# Using in situ Technique to Estimate Nutrient Availability of Six Barley Varieties for Ruminants

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## Abstract

Barley grains are as a main source of feed for ruminants in Canada. Although barley varieties have similar chemical composition, they exhibit different rumen degradation characteristics and nutrient availability. The objective of this study was to estimate nutrient availability of the six barley varieties using nylon bags incubated for 0, 2, 4, 8, 12, 24 and 48 h in the rumen of dairy cow and determine the rumen degradation parameters of DM, CP and starch according to the first order degradation kinetics equation. The results indicated that the barley varieties showed different degradation rate (Kd) of DM, CP and starch during incubation period. CDC Trey was the highest ($P<0.05$) in effective degradability of DM (498.04g/kg) while AC Metcalfe showed the highest ($P<0.05$) effective degradability of CP (63.06g/kg) and starch (344.82g/kg) compared with other barley varieties. CDC Helgason had the largest size of rumen undegradable fraction of DM (640.21g/kg), CP (83.85g/kg, NRC 2001 model) and starch (321.85g/kg). Feeds degradation features from this study involved nutrients utilization in ruminant digestive systems. Further study to investigate and compare the structural/chemical make-up characteristics between barley varieties may provide more information as to why barley varieties exhibit different biodegradation behaviors.

## Introduction

As one of the most important annual cereal grain, barley is a main source for malting and serving as animal feed in North America. Considered to have a good quality nutrients composition, barley is used widely in Canada for cattle concentrate feeds because it can provide an worthy contribution to animal growth. There are more than 50 varieties of barley, but only 10 occupy 90% of the acreage. Western Canada accounts for 90% of the national barley acreage and Saskatchewan nearly 50%. However, barley varieties exhibit different rumen degradation characteristics and nutrient availability though they have similar chemical composition (Yu et al. 2003). And some barley varieties with high starch degradation rate may increase acidosis risk for

animal. Thus, more research is necessary to evaluate the differences among varieties of barley to understand their nutrient supply availability to ruminants.

## Objectives

The objectives of this experiment were to evaluate and compare nutrient availability of 6 barley varieties for ruminants with:
1. Chemical composition
2. In situ rumen degradation characteristics of dry matter (DM), crude protein (CP) and starch (ST)

## Materials and Methods

**Barley varieties:** AC Metcalfe, CDC Dolly, McLeod, CDC Helgason, CDC Trey, CDC Cowboy
The barley samples were coarsely dry rolled through 1.59mm roller mill (Sven products, Apollo Machine and products Ltd. Saskatoon, Canada)
**Animal work:** using in situ technique to determine the degradability of barley varieties. Three mature Holstein cows fitted with a large rumen cannula (Bar Diamond Inc., Parma, ID, USA) with an internal diameter of 10 cm were used for measuring rumen degradation characteristics.
**Data analysis:** SAS software (SAS Institute, Inc. 2003)

## Results and Discussion

The chemical composition of barey varieties were presented in Table 1. Comparing the original feed samples, it showed that these six barley varieties had similar DM% (from 91.76% to 91.96%). However, there were some differences appeared in crude protein and starch percentage among the barley varieties. For crude protein, CDC Cowboy had the highest CP% (14.39%) while CDC Trey had the lowest (12.35%). For starch, CDC Dolly showed the highest ST% (58.59%), and the lowest one, McLeod, had only 48.81%.

**Table 1**. Chemical Composition of 6 Barley Varieties

| Items | AC Metcalfe | CDC Dolly | McLeod | CDC Helgason | CDC Trey | CDC Cowboy |
|---|---|---|---|---|---|---|
| Dry matter (DM) (%) | 91.89 | 91.78 | 91.76 | 91.96 | 91.94 | 91.82 |
| Crude protein (CP) (%, DM) | 14.11 | 13.08 | 13.36 | 13.19 | 12.35 | 14.39 |
| Starch (ST) (%, DM) | 58.44 | 58.59 | 48.81 | 56.39 | 55.67 | 54.15 |

Using the modified Ørskov model (Tamminga et al. 1990; 1994), the rumen degradation characteristics of barley varieties were showed as follow. The results indicated that the barley varieties showed different degradation rate (Kd) of DM, CP and starch during incubation period. The rumen degradation characteristics of barley varieties (DM, CP and ST) were showed in

