

## **Starch digestibility of rolled or sodium-hydroxide treated rye grain in dairy cows**

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### **Introduction**

Limited research has been conducted on the digestibility of nutrients in rye grain in domesticated animal species. In recent years the amount of rye grain produced in Denmark has been increasing creating a demand for knowledge on digestibility of rye grain subjected to different processing methods.

It was hypothesised that compared to rolled rye grain, sodium hydroxide (NaOH) treatment of whole rye grain would reduce the starch digestibility in the rumen whereas the small intestinal starch digestibility would be unaffected. The aim of the present study was to investigate whether rolled and NaOH treated rye grain has digestive patterns similar to rolled and NaOH treated wheat in lactating dairy cows.

### **Materials and Methods**

Four rumen, duodenal and ileal fistulated multiparous lactating Holstein cows were used in a cross over design and fed either rolled rye or NaOH rye grain (rye mixed with 10% water and 3% NaOH). Rations were composed of (% DM): grass-clover silage, 48.1; rye grain (rolled or NaOH), 43.8; soybean meal, 6.8; and minerals and vitamins, 1.3. Rations were fed ad libitum twice daily as total mixed rations. Chromic oxide was used as digesta flow marker. Samples of fluid from medial and ventral rumen contents, intestinal digesta, and faeces were obtained at 6 h intervals.

Data was analysed using a model including the fixed effects of treatment, sequence of treatment, period, and cow. Data for ruminal pH was analysed using a model including the fixed effects of treatment, sampling time, their interaction, sequence of treatment, period, and cow. The sampling time was considered as a repeated measurement within cow by period using the antedependence order 1 covariance structure. The denominator degrees of freedom were corrected using the Satterthwaite method.

### **Results and discussion**

The dry matter intake was 20.8 and 19.9 (P=0.09; Table 1) and starch intake was 5.7 and 5.4 (P=0.05) kg/d for rolled and NaOH rye, respectively. Energy corrected milk yield was 31.0 and 32.5 kg/d (P=0.80) for rolled and NaOH rye, respectively.

For dry matter digestibility, NaOH compared to rolled rye tended to increase rumen digestibility, but to decrease total tract digestibility (Table 1).

For starch digestibility, NaOH compared to rolled rye tended to decrease both rumen digestibility (78.7 vs. 88.1;  $P=0.09$ ; Table 1) and total tract digestibility (96.6 vs. 99.2;  $P=0.06$ ; Table 1). The small intestinal starch digestibility was not affected by processing method ( $P=0.25$ ), but were, however, numerically lower for NaOH treated compared to rolled rye. The lower ruminal digestibility of starch from NaOH rye led to a numerically greater amount of starch digested in the small intestine (+270 g/day,  $P=0.26$ ).

The digestive profile of starch in rolled rye with 88.1, 9.2, and 1.8% of starch intake digested in the rumen, small intestine and hind gut, respectively, resembled the profile observed for starch in rolled/cracked wheat (90, 6, and 3% in rumen, small intestine and hind gut, respectively; Larsen et al., 2009; Larsen et al., 2010).

Considering the NaOH treated rye, 78.8, 15.2, and 5.4% of starch intake was digested in the rumen, small intestine and hind gut, respectively. This resembles the profile observed for NaOH treated wheat to some extent (64.8, 25.0, and 3.1% in rumen, small intestine and hind gut, respectively; Moharrery et al., 2012), but it appears that the ruminal digestibility was not reduced to same extent with rye as compared to wheat. The NaOH treatment of rye grain did not appear to induce negative impact on small intestinal digestibility of starch as have been observed for NaOH treatment of barley grain (McNiven et al., 1995). McNiven et al. (1995) observed NaOH treatment of barley to reduce the small intestinal digestibility of starch to 20.3% from 80.8 with rolled barley.

**Table 1.** Results for intake and digestibility from trial with rolled or sodium-hydroxide (NaOH) treated rye fed to 4 lactating Holstein cows in a cross over design.

