Agricultura Scientia 21: No 1: 25-34(2024)
https://doi.org/10.18690/agricsci.21.1.3

University of Maribor Press

Supplemental Role of Fodder Tree Legumes in Dwarf Sheep and Goats Feeding Systems – A Review

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ABSTRACT

The potential of fodder tree legumes (FTL) as a promising and nutritional strategy to minimize the problem of insufficient supply of forages, especially during the dry season, in West African dwarf sheep and goats' production systems was reviewed. For more sustainable agricultural systems, including expanding the use of locally produced available feedstuffs, FTL species with a focus on *Leucaena leucocephala*, *Gliricidia sepium,* and *Enterolobium cyclocarpum* represent an interesting strategy to provide dietary nitrogen and improve feed digestibility, weight gain, and nitrogen retention, thus enhancing dwarf sheep and goats' productivity. They also contain concentrations of biologically active compounds with nutraceutical value that assist in slowing down the infections with parasitic nematodes of the gastrointestinal tract and mitigating enteric methane emissions from these animals. The dietary crude protein and tannin content ranged from 16.20 to 26.79% and 0.95 to 2.92%, respectively across the FTL species. Mean weight gain (g/day) of 43.23 to 48.59 and 32.46 to 40.87, respectively were reviewed for dwarf sheep and goats fed FTL supplementary diets. Haematological and serum biochemical variables monitored were within the permissible range for healthy animals and showed the adequacy of nutrient supply from FTL species with nutrient utilization to improve productivity. The review concluded that the combination of excellent nutritive value reported for FTL provides important opportunities for sustainable dwarf sheep and goat feeding systems.

Keywords: sheep, goats, performance, tree legumes, tannins, anthelminthic, methane mitigation

INTRODUCTION

The dwarf breeds of sheep and goats are widely distributed throughout the humid savannah zones of Nigeria where they have been part of rural livelihoods for eras, playing a significant role in the food chain and being instrumental in poverty reduction in resource-poor communities (Lebbie, 2004; Fasae et al., 2012; Adebayo et al., 2022). These animals with an average weight of 20-30kg and 25-40kg for goats and sheep, respectively have immense contributions to rural livelihoods within the West African subregion (NRC, 1991; Odeyinka, 2001; Odusanya et al., 2017). Despite the valuable contributions of these animals to farmers' livelihoods, inadequate nutrition through prolonged dry season droughts and infections with gastrointestinal parasites pose a threat and represent a major constraint to their sustainable production (Lamidi and Ologbose, 2014). During this dry period, the natural pasture does not only have low dry matter yield but is also poor in quality with low crude protein content. Hence, the nutrient bioavailability to livestock production from such feed resources is very poor to fulfill the energy requirement to maintain their body weight, resulting in low digestibility, severe drop in body condition, and poor productivity of the animals (Odusanya et al., 2017).

This has however necessitated the exploration of drought resistance fodder tree legumes (FTL) which are of good quality to meet the nutritional requirements of these animals for year-round feeding, so as to attain their genetic potential. FTL are important evergreen strategic feed resources in ruminant production systems and serve as a potential source of readily available high-quality fodder with relatively low feeding costs, to many smallholders. They have remained to complement the dry season feed supply, as they possess the potential for vigorous growth, re-growth, and palatability, serving as an integral part of farming systems that have significant promise for ruminant production in

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the tropics (Kebede et al., 2016; Getachew et al., 2022). FTL has been widely used as a source of supplemental nitrogen for ruminants. The leaves have high crude protein, minerals, and degradability when used as a supplement to low-quality roughages. (Abdulrazak et al., 1997; Reynolds and Atta-Krah, 2006; Fasae and Bello, 2023).

The presence of tannins in FTL leaves which account for up to 20% of the dry matter (Harvey et al., 2019) have likewise demonstrated noteworthy benefits for ruminants when consumed moderately. Tannins have been found to serve as a bioactive substance that significantly improves productive performance, serving as a practical and realistic alternative to non-drug gastro-intestinal parasite control strategies as well as supporting the manipulation of rumen fermentation to induce methane mitigation in ruminant production systems (Jerónimo et al., 2016; Jafari et al., 2019; Besharati et al., 2022).

