Samanea saman, a multi-purpose tree with potentialities as alternative feed for animals of productive interest

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For demonstrating the raintree (*Samanea saman* (Jacq.) potentiality as feed for animals of productive interest, the chemical composition was studied in the foliage, fruit and seeds: dry matter, crude protein, ash, neutral detergent fiber, acid detergent fiber, lignin, calcium and phosphorus concentration and presence of secondary metabolites. The existence of the main secondary metabolites, among them saponins and tannins was moderate or slight in all the studied fractions. Seeds contribute significantly to the nutritional value of the fruit. It is concluded that the fruits as well as the *S. saman* foliage contain acceptable levels of protein and minerals, moderate to slight presence of secondary metabolites and low levels of fiber, characterizing them as adequate forage resources for complementing the nutrient deficit in grazing ruminants and in other productive species. The foliage is less palatable, but presents antimicrobial and antioxidant properties that can justify its use.

Key words: *raintree (Samanea saman), foliage, fruits, nutritional value, alternative medicine*

INTRODUCTION

The utilization of natural resources in a rational and sustainable way is a viable option for obtaining profits in agricultural activities (FAO 2012). Forage trees and shrubs are an inexhaustible nutrient source contributing feed of good quality the greatest part of the year that improve the animal diet and reduce the use of concentrates in agricultural exploitations (De Andrade *et al.* 2008 and Ortega 2012). *Samanea saman* (Jacq.) Merr. is a large size tree native to the American dry tropic generalized throughout the whole humid and sub-humid tropics. It extends from Mexico by all over Central America toward Colombia and Venezuela in South America. Also, it is naturalized and widely scattered in the greatest part of the Caribbean islands, mainly in Cuba, Jamaica, Puerto Rico and Virgin Islands, as well as in Pacific islands (Staples and Elevitch 2006).

The raintree shows particular characteristics. It offers excellent shade, wood and produces and distributes great quantity of fruits (pods) of high nutritive quality that are important cattle forage supplements during the dry period. Its incorporation to the diets, in levels between 10-30 %, reveals increase in weight and in milk production in dairy cows and other productive species (Roncallo *et al.* 2009). Although this tree outstands among the promising agroforestry species, there is poor information available supporting its potentialities. The objective of this study was to demonstrate the possibilities of the *S. saman* tree as alternative feed for productive animals.

GENERAL CHARACTERISTICS OF *S. SAMAN*

It is a tall tree that in its natural habitat can attain between 10 and 25 m high. The top is wide and symmetric supported by horizontal branches widely extended in the form of umbrella with feathery foliage. Its bark is rough, grayish brown with horizontal lines. It has composite, alternate, bi-pinned leaves of 3-9 pairs of 10-34 cm width and 20-40 cm length with pilose rachis. During the dry periods of poor rainfall, trees are semi-deciduous and lose their leaves in short time. Leaves are slightly sensible to light and close during the night (Staples and Elevitch 2006 and Schmidt 2008).

The raintree flowers between January and May, with variations depending of the geography of the place where it grows. The flowering peak occurs in April and May. Flowers are of light pink color arranged in umbels. They got together in bright and colorful inflorescences located at the end of the small branches.

Fruits are pulses or pods (8 to 20 cm long, 15-19 mm wide and 6 mm thick). They are straight or slightly bended, green and fleshy before ripening and dark, brown once they ripe. They contain a dry, dark, sweet and nutritive pulp surrounded by 5 to 10 seeds. Fruit ripening is produced from February to May. Seeds are thicken, oblong, ellipsoidal from 8-11.5 mm length and of 5-7.5 mm width slightly flattened at the sides, of brown color. Each pod has from 15 to 20 seeds. The average weight for the fruits is 11.23 g, corresponding to the seeds 22.74 % of this weight.

ECOLOGY, PROPAGATION AND HANDLING

The raintree grows in light, medium and heavy soils and also adapts to alkaline and acid conditions. It can tolerate flooding for short periods, but it is intolerant to shade and cold. It requires irrigation when young being more resistant to drought when it reaches adulthood. Its most common way of propagation is by seeds, but also reproduces by cutting and roots (Selvam 2007).

