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ALTERNATIVE ROUGHAGE FEED PRODUCTION UNDER DIFFERENT DRYING METHODS AND EVALUATION OF THE FEEDING VALUE

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Dairy industry is the most prioritized livestock sub sector in economy of Sri Lanka. Lack of good quality forage year around is a major constrain to profitable dairy production. Forage conservation as silage or hay is a limited practice among Sri Lankan dairy farmers mainly due to higher labour requirement. There is a need for convenient forage conservation method which requires less labour and time. This study was designed to evaluate feasibility of conserving roughages in dry pellet form and study the palatability and keeping quality. Four forages varieties; *Gliricidia sepium*, Hybrid Napier Grass (CO3 and CO4), and *Leucaena leucocephala* (Ipil Ipil) were harvested at correct maturity and dried in oven (control), sun dried (T1) and dried in modified solar drier (T2). Dried forage samples were pelleted and analysed for crude protein, energy, ash, keeping quality, aroma, acceptability and palatability of dairy cows.

There was a significant difference ($P<0.05$) in palatability between the pellet and mash form of forages. Pelleted forage meal recorded better palatability than the fresh forages. Among the four types *Gliricidia sepium* is the most palatable forage pellet, but there was no significant different ($P>0.05$) of palatability based on drying method. There was significant difference of the dry matter content based on drying method ($P<0.05$). Average dry matter yield of samples sun dried (T1), solar dried (T2) and oven dried (control) were 21.47% and 17.86% and 24.25% respectively. Amount of dry matter yield loss of the developed solar dryer is low when compare to sun drying. Average required amount of wet forages to produce the 1 kg of dry forage pellet is 4.66 kg and cost of production of dry grass meal pellet was Rs 28/kg. Average weight of the pellet bulk was 652 kg/m^3. Under room condition, pelleted forage meal can be stored over 3 months without mould formation, off colour development and smutty smell. Sun drying is convenient but solar drying is more effective in terms of dry matter recoveries. The study indicated that pelleted grass meal is acceptable, economical, and high in quality and potential alternative method for forage conservation.

Keywords: forages, pellet, drying, conservation, palatability

Sri Lanka has a total land area of 65,610 sq. km out of which around 2 million hectares or 30 percent is agricultural land. Almost 75% of the agricultural land is under smallholdings and the balance under estates. The number of smallholdings is estimated at about 1.8 million and of this 90% are less than 2 ha in extent. About 70% smallholdings solely devoted to crop production, the remaining has a mixture of crops and livestock and in few cases solely livestock (1).

Dairy sector is considered as the most important of all livestock sub sectors in Sri Lanka. This is mainly because of the influence it can make on the rural economy. Milk production has been a Traditional industry that has survived thousands of years (2). The dairy industry has potential to contribute considerably to Sri Lanka's economic development. Good quality dairy cows are imported as a new genetic base to meet the new demands for locally produced milk. Resembling the other Asian countries, Sri Lanka needs to increase the milk production in the country up to a considerable level within next 5 years. It is very clear that this target must combine with

good quality green forages (3). Lack of good quality feed year around is a major constraint to profitable smallholder dairy production in Sri Lanka. Potentially beneficial feed technologies have been researched by Sri Lankan institutions and others in the region. Participatory approaches, thereby strengthening research-extension-farmer linkages, are required to ensure that the testing and validation of the technologies is demand/farmer driven (4). At present dairy industry in Sri Lanka primarily depends on natural pasture and fodder found on road side, ravines, tank banks and uncultivated public and private lands. Very few farmers grow pasture and fodder for the purpose of feeding their animals. A related issue is the management of communal grazing areas and public land, including roadsides. There is a serious problem in exploiting the genetic potential of improved dairy animals due to the lack of good quality year around feed at the farm level. Although the pasture development and extension is a function of the provincial state levels, there is no strong institutional arrangement to spearhead a useful programed for promotion of pasture and fodder for dairy production (5).

