HANNU T. KORHONEN & PAAVO NIEMELA

Digestibility of Heat Treated Barley in Blue Fox and Mink

ABSTRACT: *Carbohydrates are easy accessible raw material for fresh feed in domestic animal production. Barley, which mainly contains carbohydrates, has become more popular as an ingredient in feed for fur bearing animals in particular. The aim of the present study was to clarify the effects of heat treatment on digestibility of barley in farm-raised juvenile blue fox and mink. Two different heat treatments were compared here: (1) traditional heat treatment; and (2) specific treatment, including exposure to pressure and heat, and by gelatinization. Experimental animals were six adult males of dark standard-type mink or "neovison vison" and blue fox or "vulpes lagopus". The digestibility was evaluated by the AIA indicator method with 0.5 silicate (celite 545) serving as an inert indicator. Main components in the study feed were slaughter-house offal, Baltic herring, barley, and water. Ash content was higher in specific than in traditional diet ($p < 0.001$). Crude protein content tended to be slightly higher in specific diet. In blue fox and mink, digestibility of crude protein and fat were similar in traditional and specific diet ($p > 0.005$). Digestibility of carbohydrates and organic matter was significantly ($p < 0.01$) better for specific than traditional diets. Heat treatment including gelatinization can be recommended to use for better utilization of carbohydrate stuff in the diet.*
KEY WORDS: *Farmed furbearers, mink and blue fox, heat treatment, feed ingredients, fur farming, carbohydrate, and digestive value.*

INTRODUCTION

Carbohydrates are cheap and easy accessible material for feed in animal production (Berg, 1986; Pölönen, 2000; and Nenonen & Pölönen, 2002). Barley, which mainly contains carbohydrates, has become more popular as an ingredient in fur animal feed. However, digestibility of barley varies in different fur animal species. This obviously holds true also for farm-raised canid and mustelid species. Further research on this subject is needed, however.

The blue fox (*vulpes lagopus*) is a colour type of wild Arctic fox. Thus, medium-size canid is farm-raised for its excellent fur coat. As a carnivore, it generally can utilize carbohydrates fairly well. The composition of the diet of wild foxes typically varies seasonally and regionally (Frafjord, 1993; and Angerbjörn *et al.*, 1994). In an Arctic habitat, foxes tend mainly to eat meat and food scraps; whereas in a coastal area, their diet may comprise mainly fish (Nielsen, 1991). Foxes have, therefore, adapted to marked regional, annual, and seasonal fluctuations in food availability and content. See picture 1.

The mink (*neovison vison*), on the other hand, is a small-sized mustelid having an elongated body shape (Korhonen & Huuki, 2013). Due to high surface-to-mass ratio, the mink has to sustain higher basal metabolic rate than other mammals of the same body weight (Brown & Lasiewski, 1972; Iversen, 1972; and Korhonen, Harri & Asikainen, 1983). The mink typically utilize carbohydrates considerably poor. This is due to very short digestibility tract which results a short transit-period of only 4-5 hours (Sibbald *et al.,* 1962; and Jorgensen ed., 1985). Furthermore, the production of carbohydrate decomposing enzyme seems to be modest in the mink (Ostergaard, 1998). See picture 2.

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Digestibility of carbohydrates can be influenced by certain pre-treatments during manufacturing process. Particularly, heat treatment with gelatinization is expected to improve utilization of carbohydrate components such as starch (Ostergaard, 1998). This mainly is a result of clear changes in the structure of starch kernels which become more accessible for digestible enzymes, i.e. gelatinization. The extent of changes is known to depend on water contents, temperature, and certain conditions during process.

The aim of the present study was to clarify effects of heat treatment on digestibility of carbohydrates in farmed juvenile blue fox (*vulpes lagopus*) and mink (*neovison vison*) during autumn period. This time of the year is most crucial for proper formation of body composition, fattening, and furring process. Two different heat treatments were compared here: (1) traditional treatment by extruder; and (2) specific treatment including exposure to pressure and heat, and by gelatinization (Niemelä & Korhonen, 1998). Gelatinization means here boiling of starch.

Picture 1:
Picture of Juvenile Blue Fox in a Wire-Netting Farm Cage
(Photo: Pekka Eskeli, 28/10/2013)

Picture 2:
Farmed Mink in Wire-Netting Cage.
Feed is Given on Top of the Cage
(Photo: Hannu T. Korhonen, 28/10/2013)

MATERIALS AND METHODS

About the Experimental Animals.

