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Effects of Different Concentration of Dietary fat on Growth Performance of Minks (*Mustela vison*)

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ABSTRACT

The experimental design provided ranges in ME (metabolisable energy) intake, BW (body weight), ADG (average daily gain), nutrients digestibility, N-balance, energy balance and fur characteristics. The experiment consisting of two periods (phase I and phase II) with fed mink (n=88) were utilized to determine their energy requirements for growth and fur development when fed different fat levels diets. Male mink were randomly fed one of eight diets, fed containing approximately3% (group A), 6% (group B), 9% (group C), 12% (group D), 15% (group E), 18% (group F), 21% (group G) or 24% (group H) bean oil in the complete dry power respectively. Nitrogen balance and nutrients digestibility experiments were carried out when the animals were approximately 15 and 23.5 weeks of age. Over the experimental phase, the results showed when energy level was increased, there was significantly difference in final body weights, nutrient digestibility, N-balance and energy metabolism in difference groups($P < 0.05$). When diets with 21% and 24% fat levels were fed, the biggest final body weights were gain. In conclusion, The rise in dry matter, crude protein, ether extract and energy of digestibility were more dramatic with increasing energy levels in phase I. Under the conditions of this experiment, to achieve the best growth in September the amount of energy from protein should be at least 25.95%, the amount of energy from fat should be 51.80% of ME in that period. In the phase II, the efficiency of growth and fur development used for gain in group G (15% fat content) the amount of energy from protein should be at least 27.78%, the amount of energy from fat should be 42.99% of ME.

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Key words
Mink, Fat, Body weight, Nutrient digestibility, N-balance, Pelt quality

INTRODUCTION

As is well known, the mink (*Mustela vison*) is a strict carnivore and a seasonal breeder, And it is very responsive to changes in energy supply (Tauson *et al*., 1994; Tauson and Forsberg, 2002). Energy is not itself a nutrient but is, rather, a property contributed to diets by the three macronutrients: fats (lipids), carbohydrates, and proteins; of these three energy suppliers, the most concentrated source is fat, a unit weight of which supplies more than twice as much energy as the same weight of carbohydrate or proteins (NRC, 1982).

The animal requires feed energy for body heat, for body biochemical reactions, for physical activity, and, as the life-stage situation dictates, for one or more of the following: growth, fur production, reproduction, and lactation. In the absence of adequate available energy supplies, the performance of the animals in these life phases will be suboptimal. Thus, the role of feed energy is central to the metabolism and performance of minks (NRC, 1982).

Estimating the energy content is the first step in diet formulation, as it determines the amount of food eaten and hence the concentration of nutrients required to meet the animal's requirements. Additionally, being able to estimate the energy content of a diet empirically known to maintain body condition in an animal will facilitate an estimation of maintenance energy requirements (Clauss *et al*., 2010). Energy balance is the key role of in nutrient digestibility and nitrogen balance, energy is not a nutrient but a property possessed by fats, carbohydrates and proteins. Similarly, many studies on requirements of protein or of micronutrients (Hellwing *et al*., 2005; Zhang *et al*., 2012, 2013, 2014; Wu *et al*., 2014a, b, 2015; Yang

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et al., 2019). A lot of researches have been done on energy in fur animal (Borsting *et al*., 1998; Polonen *et al*., 2000; Hellwing *et al*., 2005; Burlikowska and Szymeczko, 2007; Koskinen *et al*., 2008). However, there is less accurate data of energy required for the minks, we need to provide more increase the dataset. Further studies are still essential energy required in different regions. The main purpose of this investigation was to evaluate, based on production and health parameters, minks can be fed complete dry power diets mixed with water before feeding, whether the effect of energy level on the production performance and nutrition digestion.

The mink predominates in fur animals in China, which has the largest commercial fur garment population in the world. Therefore, accurate equations to predict their energy requirements play an important role in fur garment. The objective of this study was to use nutrient digestibility and fur quality data to determine their requirement for growth and fur production.

