# NUTRIENT DIGESTIBILITY OF WHEAT IN RATS AND CHICKENS DEPENDING ON THE RYE 1B/1R TRANSLOCATION OF WHEAT VARIETIES*

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A major part of wheat production is channelized towards animal feed. In the present experiment, we first aimed to determine the relationship of the crude protein (CP) content and the individual fractions (albumin + globulin, gliadin, glutenin) of wheat varieties (with or without the rye translocation 1B/1R) with the digestibility, feed intake, feed conversion, and protein efficiency ratio (PER) of the feed in ROSS 308 chicken broilers. Secondly, we determined the CP content, biological value, net protein utilization, and effect of various fibre components of the same wheat lines in Wistar rats. Seven out of sixteen wheat varieties studied herein included the 1B/1R translocation. Nutritional values were evaluated by the Weende analysis using the Kjeldahl and the Henneberg–Stohmann methods. Moreover, acid detergent fibre and neutral detergent fibre contents, CP digestibility and PER were determined. In broiler chickens, no statistically significant differences were found. In rats, however, the presence of 1B/1R significantly increased the CP content, affecting the nutritional value. This should be considered prior to the indiscriminate use of otherwise undesirable wheat varieties as animal feed.

animal nutrition, crude protein, crude fibre, rye translocation, protein quality

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## INTRODUCTION

The global production of wheat is over 600 million tons, nearly 17% of which is used for animal nutrition (R o s e , 2003). A majority of the total wheat production in the Czech Republic (5426.9 thousand tons in 2016) is used in animal feed, even though the primary purpose is for the bakery industry (S Z I F , 2016).

Studies on the genetic background of wheat in relation to feed quality often include the effect of the 1B/1R rye translocation (RT), but variable results have been obtained (R o s e , 2003; W i s e m a n , 2006). The reason for this focus is the widespread existence of cultivated wheat varieties carrying this translocation (A m i o u r et al., 2002). Owing to their low suitability for preparing bakery, pasta, or other food items, varieties with this translocation are often used for animal feed purposes, regardless of their appropriateness for this application. From the current assortment of 70 wheat varieties registered in the Czech Republic, ten varieties have the 1B/1R translocation. Of these, nine are completely unsuitable for bakery purposes, and they are often used as animal feed.

The fact that nearly two thirds of wheat production is used for animal feed suggests the need for developing and growing wheat varieties with a high feeding quality. However, currently, there are no clear criteria for breeding and cultivating wheat varieties specifi-

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cally for these purposes. Systematic evaluation of the effect of varieties for specific nutritional values is complicated owing to numerous external and internal (genetic) factors. In addition to marked influences of external factors such as seasonal variations, as well as physicochemical properties of the grain (Svihus, Gullord, 2002; Wiseman, 2006), there are also problems in the proper nutritional evaluation of wheat grain as feed (Carre et al., 2007) for livestock, which have species-specific or growth stage-specific requirements. A major reason for the poor prediction of relationships of components and properties of the grain is the considerable variability in experimental animals used in feeding experiments. The effects of wheat have been studied at the level of the total feed mixture and for linkages to the individual components. Research on chickens suggests a large influence of genetic origin (breed) with different nutrient utilization patterns (Carre et al., 2007).

