Review

White Lupin (*Lupinus albus*) grain, a potential source of protein for ruminants: A review

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Review was carried out on the nutritional value of white lupin (*Lupinus albus*) grain, different techniques employed to reduce alkaloid contents and its potential as animal feed particularly to sheep. Lupinus can fix nitrogen from the atmosphere, fertilizing the soil for other plants, tolerant of infertile soils and capable of pioneering change in barren and poor quality soils. The seeds of the grain contain 28 to 48% (an average of about 33-40%) crude protein in dry matter, which depends on the species and climatic conditions. The composition of the seed and especially the high protein content makes white lupin highly suitable for livestock diets. However, the presence of quinolizidine alkaloids and some anti-nutritional factors results in characteristically bitter taste making the crop unacceptable for food/feed. Different strategies (processing methods) have been used to reduce/eliminate the alkaloid contents and enhance the feed value of the grain. Supplementation of ruminant diets with processed lupins has been shown to have many positive effects in terms of growth and reproductive efficiency, comparable with supplements of cereal grain.

Key words: Lupin grain, alkaloids, supplementation

INTRODUCTION

In many animal production systems feed is the biggest single cost and profitability can depend on the relative cost and nutritive value of the feeds available (McDonald *et al*., 2002). Of the major constraints limiting the increased livestock production on smallholder resource-poor farms in the tropics is the inadequacy of animal feed resources, especially during the dry season. The increased productivity of ruminant livestock during the dry season is severely constraint by low availability and poor quality of the feeds (Lanyasunya *et al*., 2006). As a result, in areas with limited grazing land and land scarcity for forage production, crop residues are used alternatively, the nutritional values of which is very poor. Lupins are the harvested seed of species from the *Lupinus* genus, a group within the leguminous bean and pea family Fabaceae. Legumes are particularly valuable agricultural crops because of their capacity to provide a grain crop and also fix and return nitrogen to soils and improve the soil value for further cropping. The oilseeds, soybeans and peanuts are also leguminous plants, though traditionally they have been cropped for their oil value, whereas lupins, are cropped for both their protein and nitrogen fixing value (Gladstones, 1998). White lupin is one of the four lupins (*Lupinus albus, Lupinus angustifolius, Lupinus luteu L.*, *Lupinus mutabilis*) widely known commercially and agriculturally important, large seeded annual legume crop for human consumption and animal feed in some countries. The composition of the seed and especially the high protein content makes white lupin highly suitable for livestock diets. Its adaptation to poor soil makes it economically feasible (Huysge, 1997). The presence of quinolizidine alkaloids and some anti-nutritional factors results in characteristically bitter taste making the crop unacceptable for food/feed (Martini *et al*., 2008; Erbas, 2010). Among the methods, soaking after roasting, boiling, germination, fermentation and alkaline treatments can be mentioned. It needs appropriate processing methods which can reduce the alkaloid content and thereby enhance its utilization as food and feed. Chemical treatment of lupin grain is the most common processing method suggested to reduce alkaloid contents of the crop (Arslan and Seker 2002).
Therefore the objectives of this paper were to review the nutritional value of the grain, different techniques employed to reduce alkaloid contents and its potential as animal feed particularly to sheep.

**SPECIES, CULTIVATION AND CHARACTERISTICS OF THE PLANT**

Lupins are the members of the Genus *Lupinus* in the legume family. The genus comprises between 200 and 600 species, with major centers of diversity in South America and western North America, in the Mediterranean Region and Africa (RIRDC, 2011). Like most members of their family, lupinus can fix nitrogen from the atmosphere into ammonia via a rhizobium-root nodule symbiosis, fertilizing the soil for other plants, this adaption allows lupins to be tolerant of infertile soils and capable of pioneering change in barren and poor quality soils (Anonymous, 2009). The thin root system with its deep penetration of up to 20 cm below the surface, enabling nutrient uptake from deeper layers, are some of the major advantages of the plants. The plant is nodulated by soil bacteria that can, under favorable conditions, provide all the nitrogen needed. The nodules are able to fix 160-200 kg nitrogen/ha during the vegetative period, of which about one half is left in the soil, thus fertilizing plants the following year (Nirenberg 2002).