MATERIALS AND METHODS

The study of minks was carried out following the guidelines established by the Canadian Council on Animal Care (1993). Animals were housed outdoors individually in conventional cages in a two-row shed. Eighty eight male minks (BW= 1.03±0.09 kg) were randomly divided into 8 groups (A-H). The animals were allocated to 8 different foodstuffs according to weight at the start of the experiment. The minks were allowed 7-days to adapt to the cage environment and experimental foodstuffs. Mink kits were accustomed to individual cages for a few weeks prior to starting the test on July (phase I), phase II were conducted in September. Table I shows all the foodstuffs nutrient composition and composition of the experimental foodstuffs.

Table I. Ingredeints (g/kg) and chemical composition of experimental foodstuffs.

Groups	A	B	C	D	E	F	G	H
Ingredients								
Extruded corn	402	372	352	322	292	255	230	190
Soybean meal	90	90	60	60	45	50	35	45
Corn protein meal	70	80	80	80	90	90	90	90
Fish meal	130	120	150	160	160	160	170	170
Bone meat meal	175	170	180	170	170	170	170	170
Cheese meal	65	70	50	50	50	50	50	50
Hydrolyzed feather meal	10	10	10	10	15	15	15	15
Dried blood	10	10	10	10	10	12	12	12
Premix[a] of mink	10	10	10	10	10	10	10	10
Soybean oil	30	60	90	120	150	180	210	240
Lysine	3	3	3	3	3	3	3	3
Methionine	3	3	3	3	3	3	3	3
Salt	2	2	2	2	2	2	2	2
Proximate analysis								
CP[#] (%)	31.80	32.82	32.48	32.65	32.59	31.91	33.61	32.15
EE[#] (%)	7.26	10.33	14.25	17.02	20.43	22.08	25.50	28.79
ME[#] ($MJkg^{-1}$)	13.88	14.56	15.10	15.55	16.28	16.62	17.41	17.72
Lys (%)	1.68	1.65	1.65	1.66	1.64	1.64	1.64	1.66
Met (%)	0.88	0.87	0.89	0.90	0.90	0.90	0.91	0.91
Ca (%)	3.05	3.04	3.12	3.06	3.05	3.06	3.08	3.09
TP (%)	2.05	2.04	2.09	2.08	2.06	2.06	2.08	2.07
% of ME protein*	34.81	31.94	29.94	28.58	27.78	25.71	25.95	23.45
% of ME fat*	19.52	26	32.78	36.74	42.99	47.06	51.80	56.44

a Contained the following per kg of premix- VA 200,000 IU; VD_3 40,000 IU; VE 5,000 IU; VB_1 125 mg; VB_2 200 mg; VB_6 200 mg; VB_{12} 2.5 mg; VK_3 40 mg; VC 7,500 mg; niacin acid 500 mg; pantothenic acid 800 mg; folic acid 100 mg; choline 10,000 mg; biotin 7.5 mg; Fe 2,000 mg; Cu 500mg; Mn 400 mg; Zn 1,500 mg; I 15 mg; Se 5 mg; Co 7.5 mg. CP, crude protein; EE, ether extract; ME, metabolizable energy; Lys, lysine; Met, Methionine; Ca, calcium; TP, total phosphorus. [#] Values were measured. *Values of % of ME (protein,fat)were calculate.

Body weights (BW) of the animals were recorded every 2-weeks after overnight fasting (accurate to 0.001 kg), it was used to determine average daily gain (ADG). This was two-stage experiment, a period of rapid growth (phase I) and winter fur production (phase II). 8 minks were moved to metabolism stalls to ensure the complete collection and separation of feces and urine. The chemical composition of foodstuffs and feces was analyzed by standard methods. Wet samples of diets and feces were analyzed for dry-matter (DM) and N, while the freeze-dried samples were homogenized and analyzed for ash, fat and gross energy (GE). Crude protein (CP) was determined using an automated Kjeltecl 8400 analyzer unit (Foss 8400, Denmark). A bomb calorimeter (IKAC2000 basic, Germany) was utilized to determine gross energy, feces energy (FE), urine energy (UE) and metabolic energy (ME).