NUTRITIVE VALUE OF *S. SAMAN*

The search for appropriate alternatives for guaranteeing the nutritional requirements of the animals turns to be a priority from the present problems facing livestock production in tropical countries, especially in dry periods (Pearson and Langridge 2008).

The tropic is rich in tree and shrub-like plants adapted to local conditions with great potential as cattle feed. Of special importance are some tree legume species as the raintree (*S. saman*), *Prosopis julifora*, *Acacia farnesiana* and *Enterolobium cyclocarpum* that in addition of their environmental benefits, offer extremely amounts of sugars and proteins per tree yearly (Navas *et al.* 2001a).

CHEMICAL COMPOSITION

Table 1 shows data obtained by different authors in studies carried out in Latin America and the Caribbean, regarding the chemical composition of *S. saman* foliage.

The average CP was higher than 20 %, similar to what was reported by León *et al.* (2012) with different tropical forage legumes. The fibrous fraction of the foliages exhibited levels of neutral detergent fiber (NDF) and acid detergent fiber (ADF) of 46.3 and 33.2 %, respectively with a mean of 14.8 % for lignin. These results coincide with those reported by Juárez *et al.* (2004) on evaluating a group of forage tree legumes introduced in Veracruz, Mexico. These authors obtained NDF and ADF concentrations between 40 and 54 and 17 and 39 %, respectively, while lignin ranged between 6 and 14 %.

Ojeda *et al.* (2012a) found that from May to October the cell wall of the raintree increased its lignification level. This factor must be considered in its nutritional assessment due to the high negative correlation between lignin and voluntary intake in ruminants (van Soest *et al.* 1991).

The presence of lipid compounds in the foliages confers higher energy value on them. Mean concentration of ether extract (EE) in the raintree was of 4.4 %, higher than 3.3 % reported by Delgado *et al.* (2001) in four tropical forage trees demonstrating the quality of the material under study. Ca and P contents varied between 0.2 and 1.3 % and 0.1 and 0.3 %, respectively. Also they are in correspondence with those reported in different tropical foliage (Delgado *et al.* 2007 ab).

The chemical composition of *S. saman* foliage performed similarly to what was reported in the literature for the edible fraction of this species (Pedraza *et al.* 2003b, García *et al.* 2006 and Pedraza *et al.* 2007) and of other tropical Fabaceae (García and Medina 2006).

The physical indicators of the forages play an important function in the passage and digestion of fibrous feeds. The measurements related to the nutritional value of the foliage are the volumetric density (VD), the water retention capacity (RCw), the average particle size and the solubility of the organic matter and of the mineral fraction. Korbut *et al.* (2009) studied these indicators in different foliages and indicated that the VD value for *S. saman* was very similar to the average obtained among all studied trees and similar to the general mean of 0.26 g/mL ± 0.04 obtained by Giger-Reverdin (2000) for fibrous materials.

Table 1. Chemical composition of *S. saman* foliage obtained in different zones of Colombia, Venezuela and Cuba

	DM	Ash	CP	NDF	ADF	Lignin	EE	Ca	P	Authors
Foliage	-	5.9	20.1	42.8	25.9	11.1	4.5	1.1	0.1	Ojeda *et al.* (2012a)
Foliage	35.9	-	20.7	61.4	40.9	17.4	3.7	0.8	0.1	Ojeda *et al.* (2012b)
Foliage	-	6.9	18.1	41.4	29.5	-	-	1.3	0.3	Galindo *et al.* (2012)
Foliage	-	3.8	20.0	56.5	40.9	15.9	-	1.0	0.1	Korbut *et al.* (2009)
Young leaves	-	-	30.9	33.8	25.4	-	-	0.2	0.3	Narvaes y Lascano (2004)
Mature leaves	-	-	22.6	47.5	36.9	-	-	0.4	0.2	
Foliage meal	45.4	6.9	12.6	-	-	-	4.9	2.4	0.2	Macías y García (2004)
Foliage	-	3.1	24.5	40.7	-	-	-	-	-	García *et al.* (2008)
Average	40.6	4.7	21.3	46.3	33.2	14.8	4.4	1.0	0.1	-
SD	-	1.6	5.2	8.9	7.0	2.7	0.5	0.7	0.08	-

The RCw for forages ranges between 3.80 mL/g for alfalfa hay and 8.87 mL/g for corncob. *S. saman* showed RCw value slightly lower to these figures and the OM solubility was of 9.5 % in correspondence with the rest of the foliages under study (Korbut *et al.* 2009).