The study was carried out at the MTT Fur Farming Research Station, Kannus (63.54 °N, 23.54 °E), Finland, during the growing-furring period (September 24th – October 3rd, 2013). The use of experimental animals was evaluated and approved by the Animal Care Committee of MTT Agrifood Research, Finland.

Experimental animals were six juvenile males of dark standard-type mink and blue fox (blue colour type of the Arctic fox). All animals were healthy and negative for plasmocytosis. They were divided into two different diet groups, as following: (1) traditional treatment group; and (2) specific treatment group, including exposure to pressure and heat, and by gelatinization. Gelatinization was made by heating carbohydrates (starch) to ≤ 100°C (Niemelä & Korhonen, 1998). The general health of the animals was visually checked daily.

During the experiment, the animals were housed singly in a wire-netting digestibility cages in an experimental hall. Inside temperature of the hall varied from +6 to +10°C. The mink cages were 70 cm long x 30 cm wide x 38 cm high. Correspondingly, the fox cages were 105 cm long x 115 cm wide x 70 cm high. Cages were lacking enrichments like platform or gnawing object. Both in mink and blue fox, experimental animals were

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genetically equal, one male kit form a single litter being taken into each of the groups.

About the Experimental Diets. The feed was manufactured daily by the Fur Farming Research Station, Kannus, Finland. The amounts of experimental raw materials were weighed with a balance, accuracy 10 g (Neigungswage Bauart FO, Dayton Vaaka, Finland; and Josef Florenz AG, Austria). Experimental raw materials were mixed with Stephan mixer (Stephan universal machine, type UM 44). Details of the raw materials and chemical compositions of the experimental diets are given in tables 1 and 2.

Animals were fed once a day at 8-9 am by hand. Daily feed portions were 350 g/animal and 900 g/animal for mink and foxes, respectively. Leftovers were collected the next day. Feed portions were measured with a Mettler SM 15 balance, accuracy ± 1 g. Watering was automatic *ad libitum*. Their daily routine treatments were conducted according to standard farming procedures.

ANALYSES AND STATISTICS

Initially, animals were kept in digestibility cages for four pre-test days. Actual experimental period started after pre-test period lasting five consecutive days (September 28th – October 2nd, 2013). Faeces of the animals were collected daily and frozen. Urine was not collected.

The digestibility was evaluated by the AIA indicator method with 0.5 silicate (*celite* 545) serving as an inert indicator. Individual feed and faeces samples were taken before and during the collection period for detailed analyses. The samples were analysed at the laboratory of the Fur Farming Research Station, Kannus (MTT), Finland. Standard procedures were used for analyses of nitrogen or *kjeldahl* and fat or *HCL hydrolysis* (Korhonen *et al.,* 2005). Carbohydrates were calculated according to equation: 100- (ash + crude protein + crude fat).

The apparent digestibility was determined according to the following equation: Apparent digestibility = a-b/a x 100, in which a = nutrient in feed/indicator in feed; and b = nutrient in faeces/indicator in faeces (Korhonen & Niemelä, 2012). The Metabolizable Energy (ME) content of the diets was calculated using the factors 18.8 (protein), 38.9 (fat), and 17.2 (carbohydrates) per gram apparent digestibility nutrient (Tauson, 1988).

Statistical analyses were performed by the General Linear Models (GLM) procedure of the Statistical Analysis System (SAS Institute Inc., 1991) using Tukey's Studentized range (HSD) test and analysis of variance (Korhonen & Niemelä, 2012).

RESULTS

Basic data and results can be found from tables 1-3. Ingredients of the diets are given in table 1. Main components in the feed were slaughter-house offal, Baltic herring, barley and water. This is a typical composition of farm feed for caged foxes and mink.

Chemical composition of the diets are shown in table 2. Ash content was higher in specific than in traditional diet. Furthermore, crude protein content tended to be slightly higher in specific diet.

In blue fox and mink, digestibility of crude protein and fat were similar in traditional and specific diets (table 3). On the other hand, digestibility of carbohydrates and organic matter was significantly better for specific than traditional diets. Digestibility of chemical components was better in blue foxes than in mink in general.

Solidity and general appearance of faces was normal in each study group. Dry matter content of faeces from traditional and specific diets were in range of normal values. In mink, the dry matter content for traditional and specific diets were 28.39 ± 2.4 and 28.60 ± 1.49%, respectively. In blue foxes, the corresponding values were 33.71 ± 0.83 and 26.86 ± 1.04%, respectively.