The growth trial lasted for 12 weeks in a randomized design during which feed intake was recorded daily and the feed efficiency and ADG were calculated. At the end of the feeding trial, all minks were pelted in accordance with normal farming practice. Mink were killed by euthanasia, according to the Welfare of Animals Kept for Fur Production.

The apparent digestibility (AD) of nutrients and energy was calculated as follows (Geng *et al*., 2012):

AD=(A−B)/Ax100 %

where A is the intake of nutrient from the diet and B the nutrient in the feces.

Digestible energy (DE)= GE- feces energy

ME= GE- feces energy - urine energy

Energy metabolic rate (EMR) = MEI/GEI x100 %

Statistical analysis

Data were analysed by the analysis of variance using the general linear models (GLM) procedure of SAS (SAS Institute, 2002). Differences between groups were tested using Duncan test. Multiple comparisons were performed by the PDIFF procedure. P-values <0.05 were set as the criterion for statistical significance. Data were represented as mean±s.d.

The following model was used:

$$Y_{ij} = \mu + d_i + \varepsilon_{ij}$$

where Yij is the observation; μ is the general mean; di is the effect of energy level (i=1, …, 5); and εij is the random error.

RESULTS

All results regarding nutrient digestibility and protein and energy metabolism data are presented in relation to the metabolic body size (MBS) of the animals (kg0.75). MBS was used as a reference to facilitate comparison among balance periods, and because the animals used in the experiment differed in live weight.

Table II. Parameters on body weight, body length and feed efficiency (mean ± SD).

Groups	Phases	A	B	C	D	E	F	G	H	P value	SEM
Initial BW (kg)		1.02± 0.07	1.03± 0.05	1.04± 0.08	1.03± 0.06	1.04± 0.06	1.03± 0.07	1.04± 0.05	1.05± 0.06	0.9826	0.0629
Final BW (kg)		1.38± 0.17^{C}	1.80± 0.18^{B}	1.77± 0.17^{B}	2.06± 0.17^{A}	2.13± 0.18^{A}	2.18± 0.15^{A}	2.23± 0.18^{A}	2.23± 0.14^{A}	<.0001	0.1776
ADG* (g)		4.09± 0.98^{Ed}	7.50± 1.23^{Dc}	7.50± 0.70^{Dc}	9.63± 1.71^{Cb}	9.84± 1.25^{BCb}	11.60± 1.44^{ABa}	12.26± 1.48^{Aa}	11.42± 1.47^{ABCa}	<.0001	3.9161
Body length (cm)		43.67± 1.63^{Bb}	45.33± 0.82^{a}	45.83± 1.47^{Aa}	45.17± 4.17^{a}	45.67± 1.52^{a}	46.17± 0.41^{Aa}	45.67± 1.21^{a}	46.17± 1.47^{Aa}	0.0236	0.3825
ADG (g)	I	8.40± 2.55^{Dc}	10.42± 2.37^{CDc}	14.25± 2.19^{BCb}	17.33± 2.39^{ABab}	18.87± 1.23^{ABa}	16.94± 6.54^{ABab}	20.73± 2.67^{Ga}	19.27± 4.99^{ABa}	<.0001	1.4788
	II	1.82± 0.50^{Cd}	9.77± 0.62^{ABc}	10.39± 4.44^{ABbc}	14.80± 4.53^{ABab}	15.50± 4.41^{Aa}	12.89± 3.41^{ABabc}	12.08± 4.22^{ABabc}	8.71± 3.54^{Bc}	<.0001	1.2543
ADFI (g)	I	95.12± 2.47^{ABab}	93.40± 5.36^{ABbc}	103.04± 5.11^{Aa}	96.31± 11.29^{ABab}	101.69± 7.28^{Aab}	85.29± 8.62^{Bc}	98.54± 12.03^{Aab}	86.00± 5.79^{Bc}	0.0002	0.6581
	II	129.18± 15.35^{ABab}	139.67± 13.24^{Aab}	146.47± 18.36^{Aa}	129.60± 21.14^{ABab}	125.41± 19.51^{ABb}	106.09± 10.26^{BCc}	94.88± 15.12^{c}	92.18± 6.05^{Cc}	<.0001	1.4328
F/G	I	12.07± 3.10^{Aa}	9.38± 2.16^{Bb}	7.37± 1.12^{BCc}	5.59± 0.62^{CDd}	5.39± 0.33^{CDd}	5.54± 1.84^{CDd}	4.78± 0.43^{Dd}	4.60± 1.13^{Dd}	<.0001	2.5376
	II	78.67± 18.42^{Aa}	14.31± 1.18^{Bb}	15.78± 5.13^{Bb}	9.10± 1.49^{Bb}	8.95± 1.37^{Bb}	8.03± 0.84^{Bb}	9.14± 2.49^{Bb}	12.10± 3.85^{Bb}	<.0001	2.7571

