

**THE EFFECT OF DIETS WITH DRIED BEET PULP  
ON GROWTH INDICATORS IN ARCTIC FOXES  
(*Vulpes lagopus* L.)**

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**Key words:** arctic fox, dried sugar beet pulp, grains, body weight, daily gains.

**A b s t r a k t**

The aim of the study was to determine the effect of feed ration with a variable content of carbohydrates on the production performance of blue arctic fox. The research included 60 blue arctic foxes which were divided into two groups: experimental (30 individuals) and control (30 individuals). The experimental group, compared to the control group, was fed with a ration with a higher level of carbohydrates, whose source were ground grains (ground barley and wheat) as well as dried beet pulp. The experiment lasted from weaning of the pups until the day when the foxes were slaughtered (29 week). Based on control weighing (at the beginning of the experiment, at 17 and 29 weeks of age) the average body weight was calculated (in kg), as well as the total (in kg) and daily (in g) body weight gain. The average final body weight of foxes in both groups was similar, and ranged from 15.67 kg (control group) to 16.20 kg (experimental group). Males were characterized by a slightly higher body weight than females (however, these differences were not confirmed statistically). In the experimental group the total and daily body weight gains during growth were higher, and during the fur growth period they were lower compared with the control group. The use of rations with an increased proportion of carbohydrates in the arctic fox nutrition, whose source were extruded ground grains and dried beet pulp, did not negatively affect on selected of the production performance of foxes over the whole experimental period compared with the control group.

## WPLYW DIET Z UDZIAŁEM SUSZONYCH WYSŁODKÓW BURACZANYCH NA WSKAŹNIKI WZROSTU LISÓW POLARNYCH (*Vulpes lagopus* L.)

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Słowa kluczowe: lis polarny, suszone wysłodki buraczane, śruty zbożowe, masa ciała, przyrosty dobowe.

### Abstrakt

Celem badania było określenie wpływu dawki pokarmowej o zróżnicowanej zawartości węglowodanów na efekty produkcyjne lisa polarnego niebieskiego. Badaniami objęto 60 osobników lisa polarnego niebieskiego, które podzielono na dwie grupy: doświadczalną (30 sztuk) i kontrolną (30 sztuk). Grupa doświadczalna, w porównaniu z grupą kontrolną, była żywiona dawką pokarmową o wyższym poziomie węglowodanów, których źródłem były śruty zbożowe (jęczmienna i pszena) oraz suszone wysłodki buraczane. Doświadczenie trwało od momentu odsadzenia szceniąt do dnia uśmiercenia lisów (29 tydzień). Na podstawie kontrolnych ważeń (na początku doświadczenia, w 17. i 29. tygodniu życia) obliczono średnią masę ciała [kg], całkowity [kg] i dobowy [g] przyrost masy ciała. Średnia końcowa masa ciała lisów w obu grupach była podobna i wynosiła od 15,67 kg (grupa kontrolna) do 16,20 kg (grupa doświadczalna). Samce charakteryzowały się nieznacznie wyższą masą ciała niż samice (różnic tych nie potwierdzono jednak statystycznie). W grupie doświadczalnej całkowite i dobowe przyrosty masy ciała w okresie wzrostu były wyższe, a w okresie kształtowania się okrywy włosowej niższe w porównaniu z grupą kontrolną. Wykorzystanie w żywieniu lisów polarnych dawek pokarmowych ze zwiększonym udziałem węglowodanów, których źródłem były ekstrudowane śruty zbożowe i suszone wysłodki buraczane, w porównaniu z grupą kontrolną nie wpłynęło negatywnie na wybrane wyniki produkcyjne lisów w całym okresie doświadczenia.

### Introduction

Optimal balancing of the ration for carnivorous fur-bearing animals always constitutes a great challenge for a breeder, as this is one of the most important factors determining health condition of these animals, their growth, size of production, and quality of the obtained pelts. Foxes are typical carnivorous animals whose digestive system is adapted to digest food that is high in protein and energy. Therefore, in breeding practice the main dietary components for them are fish and post-slaughter products of meat industry. However, it should be highlighted that a relatively cheap and easily available substitute of energy for carnivorous fur-bearing animals may be some groups of carbohydrates, mainly simple sugars and starch (AHLSTRØM et al. 2003, LAERKE et al. 2004, GUGOLEK et al. 2014). The above mentioned authors state that the process of domestication of these animals, compared with their wild ancestors, significantly increased the level of carbohydrate use. The research of AHLSTRØM et al.

