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ORIGINAL ARTICLE

Evaluating agro-industrial by-products as dietary roughage source on growth performance of fattening steers

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Abstract Silages from pineapple peel, sweet corn husk and cob mixed with bagasse and vinasse were evaluated to determine their chemical composition and fermentation characteristics as well as feeding performance in fattening steers. The experiment, which lasted 90 days, involved 48 fattening steers (264 ± 37.4 kg BW) randomly allocated to three diets. Treatments included: a control diet containing rice straw and molasses (T1); diet containing bagasse–vinasse mixture including sweet corn husk and cob silage (BS; T2); and diet containing bagasse–vinasse mixture including pineapple peel silage (BP; T3). All treatments included a commercial concentrate feed (13% CP) and *ad libitum* rice straw throughout the experiment. Results from chemical analysis showed that dry matter (DM) of BS was higher than BP ($P < 0.05$), whereas the protein content of BS and BP was similar ($P > 0.05$). For fermentation characteristics, pH in BP was lower than BS ($P < 0.05$); in addition, acetic and butyric acids in BS were higher than BP ($P < 0.05$). Findings from growth trial showed that total DM intake in steers fed T1 was higher compared to the other dietary treatments ($P < 0.05$), whereas the average BW gain was found to be grater in T3 steers ($P < 0.05$). As result from our findings, bagasse–vinasse mixture with pineapple peel silage appeared to be a viable feed ingredient in fattening steer diet and moreover it could become an economically feasible agro-industrial by-product for farmers.

1. Introduction

Nowadays the shortage of conventional feeds and fodders in countries from the tropical and sub-tropical regions is well recognized. However, livestock development is taken up in these countries on a large scale in view of its potential as a source of income and employment. Ruminants species play an

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important role in the country economy, being able to digest fibrous material and by-products, these are well suited for recycling such material and providing an additional source of income (Vasta et al., 2008; Tufarelli and Laudadio, 2011). Recent growing interest in utilizing food industrial by-products as animal feed is due to enhanced environmental and economic concerns because most food by-products are environmental waste management problems (Tufarelli et al., 2013). Thus, there is need to explore the use of alternative sources that are more economical in formulating least-cost rations. A simple and low cost option which can preserve seasonally-dependent feeds is to ensile biomass. Total mixed ration silage made by mixing the wet by-products with roughage is in practice at farms in many countries because most food by-products have a high moisture content (Cazzato et al., 2011). This also helps to omit the time of mixing before feeding, minimizes the risk of effluent production and avoids self-selection of feeds by animals (Wang and Nishino, 2008). In addition, unpalatable by-products could possibly be incorporated into a total mixed ration if their odors and flavors were altered by silage fermentation (Xu et al., 2007b).

Ethanol industry which used molasses as raw material can produce vinasse by thermal concentration of dilute vinasse. Vinasse can be used for animal feed ingredient as a source of nutrients and minerals for pigs, poultry and ruminant species (Stemme et al., 2005; López-Campos et al., 2011). The weakness of vinasse is in its low dry matter which is difficult for transportation and storage. Sugarcane is one of the crops which has great potential for capturing solar energy and providing high biomass yield. An approach to utilize sugarcane as ruminants feed includes the use of by-products out of manufacture of sugar like the bagasse. Moreover, bagasse is highly produced from industry processing (Thai Sugar Mill, 2007), and if mixed with vinasse should increase the dry matter content and it could be easily supplied to animals in the form of bagasse–vinasse mixture. However, bagasse is the highly fibrous residue remaining after sugar cane is pressed to remove sucrose (Martin et al., 2007) and results in low protein and high in cellulose (Shelke et al., 2009; Kumari et al., 2013). Therefore, bagasse–vinasse mixture (BV) should increase the bagasse quality. The BV could be used to mix with another agro-industrial by products such as corn cob, corn husk and pineapple peel which can enhance other products in terms of nutritional composition and palatability. As a result, BV could be used as feed source to add in roughage in order to increase feed intake and performance of fattening steers. In spite of the fact that food industrial by-products are common in different countries (Ishida et al., 2012), there are limited published reports and many by-products cannot be quantified because of different equivalents available in the literature. In addition, the nutrient values of food industrial by-products vary widely depending on regions. Therefore, the objective of this study was to investigate the nutritional and fermentation quality of silage from agro-industrial by-products and to determine their effects on the growth performance using fattening steers.

2. Materials and methods

2.1. Animal and diets

Forty-eight Brahman × Thai steers were used in the present study. All steers were 18 months old with an average body weight (BW) of 264 ± 37.4 kg. Animals were randomly allocated to three dietary treatments for 90 days after 14 days of adjustment period before data collection. Treatments included: a control diet containing rice straw and molasses (T1); diet containing bagasse–vinasse mixture including sweet corn husk and cob silage (BS; T2); and diet containing bagasse–vinasse mixture including pineapple peel silage (BP; T3).

For silage preparation, the bagasse and vinasse (BV) mixture was made using bagasse from sugar industry by-product and vinasse from the ethanol plant. The BV mixture was mixed at the ratio 70:30 of vinasse and bagasse, respectively. The BV was further mixed with sweet corn husk and cob silage or mixed with pineapple peel silage and considered, respectively. All dietary groups were opened and feed samples were weekly collected and analyzed for chemical composition and fermentation characteristics. Each groups received also a commercial concentrate feed (13% CP) twice a day (2 kg at 6.00 a.m. and 3 kg at 16.00 p.m., respectively). Steers were fed *ad libitum* roughage and supplemented with rice straw and molasses (Table 1). The feed consumed by steers within each group were calculated based on nutrient requirements for maintenance and production (NRC, 2001). In addition, fresh water from individually automatic bowl and mineral block were available all the time. Body weight of each steer was recorded at the beginning of the trial period and after 90 days. Feed conversion ratio was calculated as the ratio of BW gain to DM intake. Feed refusals were collected, weighed and individually bulked for analysis. Samples of refusals and feeds offered were dried at 105 °C for 24 h to determine the intake.

2.2. Chemical analysis

Samples of feeds were ground in a hammer mill with a 1 mm screen and analyzed in triplicate for dry matter (DM, 945.15), ash (967.05), crude protein (CP, Kjeldahl N × 6.25, 990.03), crude fiber (962.09), ether extract (945.16) according to AOAC (1990). The neutral detergent fiber (NDF using heat-resistant α-amylase without sodium sulfite), acid detergent fiber (ADF) and acid detergent lignin (ADL) were analyzed according to Mertens (2002), AOAC (1990) (973.187), and Van Soest et al. (1991), respectively, using the sequential procedure and the filter bag system (Ankom Technology, New York). The NDF and ADF fractions include residual ash. N-free extract was calculated by difference. Hemicellulose and cellulose were also estimated as NDF (ash free) − ADF (ash free) and ADF (ash free) – ADL (ash free), respectively

Table 1 Chemical composition of the concentrate, rice straw and molasses used in the feeding trial (% on DM basis).

Items	Concentrate	Rice straw	Molasses
Dry matter	90.68	90.00	78.98
Crude protein	13.11	2.76	4.06
Ether extract	2.50	2.00	0.55
Ash	5.82	14.54	8.62
Crude fiber	14.56	38.13	0.01
Acid detergent fiber (ADF)	25.43	55.00	–
Neutral detergent fiber (NDF)	44.23	79.00	–
Calcium	1.01	0.40	–
Phosphorus	0.33	0.25	0.06
Gross energy (kcal/kg)	3729	3320	3683