*is the whole time (PhasesI+ PhasesII). BW, body weight; ADG, average daily gain; ADFI, average daily feed intake; F/G, Feed/gain. Within the same column values with different capital letter letters extremely significantly different (P <0.01). Within the same column values with different small letter letters extremely significantly different (P <0.01).

Feed and energy intake as well as body weight of mink are presented in Table II. In this study, all male minks had similar body weights (p=0.9826). Nevertheless, the final BW increased with feeding diets in higher energy, G and H male minks had 61.59% greater body weight and 230.56% higher weight gain than A minks ($p < 0.0001$). The effect of fat levels on average daily feed intake (ADFI) and feed/gain (F/G) was different ($p < 0.0001$; $p < 0.0001$), the ADFI were lower 17.75 g in phase Iand 54.29 g in phase II, respectively. Minks in higher fat had lower F/G, the lowest F/G ratio was seen in the H group (phase I, 4.60) and F group (phase II, 8.03). Furthermore, the highest groups reduction F/G ratio is more than one and a half times (phase I) and eight times (phase II) than mink supplemented with the lowest fat groups.

Coefficients of nutrients balance and energy digestibility were shown in Figure 1.

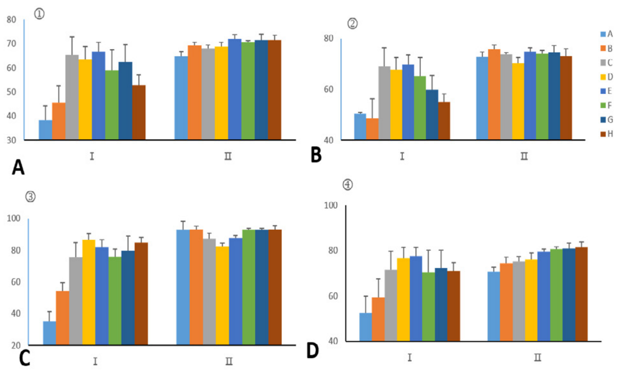

Fig. 1. Parameters on the apparent digestibility of nutrients (%) (mean ± SD). (A) represents the apparent digestibility of dry matter; (B) shows the apparent digestibility of crude protein; (C) shows the apparent digestibility of crude lipid; (4) shows the apparent digestibility of energy. The left side of each chart represents I phase and the right side represents II phase.

Dry matter and energy digestibility reflected the digestibility values of the main nutrients. Digestibility of main nutrients differed significantly among foods within each groups (p<0.0001). In the phase II, the dry matter, protein, fat and energy nutrition of each group were higher than the phase I. Dry matter digestibility ranged from 38.31% to 66.72% in phase I and from 64.81% to 71.90% in phase II. Crude protein digestibility was 48.65%–69.63% and 70.44–75.81% in phase I and in phase II, respectively. Crude lipid digestibility ranged from 35.28% to 86.44% in phase I and from 82.27% to 93.12% in phase II. Corresponding figures for energy digestibility were 52.46%–77.48% in phase I and 70.64%–81.41% in phase II. E group male minks tended to improve the apparent digestibility values of dry matter (p<0.0001; p<0.0001) and crude protein (p<0.0001; p= 0.0025) in both periods. In phaseI, apparent digestibility of fat was significantly higher than those of other groups on group D (p<0.0001). Unfortunately, group D was the least in phase II (p<0.0001). For the whole study group, there was remarkable difference in digestibility of energy, the best digestibility being recorded for E group male minks in phase I (p<0.0001) and H group in phase II (p<0.0001).