This paper reviews the supplemental role of *Leucaena leucocephala*, *Gliricidia sepium,* and *Enterolobium cyclocarpum* fodder tree legumes, based on their availability, high nutritive value, and inclusion in diets as one of the many ways of improving the utilization of poor-quality roughages in dwarf sheep and goat feeding systems.

CHEMICAL CONSTITUENTS OF FODDER TREE LEGUMES

Wide variation was observed in the crude protein (CP) contents of the leaves of FTL species (Table 1). Values obtained were within 16.20 to 25.76% which were above the threshold level of 7% CP required by the microbes in the rumen to support the metabolic functions of their host (NRC, 2000). The high dietary protein content of FTL species demonstrates their ability to correct nitrogen deficiency in augmenting the quality of local forages for sheep and goat production. Thus, assists in maintaining seasonal and yearly feed stability and also ensures sustainable rural livelihoods, when compared to ruminant systems based on grass or cereals, especially during dry periods. The dietary NDF contents across the FTL species were within the permissible limit guaranteed as optimal intake of tropical feeds by ruminant animals (Van Soest, 1994). These levels have been attributable to the better influence of dry matter intake and time of rumination by these animals. Nutritional models have predicted dietary NDF to be an important driver of rumen digesta load and therefore feed intake (Ellis et al., 1999). NDF lower than 30% can result in possible rumen health issues such as acidosis, while values higher than 60% are negatively correlated with lower consumption, which means the animal fills up faster.

The detection of trace amounts of tannins, a group of "secondary" plant metabolites described to account for up to 20% of the dry matter in forage legumes have been observed to form complexes with protein, carbohydrate, alkaloids, vitamins, and minerals. Mean moderate values obtained for tannins in FTL forages fed to dwarf sheep and goats were within the bearable range which was attributed mostly to the effect of air and sun-drying of the leaves. This supports the assertions in many reports that air and sun-drying reduce or inhibit tannin concentration in forages (Stewart and Mould, 2000; Mohamed et al., 2015). Moderate dietary tannin concentrations (<3 % dry matter-DM) in ruminant diets have been confirmed to be bloat-free with more rumen undegradable protein, and a beneficial role as antioxidants that can supply satisfactory dietary protein for post-ruminal digestion and absorption in the small intestine to significantly enhance ruminant productive performance (Lowry et al., 1996; Serra et al., 2021).

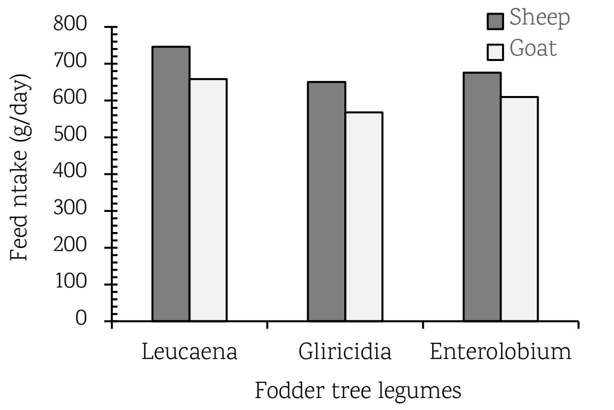
Table 1: Chemical composition range of some fodder tree legumes fed to dwarf sheep and goats

Nutrients	*Leucaena*	*Enterolobium*	*Gliricidia*
Dry matter (%)	92.93–94.56	88.82–93.77	89.54–95.32
Crude protein (%)	19.60–26.79	16.20–23.42	18.52–24.73
Ether extract (%)	2.04–6.57	4.03–10.34	2.77–7.02
Neutral detergent fibre (%)	44.67–58.70	40.42–59.00	45.89–52.65
Acid detergent fibre (%)	33.55–41.20	28.45–38.25	29.95–35.78
Acid detergent lignin (%)	10.95–14.67	13.78–14.92	9.75–13.50
Tannin (%)	1.45–2.52	1.24–2.11	0.95–1.94
Gross energy (MJ/kg dry matter)	18.01–23.60	19.21–23.07	19.23–22.72

Data summarized from: Devendra, 1982; Odeyinka et al., 2001; Oduguwa et al., 2008; Fadiyimu et al., 2012; Fasae and Omosun, 2013; Ekanem et al., 2023.