DISCUSSION

The main ingredients in fur animal feed are products of the fish and slaughter industries. Typically, their amounts have varied by year and season (Korhonen & Niemelä, 1998; and Pölönen, 2000). Also carbohydrates are used in the diet of farmed fur bearers. Carbohydrates are cheap substitute nutritional wise for protein and fat to meet the basal energy demands. Therefore, they should be favored more in

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Table 1:
The Composition of Experimental Diets

Ingredient (%)	Traditional	Specific
Slaughter-house offal	26.09	26.54
Baltic herring	36.52	37.15
Barley	15.65	15.92
Water	20.20	18.83
Celite 545	0.50	0.50

Table 2:
Chemical Composition of Diets

Variable	Traditional	Specific
Dry Matter (DM), %	33.31	33.97
In DM, %: Ash	9.93	7.82
Crude protein	28.88	27.63
Crude fat	20.43	20.05
Crude carbohydrate	40.77	44.49

Table 3:
Digestibility (%) of Traditional and Specific Diet Components in Blue Fox and Mink

Variable	Blue Fox		Mink	
	Traditional	Specific	Traditional	Specific
Crude protein	79.97	79.03	73.92	77.17
	(1.64)	(1.01)	(3.46)	(2.85)
Crude fat	91.17	89.87	77.85	80.10
	(1.74)	(1.03)	(5.82)	(2.04)
Crude carbohydrate	51.75	71.91**	43.51	69.55**
	(5.14)	(1.79)	(5.83)	(2.18)
Organic matter	66.01	76.81 **	64.78	75.27**
	(2.93)	(1.14)	(4.40)	(2.06)

Significant difference: **$p < 0.001$. Standard deviations are given in parenthesis.

the diet. They are typically also beneficial for digestibility of farm feed. Therefore, use of carbohydrates should be favored more in future. However, further research is needed before implementation in practice. This study was part of this implementation project.

The decomposition of the feed substances is done by means of alimentary enzymes. Digestibility of carbohydrates demands that enzymes have enough time to work with the decompositions. Particularly, this is problem for animals like the mink with a short intestinal canal. Starch is the main component of carbohydrates. Starch can be made better digestible by "opening" its structure. This can be done by heat treatment where the material is exposed to pressure and heat, and by gelatinization. Digestibility of carbohydrates including starch may improve, because of essential change of the structure of starch kernels which becomes more easily accessible for digestible enzymes (Ostergaard, 1998). The change of the structure is known as gelatinization. This treatment was used for our specific diet.

Comprehensive scientific interest has been to improve diet and raw material digestibility of feed in farmed fur animals. According to literature, digestibility of raw barley in mink typically is 45-52% and that of cooked barley around 60%. Carbohydrate digestibility of heated barley by extruder method, on the other hand, is 57-60% and 65-73% in mink and blue fox, respectively (Minkinkasvatus, 1967; Berg, 1986; and Niemelä & Korhonen, 1998).

In the present study, heat treatment also included gelatinization of feed stuff. The results showed that treatment significantly increased digestibility of carbohydrates both in the fox and mink. Furthermore, it was also

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found that digestibility of organic matter is increased by combination of heat treatment and gelatinization.

General concept is that digestibility of feed stuff is better in farmed foxes than in mink (Niemelä & Korhonen, 1998; and Korhonen & Niemelä, 2012). The mink typically have a short digestibility tract thus food is passing trough very fast, i.e. in 4-5 hours (Sibbald *et al.*, 1962; Jorgensen ed., 1985; and Korhonen, Sepponen & Eskeli, 2013). This also impairs digestibility of food in the digestive tract. Furthermore, foxes typically are known to utilize more versatile food than mink. The present results confirm this concept. Digestibility of carbohydrates, protein, and fat tended to be better for the blue fox than for the mink. Most pronounced this tendency was for carbohydrates and organic matter.

CONCLUSION [1]

The results of the present study are promising. They encourage us to continue in clarifying the suitability of various carbohydrate stuffs for farmed foxes and mink. In addition to barley also oat, for example, can be considered as a potential carbohydrate resource in future. The use of carbohydrates as a part of the feed for farmed furbearers is advantageous, while production costs can be declined by not using so much fat and protein.

The present results are also promising. They showed that heat treatment of barley with gelatinization is effective to increase digestibility of carbohydrates in farmed mink and fox diets. Digestibility of barley is better in farmed foxes compared to mink.

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