N-balance in relation to MBS are presented in Figure 2. The N-balance split into N intake input, outputs of N in feces (phase I, p= 0.0004; phase II, p<.0001) and in urinary. Over the experimental phase, the N intake (phaseI, p<.0001; phase II, p<.0001) and urinary N (phase I, p= 0.0221; phase II, p<.0001) were reduced linearly with the increasing dietary fat levels increased. It is not difficult to see that the urine N of the period II was significantly higher than the period I. The amount of feed had effect on the efficiency of retained N. However, the trend of the changes of retained N (phaseI, p= 0.0024; phase II, p= 0.0052) in group E was significantly higher than others in both periods.

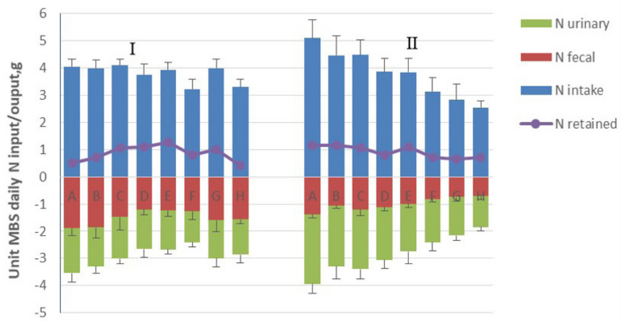

Fig. 2. N input/output relationships for mink, values are means and SD.

Data relating to energy metabolism in relation to MBS as well as body weight development were determined in Table III. The GE, FE, UE, DE and ME was influenced by amount of feed. In phase I, the DE, ME and EMR was the best on group H (p= 0.0275; p= 0.0222; p= 0.0703). In phase II, feeding diet from 12.57 to 15.50 MJ/kg of ME and DM was significantly higher than those of other groups (p= 0.0009; p= 0.0013). Over the experimental phase, groups lower than containing 15%, GE, DE and ME in the period II were above periodI. In addition, the EMR of the period II was significantly higher than the period I.

DISCUSSION

It is obvious that the energy expenditure of an animal is related to its size (body weight), live animal size is evaluated by measurement of body length or body weight (BW).

Table III. Effects of energy levels on energy metabolism (mean ± SD).

