MINERAL INTAKE IN AFRICAN GREY PARROTS (*PSITTACUS E ERITHACUS*) FED A SEED MIXTURE OR EXTRUDED PELLETS *AD LIBITUM*, AND ITS EFFECTS ON EXCRETA CHARACTERISTICS.

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Introduction

Whole-seed diets encompass several nutritional constraints when fed to parrots. First, the edible part of seeds is strongly imbalanced in calcium to phosphorus (Ca:P) ratio and is deficient in several essential amino acids and vitamins (Harrison, 1998). Next, seed mixtures are high in energy and fat content, which is further increased by the typical feeding behavior of parrots. Data of Werquin *et al.* (2005) showed an average of 16.4 ± 0.9 MJ ME/kg and 19.7 ± 6.3 % fat in commercial seed mixtures (n=30); the edible, dehulled fraction containing 22.4 ± 2.9 MJ ME/kg and 31.7 ± 13.1 % fat. In comparison, diets for chickens for fattening usually contain 12 to 13 MJ ME/kg and considerably less than 10% fat (NRC, 1994). Moreover, when provided a multi-component seed diet, parrots display a strong tendency to select mainly oilseeds such as sunflower seeds or pumpkin seeds, which results in a distinct nutrient profile between offered diet and actually ingested portion (Kalmar *et al.*, accepted). However, in spite of profound nutritional constraints, captive parrots are still commonly fed seed mixtures. A high prevalence of malnutrition related diseases in captive parrots is thus not surprising.

Pellet diets, in contrast to seed mixtures, offer the advantage that they can be formulated to best meet nutritional guidelines; moreover its content is not biased by selective feeding. Then again, nutritive value is not the only issue in dietary strategies. Feed cost, for instance, is usually higher in pellet diets compared to seed mixtures. Another important constraint against feeding pellets instead of seeds is a supposed reduction in time spent by feed intake, resulting in boredom, overfeeding and behavioral disturbances. However, Wolf *et al.* (2002) demonstrated similar time budgets for feeding behavior when parrots are fed pellets compared to seed mixtures. Another drawback against pellet diets is the initial reluctance of parrots against new food items. Nevertheless, several conversion strategies have been demonstrated to be safe and successful (Ghysels, 1997). Excreta characteristics also constitute a consideration in the evaluation of a diet. Excreta firmness is sometimes lower when fed pellets compared to seed mixtures. This can be due to an increase in excreta moisture content or by lower water binding capacity. A generally higher sodium content in pellet diets might possibly increase excreta moisture content, as demonstrated in laying hens (Smith *et al.*, 2000); whereas artificial particle size reduction in the manufacturing of pellets might negatively influence excreta water holding capacity (Kalmar *et al.*, 2007). Excreta acidity is also a trait of importance, as a low intestinal pH can contribute to protection against acid-intolerant pathogens (Naughton and Jensen, 2001).

The present trial was aimed to evaluate the effect of selective feeding and seed dehusking on mineral intake and dietary cation anion difference (DCAD) in parrots fed a seed mixture *ad* *libitum*. The effect of this dietary mineral intake and DCAD on excreta characteristics such as acidity, moisture content and consistency is compared with two pellet diets differing in protein content. Dietary protein has been shown to affect excreta acidity in broiler chickens (Namroud *et al.*, 2008).

Materials

Eight adult, 3-year old African grey parrots (*Psittacus e erithacus*), four males and four females, with an average weight of 490 ± 8 g were individually housed in wire metabolism cages. The bottom of the cage consisted of a removable, metal drawer, which facilitated total collection of feed refusals. Ambient temperature and relative humidity ranged between 19.5 and 21.1 °C, and 53.8 and 62.2 % respectively. The photoperiod was determined by outdoor sunlight. Efforts were made to relieve boredom by providing acrylic bird toys, which were changed daily, and by a timer controlled radio inside the animal house. The experimental design was a 3x3 cross-over trial with 3 nine-day feeding periods in which 3 diets were tested: a seed mixture (Prestige parrot premium(R)) and two extruded pellet diets, P15 (Nutribird P15(R) with moderate protein content (15 %)) and P19 (Nutribird P19(R) with high protein content (19 %)) (Versele Laga Ltd)**.** Food and water were provided *ad libitum* and were refreshed daily. Each of the three feeding periods consisted of 4 days of adaptation, measurement of excreta pH and consistency at day 5, followed by a 4-day period in which average daily food and water intake were measured and total excreta output collected. Food and water were provided *ad libitum* and were refreshed daily. The birds were well acquainted to all test diets prior to the trial.

