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**Abstract.** The aim of the present study was to compile data from previous studies dealing with true digestibility of different phosphorous (P) sources for sheep. The database consisted of results from some experiments carried out at the Centre for Nuclear Energy in Agriculture (CENA/USP, Piracicaba, Brazil), using sheep fed different sources of P: dicalcium phosphate (n = 14); monoammonium phosphate (n = 12); triple superphosphate (n = 12); bone meal (n = 28); rock phosphates (n = 32). True absorption of phosphorus was determined by the isotopic dilution technique. All parameters ($P_{ING}$: ingested P; $P_{ABS}$: absorbed P; $P_{FECTOT}$: total faecal P excretion; $P_{FECENDO}$: endogenous faecal P; $P_{FECNABS}$: dietary non absorbed P; and $P_{RET}$: retained P) were normalized according to dry matter intake (DMI) and linear regressions between $P_{ING}$ and the other parameters were tested. Excretion of P was affected by intake. Endogenous fraction of faecal P ($P_{FECENDO}$) was not affected by $P_{ING}$. The present study showed that only 0.37 of ingested P was absorbed, i.e. about two thirds of ingested P were excreted via faeces, contributing to environmental pollution. Some sources of phosphorus can, in the long term, promote environmental damages due to their low availability for the animals.

**Keywords.** Isotopic dilution – Mineral metabolism – Radiophosphorus – True digestibility.

***Aspects quantitatifs d'absorption et d'excrétion du phosphore chez le mouton***

***Résumé.*** *Le but de la présente étude était de rassembler les données des études précédentes traitant la digestibilité réelle de différentes sources de P chez les moutons. La base de données était composée à partir des résultats de quelques expériences effectuées au Centre de l'Énergie Nucléaire dans l'Agriculture (CENA/USP, Piracicaba, Brésil), utilisant des moutons soumis à différentes sources de P : phosphate bicalcique (n = 14) ; phosphate de monoammonium (n = 12) ; superphosphate triple (n = 12) ; farine d'os (n = 28) ; phosphates de roche (n = 32). L'absorption réelle du phosphore a été déterminée par la technique de la dilution isotopique. Tous les paramètres ($P_{ING}$ : P ingéré ; $P_{ABS}$ : P absorbé ; $P_{FECTOT}$ : excrétion totale de P fécal ; $P_{FECENDO}$ : P fécal endogène ; $P_{FECNABS}$ : P diététique non absorbé ; et $P_{RET}$ : P maintenu) ont été normalisés selon la prise de matière sèche (PMS) et des régressions linéaires entre le $P_{ING}$ et les autres paramètres ont été examinées. L'excrétion de P a été affectée par la prise. La fraction endogène de P fécal ($P_{FECENDO}$) n'a pas été affectée par le $P_{ING}$. La présente étude a démontré que seulement 0,37 de P ingéré a été absorbé, par ex., environ deux tiers du P ingéré ont été excrétés dans la matière fécale, contribuant à la pollution environnementale. À long terme et à cause de leur faible disponibilité, quelques sources de phosphore peuvent avoir des répercussions négatives sur l'environnement.*

***Mots-clés.*** *Dilution isotopique – Métabolisme minéral – Phosphore – Digestibilité réelle.*

## I – Introduction

Phosphorus (P) is one of the most polluting nutrients because of high husbandry concentrations in restricted areas (Tamminga, 1992) and therefore it greatly contributes to water pollution through excessive nutrient dejection output. Because it promotes the development of green algae in lakes and rivers, phosphorus is a major freshwater pollutant (Bravo *et al*., 2003b).

There are some remaining doubts concerning the true digestibility of phosphorus. Jarrige (1989)

pointed the coefficient of 0.55 while AFRC (1991) 0.70 for true digestibility of phosphorus. Ruminants excrete phosphorus mainly in faeces, with the faecal loss being constituted of unabsorbed dietary phosphorus and endogenous phosphorus (from saliva, intestinal cells, and digestive secretions) (Bravo *et al*., 2003b).

The aim of the present study was to compile data from previous studies dealing with true digestibility of different P sources for sheep.

## II – Materials and methods

Database consisted of results from experiments carried out at the Centre for Nuclear Energy in Agriculture (CENA/USP, Piracicaba/SP, Brazil), using sheep fed different sources of P: dicalcium phosphate (n = 14); monoammonium phosphate (n = 12); triple superphosphate (n = 12); bone meal (n = 28); rock phosphates (n = 32). The experiment was carried out at the Nutrition Laboratory (CENA/USP), according to recommendations of the Radiological Protection Service and the Animal Welfare Committee.

True absorption of phosphorus was determined by isotopic dilution technique. The animals were kept in metabolic cages for 21 days, designed for isotope studies, and a single dose was given to each animal, comprising 7.4 MBq of $^{32}P$ in 1 ml of sterile isotonic saline solution, into the right jugular vein. Blood samples were withdrawn from the left jugular vein at 24 h intervals for 7 days. From the time of injection, P balance was recorded daily for 7 days through total collection of feed, refusals, faeces and urine.

