EFFECT OF DIETARY NUTRIENT LEVEL AND SOURCE ON FEEDER MOUSE NUTRIENT COMPOSITION

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Abstract

Whole prey items may contain lower nutrient levels than desired for feeding exotic carnivores. The purpose of this trial was to gather preliminary data on the effect of different dietary treatments on the nutrient composition of mice at various ages. Dietary enrichment with vitamin E and chelated minerals in general did not improve total body levels of most nutrients, but did increase whole body manganese. Increased dietary fat resulted in higher whole body fat in feeder mice, and resulted in higher body weights of mouse pups. There was significant variation in nutrient concentration due to pup age.

Introduction

In general, diets that are fed to prey items such as rodents, rabbits, chicks and quail are designed to support maximal growth or reproduction, and little attention has been focused on optimizing the nutritional content of the prey item for the predator that will be consuming it. This is a very important consideration when feeding carnivorous animals, as the nutrient content of prey items can vary considerably, and will affect the nutritional status of the animal being fed.

Although the genetics, age, life stage (e.g., reproducing or not), and sex of the prey animal have a major impact on it's nutrient composition, many nutrients are reported to be able to be modified in the prey item in response to changing the dietary nutrient level.[1] For example, the lipid content of quail and rats was increased by feeding those animals higher dietary lipid levels.[2] Similarly, in rats, as dietary vitamin E level increased, so did plasma and testes vitamin E level, although whole body levels were not determined.[3] Increasing prey vitamin E content may be advantageous for the nutrition of the animals being fed. For example, Gyr-saker falcon hybrids fed 1-day old chicks had higher plasma α-tocopherol than did birds fed turkey breast meat, and reflects the fact that the 1-day old chicks had higher vitamin E content (~400 IU/kg) than did the turkey breast meat (7.5 IU/kg).[4]

A comparison of proximate composition of some prey items and the recommended nutrient intake for slow growing chickens demonstrates that prey items may contain lower nutrient levels than desired to meet the needs of growing animals (e.g., for birds, Table 1; for growing dogs, Table 2; for growing cats, Table 3). The nutrient requirements set for domesticated species often reflect the minimal level required to prevent a nutrient deficiency, as opposed to the optimal level required for health, well-being or performance. Additionally, nutrient requirements of exotic animals may be higher for some nutrients (e.g., protein, amino acids, and vitamin E for flying birds). Thus, it is likely that the optimal nutrient level to be fed to exotic animals is higher than minimum requirements established for domesticated species.

The purpose of this trial was to gather preliminary data on the effect of different dietary treatments on the nutrient composition of mice at various ages.

Methods

Mice (CF#1, Charles River outbred white mouse; n=140, 70 males, 70 females) were randomly assigned to breeding pairs and randomly assigned to dietary treatments. In a completely randomized design, mice were assigned to one of five diets (Table 2). Diets varied in fat level (6, 9 or 13% fat) and enrichment level (no enrichment, added vitamin E and chelated minerals, or added lutein). Animals were fed assigned diets through two breeding cycles. From each litter, pups were sampled at days 2, 8, 13 and 21, representative of pinky (~1-2 g body weight), crawler (~6-7 g body weight), small (~10-11 g) and medium (~15-16 g) pups. Sire weight, dam weight, litter size and pup weights were recorded. Pups were weighed then sacrificed, and analyses were conducted including proximate analysis and mineral analysis (Dairy One Lab, Ithaca, NY), vitamin E analysis (NP Analytical Laboratories, St. Louis, MO) and lutein analysis (Arizona State University). Dependent variables were analyzed by ANOVA for effect of dietary treatment, with breeding cycle as a covariate. Differences between means were examined using students t-test. Data were examined for effects of fat level and dietary enrichment, and significance was achieved at $p<0.05$.

Results and Discussion

Dietary enrichment did not improve total body levels of most nutrients. Dietary enrichment with vitamin E and chelated minerals increased whole body manganese ($p<0.05$), while dietary supplementation with lutein resulted in increased whole body crude fat ($p<0.05$) and dam weight ($p<0.05$) compared to no enrichment (Table 5). Vitamin E concentrations were markedly lower than reported for other mice (e.g., 4.3 μg/g in the current study versus ~35 ug/g in a previous study when parents were fed 90 IU vitamin E/kg diet[5]).

