

# The effect of diets containing different levels of structural fibre on intestinal length, dry matter content of digesta, biochemical indices and electrolyte concentration in blood serum of geese (Part IV)

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## ABSTRACT

Two experiments were conducted in which White Italian geese were fed diets containing large proportions of ground cereals: maize, oats, barley or rye; dried grass, dried sugar beet pulp, field bean or pea as well as low-glucosinolate rapeseed oilmeal, from var. Jantar. The highest body weight gains were obtained when ground oats and rapeseed oilmeal were included in the diet, the lowest, when dried beet pulp and rye were given. Favourable growth parameters go together with higher dry matter content and pH of intestinal digesta. A diet of high proportion of oats and beet pulp lowered the serum cholesterol level in the geese, a diet with high proportion of rapeseed oilmeal lowered the level of inorganic phosphorus and potassium in blood serum of geese.

**KEY WORDS:** geese, fibre, intestine, electrolytes, lipids

## INTRODUCTION

This paper presents the last results of the two experiments in which growing geese were fed diets containing an increased level of structural fibre. In earlier studies (Jamroz et al., 1991; 1992a; Wilczkiewicz et al., 1987, 1989; Wilczkiewicz, 1991a, 1991b) it was found that the proportion of structural fibre and its physical properties have a qualitative and quantitative effect on changes in the composition of the intestinal content, digestibility of crude protein, crude fibre and its components, the weight gain of the birds, the feed intake and utilization, the changes in weight and length of the intestines, the thickness and relative

proportion of the particular layers of the small and large intestines, histological changes in the internal organs of the birds and the level of certain biochemical parameters determined in the internal organs and blood serum.

This part of the series presents the changes occurring in the concentration of mineral components in blood serum and in composition of the intestinal contents of geese fed diets containing various levels of crude fibre.

## MATERIAL AND METHODS

The following feeds were used in experiment 1: dried grass (27%), ground oats (65%), dried beet pulp (31%) and ground maize (50%). In experiment 2: ground barley (60%) and rye (50%), ground pea and field bean (20% each) and rapeseed oilmeal from var. Jantar (20%) were used. The experimental design, characteristic of animals, composition of the diets and methodology during slaughter were described in detail in part III of this series (Jamroz et al., 1992a). Because the degree of intestine filling 2 hours after feeding varied considerably (Wiliczekiewicz et al., 1989), the geese were slaughtered 1 or 2 hour after feeding. The contents of the small and large intestines were collected quantitatively and used to determine the dry matter content and pH. In experiment 1 in which diets varying in the quantity and quality of the crude fibre fractions were given, the lengths of the small and large intestines and appendix were measured before their contents were removed. The mean values for the groups from both measurement are given in the tables.

During the slaughter of the geese blood was sampled from the carotid artery. In experiment 1 triglyceride, cholesterol, low density (LDL) and high density (HDL) lipoprotein levels (Boehringer Mannheim GmbH chemotests) were determined as well as temperature-sensitive and insensitive lactate dehydrogenase activity (LDH) using the temperature test (Dixan, 1964). Due to technical considerations these tests were not carried out in experiment 2, in which the calcium level was determined in blood serum (using a colorimetric chemotest from POCh)\*, along with inorganic phosphorus by a photometric method and sodium and potassium contents (with a Plapho flame photometer). The results were subjected to statistical analysis using variance analysis with the significance of the difference among groups determined by the Duncan multiple range test.

## RESULTS

### Experiment 1

The concentration of crude fibre in the control diet and that containing 50% ground maize was approximately 3.4% and was almost half that in the diets containing dried grass, ground oats or dried beet pulp. In spite of this, the geese

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from the groups receiving diets containing more crude fibre consumed only slightly more feed (307-320 g) than the birds from the control group (300 g).

The feed utilization was similar in all of the experimental group (4.0-4.2 kg/kg gain), significantly worse ( $p < 0.05$ ) result (4.8 kg/kg gain) was observed only in group V fed a diet containing beet pulp.

The intestine length of 7-8 week-old geese differed depending on the type of diet and time after feeding (Table 1). The longest intestines per 1 kg body weight were found in geese fed a diet containing a high proportion of beet pulp, therefore of pectin and lignin. The length of the particular segments of the intestines was significantly higher ( $p < 0.01$ ) 1 hour (about 13-15%) than 2 hours after feeding.

