Tropical and Subtropical Agroecosystems

Invited Review

RABBIT PRODUCTION USING LOCAL RESOURCES AS FEEDSTUFFS IN THE TROPICS

[PRODUCCIÓN DE CONEJOS EN EL TROPICO USANDO RECURSOS LOCALES COMO ALIMENTO]

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SUMMARY

This review discusses the findings of existing research surrounding the nutritional impact of some forages as well as leaf and seed meals that were incorporated in rabbit diets, furthermore the importance of dietary fiber to improve the digestive health for growing rabbits. Optimum growth performance can be achieved by feeding forages or leaf meals with concentrates in the rabbit diets. Tropical plants contain appreciable amount of protein, fat, minerals and carbohydrates that can support growth and production, however much of these plants contain also anti-nutritional factors which have negative effects on digestion or absorption of nutrients. The review revealed that different forages inclusion levels enhance rabbit production and can help overcome the protein intake deficiency in developing countries. Therefore, the utilization of forage plants as well as tropical grasses and legumes for rabbit feeding is recommended.

Keywords: Tropical plants; local forages; anti-nutritional factors; rabbit production.

RESUMEN

Esta revisión describe los hallazgos de investigación en torno al uso de algunos forrajes, así como harinas de hojas y semillas como ingredientes en las dietas de conejos, además la importancia de la fibra dietética para mejorar la salud digestiva de los conejos en crecimiento. Es posible lograr un crecimiento óptimo mediante la alimentación con forrajes o harina de hojas con concentrados, en las dietas de conejos. Las plantas tropicales contienen cantidades apreciables de proteínas, grasas, minerales y carbohidratos que pueden apoyar el crecimiento y la producción, sin embargo la mayor parte de estas plantas contienen también factores anti-nutricionales que tienen efectos negativos sobre la digestión o absorción de nutrientes. La revisión reveló que los niveles de inclusión de los diferentes forrajes mejoran la producción de conejos y pueden ayudar a superar la deficiencia del consumo de proteínas en los países en desarrollo. Se recomienda la utilización árboles forrajeros, así como de gramíneas y leguminosas tropicales como ingredientes para la alimentación de conejos.

Palabras clave: Plantas tropicales; forrajes locales; factores anti-nutricionales; producción de conejos.

INTRODUCTION

In tropical and developing countries, the interest has focused on exploring protein sweeping underutilized legumes and forages due to an acute shortage of food rich in protein, caused by population explosion and the high cost of animal protein. A lot of forages could be used in animal rations substituting a part of costly protein sources, that depending on chemical composition, low anti-nutritional factors (ANF) content, viability and palatability, thus forages' leaves and seeds are of great interest due to the high nutritional value and low cost.

The recent experience in Latin America and Asia has demonstrated that new forage-based technologies are highly effective for intensifying meat production on small farms. They also show potential as partial substitutes for concentrate supplements in feeds, thus lowering production costs.

In recent decades, though, forage specialists have identified a wide variety of tropical forage grasses and legumes that are highly productive, show superior nutritional quality, and are well suited to marginal agroecosystems characterized by low soil fertility and drought. In Central and Latin America much progress has been made toward commercializing and promoting these improved forages, similar efforts to introduce improved forages, are also under way in Africa and Asia but are less advanced (CIAT, 2006).

Tropical plants may contain large numbers of plant secondary metabolites that may act singly or in combination to produce direct (Athanasiadou *et al*., 2001) and /or indirect effects on parasites in the alimentary tract, leading to reduce nematode survival, growth and fecundity. They can also improve protein availability in the host and have direct or indirect effects on mineral or trace element status. Both of these changes in host nutrition can lead to reductions in parasite establishment, burden and fecundity through improvements in host immunoregulatory capacity. There are thought to be a number of active biochemical compounds that act against parasites including essential oils, lectins and polyphenolics such as the tannins.