Though some local feed manufactures and few multinational companies are engaged in the feed milling business in the country, the problem with the branded feed is that they are very expensive and the small holders cannot make a profit by using them in their production. Therefore, most of small holders tend to use self-mixed feed or raw feed materials in order to gain a higher margin. Forage conservation as silage or hay is a limited practice among the Sri Lankan dairy farms mainly due to higher labour requirement. There is a need for convenient forage conservation method which require less labour and time. Conserved forage can also be made commercially available to farmers. This study was designed to evaluate feasibility of conserving roughages in dry pellet form and study the palatability, nutritive and keeping quality.

MATERIALS AND METHODS

Selection of forages

The experiment were conducted using four main forage species which are currently in use. Those were Hybrid Napier Grass (variety CO4 and CO3), *Gliricidia sepium* and *Leucaena leucocephala*.

Hybrid Napier grass *(variety CO-3)*

It is an inter-specific hybrid between Bajra (*Pennisetum americanum* L.) and a selection of a common Napier (*Pennisetum purpureum Schum*.). Common Napier grass (*Pennisetum perpureum)* is also called as Elephant Grass due to its loftiness and vigorous vegetative growth. Unfortunately, the grass is coarse-textured, the leaf blade and sheaths are hairy, leaf margins are sharply serrated and stems are less juicy and fibrous. A cross was made between Napier grass and pearl millet *(Pennisetum americarnum)* which is more succulent, leafy, fine-textured, palatable, fast growing and drought resistant (4).

Hybrid Napier grass *(variety CO-4)*

This is a cross between hybrid Napier grass and pearl millet *(Pennisetum americarnum)*. This is a very high yielding grass variety. With proper care, the possible harvest would be around 150 tons per year per acre. This has average protein content ranging from 8% to 11% (4).

Leucaena leucocephala *(*Ipil Ipil)

Leucaena leaves contain 21- 24% crude protein. *Leucaena* provides palatable, digestible and nutritious forage for ruminants such as cattle, water buffalo, and goats and thus helps to increase milk production. *Leucaena* 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. Animal production on *Leucaena* based pastures is excellent (6).

Gliricidia sepium

Gliricidia leaves have high feeding value, with crude protein level of 20-30% of the dry matter, a crude fibre content of only about 15% and in-vitro dry matter digestibility of 60-65%. Gliricidia is generally used as a high protein supplement to low quality basal feeds such as grass, straw and other crop residues.

Supplementation levels vary but are usually in the range 20-40%. There are numerous reports of increases in weight gain and milk production in both large and small ruminants when Gliricidia forage is used as a supplement (6).

Experimental Area

This study was carried out from March to July in 2016 at the Department of Livestock and Avian Sciences, Faculty of Livestock, Fisheries and Nutrition, Wayamba University of Sri Lanka which is located in low country intermediate zone (IL2) at the coordinates of 7°19'25.0"N 79°59'17.9"E.

Preparation of solar drier

A cabinet type solar dryer was designed (Figure 1) for drying forages. The dryer was built with three stacks of drying trays using wooden rafters, covered with wire mesh and thick black polyethylene leaving air vents on either sides.

Drying, pelleting and evaluation of the selected forage material

Selected forages were dried to constant weight in three methods: Oven drying at 70°C (control), sun drying (T1) and solar drying (T2). Dry matter yield were estimated based on the fresh weight of the raw forages subjected to drying and compared with control.

Figure 1 Developed solar dryer-(before covering with black polyethylene)

Dried forages were assessed for appearance and aroma. Samples were reduced to 4mm to 5mm particle size by grinding and pelleted to 10-12mm size using dry pelleting machine. Dried samples were analysed for density and proximate composition; crude protein, gross energy, and ash contents as per AOAC (7) methods. Samples were packed and stored under room conditions to test shelf-life.

