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Effect of ammonia fiber expansion on the available energy content of wheat straw fed to lactating cattle and buffalo in India

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ABSTRACT

The seasonal lack of availability of lush green forages can force dairy farmers in developing nations to rely on crop residues such as wheat and rice straw as the major feed source. We tested whether ammonia fiber expansion (AFEX) treatment of wheat straw would increase the energy available to Murrah buffalo and Karan-Fries cattle consuming 70% of their diet as wheat straw in India. Forty lactating animals of each species were blocked by parity and days in milk and randomly assigned to 1 of 4 treatment diets (n = 10). Treatments were a nutrient-rich diet with 0 to 20% straw (positive control; PC) and 3 high-straw diets with various levels of AFEX-treatment: (1) 70% untreated straw (no AFEX), (2) 40 to 45% untreated straw with 25 to 30% AFEX-treated straw (low AFEX), and (3) 20% untreated straw with 50% AFEX-treated straw (high AFEX). The AFEX-treated straw was pelleted. Urea was added to the no and low AFEX diets so they were isonitrogenous with the high AFEX diet. Animals were individually fed the PC diet for 14 d followed by 7 d of adaptation to treatments, full treatments for 28 to 35 d, and finally PC diets for 21 d. Compared with buffalo fed the PC diet, those fed high-straw diets consumed 29% less feed dry matter, put out 16% less milk energy, and lost 0.8 kg/d more body weight; the AFEX treatment of straw did not alter intake or milk production but greatly ameliorated the body weight loss (−1.0 kg/d for no AFEX and −0.07 kg/d for high AFEX). In Karan-Fries cattle, high-straw diets decreased dry matter intake by 39% and milk energy by 24%, and the high AFEX diet increased intake by 42% and milk energy by 18%. The AFEX treatment increased digestibilities of organic matter, dry matter, neutral detergent fiber, acid detergent fiber, and crude protein by 6 to 13 percentage points in buffalo and 5 to 10 points in cattle. In conclusion, AFEX treatment increased the digestibility and energy availability of wheat straw for lactating buffalo and cattle and has commercial potential to improve milk production and feed efficiency when high-quality forages or grains are not available.
Key words: ammonia fiber expansion, Murrah buffalo, dairy cow, energy intake

INTRODUCTION

India is the world's largest milk producer and is expected to see increased demand for dairy products in the near future (Deshmukh and Jadhav, 2015). This demand is placing substantial stress on the supply of feed for cattle and buffalo, particularly as per-animal productivity in India remains low relative to that of animals in the industrialized world. Of particular concern is the availability and seasonality of lush green forages, as ensiling is not a common practice in many parts of the country nor is it practical for small farmers. The Indian government predicted a 33% shortage of green forage from 2012 to 2017, and such shortages are expected to continue (Government of India, 2011). In contrast, rice and wheat straw residues are abundant in several parts of India, particularly in the northwest states of Punjab and Haryana. Although wheat straw is currently used throughout India as a cattle feed ingredient (Mishra et al., 2010), rice straw in particular is often left on the field and burned, causing severe pollution and health problems in Delhi and surrounding regions (Sharma et al., 2010; Yadav et al., 2014). Because of this pollution, the Indian government is encouraging alternative uses of straw.

One approach to improve feed quality and reduce pollution from burning straw is to treat or supplement the straw to improve its nutritional quality. Urea-molasses blocks, for example, have been studied as an approach for improving productivity in Latin America, Africa, and Asia (FAO, 2007). Likewise, alkaline treatment

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of straw, particularly with lime or ammonia, has been shown to improve the digestibility of the fiber (Schiere and de Wit, 1995; Sarnklong et al., 2010). Although often effective, these alkaline treatments have struggled to obtain commercial acceptance due in part to the high labor requirements for the local farmers and the difficulties of handling toxic chemicals such as ammonia on-farm.

