Influence of feeding diets with barley or oat to growing geese on performance, digestibility of nutrients and concentration of VLDL, triglyceride and cholesterol in blood plasma

Einfluß verschiedener Futterrationen auf Basis von Wintergerste und Hafer auf die Leistung, auf die Verdaulichkeit der organischen Substanz und auf die Gehalte an VLDL-Lipoproteinen, Triglyceriden und Cholesterol im Blutplasma von Junggänsern

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Introduction

In recent years, the nutritional role of non starch polysaccharides (NSP) in monogastric diets has been described. It is obvious that there is a considerable difference in cereals (barley, wheat, oat) between gross and metabolisable energy and the presence of arabinoxylans and β-glucans in oat and barley have been associated with this difference (AMAN 1987, KNUDSEN and HANSEN 1991, KNUDSEN et al. 1993a). NSP are responsible for increasing the viscosity of the gut contents (WHITE et al. 1981, BROZ 1993) and make nutrients, like starch and proteins, less available for digestion (KNUDSEN et al. 1993b) which reduces their utilisation and the growth rate (JEROCH and DÄNlCKE 1995).

It is well known that some dietary fibers have cholesterol lowering effect, guar gum, pectin and barley have repeatedly been shown to reduce plasma cholesterol concentration (WANG et al. 1992, MARTINEZ et al. 1992). ILMAN et al. 1991, JONNALAGANDA et al. 1993 found hypcholesterolemic effect of oat bran in rats and hamsters. By contrast, we did not find such effect of barley based diets in table ducks (VETESI et al. 1996).

There are several hypotheses explaining the cholesterol lowering effect of fibers. GALLAHER et al. 1993 found that the greater viscosity of intestinal content is strongly associated with cholesterol reduction. In addition to the direct effect of viscous NSPs there are some indirect effects, which have influence on lipid metabolism. One such effect may be the propionic acid, as one of the products of the fiber fermentation in the gut, and it could reduce the cholesterol synthesis in the liver (ANDERSON and CHEI 1979). On the other hand the NSPs with viscous properties cause a depressed fat emulsification or micelle formation by reduced mucosal uptake of lipids and by increased amount of unabsorbed endogenous fat in the chyme (SMITS and ANNISON 1996).

At the same time the results of IKEDA et al. 1989 showed that the type of dietary fat has significant influence on the effect of dietary fibers on lipid metabolism.

Owing to the complexity of these processes the importance of the different factors may depend on the experimental species and nutrition.

The objective of present study was to investigate the effects of barley and oat based diets on performance, carcass yield and some parameters of lipid metabolism of young geese.

Materials and methods

Experimental animals: Landes breed geese, in a sex ratio of 1:1, with 32 birds/group in two replicates of each group. Pelleted starter diet to 21th day of age, grower diet from 22th to 35th day of age and finisher diet from 36th to 55th day of age were fed (Table 1).

Feeding regime:
1. control (without barley or oat)
2. 45% barley in the diet (isoenergetic and isonitrogenous)
3. 45% oat in the diet (isoenergetic and isonitrogenous)

Feed intake of groups was measured daily and individual live weight was measured weekly. At the last day of experiment 12 randomly selected birds from each group were slaughtered, carcass yield and abdominal fat as well as liver weight were measured gravimetrically.

Investigation on digestibility of nutrients

The measured parameters included: crude protein, crude fat, nitrogen-free extract, crude fiber using the method according to the Hungarian National Standard (1994). The amount of total dietary fiber (TDF), the soluble and insoluble NSPs were determined by the method as was proposed by AOAC (985.29/1990) using enzymatic-gravimetric kit (Sigma, St. Louis).

Eight weeks old geese were kept in individual cages (6 repetitions). Excreta were collected after five days adaptation period during the main period, which lasted for 6 days.