THE IMPORTANCE OF DIETARY FIBER IN RABBIT NUTRITION

Initially, dietary fiber is one of dietary components which usually contain 35 to 40% neutral detergent fiber (De Blas and Mateos, 1998). It helps to maintain a high rate of passage, avoiding the accumulation of digesta in the caecum that reduce feed intake and impairs growth (De Blas *et al*., 1999). Moreover, fiber is a substrate for cecal micro organisms, where its fermentation product is mainly volatile fatty acids (VFA) which may reduce the incidence of digestive disorders and mortality. In that, results of Yu and Chiou (1992) showed that dietary fiber level did not affect VFA concentration in caecum or colon, whereas molar proportion of VFA was significantly affected. Tortuero *et al*. (1994) reported that total VFA concentration in caecal digesta was higher as feeding diets with olive and grape pulps than that of diet included lucerne hay meal. Gidenne and Bellier (1998) indicated that significant variations in caecal VFA levels were observed due to different sources of dietary fiber containing diets. Also, Nicodemus *et al*. (1999) revealed that decreasing acid detergent lignin (ADL) inclusion linearly increased caecal VFA concentration of growing rabbits.

The effect of fiber type on the rate of digesta passage in rabbits was studied by Fraga *et al*. (1991) who reported that mean retention time was found to be higher (21.3 h.) in the rice hulls diet, whereas the lowest was attained with grape marc ones which was 9.3 h., Gidenne (1992) measured the rate of passage of cell wall particles of size from 0.05 to over 1 mm, in rabbits fed diets containing 2.3 and 7.6% acid detergent fiber (ADF). However, mean particle retention time was slight in the passage rate among particles of size 0.3 and 1 mm.

Moreover, the subject of dietary fiber has became more important as an economic considerations being increasingly involved in production process and cost, where feeding rabbits on high quantity of digestible fiber promoted a best fermentative activity especially at weaning stage (Gidenne *et al*., 2002). Moreover, it is of a great importance that feeding rabbits diets with higher dietary fiber levels not only provides nutrient substances, but also has the function of maintaining micro-ecological balances of gut, promoting digestive system development and consequently improving the productive performance (Gu *et al*., 2004). These findings enhance the interest in using inclusion of inexpensive tropical feed resources in commercial feeds for growing rabbits with respect to sources used at present.

UTILIZATION OF TROPICAL PLANTS IN RABBIT NUTRITION

Some plant leaves and seeds have been used as feedstuffs for rabbits and other animals as a partial or complete substitute for the conventional grains and forages.

In this regard, Bamikole *et al*. (2005) investigated the potential of using Mulberry leaves (*Morus spp*) in rabbit production in a 12-week long experiment where feed intake, weight gain, and nutrient digestibility of the rabbits were studied; Mulberry leaves were incrementally replaced from the concentrated diet by 0, 25, 50, 75 and 100%. The intakes of crude protein (CP) and crude fiber (CF) increased significantly whilst those of ether extract (EE), ash, and nitrogen free extract (NFE) decreased significantly with increasing level of mulberry leaves in the diets. The apparent nutrient digestibility of the diets was high and there were no significant differences among the treatments for dry matter, organic matter, CP, CF, and ash.

Weight gain of rabbits on diets containing 25 and 50% mulberry leaves were not significantly different from that of all-concentrate ration, but these were significantly higher than those of 75 and 100% mulberry leaves. It was concluded that mulberry leaves could support feed intake and digestibility with satisfactory weight gain in rabbits up to 50%, and could reduce reliance on and cost of expensive concentrate diets.

Farinu *et al*. (2008) evaluated the nutritive potential of pigeon pea (*Cajanus cajan*) grain and leaf meals on growth performance of pre-pubertal rabbits in the tropics. The experimental diets contained 0% pigeon pea, 15% pigeon grain meal and 15% pigeon pea leaf meal respectively, in replacement of maize offal as the main energy source. The final live weight, daily weight gain and feed conversion ratio values were not significantly affected by the dietary treatments. It was concluded that 15% pigeon pea grain meal inclusion in rabbit diet with maize offal rather than maize, as the main energy base, resulted in better performance of growing rabbits.

