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Aerobic exposure of grass silages and its impact on dry matter intake and preference by goats

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ABSTRACT

The effect of aerobic exposure of grass silages on short-term feed intake and preference by goats was studied. Eight grass silages differing in dry matter (DM) (25% and 33%), chop length (short and long) and compaction pressure at ensiling (0.1 MPa and 0.2 MPa) were exposed to air for eight days. Chemical analyses were conducted in 2-day (d) intervals (d0, d2, d4, d6 and d8 after silo opening) for proximate constituents, fermentation products and other volatile compounds as well as determination of microbiological status (yeasts, moulds and aerobic mesophilic bacteria). Furthermore, d0- to d8-silages were stored anaerobically in vacuum-sealed plastic bags for use in preference trials. After aerobic exposure, eight preference trials with Saanen-type wethers ($n = 5$) were carried out, where each possible two-way combination of silages and a standard hay ($n = 15$) was offered for 3 h. Data were analyzed using the SAS procedure Multidimensional Scaling, analysis of variance and correlation analysis between silage characteristics and DM intake (DMI). All silages were aerobically stable during the examination time. In trials with 33% DM-silages, DMI decreased at d6 or d8 (in each of two trials) of aerobic exposure. Silage that had been exposed to air for 8 d was avoided in each case with a reduction (mean ± standard deviation) of 50 ± 6.7% in comparison to the freshest silage. Low-DM silages showed signs of malfermentation with higher concentrations of butyric acid and ammonia-nitrogen (NH_3-N). Both DMI and the impact of aerobic exposure on DMI were lower. Mean decrease in DMI after 8 d of aerobic exposure was 20% (±11.0%). Products from protein and amino acid degradation (NH_3-N, butyric acid) were negatively correlated to DMI ($r = -0.55$ and -0.59; $P < 0.001$). It was concluded that in well-fermented silages, aerobic exposure for a length of time that is of practical relevance does have a negative impact on short-term DMI and preference by goats, even if silages are at an apparently low stage of deterioration. It is assumed that goats can detect subtle differences caused by aerobic exposure, sometimes even before an increase in temperature or changes in chemical composition occur. After a 1-d exposure of each variant, goats were able to differ between forages and showed preference or avoidance for different silages, with a high correlation between initial and total DMI. Therefore, results showed the potential for 30 min measurements in short-term preference trials, as goats remember post-ingestive feedback from the adaptation period.

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1. Introduction

Grass silage is a major forage used in ruminant feeding, but due to the impact of crop management and weather, strong variations of the nutritional value and fermentation quality can occur (McDonald et al., 1991). Both of them can have a strong impact on feed intake (Forbes, 1995). During storage or feed-out, oxygen ingress into the silage can cause dry matter (DM) and nutritional losses and also increase the risk of proliferation of potentially pathogenic or otherwise undesirable microorganisms (Driehuis and Oude Elferink, 2000). The changes occurring during the aerobic feed-out phase are equally as important as those taking place in the anaerobic storage phase from the viewpoint of preserving nutrients and maintaining good quality until fed to the animal (Wilkinson and Davies, 2013). Furthermore, the activity of aerobic spoilage organisms may lead to changes in the composition of volatile compounds and therefore affect fermentation quality. Huhtanen et al. (2002) showed that variation in fermentation quality affects voluntary feed intake of cattle. However, it is difficult to attribute changes in DM intake (DMI) to a single fermentation product as some of them are strongly interrelated (e.g. ethanol and the ethyl esters of acetate and lactate (Weiß and Auerbach, 2012)). Mo et al. (2001) identified more than 50 different fermentation products in grass silages. Since a majority of them, especially esters, are known to be odorous, they all may have (to a greater or lesser extent), an effect on the smell and taste of feed and, consequently, feed intake. For unspoilt silages, attempts have been made to find a relationship between silage quality and intake (Huhtanen et al., 2003; Eisner et al., 2006; Krizsan and Randby, 2007). However, composition of volatile compounds may change as a result of aerobic spoilage, which often occurs after few days of oxygen ingress.

