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Effects of NaOH-treated wheat and a mixture of barley and oats on the voluntary feed intake and milk production in dairy cows

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ABSTRACT

An experiment was conducted to examine how including NaOH-treated wheat in the diet of dairy cows affects dry matter intake (DMI) and milk production, using diets based on rolled wheat and an oat/barley mixture for comparative purposes. The study was based on 24 Swedish Red dairy cows that were 147 ± 51 d in milk (DIM), with an average milk yield of 31 ± 5.6 kg/d and a live weight of 611 ± 66 kg. The cows were blocked according to DIM and randomly assigned to six replicated 4 × 4 balanced Latin squares with 21-d experimental periods. The diets were fed as total mixed rations consisting of grass silage supplemented with concentrates in a ratio of 52:48. Four diets were examined: an oat/barley mixture (OBM), 100% rolled wheat (RW) of which 50 (SHW/RW) or 100% was replaced with NaOH treated wheat (SHW). Total tract digestibility was determined using acid-insoluble ash as an internal marker. Ruminal degradation parameters for the cereal feeds were estimated using an *in vitro* gas production technique and modelling approach. Increased inclusion of NaOH-treated wheat did not affect DMI or milk production. NaOH-treatment reduced ($P<0.01$) milk protein concentrations and milk N efficiency ($P<0.05$), and tended ($P=0.10$) to decrease milk protein yield. There were no differences between the OBM and RW diets in terms of DMI, milk production, or milk composition. Increased levels of NaOH-treated wheat in the diet caused linear increases ($P<0.05$) in faecal N output and estimated urinary volumes and decreasing milk urea concentrations. This indicates that NaOH-treatment increased the mineral load of the diet and shifted starch digestion from the rumen to the small and large intestines. These results were consistent with the lower observed *in vitro* ruminal digestion rates of NaOH-treated wheat. It is concluded that the oat/barley mixture and the rolled wheat had comparable feeding values despite the higher tabulated metabolisable energy and protein concentrations of the latter. It is concluded that NaOH-treatment of wheat has no beneficial effects that justify its use.

1. Introduction

The availability of grain at affordable prices has favoured the inclusion of cereals in dairy cow diets during the last few decades (*e.g.* Campling, 1991). The substitution of grain for forage increases dry matter (DM) intake (DMI) and milk production. However, an excessively high grain intake can cause rumen acidosis and reduce DMI, as discussed by Krause and Oetzel (2006). Excessive starch concentrations can also reduce neutral detergent fibre digestibility (NDFD; Allen, 2000; Stensig et al., 1998) and milk fat concentration (Reynolds, 2006). Wheat grain has

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become a popular energy source for ruminants because of its high agronomic yields and higher tabulated concentrations of metabolisable energy (ME) and metabolisable protein (MP) compared to barley and oats. However, it has not been proven that these higher tabulated nutritional values yield increased milk production.

It has been suggested that shifting starch digestion from the reticulo-rumen to the small intestine improves the efficiency of energy utilisation due to smaller losses of energy as heat and methane (Reynolds, 2006). This can be achieved by treating the grain with a solution of NaOH, which dissolves the bran and leaves the endosperm naked (Ørskov et al., 1974). NaOH-treatment is an alternative to mechanical processing (*e.g.* rolling) and is often conducted by mixing grains with NaOH granules and water and then storing the treated grain on a concrete floor until feeding (Ørskov et al., 1981). Campling (1991) reviewed the effects of processing cereal grains and concluded that NaOH-treatment of barley could have positive effects on ruminants' forage intake by reducing the acidity of the rumen. On-farm alkali (NaOH) treatment of cereals for storage and feeding can be conducted using established technologies—specifically, the mixer wagons that are used for preparing total mixed rations (TMR) (Ørskov et al., 1981). Despite these theoretical advantages, the practical benefits of NaOH-treatment and the associated phenomenon of rumen escape starch have been questioned (Ørskov, 1986; Phipps et al., 2001). While there has been significant interest in using NaOH-treated grain in the Nordic countries, there have been no production experiments examining the impact of adding NaOH-treated grain to diets based on grass silages with high intake potential. There is also interest in replacing barley and oats in dairy concentrates, but the data comparing these grains is very limited in cows fed grass silage-based diets.

