Nutrition of the domestic pigeon (Columba livia domestica)

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Nutrition of the domestic pigeon (*Columba livia domestica*)

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Despite the use of pigeons (*Columba livia domestica*) since 2500 BC by man for meat production, ornamentals, sports and experimental animals, limited information is available on their nutrient requirements and feeding. This could partly be attributed to the rearing of growing chicks (squabs) to mature body weight at 28 days by the parents. Squabs have an extraordinary high rate of maturing (0.1466 to 0.1945 g/d) in comparison to other domesticated avian species such as poultry (0.0450 g/d) and quail (0.077 to 0.097 g/d). This growth rate is achieved by regurgitation of a holocrine substance (crop milk) by both parents, formed in response to prolactin secretion and triggered by brooding. Crop milk consists primarily of protein (11.0 to 18.8% on as is basis) and fat (4.5 to 12.7% on as is basis), and lacks significant levels of carbohydrates. Furthermore, adult pigeons are mainly fed mixtures of whole grains. Special feeding characteristics inherent to the pigeon thus prevent extrapolation of nutrient requirements determined with other avian species. A dietary crude protein content of between 12 and 18%, and metabolizable energy (ME) content of around 12 MJ/kg, based on production of offspring, is recommended for feeding of adult pigeons. Apparent metabolizable energy, corrected for nitrogen retention (AME_n) for maize (14.76 MJ/kg), barley (12.36 MJ/kg), sorghum (13.87 MJ/kg) and peas (14.01 MJ/kg) did not differ substantially from values derived for poultry. Pigeons could utilize lipids better than carbohydrates as energy sources. Feed additives and suggestions for future research are discussed.

Keywords: pigeon; *Columba livia domestica*; nutrition

Introduction

Domesticated pigeons (*Columba livia domestica*) are kept for production of sports, ornamental and utility (meat-type) birds (Fekete *et al.*, 1999), as well as experimental animals in behavioural analyses and studies for the improvement of human health

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(Griminger, 1983). The establishment of a special relationship between pigeons and man over a period of thousands of years has created a volume of information about the digestive processes and nutritional habits in the pigeon (Levi, 1974; Griminger, 1983). However, very little information is available on the nutrient requirements and metabolism of nutrients in this species. This could partly be attributed to the complexity of studies to evaluate the nutrient requirements of pigeons, caused by the fact that young growing pigeons (squabs) continuously stay in the nest and are fed by the parents, initially with a special feed, the so-called crop milk (Waldie *et al.*, 1991).

The use of a compound pellet in pigeon feeding is still marginal. Pigeon feeds mainly consist of whole grains and seeds while minerals, vitamins and some other nutrients are provided as separate supplements. A crude extrapolation of findings in common poultry is thus not recommended (Janssens *et al.*, 2000a).

A review was written in an attempt to compile all available information regarding nutrition of growing and adult domesticated pigeons found in the scientific literature. This includes the unique phenomenon of parental crop milk feeding of squabs, nutrient requirements of adult pigeons, nutrient availability of different feed ingredients to pigeons, and the use of additives in pigeon nutrition.

Digestive system

As in most birds the digestive system of the pigeon consists of a beak, the buccal cavity (mouth) with a tongue and outlets for digestive glands, the pharynx, which opens in the oesophagus, followed by the crop, proventriculus, gizzard, duodenum, ileum, a rudimentary caeca, rectum and cloaca (Griminger, 1983). The digestive tract of pigeons in relation to body size is 7:1, in comparison to 8:1 in fowl (Kakuk, 1991), presumably because of their flying ability, which requires that the body be as light as possible. The shorter intestinal tract of the pigeon is compensated for by the well-developed network of intestinal villi covering the intestinal mucosa, as well as by the more acidic character of all portions of the intestinal tract compared with that of the fowl (Hullar *et al.*, 1999). According to Hatt (2002) the average mean retention time in the pigeon digestive track of the liquid phase marker cobalt (Co) was 5.3 h, while 6.8 and 8.4 h were reported for the particle phase markers chromium (Cr) and *n*-alkane hexatriacontane (C_{36}), respectively. Transit time was less than 1 h, shorter than the 2.5 h reported by Vogel (1980).