Under tropical conditions Eshiet *et al*. (1979) studied the effects of feeding graded levels of cassava root meal on the performance of growing rabbits. The experiment showed that rabbits could tolerate up to 30% cassava root meal diet without adverse effects on feed intake and growth rate.

A feeding trial was conducted using growing rabbits by Ayers *et al*. (1996) to evaluate hybrid poplar (*Populus spp*.) leaves as animal feed under tropical conditions. The treatments were 0, 10, 20, and 40% hybrid poplar foliage; a diet with 40% Alfalfa Meal was the control. There was no difference in growth rates of rabbits on the various diets, even though digestibility was lower in those fed diets with hybrid poplar than those fed the control. Generally, better performance was obtained when hybrid poplar included in rabbit diets.

The effect of replacing grain with lucerne meal on the performance of weanling rabbits has been investigated (Pote *et al*., 1980). Even when corn was completely replaced by lucerne meal, there was no reduction in average daily gain. As the lucerne level increased, caloric density of the diet decreased, but the animals increased their feed intake to maintain the same caloric intake. This demonstrates that the rabbit, like other species, eats sufficient feed to meet its energy requirements. The group fed the high energy corn-soy diet with no lucerne had the poorest growth rate. Enteritis caused mortality in all treatments except the one which lucerne completely replaced corn, which supports the carbohydrate overload theory of enteritis when high caloric and low fiber diets used in rabbit feeding.

Table 1. Performance of growing rabbits fed different unconventional feedstuffs.

Ingredients	Highest level studied (%)	Accepted level (%)	Substituted mainly to	Source
Mulberry leaves (*Morus spp*)	100	50	Concentrated diet	Bamikole *et al*. (2005)
Pigeon pea (*Cajanus cajan*) grain meal	15	15	Maize offal	Farinu *et al*. (2008)
Cassava root meal	30	30	Concentrate	Eshiet *et al*. (1979)
Cassava peel meal	40	40	Complete diet	Omole and Sonaiya (1981)
Hybrid poplar foliage (*Populus spp*.)	40	40	Alfalfa Meal	Ayers *et al*. (1996)
Crotalaria ochroleuca	45	15-30	Sunflower meal	Laswai *et al*. (2000)
Tridax procumbens forage	75	50	Concentrate	Adeyemo *et al*. (2014)
Acacia saligna meal	30	30	Clover hay	El-Gendy (1999)
Cooked *Mucuna pruriens* seed meal	30	30	Concentrate	Ani and Ugwuowo (2011)
Dried *Leucaena leucocephala* leaves	30	15	Wheat bran	Parigi-Bini *et al*. (1984)
Leucaena leucocephala leaf meal	40	40	Complete diet	Nieves *et al*. (2004)
Moringa Oleifera leaf meal	15	15	Soybean meal	Odetola *et al*. (2012**)**
Portulaca oleracea forage	20	20	Soybean meal	Abaza *et al*. (2010**)**
Brosimum alicastrum forage	100	38	Complete diet	Martinez *et al*. (2010)
Gliricidia sepium leaf meal	20	20	Soybean Meal	Amata and Bratte (2008)

Adeyemo *et al*. (2014) studied the effect of concentrate to forage (*Tridax procumbens*) ratio on the performance and carcass characteristics of growing rabbit. The forage was included in the diets by 0, 25, 50 and 75%. The final weight, weight gain and feed conversion ratio were significantly better for rabbits fed 50% *Tridax procumbens* forage in comparison to the other experimental group. The authors also reported that the rabbits fed 50% forage had the highest live weight, dressed weight and dressing percentage. Therefore for optimum performance of rabbits, they should be fed 50% of concentrate and 50% of forage.