An alternative alkaline treatment is ammonia fiber expansion (**AFEX**), which involves exposing the straw to high levels of ammonia at elevated temperature and pressure for <1 h. Unlike traditional approaches to treat straw, AFEX treatment would be performed at a local industrial center, and the finished product can be pelleted to facilitate long-distance transportation of the feed (Eranki et al., 2011). Thus, AFEX pellets can be supplied to areas with seasonal scarcity of forages without significantly burdening a farmer's time or available resources. Furthermore, in vitro tests have demonstrated that AFEX increases the digestibility of fodder to a greater extent than other on-farm treatments (Bals et al., 2010; Scott et al., 2011). Initial in vitro digestibility of NDF was increased 19 to 20 percentage points for corn stover and wheat straw (Bals et al., 2010). Likewise, AFEX treatment of barley straw increased in vitro production of VFA from 51 to 60 mmol/d, compared with untreated barley straw (Griffith et al., 2016). Feeding trials with AFEX-treated straw have been limited to date, although preliminary experiments have demonstrated that the material is palatable and maintains the general health of the animals (Weimer et al., 2003; Blummel et al., 2014).

Thus, the overall goal in this project was to determine the effectiveness of AFEX treatment on wheat straw as a feed ingredient for Indian dairy cattle and buffalo. We hypothesized that AFEX treatment would increase the digestibility and apparent NE_L value of wheat straw and increase milk production over urea-supplemented wheat straw. If our hypothesis was correct, then AFEX treatment could be used to provide a reasonable replacement for fresh green forages during the dry season. We devised 2 experiments to test these hypotheses in cattle and buffalo, with both experiments using breeds commonly found in India. In addition, a sensory evaluation of the milk was performed to determine whether AFEX treatment had any negative effect on milk flavor.

MATERIALS AND METHODS

Animals

Experimental procedures were approved by the Institutional Animal Ethics Committee and Institute Animal Allotment Committee at the National Dairy Research Institute (**NDRI**) in Karnal, Haryana, India. Studies were performed at NDRI's research farm between October 2016 and January 2017. As a precautionary measure, milk from animals consuming AFEX pellets was not allowed to enter the human food chain other than for the sensory evaluation, which was conducted with the approval of the Michigan State University Institutional Review Board, Human Research Protection Programs.

Forty Murrah buffalo and 40 Karan-Fries cattle were used for these experiments. No animals were pregnant during the course of the study. Animals were blocked by parity (first, second, or third or later lactation) and stage of lactation and randomly assigned within block to 1 of 4 treatments. Buffaloes had an average of 72 DIM (SD 42) and cows had an average of 96 DIM (SD 34) at the start of the trial. Animals were housed in individual tiestalls in a barn, with all animals from each experiment on the same side of the barn. The barn was oriented in a north–south direction, and thus all animals received roughly equal sunlight. Before the experiment, all animals were given ivermectin (100 mg) and fenbendazole (3 g) for deworming (Fendikind-Plus, Mankind Pharma Ltd., New Delhi, India). Animals were milked by hand twice a day at approximately 0600 and 1800 h. Animals were provided with 2 h of exercise in an open area (at approximately 0800 to 1000 h) before being offered the forage for the day. Animals had access to water 3 times per day (after each milking and at approximately 1400 h) by providing a bucket with water and allowing each animal to drink as long as desired.

Diets

Treatments were a nutrient-rich diet with 0 to 20% straw (positive control; **PC**) and 3 high-straw diets with 3 levels of AFEX treatment: (1) 70% untreated straw (no AFEX), (2) 40 to 45% untreated straw with 25 to 30% AFEX-treated straw (low AFEX), and (3) 20% untreated straw with 50% AFEX-treated straw (high AFEX). The AFEX-treated straw was pelleted and the untreated wheat straw was chopped to a particle size of ~4 cm. Urea was added to straw in the no and low AFEX diets to keep these diets isonitrogenous with the high AFEX diet; no attempt was made to make the PC diet isonitrogenous with the high-straw diets, as it was designed to show the animals' potential under optimum nutrition. Diets as consumed are shown in Tables 1 and 2 for buffalo and cattle, respectively, and the composition of the feed ingredients is shown in Table 3. Moisture content of feeds was tested weekly, and composition was tested every other week. For buf-