FEED INTAKE OF FODDER TREE LEGUMES IN DWARF SHEEP AND GOATS

The feed intake (% DM) of FTL by dwarf sheep and goats was considerably high with both species of animals consuming an average of 3 to 4 % of their body weight (Figure 1). The high crude protein (CP) content observed in FTL species has been an important factor that enables high feed consumption by these animals. These reportedly promote a favorable rumen environment ensuing enhanced fermentation of low-quality forages, thus increasing microbial protein synthesis, rate, and extent of digestion which prompted an increase in DM intakes (Bonsi et al., 1994; Abdulrazak et al., 1996; Jabbar et al.,1997; Fasae et al., 2011; Kang et al., 2015).



Data summarized from: Smith et al., 1995; Odeyinka, 2001; Fasae et al., 2010; Oduguwa et al., 2013; Ekanem et al., 2022.

Figure 1: Mean dry matter feed intake (g/day) of supplementary fodder tree legume diets by Dwarf sheep and goats

Feeding FTL levels of less than 30% as supplemental diets to dwarf sheep and goats significantly improved dry matter intake and performance (Smith et al., 1995; Fasae et al., 2011; Ekanem et al., 2022). Low to moderate dietary tannin concentrations have been found to possess minimal bitter and astringent taste, thus increasing palatability, preference, and eventually voluntary feed intake in ruminants (Fasae and Omosun, 2013; Tseu et al., 2020). However, low DM intake observed in some FTL forages like Gliricidia, supports few studies that recognized its feeding value to an odour adduced to the volatile compounds released from its leaves surface which has been implicated in this initial reluctance of animals to eat Gliricidia (Odeyinka et al., 2001; Fasae et al., 2010). Besides, wilting and a short period of adaptation have been found to overcome these palatability problems associated with Gliricidia forage, with no long-term detrimental effects on the animals, once adapted.

NUTRIENT DIGESTIBILITY, NITROGEN UTILIZATION AND METHANE PRODUCTION BY DWARF SHEEP AND GOATS FED FODDER TREE LEGUMES SUPPLEMENTARY DIETS

The mean values for nutrient digestibility (%), nitrogen retention, and methane production of FTL diets fed to Dwarf sheep and goats are presented in Table 2. The dry matter and crude protein digestibility values were reasonably high across animal species reportedly attributed to the high dietary protein content in FTL plants (Ikyume et al., 2018; Garba Bala and Rabiu Hassan, 2023). This assertion corroborates other studies that have shown the influence of increasing dietary protein levels from forage legumes to have improved the apparent nutrient digestibility of low-quality forages. Different outputs from research demonstrated a linear increase in CP digestibility with increasing levels of FTL leaf meal supplementation and established their advantages in the process of digestibility improvements (Tolera and Sundstøl, 2000; McDonald et al., 2002).

Table 2: Mean nutrient digestibility, nitrogen retention, and methane production of fodder tree legumes supplementary diets fed to Dwarf sheep and goats

Nutrients	Sheep	Goats
Dry matter digestibility (%)	74.92	73.40
Crude protein digestibility (%)	77.48	75.68
Neutral detergent fibre digestibility (%)	62.69	64.32
Nitrogen retention (%)	71.81	69.68
Methane (g CH_4 kg/DMI)	20.12	19.72

Data summarized from: Osakwe and Steingass, 2006; Fasae et al., 2010; Oyedele et al., 2016; Ikyume et al., 2018.

Moreover, the influence of moderate concentrations of dietary tannins was described to improve the digestive utilization of feed mainly due to a reduction in protein degradation in the rumen and a subsequent increase in amino acid flow to the small intestine (Frutos et al., 2004; Wen et al., 2020; Besharati et al., 2022), with effects reflected in animal performance. Cabral Filho et al. (2013) investigated three levels of tannin in the diet of sheep and reported a different DM digestibility between high- and low-tannin plants. The low tannin content diet had a higher CP digestibility, and there were no significant differences between the medium tannin content and high tannin content diets.