On the other hand, Linga *et al*. (2003) reported that rabbits fed the control diet significantly consumed more feed than those received other experimental diets which contained lablab forage (fresh or hay), moreover feed conversion ratio of the control group was significantly better than those of the other groups. Kamel and Brekaa (2005) found that the higher level (60%) of *Acacia saligna* meal containing diet significantly reduced feed intake and negatively affected the feed conversion ratio as compared to that of the control group. Nicodemus *et al*. (2006) also noted that feed intake was decreased significantly for rabbits fed diet contained 75% substitution of Lucerne hay by a mixture of paprika meal, sugar beet pulp and soybean hulls compared with the average of other diets which contained 0, 25 and 50% of the mixture. In regard to feed efficiency, authors found that animals fed a 50% mixture substitution diet showed significantly better feed efficiency by about 4.3% than the average of all other dietary treatments.

ANTI-NUTRITIONAL FACTORS PRESENT IN TROPICAL PLANTS

Anti-nutritional factors are compounds mainly organic, which when present in a diet, may affect the health of the animal or interfere with normal feed utilization.

Anti-nutritional factors may occur as natural constituents of plant and animal feeds, as artificial factors added during processing or as contaminants of the ecosystem (Barnes and Amega, 1984). Ingestion of feed containing such substances induces, in some cases, chronic intoxication and in others interferes with the digestion and utilization of dietary protein and carbohydrate and also interferes with the availability of some minerals, thus feed efficiency, growth rate and, consequently, the production of the edible products.

Some of the anti-nutritional factors act on inhibiting enzymes directly forming complexes with nutrients rendering them indigestible by proteolytic enzymes (Abeke *et al*., 2003). Furthermore, vicinyl hydroxyl groups of phenolic compounds may chelate metal ions and reduce their bioavailability (Layrisse *et al*., 2000).

Although anti-nutritional factors are present in many conventional feeds, they are more common in most of the non-conventional feeds.

DESCRIPTION AND CHARACTERISTICS OF SOME TROPICAL PLANTS AVAILABLE IN THE TROPICS

Mucuna pruriens.

Mucuna seeds (Velvet bean) originated from India and have been widespread in tropical and subtropical regions due to their easy adaptation. These seeds have potential as a protein supplement to improve ruminant and non-ruminant nutrition if the adverse effect of anti-nutritional factors such as L-Dopa, tannins, phenols, phytic acid and protein inhibitors can be diminished. Moreover, this legume has low fat quantity and high content of fiber, minerals and essential amino acids.

Amino Acids content

The seed flour contained a good array of amino acids but was low in cystine and methionine.

Table 2. Composition of amino acids in Mucuna beans

Amino acid	**composition ($mg.g^{-1}$ CP)**
Alanine	63.9
Arginine	90.6
Aspartatic acid	171
Cysteine	traces
Glutamatic acid	155.5
Glycine	50.5
Histidine	35.3
Isoleucine	92.3
Leucine	90.8
Lysine	46.4
Methionine	traces
Phenyalalanine	80.8
Proline	151
Serine	41.5
Threonine	44.4
Tryptophan	22.3
Tyrosine	70.9
Valine	58.3
Total essential amino acids (%)	39.8
In vetro protein digestibility (%)	84.6

Source: Agbede and Aletor (2005)

Anti-nutritional factors

The use of Mucuna as an animal feed is limited because the raw seeds contain such anti-nutritional factors as trypsin inhibitors, total phenolics, tannins, and cyanogenic glucosides (Ravindran and Ravindran, 1988); anticoagulants (Houghton and Skari, 1994); analgesic, antipyretic and anti-inflammatory factors (Iauk *et al*., 1993); L-dopa (3, 4 Dihydroxy-L-phenylalanine, a potential neurotoxic agent) and others (Olaboro *et al*., 1991; Hussain and Manyam, 1997). The feed potential of Mucuna can be enhanced by reducing these anti-nutritional factors to safe levels either by boiling and roasting or by fermentation (Mary-Josephine and Jonardhanan, 1992).

