Effects of dry dietary protein on digestibility, nitrogen-balance and growth performance of young male mink

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ABSTRACT

The experiment was to study the nutrient digestibility and metabolism performance of male minks, which were fed different protein level diets during growth period. Effects of protein quantity on growth and development of minks and feed conversion ratio (FCR) were also investigated. Sixty healthy male minks of 45 d were randomly allocated into six groups with ten replicates, which was one sable for each replicate. The minks in six groups were fed diets in which protein levels were 28, 30, 32, 34, 36 and 38%, respectively. The six groups were denoted as P28, P30, P32, P34, P36 and P38. After 2 wk, all minks were weighed, average daily gains (ADG) were calculated, and the digestibility values of nutrients were determined. The results indicated that digestibility of calcium, nitrogen of fence, nitrogen deposition, net protein utilization (NPU), and biological value of protein (BV) were similar (P > 0.05), however, nitrogen intake greatly varied among groups (P < 0.01). Compared with group P28, groups of P34, P36 and P38 showed significant difference (P < 0.01) in ADG and FCR. In conclusion, it was recommended that adding 34% protein to mink diet would optimize production parameters including ADG, digestibility of nutrition, and FCR, and negative result was observed when diet protein was lower than 28%.

1. Introduction

Mink (Mustela vison) is a strict carnivore that originated from North America, and is a precious fur-bearing animal (Søren and Anne-Helene, 1998; Stubbe, 1993). Mink has been raised for more than 25 million yr in European and cultivated as the main animal species that is kept for fur throughout the world (Sari et al., 2008; European Commission, 2001).

Wild minks always capture fish, frogs, and small mammals to eat. Although mink is carnivorous, carbohydrate plays an important role as a dietary ingredient for farmed mink (Bersting et al., 1995). Mink is unable to digest carbohydrates in the small intestine, which was normally observed in monogastric animals (Glem-Hansen et al., 1977; Graham et al., 1986). Several technological means such as the conventional drum dryer and extrusion can increase the digestibility of plant materials for mink (Östergard and Mejbol, 1989).

The ingredients of mink diet varied greatly in the past couple of decades. Since plant stuff was employed in the diet, the fat and protein contents were different from those of previous feed formula diets. Therefore, the recommendations of diet ingredient for mink that is currently based on fresh meal research for juvenile mink (NRC, 1982; Hansen et al., 1991) needs to be amended and take animal growth condition into consideration. Mink kids are capable of growing very fast during lactation, which is the first three wk after birth (Tauson, 1994), and they can keep growing rapidly in the early period after weaning.

Due to high protein demand of dams, nutritional intake from feed could not meet the requirement of baby minks, and resulted
in weight losses (Hansen, 1997; Tauson, 1988). Protein quality has a direct influence on the growth and the health of juvenile mink, and contributes greatly to the fur area and fur quality in the pelting period.

The current study aims to determine the requirement of dietary protein for young male minks fed dry power feed. The effects of experimental diet on body growth rate, feed conversion ratio (FCR), nutrients digestibility and nitrogen balance were investigated.

2. Material and method

2.1. Animal and feeding management

Sixty healthy 45-day-old male sables (initial weight 1.065 ± 0.118 kg) were randomly divided into six groups. Each of the six groups contains ten biological replicates. There was no significant difference in body weights (BW) among groups (P > 0.05). The minks were fed six experimental diets in which serial protein levels were 28, 30, 32, 34, 36 and 38%, respectively. The six groups were denoted as P28, P30, P32, P34, P36 and P38. All the animals were injected with distemper vaccine and canine parvovirus before the trial started. Diets were distributed at 0800 and 1600, and water was taken freely by animals.

The minks were individually housed outdoors in traditional cages (70 cm × 30 cm × 45 cm) with two row sheds. The animals in this experiment were well taken care of according to the guidelines provided by Canadian Council on Animal Care (1993).