Groups	Phases	GE ($KJ \cdot d^{-1} \cdot kg^{-0.75}$)	DE ($KJ \cdot d^{-1} \cdot kg^{-0.75}$)	ME ($KJ \cdot d^{-1} \cdot kg^{-0.75}$)	EMR (%)
A	I	1455.70 ± 97.74^{bc}	781.74 ± 137.40^{Ed}	740.57 ± 133.65^{Ed}	49.72 ± 7.53^{b}
	II	1810.79 ± 233.86^{a}	1302.05 ± 185.06^{a}	1229.58 ± 179.57^{a}	67.13 ± 1.93^{c}
B	I	1410.58 ± 84.83^{bc}	831.50 ± 130.10^{DEcd}	785.80 ± 133.17^{DEd}	56.13 ± 8.13^{b}
	II	1548.13 ± 247.22^{b}	1155.21 ± 196.93^{a}	1109.63 ± 193.57^{a}	71.59 ± 3.13^{b}
C	I	1541.81 ± 88.23^{ab}	$1101.26 \pm 138.96^{ABCab}$	$1046.57 \pm 132.78^{ABCbc}$	67.90 ± 7.83^{a}
	II	1652.46 ± 200.94^{ab}	1241.31 ± 125.15^{a}	1188.74 ± 116.77^{a}	72.10 ± 2.28^{b}
D	I	1447.38 ± 158.41^{bc}	$1112.22 \pm 161.72^{ABCab}$	$1070.22 \pm 153.32^{ABCabc}$	73.83 ± 4.95^{a}
	II	$1503.85 \pm 192.1^{4}b$	1147.01 ± 159.12^{a}	1098.83 ± 153.69^{a}	73.02 ± 2.66^{b}
E	I	1594.93 ± 108.10^{a}	1234.79 ± 89.86^{Aa}	1198.21 ± 89.62^{Aa}	75.19 ± 4.11^{a}
	II	1519.98 ± 205.37^{b}	1207.94 ± 176.40^{a}	1165.74 ± 167.47^{a}	76.63 ± 1.62^{a}
F	I	1363.84 ± 159.09^{c}	$964.80 \pm 188.93^{CDEbc}$	938.05 ± 193.18^{CDc}	68.43 ± 10.11^{a}
	II	1181.39 ± 189.86^{c}	953.31 ± 157.10^{b}	907.44 ± 148.83^{b}	76.80 ± 1.12^{a}
G	I	1626.97 ± 142.81^{a}	1170.29 ± 96.40^{ABa}	1139.86 ± 93.01^{ABab}	70.46 ± 7.98^{a}
	II	1171.82 ± 246.39^{c}	948.70 ± 203.52^{b}	909.51 ± 197.69^{b}	77.59 ± 2.59^{a}
H	I	1412.63 ± 124.22^{bc}	$1006.04 \pm 116.03^{BCDb}$	973.31 ± 114.23^{BCDc}	68.81 ± 3.74^{a}
	II	$1132.55 \pm 110.8^{1}c$	926.68 ± 86.08^{b}	899.52 ± 80.63^{b}	79.30 ± 2.91^{a}
P value	I	0.0005	<.0001	<.0001	<.0001
	II	<.0001	0.0002	0.0004	<.0001
SEM	I	0.5695	46.4998	0.2424	1.5005
	II	1.2683	0.6953	0.6600	2.4736

GE, total energy; DE, apparent digestible energy; ME, apparent metabolizable energy; EMR, Total energy metabolic rate. Within the same column values with different capital letter letters extremely significantly different (P <0.01). Within the same column values with different small letter letters extremely significantly different (P <0.05).

Mink's live animal body length is measured by laying it down on the table hind legs stretched backwards and measuring its length from the nose to the point of buttock, BW were recorded by weighing (with the accuracy of 0.001 kg) biweekly after overnight fasting, and mean BW were used to determine growth rate. However, nutrition physiology scientists have noted that larger animal species require less energy per unit of weight than smaller animals. Mink is small fur animal, the most vigorous period of growth and development in mink is growing-furring period. The diet energy level is important to give full play to the performance of growth.

The mink responded to changes in energy supply by rapid increase and decrease in body weight. In the present investigations, the body weight tended to increase as the energy level was increased in phaseI. When the minks were 10 wk old, the highest weights were found for H group male kits from kits fed the 17.72 MJ/kg energy levels. Animals of all experimental groups sustained good health throughout the experiment. This can probably be ascribed to the highest fat and energy content in this diet, which has previously been shown to increase growth of kits. A similar effect of dietary energy level in growing mink was shown by Hellwing *et al*. (2005). It reported that energy balance was not affected by the low protein provision during the period of rapid growth at 8 weeks of age. However, low protein provision resulted in more energy being retained in fat than was observed, Body weight gain from 19 weeks onwards was thus accomplished through a higher accretion of fat, which concurs with previous findings in mink. An adequate level and quality of nutrition is of the utmost importance if an animal is to express its potential for growth (Rasmussen and Børsting, 2000). A similar effect of decreasing dietary energy level in fox was shown by Ahlstrøm (1995) and Kopczewski *et al*. (2001) who reported that an increase in feed energy content caused a significant increase in the body weight. Zhu (2003) reported that with the increase of energy level, the growth of New Zealand rabbit weight have different degree rise, when the reaches a certain level of energy and a downward trend.