The harmful effects of the 3, 4-dihydroxy-l-phenylalanine (L-dopa) in *Mucuna pruriens* seeds have limited its use as a protein supplement for monogastric animals. If a simple and effective method to reduce or eliminate anti-nutritional toxic factors can be developed, the mucuna beans can be increasingly used as high protein feedstuff for livestock.

Mucuna for feeding of rabbits

Mucuna bean seed meal and Mucuna bean leaves can be fed to rabbits. Seeds and leaves can be fed together to rabbits, resulting in higher intake, increasing diet digestibility and higher growth rates (208 g/week *vs.* 167 g/week on basal diet) (Aboh *et al*., 2002). Up to 20% cooked mucuna seed meal can be included in the diet of weaned rabbits (Taiwo *et al*., 2006). Mucuna bean leaves compared favorably with soybean meal and gave similar daily weight gains (15 g/day *vs.* 16 g/day) (Bien-aimé and Denaud, 1989). Additionally, no significant differences were detected among rabbits fed 0, 10, 20 and 30% cooked *M. pruriens* seed meal in the final body weight, daily weight gain, daily feed intake and feed conversion ratio as reported by Ani and Ugwuowo (2011).

Leucaena leucocephala

Leucaena is well known for its high nutritional value and for the similarity of its chemical composition with that of alfalfa (N.A.S, 1975). It could be used as an alternative feedstuff for commercial livestock in the tropics. The leaves contain high level of protein, which ranges from 20 to 34% CP on dry matter basis; additionally it has an acceptable profile of essential amino acids, vitamins and minerals (Abou-Elezz *et al*., 2011). However, leucaena forage can be low in sodium and iodine, but is high in β-carotene. Tannins in the leaves and especially the stems of leucaena reduce the digestibility of dry matter and protein.

Dry matter productivity of leucaena varies with soil fertility and rainfall. Edible forage yields range from 3 to 30 tons dry matter/ ha/ year.

Age of cutting

It should be cut 75-100 cm above the ground every 2-4 months after the first pruning (9 months after planting). Leucaena can produce well for 10 to 20 years or even up to 35 years (N.A.S, 1975).

Toxicity of Leucaena

Although leucaena has tremendous potential as a protein source in tropical countries, it contains a toxic amino acid which is mimosine; this component is considered toxic for monogastric animals and constitutes 7% of the total protein of *Leucaena leucocephala* leaves (Meulen *et al*., 1979). The mimosine causes alopecia (loss of hair) and in ruminants causes goiter. The leaves contain over than 30% protein. Leucaena when fed along with other tropical forages can be very effectively used by animals as a protein source. Plant breeders in Australia and Hawaii are developing low mimosine varieties of leucaena, which should improve the feeding value of this high protein plant (McNitt *et al*., 2013). Mimosine toxicity symptoms disappear after a short time and leave no residual effects when the plants are removed from the diet.

Leucaena for rabbit feeding

Leucaena leucocephala leaves (fresh or dried) or leaf meal enhance feed intake, feed conversion ratio and animal performances. Recommended inclusion levels range from 24 to 40% for growing or fattening rabbits fed on fresh *L. leucocephala* leaves (Onwuka *et al*., 1992; Muir and Massaete, 1992; Rohilla and Bujarbaruah, 1999; Rohilla *et al*., 2000; Nieves *et al*., 2002; Nieves *et al*., 2004). *L. leucocephala* can replace alfalfa (Scapinello *et al*., 2000). Nieves *et al*. (2004) found that complete diets containing 30 or 40% leucaena leaf meal were more palatable than diets containing the same levels of *Arachis pintoi* meal.

