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ScienceDirect
Small Ruminant Research 70 (2007) 292–296
Small Ruminant Research
www.elsevier.com/locate/smallrumres

Technical note

Evaluation of the phytosanitary, fermentative and nutritive characteristics of the silage made from crude artichoke (*Cynara scolymus* L.) by-product feeding for ruminants

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Received 3 October 2005; received in revised form 8 May 2006; accepted 15 May 2006
Available online 11 July 2006

Abstract

The crude by-product left after industrial processing of artichoke (*Cynara scolymus* L.) was ensiled in microsilos and sampled at different times. To evaluate its suitability as animal feed, various fermentative, chemical and phytosanitary parameters were determined. The by-product showed a good aptitude for ensilage, having a pleasant smell and good visual characteristics. The DM content was 297 g kg^{-1}, and no effluents were detected. It stabilized after 12 days of ensiling and showed a pH value of 4.1 at the end of the process. Only small losses were detected in its chemical value after the ensiling period. Prometryn was the only phytosanitary product found at day 0 (0.04 ppm a concentration below the maximum amount permitted by law), but was not detected after 12 days of ensilage. It is concluded that the silage by-product can be used as animal feed.

Keywords: Artichoke; Silage; By-product; Phytosanitary product

1. Introduction

Increases in the world's population mean that food production must also increase. If unwanted materials and sub-products can be used as animal feed, they will represent no competition with human consumption, although it must be ensured that the products are healthy to animals and do not increase environmental pollution. In light of this, an interesting range of vegetable by-products can be considered.

Using the by-products from the vegetable processing industry as animal feed is an economical and environmentally sound way for food processors to decrease waste discharges and to reduce waste management costs. The sale of by-products can also generate additional revenue. Livestock producers can save money if the by-products offer a less expensive source of nutrients than traditional feeds and if they permit acceptable animal performance (Megías et al., 1998). To estimate whether a material is appropriate for animal feeding, farmers must take into consideration several factors, including

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doi:10.1016/j.smallrumres.2006.05.008

the type of by-products, unevenness in the nutrient and moisture content, storage, the potential growth of molds and related mycotoxins, and/or the probable presence of chemical or physical contaminants (insecticides, herbicides, bactericides and fungicides, glass, plastic, sticks, etc.). At the present time, the use and presence of phytosanitary products is of great interest for farmers and consumers in the case of intensive crops like artichoke.

The traditional problems encountered with by-products are the seasonality of supply and their high moisture content which means that spoil and are often wasted. Ensilage is usually the most appropriate way for preserving such by-products for long periods. Silages may be defined as moist forage in the absence of air and preserved by fermentation (McDonald et al., 1991). During ensilage, lactic acid bacteria ferment carbohydrates of the forage, producing volatile fatty acids and lactic acid, which lower the pH and so help conserve the material.

Different studies have pointed to the good quality of artichoke wastes. This by-product must provide an answer to the three important questions: Is it necessary to ensile it? Is there sufficient quality and quantity of them to ensile? And are good the conditions to make silage? (Mannetje, 1999). However, to complete ours knowledge this study was carried out to ascertain the ensiling capacity, chemical composition and, specially, the phytosanitary state of fresh artichoke (*Cynara scolymus* L.) by-products for use as ruminant feed.

2. Materials and methods

The material studied was the crude artichoke (*C. scolymus* L.) by-product left over after the industrial processing of artichoke hearts. The material was obtained from the first stage of the industrial process, when the artichoke was cleaned by hand, and mainly consisted of the outside bracts and stems. In the laboratory the materials were placed in eight polyethylene containers of 12.5 l capacity. These were filled and sealed, except for a small opening at the base, which was sealed because there was no seepage.

The containers were individually opened and sampled after 1, 2, 3, 4, 8, 12, 24 and 50 days. Day 0 corresponds to the initial material before ensiling. Three samples were taken from the top, centre and bottom of each ensiled mass and were frozen at −20 °C until analysis. Their chemical composition was determined as followed (Megías et al., 2002). Silage suitability was determined by taking measurements with a pH-meter. The method described by Barnett and Millar (1950) was used for determining the water-soluble carbohydrates (WSC) content. Lactic acid and the amount of ammonia-N were measured as described by Madrid et al. (1999a) and Chaney and Marbach (1962), respectively. The level of volatile fatty acids (VFAs) was determined in water extracts of fresh silage by capillary gas chromatography as described by Madrid et al. (1999b).

The samples were analysed for phytosanitary products (insecticides, herbicides, bactericides and fungicides) at 0, 4, 12 and 50 days. The phytosanitaries studied were diazinon, chlorpyrifos methyl, fenitrothion, quinalphos, prometryn, myclobutanil, penconazole, pendimethalin, triadimefon, using gas chromatography with electron capture detector (ECD) or nitrogen–phosphorus detector (NPD). The concentrations were estimated by the retention times and comparing the detector signals; the multiresidue concentrations were then obtained in ppm. The methods used are described by Oliva et al. (2000) and Navarro et al. (2000), respectively.

Analyses of variance were performed following the procedures described for comparing the fermentative and chemical values obtained after different ensilage times (Steel et al., 1996).

3. Results and discussion

3.1. Fermentative and nutritive evaluation

Table 1 shows the chemical and fermentative composition of the raw artichoke materials during the 50 days of ensiling. The artichoke by-product showed a good aptitude for ensiling, and the end-product had a pleasant smell and good visual characteristics. The process produced no significant differences in pH (4.96) after the first 8 days of ensiling. Values of pH obtained in our study classified the silage as good quality for silages with 300 g kg^{-1} of DM, according with recommendations based on DM content from Keady and Murphy (1998). The low pH obtained which is usually accomplished through the fermentation of sugars in the crop to lactic acid by lactic acid bacteria, decreases plant enzyme activity and prevents the proliferation clostridia and enterobacteriae (Woolford, 1984).

During the ensiling process, the artichoke by-product showed a steady increase in lactic acid concentration until day 24 (31.5 g kg^{-1} DM), after which it decreased to reach 19.8 g kg^{-1} at the end of the experiment. The values obtained are near the lowest limit considered as very best for good silage (McDonald et al., 1991). Lactic acid is the most effective acid for reducing silage pH, thereby conserving the high quality of the forage. Ensiled forages with the high lactic acid concentrations tend to be