In the present investigations, the growth of mink weight tended to increase at first and then decreased as the energy level was increased in phase II. Mink adjust feed intake according to the energy level, but animals get nutrients from feed is directly related to feed intake. Excessively high energy leads to low intake, lead to minks from feed nutrient deficiency, which affects the growth of its performance. It shows that the energy can increase the weight of mink in a certain range, and the energy is too high to inhibit its growth. Clausen and Sandbol (2014) reported the requirements of the dietary energy is distributed in the growing, in that study, the mink was able to gain more weight in July, the energy distribution in the feed for kits required that the metabolic energy from protein should be at least 32%, the fat should be between 53% and 56%, and carbohydrate should no more than 18% of ME.

Optimizing the growth, feed intake and feed efficiency is essential in all fur animal production. Our results demonstrate that the feed intake of mink is related the actual useful metabolic energy content of the specific diet within a certain range. With the increase of feeding energy level, the mink intake has been decreasing. When fed unbalanced foods under no-choice conditions, mink was forced to trade off eating more of lipid against eating less of the other macronutrient relative to what they would eat if they were able to reach the intake target. Nutrient digestibility is dependent on the availability of the feed ingredients (Mayntz *et al*., 2009). Dietary ingredients that change the feed transit time through the gastrointestinal tract may, therefore, lead to changes in nutrient digestibility (Hellwing *et al*., 2005). There was a direct relation between the feed amount and the apparent digestibility of the feed of mink (Sinclair *et al*., 1962). Ahlstrøm (1995) research shows that as the energy level increases, the apparent digestibility of the nutritive substances of mink increases.

Feed efficiency is an important for all fur animals, because feed is a major production cost and feed prices are expected to continue to rise. Many studies have indicated that part of the economic advantage of larger animal size and, hence, larger pelt size is lost due to higher feeding costs (Peura *et al*., 2004). The apparent digestibilities of CP and EE in this trial were slightly lower compared to values reported in other trials (Ahlstrom and Skrede, 1998; Hellwing *et al*., 2005; Gugolek *et al*., 2010; Zhang *et al*., 2012). This is likely due to the composition of the diet. In the present study, a major factor influencing the digestibility of nutrients is the diet composition, the nutritional value of diets, determined based on chemical composition, met the nutrient requirements of growing mink (NRC, 1982). It has been found that in another fur animal species, the Arctic fox, nutrients from diets composed of animal meals are characterized by lower digestibility than components of fresh feed (Vhile *et al*., 2005; Gugolek *et al*., 2010). In addition, another factor influencing the digestibility of nutrients is the fat: carbohydrate (F:C) ratio. The digestibility of CP increased whereas that of carbohydrates decreased with the F:C ratio increasing (Suvegova *et al*., 2000). The increase in dietary fibre and fat contents may interfere with the apparent digestibility of CP and EE in the present experiments. Suvegova *et al*. (2001) reported that the digestibility of CP and fats decreased with increasing percentual proportion of poultry shanks in feed rations for minks for CP from 80.75 to 70.35%, and for fats from 90.14 to 84.24%. In addition, dry matter and energy digestibilities reflected the digestibility values of the main nutrients. In our study, the apparent digestibility of DM, CP and energy increased then declined as the oil content of the diet increased. All results pertaining to nutrient digestibility were significantly higher in phaseIthan those in phaseIIin female mink. This would imply a slightly more efficient utilization for nutrients in phaseI. A similar effect of increasing dietary fat level in blue foxes was shown by Geng *et al*. (2012) who reported that the energy digestibility values were ranged from 74.3% to 90.3% (phase 1) and from 78.9% to 90.1% (phase 2) when diet fat levels were ranged from 12% to 54%, as energy from fat whereas the nitrogen digestibility values were varied from 72.9% to 85.5% (phase I) and from 72.7% to 84.8% (phase II). In practice, exclusive focus on the percentages of nutrients, and disregard of the absolute amount of food actually ingested, can lead to dietetic problems. A typical example is that when feeding lower amounts of food to obese animals to facilitate weight reduction, the protein content of the diet needs to be increased in order to prevent protein deficiency and loss of lean body mass (Clauss *et al*., 2010).