2.2. Experimental diets

According to the feed component of previous studies, protein concentrations of feed were designed as 28, 30, 32, 34, 36 and 38% in this experiment. The nutrients of feeds were listed in Table 1.

2.3. Digestion metabolism experiment

Six minks with similar BW were chosen from their respective groups to undergo the digestive experiment on day 14. The digestive experiment lasted for 4 d that was from July 28, 2009 to July 31, 2009. During the period, excretions of animals were collected every 2009. During the period, excretions of animals were collected every 2 weeks. Feed intake and residues were accurately recorded to evaluate concentrations of Ca and P in feed, respectively (AOAC, 1991, 1995).

2.4. Body weight

All animals were weighted in the morning before feeding per two weeks. Feed intake and residues were accurately recorded to calculate ADG and FCR.

2.5. Measure parameters

2.5.1. Feed intake

Total feed supply and residual were recorded and used for calculating the feed intake for each mink and for each group.

2.5.2. Trial determined index

The feed material was stoved at 65 °C to determine dry matter (DM). Crude protein (CP) and ether extract substance were determined using Kjeldahl Nitrogen method and Soxhlet extract method, respectively. Potassium permanganate titration and ammonium heptamolybdate tetrahydrate colorimetry were employed to evaluate concentrations of Ca and P in feed, respectively (AOAC, 1991, 1995).

2.6. Statistical analysis

The data were presented as means ± SD and analyzed by one-way ANOVA with SPSS 16.0, P < 0.05 means significant difference, and P < 0.01 means greatly significant difference.

### Table 1

| Item                    | Group | P28 | P30 | P32 | P34 | P36 | P38 |
|-------------------------|-------|-----|-----|-----|-----|-----|-----|
| **Ingredients**         |       |     |     |     |     |     |     |
| Extrusion corn          |       | 38.50 | 31.50 | 36.50 | 33.50 | 32.50 | 28.50 |
| Soybean meal            |       | 6.00 | 6.00 | 6.00 | 5.00 | 4.00 | 3.00 |
| Corn gluten             |       | 2.00 | 6.00 | 8.00 | 10.00 | 10.00 | 10.00 |
| Corn germ meal          |       | 9.00 | 5.00 | 5.00 | 3.00 | 0.00 | 0.00 |
| Chicken meal            |       | 8.00 | 6.00 | 5.00 | 6.00 | 6.00 | 6.00 |
| Bone meat meal          |       | 15.00 | 16.00 | 12.00 | 16.00 | 16.00 | 19.00 |
| Cheese meal             |       | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 |
| Fish meal               |       | 8.00 | 16.00 | 12.00 | 13.00 | 18.00 | 19.00 |
| Bean oil                |       | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 |
| Salt                    |       | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 |
| Premix                  |       | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 |
| Total                   |       | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| **Nutrient Composition**|       |     |     |     |     |     |     |
| ME (MJ/kg)              |       | 10.16 | 10.45 | 10.08 | 10.17 | 10.75 | 10.79 |
| CP (%)                  |       | 28.49 | 30.18 | 32.35 | 34.18 | 36.08 | 38.03 |
| Ca (%)                  |       | 3.48 | 3.26 | 3.20 | 3.20 | 3.37 | 3.74 |
| TP (%)                  |       | 2.78 | 2.61 | 2.56 | 2.67 | 2.81 | 3.12 |
| Lys (%)                 |       | 1.98 | 2.30 | 2.42 | 2.62 | 2.76 | 2.91 |
| Met + Cys (%)           |       | 1.60 | 1.68 | 1.79 | 1.89 | 2.05 | 2.16 |