Measurement of excreta pH was done on 3 fresh droppings per bird, per diet, using a digital glass electrode probe with an accuracy of 0.1. Excreta consistency index (ECI) was assessed on 5 fresh excrements per bird, per diet by ratio of surface area to weight, as described by Kalmar *et al.* (2007). With this method, a lower ECI-value represents a higher firmness of droppings. Excreta output per bird, per period was lyophilized and dried to determine dry matter content.

The total amount of seed remainders was pooled per bird and homogenized. Mineral analysis was performed on subsamples of offered diets and seed remainders. These samples were ashed at 500 °C and subjected to acid digestion in HCL followed by ICP analysis of sodium (Na), potassium (K), calcium (Ca), magnesium (Mg), phosphorus (P), sulphur (S), zinc (Zn), manganese (Mn), and copper (Cu). Chlorine (Cl) was determined potentiometrically using an ion selective electrode.

Mineral (X) concentration of ingested fraction and DCAD were calculated as follows:

$$[X]_{\text{ingested fraction}}\ (\%) = \frac{([X]_{\text{offered mixture}}\ (\%) * \text{offered mixture (g)}) - ([X]_{\text{remainder}} * \text{remainder (g)})}{(\text{offered mixture (g)} - \text{remainder (g)})}$$

DCAD (mEq/kg) = Na + K + Ca + Mg + P + Cl + S

In which minerals are expressed as $\frac{\text{mg/kg * valence}}{\text{molecular weight}}$

As guidelines on mineral content are usually expressed on caloric basis, proximate analysis was performed on above mentioned food samples according to standard methods of the Association of Official Analytical Chemists (AOAC, 1984). Analysed nutrient composition and calculated ME content of test diets, including the consumed fraction of the seed diet, are presented in table 1.

Table 1: Nutrient content and energy density of test diets and consumed fraction of the offered seed mixture (as fed).

		P15 pellets	P19 pellets	Seed Mixture offered	Seed Mixture consumed
Crude Protein	(%)	15.5	19.0	14.0	26.9 ± 3.4
Ether Extract	(%)	14.5	14.2	14.6	42.2 ± 3.4
Crude Fiber	(%)	3.5	3.5	16.0	7.1 ± 0.6
Crude Ash	(%)	5.3	4.6	5.6	3.2 ± 0.7
N-Free Extract	(%)	55.3	53.6	44.5	20.9 ± 2.9
ME	(*)	1785	1807	1577	2486 ± 151

[*] ME = 18 CP + 39 EE + 17 NFE (Schoemaker and Beynen, 2001) with: ME: metabolizable energy (kJ/100 g); CP: crude protein (%); NFE: N-free extract (%): EE: ether extract (%)

Results

Daily water and food intake were similar between P15 and P19 pellets, but were significantly and considerably lower when fed the seed diet. The pH of excreta did not differ between pellet diets but was considerably lower when fed seeds. The ECI shows that feeding P19 pellets lead to firmest droppings. Dry matter content of droppings was significantly higher when fed seeds compared to pellets (table 2).

Table 2: Daily intake and excreta characteristics in African grey parrots fed either extruded pellets with moderate (P15) or high (P19) protein content or a seed diet *ad libitum* (N=8).