Dietary fat level fed to breeding mice affected several nutrient parameters (Table 6). Whole body crude fat was increased with 13% dietary fat compared to 6% dietary fat ($p<0.05$), similar to previous research.[2] Whole body calcium and selenium were reduced in pups from parents fed 13% dietary fat compared to those fed 6% dietary fat ($p<0.05$). Dietary fat level also affected pup weight. Pups from parents fed 13% fat were consistently larger than those from parents fed 6% or 9% dietary fat.

Most notable was the effect of pup age on body composition (Table 7). In general, whole body nutrient levels were significantly higher in 2 day old and 21 day old pups compared to 8 day old and 13 day old pups. This was the case for moisture, crude protein, vitamin E, selenium, zinc, iron, phosphorus, and calcium ($p<0.05$ for each). Conversely, crude fat was highest for 8 day old and 13 day old pups as compared to 2 day old and 21 day old pups ($p<0.05$). Molybdenum, copper and potassium were significantly higher in 2 day old pups than in all other age classes ($p<0.05$ for each). Manganese was significantly higher in 21 day old pups than in all other age classes ($p<0.05$). Previous research has demonstrated differences in body composition due to age of pups; moisture and protein decreased with age, while ash and crude fat increased with pup age.[5] Mineral concentrations of feeder mice were also variable due to age, but not consistently increased or decreased with pup age.[6] These differences are likely due to the stage of development of the animal and differences in use and storage of nutrients during different developmental stages, although research in this area is lacking.

Overall these data support further research with even higher concentrations of vitamins and minerals to attempt to enrich whole prey items, and emphasize the importance of analyzing feeder prey items due to potential variation in nutrient composition due to species, strain and age. Increased dietary fat level can increase the overall energy content of mouse pups, due to higher lipid content, and increased pup weights. These results may be useful to rodent breeders when performance criteria are evaluated. Variation in composition due to age is a significant factor affecting nutrient composition, and should be taken into account when formulating diets or conducting research.

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Table 1. Average composition of selected prey items (data adapted from Clum et al., 1996) compared to the NRC recommendations for slow growing egg-type chickens.[7] NRC recommendations are for chicks fed 2900 kcal/kg; calculated nutrient levels for higher caloric density diets are also shown. Data in bold represent values below the NRC recommendations at 2900 kcal/kg diet.

	Quail	Rats	Mice	NRC slow growing egg-type chickens Adjusted for caloric density (kcal)			
	Mean	Mean	Mean	2900	4500	5500	6000
Moisture (%)	65.4	64.6	67.2				
Lipid (%)	31.9	38.1	23.2				
Protein (%)	71.5	66	63.3	17	26.4	32.2	35.2
Ash (%)	9.9	7.3	10.4				
Vit A (IU/kg)	70294	76812	945544	1500	2328	2845	3103
Vit E (IU/kg)	67	140	73	10	16	19	21
Ca (%)	3.4	2.7	3.6	0.9	13.9	17	18.6
Cu (mg/kg)	**2.6**	**1.6**	4.2	4	6.2	7.6	8.3
Mg (mg/kg)	**549**	**328**	**492.1**	600	620.7	758.6	827.6
Fe (mg/kg)	74.9	**46.9**	101.4	60	93.1	113.8	124.1
Mn (mg/kg)	**6.4**	**2.3**	**5.3**	30	46.6	56.9	62.1
Zn (mg/kg)	53	30.3	53.8	35	54.3	66.4	72.4
Calculated kcal/kg	5734	6062.5	4742.5				

Table 2. Average composition of selected prey items (data adapted from Clum et al., 1996) compared to the NRC recommendations for growing dogs fed various energy levels.[8] Data in bold represent values below the NRC recommendations at 4000 kcal/kg diet.

