

CUBES AND PELLETS OF LEGUME TREE LEAVES FOR DRY SEASON FEED IN SEMI-ARID REGION OF INDONESIA

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ABSTRAK

Cubes dan Pellet Daun Leguminosa Pohon untuk Pakan Ternak di Daerah Semi-Arid, Indonesia. Ternak, khususnya sapi merupakan komoditas penting sebagai sumber pendapatan bagi petani di Nusa Tenggara Timur (NTT), Indonesia. Namun demikian, produktivitas ternak sapi di daerah ini masih rendah disebabkan karena kurangnya pengetahuan petani dalam usahatani ternak dan terbatasnya ketersediaan pakan terutama selama musim kemarau (8-9 bulan per tahun). Di lain pihak, ketersediaan pakan berlimpah di musim hujan. Beberapa leguminosa pohon sudah lama digunakan sebagai sumber pakan di daerah ini, namun karena panjangnya musim kemarau menyebabkan terjadinya gugur daun pada tanaman ini. Karena itu penting untuk melakukan teknologi pengawetan pakan yang dapat diadopsi oleh petani. Suatu seri penelitian dan pengkajian telah dilakukan di Timor pada Balai Pengkajian Teknologi Pertanian (BPTP NTT) untuk meneliti dan mengkaji tentang pembuatan cubes dan pellet dari daun leguminosa pohon, seperti *Leucaena leucocephala*, *Glirisdia sepium*, dan *Sesbania grandiflora*, menggunakan tepung ubi kayu sebagai perekat atau pengikat sekaligus sebagai sumber energi. Pengkajian ini telah menemukan formulasi yang sesuai untuk pembuatan cubes dan pellet, informasi nilai nutrisinya, peralatan pembuat cubes dan pellet, penambahan berat badan ternak jika diberikan cubes dan pellet sebagai pakan suplemen, dan pengalaman dalam melakukan kajian diseminasi teknologi pembuatan cubes dan pellet kepada petani di Timor. Kajian ini juga menguraikan lebih lanjut tentang beberapa implikasi praktis yang dapat dilakukan untuk mendorong penggunaan cubes dan pellet di NTT.

Kata kunci: *Cubes, pellet, leguminosa pohon, tepung daun, pengawetan pakan*

ABSTRACT

Livestock (especially cattle) is an important income generating source for farmers in the semi-arid region in East Nusa Tenggara Province, Indonesia. Cattle production in the region, however is still low, lack of farmers knowledge in animal husbandry, and the lack of year round feed supply especially during dry periods (8-9 month dry season in a year). Fodder availability, however, in fact is usually abundant during the wet season. Some tree legumes have long been important sources of fodder in the region, however, owing to the long dry period considerable loss of leaf occurs. Thus there is an urgent need to encourage the application of feed preservation technologies adoptable by farmers. A series of experiments and assessments were conducted at the East Nusa Tenggara Assessment Institute for Agriculture technology (BPTP NTT) to investigate the making of cubes from the leaves of legume trees such as *Leucaena leucocephala*, *Glirisdia sepium*, and *Sesbania grandiflora*. Cassava meal was used as the binding agent as well as the source energy. The experiments and assessments have obtained a proper formula for making cubes, information on the nutritive values, equipments to produce cubes and pellets. Beside, information on the preferences of cattle to the cubes and pellets, live weight gain when fed as supplement, and some experiences in the dissemination of cubes and pellets making to the farmers was also obtained. The paper also elaborated further into explaining some practical implications of ways to encourage cubes usages in East Nusa Tenggara.

Key words: *cubes, pellets, legume trees, leaf meals, feed preservation, semi-arid*

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INTRODUCTION

East Nusa Tenggara is one of the 30 provinces of Indonesia, lies between West Nusa Tenggara Province in the west and Republic of Timor Leste in the east, and comprises of 3 major islands (West Timor, Flores and Sumba). Rainfall in the region is short and erratic, ranging from 800 mm to 2500 mm, between November to March, but the intensity is only high during December to February. The soils of Timor and Sumba islands have been derived from marine sediments, highly calcareous with soil pH between 7 to 9.

The economic support and growth of Sumba and West Timor are much relied on livestock productions, while Flores is much more concentrated on estate crops cultivation (Cacao, Coconut, Coffee, Clove, Candle and Cashew nuts) but livestock is also an important component in the farming system. The province, however, in total supplied about 40.000 to 60.000 heads of cattle per year for consumers in Java Island, especially Jakarta.