**DM digestibility (%)** = (DM intake − DM output)/DM intake × 100.

**Protein digestibility (%)** = ([Protein intake − Protein in feces]/Protein intake) × 100.

**Fat digestibility (%)** = ([Fat intake − Fat in feces]/Fat intake × 100.

**Ca digestibility (%)** = ([Ca intake − Ca in feces]/Ca intake) × 100.

**P digestibility (%)** = ([P intake − P in feces]/P intake) × 100.

**N deposition (g/d)** = N intake − Urinary N − Fecal N.

**NPU** = (N deposition/N intake) × 100.

**BV (%)** = [N deposition/(N intake − Fecal N)] × 100.

**ADG (g)** = (Final weight − Initial weight)/Trial days.

**FCR** = (Final weight − Initial weight)/Feed intake.
3. Results

3.1. Effects of diet on feed intake and dry matter digestibility

Effects of dietary protein on feed intake and DM digestibility of young male mink were investigated in this study. As seen in Table 2, feed intakes of P32 and P34 were higher than those of other groups (P < 0.05), and the lowest feed intake was observed in P30. The DM outputs of P34, P36 and P38 groups were greatly and significantly lower (P < 0.01) than that of P28. We believe the dietary protein contributes to high feed intake and low dry matter output. The DM digestibility of P28 and P30 were greatly and significantly lower (P < 0.01) than other groups, and no significant difference was observed among P32, P34, P36 and P38 (P > 0.05).

3.2. Digestibility efficiency of nutrients

Effects of the dietary protein on digestibility of main nutrients are shown in Table 3. The digestibility of CP of the group P28 was obviously lower than that of the group P30 (P < 0.05). Groups of P32, P34, P36 and P38 had similar CP digestibility values, which was positively correlated with amount of dietary protein (P > 0.05). The digestibility values of crude fat of P34, P36 and P38 were greatly and significantly higher than those of P28 and P30 (P < 0.01). All groups showed no significant difference in digestibility values of Ca (P > 0.05). Although P digestibility in P34 was higher than those of P30 and P36 (P < 0.05), no significant difference was observed among P28, P32 and P38 (P > 0.05).

3.3. Nitrogen metabolism

The effect of dietary protein on nitrogen metabolism balance is shown in Table 4. The nitrogen intakes of P28 and P30 were greatly and significantly lower than those of P32, P34, P36, and P38 (P < 0.01). Fecal nitrogen, which was probably not influenced by dietary protein, showed no difference among groups (P > 0.05). The urea nitrogen drains of groups P36 and P38 were greatly and significantly higher than those of other groups (P < 0.01). The values of nitrogen retention, NPU and BV of protein had no significant difference of all minks (P > 0.05).

3.4. Body weight growth and feed conversion ratio

Effects of dietary protein on BW and FCR of mink are shown in Table 5. The final BW of P28 was greatly and significantly lower than those of P32, P34, P36 and P38 (P < 0.01), but no difference was

| Table 2 |
|-----------------|--------|--------|--------|--------|
| Item           | Group  |       |       |       |
|                | P28    | P30    | P32    | P34    |
| Feed intake, kg| 1.0010 ± 0.0522<sup>ab</sup> | 0.9665 ± 0.0512<sup>a</sup> | 1.0376 ± 0.0538<sup>b</sup> | 1.0516 ± 0.0275<sup>b</sup> |
| DM intake, kg  | 0.2721 ± 0.0141<sup>ab</sup> | 0.2630 ± 0.0199<sup>a</sup> | 0.2812 ± 0.0145<sup>b</sup> | 0.2867 ± 0.0074<sup>b</sup> |
| DM output, kg  | 0.0885 ± 0.0079<sup>ab</sup> | 0.0831 ± 0.0025<sup>a</sup> | 0.0775 ± 0.0119<sup>b</sup> | 0.0747 ± 0.0093<sup>b</sup> |
| DM digestibility, % | 67.49 ± 2.00<sup>a</sup> | 69.03 ± 2.57<sup>b</sup> | 72.52 ± 3.18<sup>ab</sup> | 73.89 ± 3.56<sup>b</sup> |