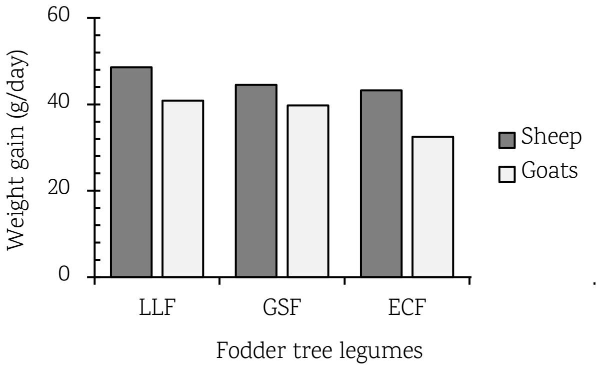
The positive nitrogen retention values demonstrated that the FTL-supplemented diets were well utilized and efficiently used as fermentable nitrogen sources for microbial growth in the rumen. Nitrogen balance has been described as a good indicator of the protein value of a diet when the amino acid supply is balanced with the energy supply (Babayemi and Bamikole, 2006). McSweeney et al. (2001) reviewed the effects of decreasing dietary tannin to have increased nitrogen digestibility and excretory nitrogen in sheep faeces.

Feeding FTL as supplementary diets to dwarf sheep and goats shows its capability in methane mitigation. The quantity and rate of fermentability of tannin contained FTL diets were reported to affect ruminal pH, volatile fatty acids production, incorporation and stimulation of the ruminal ammonia nitrogen into microbial protein for adequate utilization in the rumen of sheep and goats (Osakwe and Steingass, 2006; Olafadehan et al., 2016). Tannins have ample biological activity in ruminal fermentation processes as they somehow affect the growth rate of the rumen microbial population to irritate changes that induce mitigation of enteric methane emissions in ruminants. They support the manipulation of rumen fermentation and induce a reduction in methane synthesis in the rumen (Jafari et al., 2019), directly or indirectly by either impeding methanogens or protozoal population and nitrogen-producing microbes. with several possible hypotheses to describe the mechanisms of action of tannins on enteric methane mitigation (Newbold et al., 1997; Jayanegara et al., 2015; Naumann et al., 2017; Adejoro, 2019). Tenzin Tseten (2022) acknowledged that feed manipulation remains the most cost-effective approach, attaining a substantial 60% reduction in methane by meticulously opting for the type or quality of forage and optimizing the concentrate-to-forage ratio in feed. A review by Eckard et al. (2010) noted a 13–16% methane reduction per kg DM intake with tannin-containing forages across a number of studies. Reduced methane emissions from ruminants fed on legume-based forage diets tend to have less negative environmental impact on biodiversity, nitrogen losses to water, as well as greenhouse gas emissions (Phelan et al., 2015). Economically, apart from its environmental benefits, FTL used as feed supplements has the primary advantage of improving farmers' income by reducing protein costs and improving the efficiency of productive ruminants.

FODDER TREE LEGUMES' SUPPLEMENTARY EFFECT ON WEIGHT GAIN OF DWARF SHEEP AND GOATS

The trend in weight change of dwarf sheep and goats fed supplementary diets of FTL is depicted in Figure 2. The responses of these animals to the high dietary CP levels from FTL could have initiated the trend for greater weight gain which is consistent with several studies that have proved the advantageous effects of FTL in improving weight gain in various breeds of sheep and goats (Srivastavam and Sharma, 1998; Helal et al., 2018, Dana et al., 2000). FTL are rapidly degradable, initiating higher fractional outflow rates of particulate matter from the rumen, so assisting in meeting the requirements of rumen microorganisms for efficient degradation of low-quality roughages (Adu et al., 1990). These further boosts the production of protein by ruminal microbes and the efficiency of microbial nitrogen production, providing a productive balanced diet that improves animal weight gain (Mupangwa et al., 2000). Moreso, better weight gains of dwarf sheep and goats were

also attributed to their beneficial responses to moderate dietary tannin in enhancing their performance by augmenting urea recycling and activating microbial efficiency. This further protects plant protein from excessive degradation in the rumen (Norton and Poppi, 1995; Hidosa, 2016) by providing the host animal with a significant source of additional protein for absorption and utilization with an improvement in weight gain.