The productivity of cattle in the province, however, is hindered by the lack of fodder and feed supply, especially during the dry season (both in quantity and quality), which among other things bring about high live weight loses during the dry season (up to 30-40% of the weight gained during the wet season), high calf mortality of around 20-40% (especially in Bali cattle), and long calving interval (especially in Ongole cattle) (Bamualim and Wirdahayati, 2002). The lack of feed supply is significant during long period of droughts (often up to 8-9 months), and the most critical period is between September to November. Fodder production (grasses and legumes), however is abundant during the wet season.

There are some important tree legumes in the region, i.e. *Leucaena leucocephala*, *Gliricidia sepium* and *Sesbania grandiflora*, used in the farming system especially as sources of fodder for ruminants. In the 1930-s, the Dutch administration introduced *Leucaena leucocephala* into Amarasi area (Piggin, 2003) and by the 1970-s, the Provincial Livestock Services started with cattle fattening programs

which relied much on the usage of the legume as almost a sole diet. Though the attack of psyllid (*Heteropsylla cubana*) in 1987 reduced the productivity of *L. leucocephala* in the region for some times, recovery has occurred recently (Nulik et al., 2005). The introduction of more resistant and higher production varieties (i.e. the hybrid KX, and *L. leucocephala* cv. Tarramba), which had been successful in the Philippines and Vietnam (Shelton, 2006) and had been observed to be superior too in Timor and Sumba Islands (Nulik et al., 2004), has shown promises that leucaena would still be an important source of high quality fodder for livestock in the region.

Gliricidia sepium, compared to *Leucaena leucocephala*, was just recently (1970s) introduced into the region, where at first it was intending for revegetation programs, however its usage in the farming system (mainly for life fencing) has accelerated its wide distribution. The legume is readily eaten by cattle and goats in some sites of Indonesia, such as in Bali, and Sumbawa Island of West Nusa Tenggara – Indonesia (in Seneo Village of Dompu), but in Timor it is only palatable to goats. The legume is more palatable for cattle in Timor only after ensilaging (Nulik et al., 2005).

Both of the legumes, produced high biomass during the wet season, but they will experience considerable leaf loss during the long period of dry season, and thus there is an urgent need to preserve them to ensure continuity of good quality year round feed supplies.

Quick declining in nutritive values of native grasses soon after the rainy season (Jelantik, 2001; Bamualim and Wirdahayati, 2002) and partly or totally leaf losses or fall in tree legumes during the dry season in the semi-arid region such as in East Nusa Tenggara Province of Indonesia as well as the urgent need to overcome problem of live weight losses during cattle transportation (i.e. from Timor to Java) indicated the need to promote feed preservation technologies. A series of experiments and assessments have therefore been done at the East Nusa Tenggara Assessment Institute for Agriculture Technology to produce cubes from local available fodder and feed components, these includes *Leucaena leucocephala* leaf meal, *Gliricidia sepium* leaf meal, *Sesbania*

grandiflora leaf meal, and cassava meal (mixed with heated salt water as the binding agent).

METHODOLOGY

A series of experiments and assessments has been conducted at the East Nusa Tenggara Assessment Institute for Agriculture Technology in West Timor over a three years period (2001 to 2003), and further continued to introduce the findings to farmers in the villages in Timor between 2004 and the present. Experiments include observing several methods for fodder drying, designing and assessing the capacity of the equipment for leaf milling, pelleting and cubing, assessments of efficient and practical ways and appropriate times to produce cubes in consideration of the availability of labor in the villages that match the availability of high quality fodder in sufficient supply. Assessments were also undertaken to test the palatability of the preserved feed to the cattle.

The first experiment was aimed to determine appropriate temperature to dry leaf of legumes using the laboratory oven method. Three levels of temperatures were tested: 60, 70 and 80°C. Observations included the nutritional analysis of the dried leaves obtained from the different drying temperatures. Further work was done to design a drying cabinet with a reasonable capacity to dry forage leaf (3 to 4 tons) during the wet period, when high quality leaves were abundant.

The multipurpose milling equipment was designed (hammer mill type) and tested for its capacity to grind several materials that can be used in formulating livestock feed such as corn, cassava tuber, leaves of legume trees (*L. leucocephala*, *G. sepium*, and *S. grandiflora*), rice straw, mung bean etc.