Lupin is considered to be a cool season crop. Early planting is ideal due to the plants’ cold tolerance. Lupin can tolerate temperatures of 16°F (-9°C). Minimum soil temperatures at planting should be 45-50°F (7-10°C). Flowering is a critical stage in lupin production. Continuous temperatures of 85°F or higher for long periods may cause the plant to abort its flowers, thereby decreasing yields. Early planting is a method to avoid these higher temperatures at flowering (GGI, 2003). Several characteristics of white lupine make it suitable as an alternative crop. The species is adapted to the coarse-textured, relatively infertile, acidic soils (Mask et al., 1993). *L. albus* (white lupine) is an autogamous plant. It reaches the height of 0.75–1 m. The flowers are blue or white. The seeds are large, cream in colour with a circular flattened shape, and with a 1,000-seed weight of 350-400 g. Narrow-leaved lupine (*L. angustifolius*) is 0.40-1 m high; the flowers are white and blue and the plant has considerably narrow leaflets of palmate compound leaf. Yellow lupine (*L. luteus*) is predominantly autogamous, 0.40-0.75 m high with yellow or orange flowers (Anonymous 2007). Lupine has been included among eight potential vegetable sources of protein for the use in feed and food that replace proteins of animal origin in the diets (Dijkstra et al. 2003).

**CHEMICAL COMPOSITION OF LUPIN GRAIN**

Legume seeds are an abundant source of proteins and, among them, lupin is one of the richest (Kohajdova et al., 2011). Chemical composition of lupin is influenced by species. Lupin is a good source of nutrients, not only proteins but also lipids, dietary fibre, minerals, and vitamins (Martinez-Villaluenga et al, 2009). The crude protein content of the grain was reported 35.8 % (Glencross 2000), 38% g/kg (Mohamed and Rayas-Duarte, 1995), 38.8 % (Mikić et al., 2009), 32.2 % (Erbas et al. 2004) and 38.01% (Vladimir et al., 2008). Sofia (2008) also reported that lupin grain had high protein (30%-40%) and dietary fiber (30%) and low fat (6%) contents. Volek and Marounek (2008) showed that white lupin contains 896 g/kg dry matter and 11.8 g/kg digestible energy (MJ/kg DM). Gebru (2009) also documented the CP content of white lupin as 38.5%. Hawthorne and Fromm (1977) showed that lupin grain contains 49 g N, 20.1 MJ g/kg gross energy, 86% digestible energy, and 15.7 MJ ME/kg on DM bases. Glencross (2000) also reported the chemical composition of *lupines albus* (white lupin) on DM bases as 95 g/kg Crude fat,428 g/kg nitrogen free extract,103 g/kg crude fiber, 143 g/kg acid detergent fiber, 172 g/kg neutral detergent fiber and 33 g/kg ash . Vladimir et al. (2008) documented the ADF, NDF and NFE content of lupin seed as 179.5 g/kg, 198 g/kg and 370.9 g/kg respectively. The two raw cultivars of *Lupinus albus* from Dangla and Tilli sites have total energy content of 391.19 KCal/100gm and 388.12 KCal/100gm respectively (Paulos, 2009). Yellow lupin (*L. luteus*) is generally regarded as having the highest protein content of the lupin species, with whole seeds typically having protein levels of 40%- 45% DM. Different authors also reported the energy contents of the grain as 86% and 20.1 MJ g/kg digestible and gross energy on DM basis (Morgan, 1994), and 19.6 MJ g/kg DM gross energy (Glencross, 2000). However, the nutritional value and performance of white lupin can be affected by planting date and row spacing during seeding (Harbans et al., 2004).

**USES OF LUPIN GRAIN**

Four species of the genus *Lupinus* (*L. albus, L. angustifolius, L. luteus, L. mutabilis*) are cultivated in the world for one or more of three main uses: human food, green manure, and ruminant feed (Anonymous, 2009). *Lupinus albus* is a universal plant with numerous useful properties. It can be used both as fodder and for soil fertilization (Maknickien and Asakavictute, 2008).