Growing chicks

GROWTH

The growth performance and developing of pigeon squabs are of crucial importance for meat producing as well as racing pigeons (Janssens *et al.*, 2000b). The rate of maturing of pigeons, derived from the Gompertz equation, in comparison to other avian species are presented in *Table 1*. Growth rate of pigeons is almost twice that of quail.

CROP MILK

Unlike other avian species, such as chicken or quail, squabs hatch with unopened eyes and cannot digest adult birds' diets (Kirk Baer, 1999). The Columbidae (pigeons and doves), together with some species of flamingos and penguins, typically regurgitate milk from the crop by both parents, a highly nutritive substance being mainly composed of proteins and lipids (Carr and James, 1931; Dabrowska, 1932; Davies 1939; Reed *et al.*, 1932; Vandeputte-Poma, 1968), for the nourishment of the young. Crop milk formation

Table 1 Rate of maturing (growth constant) derived from the Gompertz equation for different avian species.

Specie	Rate of maturing	Source
Broiler	0.0450	Gous *et al.* (1999)
Quail	0.077-0.097	Du Preez and Sales (1997)
Guinea-fowl	0.029-0.031	Sales and Du Preez (1997)
Ostrich	0.0085-0.0091	Cilliers *et al.* (1995)
Pigeon	0.1466-0.1945	Vandeputte-Poma and Van Grembergen (1967)

Gompertz equation: $C = C_m \times \exp(-\exp(-B \times (t-t^*)))$ where C_m is the final mature weight (g), B is the growth constant (g/d), and t* is the age (days) of maximum gain.

Table 2 Chemical composition of crop milk.

Nutrient	Concentration	Nutrient	Concentration
Proximate analysis (% as is)*		Fatty acids (weight % dry matter)‡	
Moisture	64-84	14:0	0.49
Crude protein	11-18.8	16:0	16.67
Ether extract	4.5-12.7	16:1(n-9)	7.90
Ash	0.8-1.8	18:0	12.13
Carbohydrate	0-6.4	18:1(n-9)	41.26
		18:2(n-6)	13.81
Amino acids (% of dry matter)†		18:3(n-3)	0.78
Arginine	5.48	20:0	2.99
Glycine	4.99	20:1(n-9)	2.06
Serine	5.20	20:2(n-6)	0.26
Histidine	1.52	20:3(n-6)	tr
Isoleucine	4.50	20:4(n-6)	0.45
Leucine	8.96	20:5(n-3)	tr
Lysine	5.87	22:0	0.59
Methionine	2.84	22:1(n-9)	tr
Methionine plus cysteine	3.18	22:4(n-6)	0.11
Phenylalanine	5.50	22:5(n-6)	tr
Tyrosine	5.36	22:5(n-3)	tr
Treonine	5.49	22:6(n-3)	0.23
Tryptophan	2.80	24:0	0.34
Valine	5.61		
		Minerals (% of dry matter)§	
		Calcium	0.81
		Potassium	0.62
		Magnesium	0.08
		Sodium	0.54
		Iron (ppm)	429

* From Carr and James (1931), Dabrowka (1932), Reed et al. (1932), Davies (1939), Farrando et al. (1971), Leash et al. (1971), Hedge (1972), Desmeth and Vandeputte-Poma (1980), Sim and Hickman (1986), Kirk Baer and Thomas (1996).
† From Hedge (1972).
‡ From Desmeth (1980).
§ From Kirk Baer and Thomas (1996).

and composition were reviewed by Kirk Baer (1999). Prolactin stimulates the growth and development of specialized epithelial cells lining the crop sac of pigeons and doves, leading to formation of crop milk. To support the feeding of crop milk a complex array of behavioural adaptations, such as elevated food intake (hyperphagia), nest attendance, and regurgitation feeding of the squab, are supported by high levels of prolactin secretion in pigeons during parenting (Horseman and Buntin, 1995). Crop milk is produced by day 14 of brooding, and may continue till the 25th day after hatching (Vandeputte-Poma and Desmeth, 1978). When squabs grow older, crop milk is mixed with grains soaked in the crop of the parents and gradually replaced by grains (Vandeputte-Poma, 1980). Although data indicated that crop milk feeding could vary from 6 to 20 days after hatching (Schooley and Riddle, 1938; Leash *et al.*, 1971; Levi, 1974), Vandeputte-Poma (1980) found that the crop contents of squabs is maximal till day four after hatching (20.61% of body weight), shows a first steep decline between day eight (18.81% of body weight) and day 10 (13.67% of body weight), and a second one between day 19 (11.84% of body weight) and day 22 (5.36% of body weight), with a further decline to adulthood (1.77% of body weight). Until day three all squabs receive crop milk only, and by day 28 "lactation" has virtually ceased. While crop milk formation already declines after three days of feeding in the female, crop milk production in the male regresses after 13 days of feeding the squabs (De Cock *et al.*, 1991).