Not all trials with leucaena have been positive. In an experiment where dried leucaena replaced wheat bran, its nutritive value for growing rabbits was significantly reduced when the percentage of leucaena in the diet was higher than 10-15% (Parigi-Bini *et al*., 1984). 20-25% leucaena fresh leaves inclusion may have deleterious effect on female mortality and on youngs (up to 55% mortality) (Muir and Massaete, 1995; Sugur *et al*., 2001). $FeCl_3$ can be added to *Leucaena leucocephala* so that it alleviates mimosine toxicity (Gupta *et al*., 1998).

Moringa oleifera

It is one of the world's most useful plants. It is cultivated in all the countries of the tropics for its leaves, fruits, and roots for a variety of food and medicinal purposes (Morton, 1991). It is now indigenous to many countries in Africa, South East Asia, the Pacific and Caribbean Islands and South America. As more becomes known of the various uses and products of the tree the greater its significance has become in the development of many of the poorest areas of developing countries. It is suggested that the plants could be harvested 7 times/year, when the annual fresh biomass yield would be from 43 to 52 tons/ha.

Anti-nutritional factors

The concentration of total phenol content and simple phenols do not produce any adverse effect when eaten by animals. Phytates are present to the extent of 1 to 5% in legumes and are known to decrease the bioavailability of minerals in monogastric animals (Reddy *et al*., 1982). Saponins from some plants have an adverse effect on the growth of animals but those present in Moringa leaves appear to be innocuous (did not show haemolytic activity). Leaves have negligible levels of tannins and saponins, which are similar to those present in soybean meal, Trypsin inhibitors and lectins were not detected. However, Foidl *et al*. (2001) suggested that Moringa is a good source of protein for monogastric animals.

M. Oleifera in rabbit nutrition

Djakalia *et al*. (2011) found that the supplementation of Moringa at 3% in the feed of young post-weaning rabbits, gives the best results in terms of gross weight, growth rate and survival of young rabbits. The performances have been achieved due to the high digestibility of its proteins and its antimicrobial activity. So that *M. oleifera* could be used as an active biochemical compound to replace antibiotics.

Moringa leaf meal is non-toxic for weaning rabbits at least at the 20% diet inclusion level. It could be used to replace soybean meal partially or completely in rabbit diets as a non-conventional protein source. The productive performance of the weaning rabbits improved by inclusion of moringa leaf meal up to 20% in the diets. Additionally, moringa leaf meal has the potential to reduce cholesterol level in blood and the meat of rabbits **(**Nuhu, 2010**).**

Portulaca oleracea

Portulaca oleracea (Purslane) is a grassy plant with small yellow flowers and stems sometimes flushed red or purple, which grows widely in different areas of the world. Purslane has been used as antibacterial, antidiabetic, antifungal, anti-inflammatory, diuretic and analgesic activity (Chan *et al*., 2000). Grubben and Denton (2004) reported that this crop yields of 12–17 tons/ha in the tropics.

Nutritional Value

P. oleracea contains many biologically active compounds and is a source of many nutrients. Some of the biologically active (and, in some cases, potentially toxic compounds) include free oxalic acids, alkaloids, flavonoids and cardiac glycosides. It has high contents of Omega-3 fatty acids and protein (compared to other vegetables) (Ezekwe *et al*., 1999). The quantity of these compounds in *P. oleracea* varies with the growing conditions (e.g., planting date, soil quality, fertilization) and the age of the plant.

Age of cutting

The plants should be harvested at 16-true leaf stage, which optimize growth, maximize omega-3 fatty acids and minimize oxalic acid concentrations (Palaniswamy *et al*., 2004).

Toxicity

No data on the toxicity of *P. oleracea* could be found in the literature. However, the plant does contain cardiac glycosides and oxalic acids, which can be toxic.

Nevertheless, other results confirmed that consumption of purslane by goats caused weakness of the fore and hind limbs with inability to stand, greenish watery diarrhea and polyuria, Obied *et al*. (2003). The plant is not recommended for animal nutrition when is given daily, fresh and in large quantities.