TABLE 1  
Performance of geese from 3 to 11 week (Exp. 1)\*

Item		Feeding groups				
		I	II	III	IV	V
		control	maize	grass meal	oats	dried sugar beet pulp
Weight gain	g/day	74.2	73.7	72.1	79.6	64.2
Daily feed intake	g	300	307	305	320	309
Daily crude fibre intake	g	10.38 <sup>A</sup>	10.35 <sup>A</sup>	22.14 <sup>B</sup>	21.54 <sup>B</sup>	25.21 <sup>B</sup>
Feed/gain	kg/kg	4.04 <sup>a</sup>	4.16	4.23	4.02 <sup>a</sup>	4.81 <sup>b</sup>
Length of intestine (cm/kg of body weight)						
Small intestine		69.6 <sup>A</sup>	71.5 <sup>A</sup>	73.0 <sup>A</sup>	71.9 <sup>A</sup>	89.3 <sup>B</sup>
Large intestine		4.99	5.35	5.28	5.08	6.18
Caeca		16.4 <sup>A</sup>	16.3 <sup>A</sup>	17.8 <sup>A</sup>	17.8 <sup>A</sup>	23.6 <sup>B</sup>

\* Each value was the mean of 24 observations per diet

A,B =  $P < 0.01$

a,b =  $P < 0.05$

The amount of dry matter in the ileum and large intestine digesta of the geese in groups I, II and III was from 15 to 16.3% and was higher ( $p < 0.01$ ) than in the birds receiving dried beet pulp as their basic source of crude fibre (10.1%) but lower than in the birds which consumed large amounts of ground oats – 18.6% (Table 2).

The amount of fresh digesta in the ileum of birds consuming more crude fibre (groups III, IV and V) was significantly higher ( $p < 0.01$ ) than in the control and II groups. The amount of fresh digesta in the large intestine, regardless of the diet, was similar, with the exception of the birds receiving beet pulp, where it was four or five times higher (Table 2).

In the blood serum of birds fed diets with a high crude fibre content,

TABLE 2

Dry matter content in digesta (Exp. 1)

Item	Feeding groups				
	I	II	III	IV	V
	control	maize	grass meal	oats	dried sugar beet pulp
Dry matter content in digesta (%)					
- ileum	15.86 <sup>A</sup>	16.34 <sup>A</sup>	15.04 <sup>A</sup>	18.65 <sup>B</sup>	10.14 <sup>C</sup>
- large intestine	16.39 <sup>AC</sup>	16.97 <sup>AC</sup>	14.68 <sup>ABa</sup>	20.32 <sup>C</sup>	10.30 <sup>Bb</sup>
Total amount of fresh digesta (g)					
- ileum	33.2 <sup>aa</sup>	3.7 <sup>Aa</sup>	51.5 <sup>Ab</sup>	40.1 <sup>A</sup>	83.8 <sup>B</sup>
- large intestine	7.43 <sup>A</sup>	5.71 <sup>A</sup>	8.96 <sup>A</sup>	7.21 <sup>A</sup>	28.50 <sup>B</sup>

A,B,C = P&lt;0.01

a,b = P&lt;0.05

especially that from oats and beet pulp, a 10 to 18% lower triglyceride content was found along with lower cholesterol level, in comparison with the control and II groups. The highest lipoprotein contents, both of the high and low density fractions, were found in the serum of birds from group II - 0.92 mmol/l LDL and 1.86 mmol/l HDL while the lowest in groups V - 0.70 and 1.55 and IV - 0.70 mmol/l and 1.77 mmol/l, respectively.

Lactate dehydrogenase activity assayed in the temperature-sensitive and temperature-stable fractions of serum (Table 3) was highest in the group

TABLE 3

Biochemical indices of blood serum

Measurement	Feeding groups				
	I	II	III	IV	V
	control	maize	grass meal	oats	dried sugar beet pulp
Concentration (mmol/l)					
- Triglycerides	3.53	2.90	2.95	2.90	3.16
- Cholesterol	4.05	4.12	3.93	3.76	3.63
- Low density lipids	0.80	0.92	0.91	0.70	0.70
- High density lipids	1.74	1.86	1.75	1.77	1.55
Lactic dehydrogenase activity (nkat)					
- thermolabile fraction	915.0	1057.5	975.0	1132.5	776.3
- thermostatic fraction	285.7	367.5	352.5	412.5	341.2

receiving ground oats (1132 and 412 nkat) and lowest in geese from group V, fed the beet pulp-containing feed.

Higher values of the analysed serum parameters were found in the second hour after feeding than after one hour. These differences were found to be significant ( $p < 0.05$ ) only in the case of total lactate dehydrogenase activity.

## Experiment 2

The geese in all groups consumed similar amounts of feed (approximately 252 g/day), and because the diets had equal protein and energy contents, their crude protein and energy intakes were also equivalent (Table 4). Introduction of rye as a major component of the diet decreased feed utilization by 19% in comparison with the control group.