Data on the composition of crop milk (*Table 2*) are not consistent due to sampling difficulties and feed ingested by the pigeons (Yang and Vohra, 1987).

About 17% of the total nitrogen in crop milk is in the form of free amino acids (Vandeputte-Poma and Van Grembergen, 1959). Crop milk lipids contain about 81.2% triglycerides and 12.2% phospholipids (Desmeth and Vandeputte-Poma, 1980). In total, 21 different fatty acids were identified in cropmilk, 18:1 being the predominant fatty acid (Desmeth, 1980). The characteristic lack of significant carbohydrate levels in crop milk reflected that it is a holocrine secretion, consisting primarily of epithelial cells (protein) and lipid droplets (Kirk Baer, 1999).

According to Kirk Baer and Thomas (1996) dry matter, fat, protein, and individual fatty acids in crop milk do not change between day one and three post-hatching. Concentrations of methionine, lysine and threonine increase significantly over days one, two and three. Mineral concentration does not change during the first three days of "lactation", except for magnesium that increases with time (Kirk Baer and Thomas, 1996). The dry matter crop contents of squabs were found to be 30% at day one, and 73% on day 27. Corresponding crude protein values on a dry matter basis were 46 and 17% respectively, while fat decreased from 27 to 3% (Leash *et al.*, 1971).

HAND REARING

A few attempts have been made to hand feed squabs, but not always from the day of hatching (Levi, 1974; Haque *et al.*, 1982; Yang and Vohra, 1987; Du *et al.*, 1993; Tsai *et al.*, 1994). With hand feeding, the diet must be diluted with water before diets move down the crop into the intestinal tract. For days one to four, 86% water is recommended, 80% for days five to six, and 75% for days seven to 28 (Yang and Vohra, 1987). Recommendations for diets suitable for hand rearing of squabs varied from 20 to 22% dietary crude protein and 13.14 to 13.39 MJ/kg metabolizable energy (ME) (Yang and Vohra, 1987; Salas *et al.*, 1994).

Data on growth (Vandeputte-Poma and Van Grembergen, 1967), feather weight of squabs (Wolter *et al.*, 1970), and chemical composition of pigeons (Griminger and Gamarsh, 1972), were used to determine maintenance protein requirements, protein requirements for growth and energy necessary for maintenance heat (*Table 3*), according to the Edinburgh model (Emmans and Fisher, 1986; Emmans, 1989), as follows:

The growth of the live, body protein and feather protein weight were described by means of the Gompertz equation:

$$C = C_m \times \exp(-\exp(-B \times (t-t^*)))$$

where C_m is the final mature weight (g),
B is the growth constant (g/d), and
t* is the time from hatching (days).

The growth rate of protein in the empty body weight was calculated by:

$$dP/dt \text{ (g/day)} = B^* \times P_m \times u \times \ln(1/u)$$

where B* (growth coefficient) is $B.P_m^{0.27}$,
P_m is the mature protein weight of the empty body weight (g), and
u is the degree of maturing (P_t/P_m).

while the growth rate of feather protein (FP) was determined by:

$$dFP/dt \text{ (g/day)} = B \times FP_t \times \ln(FP_m/FP_t)$$

where FP_t is the protein weight (g) of feathers at any given time,
FP_m is the final mature feather protein weight (g), and
B is the growth constant for feather protein (g/d).

Maintenance protein requirement (g/d) for empty body weight was calculated by:

$$0.008 \times P_m^{-0.27} \times P_t$$

where 0.008 is the ideal protein needed (g/unit),

while maintenance protein for feathers (g/d) was determined as 1% of feather protein weight per day.

Protein requirements needed for growth of either empty body weight or feathers (g/day) were determined by multiplying the protein growth by 1.25, where 1.25 is the reciprocal of the presumed net efficiency of 0.80.

From the above the total protein requirements (g/day) could be calculated. Maintenance heat was determined by:

$$MH \text{ (MJ/day)} = 1.63 \times P_m^{0.73} \times u$$

where 1.63 is the energy (MJ/unit) needed.

