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Nutritional value of biofuel residues from beet evaluated in sows and sheep

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ABSTRACT

An alternative substrate in the biogas or bioethanol production may be the sugar containing juice obtained after fractionation of beets into a juice used for fermentation and into a pulp used for feeding. The objective of the present experiment was to evaluate the fresh pulp of top and root from sugar (*Angus*) and fodder (*Colosse*) beets as feed for pigs and ruminants. The pulp was prepared by a cold mechanical pressing. Two digestibility experiments were carried out according to the difference method. In experiment 1, 30 sows were housed individually in metabolic cages for 12 d, and urine and feces were collected during the last 7 d. The daily ration consisted of either root or top pulp combined with a basal diet. In experiment 2, 25 wethers were housed individually, and feces were collected during the last 7 d of the experiment. The daily ration was either root or top pulp combined with hay. The chemical composition of the pulp of the 2 beet varieties varied only little. However, the top fraction contained more ash (150 *vs.* 34 g/kg DM), crude protein (175 *vs.* 53 g/kg DM) and total dietary fibre (460 *vs.* 206 g/kg DM) compared to the root fractions. The *in vitro* and the apparent digestibility of sows and wethers were higher for root pulp than for top pulp, whereas there were no differences between the two beet varieties. The fresh root pulp may be considered a good energy source for both sows and ruminants, whereas the fresh top pulp may serve as a satiety-enhancing feedstuff for sows. The protein value of both root and top pulp is considered to be low.

1. Introduction

The production of biomass such as maize for energy purposes limits the land area available for feed and food production. The beet production for use as feedstuffs for ruminants has almost given way to the growing of maize in Denmark during the last two decades. However, sugar and fodder beets have a potential yield of up to 30–40,000 kg root and top DM/Ha depending on the variety (Pedersen, 2009). This yield is much higher than that of maize, but when used only as a feedstuff for ruminants, the profit is diminished by high handling costs. Furthermore, in order to achieve the 20% biofuel target, the energy production will become an integrated part of agriculture. In order not to have a severe effect on the food and feed production, it may be important to combine the energy production with the food production. The aim is to achieve multiple products from the same crops, preferable with synergistic effects. It is possible to extract the juices from both the beet

Abbreviations: A, *Angus*; AAT, intestinal absorbable amino acids; ADFom, acid detergent fibre; C, *Colosse*; ME, metabolizable energy; aNDFom, neutral detergent fibre; NSP, non-starch polysaccharides; PBV, protein balance in the rumen.

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Table 1
Composition of the basal diet for sows.

Ingredients	g/kg as-fed
Barley	747.6
Soybean meal, toasted	80.9
Wheat bran	50.0
Green grass meal	50.0
Molasses, beet	30.0
Fat	20.0
Calcium carbonate	11.0
Monocalcium phosphate	6.2
Sodium chloride	2.3
Vitamin/mineral premix[a]	2.0

[a] Providing per kg diet: 262 mg calcium; 100 mg zinc; 84 mg iron; 58 mg sulphur; 42 mg manganese; 15 mg cobber; 11 mg potassium; 0.21 mg iodine; 0.3 mg selenium; 84 mg vitamin E; 21 mg niacin; 10.5 mg D-pantotenic acid; 2.1 mg vitamin B_1; 2.1 mg vitamin B_2; 3.1 mg vitamin B_6; 0.02 mg vitamin B_{12}; 0.05 mg biotin; 2.1 mg vitamin K_3; 4200 IU vitamin A; 420 IU vitamin D_3.

root and the top of sugar beets achieving a sugar rich stream suitable for either the ethanol or methane fermentation or a combination of both. A scenario where the beets are fractionated into compounds with a collective higher value can be accomplished by using the sugar containing juice fraction for *e.g.* biogas or bioethanol production and the remaining fibrous fraction as feedstuff for ruminants or sows. A low-technology processing technique may be a prerequisite if the bioenergy production is to take place on small farm-based plants. This means that the transportation of raw materials and products can be limited. From a sustainability point of view it is not feasible to transport biomass with a relatively low energy content over large distances for processing – let alone to transport both products and residues that are very often used as fertilizers for farmland back to the farms. In general, the cost of transporting the biomass is higher than the cost of transporting its energy products (Searcy et al., 2007). Hence, small decentralized “on-farm biorefineries” co-producing fuel, feed and fertilizer based on sugar rich crops such as sugar beet may be a promising alternative or supplement to the large centralized lignocellulosic plants co-producing bioethanol and electricity. At present, all technologies are available, and all that needs to be clarified before the production can begin is the combination and scaling of techniques.

The present experiment is part of a larger program set up to evaluate the overall economical potential in a continuous low-technology on-farm bioenergy production with a local and instant use of the fresh residuals in the animal production.

Dietary fibres for pigs are interesting as a source of energy and because of welfare aspects (De Leeuw et al., 2008). An aggressive behavior among sows is believed to be caused by restrictive feeding. *Ad libitum* feeding of roughage such as beet pulp might alleviate behavioral problems, as the sows change feeding behavior (Brouns et al., 1997). Furthermore, pigs must be provided with roughage *ad libitum* in the European organic production (Council Regulation, 2007).

This research was conducted with the aim of evaluating pressed top and root fractions from sugar and fodder beets as roughage for ruminants and sows. This was addressed by *in vitro* studies and digestibility studies using sheep and pregnant sows.

2. Materials and methods

2.1. Pulp preparation

The experimental diets were similar for sows and sheep and consisted of 4 types of pulp: Root A (root of *Angus* sugar beet), Root C (root of *Colosse* fodder beet), Top A (top of *Angus* sugar beet) and Top C (top of *Colosse* fodder beet). The varieties were chosen because of their high yield and smooth surface. The top and root were harvested separately. The top was stored at −20 °C, and the root was washed and stored at 5 °C until processing. The pulp was prepared by a cold mechanical pressing of the thawed and cut beet fractions at 4 bars until the flow of liquid subsided. The yield of juice was between 340 and 520 g/kg. The pulp was prepared in 18–27 preparation batches per type and mixed in a globe mixer. A sample was taken from each preparation batch, and a collective representative sample was taken for analysis. Based on previous experiences with roughage fed to sows (Jørgensen et al., 2010) and sheep (Hartnell et al., 2005), daily rations were packed in amounts known give minimum feed residuals and were stored at −20 °C.

2.2. Experiment 1

A total of 30 sows in parity 3–6 were used in the experiment. The sows were diagnosed pregnant on d 28 after insemination and were subsequently assigned 5 different experimental diets according to their weight. The basal diet was optimized according to the Danish recommendations (Jørgensen and Tybirk, 2008) for amino acids and minerals (Table 1).

The sows were fed the experimental diets for 12 d while housed individually in stainless steel metabolic cages with slatted flooring and collection trays. The digestibility study was carried out after the difference method, feeding the sows either one of the experimental diets combined with a basal diet or the basal diet alone. After 5 d of adaptation, all sows were fitted with urine bladder catheters allowing separate collection of urine and feces for 7 d. Containers for urine collection were acidified