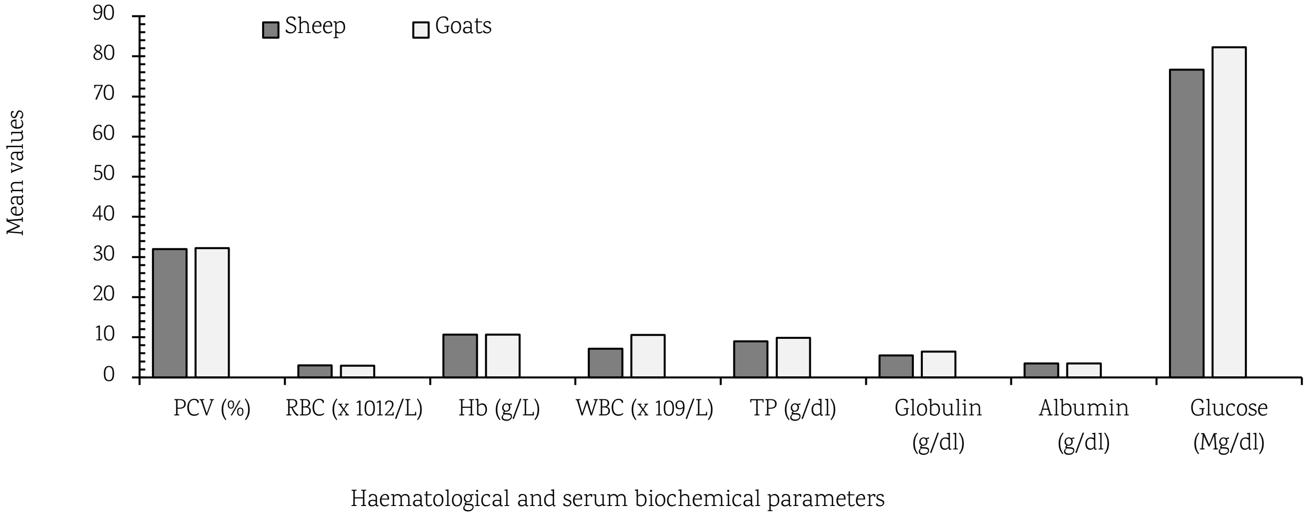
Data summarized from: Smith et al., 1995; Odeyinka, 2001; Fasae et al., 2011; Oduguwa et al., 2013; Ikyume, 2018. LLF – *Leucaena leucocephala,* GSF – *Gliricidia sepium,* ECF – *Enterolobium cyclocarpum*

Figure 2: Mean weight gain (g/day) of Dwarf sheep and goats fed supplementary fodder tree legumes

HAEMATOLOGICAL AND SERUM BIOCHEMICAL OF DWARF SHEEP AND GOATS FED FODDER TREE LEGUME SUPPLEMENTED DIETS

Haematological and biochemical parameters of Dwarf sheep and goats fed FTL-supplemented diets (Figure 3) showed values within the permissible range for healthy animals (Daramola et al., 2005; Carlos et al., 2015), which point to the non-adverse effects of these diets on the animals. These blood variables have often been suggested when evaluating the effects of a diet on animal performance in the short to medium term (Pambu-Gollah et al., 2000). They signify an integrated index of the adequacy of nutrient supply and give an immediate indication of the nutritional status of an animal at that point in time. They are also used to monitor the health and immunity status as well as an index of transportation stress in ruminants (Ambore, 2009; Mohammed et al., 2016).

In the reviewed studies, the experimental animals did not show any major clinical signs of ill health or toxicity credited to the moderate inclusion levels of FTL as supplementary diets. The PCV values show no dehydration or anemia deficiency in the animals, while the red blood cell and hemoglobin indices indicated the absence of haemolytic anaemia and the oxygen-carrying capacity of the blood, respectively (Daramola et al., 2005). The glucose concentrations suggest that the FTL supplementary diets were sufficient to maintain blood glucose homeostasis in the animals. Mean normal WBC counts showed that the concentration of FTL in the diets was below the level that could cause adverse effects. Though, indigenous goats possess a protective system that provides a rapid potent defense against infectious agents (Belewu and Ojo-Alokomaro, 2007).



Data summarized from: Ukanwoko and Ironkwe, 2012; Mohammed et al., 2016; Odusanya et al., 2017.

Figure 3: Mean haematological and serum biochemical parameters of dwarf sheep and goats fed fodder tree legume supplemented diets

FORAGE TREE LEGUMES AND THEIR ANTHELMINTHIC EFFECTS ON DWARF SHEEP AND GOATS

The mechanisms involved in gastrointestinal parasites' response to the diets containing FTL fed to dwarf sheep and goats demonstrate the potential of the tannin-rich FTL as a bioactive substance that has been proven to play an important role in animal health, especially as an anthelminthic in reducing the level of gastrointestinal nematodes in animals (Fasae and Omosun, 2013). For decades, plants containing bioactive compounds have been employed in worm control, which is still in practice today. Some *in vivo* and *in vitro* studies have made known that bioactive plants containing diverse types of secondary metabolites, such as condensed tannins are a capable option for nematode control in livestock production systems (Garcia-Bustos, 2019; Rodríguez-Hernández, 2023).