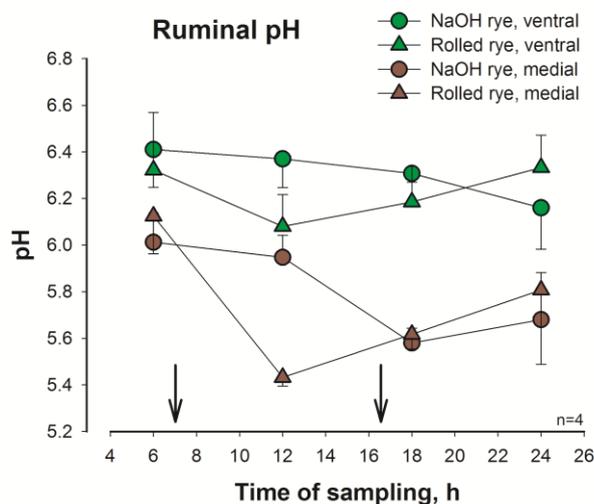
| Item   | Treatment of rye grain |      | SE   | P-value |
|--|------------------------|------|------|---------|
|  | Rolled                 | NaOH |      |         |
| Dry matter intake, kg/d                                | 20.8                   | 19.9 | 0.21 | 0.09    |
| Starch, g/kg DM  | 273                    | 269  |      |         |
| <b>Dry matter digestibility, % of entering</b>         |                        |      |      |         |
| Ruminal  | 21.0                   | 23.4 | 0.59 | 0.10    |
| Small intestinal                                       | 57.4                   | 53.4 | 1.30 | 0.16    |
| Hind gut   | 28.7                   | 25.4 | 2.90 | 0.50    |
| Total tract  | 76.8                   | 74.2 | 0.47 | 0.06    |
| <b>Starch digestibilities, % of entering</b>           |                        |      |      |         |
| Ruminal  | 88.1                   | 78.7 | 2.11 | 0.09    |
| Small intestinal <sup>1</sup>                          | 76.3                   | 62.1 | 3.44 | 0.25    |
| Hind gut <sup>1</sup>                                  | 69.1                   | 57.4 | 2.37 | 0.22    |
| Total tract  | 99.2                   | 96.6 | 0.36 | 0.04    |
| <b>Starch digestibilities, % of intake<sup>1</sup></b> |                        |      |      |         |
| Small intestine <sup>1</sup>                           | 9.2                    | 15.2 | 1.06 | 0.19    |
| Hind gut <sup>1</sup>                                  | 1.8                    | 5.4  | 0.25 | 0.08    |
| <b>Digested starch, kg day</b>                         |                        |      |      |         |
| Small intestine <sup>1</sup>                           | 0.50                   | 0.77 | 0.07 | 0.26    |
| Hind gut <sup>1</sup>                                  | 0.10                   | 0.27 | 0.01 | 0.08    |

<sup>1</sup> Only data from three cows on the NaOH treatment.

Medial rumen pH decreased postprandial for rolled rye as compared with stable postprandial pH for NaOH rye (interaction:  $P=0.01$ , Table 2, Figure 1). Limited effects were observed for ventral ruminal pH (interaction:  $P=0.39$ , Table 2, Figure 1). This indicates that rolled rye did not result in problematic low pH in the ventral sac even with the present high allocation.

**Table 2.** Results for ruminal pH from trial with rolled or sodium-hydroxide (NaOH) treated rye fed to 4 lactating Holstein cows in a cross over design.

| Item                | Treatment (Trt) of rye grain |      |      | P-values |      |            |
|---------------------|------------------------------|------|------|----------|------|------------|
|                     | Rolled                       | NaOH | SE   | Trt      | Time | Trt × Time |
| Ventral rumen fluid | 6.23                         | 6.31 | 0.07 | 0.42     | 0.88 | 0.39       |
| Medial rumen fluid  | 5.75                         | 5.81 | 0.07 | 0.55     | 0.01 | 0.01       |



**Figure 1.** Diurnal pattern of ruminal pH in fluid samples obtained from the liquid phase of the rumen (ventral) and from the particulate phase (medial). Arrows indicate time of feeding (0700 and 1630 h). See Table 2 for statistical analysis.

## Conclusion

In conclusion, NaOH treatment of rye grain reduced ruminal digestibility of starch resulting in slightly higher and more stable pH in comparison with rolled rye in medial, but not in ventral rumen. The small intestinal starch digestibility remained relatively high in spite of the reduced ruminal digestibility. The total tract digestibility was reduced, however, to a limited extent without significance in practical feeding. Overall, the digestive profiles of starch from both rolled and NaOH treated rye were similar to earlier observations with wheat.

## References

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