*Slovak J. Anim. Sci., 39, 2006 (1-2): 113 - 116*
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# Influence of different sources of starch on digestibility of nutrients and balance of nitrogen in young bulls

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## ABSTRACT

A study was carried out to determine the effects of various concentrates, i.e. different sources of starch with a constant ratio to fibre (2.1: 1) and the same percentage of fibre in dry matter of feed rations (16 – 17 %), on balance nutrient digestibility and nitrogen balance. Experiment involved six Black-Spotted bulls with mean live weight of 304 kg, which were offered diet twice a day – at 06.00 and 18.00. A base of feeding ration was meadow hay, supplemented with wheat meal (treatment a), or maize meal (treatment c), or their combination at a 1: 1 ratio (treatment b). An 11-day adaptation period was followed by an 8-day experimental period.
From variants of feeding were taken samples of feedstuffs, in which was determined content of nutrients by Order of MP SR Nr. 1497/4/1997-100 (MP SR, 1997). During experimental period was quantitative batched excrements and urine. From collected amount for 24 hour were taken average samples for chemically analyses on the content of nutrients (MP SR,1997). Significance of differences between feed rations was evaluated by t– test with program Statgraphics, Version 5.0. Digestibility of dry matter (72 %), organic matter (74 %) and fibre (52 %) was observed for wheat meal combined with maize meal. Most crude protein (69 %) showed significant apparent digestibility when bulls were offered wheat meal, but their effectiveness was higher significantly for wheat meal combined with maize meal. The highest percentage of nitrogen retained out of both N intake and digested nitrogen was found in this experiment with feeding wheat meal combined with maize meal (treatment b).

**Keywords:** wheat meal, maize meal, starch, fibre, digestibility of nutrients, nitrogen balance

The variability of saccharides degradation rate can significantly influence the digestibility and efficiency of nutrients in ruminants. According to this it is important to put accent on the use of a qualitative starch source and its ratio to structural polysaccharides. The energy value of starch fermented in rumen to volatile fatty acids is lower than those of starch absorbed in small intestine in the form of glucose (Weurding, 1998). Increasing of undegradable starch share and its flow into small intestine is very important especially for energy supply in high performance dairy cows that took about 2-10 kg starch from various feeding rations within the daily diet. Depending on the starch source and received feed amounts about 50-95 % of feed starch hydrolyse in rumen to glucose and ferment to volatile fatty acids. The starch fermentation and production of volatile fatty acids in rumen is theoretically linked with more than 40 % losses compare to enzymatic starch digestion in small intestine (Owens, 1986).

Lebzien, Engling (1995) referred that by wheat feeding about 89 % of starch degrades in rumen, by barley about 81 % and only 69 % by maize meal feeding.

Čerešňáková et al. (2003) determined huge differences in degradability of N-substances and starch in various cereals fed by ruminants. The lowest degradability of N-substances and starch was determined in maize grain and the highest one in wheat varieties. Nutrient digestibility can be influenced by starch source in the feeding ration and feed concentrates amount. With increasing ratio of concentrates (by it starch, too) increase the digestibility of organic matter and apparent digestibility of nitrogen substances (Klejmenov et al., 1986; Robinson, 1987). Also Pajtáš et al. (2003) confirmed the impact of feeding by various feed concentrates on the utilization of nutrients, a higher percentage of fixed nitrogen compare to received one was stated in case where as the starch source in feeding ration of young

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bulls maize meal was used.

Objective of this paper was to determine the effect of various concentrates, i.e. different starch sources with a constant ratio to fibre (2.1: 1) and the fibre percentage in feeding ration dry matter of 16 – 17 % on the balance nutrient digestibility and nitrogen balance.

## MATERIALS AND METHODS

Experiment involved six Black-Spotted bulls with mean live weight of 304 kg. Animals were offered feed twice a day – at 06.00 and 18.00. An 11-day adaptation period was followed by an 8-day experimental period.

A base of feeding ration was meadow hay, supplemented with wheat meal (treatment a), wheat meal in combination with maize meal at a 1: 1 ratio (treatment b), or maize meal (treatment c) (Tab. 1). Dry matter, energy and nutrients content in offered feed are showed in Tab. 2. The starch/fibre ratio and the percentage of fibre in dry matter of feed rations were constant in single treatments (Tab. 3). Feeding rations were composed not to exceed 1.5 of maintenance requirements. Samples of feedstuffs were taken from feeding variants (in three rep. for each feedstuff), in which the nutrient content according to the Order of MP SR Nr. 1497/4/1997-100 (MP SR, 1998) was determined. The feedstuff energy value and PDI content was determined according to the Order of MP SR Nr. 39/1/2002-100 (MP SR, 2002).