In this calculations the following assumptions were used:

- Live weight was calculated as body weight without crop content (Vandeputte-Poma, 1980).
- Protein content of empty body was 15.8% for all ages and sexes (Griminger and Gamarsh, 1972).
- Protein content of feathers was 61% for all ages and sexes (Griminger and Gamarsh, 1972).
- Feathers were 3.2% of live weight for all ages and sexes (Wolter *et al.*, 1970).

Due to the high growth rate of squabs, protein requirements determined according to this model are very high. At eight days the bird will have to consume 10% of its live weight as protein. The relatively high growth rate of squabs, and a high growth rate achieved with poultry chickens when fed pigeon crop milk (Pace *et al.*, 1952; Hedge, 1973), were attributed by Shetty and Hedge (1993) to a polypeptide with a molecular weight of 6000, the so-called pigeon-milk growth factor, found in crop milk.

Table 3 Protein requirements for growth and maintenance and energy needed for maintenance heat by pigeons.

Age (days)	Protein requirements (g/day)		Energy requirements for body maintenance (kJ/day)
	Maintenance	Growth	
1	0.01	5.55	1.45
2	0.02	7.55	2.32
3	0.03	9.58	3.46
4	0.04	11.45	4.86
5	0.05	13.01	6.49
6	0.06	14.15	8.31
7	0.07	14.84	10.24
8	0.09	15.09	12.24
9	0.10	14.94	14.24
10	0.12	14.45	16.20
11	0.13	13.72	18.07
12	0.15	12.81	19.84
13	0.16	11.80	21.48
14	0.17	10.74	22.98
15	0.18	9.68	24.33
16	0.19	8.64	25.55
17	0.19	7.67	26.64
18	0.20	6.76	27.59
19	0.21	5.92	28.44
20	0.21	5.17	29.17
21	0.22	4.49	29.82
22	0.22	3.90	30.37
23	0.23	3.37	30.86
24	0.23	2.90	31.27
25	0.23	2.50	31.63
26	0.23	2.15	31.94
27	0.24	1.84	32.20
28	0.24	1.58	32.43
29	0.24	1.35	32.62
30	0.24	1.15	32.79

Adults

REQUIREMENTS

Information about indirect breed-related weight and weight gain (Pelzer, 1990 a; b), feed conversion ratio (Rizmayer, 1969), feed consumption (Morice, 1970; Klein, 1974; Orban, 1975; Csontos, 1981; Böttcher *et al.*, 1985), written in languages other than English, were used to establish the crude protein requirements of adult pigeons between 12 and 18%.

Dietary ME content (11.1, 12.1, 13.2 MJ/kg) did not appear to influence the production of offspring. It was concluded by Waldie *et al.* (1991) that a single 16% crude protein diet could replace the usual 22% crude protein diet fed with maize in a cafeteria-style feeding system without adversely affecting egg production or number of young pigeons produced. Meleg *et al.* (1999; 2000) found that different dietary protein levels (12, 14, 16, 18 and

20%) at a ME concentration of 11.8 to 12.1 MJ/kg failed to affect the length of the egg cycle (28.9 days), annual egg production (21.4), egg weight (21.7 g), hatchability of eggs laid (62.2%), hatchability of fertile eggs (65.5%) and mortality of squabs up to weaning (31.1%). However, increasing dietary crude protein content increased the weaning weight (502.6 to 532.3 g) of squabs at 28 days and annual production per pair (4.1 to 5.4 kg) significantly. According to Böttcher *et al.* (1985) increasing protein content (12, 14, 15, 16 and 18%) of the diet did not influence annual squab production per breeding pair. However, meat percentage of the carcass, in particular the breast (24.8 to 27.5% of carcass weight), was higher in squabs when parents were fed diets with the higher dietary protein percentages. Wolter *et al.* (1970), fed diets containing 12 to 26% crude protein to parents and found that 18% dietary crude protein caused an optimal growth (from 19 to 430 g over 28 days) of squabs.

Feed ingredients

Pigeons exhibit stable, although idiosyncratic, patterns of food selection (Griminger, 1983). Of the feeds normally fed to pigeons (maize, wheat, barley, red and white millet, sorghum, canary seed, peas, lentils, sunflower and hemp) intake was highest for peas, and lowest for sorghum and wheat (Hullar *et al.*, 1999; *Table 4*).