(2003) indicated a higher ability to digest carbohydrates in the feed (including starch and glucose) in blue arctic foxes than in foxes living in the wild. On the other hand, KORHONEN and NIEMELÄ (2014) found that farm-raised foxes digested carbohydrates better than minks. Carbohydrates constitute not only a cheap source of energy for animal's body but they also play a significant role in fat conversion – they are precursors of producing oxaloacetic acid which takes part in oxidation and synthesis of fatty acids in the liver. Deficiency or lack of carbohydrates in the diet of carnivorous fur-bearing animals leads to metabolic disorders which may result in acetonaemia (*Zalecenia żywieniowe...* 2011). In order to avoid mistakes in nutrition, minimal percentage proportion of energy should be observed in the total amount of metabolic energy (EM) in the ration. According to NRC (1982) and *Normy żywienia...* (1994), minimal proportion of energy from carbohydrates should be 12% and the maximal one 20% EM of the diet, irrespective of the nutrition period. The latest Polish nutrition recommendations for fur-bearing animals (*Zalecenia żywieniowe...* 2011) state that proportion of energy from carbohydrates in rations for farm-raised foxes and minks should be within a range from 20% EM.

In breeding practice, the most frequent source of carbohydrates in rations for carnivorous fur-bearing animals are ground grains of barley and wheat. Although alternative carbohydrate sources to cereal plants (e.g.: potatoes, potato pulp, Jerusalem artichoke, distillers dried grains with solubles DDGS, beet pulp) were also tested, yet with a conclusion that they may be used in limited amounts (RUVIENEN-WATTI et al. 2000, ZAKRZEWSKA-CZARNOGÓRSKA and BRZOZOWSKI 2000, LAERKE et al. 2004, LISITSKAYA et al. 2011).

The aim of the research was to determine if dried beet pulp may be used in the diet of arctic foxes (*Vulpes lagopus* L.) as an additional source of carbohydrates, apart from ground grains, without a negative effect on the production performance.

## Material and Methods

The experiment was carried out on a fox farm in the Kuyavian-Pomeranian Voivodship. 60 blue arctic foxes were selected for studies after weaning at 10 weeks of age. The pups were divided into two nutrition groups, each including 30 foxes (15 ♀: 15 ♂). The foxes were kept in individual cages (0.6 m<sup>2</sup> per fox) in a shed system, providing them with a continuous access to water. Two types of diet were used in fox nutrition over the period of growth and development (July-September) as well as over the fur growth period (October-November). The feed was given once a day at the same time. For the whole experimental period, from weaning until the slaughter day, the foxes had ad libitum access

Table 1

Components [%] and energy value of fox diets

Item	Growth period		Fur growth period	
	control group	experimental group	control group	experimental group
Whole flounder	12.0	12.0	10.0	10.0
Whole cod	10.0	10.0	2.0	2.0
Bones	10.0	10.0	10.0	10.0
Various poultry wastes	11.0	6.0	16.0	9.5
Poultry meat	12.0	12.0	8.0	8.0
Poultry viscera	25.0	25.0	30.0	30.0
Fish meal	1.0	1.0	2.0	2.0
Blood meal	1.0	1.0	1.0	1.0
Meat and bone meal	3.5	3.5	4.0	4.0
Animal fat	3.5	2.5	5.0	4.0
Dried beet pulp	0.0	3.0	0.0	4.0
Extruded cereals (barley/wheat)	11.0	14.0	12.0	15.5
In total	100.0	100.0	100.0	100.0
Vitamin and mineral supplement*	+	+	+	+
Metabolic energy [MJ kg <sup>-1</sup> ]	7.03	7.05	7.74	7.85
Energy share [%] from:				
protein	35.72	35.70	30.80	30.63
fat	52.11	45.00	57.14	49.37
carbohydrates	12.17	19.30	12.06	20.00