**Table 1: Composition of diets in dry matter (kg)**

| Feed | Diet | | |
|---|---|---|---|
| | a | b | c |
| Meadow hay | 2.4 | 2.4 | 2.4 |
| Wheat meal | 2.6 | 1.3 | - |
| Maize meal | - | 1.3 | 2.6 |

During the balance experimental period lasting for 8 days excrements and urine were quantitative collected in each feeding variant. Before morning feed, after weighting and homogenisation samples (3% of excrements and 3% of urine) for chemical analysis were taken from the collected 24-hour amount. Excrement samples were dried immediately and an average sample was made. Urine used for average sample was preserved by hydrochloric acid and stored at 5°C. Daily excrement samples were analysed 4 times (every other day in each feeding variant) during the balance experiment period. In collected excrement samples the nutrient content according to the Order of MP SR Nr. 1497/4/1997-100 was determined. The starch content was determined polarimetrically. The content of nitrogen was determined in urine.

Differences between feed rations were evaluated by t– test with program Statgraphics, Version 5.0.

## RESULTS AND DISCUSSION

As showed in Tab. 3 by offering several starch sources the starch/fibre ration was constant in single variants and the fibre/feeding rations dry matter share was well balanced.

The impact of maize and wheat meal on the digestibility of nutrients, dry matter and organic matter is showed in Tab. 4.

Significantly the highest (69 %) digestibility of nitrogen substances was observed by offering wheat meal (treatment a). The digestibility of dry matter and organic matter was similar (72 %, 74 % resp.) by offering pure wheat meal (treatment a) or wheat/maize meal combination (treatment b). The balance nutrient digestibility was influenced by offering different starch sources, these correspond to conclusions of Kaufman and Kirchgessner [3]. The highest digestibility of fibre was observed by maize meal feeding (treatment c), which was significantly higher compare to wheat meal feeding (treatment a). These results correspond with conclusions of Pajtáš at al. [7] who determined a higher fibre digestibility when as the starch source maize meal was used.

**Table 2: Content of dry matter, energy and nutrients in feeds**

| Feed n = 9 | DM | NEL | NEV | PDI | Crude protein | Fat | Nitrogen-free extract | Starch | Crude fibre | Organic matter | Ash |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | $g.kg^{-1}$ FM | $MJ.kg^{-1}$ DM | | g.kg$^{-1}$ DM | | | | | | | |
| Meadow hay | 854.4 | 5.19 | 4.93 | 72 | 103 | 14 | 472 | 6 | 303 | 892 | 108 |
| Wheat meal | 852.6 | 8.7 | 9.26 | 63 | 99 | 15 | 836 | 680 | 34 | 984 | 16 |
| Maize meal | 856.5 | 9.11 | 9.89 | 72 | 95 | 40 | 816 | 701 | 30 | 981 | 19 |

DM – dry matter; FM – fresh matter; NEL – net energy of lactation; NEV – net energy of gain; PDI – protein digestible in intestine

**Table 3: Intake of dry mater, energy and nutrients from different diets at one day**

| Intake | | | Diet a | Diet b | Diet c |
|---|---|---|---|---|---|
| DM | | g | 4970 | 4950 | 4960 |
| Energy | NEL | MJ | 34.58 | 34.70 | 35.82 |
| | NEV | MJ | 35.72 | 35.71 | 37.20 |
| Nutri-ents | PDI | g | 318 | 335 | 357 |
| | Crude protein | g | 450 | 504 | 490 |
| | Fat | g | 65 | 107 | 136 |
| | Nitrogen-free extract | g | 3277 | 3219 | 3225 |
| | Starch | g | 1774 | 1749 | 1816 |
| | Crude fibre | g | 826 | 818 | 801 |
| | Organic matter | g | 4668 | 4648 | 4653 |
| | Ash | g | 302 | 302 | 307 |
| ratio of starch to fibre | | | 2.15 : 1 | 2.14 : 1 | 2.26 : 1 |
| percentage of fibre | | | 16.6 | 16.5 | 16.2 |

DM – dry matter; NEL – net energy of lactation; NEV – net energy of gain; PDI – protein digestible in intestine

The lowest (96 %) starch digestibility was determined in treatment c, when as the starch source maize meal was used. DeVisser (1980), Klejmenov et al. (1986) and Robinson et al. (1987) reported that by increasing starch ratio in feeding rations increase the balance nutrient digestibility of organic matter and nitrogen substances. We came to an opposite result in our experiment, i.e. the lowest digestibility of organic matter and nitrogen substances was observed by higher starch income. When as the starch source wheat meal was used (treatment a) the digestibility coefficient of fat was significantly lower (for 5 % or up to 11 %) compare to other two variants.