The preferences of feed ingredients by pigeons determined in a choice feeding experiment are presented in *Table 5* (Janssens *et al.*, 2002b). While maize was the ingredient of choice by both females and males, females prefer peas to wheat, with the opposite found for males.

Because of their lively temperament and high metabolic rate, pigeons require a larger quantity of feed in proportion to their body weight than poultry. Due to the faster intestinal passage resulting from this metabolism, the efficiency of digestion is assumed to decrease (Engelman, 1963). However, apparent protein digestibility of barley and sorghum was substantially higher in pigeons than reported values for chickens, while values for maize, peas and sunflower were similar between species (*Table 4*; Hullar *et al.*, 1999). Apparent metabolizable energy, corrected for nitrogen retention (AME_n), was comparable between pigeons and chickens for maize, barley and sorghum. However, Dublecz *et al.* (1999) found that feeding of compound diets resulted in a significant higher AME_n value in pigeons (17.52 MJ/kg) than either guinea-fowls (15.98 MJ/kg) or broiler chickens (15.52 MJ/kg). Endogenous energy losses (EEL) in pigeons (19.86 kJ/kg body weight) were not different from that in guinea-fowls (20.07 kJ/kg body weight), but tended to be significant lower than that in broiler chickens (41.87 kJ/kg body weight). It was concluded by Hullar *et al.* (1999) that it was more accurate to determine the ME contents of potential pigeon feeds directly by experimental methods rather than by an equation based on the chemical composition of feeds.

The data in *Table 4* seem to confirm the suggestions of Goodman and Griminger (1969) that pigeons could utilize lipids more efficiently than carbohydrates as energy sources. The lack of a gall bladder in the pigeon does not prevent the utilization of fat contained in oilseeds, because bile production in the liver can adapt to the changing demands in a versatile manner (Hullar *et al.*, 1999). According to George and Jyotti (1955) 55% of the energy necessary for muscle function in pigeons is derived from the oxidation of lipids. In the experiments of Goodman and Griminger (1969), in which fat supplementation was used, racing homing pigeons receiving fat-supplemented (5%) feed surpassed the control pigeons in performance.

Apparent digestibility of ether-extract (*Table 4*) was higher in pigeons for barley, sorghum and peas, with the opposite found for apparent digestibility of nitrogen free-extract. Considerable differences in apparent digestibility values of the same ingredient in pigeons between different studies are clear from *Table 4*. Differences in digestibility of dry

Table 4 Intake, apparent metabolizable energy and nutrient digestibility values of different feed ingredients for pigeons in comparison to values derived with poultry.

Ingredient	Intake (g/d/bird)	AME_n (MJ/kg)		Dry matter (%)		Organic matter (%)			Crude protein (%)		Ether extract (%)			Nitrogen free extract (%)		
	Pigeons*	Pigeons*	Poultry†	Pigeons*	Pigeons‡	Pigeons*	Pigeons‡	Pigeons§	Pigeons*	Poultry†	Pigeons*	Pigeons‡	Poultry†	Pigeons*	Pigeons‡	Poultry†
Maize	22.5	14.76	14.65	81.25	84.4	82.38	86.3	-	85.15	84.00	82.33	84.5	92.00	77.27	92.2	90.00
Wheat	17.4	13.91	-	75.52	-	77.80	-	78.1	85.75	-	73.20	-	-	70.85	-	-
Barley	23.1	12.36	12.01	71.25	-	71.84	-	64.1	86.30	68.00	75.58	-	61.00	62.37	-	83.00
Millet (red)	21.6	14.77	-	67.35	-	73.83	-	-	84.16	-	90.44	-	-	65.43	-	-
Millet (white)	26.7	13.74	-	70.86	-	75.18	-	-	85.35	-	90.69	-	-	68.21	-	-
Sorghum	16.1	13.87	14.14	76.81	-	82.13	-	-	86.02	72.00	93.32	-	83.00	77.57	-	91.00
Canary seed	26.5	14.68	-	69.65	-	74.53	-	-	85.75	-	94.10	-	-	68.57	-	-
Peas	33.0	14.01	11.72	71.71	63.3	71.20	67.9	77.9	85.70	86.00	82.59	76.8	80.00	63.45	85.4	77.00
Lentils	26.5	12.79	-	64.65	-	65.51	-	74.6	85.48	-	93.64	-	-	56.21	-	-
Sunflower	19.2	22.18	14.33	69.28	-	68.98	-	-	85.97	85.00	98.10	-	96.00	57.56	-	12.00
Hemp seed	25.5	18.02	-	58.58	-	63.95	-	-	86.86	-	98.44	-	-	51.62	-	-