Testing acceptability and the palatability

Cow in early lactation were selected (n=6) to test the acceptability and Palatability of feeds. Acceptability of the each forages type was tested first by offering three forms of feed (fresh, dry and pelleted) of single species parallel, before the regular rations or other feed was offered to animals. After establishing the acceptability of the form of feed, the second test was conducted to access the palatability of difference forages in accepted form. The reaction of the animals were observed and recorded for 5 minutes. Acceptability and palatability tests of different varieties were repeated three times and conducted in three days interval. The intake of the preferred form of feed were estimated by measuring the remaining amount after 3 minutes.

Analysis of results

T-tests were carried out using SAS 9.2 and SPSS to analyse the palatability and dry matter changes.

RESULTS AND DISCUSSION

Solar dryer with natural convectional draft had an average temperature of 52.9°C between 9.00 to 16.00 hours of the day when kept in sun without forage load and the minimum and maximum temperatures were recorded from 30 to 55°C during drying when the ambient temperature was between 27 to 36°C. The material with average initial moisture content of 76% to 82% could be dried up to 10% -12% moisture level in about 12 to 18 hours of continuous drying cycle. The drying rate was high in top most stack of drying trays, low in the middle and the lowest stacks and shuffling forages between stacks two to three times per day was necessary for uniform drying. Order of drying rates of fresh forages from the highest to lowest were *Leucaena, Gliricidia,* CO-3 and CO-4 respectively and delay of drying in the CO-3 and CO-4 were evident. Leaf dehydration was faster when compared to the stems in all drying methods. Drying in the shelter promoted the lesser re-hydration of the plants at night due to dew (8). Colour

of the dried material was dark green to straw (Figure-1) and strong in aroma in *Gliricidia,* sweet grassy aroma in CO-3 and CO-4 and mild leguminous aroma in *Leucaena*. In sun drying method the temperature on the material throughout the day time (9.00 to 16.00 hours) was recorded to be between 31.2 to 37.6°C. The material with average initial moisture content of 76% to 82% could be dried up to 10% -14% moisture level in about 18 – 24 hours (3 -4 days of sunning) by exposing to sun in continuous drying cycle with three to four times turning and mixing of material per day. Drying was not uniform without turning the material. The order of drying rates of the fresh forages from highest to lowest were *Leucaena, Gliricidia,* CO-3 and CO-4 respectively and slow drying in thick soft stems of the CO-3 and CO-4 were observed. Delayed drying observed in CO-3 and CO-4 may be mainly due to presence of thick soft stems which took longer for drying. Bleaching of material was observed very early when drying in hot sun. Pellet colour of material was light green to straw in CO-3, and *Leucaena* when dried in sun. CO-4 and *Gliricidia* was light green to dark green in solar drying. Strong sunny aroma in *Gliricidia,* and *Leucaena* and sunny and dry grassy aroma in CO-3 and CO-4 could be detected. Open sun drying was found difficult for *Gliricidia* and *Leucaena* due to leaf senescence, shedding and dispersion by wind and dry mass loss was very high. However, sun drying is the most convenient for the farmers in their opinion though low dry matter yield and relatively low product quality. Solar drier is efficient and results better drying of forages into very brittle material but require modifications for large scale use.

Dry matter yield according to drying method

According to the average dry matter yield recorded(Table 1) there is a significant different ($P<0.05$) of dry matter yield depending on method of drying. Both solar drying and sun drying yield low dry matter content compared to control. High dry matter yield could be obtained in solar drying (T2) than in sun drying (T1) possibly because of faster drying which reduces dry matter losses through respiration of live tissues of plant material. Respiration also causes a significant forage quality loss since lost starch and sugar. Loss of sugar and starch increases the content of remaining components. A 4% loss in starch and sugar would raise NDF (neutral detergent fibre) slightly over 3%. Hay should be managed to dry, as quickly as possible, to 60% moisture or less on the day it is cut. When forage moisture falls below 60%, respiration is greatly reduced (9). Solar drying reduced the moisture level of the forage material faster up to 52% within first day of drying.