\* commercial vitamin and mineral supplement was added to diets in quantities recommended by the producer

to feed. In rations for foxes from the control group, the source of carbohydrates were cereal plants (extruded barley and wheat in a proportion of 1:1). The experimental animals were fed with a ration to which, apart from extruded cereals, dried beet pulp was added. All diets were balanced according to nutrition recommendations for raising foxes (NRC, 1982, Normy żywienia... 1994, *Zalecenia żywieniowe...* 2011). The content of protein, fat and carbohydrates in the feed was determined with the use of a full-spectrum Diode Array NIR Analyzer 7200, at the laboratory of the National Association of Breeders and Producers of Fur-Bearing Animals, Tarnowo Podgórne. Energy value of tested diets was evaluated based on chemical ingredients and energy equivalents adapted from *Zalecenia żywieniowe...* (2011). The main components of the tested diets (Table 1) were products of animal and fish origin. The proportion of plant feeds in control diets over the period of growth and development as well as over the fur growth period oscillated on the level of 11 and 12%, and it was lower than in the experimental diets by 3 and 3.5%, respectively. In rations

for control foxes the source of carbohydrates were extruded ground grains such as: ground barley and ground wheat, used in a proportion of 1:1. However, apart from ground grains, dried beet pulp was additionally introduced to the experimental diets. Energy value of the rations in particular experimental periods and percentage proportion of EM from protein in their total energy value were comparable. Percentage proportion of EM from carbohydrates compared with the total energy value of the diet of control foxes oscillated on the level of about 12%, and was lower by over 7% compared with rations for the experimental foxes. Inverse dependences were found compared with the percentage proportion of EM from fat.

During research, body weight of foxes was controlled individually three times (at the beginning of the experiment, at 17 and 29 weeks of age) with an accuracy to 0.1 kg. The average body weight was calculated [kg], as well as the average total body weight gain [kg], and the average daily body weight gain [g].

The results were subjected to statistical analysis using program Statistica (StatSoft Inc. 2010). An arithmetic mean ( $\bar{x}$ ) was calculated as well as standard deviation (SD). To evaluate the effect of nutrition and sex, fixed effects model (GLM) was used, as well as a two-way analysis of variance with the use of cross classification with an interaction. The model included the following effects: diet and sex.

$$y_{ijk} = \mu + \alpha_i + B_j + (\alpha B)_{ij} + e_{ijk}$$

where:

- $y_{ijk}$  – value of the studied trait (body weight, total gains, daily gains)
- $\alpha_i$  – the effect of  $i^{\text{th}}$  diet,
- $B_j$  – the effect of factor  $B$  (sex) of  $j^{\text{th}}$  sex,
- $(\alpha B)_{ij}$  – interactions between factors,
- $e_{ijk}$  – random error.

## Results

From the data presented in Table 2 it follows that at the beginning of the experiment, an average body weight of pups in both groups was equal and oscillated on the level of 3.80 kg. At 17 weeks of age, both males and females fed with a diet with a proportion of ground grains and dried beet pulp (experimental group) were heavier ( $P \leq 0.01$ ) than foxes getting a ration in which the source of carbohydrates were only ground grains (control group), by 17 and 20%, respectively. However, no significant differences were indicated between the groups in an average body weight of whole fox populations. On the