Lupin seeds have been part of normal food intake since ancient times and are consumed as snacks (EFSA, 2005). The fatty acid profile of lupin seed has been noted as having excellent emollient properties for the cosmetic industry (Stanford et al., 2004). Lupins contain high levels of fiber and protein, including essential amino acids with levels higher than those found in soybean. Lupin flour and bran are currently being used to enrich European breads, pastas, cakes and biscuits with these nutrients (Loblay et al., 2007).
**Lupinus albus** (white lupin) seeds grown in Ethiopia and locally known as ‘Gibbo’, is used as roasted bean ‘kolo’ and to prepare local alcoholic drink ‘Arekie’ and other food products especially in the northwestern part of the country (Tizazu et al., 2010). The food value of lupin is not a priority, its importance as food source in the rainy season (the time in which food shortage is common) shows the high value of lupin as a shock absorber. When they use it as human food, it is mostly used as a snack and as local sauce called ‘Shiro’ (Likawent et al., 2010).

The same study reported that lupin products are believed to be helpful to get rid of and prevent pneumonia, bowl and hypertension related problems. Lupin meal can be directly used as food for livestock, fish and poultry, and can be finely ground into lupin flour or coarsely ground into lupin grits. Lupin flour is a super source of protein and other important nutrients, ideal for use in baby foods, cereals and various low-calorie foods and drinks (GGI, 2003).

**Lupin crop as animal feed**

The feed value of forage is a function of its nutrient content, digestibility, its palatability and associative effects with other feeds (Abebe, 2008). Legume forages and foliages are alternative resources which can serve as a source of fermentable N and of bypass protein in animal feeding (Preston, 1986). Many indigenous forage species in the tropics have low productivity and low digestibility, which reduces their usefulness for livestock nutrition; but leguminous species selected for their productivity, palatability and ability to withstand managed grazing can significantly increase livestock production (Alemayehu, 2002). White lupin is a valuable multipurpose crop which has the ability to maintain soil fertility and serve as a source of feed (Likawent et al., 2010). The crop is an excellent protein and energy source for ruminants. It can be fed as whole seeds, ground seeds, whole plant silage, and even as hay. However, its bitter taste due to its high alkaloid content remains to be a big challenge (Likawent et al., 2010).

**Effect of supplementation of lupin grain for Ruminants**

Protein is an essential key nutrient of animal feeds. The name lupin applies to a collection of four agriculturally important species. The two most important being *L. albus* and *L. angustifolius* offering relatively high yields (32–40 % DM) of crude protein. For sheep and cattle they can be the sole concentrate protein feed. Sweet varieties of lupins should be used to avoid any problems with alkaloids (Stephen et al., 1996). Supplementation of ruminant diets with lupins has been shown to have many positive effects in terms of growth and reproductive efficiency, comparable with supplements of cereal grain (Robert and Barneveld, 1999).

**Feed intake**

Supplementation with lupin grain has shown positive effects on feed intake. Marley et al. (2008) reported a daily intake of lupin grain by dairy cows as 18.3 kg DM, 203 ME (MJ) on DM basis and 0.62 kg nitrogen compared to 19.3 kg DM, 215 ME (MJ) ,0.062 kg nitrogen intake of soya bean meal. Curtis and Doyleb (1994) documented the daily lupin grain dry matter intake for weaner and adult sheep, respectively, as 193 and 290 grams it was also shown that supplementation with lupin at 150 g per day significantly improved DM intake by 195 g/day DM digestibility by 8.7% (Miao et al., 2001). Gebru (2009) also reported the dry matter and CP intake of raw lupin to be 133 and 88.5 g/day when washera sheep was supplemented with 300g/day on DM basis of the different forms of the grain in hay based feeding. On the same breed of sheep Yilkal et al. (2014) indicated the DM (728.9-764.4) g/head/day) and crude protein (CP) (109.3-150.9 g/head/day) intakes of lupin.

**Digestibility**

A study conducted by Murray (1992) indicates that the apparent dry matter digestibility of lupin grain was 91.1%. Gebru (2009) also reported that the apparent dry matter digestibility (%) of CP raw lupin as 85 in Washera sheep fed Rhodes grass hay which was significantly higher than the digestibility of Rhodes grass (60%). Allan and Booth (2004) reported the apparent crude protein and organic matter digestible coefficients of lupin grain as 91% and 50% respectively. Higher digestibility of crude protein (80.8%), ether extracts (57%), crude fiber (45.5%), NDF (60.2%) and ADF (57.8%) was found for lupin compared with extracted soya bean meal (Pisarikova et al., 2008). The mean dry matter digestibilities (%) calculated by extrapolation for whole lupin grain, hammer milled lupin grain and whole lupin grain cracked during ingestion or rumination were, respectively, 66.8, 77.5 and 75.9 for the oaten hay based diet and 62.2, 80.2 and 79.7 for the oaten pasture based diet(Valentine and Bartsch, 1986). Rodehutscord et al. (1999) reported that organic matter digestibility of lupin as 73.1%. Similarly Yilkal et al. (2014) reported CP digestibility in percent as 81, 87 and 89 respectively for roasted coarsely ground, roasted soaked and roasted soaked coarsely ground lupin grains in washera sheep fed natural grass hay as a basal diet. The same researcher revealed the NDF digestibility of roasted soaked and roasted soaked coarsely ground lupin grains to be 66 and 65%.

