

CHEMICAL COMPOSITION AND ALKALOIDS CONTENT OF SILAGES OF *LUPINUS EXALTATUS* AND *LUPINUS ALBUS* CULTIVATED IN JALISCO, MEXICO

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ABSTRACT

The genus *Lupinus* is widely distributed around the world, and at the present *Lupinus albus*, a sweet lupin species has been utilised as ruminant feedstuff. In contrast wild lupin species are being used experimentally as starting material to prepare silage with similar chemical characteristics than *L. albus*. Therefore, the aim of this study was to determine the chemical composition and alkaloid content of silages elaborated with forages of *Lupinus exaltatus*, or *Lupinus albus*. Plant materials were sown in winter and harvested at early bloom or late bloom stages. After 24 hr wilting plants were chopped manually into 1.5 to 2.5 cm length and combined with corn straw at 100/0, 75/25 and 50/50 ratios, enriched with cane molasses and lactobacillus, and ensiled using plastic flasks of 1 kg capacity. The flasks were opened, after 20 days, and analysed either fresh (pH, lactic acid, ammonia nitrogen), or dry (dry matter, crude protein, neutral detergent fibre NDF, acid detergent fibre ADF, alkaloids). The pH of *L. exaltatus*, and *L. albus* silages ranged between 3.7 to 5.0. The highest crude protein content was 15.19% while the lowest was 10.8%. The highest alkaloid content was in the 100:0 *L. exaltatus* silage, comprising 2.2% (DM), while the lowest was in the 50:50 *L. albus* silage at 0.07% (DM). Based on our results it is possible to obtain silages from wild lupins with similar chemical composition to *L. albus* silages but with high alkaloid levels.

KEYWORDS

silage, alkaloids, *L. exaltatus*, *L. albus*, wild lupins

INTRODUCTION

The genus *Lupinus* is widely distributed throughout the world. Lupins species present excellent foraging characteristics have the ability to fix nitrogen, and have low nutritional requirements for cultivation (Lorca, 1983). It has been also demonstrated that white lupins can be successfully ensiled as a whole-crop alone or with application of an inoculant (*Lactobacillus plantarum*); Fraser *et al.* 2005 (*Lactobacillus plantarum*, *Pediococcus acidilactici*, *L. lactis* and

cellulose and hemicellulase enzymes) Martins *et al.* 2005a, (*Lactobacillus plantarum*, *Pediococcus acidilactici*, *Streptococcus faecium* and cellulose enzyme and condensed tannin) Martins *et al.* 2005b.

The sweet lupin forage is being used in the production of silage for their high content of protein and fibre in feeding beef, and dairy cattle, and as feasible pasture for sheep. On the other hand wild lupins species that are widely distribute in Mexico, contain high concentration of alkaloids in their forages and seeds, a factor that constrains their use because of the bitter taste and high toxicity, (Muzquiz, 1988; Moss *et al.* 1996). Quinolizidine alkaloids in the lupins, represent a chemical defence system against herbivores and to a lesser extent against phytopathogens such as bacteria, fungi and viruses (Wink, 1984; Wink, 1988; Wink, 1992). Studies indicate that in lupins before flowering the highest concentration of alkaloids is found in leaves, follow by stems, and roots, probably due to the leaves at this stage of development are the organs most likely to be consumed by herbivores (Williams and Harrison, 1983; Wink and Roberts, 1998).

The alkaloids present in bitter lupins have pharmacological effects on humans and animals, their consumption can cause damage to the central nervous system, disturbances in the balance, stomach and intestinal discomfort, nausea, mydriasis, paralysis of the respiratory system, progressive state of weakness, coma and death (Muzquiz, 1988). In cattle and sheep the clinical signs are characterised by respiratory depression, hypotensive action, inhibition of neuromuscular transmission and cardiac fibrillation. In acute cases it has been observed that dramatically reduces the consumption of food (Merck, 1993; Cubillos *et al.* 1999). In order to use bitter lupins species as feed is required to implement simple technological processes that eliminate or reduce the alkaloids in the seed or forage. The aim of this study was to determine the chemical composition and alkaloids content of silages of *Lupinus exaltatus*, and *Lupinus albus* alone or combined with corn straw, molasses and lactic acid bacteria.

MATERIAL AND METHODS

L. exaltatus and *L. albus* seeds were sown in November 2007 in Zapopan, Jalisco, Mexico, at proportions of 60 kg and 120 kg/ha respectively, in plots of 10 m x 30 m each. The lupins crops were maintained weed-free manually, the *L. albus* plants were harvested at early bloom stage and *L. exaltatus* at late bloom stage. The forages were chopped by hand to a size of 1.5 to 2.5 cm. The silages at laboratory-scale were made in plastic flasks of 1 kg. The treatments consisted of forages alone or combined with corn straw in rate of 100/0, 75/25 and 50/50, respectively, plus 10% of molasses and microbial inoculant (*Lactobacillus plantarum* and *Pediococcus pentosaceus* 100,000 UFC/g of silage), the material were mixed and compressed by hand using a wooden cylinder, the mini-silages were stored at room temperature. The flasks were opened, after 20 days of fermentation. Laboratory analysis: The samples of lupins plants and silages were analysed by triplicate according to the methods described on the AOAC for pH, lactic acid, ammonia nitrogen NH₃-N, dry matter, and crude protein. While the analysis for, NDF, ADF, and alkaloids were performed in according to the methods described by Van Soest (1981) and Wysocka and Przybyl (1994).

