

CALCIUM (Ca) AND PHOSPHORUS (P) CONCENTRATION IN DAIRY COW FEEDS

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Abstract

Calcium and phosphorus are found in the highest proportion in the animal body. The elements have an important role in the development and maintenance of the organism. These two macroelements should be analyzed together when feed ration of dairy cows is formed, because the ratio Ca:P may affect their absorption and utilization in the body, while an insufficient intake limits the nutritional value ration. The purpose of this study was to determine calcium and phosphorus concentration of 39 samples of feeds used in feeding dairy cows (alfalfa, corn silage, alfalfa hay, middlings corn, sunflower meal, and wheat bran). The calcium concentration was assessed by atomic absorption spectrometry method, while phosphorus concentration was measured through spectrophotometric method. Average concentration of calcium, at dry mass, from analyzed samples ranged from 0.84 g/kg to 12.18 g/kg and average concentration of phosphorus ranged between 1.05 g/kg and 10.24 g/kg. The results can be used to design a dairy cow ration that meets the calcium and phosphorus requirements.

Key words: calcium, phosphorus, feed, dairy cows

INTRODUCTION

In plant life, calcium and phosphorus are two important elements that play specific functions: calcium role is to give plants shape and consistency, to grow plants tissues (tips, shoots, fruits) and roots development, influences the cell membrane permeability and acts as an activator of some enzymes [8, 12, 16, 19].

Phosphorus is part of the cell structure composition; participates in several key processes including photosynthesis, respiration. It plays an important role in the processes of energy storage and transfer, in cell division and is a nutrients transporter through the plants cells [8, 16, 19]. The presence of those two essential minerals in crops production determined the performance of several research studies based on the presence, accumulation, availability and their absorption into the soil, plants and then along the food chain in animals and humans.

The purpose of this study was to determine the macro elements content (calcium and phosphorus) in dairy cow feeds.

MATERIAL AND METHODS

This study was conducted on thirty-nine animal feedstuffs samples harvested in 2011 from a unit in Iasi, profiled on raising dairy cows. Feed samples were: alfalfa, corn silage, alfalfa hay, middlings corn (corn and cobs meal), sunflower meal, wheat bran. Sampling of the six types of feed was performed by compliance with the rules in the current standards, in order to be representative for the identification and evaluation of the two macro minerals (Ca, P).

Total phosphorus concentration in animal feeding stuffs was determined by using spectrophotometric method. About 1 g of the sample was weighed in porcelain crucibles, and then calcined in the furnace at 550°C until white or grey ashes were obtained. On the obtained ash, it was added 6M hydrochloric acid solution until effervescence ceased; crucibles were placed on a sand bath to evaporate until dry. After redissolution of residues in 6M hydrochloric acid solution, there were boiled 5 minutes on the sand bath without evaporating until dry. The solutions were filtered and brought to the mark with double-distilled water in 50 mL volumetric flasks. Part of each solution filtered, diluted

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to obtain a phosphorus concentration of no more than 40 mg/L, was introduced in the test tube with molybdovanadate reagent. After mixing the solutions, there were left to stand for 10 minutes for the development of yellow coloration. Absorbance measuring was made on UVmini-1240 SHIMADZU spectrophotometer at a wavelength of 430 nm compared with the reference solution.

The calibration curve was drawn within 5 points by preparation from the standard solution, solutions with different concentrations of phosphorus respectively 5, 10, 20, 30 and 40 mg/L. Phosphorus concentrations, expressed in g/kg DM (dry matter), were calculated according to the weighed sample mass and the dilutions which were made.

Calcium concentration of the samples was determined using atomic absorption spectrometry method (EN ISO 6869/2002). Animal feedstuffs samples went through the same stages of weighing, ashing, solubilisation, and filtration and brought to the mark in volumetric flasks, as in the method for phosphorus assessment.

A portion of filtered solution was diluted with double-distilled water then was added

the buffer solution of lanthanum/caesium chloride (Merck) and 6M hydrochloric acid solution. Absorbance was measured at a flame atomic absorption spectrophotometer AA-6300 SHIMADZU at a wavelength of 422.6 nm compared to the control solution of lanthanum/caesium.

The calibration curve was drawn within 3 points by preparation from the standard calcium solution (Merck), with different concentrations of calcium respectively 0.5, 1.5 and 2 mg/L. Calcium concentrations, expressed in g/kg DM, were calculated according to the weighed sample mass and the dilutions which were made.

The test results were processed statistically by calculating the average (\bar{X}), standard error of the mean ($\pm s_{\bar{X}}$), the coefficient of variation (V %) and safety limits of the average ($t_{\alpha=0,05}$) using Student test.

RESULTS AND DISCUSSIONS

The average concentrations of calcium acquired from analyzes performed on feedstuffs samples used in feeding dairy cows are presented in table 1.