**Growth and production performance**

Supplementation of ruminant diets with lupins has been shown to have many positive effects in terms of growth and reproductive efficiency, comparable with
Supplements of cereal grain (Robert and Barneveld, 1999). It has been shown that supplementation of lupin grain to late-born Merino lambs before weaning on lupin stubble resulted in 3.6 kg live weight gain by these lambs (1999). It has been shown that supplementation of lupin grain on hay based feeding of Washera sheep resulted in 16.4 gram body weight gains (1999). Gebru (2009) reported the live weight gain and weight change of Washera sheep fed on grass hay and supplemented with different forms of processed lupin grain. Mukisira (1993) also reported that when lupin grain was fed to dairy cows by mixing with maize grain resulted in the highest milk yield of 15 kg/day as compared to feeding lupin alone (10.3 kg/day).

Field et al. (2000) reported the live weight gain and wool growth in Merino weaner sheep fed lupin as 27g/day. Gebru (2009) also showed that a 300 g/day DM supplementation of lupin grain on hay based feeding of Washera sheep resulted in 16.4 gram body weight gains per day. According to Vicenti et al. (2009) feeding lupin seed to young bulls resulted in a daily weight gain of 1.1kgs, which was comparable with soya bean meal feeding of the same animals (1.17kgs/day). The mean increase in live weight gain/day and wool growth for ewes fed lupins was 1kg and 39% respectively (Kenney et al., 1980). Gebru (2009) reported that the total edible offal components of sheep fed on Rhodes grass hay and supplemented with raw lupin grain as significantly higher (4933 g) for supplemented sheep than non-supplemented sheep (3474 g). The same report showed that weight in visceral fat, kidney fat, tail, heart, kidney and liver were significantly higher for supplemented sheep as compared to non-supplemented ones. Yilkal et al. (2014) also reported positive responses of Washera sheep on a hay based supplementation of different forms of processed lupin grain and this is indicated in Table 1.

Yilkal et al. (2014) also reported appreciated results in slaughter weight, empty body weight, hot carcass weight and rib eye muscle area of sheep supplemented with processed lupin grain. The same report indicated that among the different forms of processed lupin grain, sheep supplemented with roasted soaked and roasted soaked coarsely ground lupin grain showed higher increase in live weight gain/day and wool growth for ewes compared to non-supplemented ones. Yilkal et al. (2014) also reported appreciated results in slaughter weight, empty body weight, hot carcass weight and rib eye muscle area of sheep supplemented with processed lupin grain. The same report indicated that among the different forms of processed lupin grain, sheep supplemented with roasted soaked and roasted soaked coarsely ground lupin grain showed higher increase in live weight gain/day and wool growth for ewes compared to non-supplemented ones.

Reproductive performance

The effect of supplementing lupin grain on reproductive performance of maiden and mature ewes fed hay showed that ovulation rate increased in ewes which received the supplement (Brien et al., 2009). Supplementation with lupin grain significantly increased ovulation rate by 37% through increasing the proportion of ewes with two ovulations (Nottle et al., 1990). It was also reported that lupin supplementation had significant effects on the plasma concentrations of prolactin, growth hormone and insulin (Downing et al., 1995).

Ewes in a flock of Merino sheep with regular estrous cycles consistently showed a 20-30% increase in ovulation rate when supplemented with lupin grain for 2-5 week in late autumn (Radford et al., 2011). Feeding 500 g lupins/head/day for 14 days commencing 12 days after the introduction of vasectomised rams, increased the number of ovulations from 126 to 146 per 100 ewes exposed to rams (Nottle et al., 1997). For every 0.2 kg of lupin fed per day the ovulation rate and lambing rate of ewes increased by 0.06 and 0.03 per ewe respectively (Kenney et al., 1980).

