibility coefficients, feed efficiency and milk production with no deleterious effect on general health of animals fed BCD as compared to animals fed the control ration.

REFERENCES

AOAC., 1995. Official Methods of Analysis. 16th Edn., Vol. 1. Agricultural, Chemicals, Contaminats, Drugs. Washington, DC., USA.

ARC., 1965. The Nutrient Requirement of Livestock. No. 2. Ruminants Tech. Rev. and summaries Agric. Res. Council, London, UK.

Armstrong, W.D. and C.W. Carr, 1964. Physiological Chemistry: Laboratory Directions. 3rd Edn., Bures Publishing Co. Minneapolis, Minnesota, USA., pp: 75.

Ashraf, M.Y., A. Khan, M. Ashraf and S. Zafar, 2006. Studies on the transfer of mineral nutrients from feed, water, soil and plants to buffaloes under arid environments. J. Arid Environ., 65: 632-643.

Barnett, A.J.G. and G. Abd El-Tawab, 1957. Determination of lactose in milk and cheese. J. Sci. Food Agric., 8: 437.

Brommage, R. and H.F. DeLuca, 1985. Regulation of bone mineral loss during lactation. Am. J. Physiol., 248: E182-E187.

Call, J.W., J.E. Butcher, J.L. Shupe, R.C. Lamb, R.L. Boman and A.E. Olson, 1987. Clinical effects of low dietary phosphorus concentrations in feed given to lactating dairy cows. Am. J. Vet. Res., 48: 133-136.

Clark, J.H., H.R. Derring and M.R. Bennink, 1977. Milk production, nitrogen utilization and glucose synthesis in lactating cows infused postruminal with sodium caseinate and glucose. J. Nutr., 107: 631.

Corah, L., 1996. Trace mineral requirements of grazing cattle. Anim. Feed Sci. Technol., 59: 61-70.

De Boer, G., J.G. Buchanan-Smith, G.K. Macleod and J.S. Walton, 1981. Responses of dairy cows fed alfalfa silage supplemented with phosphorus, copper, zinc and manganese. J. Dairy Sci., 64: 2370-2377.

Doumas, B., W. Wabson and H. Biggs, 1971. Albumin standards and measurement of serum with bromocresol green. Clin. Chem. Acta, 31: 87.

Duncan, D.B., 1955. Multiple range and multiple F-tests. Biometrics, 11: 1.

Ferguson, J.D., 1996. Diet, production and reproduction in dairy cows. Anim. Feed Sci. Technol., 59: 173-184.

Forbes, R.M. and W.P. Garrigus, 1948. Application of a lignin ratio technique to the determination of the nutrient intake of grazing animals. J. Anim. Sci., 7: 373-382.

Fukuda, S. and H. Iida, 1993. Histomorphometric changes in iliac trabecular bone during pregnancy and lactation in beagle dogs. J. Vet. Med. Sci., 55: 565-569.

Gallup, W.D., C.S. Hobbs and H.M. Briggs, 1945. The use of silica as a reference substance in digestion trials with ruminants. J. Anim. Sci., 4: 68-71.

Goff, J.P., 1998. Phosphorus Deficiency. In: Current Veterinary Therapy 4: Food Animal Practice. Howard, J.L. and R.A. Smith (Eds.), W.B. Saunders Co., Philadelphia, pp: 218-220.

Gowenlock, A.H., J.R. McMurray and D.M. McLaunchlan, 1988. Practical Clinical Biochemistry. 6th Edn., Heineman Medical Books, London.

Graham, T.W., 1991. Trace element deficiencies in cattle. Vet. Clin. North Am. Food Anim. Pract., 7: 153-215.

Hegsted, D.M., 1973. Modern Nutrition in Health and Diseases. 5th Edn., Lea and Febiger, Philadelphia.

Horst, R.L., 1986. Regulation of calcium and phosphorus homeostasis in the dairy cow. J. Dairy Sci., 69: 604-616.

Jackson, M.L., 1958. Soil chemical analysis. Prentice-Hall, Inc. Englewood Cliffs, N.J., pp: 164-197.

Jenness, R., 1985. Biochemical and Nutritional Aspects of Milk and Colostrum. In: Lactation. Larson, B.L. (Ed.), The Iowa State Univ. Press, Ames.

Liesegang, A., R. Eicher, M.L. Sassi, J. Risteli and M. Kraenzlin *et al.*, 2000. Biochemical markers of bone formation and resorption around parturition and during lactation in dairy cows with high and standard milk yields. J. Dairy Sci., 83: 1773-1781.

Ling, E.R., 1963. Text Book of Dairy Chemistry. Vol. 2. Practical. 3rd Edn., Chapman and Hall, Ltd., London, UK.

Lopez, H., F.D. Kanitz, V.R. Moreira, M.C. Wiltbank and L.D. Satter, 2004. Effect of Dietary Phosphorus on Performance of Lactating Dairy Cows: Milk Production and Cow Health. J. Dairy Sci., 87: 139-145.

National Research Council, 2001. Nutrient Requirements of Dairy Cattle. 7th Rev. Edn., Natl. Acad. Sci., Washington, DC.

Patton, C.J. and S.R. Crouch, 1977. Spectrophotometric and kinetics investigation of the berthelot reaction for the determination of ammonia. Anal. Chem., 49: 469.

Peterson, A.B., M.W. Orth, J.P. Goff and D.K. Beede, 2005. Periparturient responses of multiparous holstein cows fed different dietary phosphorus concentrations prepartum. J. Dairy Sci., 88: 3582-3594.

Reitman, S. and S. Frankel, 1957. Colorimetric method for the determination of serum glutamic-oxaloacetic and glutamic-pyrovate transaminase. Ann. J. Clin. Path., 28: 56.

Rotz, C.A., A.N. Sharpley, L.D. Satter, W.J. Gburek and M.A. Sanderson, 2002. Production and feeding strategies for phosphorus management on dairy farms. J. Dairy Sci., 85: 3142-3153.

Segerson, E.C., Jr., F.A. Murray, A.L. Moxon, D.R. Redman and H.R. Conrad, 1977. Selenium/vitamin E: Role in fertilization of bovine ova. J. Dairy Sci., 60: 1001-1005.

Siest, G., J. Henny and F. Schiele, 1981. Interpretation des examens de laboratoire. Kargered, pp: 206.

Snedecor, G.W. and W.G. Cochran, 1982. Statistical Methods. 7th Edn., Iowa State Unvi. Press, Ames, Iowa, USA.

Troug, E. and A.H. Meyer, 1939. Improvement in deiness colorimetric method for phosphorous and arsenic. Ind. Eng. Chem. Anal. Ed., 1: 138.

Valk, H. and L.B.J. Sebek, 1999. Influence of longterm feeding of limited amounts of phosphorus on dry matter intake, milk production and body weight of dairy cows. J. Dairy Sci., 82: 2157-2163.

Wu, Z. and L.D. Satter, 2000. Milk production and reproductive performance of dairy cows fed two concentrations of phosphorus for two years. J. Dairy Sci., 83: 1052-1063.

Wu, Z., L.D. Satter and R. Sojo, 2000. Milk production, reproductive performance and fecal excretion of phosphorus by dairy cows fed three amounts of phosphorus. J. Dairy Sci., 83: 1028-1041.

Wu, Z., L.D. Satter, A.J. Blohowiak, R.H. Stauffacher and J.H. Wilson, 2001. Milk production, estimated phosphorus excretion and bone characteristics of dairy cows fed different amounts of phosphorus for two or three years. J. Dairy Sci., 84: 1738-1748.