Investigation on some lipid-parameters of blood plasma

Blood samples were taken from 10 randomly selected geese/group at 21th, 35th, and 55th day of age, respectively.
Table 1. Composition (% of diet) and nutrient content

| Table 2. Effects of feeding barley and oat on digestibility of nutrient Einfluß der Fütterung von Gerste und Hafer auf die Verdaulichkeit der Nährstoffe |
|------------------|------------------|------------------|
| Nutrient         | Control (n = 6)  | 45% barley (n = 6) | 45% oat (n = 6) |
| Organic matter, % | 79 ± 2.7 76 ± 2.3 ns | 74 ± 2.1* |
| Crude protein, % | 72 ± 3.4 72 ± 4.4 ns | 73 ± 2.7 ns |
| Crude fat, %     | 88 ± 1.4 88 ± 2.3 ns | 91 ± 1.4 ns |
| Nitrogen-free extract, % | 86 ± 1.8 | 84 ± 1.5 ns | 82 ± 1.5* |
| Crude fiber, %   | 11 ± 10.9 23 ± 9.1 ns | 12 ± 6.3 ns |
| TDF1, %          | 19 ± 3.8 35 ± 9.0 ns | 22 ± 4.4 ns |
| Soluble NSP, %   | 79 ± 3.8 88 ± 4.6* | 49 ± 4.4** |
| Insoluble NSP, % | 8 ± 3.1 20 ± 10.3 ns | 19 ± 4.4 ns |

1 = Total Dietary Fiber
* = significant difference compared to control (P < 0.05)
** = significant difference compared to control (P < 0.01)

The cholesterol and triglyceride (TG) content of plasma were determined with enzymatic methods using commercial kits (Clinisotest, Institute of Isotopes Ltd., Budapest). The VLDL level was measured using precipitating turbidimetric assay of GRIFFIN and WHITEHEAD 1982 as was validated for waterfowl (MEZES et al. 1995).

All results are the means ± SEM of measurements. Statistical analysis was performed by Student’s paired t-test.

Results and discussion

Investigation on digestibility of nutrients

In the case of 8 weeks old geese, feeding 45% oat in the diet decreased the apparent digestibility of organic matter and nitrogen-free extract. In this experiment we did not find depression in digestibility of crude protein, and fat as generally written in literature (WANG et al. 1992, KNUDSEN et al. 1993b). The possible reason of this result could be the age of investigated geese: the birds were 8 weeks of age and by that age they have been probably adapted to the high NSPs containing diet. The apparent digestibility of structural fiber was higher (8% vs. 19%) in the oat fed birds, than the control. The apparent digestibility of soluble NSP was lower, than the control (79% vs. 49%), therefore the apparent digestibility of crude fiber and total dietary fiber were similar to control (Table 2).

45% barley in the feed did not modify considerably the apparent digestibility of each organic matter except the fiber materials. The apparent digestibility of crude fiber, total dietary fiber, soluble and insoluble NSPs tendentiously increased as compared to control (Table 2).

The difference of apparent digestibility of crude fiber, total dietary fiber, soluble and structural NSPs among the groups is due to several reasons. The fiber content and composition of the corn, barley and oat is different for that
found that the broiler chickens finishing weight (control: 4181 g, barley fed: 3953 g). Similarly, and 1310 g) and the rate of rapid growth within the last young age (1-21 day: 1262 g weight gain in the control
similar to us (1999) have found that barley in the diet caused increased count of micro-organism in different parts of the intestine in broiler chickens. The increase in the amount of micro-organism produce higher fermentation activity, therefore digestibility of fiber is changing as an effect of NSPs rich diet. However, it should be necessary to investigate other parameters – e.g. the amount of VFAs as fermentation products – in younger birds, which play a part in the fiber degradation to describe this digestive process.

### Performance traits

Feeding 45% oat in the diet had an anti-nutritive effect on performance in geese. The soluble NSPs enriched diet decreased the growth rate in young birds in the first 5 weeks: average weight gain 1–21st day 1262 g in the control and 1250 g in the oat fed groups, 22–35th day of age: 1428 g and 1358 g. It was followed by rapid growth so the finishing weight was similar to the control in the case of oat based diet (4081 g and 4125 g). The feed intake of oat fed birds was higher, than controls and this resulted in a significant increase in FCR (1–21 days: 1.52 kg and 1.65 kg; 22–35 days: 2.27 kg and 2.63 kg).