ANT-NUTRITIONAL FACTORS IN LUPIN GRAIN

Alkaloids are alkali-like compounds that form salts with acids and contain nitrogen, generally in heterocyclic and/or ring structures. Found in a wide variety of plants, animals, and fungi, many alkaloids have medicinal and toxic properties (David, 2009). Many species of lupin show...
have a high alkaloid content which results in a characteristically bitter taste making them unacceptable for food/feed, although the alkaloids can be removed by steeping the seeds in water (Martini et al., 2008).

Alkaloid content in lupines depends on numerous factors such as species variety, age (developmental stage), environment and geographical location. The highest content of alkaloids was identified in the periods of full blossom. A lower content was noted during shoot formation, and the lowest in the full maturity period (Maknickiené and Asakavičiūtė, 2008). The growth performance of lambs offered sweet white lupin seed as a protein supplement was limited by the presence of alkaloids (Brand and Brandt, 2000). Alkaloids have been implicated in the reduced performance and depressed appetite of animals (Mukisira et al., 2001). There was evidence, however, that lambs could adapt to the presence of alkaloids in lupin seed and that over time, the deleterious effects of alkaloids in lupin seed may be obliterated (Brand and Brandt, 2000).

**LUPIN GRAIN PROCESSING STRATEGIES**

The bitter taste due to its high alkaloid content remains a big challenge for efficient utilization of lupin grain by the local farmers and emerging food and feed industries. Hence, any lupin improvement strategy has to focus on minimizing the alkaloid content of the crop (Likawent et al., 2010). There are some physical and chemical treatments with acids and alkalis for eliminating these anti-nutritional factors (Arslan and Seker, 2002). Beyond removing the unwanted anti-nutritional factors, some forms of processings improve the nutritive value and digestibility of the grain (Khalil et al., 2006).

The prior limitation to the consumption of *Lupinus albus* is the presence of alkaloids. An elaborate cooking process is necessary to remove toxic alkaloids in the seeds (Kurzbaum et al., 2008). Heating lupin seed at temperatures from 105 to 150°C for 15 min resulted in a quadratic increase in feed conversion ratio to carcass and a linear increase in back fat thickness (Batterham et al., 1986). The same author indicated that autoclaving of lupin seed from 5 to 45 min at 121°C also resulted in a linear increase in carcass feed conversion ratio. Traditional processing methods have shown both an increasing and decreasing effects on the various chemical and nutritional compositions of the raw seed. Roasting followed by soaking in water improves the protein contents of lupin grain from 37.87% to 44.15% (Paulos, 2009). The same author reported that boiling followed by soaking for five days in water improves the crude protein contents of lupin grain from 37.87 to 47.25% DM and the crude fat contents from 9.34 to 15.15g/kg DM. Soaking lupin seed in water for 12 hrs improves its protein content from 34.5 to 41.1 percents (Masucci et al., 2005).

On the other hand heating of lupin grain resulted in a reduction of the protein contents from 38.5% to 36.2% DM (Gebru, 2009). Lupin grain was detoxicated by soaking in a 0.5 per cent solution of hydrochloric acid and by subsequent maceration in water; its alkaloid content (up to 2.38 per cent prior to detoxication) was reduced by this procedure to 0.06-0.18 per cent.

Detoxication by this procedure decreases the protein contents from 34.86 % to 32.2% (Nagorskaja, 1940). Optimized instantaneous controlled pressure drop technology (DIC) treatment combined with an adequate 2hour soaking in water reduced the alkaloid content from 5.5% to 2.2% of *L. mutabilis* and from 0.025% to 0.0075% of *L. albus* (Haddad et al., 2006). Keeping the seed at 120°C for 0.5 h then soaking in running water for 7 days, after which only 2 remained of the 12 alkaloids originally found in whole seed (Bolodia and Hailu, 1970). Germination has been suggested as an effective treatment to remove anti-nutritional factors from legumes and to increase nutritive value (Uebersax, 2006). The process is simple and inexpensive and different seeds have been germinated for use as food/feed (Paulos, 2009). Fermentation is also a very interesting process used in plant foods to increase the nutritional quality and remove undesirable compounds (Frias, et al., 2004). The chemical composition of processed grain was reported by different authors. Prandini et al. (2005) reported the ether extract and CP content on g/kg basis as 77.4 and 99.8 for ether extract and 35.05 and 35.44% for CP in raw and extruded lupin grains. Gebru (2009) reported the CP contents of soaked dehulled, roasted and raw soaked lupin grains as 58.3, 36.2, and 43.6 percents on dry matter basis respectively. While roasting decreases the CP content of the grain as compared to raw, other forms of processing increases the CP content.

