Ileal Digestibility of Crude Ash and Minerals in Feeds for the Polar Fox during the Non-mating Period*

Roman SZYMECZKO, Anna PIOTROWSKA and Monika BOGUSŁAWSKA-TRYK

Accepted November 4, 2005

Minerals determine animal growth, development, reproduction and health. They are part of the tissues and body fluids. They are components or activators of numerous hormones, enzymes and vitamins. When combined with proteins, they allow for maintaining cellular oxidation activity and oxygen transport, determining the right metabolic processes (NRC 1980; KING et al. 2001; VASKONEN 2003). Absorption of minerals depends on the type and composition of the diet. The absorption of bioelements depends on the chemical form of the component, its deficit or surplus in feed, the quantitative ratio and the presence of factors activating or inhibiting absorption (DELZENNE et al. 1995; BRONNER & PANSU 1999; LIU et al. 2000; BURKHALTER et al. 2001; HILL et al. 2001).

The alimentary canal in carnivorous fur animals is short and shows a simple structure, adapted to the concentrated and highly-energetic feeds of animal origin. Traditionally the digestibility of nutrients in carnivorous animals is determined along the entire alimentary canal. Experiments on different monogastric animal species showed that the processes of nutrient fermentation and endogenous secretion observed in the large intestine caused by bacterial enzymes affect the concentrations of minerals in the large intestine digesta (LARSEN & SANDROM 1993; DINTZIS et al. 1995; WOLF et al. 1998; HILL et al. 2001). Similarly research on mink demonstrated that, despite a short digesta passage time and a considerably lower bacterial activity, as compared with other species of monogastric animals, in these animals the large intestine shows processes of microbiological degradation of carbohydrates and endogenous secretion (BØRSTING et al. 1995; WILLIAMS et al. 1998; LAERKE et al. 2004). These processes can affect the right estimation of the amount of nutrients absorbed by the animal. The intestinal method of estimating the apparent digestibility eliminates the effect of these processes and, as compared with the faeces method, is more precise, informing directly about the bioavailability of minerals ingested with feed. In an experiment which involved cannulated dogs, HILL et al. (2001) defined the ileal digestibility of minerals from diets with a different amount of animal and plant protein. However, no

*Supported by the Polish State Committee for Scientific Research (KBN), Project No. 5PO6E02618.
reports on the ileal digestibility of minerals in po-
lar foxes were found in the literature available.

The aim of the present study was to compare the
content and apparent ileal digestibility of ash and
minerals in feeds used in feeding reproductive po-
lar foxes during the non-mating period on two do-
mestic farms differing in reproductive results in
the preceding breeding cycle.

Material and Methods

Experimental animals

The experiment included 5, from the same litter,
one-year-old male polar foxes of a similar body
weight (6.18±0.15 kg). In these animals ‘end-to-
-end’ ileorectal anastomosis was made surgically
following the method developed in foxes by
SZYMECZKO (2001). Foxes were premedicated with
tranquilizer (0.08 ml kg−1) and atropine (0.03 mg kg−1).
General anaesthesia was induced with ketamine
(10 mg kg−1) and foxes were placed on their back
side for the surgical procedure. The abdominal cav-
ity was opened and the marked segment of large in-
testine for resection was located. In the mesentery
anastomosed to it – successive blood vessels were
ligated and then the segment of the large intestine
was resected. Free sections of ileum and rectum were
anastomosed with two continuous sutures with the
‘end-to-end’ technique. Having completed the an-
stomosis, the ends of the free mesentery and body
layers were sutured, the area around the wound
was washed and disinfected. Over five days fol-
lowing the operation, antibiotics and tranquilizers,
antihaemorrhage and anti-swelling medications were
administered to the foxes with dosages recommended
by the producers. During the first two days after
surgery, liquids were supplemented, administering
subcutaneous physiological saline solution and glu-
cose. During the following days the foxes were fed
with a liquid diet with an increasing concentration
of nutrients and from the tenth day, the animals
were given an entire feed ration. After the veteri-
nary examination in the third week after the opera-
tion, the foxes were considered clinically healthy.
They were housed separately in metabolic cages,
in an environmentally controlled room at 18°C and
a 14-10 hours light-dark cycle. The use and handling
of animals for this experiment were approved by
the Local Ethical Committee in Bydgoszcz.