Observation of cubing equipment was focused first on designing an appropriate tool to produce cubes or pellets. The first model designed was a hand operating pressure type with an outlet that could produce either cubes or pellets. The second design used a spiral iron rod to force the material (pulp of leaf meal and cassava mix) through similar outlet forms (cubes and pellets). Manual cubing was also trialed to

assess its potential for small capacity production by individual families in villages. The size of the cubes was 3x 3 x 3 cm³.

To determine the most effective binding capacity of cassava and leaf meals in forming the cubes and pellets, different proportions were trialed, i.e. 80% leaf meal + 20% cassava meal, 75% of leaf meal + 25% of cassava meal, and 70% of leaf meal + 30% cassava meal. The mixing methods were tested in two ways. In the first method, where the cassava binding agent was prepared by stirring the cassava meal into boiled water. The pulp-like mix was then added thoroughly into the leaf meal. The second method was conducted by stirring the salt water and cassava meal and then heating to boiling point to produce a glue-like substance. The substance was then added into the leaf meal. The binding capacity of the cubes, pellets and wafers was tested by dropping them from a height similar to the distance between a cow's mouth and a feed trough, crushing them by hand and by feeding them to animals.

Intake experiment was conducted using 12 heads of Bali cattle with an average live weight of 150 kg/hd. Firstly, intake was compared for preferences between pellets and cubes. In the next phase of the experiment the use of cubes as a supplement to native grass hay was examined. In this case cubes of *G. sepium* were compared to that of *L. leucocephala*.

Data were analyzed according to their characteristics, either for the experimental and assessment data (Table 1).

Table 1. Data Analysis According to Their Characteristics

Parameter Assessed	Type of Analysis
• Fodder drying	• Mean values of proximate analysis
• Equipment design and assessment	• Mean values and descriptives analysis
• Forms of cubes and palatability tests	• Descriptives analysis and ANOVA
• Nutritional values of cubes	• Mean values of proximate analysis
• Dissemination of cubes making	• Descriptives analysis

RESULTS AND DISCUSSIONS

Fodder Drying

For the leaves drying experiment it was found that drying at 70°C in 24 hours was the best temperature, which produced the best quality dried leaves. Cassava tubers were best dried at 80°C. Attempted to build a relative large capacity drying cabinet was not quite successful, and thus other ways were assessed. Finally it was determined that the drying of the leaves be better done by way of sun drying. The problem in this case was to find the best moment to do that. After assessing the time of harvests, considering the availability spare time of farmers and occurrences of rains, it was therefore concluded that drying be best done just after the rainy season (May to June), when leaves of *Gliricidia sepium* can still be harvested (before leaf fall starts, in July). Here drying was done by lopping the branches of the trees and gathered all material and spread over a concrete floor where the leaves will fall off the stems when dried. After one to two days of drying, leaves were collected and ground to powder using a hammer mill (developed in the experiments) and put into black plastic bags of 30 to 40 kg capacity each. This leaf meal can then be stored at room temperature in a storage room and can be processed into cubes or pellets whenever time is available to do so during the dry season.

Drying of cassava tubers can be done in around September to October (the harvest time of cassava in the region) the year before and stored in the form of dried cassava chips. The grinding than be done at the time of making the leaves meal.

Equipment Design and Assessment

Equipments designed and assessed in the experiments included, hammer mill, drying cabinet, mixer, and cubing/pelleting machine.

A manual method of making preserved food was assessed. In this technique leaves were sun-dried, ground using a machine to make leaf meal. The leaf meal, cassava meal pulp and salt were mixed with water and the resulting paste pressed into a mould. The moulds were

manually filled and placed in the sun to dry. Drying took from 2-3 days depending on the strength of the sun. Using this method, farmers could make cubes per day. Each cube was approximately 3x3x3 cm³ in size and weighed 15 g. This manual method can still be improved. Changes suggested are an increase in the number of cubes produced per mould as well as the number of moulds available to the farmers. This would allow cube production to be increased and would be beneficial for villages where it would be difficult for low income farmers to obtain machines and equipment.



Figure.1 Producing Cubes Manually.

Equipment was then further designed to be able to produce feed in the forms of either pellet or cubes when forced through two types of exchangeable cutter at the outlet (Figure 2.).

