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The influence of ensiling potato hash waste with enzyme/bacterial inoculant mixtures on the fermentation characteristics, aerobic stability and nutrient digestion of the resultant silages by rams

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ABSTRACT

The present study aimed to evaluate effects of ensiling potato hash (PHW) with enzyme either alone or in combination with bacterial inoculants on the fermentation characteristics, aerobic stability and nutrient digestion using rams. The PHW was mixed with wheat–bran (B) at 80:20 (% fresh matter) and ensiled in 210 L drums for 90 days. The PHWB mixture was treated as: control (untreated), viscozyme, an enzyme containing hemicellulase and pectinase from *Aspergillus spp* (denoted as Visco), Viscozyme + Lalsil fresh LB (*Lactobacillus buchneri NCIMB 40788*) (denoted as E + LAB_1), and viscozyme + silosolve (containing strains of *Lactobacillus plantarum* (DSM 16568), *Enterococcus faecium* (DSM 22502) and *Lactobacillus buchneri* (DSM 22501) (denoted as E + LAB_2). After 90 days of ensiling, PHWB silage samples were collected per treatment and analysed for fermentation characteristics and nutritive values. The PHWB silage was then mixed with ground alfalfa hay at 68:32 (% DM basis) and fed *ad libitum* to 24 (6 rams/treatment) matured South African Dorper rams (39.7 ± 2.21 kg live weight) in a digestibility study. The fibre fractions (aNDF and ADF) and ADL content of PHWB silage were significantly reduced (P < 0.05) in the treated silages compared to the control (306 g aNDF/kg DM and 124 g ADF/kg DM) respectively. Lactic acid content was lowest (58 g LA/kg DM; P < 0.05) in the control compared to the treated silages. The E + Lab_1 treated PHWB silage had lowest (P < 0.05) content of CP (<142 g CP/kg DM) and significantly greater (P < 0.05) content of ammonia-N (>5.3 NH_3-N g/kg TN) compared to other treatments. Acetic acid content was lowest (3.4 g AA/kg DM; P < 0.05) in the Visco treated silage compared to other treatments. This resulted in greater (P < 0.05) CO_2 production (41 g CO_2/kg DM) in the Visco treated silage compared to other treatments when exposed to air. However, the addition lactic acid bacteria (LAB) to viscozyme (E + LAB_1 and E + LAB_2) increased (P < 0.05) the contents of LA and AA and improved silage aerobic stability compared to other treatments. Greater (P < 0.05) intake of DM (1887 g/d) and lower (P < 0.05) digestibility of DM were obtained in rams fed on the control silage diet compared

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to those fed the treated PHWB silage diets. The E + LAB_1 and E + LAB_2 treatments improved ($P < 0.05$) nutrient digestion, nitrogen (N) retention and energy balance in rams compared to control treatment.

1. Introduction

Potato hash waste (PHW), a food by-product that derives from the production of snacks in South Africa, contains nutrients that can benefit livestock production (Nkosi et al., 2010). The production of PHW in South Africa is estimated at 50 tons per day, and if not effectively used, is dumped. However, one of the limitations for the use of PHW in livestock production is its low dry matter (DM) (<200 g DM/kg) content. Charmley et al. (2006) have shown that the production of meal from PHW is technically feasible, but high costs of drying and processing are economic deterrents. Therefore, ensiling can be considered an efficient way of preserving high-moisture by-products such as PHW, provided all basic principles of ensiling are followed (Cao et al., 2009).

The ensiling of PHW cannot be done successfully without the addition of dry resources or absorbents (e.g. ground hay, wheat bran, etc.) to improve its DM content to warrant efficient fermentation. The addition of these resources to PHW will increase the fibre and lower the digestibility of PHW silage, making it less suitable as feed for growing ruminants. Although bacterial inoculants have improved PHW silage fermentation quality (Nkosi et al., 2010), their effects on fibre degradation is not consistent because lactic acid bacteria (LAB) cannot effectively use fibre as an energy source to produce lactic acid. Okine et al. (2007) ensiled potato pulp with a fungal inoculant (*Rhizopus oryzae*) and reported little effect on fermentation quality, with no effect on starch degradation compared to control. The PHW contains high (>500 g/kg DM) levels of starch (Nkosi et al., 2010) that consist of 80–90% water insoluble amylopectin (Green et al., 1975), which cannot be rapidly fermented by LAB alone (McDonald et al., 1991; Petrova et al., 2013).