		P15 pellets	P19 pellets	Seed mixture	SEM	*P*
Intake						
Water	(ml/d)	52^{a}	51^{a}	31^{b}	3	< 0.001
Food	(g/d)	29^{a}	30^{a}	19^{b}	1	< 0.001
Excreta characteristics						
Moisture	(%)	74.3^{b}	74.4^{b}	71.6^{a}	0.5	0.024
ECI		32.5^{a}	26.4^{b}	28.6^{b}	0.7	0.001
pH		7.9^{a}	7.9^{a}	5.6^{b}	0.2	< 0.001

[a,b] different superscripts within a row indicate a significant difference at P < 0.050

DCAD in P15 pellets, offered seed mixture and P19 pellets was 477 mEq/kg, 486 mEq/kg and 526 mEq/kg, respectively. However, DCAD in the ingested fraction of the offered seed mixture was only 121 ± 97 mEq/kg. Sodium content was only above recommendations in P15 pellets, whereas Ca and Mg requirements were covered in all test diets and none of the diets contained sufficient Cl according to available guidelines. The ingested fraction of the seed diet was also deficient in K and P content. Next, Ca:P ratio was sufficient in both pellet diets and offered seed mixture, but feeding behavior deteriorated Ca:P ratio when fed the multi-component seed diet. Finally, both pellet diets were sufficiently high in all tested trace elements, but the offered mixture was too low in Mn and Zn. The ingested fraction of the seed diet was also far below the recommended guideline of Cu (table 3).

Table 3: Mineral and trace mineral concentration in offered and ingested diets.

		Pellets		Seed Mixture		Requirement[(a,b)]
		P15	P19	Offered	Consumed	
Minerals (g/MJ ME)						
Sodium	(Na)	0.10	0.08	0.02	0.02 ± 0.00	0.10 [a]
Potassium	(K)	0.35	0.45	0.34	0.20 ± 0.03	0.3 [a]
Calcium	(Ca)	0.57	0.57	0.75	0.22 ± 0.10	0.2-1.0 [a]
Magnesium	(Mg)	0.10	0.12	0.12	0.08 ± 0.01	0.05 [a]
Phosphorus	(P)	0.21	0.22	0.25	0.19 ± 0.03	0.2 [a]
Chlorine	(Cl)	0.04	0.03	0.02	0.01 ± 0.00	0.10 [a]
Trace minerals (mg/MJ ME)						
Sulfur	(S)	23.81	29.16	27.90	18.61 ± 2.94	-
Zinc	(Zn)	7.39	9.52	3.61	2.40 ± 0.78	4.0 [a]
Manganese	(Mn)	6.05	8.80	4.11	3.37 ± 1.51	5.2 [a]
Iron	(Fe)	11.04	10.85	10.84	-	6.5 [a]
Copper	(Cu)	0.98	1.29	0.71	0.29 ± 0.09	0.6 [a]
Ca:P		2.73	2.61	3.04	1.23 ± 0.60	min 1.50 [b]

[a]Bavelaar and Beynen (2003); [b]Wolf (2002)

Discussion

To date, species-specific scientific data on mineral requirements are still scarce, hence above mentioned guidelines are tentative. However, suboptimal Ca supply and Ca:P ratio when fed seed-based diets is a well-known cause of impaired skeletal mineralisation and is consistent with clinical presentation in practice (Wolf *et al.*, 1998). The profoundly low Cu content in ingested seed fraction is also likely to be of significance for parrot health, as Cu is an essential compound in several enzymes and is important in sustaining erythropoïesis (Tollefson, 1982).

Absence of effects of dietary protein content on excreta acidity are not consistent to results of Namroud *et al.* (2008), who demonstrated effects of dietary protein content on excreta acidity in broilers. In the current trial, the vastly lower DCAD in ingested seed fraction compared to both pellet diets, has likely contributed to the lower excreta pH when fed seeds.

The low dietary Na level in the ingested fraction of the seed mixture coincided with a lower dropping moisture content than when fed either pellet diets, which is in accordance with data in laying hens (Smith *et al*,. 2000). Yet, similar moisture content between both pellet diets concomitant with much firmer droppings when fed P19 pellets compared to P15 pellets, points to differential water binding capacity of droppings.

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