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# Effects of wilting and lactic acid bacteria inoculation on fermentation quality of white lupin and fababean silages

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**ABSTRACT:** Fababeans and lupins are short-term catch crops with a high crude protein content, which provide a high forage yield in a short growing period. Legumes are difficult to conserve as silages because of their low water soluble carbohydrates content (WSC) and high buffer capacity. To our knowledge, little information is available on the ensiling of fababeans and lupins in Southern Europe. The research was carried out in Lodi (Italy) in order to evaluate the effects of wilting and inoculation with lactic acid bacteria (LAB) on fermentation characteristics of the resulting silages. The data show that both wilting and LAB inoculant significantly improved fermentation quality of the legumes silages.

**Key words:** Grain legume, Ensiling, Lactic acid bacteria, Wilting.

**INTRODUCTION** – The use of grain legumes like fababeans and lupins offers a possibility to increase the protein self-sufficiency in dairy farms throughout Europe. Ensiling pulses as a whole-crop forage, could supply a source of protein and starch for livestock, allowing a minimal feeding of purchased concentrates (Adesogan *et al.*, 2004). Pulses are characterised by high moisture content at cutting and relatively high buffering capacity (Borreani *et al.*, 2006; Fraser *et al.,* 2001, 2005), making pulses unsuitable for direct ensiling as whole-crop in early stages of growth. The research was carried out to evaluate i) the possibility of a successful harvesting by ensiling of fababean and white lupin, and ii) the effects of wilting and inoculation with LAB on fermentation characteristics of fababean and lupin silages.

**MATERIAL AND METHODS** – The trial was carried out in 2003 in Lodi (northern Italy) under ordinary growing conditions. Two grain legume species, fababean (*Vicia faba* var. *minor* cv Vesuvio) and white lupin (*Lupinus albus* L. cv Gamma) were sown in late winter. White lupin was harvested at two subsequent stages of growth (end of May, mid June) due to the late development of the crop. Herbage samples for the yield and quality measurements were collected with a forage mower and chopped with a slicer to a length of 20 to 30 mm. The herbage was directly ensiled (UW) or wilted (W) in the field for about 6 hours. Two effects were studied: wilting and inoculation with (I) or without (C) a LAB inoculant. Furthermore the effect of stage of growth was studied for lupin.
Chopped herbage was ensiled in sterile, 2-litre laboratory glass silos. The inoculant treatment was applied by spraying 50 ml of water suspension onto 10 kg of herbage at a rate of $10^6$ colony forming units (CFU) of *Lactobacillus plantarum* per gram of fresh matter (strain of *Lactobacillus plantarum*, CSL, Italy, for legume crops). Three replications were performed at each wilting level of the I and C treatments. The silos were weighed immediately after being filled. During conservation the silos were consecutively weighed at 1, 4, 7, 14, 21, 31, 45, 61, 76, 90 111, 130 d and at the end of the conservation period (145 d) to estimate the fermentation losses. The herbage and silage samples were analyzed to determine: DM, crude protein (CP), Ash, NDF and ADF content. Silage samples were analyzed to determine: pH, ammonia nitrogen ($NH_3$-N) content, lactic and monocarboxylic acids (acetic and butyric acids) (Canale *et al.*, 1984). The chemical compositional data were analysed for their statistical significance via analysis of variance, with their

significance reported at a 0.05 probability level using the general linear model of the Statistical Package for Social Science (v 11.5, SPSS Inc., Chicago, Illinois, USA).

**RESULTS AND CONCLUSIONS** – Table 1 shows the chemical composition of wilted and unwilted herbage of the fababean and lupin at ensiling. NDF, ADF and CP concentrations of the white lupin were unaffected by harvest date. CP content was lower in fababean than in white lupin, while NDF and ADF concentrations were comparable within species. Fiber and CP values obtained during the present study were consistent with those reported by Fraser *et al.* (2001) for fababean cut at first pod set and by Fraser *et al.* (2005) for white lupin cut at young green pod. Following a 6 hours wilting, the DM content of the fababean increased from 277 to 330 g kg$^{-1}$, while the DM content of lupin increased from 142 to 173 g kg$^{-1}$ and from 130 to 212 g kg$^{-1}$ for the first and second stage of growth, respectively. In lupin the increase in DM content after wilting was higher at the second cut, due to better weather conditions during field wilting.

Table 1. Chemical composition at harvest of the fababean and lupin wilted and unwilted herbage.

| Species | Stage | DM yield (t ha$^{-1}$) | Wilting | DM (g kg$^{-1}$) | Ash (g kg$^{-1}$ DM) | CP (g kg$^{-1}$ DM) | NDF (g kg$^{-1}$ DM) | ADF (g kg$^{-1}$ DM) |
|---|---|---|---|---|---|---|---|---|
| Fababean | I | 11.2 | UW | 277 | 71.6 | 194 | 354 | 311 |
| | | | W | 330 | 73.7 | 185 | 364 | 329 |
| Lupin | I | 5.9 | UW | 142 | 90.8 | 239 | 363 | 308 |
| | | | W | 173 | 86.1 | 239 | 338 | 309 |
| | II | 7.3 | UW | 130 | 66.4 | 229 | 369 | 309 |
| | | | W | 212 | 66.1 | 235 | 373 | 310 |

The fermentation characteristics and the CP content of the silages after 145 days of conservation are given in Table 2. The DM content of the silages made from unwilted herbage ranged from 110 g kg$^{-1}$ of white lupin to 268 g kg$^{-1}$ of fababean, and from 136 of white lupin to 316 g kg$^{-1}$ of fababean in silages made from wilted herbage. Significant differences in white lupin CP content were found between inoculated silages vs not inoculated.