Wheat grain as a component of feed mixtures is primarily a source of energy. In commercial feed mixtures, wheat accounts for approximately 70% of the metabolisable energy (ME) content but only 40% of the digestible protein. The protein efficiency ratio (PER) of compound feeds is mainly affected by the presence of gross protein and energy. Therefore, in feeding assays, wheat is primarily considered a source of apparent metabolisable energy (AME), linked to wheat starch, fat, and protein contents (Hew et al., 1998). Significant inter-varietal differences in AME have been reported in a wide range of Australian, North American, and European cultivars of wheat (Mollah et al., 1983; Rogel et al., 1987; Wiseman, Blanch, 1994). As a result of the similar *in vitro* digestibility of starch isolated from cultivars with different AME values, several other 'antinutritional' components might be affecting the feed value of wheat grain (Rogel et al., 1987). Wheat protein is generally considered to be of low value owing to a poor representation of essential amino acids, which is profoundly influenced by external conditions (Henry, Kettlewell, 1996; Bedford et al., 2003; Oury et al., 2006). Svihus, Gullord (2002) confirmed the significantly negative effect of protein content on ME and found that high protein content was positively related to improved weight gain in chickens. The profile of wheat protein fractions (albumins, globulins, gliadins, and glutenins) with different proportions of essential amino acids might also be an important factor affecting the nutritional quality of wheat grain (Wiseman, 2006).

In the present study, we first aimed to determine the relationship of the crude protein (CP) content and the individual protein fractions (albumin + globulin, gliadin, glutenin) with the digestibility, feed intake, and conversion of the feed in chicken broilers. Second, in rats, we aimed to determine the PER of wheat cultivars (with or without RT 1B/1R) in feed and the interaction among the grain parameters.

## MATERIAL AND METHODS

### Wheat varieties

In this two-year experiment (harvests in 2015 and 2016), totally 16 varieties were used. Fourteen winter wheat lines with different baking qualities were used, of which seven lines contained the 1B/1R RT. In addition, two contrasting waxy wheat varieties without RT, winter Waximum and spring Waxypen, with minimal amylose content, were also included. These varieties were deliberately chosen because of their poor baking quality and possible use as animal feed.

Prior to feeding, the wheat kernels were pulverised. The experimental diet comprised wheat (99%) and chromium oxide supplement (1%; an exoindicator for determining the digestibility).

### Rats

Specific pathogen-free male laboratory rats (*Rattus norvegicus*) of the outbred race Wistar housed individually in balance cages were included in the four-week experiment. Ninety-six rats (age 21 days, initial mean body weight 65.0 ± 0.8 g) were divided into sixteen groups per three animals in two replicates. Each of the 16 wheat varieties was tested four times, using the Latin square method.

Balance experiments with isonitrogenous and isoenergetic diets based on the tested wheat varieties were performed. To supplement the missing nutrients within the nutritional standard needs of other components, sucrose, rapeseed oil, and vitamin-mineral premix free from synthetic amino acids were added. To avoid overestimating the energy intake from starch, pure polyethylene powder was used as a ballast.

The rats were fed *ad libitum* for 7 days; 3 days were for the acclimatisation to the experimental conditions, and 4 days were for balance. During the experiment, faeces were collected for analysis in a reference laboratory.

The following grain parameters were tested by chemical analysis: crude protein (CP) content by the Kjeldahl method (Czech standard ČSN 56 0512-12); crude fibre (CF) content by two-stage alkaline and acidic hydrolysis using an ANKOM Technology method (Macedon, USA), and acid detergent fibre (ADF) content and neutral detergent fibre (NDF) content, all by Weende analysis (Commission Regulation (EC) No 152/2009).

### Broiler chickens

For the balance experiment, 22 ROSS 308 broiler cockerels (35-days-old, initial mean weight 2.45 ± 0.20 kg) housed in two-piece balance cages were used. The cockerels were divided into two groups: the first of 10 cockerels fed wheat varieties with the

RT, and the second of 12 cockerels fed wheat varieties lacking the RT. During the acclimatisation period of 3 days, the animals became accustomed to the new environment and feed. The feed comprised only wheat grain (99%) and chromium oxide (1%). Cockerels had *ad libitum* access to feed and water. After 7 days of the balance experiment, the chickens were slaughtered, and the ilea were removed. Samples of both animals from the same cage were mixed. The ileum contents were lyophilized. Dry matter (DM) content was determined at 103°C, and nitrogen content was assessed according to Kjeldahl method (Czech standard ČSN 56 0512-12). Chromium oxide iodometry was performed to determine sodium thiosulphate.