Using oat hull in the broiler diet SVIHUS and HETLAND (1999) showed comparable findings to these results. Similarly to the findings of BEDFORD and SHEPPY 1995, not weight gain, but the FCR was found to be the more sensitive indicator of the anti-nutritive effect of oat (Table 3). The 45% barley content diet caused large reduction in young age (1–21st day: 1262 g weight gain in the control and 1150 g in the barley fed groups; 22–35th day: 1428 g and 1310 g) and the rate of rapid growth within the last three weeks of growing was not enough to reach the control finishing weight (control: 4181 g, barley fed: 3953 g). Similarly to us JEROCH et al. (1993) and PHILIP et al. (1995) found that the broiler chickens in the first few weeks of life were more sensitive for dietary barley, than later.

| Table 3. Effects of feeding barley and oat on performance traits in geese
| Einfluß der Fütterung von Gerste und Hafer auf die Leistung der Gänse |
|---------------------------------|---------------------|---------------------|
|                                | Control             | 45% barley          | 45% oat             |
| Finishing weight (g)           | 4,177 ± 397         | 3,950 ± 264         | 4,250 ± 387         |
| Average weight gain, g         |                     |                     |
| 1–21 day                       | 1,262 ± 113b        | 1,150 ± 145.7ac    | 1,250 ± 1310b       |
| 22–35 day                      | 1,428 ± 127.6b      | 1,310 ± 89.1ab     | 1,358 ± 165.6ns     |
| 36–55 day                      | 1,391 ± 132.2b      | 1,393 ± 93.1c      | 1,547 ± 170.1b      |
| Cumulative weight gain, g      | 4,081 ± 387.8b      | 3,853 ± 257.5ac    | 4,125 ± 375.6b      |
| Average daily feed intake, g   |                     |                     |
| 1–21 day                       | 91                  | 90                  | 92                  |
| 22–35 day                      | 232                 | 246                 | 269                 |
| 36–55 day                      | 281                 | 275                 | 316                 |
| Cumulative daily feed intake, g| 195                 | 197                 | 212                 |
| FCR, kg/kg                     |                     |                     |
| 1–21 day                       | 1.52                | 1.65                | 1.55                |
| 22–35 day                      | 2.27                | 2.63                | 2.77                |
| 36–55 day                      | 4.03                | 3.95                | 4.08                |
| Cumulative FCR, kg/kg          | 2.62                | 2.80                | 2.80                |

Table 4. Effects of feeding barley and oat on slaughter yield of geese
Einfluß der Fütterung von Gerste und Hafer auf die Schlachtleistung der Gänse

<table>
<thead>
<tr>
<th></th>
<th>Control (n = 12)</th>
<th>45% barley (n = 12)</th>
<th>45% oat (n = 12)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carcass yield, %</td>
<td>59.80</td>
<td>58.55</td>
<td>57.30</td>
</tr>
<tr>
<td>Abdominal fat, g</td>
<td>144 ± 38.0</td>
<td>160 ± 27.0</td>
<td>158 ± 45.0</td>
</tr>
<tr>
<td>Abdominal fat, %</td>
<td>3.42</td>
<td>3.92</td>
<td>3.76</td>
</tr>
<tr>
<td>Liver weight, g</td>
<td>114 ± 20.0</td>
<td>105 ± 7.5</td>
<td>113 ± 11.8</td>
</tr>
<tr>
<td>Liver weight, %</td>
<td>2.71</td>
<td>2.61</td>
<td>2.69</td>
</tr>
</tbody>
</table>

The cumulative daily feed intake (197 g) was the same, as the control (195 g). The feed conversion efficiency was worse in this group (1–21 day: 1.65 kg 22–35 day: 2.63 kg), than the control (1.52 kg and 2.27 kg) as consequence of the lower weight gain and higher feed intake. The cumulative feed conversion efficiency was the same as the oat-group and higher as the control: 2.62 kg, barley or oat fed: 2.80 kg (Table 3).

The feeding of 45% oat and 45% barley in diet had no considerable influence on carcass yield and liver weight, but (not significantly) increased the abdominal fat content (control 3.42%, barley fed: 3.92%, oat fed: 3.76%), probably owing to the rapid growth (Table 4).

The results suggest that the lower density of feed due to the higher fiber content causes higher rate of lipid transport and more effective fat deposition during the late phase of fattening. The same effect of restricted feeding on fat deposition was found in a previous experiment with broiler chicken (WISEMAN, 1988). That phenomenon can be explained with the compensatory growth effect, which causes primarily not protein, but fat deposition during the late phase of fattening.