3. Table 3

| Item               | Group  |       |       |       |
|--------------------|--------|-------|-------|-------|
| Item              | P28    | P30    | P32    | P34    |
| Fecal protein, g   | 5.45 ± 0.48<sup>a</sup> | 5.90 ± 0.82<sup>ab</sup> | 5.46 ± 0.50<sup>a</sup> | 5.30 ± 0.45<sup>a</sup> |
| CP digestibility, %| 65.37 ± 3.34<sup>a</sup> | 69.71 ± 3.01<sup>b</sup> | 74.81 ± 2.89<sup>c</sup> | 76.92 ± 3.56<sup>c</sup> |
| Fecal CF, g        | 8.47 ± 1.79<sup>a</sup> | 7.94 ± 0.80<sup>cd</sup> | 7.67 ± 2.54<sup>bc</sup> | 8.39 ± 2.79<sup>bc</sup> |
| EE digestibility, %| 66.29 ± 5.73<sup>a</sup> | 74.15 ± 8.00<sup>cd</sup> | 76.97 ± 7.87<sup>bc</sup> | 81.92 ± 2.79<sup>bc</sup> |
| Fecal Ca, g        | 5.86 ± 1.22<sup>a</sup> | 6.02 ± 0.32<sup>ab</sup> | 5.60 ± 1.07<sup>a</sup> | 5.92 ± 1.04<sup>ab</sup> |
| Ca digestibility, %| 32.10 ± 15.17<sup>a</sup> | 32.75 ± 2.24<sup>b</sup> | 38.11 ± 8.97<sup>a</sup> | 39.74 ± 10.93<sup>a</sup> |
| P digestibility, % | 27.92 ± 5.66<sup>bc</sup> | 19.42 ± 8.15<sup>ab</sup> | 24.06 ± 7.14<sup>ab</sup> | 30.65 ± 6.83<sup>ab</sup> |

4. Table 4

| Item               | Group  |       |       |       |
|--------------------|--------|-------|-------|-------|
| Item              | P28    | P30    | P32    | P34    |
| N intake, g/d     | 10.92 ± 5.70<sup>a</sup> | 12.53 ± 5.12<sup>b</sup> | 14.13 ± 7.33<sup>a</sup> | 14.91 ± 3.88<sup>b</sup> |
| Fecal N, g/d      | 3.79 ± 0.42<sup>a</sup> | 3.79 ± 0.34<sup>a</sup> | 3.57 ± 0.67<sup>b</sup> | 3.43 ± 0.48<sup>b</sup> |
| Urine N, g/d      | 4.97 ± 0.50<sup>a</sup> | 6.43 ± 0.94<sup>ab</sup> | 6.81 ± 0.85<sup>bc</sup> | 7.68 ± 0.93<sup>cd</sup> |
| N retention, g/d  | 2.16 ± 0.46<sup>a</sup> | 2.32 ± 0.92<sup>b</sup> | 3.75 ± 0.86<sup>b</sup> | 3.79 ± 1.35<sup>a</sup> |
| NPU, %            | 19.91 ± 4.78<sup>a</sup> | 18.47 ± 7.27<sup>b</sup> | 26.60 ± 6.21<sup>a</sup> | 25.53 ± 8.47<sup>b</sup> |
| BV, %             | 21.64 ± 5.16<sup>a</sup> | 19.88 ± 7.75<sup>b</sup> | 28.34 ± 6.53<sup>a</sup> | 26.84 ± 8.84<sup>b</sup> |

NPU – net protein utilization; BV – biological value; P28 – diet contains 28% crude protein, etc.

<sup>a,b,c</sup>Means in the same row with different lowercase letter superscripts were significantly different (P < 0.05).

<sup>a,b,c</sup>Means in the same row with different lowercase letter superscripts were greatly and significantly different (P < 0.01).
detected among P32, P34, P36 and P38 (P > 0.05). Compared with minks in other groups (P < 0.01), minks in P28 showed the lowest ADG. The FCR of P28 was significantly lower than those of groups P34, P36 and P38 (P < 0.05). When dietary protein exceeded 34%, growth performance of mink showed no significant difference (P > 0.05).