The CP digestibility was calculated from the measured values converted to 100% DM according to the following formula:
Digestible CP (%) = 100 – (ifeed × nfaeces)/(ifaeces × nfeed) 56 0512-12
where:
ifeed = indicator in the feed
nfaeces = nutrients in the faeces
ifaeces = indicator in the faeces
nfeed = nutrients in the feed
PER was calculated from the observed values converted using the following formula:
PER = weight gain/CP intake
Conversion of feed was calculated for the period between days 28–35 of fattening according to the following formula:
Feed conversion = feed intake/weight gain

**Statistical analysis**

The results were evaluated using the statistical package STATISTICA, Version 12. Significance ($P \leq 0.05$) of evaluated factors (genotype, year, and RT) and differences among grain parameters of double haploid (DH) lines were tested by ANOVA/MANOVA with Tukey's HSD test.

## RESULTS

No statistically significant differences in broiler chickens for various nutritional parameters in terms of wheat type were found. However, in rats, the presence of the 1B/1R RT significantly increased the CP content. The growth years and individual physicochemical properties of the grain were found to markedly influence the feed quality parameters studied herein. The inclusion of wheat lines carrying the 1B/1R RT in the feed increased rat body weight. However, compared to the difference between the individual lines for the evaluated years, this effect was significantly lower. Therefore, the mere presence of the RT in wheat does not indicate high feed quality for poultry, and the indiscriminate use of such varieties for feeding purposes might not always be effective.

Table 1. Differences in nutritional parameters of wheat in rats (values are means ± standard deviations)

| Type of wheat (%) | With RT ($n$ = 10) | Without RT ($n$ = 12) |
|---|---|---|
| CFD | 35.96 ± 0.63* | 32.46 ± 0.56* |
| NDFD | 45.26 ± 0.46 | 42.26 ± 0.51 |
| ADFD | 38.63 ± 0.52* | 35.02 ± 0.45* |
| BV | 70.15 ± 1.40 | 68.67 ± 1.08 |
| NPU | 62.74 ± 1.62 | 61.91 ± 1.26 |

RT = rye translocation, CFD = crude fibre digestibility, NDFD = neutral detergent fibre digestibility, ADFD = acid detergent fibre digestibility, BV = biological value, NPU = net protein utilization

*$P \leq 0.05$

**Rats**

As seen in Table 1, significant differences in the digestibility of CF and ADF were found for the RT. Significant differences were also found in biological value (BV), net protein utilization (NPU), and NDF for year of harvest.

CF digestibility of RT-bearing wheat was 35.96%, which was 3% higher than the digestibility of wheat without this translocation (32.46%). Samples with the RT also showed significantly higher ADF digestibility (38.63%) than samples without the RT (35.02%). However, the NDF content (with RT: 45.26%; without RT: 42.26%), BV (with RT: 70.15%; without RT: 68.67%), and NPU (with RT: 62.74%; without RT: 61.91%) showed no statistically significant differences ($P > 0.05$).

**Broiler chickens**

The results in Table 2 show the specific values from the experimental observations. The differences in CP, albumin + globulin, gliadin, glutenin, digestibility of CP, feed intake, feed conversion, and PER values were not significantly different for the wheat variety used.

## DISCUSSION

The objective of our experiments was to determine the possible relationship of the 1B/1R RT with the nutritional value of wheat grains, and possibly, the dietary value of such varieties in rats and chickens. According to the literature, we considered that the individual CP fractions would also be different, which would have implications in improving the nutrient utilization and PER of the feed used. This difference is not significant, but we hypothesised that wheat with RT might have higher nutritional and production value.