Experimental diets

The digestibility of ash and minerals in diets
used in polar fox nutrition were carried out on two
domestic breeding farms (A and B) over the non-
mating period (July 15-December 1). On farm A
the best (8.1 kits per female), and on farm B – the
worst (1 kit per female) reproductive results in the
1999/2000 season were recorded. The ingredient
compositions of feeds given in the first feeding pe-
riod from July 15- September 15 (regeneration af-
ter reproduction period – diets A1 and B1) and in
the second feeding period from July 15 to Decem-
ber 1 (winter furring period – diets A 2 and B2) are
shown in Table 1. The diets were based on animal
offal, with the farm A feed composition diversi-
fied, while farm B feeds were based exclusively on
beef offal and pre-cooked barley meal. The diets
used in digestibility experiments contained 0.5%
of chromic oxide (SZYMECZKO & BURLIKOWSKA
1996). Foxes were fed once a day at 8 a.m., at
the amount covering their metabolizable energy re-
quirements: 90 kcal ME kg−1 of body weight (NRC
1982) and had free access to water.

Digestibility experiment

Testing each diet was divided into two 4-day pe-
riods; preliminary, constituting a period of animal
adaptation to the feeds investigated and a period of
continuous 96-hour ileal digesta collection. All
the experimental digesta was immediately col-
lected after being excreted into plastic boxes with
withstanding lids kept on ice trays which were
stored at +4°C between successive daily collec-
tions. After collection of digesta, the containers
were stored at −25°C before being analysed.

Chemical analysis

The ileal digesta and feed samples were freeze-
dried. The content of nutrients in feeds was deter-
mined with standard methods. The content of min-
erals in diets and ileal digesta were determined
after a prior sample mineralization (20 min) in the
nitric and perchloric acids medium at 230°C using
the Milestone Ethos Plus Microwave Labstation. In
the samples the contents of calcium (Ca), magnesium
(Mg), sodium (Na), potassium (K), and chromium
(Cr) were determined using the atomic absorption
spectrophotometer 969 by Unicam, applying ade-
quate wavelengths: Ca – 422.7 nm, Mg – 285.2
nm, Na–589 nm, K–766.5 nm and Cr–357.9 nm.
The content of phosphorus (P) was determined
with the colorimetric method at a wavelength of
420 nm (SAPEK & SAPEK 1997). The digestibility
of crude ash and minerals was defined with the in-

Statistical analysis

The results obtained were verified with statistic-
al analysis with the Student’s t-test for dependent
samples using Statistica software (1998). The level of significance was set at P<0.05.

Results and Discussion

The chemical composition of feeds and the content of minerals in the dry matter of diets are given in Table 2. The content of nutrients in diet A during both feeding periods was similar, while diet B showed an increased concentration of protein (by about 22%) and crude ash (by about 23%) over the winter furring period (September 15-December 1). The differences in the content of nutrients between A and B farm feeds were found mainly in fat, carbohydrates and crude ash. The greatest differences between diets were demonstrated in the concentration of crude ash whose content in diets A was over 3-fold higher than its amount in diets B and exceeded the nutrient requirements recommended for this animal species (NRC 1982). A high content of crude ash in the diet fed on farm A in both feeding periods examined agree well with a higher content of calcium, phosphorus and sodium in that feed, accompanied by a relatively balanced amount of magnesium and potassium in both diets. As compared with the polar foxes feeding recommendations for the non-mating period, diet A showed an excessive concentration of calcium and sodium, while diet B was a deficient feed as far as the content of calcium and phosphorus in both breeding periods was concerned (NRC 1982; SŁAWON 1987; JAROSZ 1994).

The digestibility results presented in Table 3 showed a higher apparent ileal digestibility of ash and the macroelements investigated (except for sodium) from feeds used in polar fox nutrition on farm B in both feeding periods. As for most of the parameters analyzed, the differences were statistically significant (P<0.05). Sodium absorption, measured at the end of the ileum, was higher (P<0.05) from diets A1 and A2 composed of poultry and fish offal. A high content of ash in diets can lower not only the digestibility of basic nutrients but also the absorption of minerals (SŁAWON 1987; ROUVINEN & KIISKINEN 1991), which is confirmed by the present results. A high degree of variation in the crude ash digestibility in diets A
and B agree well with the results reported by other authors. HLSTRØM et al. (2003) and HLSTRØM & SKREDE (1998), estimating the total digestibility of nutrients in foxes from diets rich in carbohydrates and commercial pet food in which the concentration of crude ash ranged from 6 to 7%, recorded ash digestibility coefficient values ranging from 34 to 58%.

