Available online at www.sciencedirect.com

SCIENCE DIRECT®

Animal Feed Science and Technology
127 (2006) 101–111

ANIMAL FEED
SCIENCE AND
TECHNOLOGY

www.elsevier.com/locate/anifeedsci

Effect of ensiling technology on protein degradation during ensilage

David Slottner*, Jan Bertilsson

Kungsängen Research Centre, SE-75323 Uppsala, Sweden

Received 5 November 2003; received in revised form 7 September 2004; accepted 11 October 2004

Abstract

The object of this experiment was to examine the difference in fermentation pattern and protein breakdown when a crop is ensiled in large, round bales or precision-chopped and ensiled in a steel silo. Potential differences in effects of additives between bales and silos were also of interest. A second cut of a grass ley was cut with a mower-conditioner and wilted to ~300 and 400 g dry matter kg^{-1}. The crop was then ensiled in large, round bales or chopped and ensiled in small 25 L stainless-steel silos. The herbage was either ensiled without additive or with addition of Kofasil® Life, an inoculant, to supply 10^5 or 10^6 CFU g^{-1} fresh matter (FM) in 3.5 L water t FM^{-1}, formic acid (6 L t FM^{-1}), Proens™ (6 L t FM^{-1}) or Kofasil® Ultra (4 L t FM^{-1}). After 100 days, the silages were weighed, bales were inspected, and bales and silos sampled. All silages were well fermented without butyric acid or excessive amounts of ammonia. The inoculants increased the production of lactic acid and resulted in the lowest pH of the treatments. Chemical additives reduced fermentation and Kofasil® Ultra resulted in as high or higher pH than the control. Slightly less water-soluble N (WSN) was found in baled silage as compared to silage made in silos. Increasing the dry matter content and using additives, reduced proteolysis and formation of amino acids during ensilage.

Keywords: Ensiling; Silos; Bales; Additive; Protein degradation

---

Abbreviations: CFU, colony forming units; CP, crude protein; DM, dry matter; FM, fresh matter; LAB, lactic acid bacteria; NPN, non-protein nitrogen; S.E.M., standard error of mean; TCA, tricloro acetic acid; TP, true protein; Tot-N, total nitrogen; VFA, volatile fatty acids; VOS, in vitro digestible organic matter; WSC, water-soluble carbohydrates; WSN, water-soluble nitrogen

* Corresponding author. Tel.: +46 18671635; fax: +46 18671988.
E-mail address: david.slottner@huv.slu.se (D. Slottner).

0377-8401/$ – see front matter © 2006 Published by Elsevier B.V.
doi:10.1016/j.anifeedsci.2004.10.007

1. Introduction

In the growing plant, approximately 0.75–0.90 of the N is in the form of true protein (TP). In silage, this figure is more likely to be 0.30–0.50. The main cause of this is not microbial but enzymatic activity in the plant before ensiling (Kemble, 1956). These plant proteases have different functions and individual species have different optimal pH and different stability regarding pH and temperature (McKersie, 1981, 1985 and Jones et al., 1995). Microorganisms do play a role, however, but it is not yet determined as to what extent (Winters et al., 2002).

There are four main factors that determine the rate of proteolysis during ensiling: dry matter content (DM), pH, temperature and the presence of different inhibitory compounds. A higher DM often results in less proteolysis (Hristov and Sandev, 1998, Muck et al., 1996). According to Muck et al. (1996), DM and pH are the most important factors affecting proteolysis in a given species and even a slight increase in DM can have a large impact on the rate of proteolysis (Pitt et al., 1985). Wilting does not always improve the protein quality however. Papadoupulus and McKersie (1981) found that a wilting from ca. 0.20–0.30 DM in 24 h actually increased proteolysis. In other studies, the rate of proteolysis has been unaffected by wilting from 0.27 to 0.50 DM (Muck et al., 1996). The reason for this is mainly assumed to be a slower decline in pH in drier silages (Muck et al., 1996). Bergen (1975) found, that in alfalfa silages, the water-soluble non-protein nitrogen (NPN) fraction was reduced from 0.545 of total N to 0.362 and 0.178 when DM was increased from 0.225 to 0.445 and 0.800, respectively. The effect was not as pronounced in corn silages when DM was increased from 0.317 to 0.845. Other studies indicate a larger proportion of the N being soluble in hot water if the crop is wilted before ensiling (Makoni et al., 1991), but the in situ rate of protein degradation in the rumen, was lower for the wilted silage.

The pH of silage is very important for proteolysis. It has been assumed that a pH under 4 will totally inhibit proteolysis (Virtanen, 1933), but in trials with gamma-irradiated grass, Heron et al. (1989) found that the lowest activity was at a pH of ca. 3. Lower pH than that does not seem to have positive effects, since acid hydrolysis will occur (Heron et al., 1989). The optimal pH seems to vary between species. According to Jones et al. (1995), the optimal pH for the proteases is 5.5 in both alfalfa and red clover but McKersie (1985), found that the optimal pH for alfalfa was 6.5 and 7 for red clover. The optimal pH for proteolysis in rye grass seems to be ca. 6, but also to be dependant on temperature (Heron et al., 1989).

Low application rates of acids do not seem to give as favourable results. Davies et al. (1998), found that using lactic acid bacteria (LAB) reduced the proteolysis more than the use of formic acid ton at 3 L FM^{-1}. The reason for this is possibly the rapid acidification that takes place after inoculation. In this case, an application of 3 L formic acid t^{-1} FM reduced the pH to 5. After 2 days, it was still ca. 5, but by then, the pH of the inoculated silage was ca. 3.7. Fairbairn et al. (1992), found that the application of 4.5 L formic acid ton FM^{-1} reduced proteolysis in alfalfa, but not in maize silage, during ensiling. The pH of untreated silages may explain this difference. After 90 days, pH was lower in the untreated maize silage than in formic acid-treated silage, but for alfalfa, pH was lower in the treated silage.

It has been suggested that formic acid can have an effect similar to formalin, but Carpintero et al. (1979) used sulphuric and formic acid to reduce the pH of the silage,