S. saman offers high pod production during the dry season, very palatable, with high protein value, advisable as supplement for animal feeding with poor quality diets. Studies aimed at determining the chemical composition of the foliage, fruits and seeds of *S. saman* for their use as supplement in animal feeding, demonstrated their potentialities as feed for ruminants and monogastrics.

The literature indicates that the CP level of the whole ripe pods (even the seeds) is between 14 and 18 % while the seed contains 30-37 % (Esuoso 1996). Table 2 shows the results of the chemical composition of the whole fruit and the seeds obtained in experiments realized in different countries. It can be indicated that CP is between 10 and 18 % and 23 and 30 % for the whole fruit and seeds, respectively coinciding with the previous information.

On comparing the nutrient contents of *S. saman* pods with the fruits of other woody forage legumes, commonly consumed by ruminants: (*Chloroleucon manguense*, *Enterolobium cyclocarpum*, *Acacia macracantha*, *Senna atomaria*, *Caesalpinia granadillo* and *Caesalpinia coriaria*) it was found in all species studied high CP contents (16-30 %) and nitrogen free extract (Cecconello *et al.* 2003), as well as high levels of calcium, phosphorus, magnesium, sulfur and copper. This represents an important source of nutrients during the dry period for grazing ruminants.

The above cited authors confirmed that *S. saman* together with *E. cyclocarpum* and *A. macracanth*, is within the species that showed higher phosphorus levels (0.27 to 0.32 %) than those in tropical pastures (0.03 to 0.10 %), thus these fruits can cover the requirements of this mineral for beef cattle. In the results reported in Cuba (Beltrán 2012), P content was lower (0.12 %). This could be due to the characteristics of the soils from where the samples came. In general, it concerns soils of low contents of this mineral and this have an effect on the P concentrations in the plants.

S. saman fruit presents in its composition other not less important nutrients. Early studies carried out by Esuoso (1996) indicated that in the fleshy mesocarp, sugars represent 32.65 % of the total nutrient content and of the four types of sugars identified. Fructose was predominant with a concentration of 16.20 %. The fruit of the raintree is oleiferous. The oil obtained from the seeds contains 5.6 % of free fatty acids and it is composed of nine fatty acids. From them, more than 90 % are unsaturated (Esuoso 1996).

Table 2. Chemical composition of the whole fruits and seeds of *S. saman*

	DM	Ash	CP	NDF	ADF	Lignin	EE	Ca	P	Authors
Fruits	93.1	4.5	18.1	29.2	24.6		1.4	-	-	Anantasook y Wanapat (2012) ,Thailand
Fruits	60.5	5.0	24.5	53.0	42.0	20.0	15.0	-	-	Babayemi *et al.* 2010
Fruits	79.5	1.3	10.2	-	-	-	5.2	0.2	0.2	Tacón (1987), Latin America and the Caribbean
Seeds	86.5	4.2	27.3	-	-	-	0.6	0.1	0.3	
Fruits	-	4.2	14.0	31.5	23.7	7.9	1.1	0.3	0.3	Cecconello *et al.* (2003), Venezuela
Seeds	-	-	30.0	-	-	-	-	-	-	
Fruits	85.4	3.3	16.6	33.8	25.9	4.7	-	0.3	0.2	Beltrán (2012), Eastern zone of Cuba
Seeds	95.7	3.4	25.3	29.6	23.2	5.4	-	0.4	0.1	

PRESENCE OF SECONDARY COMPOUNDS IN *S. SAMAN* FRUITS AND FOLIAGE

Plants produce substances as defense against their predators, known as secondary compounds (Jiménez *et al.* 2011). In spite that they are considered harmful, in some cases could be beneficial for the animal, especially in ruminants.

Some reports indicate the toxicity of *S. saman* leaves and pods. Escobar (1972) stated that seeds and the leaf extract are extremely toxic, due to the PITECOLOBINA, which is a toxic alkaloid with abortion-inducing properties. However, the toxicological studies of Leonard and Sherratt (1967) on purified PITECOLOBINA showed that although the intra-peritoneal injection in mice provoked convulsions, in a six-month feeding essay in rats there was no symptoms. Moreover, animals gain weight.