The degree of utilization of calcium and phosphorus from feeds depends on the right ratio of these macroelements. An optimal calcium to phosphorus ratio in fox feeds is 1:1 to 1.7:1, and rations outside this range may result in improper growth of bone, even when the diet contain large amounts of vitamin D (NRC 1982). Both an increase in the content of ash and widening of the Ca: P ratio show an adverse effect on the absorption of these elements, which is confirmed by the present results. A lower apparent ileal digestibility of calcium and phosphorus in both feeding periods was observed for the farm A diets, showing a high concentration of ash and a widened ratio of Ca: P (4.9:1 diet A1; 5.1:1 diet A2). This relationship is confirmed by VALAJA et al. (2000), who, investigating growing foxes, and observed the highest digestibility of calcium (19.9%) and phosphorus (50.9%), measured throughout the alimentary canal of these animals when the foxes were fed with diets with a low content of ash (47g kg⁻¹ DM) and 1.4:1 Ca: P ratio.

The literature available shows no reports on macroelement ileal digestibility in polar foxes. HILL et al. (2001), reporting on an experiment which involved cannulated dogs fed with a 100% beef protein diet, show a considerably lower apparent ileal digestibility of phosphorus (25.9%), sodium (36.8%) and magnesium (12.4%) and a greater ileal digestibility of potassium (92.9%), as compared with the digestibility of these macroelements from experimental feeds B1 and B2 in which beef offal was the main ingredient of the di-

### Table 2
Chemical content of nutrients and mineral composition of diets fed to polar foxes on farm A (diet A1 and A2) and B (diet B1 and B2)

<table>
<thead>
<tr>
<th>Feeding period</th>
<th>15.07-15.09.</th>
<th>15.09-01.12.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diet</td>
<td>A1</td>
<td>B1</td>
</tr>
<tr>
<td>Dry matter, g kg⁻¹</td>
<td>941.9</td>
<td>958.5</td>
</tr>
<tr>
<td>Crude protein</td>
<td>351.3</td>
<td>338.3</td>
</tr>
<tr>
<td>Crude fat</td>
<td>209.0</td>
<td>232.1</td>
</tr>
<tr>
<td>Crude carbohydrates</td>
<td>203.6</td>
<td>296.6</td>
</tr>
<tr>
<td>Crude Ash</td>
<td>163.7</td>
<td>51.5</td>
</tr>
<tr>
<td>Calcium</td>
<td>35.10</td>
<td>2.04</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>7.19</td>
<td>1.96</td>
</tr>
<tr>
<td>Magnesium</td>
<td>1.74</td>
<td>1.78</td>
</tr>
<tr>
<td>Sodium</td>
<td>15.50</td>
<td>4.59</td>
</tr>
<tr>
<td>Potassium</td>
<td>5.80</td>
<td>6.08</td>
</tr>
</tbody>
</table>

### Table 3
Apparent ileal digestibility of crude ash and minerals (%) in diets fed to polar foxes on farm A (diet A1 and A2) and B (diet B1 and B2)

<table>
<thead>
<tr>
<th>Feeding period</th>
<th>15.07-15.09.</th>
<th>15.09-01.12.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diet</td>
<td>A1</td>
<td>B1</td>
</tr>
<tr>
<td>Ash</td>
<td>11.40 ± 3.10*</td>
<td>23.50 ± 3.80*</td>
</tr>
<tr>
<td>Calcium</td>
<td>19.52 ± 11.23</td>
<td>21.44 ± 11.84</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>46.33 ± 2.52</td>
<td>63.26 ± 5.36*</td>
</tr>
<tr>
<td>Magnesium</td>
<td>0.90 ± 9.24</td>
<td>5.96 ± 6.89*</td>
</tr>
<tr>
<td>Sodium</td>
<td>78.99 ± 4.71</td>
<td>52.25 ± 13.38*</td>
</tr>
<tr>
<td>Potassium</td>
<td>75.10 ± 4.25</td>
<td>81.49 ± 5.24</td>
</tr>
</tbody>
</table>

(1) Results are expressed as mean value ± SD  
* Means in the same feeding period differ significantly (P<0.05)
Ileal Digestibility of Minerals in Foxes


References


AHLSTROM Ö., SKREDE A. 1998. Comparative nutrient diges-


d. The differences are most probably due to the diet composition and different bioavailability of the diet minerals (DELENZENNE et al. 1995; BURKHALTER et al. 2001; HILL et al. 2001).

The present study shows that an excessive content of crude ash in feeds used in the polar foxes feeding over the non-mating period (diets A) decreased the digestibility of both ash and the macro-elements estimated. The literature available offers no data on mineral digestibility in foxes, which suggests a need for further research which would provide data to facilitate defining their optimal level in diets for this animal species. The present results constitute a basis for further research into the ileal digestibility of both macroelements and microelements in polar foxes, using the ‘end-to-end’ ileorectal anastomosis method.

decreased the digestibility of both macro-


DELENZENNE N., AERTSEEN S., VERPLAETSE H., ROCCARO M., ROBERFROID M. 1995. Effect of fermentable fructo-