* Hullar *et al.* (1999); mean determined with 5 homing male pigeons, 2-3 years old, average body weight 460 g.
† Janssen (1989).
‡ Janssens *et al.* (2002a); mean determined with 4 adult female pigeons.
§ Engelman (1963).
AME_n Apparent metabolizable energy corrected for nitrogen retention
Crude protein corrected for uric acid

matter, crude protein, ether-extract and AME_n between breeds and sexes were stated as small and of no practical significance (Fekete *et al.*, 1999). The *n*-alkane method was found as a promising marker for intake (C_{31}, C_{32}) and digestibility (C_{36}) studies in pigeons if corrected for recovery rates (Hatt *et al.*, 2001).

Table 5 Intake (g/d/bird) of different feed ingredients by pigeons (n = 24) in a choice feeding experiment (Janssens *et al.*, 2002b).

Ingredient	Female	Males
Maize	39	61
Peas	31	25
Wheat	21	31

ADDITIVES

Growth improvement of squabs was found when drinking water of parents was supplemented with L-carnitine, probably due to a quantitative impact on crop milk production. No significant differences were found in growth when feeding L-carnitine to the squabs (Janssens *et al.*, 2000b). Other effects, such as delayed fatigue (Borghijs and De Wilde, 1992), enhanced energy utilisation efficiency during flight exercise (Janssens *et al.*, 1998), and improved specific antibody response after bovine serum albumin challenge (Janssens *et al.*, 2000c), were also demonstrated due to oral L-carnitine supplementation in pigeons.

Pigeons are more sensitive to carbohydrase enzymes than poultry (Janssens *et al.*, 2000a). Despite feed restriction, intake was higher for the enzyme-supplemented diet. Enzyme addition improved digestibility of dry matter, organic matter, nitrogen, energy and fibre. A trial with dietary carbohydrases supplementation in breeding pigeons could not demonstrate better growth rates of the squabs, but changes in water intake gave indications for improved excreta consistency, which is important from a prophylactic viewpoint (Janssens *et al.*, 2001). Fructo-digosaccharides or lactose were recently tested as prebiotic drinking water supplements (Janssens *et al.*, unpublished results), but failed to inhibit salmonellosis in artificially infected pigeons. Nevertheless, both supplements restored fibre digestibility significant quicker after the pigeons had recovered from salmonellosis, indicating a positive action in the long intestine.

Conclusions and recommendations for further research

Although the biology and anatomy of the pigeon have been intensively studied, very little is known about the nutrition of this species. One reason for this could be the rearing of the young until mature body weight (at 28 days of age) by both parents on crop milk, a holocrine substance consisting primarily of protein and fat, and formed due to prolaction stimulation. This is putting a restriction on the number of offspring (normally two) being produced. Although hand rearing of chicks in commercial production seems unpractical, the domestic pigeon could serve as a model for hand rearing of exotic and endangered pigeon species. Especially the simulation of crop milk warrants investigation. The extraordinary high growth rate of squabs achieved on crop milk is not yet well understood. Nutrient specifications of adults (12 MJ/kg ME and 12 to 18% crude protein) are based on production and growth of offspring, with no scientific evidence available on amino acid, mineral or vitamin requirements. Pigeon feeds are based on mixtures of grains, mainly because this is preferred by the owners in order to prevent adaptation of pigeons to a pelleted diet. Although energy and nutrient availability in feed ingredients (maize, barley, sorghum, sunflower) seem to be comparable between pigeons and poultry, some of the ingredients (millet, canary seed, lentils, hemp seed) are not used in commercial poultry production and thus have never been evaluated. From limited data it seems that there is selection for certain ingredients by pigeons, thus, the question arises if digestibility values determined on single ingredients will be additive when compound diets are fed. The use of enzymes in pigeon nutrition and the development of a proper compound pelleted diet for pigeons, based on nutrient requirements, are open for research. It can be concluded that pigeon nutrition differs somewhat from nutrition of other avian species. Thus, extrapolations might fail, and more direct research should be devoted to this industry.

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