Table 2. Fababean and lupin fermentation characteristics (g kg$^{-1}$ DM) of the silages in the control (C) and inoculated (I) treatments at two wilting levels.

| Species | Stage | Wilting | Inoc. | DM | pH | CP | $NH_3$-N | Lactic acid | Acetic acid | Butyric acid | DM losses |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Fababean | I | UW | C | 252a | 5.25d | 190 | 178b | 21a | 28b | 50d | 134c |
| | | | I | 268a | 4.91c | 193 | 67a | 18a | 8a | 22c | 48b |
| | | W | C | 316b | 4.61b | 194 | 48a | 23a | 10a | 12b | 57b |
| | | | I | 315b | 4.31a | 188 | 52a | 30b | 12a | 2a | 28a |
| | | | SE | 8.8 | 0.11 | 2.58 | 17.6 | 1.48 | 2.5 | 5.5 | 12.2 |
| Lupin | I | UW | C | 110a | 5.48b | 190a | 618b | 40b | 79b | 165b | 275b |
| | | | I | 152bc | 3.72a | 255b | 141a | 119d | 14a | 0.1a | 35a |
| | | W | C | 136ab | 5.50b | 168a | 560b | 32a | 62b | 135b | 286b |
| | | | I | 169c | 3.80a | 251b | 159a | 111c | 18a | <0.01a | 55a |
| | | | SE | 7.1 | 0.26 | 12.0 | 69.1 | 12.0 | 9.2 | 23.3 | 37.7 |
| | II | UW | C | 125a | 5.47c | 169a | 614b | 35a | 56 | 147b | 289c |
| | | | I | 170b | 3.71a | 238b | 175a | 102c | 13 | 1a | 41a |
| | | W | C | 189c | 3.95b | 256b | 177a | 78b | 12 | 3a | 68b |
| | | | I | 195c | 3.77a | 250b | 168a | 95c | 13 | <0.01a | 37a |
| | | | SE | 9.3 | 0.26 | 12.6 | 68.6 | 9.4 | 8.0 | 22.5 | 37.2 |

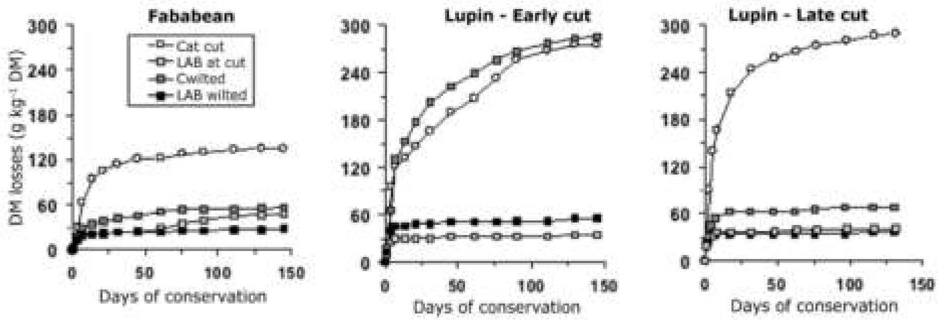
*Within columns, species and stages, means followed by a different letter are significantly different at the 0.05 probability level; values lower than 0.01 were set to 0.01 for statistical analysis.*

Lactic acid content was affected by wilting in fababean and by inoculation treatment and wilting in lupin. LAB inoculum and wilting lowered ammonia nitrogen concentration and pH values in both species. Butyric acid was detected in all fababean silages; however butyric acid concentration was affected by wilting and by inoculum in the two species as well as by the growth stage in lupin. Butyric acid was substantially absent in inoculated lupin silages. Legume generally have a two-fold disadvantage as they are both highly buffered and have a low WSC content and, as a consequence, clostridia tend to dominate the fermentation of these crops, unless they are wilted and/or treated with a suitable additive (McDonald *et al.*, 1991).

The DM losses during the ensiling were reduced by wilting in faba bean and lupin at late cut, and greatly reduced by inoculum in all the silages, as shown in Figure 1. Higher DM losses were associated to butyric fermentation with higher pH, ammonia, acetic and butyric acid contents (Table 2).

The data show that fababeans and lupin can be successfully ensiled after a wilting period under good weather conditions and the application of a LAB inoculant was beneficial, resulting in silages with a lower pH and lower ammonia-N and butyric acid concentrations.

Figure 1. DM losses during the ensiling of fababean and lupin harvested at two different stages in lab-scale silos.

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