Tables 2, 3 and 4, respectively. For in situ DM degradation characteristics (Table 2), the results showed that the barley varieties differed ($P<0.05$) in situ degradation characteristics (S, D, U, RUDM and EDDM) except the T0 which indicated that the barley varieties had different degradation behaviors after entering the rumen. CDC Trey was the highest ($P<0.05$) in effective degradability of DM (498.04g/kg). And CDC Helgason had the largest size of rumen undegradable fraction of DM (640.21g/kg)

**Table 2**. In situ Rumen Degradation Characteristics of Dry Matter (DM) of 6 Barley Varieties

| Items | AC Metcalfe | CDC Dolly | McLeod | CDC Helgason | CDC Trey | CDC Cowboy | SEM[Z] | P value |
|---|---|---|---|---|---|---|---|---|
| In situ rumen degradation characteristics of DM[y] | | | | | | | | |
| S (%) | 0.81 *ab* | 0.39 *cd* | 0.62 *bc* | 0.20 *d* | 1.16 *a* | 0.63 *bc* | 0.146 | 0.0065 |
| D (% | 76.99 *ab* | 69.05 *d* | 72.10 *cd* | 74.44 *bc* | 79.03 *a* | 77.55 *ab* | 1.512 | 0.0049 |
| U (%) | 22.20 *cd* | 30.56 *a* | 27.28 *ab* | 25.36 *bc* | 19.80 *d* | 21.81 *cd* | 1.576 | 0.0040 |
| T0 (h) | 0.91 | 1.34 | 1.00 | 0.90 | 0.95 | 1.04 | 0.199 | 0.6555 |
| Kd (%/h) | 10.04 *a* | 7.84 *b* | 9.63*a b* | 5.62 *c* | 9.72 *a* | 8.29*a b* | 0.671 | 0.0025 |
| RUDM (%) | 51.34 *d* | 60.51 *b* | 55.00 *c* | 64.02 *a* | 50.20 *d* | 54.54 *c* | 0.999 | <0.0001 |
| RUDM (g/kg, DM) | 513.35 *d* | 605.08 *b* | 550.02 *c* | 640.21 *a* | 501.96 *d* | 545.37 *c* | 9.988 | <0.0001 |
| EDDM (%) | 48.66 *a* | 39.49 *c* | 45.00 *b* | 35.98 *d* | 49.80 *a* | 45.46 *b* | 0.999 | <0.0001 |
| EDDM (g/kg, DM) | 486.65 *a* | 394.92 *c* | 449.98 *b* | 359.79 *d* | 498.04 *a* | 454.63 *b* | 9.988 | <0.0001 |

[Z] SEM= standard error of mean. Means with the different letter in the same row are significantly different ($P<0.05$).

[y] S= rapidly degradable fraction; D= potentially degradable fraction U= undegradable fraction, Kd = degradation rate, RUDM = rumen undegradable fraction of DM, EDDM= effective degradability of DM

Rumen undegradable protein (RUP) was correlative with the protein digestibility in rumen. Those proteins with higher digestibility would decrease the RUP. As the results showed below, protein digestibility of different barley varieties differed significantly. For CP degradation characteristics (Table 3), AC Metcalfe showed the highest ($P<0.05$) effective degradability of CP (63.06g/kg) compared with other barley varieties. CDC Helgason had the largest size of rumen undegradable fraction of CP (83.85g/kg, NRC 2001 model).

**Table 3**. In situ Rumen Degradation Characteristics of Crude Protein (CP) of 6 Barley Varieties

| Items | AC Metcalfe | CDC Dolly | McLeod | CDC Helgason | CDC Trey | CDC Cowboy | SEM[Z] | P value |
|---|---|---|---|---|---|---|---|---|
| In situ rumen degradation characteristics of CP[y] | | | | | | | | |
| S (%, ) | 3.73 *a* | 1.97 *b* | 0.76 *c* | 2.11 *b* | 0.71 *c* | 2.40 *b* | 0.360 | 0.0002 |
| D (%,) | 78.38 *abc* | 73.35 *c* | 78.05 *bc* | 79.89 *ab* | 83.76 *a* | 81.45 *ab* | 2.194 | 0.0270 |
| U (%,) | 17.89 *b* | 24.68 *a* | 21.19 *ab* | 18.00 *b* | 15.54 *b* | 16.14 *b* | 2.102 | 0. 0400 |
| T0 (h,) | 0.84 *b* | 1.76 *a* | 1.27 *ab* | 1.47*a b* | 1.49*a b* | 1.40*a b* | 0.283 | 0.3705 |
| Kd (%/h) | 6.72 *a* | 6.18 *ab* | 6.99 *a* | 4.55 *b* | 6.95 *a* | 5.73*a b* | 0.551 | 0.0560 |
| RUP (%) | 55.31 *c* | 60.96 *ab* | 57.44 *bc* | 63.59 *a* | 54.70 *c* | 57.83 *bc* | 1.250 | 0.0022 |
| RUP (g/kg, DM, DVE) | 86.62 *bc* | 88.51 *abc* | 85.19 *c* | 93.08 *a* | 74.96 *d* | 92.35 *ab* | 1.877 | 0.0002 |
| RUP (g/kg, DM, NRC) | 78.04 *bc* | 79.74 *abc* | 76.74 *c* | 83.85 *a* | 67.53 *d* | 83.20 *ab* | 1.691 | 0.0002 |
| EDCP (%) | 44.69 *a* | 39.04 *bc* | 42.56 *ab* | 36.41 *c* | 45.30 *a* | 42.17 *ab* | 1.250 | 0.0022 |
| EDCP (g/kg, DM) | 63.06 *a* | 51.06 *cd* | 56.88 *b* | 48.00 *d* | 55.92 *bc* | 60.67*ab* | 1.692 | 0.0003 |