P. oleracea in rabbit nutrition

Rabbit needs ration with high fiber content. The protein and fiber content of *Portulaca oleracea* are relatively high; they are 30.41% and 12.81%, respectively.

Growing rabbits could be fed 20% *Portulaca oleracea*, replacing of soybean meal without any adverse effect. Rabbits fed this diet achieve the best values of growth performance, digestion coefficients, carcass traits, globulin level and immune response. Economical efficiency was also improved with such level of *Portulaca oleracea* **(**Abaza *et al*., 2010**)**.

Guazuma ulmifolia

G. ulmifolia is a tree native to tropical Latin America with a good forage quality, and is found from Mexico to southern Brazil, and in the Caribbean. It is a tree of medium size; the plants can be harvested every four months, with a yield of 2.6 tons DM/ha (Manríquez-Mendoza *et al*., 2011)

Nutritional Value

The quality depends on the soil and climatic conditions of the location, time of year, age of regrowth, plant management and animal consumption (López *et al*., 2008). The content of CP for *G. ulmifolia* leaves ranging from 16% (CATIE, 1991) to 19.5% (Araya *et al*., 1994). Ash content in foliage ranges from 8.6% (CATIE, 1991) to 14% in 4-year-old plants and 70 days of regrowth during the rainy season (López, 2008). Regarding NDF content of this plant, it ranges from 41.1% (Bobadilla *et al*., 2006) to 74% in forage of 70 day-old regrowth (López, 2008). It is a species with the potential to improve livestock performance when they are provided with other forage species of lower nutritious quality.

Toxicity

The forage is known to contain tannins. López *et al*. (2004) analyzed the tannin content and found 12.97% free tannins content and 20.59% total condensed tannins (on dry matter basis) in the forage. However, the content of this metabolite varies with forage age, location and time of year (Scull, 2004). The content of these metabolites is important because it is negatively related to digestibility and can affect the consumption and nutrient value of the forage (Soca, 2004).

G. ulmifolia for feeding of rabbits

This forage has not been extensively studied for monogastric animals; however the studies performed on cattle, sheep or goats have indicated greater consumption and preference with higher body weight gain when the animals fed *G.* ulmifolia (Vallejo *et al*., 1994; Pérez *et al*., 2006; López, 2008).

Brosimum alicastrum

This tree is an important species that grows in the wet and dry tropical forest of Mexico and Central America, as well as in the Caribbean Islands. The tree can grow up to 45 m in height (Cruz-Bacab, 2009). Producing abundant yields and with several harvests possible in one year. Foliage yields from *B. alicastrum* may reach 2 tons DM/ha/year. It keeps its leaves throughout the year and, therefore, it is an important source of forage for any tropical area that suffers feed shortages during the dry season (N.A.S., 1975).

Toxicity

The foliage of *Brosimum alicastrum* has been traditionally used in the tropical regions as an animal feed, and no reports have been made of negative impacts or toxicity of this plant (Mendoza-Castillo *et al*., 2003).

B. alicastrum for feeding of rabbits

B. alicastrum has been identified as well accepted forage for rabbit feeding and it is preferred over other local plants species (Cruz-Bacab, 2013). Feeding *Brosimum alicastrum* to growing rabbits resulted in higher daily weight gain (24. 7 g d^{-1}) than the *Hibiscus rosa-sinensis* treatment which was 23.8 g d^{-1} in average (Martinez *et al*., 2010). Additionally, Rojas (2008) reported that *B. alicastrum* did not have negative effects on digestibility of gross energy when incorporated by 20, 40 or 60% in the growing rabbit diets.

CONCLUSION

It can be concluded from this review that forage, grass and legume plants could be used as alternative feed resources to implement sustainable rabbit production in tropical countries. For effective utilization of these plants, it may be necessary to develop processing methods to reduce or completely eliminate anti-nutritional factors that are present in them.

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