TABLE 4  
Performance of geese from 3 to 11 week (Exp. 2)

Item		Feeding groups					
		I control	II barley	III rye	IV field bean	V pea	VI rapeseed meal
Weight gain,	g/day	62.0	59.1	52.3	59.4	63.4	70.9
Daily feed intake,	g	251	256	251	251	253	251
Daily crude fibre intake	g	9.99 <sup>Aa</sup>	11.21 <sup>b</sup>	8.47 <sup>Aa</sup>	10.84	10.30	13.08 <sup>B</sup>
Feed/gain	kg/kg	3.85	3.77	4.57	4.01	3.56	3.35

A,B =  $P < 0.01$

a,b =  $P < 0.05$

The amount of fresh digesta in ileum was highest in the groups receiving field bean and pea, that is, feeds rich in beta-galactans. Feeding the birds diet with rye caused slight diarrhoea and digestive disorders, the ileum digesta of these birds had the lowest content of dry matter (13.8 vs. 17.2% in other groups).

The pH of the ileum digesta of geese from groups I, II and VI equalled, on average, 7.3 and was significantly ( $p < 0.01$ ) higher than the pH of ileum digesta of III, IV and V groups (6.9% average) (Table 5).

The blood serum calcium, inorganic phosphorus and sodium levels did not differ significantly among the experimental groups with the exception of the significantly lower potassium content in geese fed diets containing rapeseed meal. The time of slaughter of the geese (1 or 2 hour after feeding) did not affect the pH of the ileum digesta and serum electrolyte levels.

TABLE 5

Fresh and dry matter content and pH of digesta in ileum,  
electrolytes concentration in blood serum (Exp. 2)

Item	Feeding groups					
	I control	II barley	III rye	IV field bean	V pea	VI rapeseed meal
Total content of fresh ileum digesta (g)	32.8	3.6	3.8	39.7	35.7	3.1
Dry matter content in ileum digesta (%)	17.52 <sup>A</sup>	17.64 <sup>A</sup>	13.78 <sup>B</sup>	16.60 <sup>A</sup>	17.30 <sup>A</sup>	16.94 <sup>A</sup>
pH of ileum digesta	7.27 <sup>A</sup>	7.24 <sup>A</sup>	6.74 <sup>B</sup>	6.93 <sup>B</sup>	6.93 <sup>B</sup>	7.43 <sup>A</sup>
Electrolytes concentration in blood serum (mmol/l)						
Calcium	2.77	2.93	2.76	3.03	2.91	2.89
Inorganic phosphorus	2.29	2.27	2.26	2.19	2.14	2.04
Sodium	147.47	149.14	145.83	145.34	147.58	146.03
Potassium	6.01 <sup>a</sup>	6.67 <sup>ab</sup>	6.73 <sup>ab</sup>	6.87 <sup>Ab</sup>	6.19 <sup>a</sup>	5.71 <sup>Bb</sup>

A,B = P<0.01

a,b = P<0.05

## DISCUSSION

In both experiments, the weight gain and feed consumption were not strictly dependent on the amount of crude fibre and its components, mainly lignin and cellulose, which are considered to be factors lowering body weight gains and increasing feed intake. Although the geese fed a diet whose basic component was ground oats did consume a higher amount of structural fibre, including hemicellulose and cellulose than the birds in the control groups, they also had the highest daily weight gains and a similar or lower feed utilization. According to Salo and Kotilainen (1970), cellulose makes up about 31% of the structural fractions of oats and the proportion of lignin and gum-like substances is very low (below 5%). Ground oats is only slightly hydrophylic (Struthers, 1986; Wiliczkievicz, 1991a), which had an influence on the increase of dry matter content in the digesta.

In the serum of geese receiving ground oats a low level of triglycerides (2.9 mmol/l), cholesterol (3.7 mmol/l), and LDL (0.7 mmol/l) was observed while the HDL level was in the median range (1.8 mmol/l). Studies conducted by

several authors (Anderson et al., 1984; Mc Naughton, 1978; Weiss and Scott, 1979; Wiliczkiwicz et al., 1987) have indicated that humans and animals who consume large amounts of crude fibre show lower serum levels of parameters associated with lipid metabolism. Fibre affects the absorption of cholesterol, combines with bile acid salts, shortens the passage time of food through the digestive tract and accelerates steroids excretion.

The activity of temperature-stable and sensitive LDH, which catalyses anaerobic glycolysis, determined in blood serum of geese receiving the experimental diets varied. This would suggest that the particular fractions of crude fibre have an effect on carbohydrate metabolism. However, an unequivocal interpretation based on the results obtained in this study is difficult.