4. Discussion

4.1. Feed intake and digestibility of dry matters of mink

As suggested by NRC nutrition standard (1982), the feed intake of mink was affected by palatability and energy levels of feed. In previous research, it seemed that the digestibility values were higher when mink were fed animal original feed. The DM digestibility values of P34, P36, and P38 were greatly and significantly higher than that of P28. The minks in P34, P36 and P38 had high percentage of feed intake, which was consistent with the previous studies. Therefore, we speculate that mink were able to adjust feed intake according to the energy intake needed for living, and this eliminates the differences caused by various batches of feed stuff. Feed intake and digestibility of DM were mainly affected by the dietary protein concentration.

4.2. Digestibility of the nutrients

As seen in Table 3, the digestibility of protein and fat presented an enhanced trend as dietary protein increased. It was demonstrated that mink was capable of digesting protein over 38% during development stage. The mink in higher protein groups had a good appetite and ate more feed. Metabolic fecal nitrogen of lower protein groups was higher than that of higher protein groups. Zhang et al. (2011) studied the protein requirement in mink fed fresh feed, and the result showed that a reduction in dietary protein would lead to an increase in the relative amount of endogenous nitrogen secretion, which in turn reduced the apparent digestibility of protein. Margareth et al. (2006) reported that promoting the dietary protein had no effect on the digestibility of macro nutrient, using fish meal and bacterial protein as models. In this trial, the minks showed high digestibility of fat when diets were supplemented with increased amount of dietary protein, indicating that minks in current physical stage, triggered by sufficient nutrition, had rapid growth and development.

4.3. Nitrogen metabolism

It was reported that protein intake was closely correlated with the urea nitrogen (Pfeiffer et al., 1995; Kerminen-Hakkio et al., 2000). In this study, nitrogen intake had great and significant difference among groups, the same for urinary nitrogen, and no difference was detected for fecal nitrogen in all groups. Basically, urine nitrogen increased as dietary protein rose (Table 4), which was in good agreement with previous study (Kerr et al., 1995; Yang et al., 2005). Nevertheless, approximately accounted for 50% nitrogen intake, which was increased to 53% in P38 which was supplemented with the highest protein diet in this study, and 80% in the study carried out by Newell (1999)was excreted as urinary nitrogen during growing period. Mink mediated the balance of protein and energy intake, and surplus of protein was decomposed to ATP and drained by urine. Glem-Hansen (1976) reported that nitrogen deposition per kilogram BW gradually decreased BW of mink before 21 wk. Besides, nitrogen retention was observed to have correlation with the dietary protein percentage in the experiment.

4.4. Body weight and feed conversion ratio

All BW increases along with dietary protein level. Among all groups, the ADG of group P34 was the highest (Table 5). Oversupply of protein as well as imbalance of amino acid probably caused a large amount of urinary nitrogen excretion and low nitrogen utilization rate (Mayntz et al., 2009). Liu et al. (2006) used fresh meal to study the requirement of protein, suggesting that young male minks need 36% protein in diet. Although dry feed instead of the fresh meal was employed, no significant change of BW was observed during the period. Gao and Yang (1989) demonstrated that the live BW and fur length at stage had positive correlation to BW in fur-growing period. In this trial, group P34 had the biggest BW and the longest fur, based on the correlation coefficients.

5. Conclusion

Nitrogen excretion increased along with dietary protein level as we found in these young minks. The nitrogen retention, NPU and BV were not affected by protein level. The optimal ratio of protein to energy was 3.36 in the diet for mink. Diet supplemented with 28% protein was not able to meet the requirement of young male mink. When protein concentration reached 34% in the diet, ADG increased and FCR was ideal for minks. In the context, 34% protein in dietary feed for young male mink was recommended.

Conflict of interest statement

The authors declare that they have no competing interests.

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