Table 1 The average concentration of calcium in feedstuffs (g/kg DM)

Feedstuff	Sample	$\bar{X} \pm s_{\bar{X}}$	V%	Min.-Max.	Safety limits of the mean ($t_{\alpha=0,05}$)
Alfalfa	10*	12.18±0.041	10.63	10.38-14.31	11.25-13.10
Corn silage	7**	2.17±0.009	11.52	1.85-2.56	1.94-2.40
Alfalfa hay	7	11.23±0.040	9.32	9.85-12.37	10.26-12.20
Middlings corn	5***	0.84±0.002	6.25	0.78-0.91	0.78-0.91
Sunflower meal	5	3.13±0.007	5.34	3.00-3.38	2.92-3.34
Wheat bran	5	1.25±0.004	7.92	1.12-1.38	1.12-1.37

*DF=9; $t_{\alpha=0,05}=2.262$ **DF=6; $t_{\alpha=0,05}=2.447$ *** DF=4; $t_{\alpha=0,05}=2.776$; DF= degrees of freedom [7]

It can be observed that the highest average concentration of calcium in the DM was in the alfalfa, of 12.18 g/kg DM in green mass and of 11.23 g/kg DM in hay; middlings corn had the lowest calcium content (0.84 g/kg DM).

Researches confirmed that the best sources of calcium are leguminous plants, like alfalfa green or alfalfa hay; in general, leguminous plants are 2-3 times richer than grasses; the calcium content is low in seeds and their products [6, 11, 21, 22]. In table 2

there are shown the average concentrations of total phosphorus from the 39 analyzed feedstuffs samples. The highest mean concentration of total phosphorus was recorded in sunflower meal (10.24 g/kg DM) and the lowest was found in middlings corn (1.05 g/kg DM).

In general, forages have a low content of calcium compared to cereals and their by-products which are a good source for this element [6, 11, and 21].

Table 2 The average concentration of total phosphorus in feedstuffs (g/kg DM)

Feedstuff	Sample	$\bar{X} \pm s_{\bar{X}}$	V%	Min.-Max.	Safety limits of the mean ($t_{\alpha=0.05}$)
Alfalfa	10*	1.54±0.005	10.19	1.35-1.82	1.43-1.65
Corn silage	7**	1.85±0.005	7.73	1.63-2.05	1.72-1.99
Alfalfa hay	7	1.45±0.006	10.83	1.33-1.79	1.30-1.59
Middlings corn	5***	1.05±0.005	10.05	0.90-1.19	0.92-1.18
Sunflower meal	5	10.24±0.014	3.14	9.73-10.60	9.84-10.64
Wheat bran	5	10.11±0.010	2.12	9.83-10.41	9.84-10.37

*DF=9; $t_{\alpha=0.05}=2.262$ **DF=6; $t_{\alpha=0.05}=2.447$ *** DF=4; $t_{\alpha=0.05}=2.776$; DF= degrees of freedom [7]

Figure 1 depicts the variation of Ca and total P content from the same analyzed feedstuffs samples. Ratio content of Ca and P in alfalfa was 7.91 Ca: 1 P; in silage corn was 1.17 Ca: 1 P, in alfalfa hay was 7.74 Ca: 1 P.

The ratio of Ca/P changed in P favour, in certain feedstuffs: 1 Ca: 1.25 P in the corn middlings; 1 Ca: 3.27 P in sunflower meal and 1 Ca: 8.09 P ratio in wheat bran.

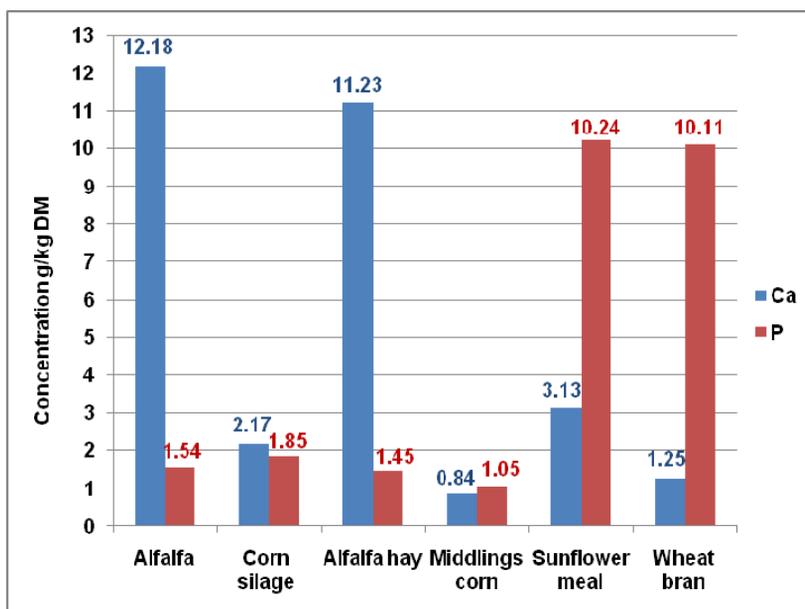


Fig. 1 Average concentrations of calcium and total phosphorus in various feedstuff