Table 2

## Indicators of growth rate in foxes

Item	Statistical measures	Feeding groups					
		control			experimental		
		♀	♂	♀ + ♂	♀	♂	♀ + ♂
Body weight [kg]							
10 weeks	$\bar{x}$	3.77	3.84	3.81	3.57	3.99	3.78
	SD	0.31	0.30	0.30	0.46	0.68	0.61
17 weeks	$\bar{x}$	9.89 <sup>A</sup>	10.09 <sup>B</sup>	9.99	11.55 <sup>A</sup>	12.15 <sup>B</sup>	11.85
	SD	1.91	1.05	1.52	1.37	1.68	1.54
29 weeks	$\bar{x}$	15.35	15.99	15.67	15.49	16.90	16.20
	SD	1.50	1.05	1.31	1.92	2.25	2.18
Total body weight gain [kg]							
10–17 weeks	$\bar{x}$	6.12 <sup>a</sup>	6.25 <sup>B</sup>	6.18 <sup>C</sup>	7.97 <sup>a</sup>	8.16 <sup>B</sup>	8.07 <sup>C</sup>
	SD	1.70	0.98	1.36	1.13	1.54	1.33
18–29 weeks	$\bar{x}$	5.47 <sup>A</sup>	5.90 <sup>b</sup>	5.68 <sup>C</sup>	3.94 <sup>A</sup>	4.75 <sup>b</sup>	4.35 <sup>C</sup>
	SD	1.30	0.56	1.01	1.01	2.00	1.61
10–29 weeks	$\bar{x}$	11.58	12.15	11.86	11.91	12.91	12.42
	SD	1.32	1.05	1.20	1.66	1.85	1.80
Daily body weight gain [g]							
10–17 weeks	$\bar{x}$	98.71 <sup>A</sup>	100.80 <sup>B</sup>	99.68 <sup>C</sup>	128.60 <sup>A</sup>	131.61 <sup>B</sup>	130.11 <sup>C</sup>
	SD	27.40	15.83	22.02	18.15	24.89	21.46
18–29 weeks	$\bar{x}$	71.04 <sup>A</sup>	76.62 <sup>b</sup>	73.77 <sup>C</sup>	51.17 <sup>A</sup>	61.69 <sup>b</sup>	56.49 <sup>C</sup>
	SD	16.30	7.02	12.64	13.11	26.01	20.95
10–29 weeks	$\bar{x}$	83.31	87.41	85.32	85.71	92.87	89.33
	SD	9.41	7.47	8.60	11.92	13.29	12.94

Explanations: *aa*, *bb* – means (in rows) differ significantly at  $P \leq 0.05$ ; *AA*, *BB*, *CC* – means (in rows) differ significantly at  $P \leq 0.01$

slaughter day (29 weeks of age) arctic foxes from the experimental group reached a similar body weight to foxes from the control group.

In the period of growth and development the total body weight gains of foxes (Table 2) fed with a ration with a proportion of ground grains and dried beet pulp were higher by 30% ( $P \leq 0.01$ ) compared with the control group. In the fur growth period, it was indicated that, compared with the control group, diets with a maximal proportion of energy from carbohydrates significantly decreased ( $P \leq 0.05$  and  $P \leq 0.01$ ) the total gains in males and females by 28 and 19%, respectively, and by 23% in the whole fox population. The total body weight gains for the whole experimental period in both groups were comparable.

Growth rate of arctic foxes (Table 2) fed with rations with a maximal proportion of energy from carbohydrates between 10 and 17 weeks of age was on average by about 30% higher ( $P \leq 0.01$ ) than growth rate in control foxes. In the fur growth period, an inverse dependence was indicated. Higher variation

in daily body weight gains was observed between females (28%) than between males (19%) of the compared groups. Average daily body weight gains of the whole population of foxes fed with rations with a high proportion of carbohydrates were lower by 23% ( $P \leq 0.01$ ) compared with the population of control foxes. Average daily body weight gains in foxes over the whole experimental period in the control and experimental group were comparable. The rate of fox growth between 18 and 29 weeks of age was lower than between 10 and 17 weeks of age, over twice as low in the group fed with a diet with approximately 20% proportion of energy from carbohydrates, and over 1.4-fold in the control group. Males were characterized by a slightly better production performance than females, however the occurring differences were not confirmed statistically.