CO-4

Leucaena

CO-3

Gliricidia,

Figure 1: Colour of pellets made out of solar dried forage material

Sun drying leads to almost 40 to 50% more loss of dry matter in CO3 and CO4 compared to that in solar drying.

Leucaena and *Gliricidia* when kept under the sun and with some turnings, shows poor quality and high dry matter loss due to their leaf fall. Marcela (8) has reported that alfalfa hays that remained under the sun were the worst quality with reduction in crude protein contents and increase in fibre. Low dry matter yields resulted in sun drying could be due to losses of soluble carbohydrates during delayed drying.

Acceptability and palatability

Acceptability of the pelleted forages were always higher compared to dry non-pelleted forages and the lowest acceptability was recorded for fresh forages when offered parallel to dry and pelleted forms. According some test on animals fed indoors, it is well known that the same hay in long, chopped or ground form is not eaten at the same rate and in the same amount. As it is established that physical characteristics such as particle size and water content contribute to the sensory response invoked by the feed. These are considered in this review as features of palatability (10).

When offered all species of forages in pelleted form all most all the animals accepted pelleted *Gliricidia* immediately and recorded the highest intake within 3 minutes (Table 2). Though solar dried meal pellets have relatively high palatability, there was no significant differences of palatability based on drying method.

According to the result of table 2 there is a significant difference ($P<0.05$) of palatability between the form of forage within the species. Pellets of different species of forges also have significant difference of palatability ($P<0.05$) and pelleted *Gliricidia sepium* is the most palatable among the four species tested. If unlimited amounts are presented over short test durations, animals can show an exclusive preference for one single feed (10).

Palatability is obviously not a quantitative

Table 1: Average Dry matter yield based on drying method

Drying method	Forage type	Dry matter yields Mean percentage (% ± SD)*	Colour
Sun drying (T1)	*Gliricidia*	17.80 ± 1.80 [b]	Light green
	CO-3	10.97 ± 2.03 [d]	Light green
	CO-4	10.85 ± 1.84 [d]	Green
	Leucaena	18.90 ± 2.32 [b]	Greenish brown
Solar drying (T2)	*Gliricidia*	23.50 ± 2.18 [a]	Dark green
	CO-3	16.28 ± 1.68 [b]	Light green
	CO-4	14.36 ± 2.01 [b]	Bright Green
	Leucaena	32.83 ± 3.04 [c]	Greenish brown
Oven drying (control)	*Gliricidia*	24.37 ± 2.01 [a]	Light green
	CO-3	18.50 ± 1.96 [b]	Light green
	CO-4	20.33 ± 2.01 [b]	Green
	Leucaena	27.85 ± 2.78 [a]	Greenish brown

* Values preceded by different superscript letters were significantly different

Table 2 Palatability of fresh, dry and pelleted forages in first three minutes

Ingredient	Form of feed	Average intake (g)	SD
CO-3	Fresh	142.0 [a]	±8.31
	Leafy -Dry T1	247.4 [b]	±2.87
	Leafy -Dry T2	271.8 [b]	±4.15
	Pellet T1	371.7 [c]	±3.66
	Pellet T2	387.6 [c]	±3.72
CO-4	Fresh	145.0 [a]	±17.20
	Leafy -Dry T1	233.7 [b]	±2.63
	Leafy -Dry T2	242.8 [b]	±3.85
	Pellet T1	465.0 [d]	±2.92
	Pellet T2	492.0 [d]	±2.11
Gliricidia	Fresh	192.0 [e]	±13.21
	Leafy -Dry T1	454.3 [d]	±2.24
	Leafy -Dry T2 Pellet T1	432.3 [d]	±5.41
	Pellet T2	696.2 [f]	±6.22
		757.7 [f]	±7.72
Leucaena	Fresh	185.0 [e]	±12.28
	Leafy -Dry T1	310.4 [c]	±2.91
	Leafy -Dry T2	342.1 [c]	±6.27
	Pellet T1	532.3 [g]	±3.28
	Pellet T2	574.7 [g]	±6.01