	Quail Mean	Rats Mean	Mice Mean	NRC growing dogs post-weaning Adjusted for caloric density (kcal) 4000	4500	5500	6000
Moisture (%)	65.4	64.6	67.2				
Lipid (%)	31.9	38.1	23.2	8.5	9.6	11.7	12.8
Protein (%)	71.5	66	63.3	17.5	19.7	24.1	26.3
Ash (%)	9.9	7.3	10.4				
Vit A (IU/kg)	70294	76812	945544	5052	5684	6947	7578
Vit E (IU/kg)	67	140	73	30	34	41	45
Ca (%)	3.4	2.7	3.6	1.2	1.4	1.7	1.8
Cu (mg/kg)	**2.6**	**1.6**	**4.2**	10.8	12.2	14.9	16.2
Mg (mg/kg)	549	**328**	492.1	400.0	450.0	550.0	600.0
Fe (mg/kg)	**74.9**	**46.9**	101.4	88.0	99.0	121.0	132.0
Mn (mg/kg)	6.4	**2.3**	**5.3**	5.6	6.3	7.7	8.4
Zn (mg/kg)	53	30.3	53.8	100.0	112.5	137.5	150.0
Calculated kcal/kg	5734	6062.5	4742.5				

Table 3. Average composition of selected prey items (data adapted from Clum et al., 1996) compared to the NRC recommendations for growing cats fed various energy levels.[8] Data in bold represent values below the NRC recommendations at 4000 kcal/kg diet.

	Quail Mean	Rats Mean	Mice Mean	NRC growing cats post-weaning Adjusted for caloric density (kcal) 4000	4500	5500	6000
Moisture (%)	65.4	64.6	67.2				
Lipid (%)	31.9	38.1	23.2	9.0	10.1	12.4	13.5
Protein (%)	71.5	66	63.3	22.5	25.3	31.0	33.8
Ash (%)	9.9	7.3	10.4				
Vit A (IU/kg)	70294	76812	945544	3332	3749	4582	4998
Vit E (IU/kg)	67	140	73	38	42	52	56
Ca (%)	3.4	2.7	3.6	0.8	0.9	1.1	1.2
Cu (mg/kg)	**2.6**	**1.6**	**4.2**	8.4	9.5	11.6	12.6
Mg (mg/kg)	549	**328**	492.1	400.0	450.0	550.0	600.0
Fe (mg/kg)	**74.9**	**46.9**	101.4	80.0	90.0	110.0	120.0
Mn (mg/kg)	6.4	**2.3**	5.3	4.8	5.4	6.6	7.2
Zn (mg/kg)	53	30.3	53.8	74.0	83.3	101.8	111.0
Calculated kcal/kg	5734	6062.5	4742.5				

Table 4. Dietary treatments fed to breeding mice to alter whole body composition.

Diet	A	B	C	D	E
Fat, %	6	9	13	9	9
Enrichment	None	None	None	Added Vit E, chelated Zn, Mn, Fe, Cu	Added lutein
Nutrients					
Moisture (%)*	10.20	9.00	4.30	6.70	4.60
Ash (%)	6.19	6.19	6.13	6.48	6.14
Protein (%)*	18.50	18.80	18.80	18.90	19.30
Fat (%)*	6.70	8.20	13.70	9.20	9.80
Crude Fiber (%)*	4.30	4.60	6.50	6.30	5.70
NDF (%)*	14.20	14.20	15.90	17.90	16.10
ADF (%)*	7.40	6.00	11.20	8.30	9.30
Ca (%)*	0.99	1.05	1.04	1.20	1.34
P (%)*	0.58	0.62	0.63	0.62	0.63
Cl (%)	0.55	0.54	0.54	0.54	0.54
Mg (%)*	0.20	0.21	0.20	0.20	0.21
K (%)*	0.83	0.87	0.88	0.85	0.86
Na (%)*	0.30	0.32	0.32	0.34	0.35
Fe (ppm)*	388	375	397	595	405
Zn (ppm)*	156	160	167	483	157
Mn (ppm)*	132	132	146	306	146
Cu (ppm)*	22	23	26	119	24
Se (ppm)*	0.63	0.60	0.66	0.78	0.62
Vit A (IU/kg)	11000	11000	11000	11000	11000
Vit D3 (IU/kg)	2160	2160	2160	2160	2160
Vit E (IU/kg)*	102	87	99	234	119
Vit K (ppm)	3.24	3.23	3.23	3.23	3.23
Vit B_{12} (ug/kg)	46	44	44	44	44
Choline (ppm)	1900	1900	1900	1900	1900
Niacin (ppm)	60	60	60	60	60
Pantothenate (ppm)	24	24	24	24	24
Pyridoxine (ppm)	24	14	14	12	14
Riboflavin (ppm)	15	8	8	8	8
Thiamin (ppm)	18	18	17	18	18
Folic acid (ppm)	4	4	4	4	4
Biotin (ppm)	0.27	0.27	0.27	0.27	0.27
Lutein (ppm)*	25	47	31	263	1791
Zeaxanthin (ppm)*	9	13	8	25	138