## Discussion

An important aspect of nutrition of farmed fur-bearing carnivorous animals is an appropriate proportion of plant material in the diet which should oscillate from several to a dozen or so percent (LOREK et. al. 2002, GUGOLEK et. al. 2012). In our studies, the proportion of plant material in the component composition of diets was a factor varying fox nutrition, and depending on the nutrition period in the control group oscillated on the level of 11–12%, and in the experimental group on the level of 17 and 19.5%. Introducing a higher amount of plant components into the experimental diet than in the control diet, in the form of extruded ground grains (ground barley and ground wheat) and dried beet pulp, increased % proportion of EM from carbohydrates in the total energy value of rations from 12 to about 20%. From the available literature (ZAKRZEWSKA-CZARNOGÓRSKA and BRZOWSKI 2000, AHLSTRØM et al. 2003, LAERKE et al. 2004, GUGOLEK et al. 2007, GUGOLEK et. al. 2012, KORHONEN and NIEMELÄ 2014) it follows that the degree of plant feed utilization by carnivorous animals is diversified and depends, among other things, on carbohydrate groups occurring in them, on animal species and technological treatment before feeding. Among various carbohydrate groups, simple sugars and starch subjected to thermal treatment are the most bioavailable for carnivorous animals. Therefore, in breeding practice the most popular plant component of diets for fur-bearing carnivorous animals are extruded ground grains, mainly ground barley and ground wheat. The studies of KORHONEN and NIEMELÄ (2014) indicated that the process of extruding barley grain significantly increased digestibility of carbohydrates in diets of farmed minks and foxes, from 45–52% to 57–60% and 65–73%, respectively, with an approximately 16% proportion of this cereal in the ration structure. Moreover,

farm-raised foxes digested carbohydrates better than minks. ZAKRZEWSKA-CZARNOGÓRSKA and BRZOZOWSKI (2000) indicated a favorable effect of enzymatic preparations added to diets with a 21% proportion of ground grains on digestibility of nutrients in red foxes. The cited authors state that easily digestible and highly bioavailable feed guarantees good production performance in foxes, proper animal size and quality of their pelts. Introducing dried beet pulp into rations as an additional, apart from extruded ground grains, source of energy significantly increased body weight of arctic foxes at 17 weeks of age, however it did not vary the final body weight of animals compared with the foxes fed with a diet with a proportion of ground wheat and ground barley. It should be highlighted that average body weights of foxes both at 17 (6.18 and 8.07 kg) as well as at 29 weeks of age (15.67 and 16.20 kg) were higher compared with the results of research of other authors (LOREK et al. 2002, GUGOLEK et al. 2004, GUGOLEK et al. 2007, GUGOLEK et al. 2012, NOWICKI et al. 2013, PRZYSIECKI et al. 2013). GUGOLEK et al. (2007) and GUGOLEK et al. (2012) states that for arctic foxes raised under Polish production conditions, the final body weight oscillated on the level of 10–11.5 kg. In our studies, feeding with rations with plant carbohydrate feeds (ground grains and dried beet pulp) on the level of 17% favorably affected the total and daily body weight gains in foxes over the period of growth compared with the foxes fed with a diet with 11% proportion of carbohydrates. Inverse dependencies were observed in the fur growth period, in which experimental foxes were fed with rations with a proportion of carbohydrate feeds on the level of about 20%. It was indicated in author's research results that body weight gains in males between 10 and 17 weeks of age and between 18 and 29 weeks of age were higher than in females regardless of the type of diet. The research of PRZYSIECKI et al. (2013) indicated similar results. The analyzed production performance for the whole experimental period in both groups was similar but higher from 37 to 42%, compared with the results presented by PRZYSIECKI et al. (2010). Literature data state that carbohydrates contained in plant feeds not only provide animal body with energy but also affect physical and chemical properties and functioning of the digestive system (LOREK et al. 2001, LAERKE et al. 2004, GUGOLEK et al. 2012, KORHONER and NIEMELÄ 2014). LAERKE et al. (2004) indicated that diets with a proportion of beet pulp and corn starch on the level of 4.40 and 11.31%, respectively, increased minks' ability to fix water from the digesta, and decreased digestibility of nutrients compared with diets in which the source of carbohydrates were such cereal products as expanded wheat and oat flakes.

## Conculsion

The use of rations with an increased proportion of carbohydrates in arctic fox nutrition whose source were extruded ground grains and dried beet pulp, compared with the control group which was fed with a diet supplemented with only extruded ground grains:

- increased body weight of foxes at 17 weeks of age but did not vary this parameter in the period before slaughter;
- favorably affected total and daily body weight gains in foxes in the period of growth, however it decreased analyzed production indicators in foxes in the fur growth period;
- did not impact analyzed production parameters for the whole experimental period.

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