Values preceded by different superscripts were significantly different

Table 3 Feeding value of ingredients

Ingredient	Drying method	Crude protein (%)*	Ash (%)	Energy (kcal/g)
Hybrid Napier Grass (CO-3)	T1	13.21±0.27 [a]	11.95±0.10	3.02±0.09
	T2	15.49±0.20 [b]	11.35±0.09	5.09±0.12
Hybrid Napier Grass (CO-4)	T1	11.78±0.27 [c]	15.16±0.18	3.07±0.09
	T2	14.28±0.31 [a]	14.45±0.34	4.57±0.10
Leucaena leucocephala	T1	18.27±0.29 [d]	17.40±0.19	3.12±0.11
	T2	23.20±0.15 [e]	16.31±0.12	4.01±0.08
Gliricidia sepium	T1	17.63±0.170 [d]	9.56±0.14	3.21±0.09
	T2	22.63±0.170 [e]	8.76±0.10	4.31±0.09

Values are presented as mean ± SD (Standard deviation)
* Values preceded by different superscript letters were significantly different

measure unless feed intake is measured per unit time (11). An ideal measure of palatability will not be influenced by the consequences of previous ingestion of feeds (12) nor by the post-ingestive consequences of intake (13). Baumont describes that palatability usually designates characteristics of a feed that invoke a sensory response in the animal, and is considered to be the corollary of the animal's appetite for the feed. When only one feed is given to animals fed indoor, palatability can be

evaluated by the eating rate at the beginning of the meal (14).

Feeding value

The nutritive vales of the forages were significantly different in terms of protein and energy content based on drying method (Table 3).

Dry matter loss added with protein and energy loss is critical based on drying methods. Alfalfa hays that remained under the sun were the worst quality with reduction in crude protein contents and increase in NDF, ADF, NDIN and ADIN. However, in vitro dry matter digestibility and cell wall digestibility did not suffer any alteration because of the different dehydration methods (8).

Shelf life

Keeping quality is one of most important factors considered quality of animal feed. Dry forages in leafy form and meal form was observed getting fungal attacks and mould growth after 5-6 weeks and caking of meal was observed in store bags after 4-5 weeks of processing. According to Rotz, hay is hygroscopic, i.e., it can absorb or lose water to the environment, allowing relative humidity (RH) to influence on moisture content of a material exposed to the environment (15). Pelleted feed can be stored over a period of 10 -12 weeks without development of off colour and smutty smell.

Cost analysis

Around 200 to 300kg of fresh grass can be harvested and handled for drying by standard man day. Therefore, average cost of cutting, drying and pelleting of forages was estimated to be Rs, 6/ kg on and fresh weight basis. Requirement of fresh grass and legumes to produce 1kg dry forage and pellets varies vary between 3.06 to 9.08kg with an average of 5.45kg for grass and 3.57kg for legumes. At that conversion rate, the cost of production of 1/kg dry grass meal pellet was around Rs. 32.79 and Rs. 18.36 for legume pellets.

Average bulk weight of legume pellet and grass pellet was 652 kg/m^{-3} and 594 kg/m^{-3} respectively. Therefore, the bulk density of both grass and legumes were high compared to leaf meal or hay. Therefore pelleted forages require less store space and were found easy for storage.

CONCLUSION

The study indicated solar drying of forages is a cost effective and relatively fast conservation method for the selected four species of forages. Dried forage in pelleted form is acceptable, economical and high in nutritive quality. Drying and pelleting of forages is potential alternative method for forage conservation for small scale dairy farmers. The concept may be further experimented to produce commercial forage pellets for ruminants.

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