In addition, PHW contains low levels of water-soluble carbohydrates (WSC) (Nkosi et al., 2010) which might be lost during food processing (Moon, 1981). Consequently, enzymes are added to forage at ensiling to degrade cell walls and increase the availability of WSC to be consumed by LAB (McDonald et al., 1991; Selmer-Olsen et al., 1993). However, the use of enzymes alone during the ensiling of forages has shown to reduce both the digestibility of fibre (Nadeau et al., 2000) and aerobic stability of silage (Weinberg et al., 1993; Nkosi et al., 2012). Therefore, when LAB is combined with enzymes (enzyme/inoculant) during ensiling, a greater effect should be expected because more fermentable sugars will be released enabling LAB to produce more lactic acid. An enzyme/inoculant treatment has been reported to have a positive effect on silage fermentation quality (Kung et al., 1991; Chen et al., 1994; Nkosi et al., 2012), reduced silage fibre content (NDF and ADF) (Weinberg et al., 1993), improved dry matter (DM) and organic matter (OM) digestibility (Cai and Ohmomo, 1995) and N utilization by ruminants (Islam et al., 2001). The present experiment was conducted to study the effect of enzyme alone, or enzyme/inoculant mixtures on fermentation characteristics, nutrient composition, intake, digestibility and N balance in rams fed ensiled PHW.

2. Material and methods

2.1. Fermentation study

Potato hash waste (PHW) was collected from Simba (336 Andre Greyvenstein road, Isando, Gauteng, South Africa), a local food producing factory in South Africa for nutrient analysis, ensiling and a digestibility study with rams. The PHW was mixed with wheat bran (B) (899 g/kg DM, 101 g CP/kg DM, 570 g aNDF/kg DM, 326 g ADF/kg DM) at 80:20 fresh matter to achieve at least 350 g DM/kg. Four treatments were applied prior to ensiling of PHWB mixture. For the first treatment, Viscozyme® (hemicellulase and pectinase from *Aspergillus spp*) a commercial liquid enzyme (Novozyme, Denmark) that contained 120 fungal β-glucanase (FBG)/ml stated activity, was used. An amount of 100 ml enzyme was diluted in 1 l of tap water and sprayed over 500 kg PHWB to obtain 0.024 FBG per g fresh material.

For the second treatment, an enzyme/inoculant mixture (E + LAB) was prepared by mixing 100 ml viscozyme® with 5 g Lalsil Fresh LB inoculant (*Lactobacillus buchneri NCIMB 40788*, Lallemand SAS, Cedex, France), which was dissolved in 1 l water 4 h before application. The solution was used to treat 500 kg PHWB to obtain at least 6×10^5 cfu LAB/g fresh material. The third treatment, another enzyme/inoculant mixture was prepared by mixing 100 ml viscozyme® with 5 g Silosolve AS 200 inoculant (Chr. Hansen Inc., Animal Health and Nutrition, Czech Republic) that contains strains of *Lactobacillus plantarum* (DSM 16568), *Enterococcus faecium* (DSM 22502) and *Lactobacillus buchneri* (DSM 22501). This mixture was dissolved in 1 l water 4 h before application and was used to treat 500 kg PHWB to obtain at least 2.5×10^5 cfu LAB/g fresh material. Application rates of the inoculants were in accordance with the level of LAB in the inoculants as specified by the manufacturers. The fourth treatment (control) was PHWB mixture treated only with the same amount of water as in the additive treated PHWB mixtures. Treatments were control (Cont), viscozyme (Visco), Viscozyme + Lalsil fresh LB (denoted as E + LAB_1), and viscozyme + silosolve (denoted as E + LAB_2).

The treatments were compacted in 210 l drums (4 drums/treatment) which were lined with a double layer of polyethylene, equipped with clamps and weighted down with heavy bricks. The treatments were compacted (822 ± 33.5 kg/m^3) by trampling and the drums were individually sealed after expelling air and stored at 22–25 °C. After 3 months of ensiling, drums were opened and triplicate samples were collected (before mixing with alfalfa)