The impact of maize and wheat meal on the nitrogen balance is showed in Tab. 5. In the wheat meal diet (treatment c) we have determined that the nitrogen was digested to 69 %, in the maize meal diet (treatment c) to 63 %, in average to 66 %. By offering wheat meal the highest amount of nitrogen was excluded in urine and there was determined the lowest level of retained nitrogen from received and digested one (Pajtáš et al., 2003). The

**Table 4: Digestibility of nutrients (%)**

| Nutrients | Diet a | | | Diet b | | | Diet c | | | P (t – test) |
|---|---|---|---|---|---|---|---|---|---|---|
| | $\bar{x}$ | s | v (%) | $\bar{x}$ | s | v (%) | $\bar{x}$ | s | v (%) | |
| DM | 72 | 0.89 | 1.24 | 72 | 1.37 | 1.89 | 70 | 1.03 | 1.47 | a:c+ b:c+ |
| Crude protein | 69 | 3.78 | 5.52 | 65 | 1.51 | 2.30 | 63 | 2.32 | 3.67 | a:c+ |
| Fat | 58 | 5.38 | 10.80 | 63 | 2.53 | 4.02 | 69 | 4.08 | 5.86 | a:b,c++b:c++ |
| Nitrogen-free extract | 81 | 0.75 | 0.93 | 81 | 1.21 | 1.50 | 78 | 1.63 | 2.10 | a:c++ b:c++ |
| Starch | 99 | 0.52 | 0.52 | 98 | 0.41 | 0.42 | 96 | 0.75 | 0.79 | a:b,c++b:c++ |
| Crude fibre | 48 | 1.26 | 2.64 | 52 | 1.51 | 2.88 | 54 | 2.07 | 3.88 | a:b,c++ b:c+ |
| Organic matter | 74 | 0.84 | 1.14 | 74 | 1.33 | 1.80 | 72 | 0.89 | 1.24 | a:c+ b:c+ |
| Ash | 48 | 5.93 | 12.36 | 53 | 4.59 | 8.75 | 50 | 5.68 | 10.99 | a:b+ |

+PŁ 0,05; ++PŁ 0,01; $\bar{x}$ – average; s – standard deviation; v – coefficient of variance; P – different betwen variants significant at the level $\alpha = 0.05$ or $\alpha = 0.01$

**V. Nitrogen balance**

| Item | | | | Diet a | | | Diet b | | | Diet c | | | P (t-test) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | $\bar{x}$ | s | v | $\bar{x}$ | s | v | $\bar{x}$ | s | v | |
| Nitrogen intake (g) | | | | 72.0 | 1.1 | 1.5 | 80.6 | 1.3 | 1.6 | 78.4 | 1.2 | 1.5 | a:b++a:c+ |
| Nitrogen | excreted (g) | faeces | | 22.4 | 0.9 | 4.0 | 27.9 | 1.5 | 5.3 | 28.7 | 1.0 | 3.4 | a:b,c++ |
| | | in urine | | 31.7 | 2.1 | 6.6 | 30.3 | 1.9 | 6.2 | 29.0 | 1.6 | 5.5 | |
| | | total | | 54.1 | 3.7 | 6.8 | 58.2 | 2.6 | 4.4 | 57.7 | 3.2 | 5.4 | a:b,c+ |
| | digested (g) | | | 49.6 | 2.1 | 4.3 | 52.7 | 1.7 | 3.2 | 49.7 | 2.3 | 4.6 | |
| | retained | rec. | g | 17.9 | 1.3 | 7.3 | 22.4 | 1.6 | 7.0 | 20.7 | 1.4 | 6.7 | |
| | | | % | 25 | 1.1 | 4.4 | 28 | 1.3 | 4.5 | 26 | 1.0 | 3.8 | |
| | | dig. | % | 36 | 1.6 | 4.2 | 43 | 2.2 | 5.1 | 42 | 1.9 | 4.5 | a:b,c++ |

+PŁ 0,05 ++PŁ 0,01; $\bar{x}$ – average; s – standard deviation; v – coefficient of variance; P – different betwen variants significant at the level $\alpha = 0.05$ or $\alpha = 0.01$; rec. – retained nitrogen from received nitrogen; dig. – retained nitrogen from digested nitrogen

highest amount of retained nitrogen was determined in b feeding ration (meadow hay supplemented with wheat- and maize meal). The percentage of retained nitrogen from digested one was at highest (28 % and 43 %) in this variant.

## CONCLUSIONS

We determined that by 2,1: 1 starch / fibre ratio and a 16 % - 17 % content of fibre in the dry matter, and wheat meal or maize meal feeding does significantly influence the balance nutrient digestibility.

When as the starch source wheat meal was used, the apparent digestibility of dry matter, organic matter, nitrogenous substances and starch was significantly higher. By offering maize meal the digestibility of fat and fibre was significantly higher.

The highest percentage of retained nitrogen from received and digested ones was determined by offering wheat meal supplemented with maize meal in 1:1 ratio. According to our results there is a recommendation for praxis to increase the share of maize meal in production of feed mixtures for ruminates.

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