The reduction in faecal egg count across studies confirms the efficacy of tannins in FTL to improve animals' ability to control the biology of parasite worm populations, as well as their ability to tolerate the detrimental pathophysiological effects of nematode infections (Hoste et al., 2005). The positive effect of tannins on animal resilience has similarly been underlined in different animal species. The consumption of certain tannin-contained plants has host-mediated effects that influence animal biology and improve the immune response to decrease larval migration and development, thereby directly reducing abomasal and intestinal infections (Athanasiadou et al., 2000; Valderrábano et al., 2010). Van Houtert et al. (1995) equally observed that the increase in protein availability to the host through protein supplementation via forage during the course of a parasitic infestation could lead to a reduction in the number of nematodes in sheep due to the improvement of their immunity to parasites.

Parasitism imposes a considerable nutritional disadvantage on ruminants, and therefore controlling the parasite burden will indirectly assist the nutritional status of animals. The potential of FTL having a combined beneficial action as regards nutritional and antiparasitic could further support the issues of increased societal demands to reduce the use of chemical compounds in livestock production, thereby enhancing sustainable agriculture systems.

CONCLUSION

The review illustrates the valuable role of FTL in Dwarf sheep and goat production systems through their unique contributions as a high-quality supplementary protein source in improving animal productivity in terms of promoting weight gain, enhancing feed digestibility, anthelminthic as well as in methane mitigation, especially during the critical dry season period. The capacity of Dwarf sheep and goats to utilize and produce valuable food products from low-value feedstuffs will help retain their niches and the optimization of the productivity of these animals. This would hence improve the economic, nutritional, and social status of the resource-poor smallholder farmers with the potential to benefit the wider society through improved ecosystem services and reduced negative environmental impacts.

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Vloga krmnih stročnic kot dopolnilnega krmila pri krmljenju pritlikavih ovc in koz – pregled

IZVLEČEK

Članek obravnava pregled literature na temo potenciala krmnih stročnic kot obetavne in prehranske strategije za zmanjšanje problema nezadostne oskrbe s krmo v proizvodnih sistemih zahodnoafriških pritlikavih ovac in koz, zlasti v sušnem obdobju. Za bolj trajnostne kmetijske sisteme, vključno s širjenjem uporabe lokalno pridelane razpoložljive krme, predstavljajo krmne stročnice predvsem vrste *Leucaena leucocephala*, *Gliricidia sepium* in *Enterolobium cyclocarpum* zanimivo strategijo za zagotavljanje dušika v prehrani in izboljšanje prebavljivosti krme, za povečanje telesne mase in zadrževanje dušika, s čimer se poveča produktivnost pritlikavih ovac in koz. Vsebujejo tudi biološko aktivne spojine, ki pomagajo pri upočasnitvi okužb s parazitskimi ogorčicami v prebavnem traktu in zmanjšujejo emisije črevesnega metana pri teh živalih. Vsebnost surovih beljakovin se je v različnih vrstah krmnih stročnic gibala med 16,20 do 26,79 %, vsebnost taninov pa med 0,95 do 2,92 %. Pri pritlikavih ovcah, ki so jih dokrmljevali s krmnimi stročnicami, se je glede na objavljene raziskave prirast telesne mase povprečno povečal za 43,23 do 48,59 g/dan, pri pritlikavih kozah pa za 32,46 do 40,87 g/dan. Analizirane hematološke in serumske biokemične spremenljivke so bile v dovoljenem območju za zdrave živali in so pokazale ustrezno oskrbo s hranili iz različnih vrst krmnih stročnic in izboljšanje produktivnosti živali. Na osnovi pregledane literature lahko zaključimo, da imajo krmne stročnice odlično hranilno vrednost ter predstavljajo pomemben prehranski potencial za trajnostne sisteme krmljenja pritlikavih ovc in koz.

Ključne besede: ovce, koze, uspešnost, drevesne metuljnice, tanini, anthelmintik, blažitev izpustov metana