All parameters ($P_{ING}$: ingested P; $P_{ABS}$: absorbed P; $P_{FECTOT}$: total faecal P excretion; $P_{FECENDO}$: endogenous faecal P; $P_{FECNABS}$: dietary non absorbed P; and $P_{RET}$: retained P) were normalized according to dry matter intake (DMI) as suggested by Bravo *et al*. (2003a). Linear and quadratic regressions between $P_{ING}$ and the other parameters were tested, using PROC REG of the SAS system (SAS, 2000).

## III – Results and discussion

No quadratic effect was observed. Relationships between $P_{ING}$ and all other parameters ($P_{FECTOT}$, $P_{FECNABS}$, $P_{FECENDO}$, $P_{ABS}$ and $P_{RET}$), normalized by DMI, are summarized in Table 1.

**Table 1. Linear regressions between $P_{ING}$ (x) and other parameters (y) for sheep, normalized by dry matter intake (DMI)**

| Y | Slope | | | Intercept | | | $R^2$ | RMSE |
|---|---|---|---|---|---|---|---|---|
| | Value | SEM | P | Value | SEM | P | | |
| $P_{FECTOT}$/DMI | 0.688 | 0.0279 | <0.0001 | –0.024 | 0.2380 | 0.92 | 0.868 | 1.122 |
| $P_{FECNABS}$/DMI | 0.630 | 0.0276 | <0.0001 | –1.368 | 0.2356 | <0.0001 | 0.849 | 1.111 |
| $P_{FECENDO}$/DMI | 0.057 | 0.0189 | 0.0031 | 1.346 | 0.1618 | <0.0001 | 0.090 | 0.767 |
| $P_{ABS}$/DMI | 0.369 | 0.0275 | <0.0001 | 1.375 | 0.2354 | <0.0001 | 0.659 | 1.110 |
| $P_{RET}$/DMI | 0.312 | 0.0278 | <0.0001 | 0.028 | 0.2381 | 0.91 | 0.574 | 1.123 |

SEM: standard error of means; P: probability; $R^2$: determination coefficient of the regression; RMSE: root MSE.

Phosphorus intake ($P_{ING}$) ranged from 1.7 to 18.54 g/kg DMI (n = 98). Excretion of P was affected by intake, being around 0.69 of $P_{ING}$ excreted in faeces, or in other words, the P apparent digestibility coefficient was around 0.31. Even correcting for endogenous contribution, the P true

digestibility coefficient was only 0.37 (i.e. 1 – $P_{FECNABS}$), what is much lower than values mentioned in literature [between 0.55 (Jarrige, 1989) and 0.70 (AFRC, 1991)]. It is important to remind that one third of the results are from animals supplemented with Brazilian rock phosphates, which are known as low P availability sources.

Endogenous fraction of faecal P ($P_{FECENDO}$) consists of unabsorbed phosphorus from digestive secretions, mainly saliva (up to 0.80; Horst, 1986), and it was not affected by $P_{ING}$ (slope = 0.05 and $R^2$ = 0.09), ranging from 0.638 to 4.766 g/kg DMI. However, the relationship between ingested phosphorus and endogenous faecal phosphorus was observed by Guéguen and Durand (1976), Braithwaite (1986), and Bravo *et al.* (2003b). The low availability of P sources as rock phosphates could be responsible for the results observed in the present study.

## IV – Conclusion

The present study showed that, for Brazilian conditions, only 0.37 of ingested P was absorbed, i.e. about two thirds of ingested P was excreted via faeces, contributing for environmental pollution. Some sources of phosphorus can, in long term, promote environmental damages due to their low availability.


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### References


**AFRC (Agricultural and Food Research Council), 1991.** Technical committee on responses to nutrients. Report 6. A reappraisal of the calcium and phosphorus requirements of sheep and cattle. In: *Nutr. Abstr. Rev.*, 61. p. 573-612.

**Braithwaite G.D., 1986.** Phosphorus requirements of ewes in pregnancy and lactation. In: *J. Agric. Sci.*, 106. p. 271-278.

**Bravo D., Sauvant D., Bogaert C. and Meschy F., 2003a.** II. Quantitative aspects of phosphorus absorption in ruminants. In: *Reprod. Nutr. Dev.*, 43. p. 271-284.

**Bravo D., Sauvant D., Bogaert C. and Meschy F., 2003b.** III. Quantitative aspects of phosphorus excretion in ruminants. In: *Reprod. Nutr. Dev*., 43. p. 285-300.

**Guéguen L. and Durand M., 1976.** Utilisation des principaux éléments minéraux du maïs ensilé par le mouton en croissance. In: *Ann. Zootech*., 25. p. 543-549.

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

**Jarrige R., 1989.** *Ruminant Nutrition: Recommended Allowances and Feed Tables.* INRA/John Libbey Eurotext. 400 p.

**SAS, 2000.** *The SAS System for Windows*, Release 8.01. Cary, NC, USA: SAS Institute Inc.

**Tamminga S., 1992.** Nutrition management of dairy cows as a contribution to pollution control. In: *J. Dairy Sci.*, 75. p. 345-357.