The aim of this study was to determine the effect of aerobic exposure of grass silages on short-term DMI and preference by goats.

2. Materials and methods

2.1. Preparation of silages

Italian ryegrass (*Lolium multiflorum* L.) was cultivated at the research station Frankenforst of the University of Bonn, Germany (7°12′ E and 50°42′ N; 2010: average temperature, 9.3 °C; annual precipitation, 635 mm; average humidity, 72.3%). Grass was cut in the morning (10:00) at June 20, 2010 and wilted on the field. To achieve two different levels of DM concentration, one part was harvested and ensiled the same day in the afternoon; the other part was wilted on the field and ensiled the next day at midday. Eight silage treatments (2 × 2 × 2-factorial design) were produced differing in DM concentration, chop length (short: chopped by knives in the self-loading wagon; long: unchopped) and compaction pressure at ensiling (0.1 and 0.2 MPa). Details about the treatments are presented in Table 1 and following abbreviations are used: S = short chopping length, L = long chopping length, 33 = 33% DM, 25 = 25% DM, lo = low packing density, hi = high packing density.

Grass of both DM stages before ensiling was sampled for laboratory analyses. Each treatment was ensiled in six 120-l plastic barrels using a forklift piler with two concrete weights (1.8 t and 3.6 t) for two different levels of compaction of the forage. Anaerobic storage time in the barrels ranged between 11 and 16 months. Before starting the first trial, packing density of all silages was determined by weighing the filled barrels in April 2011.

In May 2011, the barrels containing the first two treatments were opened; the silages were taken out, each treatment was thoroughly homogenized by mixing the content of all six barrels, and stored aerobically on a heap (3 m × 3 m) for 8 d. This aerobic exposure followed by a preference trial was done with each of the eight treatments during 2011, the last trial started in November, so that a maximum of six months was allowed between opening of first and last barrel. All the aerobic exposure trials were conducted indoor with a continuous measurement of ambient temperature (data logger 175-T1, Testo, Lenzkirch, Germany). At the day of opening (d0) and at 2-d intervals (d2, d4, d6 and d8 after opening) temperature of the material was measured in a depth of 20 cm at three different points in the silage heap (middle, left, right, 1 m distance between measurement points) using a digital probe thermometer (TFA Dostmann, Wertheim, Germany); afterwards the silage was homogenized completely. Furthermore, boxes ($n = 3$) for aerobic stability tests proposed by Honig (1990) were filled with 300 g of silage and the temperature was measured in the same interval. Aerobic stability was defined as the number of days the silage remained stable before rising more than 3 K above the ambient temperature (Honig, 1990). For chemical analyses, a composite sample (1000 g) of each silage heap was taken at the respective sampling days and frozen immediately (−18 °C). Another sample (50.0 g) for determination of fermentation variables was taken and also frozen.

For subsequent use in the preference trials with goats, samples of the homogenized silage heap from each day of the aerobic exposure (d0, d2, d4, d6 and d8) were stored anaerobically in polyethylene bags (170 μm, 400 mm × 600 mm; Innovapac, Durach, Germany), which were evacuated and sealed with a chamber vacuum-packing machine (MAX-F 46, Helmut Boss Verpackungsmaschinen, Bad Homburg, Germany). For each meal for each goat a single bag was used which was filled with 1.5–1.7 kg silage (requirements + reserve = 60 bags per day and treatment). Bags were stored in a dark, dry and cool room (15 °C) until used in the preference trial. Storage time of the silages in the vacuum bags ranged from 5 to 26 d depending on the day when fed. The time difference was randomly allocated to treatments, as each treatment was fed at each day of the preference trial.

2.2. Preference trials

For each of the eight silage treatments, a preference trial was done at the Institute of Animal Science, University of Bonn, starting directly after the aerobic storage period described above. A total of ten Saanen-type wethers (German Improved White Goat breed, mean (SD) body weight 90.8 (12.35) kg) were used which were divided into two