The phytochemical sieving of the raintree pods revealed the presence of moderate amounts of the main secondary metabolites, among them saponins, steroids, alkaloids, flavonoids, tannins and resins. However, there was no presence of terpenoids, glucosides or acid compounds (Obasi *et al.* 2010). Qualitative and quantitative analyses of tannins demonstrated that these were of the condensed type (catecol), formed by cyanidin, catequin, epicatechin, antocyanidin monoglycone, delphinidin and malidin, with approximate value of 7.9 % (0.979 g) (Ukoha *et al.* 2011). These components have synergism and demonstrate antimicrobial potential because the fruit could serve not only as agglutinating

agent of protein and other beneficial compounds for the animals, but also as a new nutraceutic tea, rich in energy and tannins, destined to human use.

In table 3 are shown the secondary compounds present in the foliage and fruits of *S. saman* collected at the Eastern region of Cuba (Delgado *et al.* 2012).

The moderate presence of saponins in the fruits could have favorable effect for the animals. Various researchers report that the consumption of saponins decreases the amount of protozoa in the rumen (Hu *et al.* 2007). This favors the nitrogen economy, mainly in poor quality diets.

Other studies, related to the presence of secondary compounds in the foliage of raintree and other tropical legumes (Pedraza *et al.* 2003a), confirmed the presence of tannins in all the plants. The raintree and the gliricidia also present saponins. The unfaunal effect of tannins and saponins in the foliage and the fruit of *S. saman* could also contribute to the reduction of the methanogenesis and these contributing environmental benefits.

Table 3. Presence of secondary metabolites in the whole fruit and seeds of *S. saman*

Metabolite	Fruit	Seed	Foliage
Alkaloids	+	++	-
Tannins	++	+	+
Saponins	++	+	+
Nitrogenous compounds	+++	+++	ND
Glucosides	+++	-	ND
Resines	++	+	ND
Mucilages	++	+	ND

ND: Not determined + low presence ++ mean presence +++ high presence

PALATABILITY OF *S. SAMAN* FRUITS AND FOLIAGE

For a long time the palatability of the raintree fruits for cattle is admitted. Von Mueller (1891), cited by Durr (2001), indicated that the main utility of the tree is in its fleshy pods, which are produced in great quantity and are a very good fattening forage for all type of grazing animals. This observation was confirmed in the case of bovines, pigs, sheep and goats. Horses, however, seem that only consumed the pods when other fruits and the forage are not available (Janzen 1983).

In contrast with the good taste of the fruits, there are few detailed studies on the acceptability of the foliage. Available results are anecdotal and somewhat contradictory. Durr (1992) reported that in Nicaragua the foliage is not very attractive for the cattle and leaf consumption, in reasonable amount, is only produced when pasture is scarce. Even so, ingestion is limited, to a great extent, to regrowths and young trees. Morrison *et al.* (1996) found similar results in Jamaica. However, Conklin *et al.* (1991) classified as high the palatability of the leaves in Costa Rica. Lowry *et al.* (1992) reported that in Indonesia goats consumed the leaves routinely.

In a cafeteria trial, through consumption measurements of twelve tropical foliages, realized in the state of Trujillo, Venezuela (García *et al.* 2008), the preference of young bovines for the foliage of twelve species was evaluated. These were: *Samanea saman*, *Chlorophora tinctoria*, *Morus alba*, *Pithecellobium pedicellare*, *Gliricidia sepium*, *Guazuma ulmifolia*, *Cordia alba*, *Trichantera gigantea*, *Tithonia diversifolia*, *Leucaena leucocephala*, *Moringa oleifera* and *Azadirachta indica*. Among the least consumed plants was *S. saman* (58.72 g DM) regarding to three of the foliages more used in ruminant feeding: *L. leucocephala* (325.63 g DM), *M. alba* (293.37 g DM) and *G. ulmifolia* (292.48 g $DM.d^{-1}$).

In an acceptability study of six legume foliages and six hours of supply in the feeding trough (Pedraza *et al.* 2003b), the *S. saman* foliage showed, in the same way, low consumptions in cattle, sheep and goats (0.48, 0.25 and 0.68 g DM/kg LW, respectively), compared to the foliages of *L. leucocephala*, *M. alba* or *G. sepium* (0.69-2.07 g DM kg LW^{-1}) in cattle and between 1.07 and 2.47 g DM kg LW^{-1} in smaller species.