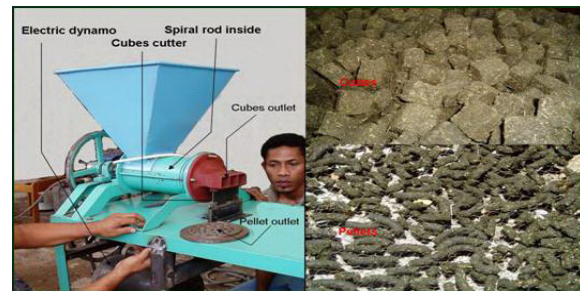


Figure 2. Cubing/Pelleting Equipment, Driven by Electric Dynamo Designed at the East Nusa Tenggara Assessment Institute for Agriculture Technology.

Recently, a milling machine (hammer type) in a larger capacity has been constructed and tested to directly mill into pellets or cubes the fresh leaf of tree legumes (*G. sepium* and *Leucaena leucocephala*) without cassava as the binding agent, but this is still under observation stages.

Forms of Cubes and Palatability Tests

At the start of the experiments, appropriate mixtures of leaf meal with cassava meal were observed and assessed for its binding capacity and preferences of intake by animal. At first round type of cube, called wafer was tried. The method of mixture was as follows: 20%, 25% and 30% of cassava meal was used with legume leaf meals. The cassava meal was added with hot salt water and stirred until formed as glue and than mixed with the appropriate amount of legume leaf. At this method, it was obtained that the mixture of 25% of cassava meal with 75% of legume leaves produced reasonable hardness of cubes or wafer, thus the mixture was than developed further for intake tests. Preserved forms (pellet, cubes and wafer) were than tested. Bali cattle was used in the tests. Observations were made on the easiness for the animal to pick up the cubes by mouth and tongue and the relative time taken to finish the feed offered. It was obtained that, although cattle can take all the forms of cubes (round wafer, square cubes and pellet), it was observed that the form of square cubes was the most preferred. The round one (wafer), about 7 cm diameter, was difficult to be picked up by cattle tongue, while the pellet in many occasions got broken and become dust and thus making the animal refuse to take it anymore as it was annoying at the breath taking while eating the pellet feed.

When the cubes of the different legume leaves were compared, it was found that cubes intake was higher in *L. leucocephala* than *G. sepium* (1.95 kg *vs.* 1.03 kg). Thus the total DM intake was also higher (4.58 kg *vs.* 5.35 kg) in *L. leucocephala* cubes treatment ($P < 0.05$) compared to that of *G. sepium*. Live weight gain was also higher ($P < 0.5$) in *L. leucocephala* cubes (0.23 kg/had/day) compared with that of *G. sepium* cubes (0.19 kg/hd/day). It should be noted, however, that although the gain was quite small, it was better than in the natural condition during the dry season in the region where most of grazing cattle experience weight loss (Jelantik, 2001; Bamualim and Wirdahayati, 2002; Kana Hau, 2004; Jelantik *et al.*, 2008).

In the following year of experimentations, improvement of mixture was further investigated. Here instead of boiling the salt water and

mixing to the cassava meal for further mixing with the legume leaf meals, it was altered to the following ways: the appropriate amount of salt water was mixed with the cassava meal and stirred well until good mixture was obtained and then heated on fire until it turned into glue like substance. The substance was then mixed with the appropriate amount of legume leaf meal or also in combinations with other meals such as rice straw meal or dried native grass meal. From this experimentation it was obtained that the mixture of about 17% of cassava meal and 83% of legume leaf meal or legume leaf meal plus rice straw meal was sufficient to produce quite excellent quality of cubes. Thus this was further recommended for making cubes for dry season feeding in West Timor using the locally available fodder or feed ingredients.

At the end of three years experimentations and assessments, it was concluded that to produce good quality cubes using the available local materials the following procedures should be employed. First harvest the materials of fodder should better be done at the end of the rainy season (during May to June), sun dried for one or two days, grinding using a hammer mill or other type of milling machine (depend on the amount needed for producing the cubes, put into plastic bags at capacity of 30 to 40 kgs and stored in room temperature in a clean storage room, provide cassava meal as needed (it can be produced any time during the year, depending on the availability of cassava tubers), weight the ratio of 17-20% of cassava meal and 83-80% of legume leaf or mixture of rice straw or dry native grass meal (60% legume leaf and 40% rice straw or dried native grass meal), provide the glue like substance of cassava meal as described above, mix the ingredients by stirring it well and produce cubes manually or using the cubing machine (depending on the capacity of production needed to feed the animal).