RESULTS AND DISCUSSION

The chemical composition of *L. exaltatus* and *L. albus* silages of the forage alone or combined with corn straw were examined. The dry matter (DM), neutral detergent fibre (NDF) and acid detergent fibre (ADF) increased when the leaves of lupins forages (*L. exaltatus* and *L. albus*) decreased in the mixtures studied. The silages values 20 d post-filling are shown in table 1.

The crude protein (CP) content of *L. exaltatus* was of 15.19, 13.27 and 11.01% of DM, and *L. albus* of 14.23, 13.41 and 10.38% of DM for the levels of 100/0, 75/25 and 50/50 respectively. These values showed a trend inverse with respect the values found in NDF, ADF and DM. The content of crude protein of in the whole plant before ensiling *L. exaltatus* was similar to the reported in lupins by Moss *et al.* (1996) and less than reported by Rodríguez *et al.* (2005) and Ruiz *et al.* (2006), (17.5 vs. 23.4 and 23.5%), NDF and ADF were similar to that reported by Moss *et al.* (1996). The CP in the *L. albus* silages was low while, NDF and ADF were similar in the *L. albus* silages treated with inoculant and enzyme (*L. plantarum*, *P. acidilactic*, *S. faecium* and cellulase enzyme) produced by Martins *et al.* (2005).

Table 1. Chemical composition of *L. exaltatus* and *L. albus* silages of the forage alone our combined with corn straw at 20th day of fermentation.

		DM	CP	NDF	ADF
<i>L./cs</i>		% DM			
<i>Lupinus exaltatus</i>	100/0	29.25 ± 1.50	15.92 ± 0.54	48.12 ± 2.38	36.50 ± 1.89
	75/25	45.75 ± 2.75	13.27 ± 0.49	56.31 ± 3.25	40.37 ± 2.11
	50/50	49.50 ± 1.91	11.01 ± 0.29	64.50 ± 3.68	44.25 ± 2.23
<i>Lupinus albus</i>	100/0	26.50 ± 1.73	14.23 ± 0.41	39.15 ± 1.43	28.64 ± 1.76
	75/25	44.75 ± 3.70	13.41 ± 0.40	49.35 ± 2.64	34.64 ± 1.94
	50/50	57.00 ± 2.58	10.38 ± 0.32	59.55 ± 3.31	40.59 ± 3.31

L./cs = *Lupinus*/corn straw. Silages 100/0 = 100% forage *Lupinus*, 75/25 = 75% forage *Lupinus*, 25% corn straw, 50/50= 50% forage *Lupinus*, 50% corn straw. Values are expressed as mean ± standard deviation.

Table 2. Fermentative parameters and NH₃-N of *L. exaltatus* and *L. albus* silages of the forage alone our combined with corn straw at 20 d of fermentation.

		pH	Lactic acid	NH ₃ -N
<i>L./cs</i>		% DM		
<i>Lupinus exaltatus</i>	100/0	4.00 ± 0.09	4.45 ± 0.44	0.60 ± 0.03
	75/25	3.92 ± 0.14	4.83 ± 0.47	0.64 ± 0.04
	50/50	3.74 ± 0.16	4.09 ± 0.46	0.31 ± 0.02
<i>Lupinus albus</i>	100/0	4.84 ± 0.05	3.52 ± 0.41	0.41 ± 0.03
	75/25	5.01 ± 0.05	3.76 ± 0.49	0.36 ± 0.03
	50/50	5.04 ± 0.07	3.90 ± 0.43	0.29 ± 0.02

L./cs = *Lupinus*/corn straw. Silages 100/0 = 100% forage *Lupinus*, 75/25 = 75% forage *Lupinus*, 25% corn straw, 50/50= 50% forage *Lupinus*, 50% corn straw. Values are expressed as mean ± standard deviation.

The ensiling characteristic at the end of the fermentation period produced values of pH of silages for *L. exaltatus* of 4.0, 3.9 and 3.7, values better than to *L. albus* of 4.8, 5.0 and 5.0 for treatments 100/0, 75/25 and 50/50, respectively (Table 2). The pH of the lupin silage decreased rapidly and developed a desirable volatile fatty acid content when ensiled in laboratory flasks, values of pH was similar to *L. albus* silages reported by Moss (1996) and Martins *et al.* (2005). The lactic acid production was higher in the *L. exaltatus* silages (4.45, 4.83 and 4.09% DM) than for the *L. albus* silages (3.52, 3.76 and 3.9% DM) in silage of the forage alone or combined with corn straw in rate of 100/0, 75/25 and 50/50, respectively, the values of silages are similar between *L. exaltatus* and *L. albus* silages but lower than for those reported for Martins *et al.* (2005) and Moss *et al.* (1996). The ammonia nitrogen (NH₃-N) decrease as the proportion corn straw increased in the silages.

The alkaloid level of whole-crops forage of *L. exaltatus* corresponded to 2.2% of DM, while in *L. albus* to 0.41% of DM. The alkaloid content of the silages after 20 days of fermentation were of 0.93, 0.59 and 0.15% of DM for *L. exaltatus*, and 0.22, 0.11 and 0.07% of DM for *L. albus*, at 100/0, 75/25 and 50/50 lupins forage/corn straw ratios, respectively. The quinolizidine alkaloids in wild lupins are the limiting factor for their use in animal feeds. Therefore, the decrease of the levels of alkaloids by dilution and the ensiling process improves the ability to use wild lupines as forage to feed ruminants.

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