According to García *et al.* (2008), the variations in consumption could be associated to the nutritive quality and to the presence of secondary compounds with aversive or stimulating consumption characteristics and their interaction with the type of animal. However, in some acceptability studies, carried out with bovines and sheep, no relationship of consumption was found with the presence of polyphenolic metabolites (Pinto *et al.* 2005 and Sandoval *et al.* 2005). This demonstrates that, in many cases, the acceptability is a phenomenon in which many factors mediate and, in occasions, difficult to understand.

Pedraza *et al.* (2003b) studied the crude protein contents and the effective degradability of rumen nitrogen in the foliage of six shrub-like legumes with approximately 60 d of regrowth growing in a livestock production area of the municipality of Camagüey, Cuba: *Albizia lebbeck*, *Erythrina berteroana*, *Erythrina variegate*, *Gliricidia sepium*, *Leucaena leucocephala* and *Samanea saman*. CP contents ranged between 23.5 and 27.9 % demonstrating the contribution that these foliages can offer to ruminant feeding.

S. saman foliage showed low ruminal degradability of DM (44.7 %) and OM (47.4 %). The effective nitrogen degradability in the rumen was between 43.6 and 52.3 %, for passage rates of 0.03 and 0.05 % h^{-1}, lower values than those reported for the rest of the foliages. *In vitro* intestinal digestibility of the nitrogen (34.8 %) was lower than for gliricidia and Leucaena (69.4 and 65.7 %, respectively).

In studies with whole and seedless fruits, in the species evaluated by Cecconello *et al.* (2003), the ruminal degradability of the meals evidenced, in the majority of the cases, values higher than 50 % and even close to 80 % in certain species. The seedless fruits of *S. saman* and *E. cyclocarpum* showed the highest effective degradability, with value of 62 % and very high soluble fraction (55.60 and 49.49 %, respectively). These species had the highest effective degradability for the whole fruits (66.59 and 81.26 %, respectively), with slowly degradable fraction, much higher than the rest of the fruits. Total digestibility of *S. saman* pods with the use of the *in vitro* technique of two steps (ruminal and intestinal digestion) demonstrated that could be as high as 74 % (Conklin *et al.* 1991). When animals are fed whole pods of *S. saman* as it occurs in natural grazing, great proportions of intact seeds pass through the digestive tract and are expelled with the feces (Janzen 1983).

Janzen (1982) determined in cattle that the passage rate is so high (96 %) for the whole seed of *Enterolobium cyclocarpum*, a similar legume, native to Central America. It has not been established if the passage rate is similar for *S. saman* seeds, but of all ways the intact seed excretion represents a potential nutrient loss for the animal. Seedless pods, by themselves, are of high nutritive value, with *in vitro* digestibility of 71 % (Conklin *et al.* 1991 and Ceconello *et al.* 2003). However, whole fruit grinding will allow a better use of the nutrients contained in the seeds.

Figure 1 shows seed contribution to the nutritional value of the whole fruit (Beltrán 2012). These nutrients will be lost if the seed is not used by the animals.

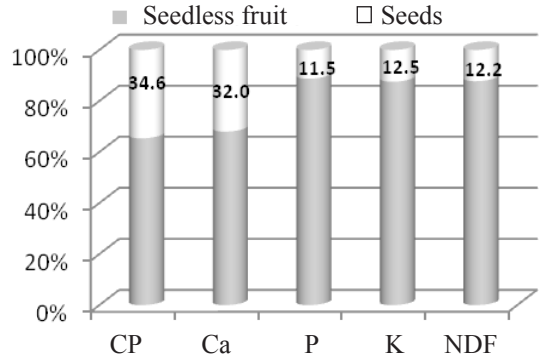

Figure 1. Proportion of nutrients (%) contributed by seeds to the total content present in 100 g of whole fruits (DB) that are lost if seeds are not available

S. SAMAN UTILIZATION IN ANIMAL FEEDING

From many years, the raintree is recognized as a forage tree. This is mainly due to the high production of nutritive pods, appetizing for the animals.