Nutritional Values of Cubes

The following are some results of proximate analysis of the cubes produced in the three years of the experimentations and assessments.

From Table 2, it can be seen that the best quality cubes was obtained from the leaf of *L.*

leucocephala, followed by *S. grandiflora* and *G. sepium*, while adding some rice straw meal (20% of the leaf meal) will decrease the nutritional value, but will still be above the maintenance nutrition needs of beef cattle (NRC, 1996), or above the 7% crude protein needed for ruminal microbes which digest fiber (Sprinkle, 2000; Pathak, 2008). These nutritive values were lower compared with results obtained by Najib and Zahari (2003), where values of 24% and 19% of crude protein contents were recorded in the cubes of *L. leucocephala* and *G. sepium*, respectively. However, the quality was much better than the quality of native grasses at this time of the year (May to June), which in many cases have fallen down to less than 5% of crude protein (Kana Hau, 2004; Jelantik *et al.*, 2008). The difference in the quality compared to the results in Malaysia can be brought about by the differences in soil fertility, the formulation of the cubes, time of harvest and method of preservation.

fresh forages during the driest month in Timor, Indonesia (Nulik, 2007).

Dissemination of Cubes Making and Usage in West Timor

The method of cubes making has been introduced to the cooperative farmers in the District of North Central Timor for a one year period observation (in the 2004). Farmers actually were quite interested to the ideas of preserving feed for dry season supply, however, owing to the lack of available feed hammer mill at the farmers group, they preferred silage to cubes making. However, there is an indication of pellet making adoption at the farmer group equipped with a relatively large capacity pelleting machine in North Central Timor District, East Nusa Tenggara.

Table 2. Nutritive Content Of Cubes Produced During The Experiments

Cubes* of	Percentage (%)								Mj/kg
	water	CP	Fiber	Fat	Ash	Ca	P	Na	GE
<i>Sesbania grandiflora</i>	3.78	15.48	14.34	2.44	8.56	1.40	0.05	0.80	18.40
<i>Sesbania</i> + rice straw	3.70	12.28	17.47	1.87	10.40	1.01	0.17	0.70	15.40
<i>Leucaena leucocephala</i>	3.64	18.99	11.70	3.12	7.22	1.23	0.06	0.36	17.20
<i>Leucaena</i> + rice straw	3.85	14.48	16.81	2.15	9.50	1.02	0.04	0.45	15.60
<i>Gliricidia sepium</i>	4.71	13.15	20.43	2.28	12.78	1.91	0.11	1.30	16.20
<i>Gliricidia</i> + rice straw	4.12	9.16	18.62	1.86	14.49	1.34	0.01	0.48	13.10

* 17% of cassava meal for the binding agent

It has been observed that the quality of the cubes stored and used to the end of dry season did not change its appearance, even up to one year in storage. The growth of fungus did not occur as long as the cubes were dried properly down to 12-10% of moisture content.

The quality of *L. leucocephala* cubes (Table 1) with about 19% crude protein is quite similar to the quality of alfalfa cubes currently trades in the market (ranging from 15% to 20% crude protein) (Hancock and Collins, 2006). Therefore in many cases *L. leucocephala* is attributed as the tropical alfalfa. Even it is a very drought tolerant forage that can produce

At governmental level the district mayor of Kupang has showed interests to collaborate to produce cubes in sufficient amount to meet the need of feed during the exportation of cattle from Kupang to Java Island (40,000 to 60,000 heads of cattle each year). The mayor suggested to first develop areas for producing sufficient amount of legume tree leaves (such as *Leucaena leucocephala* and *Gliricidia sepium*). He suggested to make use of the bare forest areas (could be found in many places in West Timor, as well as in Kupang District) or the area of forest edges to grow legume trees to enable sufficient supply of legume leaves for cubes production. This would help to establish forest in the region

which in many occasions failed because plant removal by annual grassland fires and/or by grazing animals.