Table 2. Differences in nutritional parameters of wheat in broiler chickens (values are means ± standard deviation)

| Type of wheat | With RT ($n$ = 10) | Without RT ($n$ = 12) |
|---|---|---|
| CP (%) | 14.51 ± 0.23 | 13.54 ± 0.35 |
| Albumin + globulin from CP (%) | 26.25 ± 0.27 | 24.65 ± 0.12 |
| Gliadin from CP (%) | 30.89 ± 0.28 | 30.80 ± 0.38 |
| Glutenin from CP (%) | 42.86 ± 0.16 | 44.60 ± 0.47 |
| Digestibility of CP (%) | 65.98 ± 0.64 | 68.07 ± 0.19 |
| Intake of feed (g) | 133.9 ± 1.29 | 133.7 ± 1.35 |
| Conversion of feed (kg) | 1.81 ± 0.04 | 1.84 ± 0.02 |
| PER | 2.70 ± 0.04 | 2.68 ± 0.06 |

RT = rye translocation, CP = crude protein, PER = protein efficiency ratio

*$P \leq 0.05$

This hypothesis was confirmed for some parameters in rats but not in chickens.

Carre et al. (2007) encountered many problems in defining the key features of feed-grade wheat applicable to breeding, such as the primary variability and interaction of individual grain components, species specificity of livestock intrinsic variability, or even heritability (Carre et al., 2007). The digestibility of wheat starch is high, but it can vary significantly in different wheat samples (82–99%) (Carre et al., 2002). Fluctuations in ME in different wheat varieties (15.5–16.1 MJ per kg grain DM) have also been shown in pig fattening (Rosenfelder et al., 2013). Several authors have confirmed that the nutritional value of wheat for poultry may vary considerably (Mollah et al., 1983; McCracken, Quintin, 2000; Ball et al., 2013). Therefore, it is not possible to state conclusively that wheat with RT is superior for poultry nutrition.

The difference between the CP values of the wheats with and without RT was not statistically significant. The presence of gliadin did not vary significantly (30.89% and 30.80%). Wheat with RT showed lower CP digestibility (65.98% vs 68.07%). These results indicate that the RT did not show a positive effect on the nutritional value; instead, it showed a 3.07% lower value. Similar results were also obtained when evaluating the PER. With nearly the same feed intake, i.e. 133.9 and 133.7 g per day of wheat with and without the RT, respectively, feed conversion values of 1.82 and 1.84 were obtained, respectively. Finally, the PER of the feed was 2.70 for wheat with the RT and 2.68 for wheat without the RT.

The evaluated grain characteristics of DH wheat lines corresponded with our previous published results on wheat materials with the 1B/1R translocation (Dvoracek et al., 2006, 2008). Most of the tested parameters show significant differences between years, which might be caused by meteorological conditions such as temperature or precipitations. There were no significant differences between the temperatures in the growing periods (9/2014–7/2015: 8.45°C; 9/2015–7/2016: 8.37°C; ČHMÚ, 2018a), but the differences between precipitations were significantly higher for harvest of the year 2016 (9/2014–7/2015: 493 mm; 9/2015–7/2016: 605 mm; ČHMÚ, 2018b).

Our results in the rat experiment are unique because there have been no feed tests for wheat with or without the RT using rats thus far, and we obtained interesting insights into differences between wheat lines in terms of the RT. Performing these tests in rats is crucial because they are common animal models used in metabolic and nutritional studies.

## CONCLUSION

In conclusion, our results showed no significant differences in nutrition values of wheat with 1B/1R RT in chicken. However, our results showed a significant increase of CP and ADF content in the wheat with 1B/1R RT in rats. In rats, other nutritional values (BV, NPU and NDF) showed significant differences but depending on year of harvest. To our knowledge this is the first project focused on nutritional value of wheat with and without 1B/1R RT in rats. To evaluate the role of meteorological conditions in nutritional values of wheat with and without 1B/1R RT, further experiments should continue. The knowledge of wheat nutritional values is of high importance for feeding monogastric animals, as it is the most fed feed.


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