The geese receiving dried beet pulp in their diet, as in other studies (Jamroz et al., 1991; Wiliczkiwicz, 1991a), had a lower daily weight gain (64 g daily) and used more feed per kilogram body weight gain. This diet was characterised by a high proportion of structural components and, due to the high water absorption of beet pulp, caused a significant decrease ( $p < 0.01$ ) of the dry matter content in the digesta, but the highest degree of filling the intestine, both in terms of fresh as well as dry weight. This had a significant effect on increasing ( $p < 0.01$ ) the length of the intestine of the geese in this group in comparison with that of the remaining birds. The pectin contained in beet pulp (as well as in dried grass) have a distinct effect on the dry matter content of intestines, which has also been shown by other authors (Brown et al., 1979; Giger et al., 1987; Johnson et al., 1990; Struthers, 1986). The birds in the group fed dried beet pulp showed a somewhat higher level of triglyceride, cholesterol, LDL and HDL in comparison to the average values, found for the other groups fed diets containing an elevated level of crude fibre. The activity of both fractions of lactate dehydrogenase (1117 nkat/l) was the lowest in comparison to all of the other groups.

In the diets given in experiment 2, the differences in the content of structural elements among the experimental groups were smaller. The greatest body weights and the lowest intake of feed were found in the geese fed a diet containing rapeseed meal, in spite of the higher cellulose and lignin content of this diet. Such an effect can to a certain extent be explained by the better balance of sulphur-containing amino acids in the rapeseed meal. In the blood serum of geese from the group fed the rich in fibre rapeseed meal diet somewhat lower inorganic phosphorus and potassium level was found. However, Jamroz et al. (1992b) found a slight increase in the calcium and inorganic phosphorus level in the serum of broiler chicks fed diets rich in crude fibre.

The poorest daily weight gain and feed utilization were observed in geese fed a diet containing 50% ground rye. An evident drop was found in dry matter concentration and pH of ileum digesta. The pentosanes and betaglacans

contained in rye disturb the water metabolism in intestines, accelerate the passage of digesta through the digestive tract and impede the absorption of nutrients and minerals (Annisson and Choct, 1991; Grammer et al., 1983; Wassink et al., 1989; Živković and Bowland, 1970). The serum of geese fed ground rye contained somewhat less calcium and sodium than that of birds in the remaining groups.

The time (1, 2 h) elapsing from feed intake to when the measurements were carried out caused changes in certain parameters. Two hours after feeding the intestine length increased by 13-15%, the dry matter content of the large intestine increased by 11%, the serum triglyceride and cholesterol contents rose by 4-8%, whereas the serum electrolyte level was found to be stable.

#### CONCLUSIONS

1. The body weight gains of young geese fed diets rich in fibre depend to a greater extent on the chemical composition of these fibre than on its amount determined as crude fibre. The geese receiving diets containing ground oats (65%) and rape seed (20%) grew the best, while those fed ground rye (50%) and beet pulp (31%) the worst.

2. Feeding geese dried sugar beet pulp, a feed with a high water-binding capacity, caused an increase in the length of the studied segments of the intestine ( $p < 0.01$ ) and a decrease ( $p < 0.05$ ) in the amount of dry matter in the digesta.

3. A decrease in the serum cholesterol level was observed in those birds which were fed diets containing beet pulp and oats.

4. The ileum digesta of the birds fed a diet with a high proportion of rye (50%) contained significantly less dry matter ( $p < 0.01$ ) and had lower pH.

5. In spite of the differences in the diets, the serum calcium, inorganic phosphorus, sodium and potassium levels were found to be stable, only in the serum of birds fed a diet containing rapeseed oilmeal the lower potassium level were found.

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## STRESZCZENIE

**Wpływ dawek o różnej zawartości substancji strukturalnych na długość jelita, zawartość suchej masy w treści jelitowej, wskaźniki biochemiczne i stężenie elektrolitów w surowicy krwi gęsi**

Przeprowadzono dwa doświadczenia na gąsiątach rasy Biała Włoska w wieku 3-11 tygodni. W doświadczeniu 1 (150 ptaków) dawki zawierały: 50% śruty kukurydzianej, 20% suszu z traw, 65% śruty owsianej lub 31% suszonych wysłodków buraczanych; w doświadczeniu 2 (120 gąsiąt): 60% śruty jęczmiennej, 50% żytniej lub po 20% śruty z bobiku, grochu lub poekstrakcyjnej śruty rzepakowej 00. Największe przyrosty masy ciała otrzymano przy skarmianiu śruty owsianej i śruty rzepakowej, najniższe – suszonych wysłodków buraczanych lub żyta. U ptaków o lepszych