[Z] SEM= standard error of mean. Means with the different letter in the same row are significantly different ($P<0.05$).

[y] S= rapidly degradable fraction; D= potentially degradable fraction U= undegradable fraction, Kd = degradation rate, RUCP = rumen undegradable fraction of CP, EDCP= effective degradability of CP

The results from this study indicated that AC Metcalfe showed the highest ($P<0.05$) effective degradability of starch percentage (59.01%) compared with other barley varieties. It was obvious that CDC Helgason had the lowest Kd ($P<0.05$), which meant that the digestion speed of CDC Helgason was slower than other five barley varieties in the rumen. Comparing other degradation characteristics, CDC Helgason revealed the highest RUST (321.85g/kg, DM) than others ($P<0.05$), whereas AC Metcalfe showed the highest EDST (344.82g/kg, DM).

**Table 4**. In situ Rumen Degradation Characteristics of Starch (ST) of 6 Barley Varieties

| Items | AC Metcalfe | CDC Dolly | McLeod | CDC Helgason | CDC Trey | CDC Cowboy | SEM[Z] | P value |
|---|---|---|---|---|---|---|---|---|
| In situ rumen degradation characteristics of ST[y] | | | | | | | | |
| S (%) | 2.93 | 0.51 | 0.01 | 2.14 | 0.18 | 0.09 | 1.117 | 0.2509 |
| D (%) | 85.54 *ab* | 80.32 *b* | 83.85 *b* | 79.79 *b* | 91.38 *a* | 90.12 *a* | 1.944 | 0.0056 |
| U (%) | 11.53 *b* | 19.17 *a* | 16.13 *a* | 18.07 *a* | 8.43 *b* | 9.80 *b* | 1.280 | 0.0002 |
| T0 (h) | 1.50 | 1.48 | 1.75 | 1.67 | 1.38 | 1.41 | 0.416 | 0.9826 |
| Kd (%/h) | 11.70 *a* | 7.62*c d* | 9.45*b c* | 6.32 *d* | 10.44 *ab* | 9.16 *bc* | 0.314 | 0.0036 |
| RUST (%) | 40.99 *d* | 54.60 *a* | 48.79 *b* | 57.08 *a* | 41.94 *cd* | 45.54 *bc* | 1.338 | <0.0001 |
| RUST (g/kg, DM) | 239.57 *b* | 319.87 *a* | 238.12 *b* | 321.85 *a* | 233.51 *b* | 246.59 *b* | 7.568 | <0.0001 |
| EDST (%) | 59.01 *a* | 45.40 *d* | 51.21 *c* | 42.92 *d* | 58.06 *ab* | 54.46 *bc* | 1.338 | <0.0001 |
| EDST (g/kg, DM) | 344.82 *a* | 266.03 *c* | 249.93 *cd* | 242.00 *d* | 323.21 *a* | 294.88 *b* | 7.569 | <0.0001 |

[Z] SEM= standard error of mean. Means with the different letter in the same row are significantly different ($P<0.05$).

[y] S= rapidly degradable fraction; D= potentially degradable fraction U= undegradable fraction, Kd = degradation rate, RUST = rumen undegradable fraction of ST, EDST= effective degradability of ST

## Conclusion

It was concluded that with the same processing methods, barley varieties showed different rumen digestive behavior of nutrients and thus had different nutrient supply potential to dairy cows. If microbial protein synthesis in the rumen was not decreased, the increased availability of nutrients absorbed in the small intestine could be more beneficial to the host animal.

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