CONCLUSIONS

1. The abundance leaf of tree legumes produced during the wet season can be preserved in the form of cubes or pellets and stored for the dry season feeding, as the their quality remain excellent.
2. Drying of the leaf can be done right at the end of wet season, before leaf fall occurs (especiall in *G. Sepium*) and the quality of the leaf is also sufficient for the livestock requirements and that farmers at the time would have enough time to do the work.
3. The equipments developed in the experiments (for making cubes and pellets) offerd some alternative for the stake holders, i.e. manuall equipment may be sufficient for individual farmer, and the spiral rod type driven by electric dynamo or the latest multi-purpose machine may be suitable for farmers goup and comercial parties in livestock bussines.
4. The production of cubes from *G. sepium* leafs will result in improving palatability of the leaf to cattle in the region of East Nusa Tenggara, where feeding fresh *G. sepium* leaf was still has low palatability to the animals.
5. The technology of cubes making could be important in the future to supply good quality feed for cattle transportation (from Timor to Java) which currently experience weight loss up to 10 to 15% (resulting from poor quality feed offered).

REFERENCES

Bamualim, A., dan Wirdahayati, R.B. 2002. Peternakan di lahan kering Nusa Tenggara. Balai Pengkajian Teknologi Pertanian (BPTP) Nusa Tenggara Timur. 95 hlm.

Hancock, D.W., and M. Collins. 2006. Forage Preservation Method Influences Alfalfa Nutritive Value and Feeding Characteristics. *Crop Science*, 46: 688-694.

Jelantik, I.G.N. 2001. Improving bali cattle (*Bibos banteng*) production through protein supplementation. PhD. Thesis. Royal Vet. And Agric. Univ. Copenhagen, Denmark.

Jelantik, I.G.N., M.L. Mullik, C. Leo-Penu, J. Jeremias and R. Copland. Improving Calf Survival and Performance by Supplementation in Bali Cattle. *Australian Journal of Experimental Agriculture*, 48 (7): 954-956.

Kana Hau, D. 2004. Pemanfaatan Probiotik Dalam ransum ternak sapi Bali Timor jantan. Master Thesis. University of Nusa Cendana, Kupang, Indonesia.

Najib, M.A.M and Zahari, M.W. 2003. Processing and handling of fodder products. In: "Forages and Feed Resources In Commercial Livestock Production systems" 8th meeting of the regional working group on Grazing and feed resources for Southeast Asia, Kuala Lumpur, Malaysia, 22 – 28 September 2003. Pp 83-86.

NRC (National Research Council. National Research Council).1996. Nutrient requirements of beef cattle. 7th Revised Edition. National Academy Press, Washington, DC.

Nulik, J., D. Kana Hau, P. Th. Fernandez dan S. Ratnawati. 2004. Adaptasi Beberapa Leucaena Species di Pulau Timor dan Sumba, NTT. Prosiding Seminar Nasional Teknologi Peternakan dan Veteriner. Bogor, 4-5 Agustus 2004. Puslitbang Peternakan, Bogor.

Nulik, J., P.Th. Fernandez, S. Ratnawati, D. Kana Hau dan A. Rubianti. 2005. Pengkajian pengawetan pakan di Pulau Timor, Nusa

- Tenggara Timur Proceedings Seminar Nasional, BPTP NTT. pp.211-221.
- Nulik, J. 2007. Masalah keracunan lamtoro (*Leucaena leucocephala*) belum tuntas. Prosiding Seminar Nasional, 7-8 Desember, 2007, Balai Besar Pengkajian dan Pengembangan Teknologi Pertanian bekerjasama dengan Balai Pengkajian Teknologi Pertanian Nusa Tenggara Timur.
- Pathak, A.K. 2008. Various Factors Affecting Microbial Protein Synthesis in The Rumen. *Veterinary World*, 1(6): 186-189.
- Piggin, C. 2003. The role of *Leucaena* in Swidden Cropping and Livestock Production in Nusa Tenggara Timur Province, Indonesia. ACIAR Proceedings No.113, Australian Government. Pp.115-129.
- Shelton, H.M., C.M. Piggin, R. Acasio, A. Castillo, B.F. Mullen, I.K. Rika, J. Nulik, and R.C. Gutteridge. 2000. Case Studies of Locally – Successful Forage Tree Systems. ACIAR Proceedings No. 95. pp.120-131.
- Sprinkle, J. 2000. Protein supplementation. The University of Arizona. Cooperative Extension. 11/00. AZ1186. ag.arizona.edu/pubs/animal/az1186.pdf.

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