EXPERIMENTAL RESULTS WITH THE USE OF *S. SAMAN* AS SUPPLEMENT IN ANIMAL DIETS

Dry matter ingestion is the main restriction for improving the cattle production in the tropics, mainly in the dry season. One of the main advantages of the supplementation with ground pods of *S. saman* is the increase of the dry matter and digestible energy consumption, without affecting forage ingestion. There are some studies reporting animal performance when *S. saman* foliage or fruits are supplied as supplement to the diets of productive species.

Chicco *et al.* (1973) found that up to 22 % of the concentrate for pigs could be substituted by ground pods of *S. saman* without harming live weight gains. Similar results were obtained with kids in India (Thomas *et al.* 1976). In these, the substitution of 20 % of the supplement by fruit meal of *S. saman* did not affect animal growth, but 30 % negatively influenced on the

weight. In heifers, 10 and 20 % inclusion of the fruit in the diet did not affect their development (Thole *et al.* 1992).

S. saman supplementation (15 or 30 %) with ground or whole fruits of raintree in the diet of dual-purpose cows, under grazing, indicated that regardless the level, there was a weight increase of 4.1 to 5.1 % and milk production increased between 0.5 to 1.1 L/cow/d regarding the control group. Milk of cows supplemented with 30 % of ground fruits showed higher contents of total solids (1.38 %), butterfat (1.01 %) and protein (0.59). Pregnancy was higher (16.6 %) regarding to other experimental groups (Roncallo *et al.* 2009).

Studies carried out in buffaloes by Seedtakosed *et al.* (1988) indicated that the supply of 2 kg of *S. saman* pods as supplement to a basal diet of rice straw was enough for the animals maintaining their weights during the whole dry season. In research developed in growing rabbits for determining the effect of the treatment of the seed (raw or autoclaved) on consumption, the weight gain and the feed efficiency, showed that with the seeds submitted to the autoclave, the indicators were superior regarding the crude (Oduguwa *et al.* 2000).

According to Navas *et al.* (2001a) the beneficial results observed in respect to animal performance and the efficiency of nutrient use when different animals are supplemented with *S. saman* pods could be related to its effect on the balance between the glucogenic and acetogenic short chain fatty acids and the increase between protein/energy in the nutrients absorbed.

It is also possible to use *S. saman* foliages for the preparation of silages, pre-dried hays, in multi-nutritional blocks and for the preparation of integral rations for ruminants and other species. Chumpawadee and Pimpa (2009) studied integral rations for beef cattle in which were included 40 % of leaf meal of different trees (*Plerocarpus indicus*, *Samanea saman* Jacq. Merr. and Streblus asper). With *S. saman* foliage, consumption was increased from 1.9 to 2.6 % LW and feeding performance improved.

OTHER USES OF *S. SAMAN*

In addition to its value as animal feed the raintree has other important use as melliferous, timber-yielding and medicinal plant. Presently, this latter aspect results of great interest, since it is considered as a plant with antimicrobial activity and its secondary compounds could be used for therapeutic purposes. Aqueous extracts of the plant demonstrated the inhibitory activity of *Escherichia coli*, *Staphylococcus aureus* and *Candida albicans* (Obasi *et al.* 2010 and Jagessar *et al.* 2011). More recent studies (Ukoha *et al.* 2011) suggest that ground fruits of *S. saman* could be used as an antimicrobial and antifungi natural source due to the presence of metabolites (mainly condensed tannins), capable of fulfilling these functions. Ferdous *et al.* (2010) found in the bark extract of *S. saman* good antioxidant activity and cytotoxic potential and Trusharkuman (2011) reported antioxidant and organ-protective activity in the bark, attributing it to the presence of polyphenolic compounds as the flavonoids and tannins.

FINAL CONSIDERATIONS

Samanea saman is a multi-purpose tree, adaptable to tropical conditions, and with great potentiality as alternative feed for ruminants and monogastrics. Its nutritional value is given by its production of abundant edible biomass, with crude protein levels higher than 20 %, and the presence of lipidic compounds, soluble carbohydrates and minerals in its foliage and fruits. Its utilization as supplement in the diet of productive animals could contribute to the improvement of the quality, to the substitution of imports and to cover the requirements of feeds in the dry season.

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