The objectives of the study reported herein were to evaluate the effects of replacing dried rolled wheat with NaOH-treated wheat and to compare the feeding value of a barley oat/mixtures and rolled wheat in lactating dairy cows fed grass silage-based diets.

2. Materials and methods

2.1. Animals, housing and experimental design

The experiment was conducted at the research farm of the Swedish University of Agricultural Sciences in Umeå (63°45′N; 20°17′E) between September and December of 2010 using 24 Swedish Red dairy cows (17 multi- and 7 primiparous) The cows were 147 ± 51 d in milk (DIM), had a live weight (LW) of 611 ± 66 kg and produced 31 ± 5.6 kg of milk at the start of the feeding experiment. All animal recordings and treatments were conducted with the permission of the Swedish Ethical Committee on Animal Research, represented by the Court of Appeal for Northern Norrland in Umeå. Each animal was assigned to one of six balanced 4 × 4 Latin squares according to their numbers of DIM, and within each square the animals were randomly allocated to one of the four diets. Each experimental period lasted for 21 d, with 14 d for adaptation and 7 d for data recording and sample collection. The animals were kept in an insulated loose house barn and milked twice daily, at 06:00 and 15:00 h.

2.2. Feeds and their conservation

A batch of winter wheat (DM concentration 860 g/kg) was obtained from a commercial farm and subjected to two different treatments to yield two different types of wheat grains: rolled and NaOH-treated. Rolled wheat was produced using a mobile crimper (MURSKA 700, Aimo Kortteen Konepaja Oy, Ylivieska, Finland). The NaOH-treated wheat was produced by mixing whole wheat grains with NaOH granules on a 3% fresh weight basis in a Keenan mixer-feeder (Richard Keenan & Co. Ltd, Borris, Ireland). Water was then added to the mixture on a 10% weight basis and the mixture was agitated for 15 min. More water (amounting to 16% of the weight of the grains) was then added and the mixture was mixed again for 5 minutes. The treated grain was then spread over a concrete floor to form a layer *ca.* 40 cm deep until feeding. A pelleted 1:1 mixture of oat and barley was produced at a local feed mill. Rapeseed meal pelleted with fat, vitamins, and minerals was added to the diets as a source of supplementary nutrients. Both OBM and RSM pellets were included in all TMR as crushed pellets to reduce diet selection in the feed bunks.

Grass silage was prepared from a grass ley dominated by timothy (*Phleum pratense* L) on the 17th of June, 2010. The grass was cut with a disc mower and conditioner (Kverneland Ta 339, Kverneland Group Operation AS, Kverneland, Norway). The crop was wilted for 10 h, harvested (20 mm theoretical length) with a precision-chopper (JF ES 5000 Meta Q Protec, JF-Fabrikken AS, Sønderborg, Denmark) and ensiled into bunker silos with Promyr® XR 630 (formic and propionic acids) (Perstorp Speciality Chemicals AB, Perstorp, Sweden), applied at a rate of 3.5 l per 1000 kg of fresh matter.

2.3. Diets and animal recordings

The experimental diets were administered as TMR and consisted of grass silage together with one of four grain supplements. The grain supplements considered were a mixture (1:1) of oats and barley (OBM), rolled wheat (RW) of which 50% or 100% was replaced with NaOH-treated wheat. All four diets had a forage-to-concentrate ratio of 52:48 on a DM basis (Table 1). The dietary components were mixed for seven minutes using a stationary mixer (Nolan A/S, Viborg, Denmark) prior to feeding and were distributed to the feed bunks at 06:00, 12:00, and 18:00 h using Roughage Intake Control™ feeders (Insentec B. V. Marknesse, The Netherlands). The diets were offered *ad libitum* allowing 5 kg/d of refusals and the daily feed intake was recorded for individual animals on each visit. The DM concentration of each feed ingredients was determined twice weekly and the TMR recipes were adjusted to maintain a constant DM proportion for each dietary component. The weight of TMR in each feed bunk was continuously monitored on-line using a computerised system. Residues were removed once per day at 05:45 h. Milk production was recorded daily using gravimetric milk recorders (S.A. Christensen & CO, Kolding, Denmark). Concentrations of milk fat, protein, lactose and urea