Results showed a relatively low content compared with obtained data in other conducted studies in our and foreign countries, which showed a large variability of concentration of the both macro minerals in the same feed (table 3). In the same feedstuffs, the content and bioavailability of minerals depended on many factors such as fertilization systems of soils (potassium fertilizers causes a decrease of calcium content), soil pH, synergic and antagonist

elements of the soil, botanical family, the vegetation stage [3, 10, 22, 24].

Many studies have shown that calcium level is higher in the early stages of vegetation and in higher proportions in the vegetative parts of plants, while leaves are richer than straws. Phosphorus content of feed decrease with increasing vegetation, therefore, when the feedstuffs are harvested later, the dairy cows ration must be supplemented with P [4, 13, 18, and 22].

Table 3 Average concentration of calcium and phosphorus in various feedstuffs after various authors

Feedstuff	Ca (g/kg DM)	P (g/kg DM)	Authors
Alfalfa	15.9-25.0	2.4-3.9	Burlacu Gh. (2002)
	15.5	2.2	Ewing W.N. (2005)
	12.6	2.9	Kirkpatrick B.K. (1984)
	19.6	3.0	McDowell L.R. (1992)
	16.7-2.72	1.8-4.0	Miloș M. (1980)
	13.5	2.7	Preston R.L. (2009)
	18.6-22.6	2.4	Sauvant D. (2004)
Corn silage	3.3	2.0	Bhandari S.K. (2007)
	3.8-4.2	1.8-2.6	Burlacu Gh. (2002)
	1.9	3.0	Ewing W.N. (2005)
	2.5	2.3	Gadberry S. (2009)
	2.5	2.2	Hale C. (2001)
	1.0-4.0	1.5-2.3	Hoffman P. (2004)
	2.2	2.0	Jabbari H. (2011)
	3.68	2.59	Martz F.A. (1990)
	3.3	2.3	Miloș M. (1980)
	1.5	2.6	Moreira V.R. (2009)
2.8-4.0	2.3-2.7	Preston R.L. (2009)	
Alfalfa hay	15.0-22.5	2.2-3.5	Burlacu Gh. (2002)
	12.8	2.1	Coleman R.J. (2000)
	6.3-28.6	1.4-3.5	Corbett R. (2008)
	17.8	2.8	Ewing W.N. (2005)
	11.9-15.0	2.2-3.3	Gadberry S. (2009)
	14.0	2.8	Hale C. (2001)
	13.4	3.2	Martz F.A. (1990)
	18.2	2.4	McDowell L.R. (1992)
	12.0-17.4	2.2-3.0	Miloș M. (1980)
	11.1	2.5	Moreira V.R. (2009)
11.8-14.1	1.9-2.6	Preston R.L. (2009)	
Middlings corn	0.6	2.8	Preston R.L. (2009)
Sunflower meal	4.6	11.2	Burlacu Gh. (2002)
	3.3	5.6	Ewing W.N. (2005)
	4.5	10.2	Gadberry S. (2009)
	2.3-4.2	10.3-11.4	McDowell L.R. (1992)
	2.6-4.3	11.0-12.2	Miloș M. (1980)
	4.1	10.8	Sauvant D. (2004)
	4.0	10.3	Preston R.L. (2009)
Wheat bran	1.3	11.8	Amaral-Phillips Donna M. (2006)
	1.5-2.0	8.9-11.4	Burlacu Gh. (2002)
	1.5	13.6	Ewing W.N. (2005)
	1.4	12.7	Gadberry S. (2009)
	1.3	9.9	McDowell L.R. (1992)
	1.2-3.1	11.0-15.7	Miloș M. (1980)
	1.3	12.9	Preston R.L. (2009)
1.4	9.9	Sauvant D. (2004)	

Due to the diversity of micro and macro minerals, is absolutely necessary their evaluation from feedstuffs, because it is helpful in formulating and preparing dairy cows diet rations which should meet the nutritional requirements of the animal body.

CONCLUSIONS

The concentration levels of calcium and phosphorus were lower than most literature data, due to the influence of calcium and phosphorus levels in soil.

The results show and confirm the significantly higher Ca/P ratio for alfalfa than

corn (silage or middlings) and respectively the high concentration of phosphorus in sunflower meal and wheat bran.

The bioavailability of nutrients from soil requires full analysis of soil from where the feedstuffs are harvested.

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