Nitrogen metabolism is the basis of the study of animal protein requirement, fully understand the nitrogen metabolism of animal helps to ensure that requirement the nutritional needs of fur animal protein, as far as possible to reduce nitrogen discharge pollution to the environment. To meet a certain nutrient requirement, a high-energy food of which less is fed to maintain body mass needs to contain higher percentages of nutrients than a low-energy food of which the animal will have to eat more to maintain body mass (Clauss *et al*., 2010). The energy of daily grain affects the protein digestibility, and when the energy supply is insufficient, it may result in animal failing to maintain themselves, so it needs to eat more to energy to meet the need for power, causing protein waste. The mink has a very short intestine, and a feed passage time of only 4-6 h (Hansen, 1978; Szymeczko and Skrede, 1990; Enggaard *et al*., 1991). Thus, ingested dietary protein is rapidly digested and absorbed, the excess being metabolized to C fragments used for energy metabolism and to N-containing end products which are excreted in the urine (Tauson *et al*., 1997). Therefore, the amount of protein and energy diet should be appropriate. As demonstrated by Mayntz *et al*. (2009) reported that when fed unbalanced foods under no-choice conditions, mink were forced to tradeoff eating more of either protein or lipid against eating less of the other macronutrient relative to what they would eat if they were able to reach the intake target. In the phase II, we found the diets under less energy levels (A, B, C groups) where more N-intakes was eaten. The high energy levels of diets were just opposite. It is possible that this initial trial (phase I) fed unbalanced diets resulted in little mink being unhealthy. The bases exist for selection pressure on predators to demonstrate a capacity for nutritional regulation in the field. Regulation of nutrient intake might occur by choosing among prey of different nutrient composition, by eating different amounts of prey depending on nutrient composition, or by feeding on specifics parts of a prey, such as on protein-rich muscles or fat-rich tissues and organs (Maynt *et al*., 2005). In our study, the urine N of the period II was significantly higher than the period I, it probably because of the cold weather in the period II, the weather was colder and the mink drank less water.

Since the dietary intake of energy usually is more than sufficient to fulfill the animals requirements, adult animals kept on maintenance level are assumed to be in zero energy balance, but data in the literature often indicate that positive energy balances have been obtained in adult animals. Our results demonstrate that dietary energy levels in certain range may increase dietary ME and improve production performance, but it may have negative effects on the same parameters if the amount of fat is out of the optimal range. which is strikingly similar to the previous experiments (Geng *et al*., 2012). Our results are similar to a previous study in Which the energy digestibility and metabolizability were significantly higher in phaseIthan in phase II when the high energy diets were fed (Ahlstrøm *et al*., 2006). It may be due to the air temperature drops of the mink in the second period.

CONCLUSIONS

In conclusion, digestibility of main nutrients varies significantly among different energy levels of complete dry power diets. In the phaseI, the final body weight and main nutrients were improved with increasing dietary energy level of diet. The rise in DM, CP, EE and energy of digestibility were more dramatic with increasing dietary energy levels. Under the conditions of this experiment, to achieve the best growth in September the amount of energy from protein should be at least 25.95%, the amount of energy from fat should be 51.80 % of ME in that period. In the phase II, the efficiency of production performance used for gain in group E of ME 16.28 MJ/kg (15% fat content) the amount of energy from protein should be at least 27.78 %, the amount of energy from fat should be 42.99 % of ME.

DECLARATIONS

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Ethical statement

All minks was carried out following the guidelines established by the Canadian Council on Animal Care (1993).

Generative AI or AI-assisted technology statement

The entire process of this work, whether it was data organization or writing, did not use AI and AI-assisted technology

Statemenet of conflict of interest

The authors have declared no conflict of interest.

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