### Investigation on some lipid-parameters of blood plasma

The age and the NSPs enriched diet have influence on lipid parameters as was measured: There was significantly lower VLDL level of blood plasma in 45% barley fed birds on the 21st day of age, than in the control group.
Conclusions

Feeding 45% oat, even in an isoenergetic and isonitrogenous diet, has anti-nutritive effect in young geese. It manifested in increased feed intake of oat-fed birds, and feed conversion ratio was found a more sensitive indicator, than growth depression. The growth depression of animals manifested within the first 5 weeks of growing which was followed by intensive (compensatory) growth.

Feeding 45% barley also has anti-nutritive effect in young geese, which appears in large reduction in growing within the first few weeks followed by rapid growth. Age and soluble NSPs enriched diet, barley based diet, have influence on measured lipid parameters, decreased VLDL and triglycerides level in blood plasma, which were related to the growth depression in the early weeks of life.

It was found that geese are more sensitive to the dietary barley or oat in the first 5 weeks of age, than later and the birds can adapt to the high NSP diets.

The NSPs enriched barley and oat have cholesterol-lowering effect in the blood plasma on the 55th day in geese.

Summary

Feeding trial was carried out to investigate the effect of feeding 45% barley and 45% oat in young geese diet on the digestibility of nutrients, performance, carcass yield, abdominal fat content and liver weight. Total cholesterol, triglycerides (TG) and very low density lipoproteins (VLDL) level in the blood plasma were also measured.

In the case of 8 weeks old geese, feeding 45% barley or oat in the diet the apparent digestibility of organic matter and nitrogen-free extract were decreased, but depression was not found in the digestibility of crude protein and fat. It was found that the live weight was moderately lower in groups fed 45% barley or oat during the first 5 weeks of age than the control. The feed intake and FCR increased, but within the last phase of raising the birds exhibited a more rapid growth rate. These findings could reflect the fact that the birds can adapt to the high NSPs diets. The weight of abdominal fat was moderately higher in barley or oat fed geese, than in control birds related to the rapid growth within the last 3 weeks. The cholesterol content of blood plasma was lower at the end of the investigation in barley and oat based diet fed birds.

Keywords

Geese, barley, oat, NSP, lipid transport

Zusammenfassung

Einfluß verschiedener Futterrationen auf Basis von Wintergerste und Hafer auf die Leistung, auf die Verdauung der organischen Substanz und auf die Gehalte an VLDL-Lipoproteinen, Triglyzeriden und Cholesterol im Blutplasma von Junggänsern

In der vorliegenden Untersuchung wurde der Einfluß verschiedener Futterrationen, die entweder 45% Wintergerste oder 45% Hafer enthielten, auf die Leistung der Junggänse, auf die Verdauung der organischen Substanz sowie auf die Schlachtausbeute, die Abdominalfettmenge und das Lebewicht überprüft. Ferner wurden im Blutplasma die Gehalte an Triglyzeriden, Gesamt-Cholesterin und VLDL-Lipoproteinen bestimmt.
Bei acht Wochen alten Gänsern führte die Fütterung von Ratio-
nen mit 45% Wintergerste oder 45% Hafer zu einer Verschlechte-
rung der scheinbaren Verdauungskapazität der organischen Sub-
stanz und der Stickstoff-freien Extrakstoffe (NIE). Demgegenüber
waren die Verdauungskapazität von Rohprotein und Fett nicht verän-
dernd. Das Lebendgewicht war in den ersten 5 Lebenswochen bei den Gän-
sen, die 45% Wintergerste oder Hafer erhielten, etwas geringer als in der Kontrollgruppe. Die Futteraufnahme und die Futterver-
wertung (FCR) nahmen zu. Während der letzten Phase der Auf-
zung zeigten die Tiere aber dann ein stärkeres Wachstum. Die
Ergebnisse deuten darauf hin, dass die Tiere sich an die hohen
Gehalte an NSP in den Rationen anpassen können. Der Abdomi-
nalfettgehalt war bei den Tieren, die Wintergerste oder Hafer er-
hielten, etwas höher als bei den Kontrolltieren, was auf das stär­
kere Wachstum in den letzten drei Mastwochen zurück zu führen
ist. Der Plasma-Cholesterinspiegel war bei Fütterung von Winter-
gerste oder Hafer am Ende der Untersuchung niedriger als in der
Kontrollgruppe.

Stichworte
Gänse, Gerste, Hafer, NSP, Lipidtransport

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