Above all the commonly used traditional processing method on *Lupinus albus* in Ethiopia (that is, roasting then soaking in running water for five days) has shown an improvement on the protein content at the same time brings the highest reduction in alkaloid content from 2.46% to 0.84%. Germination has the least effect in reducing the total alkaloid (2.46 % to 1.65%), but has shown good enhancement in the proximate and mineral composition (Paulos, 2009). Among the traditional processing methods, boiling and soaking in water for five days resulted in the highest increment of protein content. While, the lowest increment was observed on germinated seed (37.87 to 41.87%). Processing of the grain has many desirable effects on the feeding value of the grain. Gebru (2009) reported the dry matter intake (g/day) of raw soaked dehulled, roasted and raw soaked lupin grains as 159, 192 and 152 and the CP intake (g/day) of these forms of grain as 128.2, 104.5 and 102.7 when washera sheep was supplemented with 300g/day of the different forms of the grain in hay based feeding. The same report showed that the apparent dry matter digestibility (%) of CP in soaked dehulled, roasted and
raw soaked lupin grains was 89, 84 and 86% which was significantly higher than the digestibility of Rhodes grass (60%). As documented by Rodehutscord et al. (1999), heat treated lupin grain results in a 56 g/day body weight gain but had no effect on organic matter digestibility as compared to untreated lupin grain. Yilkal et al. (2014) also reported improved feed intake, digestibility and weight gains of washera sheep due to supplementation of processed lupin grain (roasted coarsely ground, roasted soaked and roasted soaked coarsely ground lupin grain) compared with raw lupin supplemental. The result is given in Table 2 shows that among the different processing methods employed, combination of methods (roasting/soaking/grinding) improves feeding value of the crop and sheep performance.

**CONCLUSIONS**

Supplementation with different forms of processed lupin grain has generally a positive effect on feed intake, nutrient digestibility and carcass parameters on sheep. Among the different forms of processed grain supplements, roasted soaked and roasted soaked coarsely ground, reduces the bitter tasting of the grain and increases its feeding value.

**REFERENCES**


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**Table 2. Feed intake, CP digestibility and average daily weight gain of washera sheep supplemented with processed lupin grain.**

<table>
<thead>
<tr>
<th>Parameters</th>
<th>T1</th>
<th>T2</th>
<th>T3</th>
<th>T4</th>
<th>SEM</th>
<th>SL</th>
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<tr>
<td>DMI (g)</td>
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<td>209.3</td>
<td>275.7</td>
<td>300</td>
<td>24.62</td>
<td>***</td>
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<tr>
<td>CP Digestibility (%)</td>
<td>77&lt;sup&gt;a&lt;/sup&gt;</td>
<td>83&lt;sup&gt;c&lt;/sup&gt;</td>
<td>87&lt;sup&gt;b&lt;/sup&gt;</td>
<td>89&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.53</td>
<td>***</td>
</tr>
<tr>
<td>ADG (g)</td>
<td>5.7&lt;sup&gt;d&lt;/sup&gt;</td>
<td>34.1&lt;sup&gt;c&lt;/sup&gt;</td>
<td>54.3&lt;sup&gt;b&lt;/sup&gt;</td>
<td>63.7&lt;sup&gt;a&lt;/sup&gt;</td>
<td>4.77</td>
<td>***</td>
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<sup>a-d</sup> Means with different superscript in the row are different P<0.05 (*); p<0.01(**); p<0.001(***); DMI=dry matter intake; CP=crude protein; ADG=average daily weight gain; g=gram; SEM=standard error of mean; SL=significance level; T1=control (sole hay); T2=hay+300 g roasted coarsely ground lupin; T3=hay +300 g roasted soaked lupin; T4=hay+ 300 g roasted soaked coarsely ground lupin grain.


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