* Data represent analyzed values. All other values are calculated.

Table 5. Effect of dietary enrichment on mouse body weight and body composition. [a-c] Within a column, means with different superscripts are significantly different.

Dietary treatment	Dam weight (g)	Crude fat (%, DMB)	Manganese (mg/kg; DMB)
No enrichment	57.8 ± 1.5[b]	39.7 ± 1.6[b]	3.92 ± 1.30[b]
Vitamin/mineral enrichment	55.1 ± 2.9[c]	41.0 ± 3.0[ab]	8.50 ± 2.03[a]
Lutein enrichment	67.8 ± 2.6[a]	43.4 ± 2.2[b]	3.67 ± 2.68[b]

Table 6. Effect of dietary fat level on pup weight and body composition. [a-c] Within a row, means with different superscripts are significantly different.

Dietary fat level	6%	9%	13%
d 0 pup wt	1.96 ± 0.04[ab]	1.87 ± 0.03[b]	2.02 ± 0.06[a]
d 2 pup wt	2.64 ± 0.09[ab]	2.59 ± 0.05[b]	2.89 ± 0.09[a]
d 8 pup wt	6.60 ± 0.29[b]	6.61 ± 0.12[b]	7.20 ± 0.16[a]
d 13 pup wt	10.05 ± 0.44[b]	9.90 ± 0.15[b]	11.03 ± 0.37[a]
d 21 pup wt	15.60 ± 0.57[b]	16.61 ± 0.30[ab]	17.96 ± 0.32[a]
Crude fat (%, DMB)	37.2 ± 3.8[b]	41.0 ± 1.5[ab]	42.0 ± 2.8[a]
Ca (%, DMB)	2.28 ± 0.14[a]	2.15 ± 0.07[ab]	2.10 ± 0.15[b]
Se (mg/kg, DMB)	1.10 ± 0.04[a]	1.04 ± 0.03[ab]	0.98 ± 0.07[b]

Table 7. Effect of pup age on body composition. [a-d] Within a row, means with different superscripts are significantly different.

Pup age (d)	2	8	13	21
Moisture	75.5 ± 0.4[a]	69.0 ± 0.5[b]	65.3 ± 0.6[c]	68.8 ± 0.8[b]
Crude Protein (%, DMB)	56.2 ± 0.7[a]	49.9 ± 0.6[c]	48.0 ± 0.7[c]	53.9 ± 1.0[b]
Crude fat (%, DMB)	29.2 ± 1.8[d]	43.6 ± 1.0[b]	46.3 ± 0.7[a]	34.1 ± 1.3[c]
Ca (%, DMB)	2.61 ± 0.02[a]	1.88 ± 0.05[c]	2.01 ± 0.06[b]	2.57 ± 0.05[a]
P (%, DMB)	2.32 ± 0.02[a]	1.67 ± 0.03[c]	1.66 ± 0.03[c]	1.92 ± 0.03[b]
K (%, DMB)	1.05 ± 0.03[a]	0.78 ± 0.02[b]	0.78 ± 0.12[b]	0.74 ± 0.01[b]
Fe (mg/kg, DMB)	183.3 ± 3.7[a]	104.2 ± 2.6[b]	94.9 ± 2.9[c]	188.3 ± 6.1[a]