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Research Article

Forage palatability of Broussonetia papyrifera an invasive species in Ghana: Relative preference and palatability by sheep and goats

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Abstract
Broussonetia papyrifera is an exotic tree widely grown for paper production. Due to its prolific regeneration it has invaded forest canopy gaps and degraded farmlands and has now become an invasive species in Ghana. In enhancing its value for use the plant was evaluated as potential forage for grazing animals vis-à-vis other two existing forage plants: *Ficus exasperata* and *Leucaena leucocephala*.The study assessed the palatability and preference of *Broussonetia papyrifera* using sheep and goats for the wet and dry seasons.The species were assessed in indoor pen feeding trials using eight-unit (3×3 m) pens with the cafeteria method. The amount of forage offered was 100g (fresh material) in all instances for each species and for ten minutes. Adesign based on 3×2×2 factorial in Randomized Complete Block Design (RCBD) was used to test the differences in palatability between the three forage species.Results revealed that palatability was higher ($P<0.05$) in *Leucaena leucocephala* compared with *Ficus exasperata* and *Broussonetia papyrifera* for sheep and goats across seasons. The trend shown might be the result of the effects of familiarity with the *Leucaena leucocephala* since animals tend to select plants that are familiar than newly introduced and unfamiliar plants. The study also revealed high level of condensed tannin (CT) in Broussonetia papyrifera which might have interfered with forage intake by the animals.There were no significant differences in palatability of *Broussonetia papyrifera* for goat in both dry and wet season interactions and *Ficus exasperata* for goat in both dry and wet season interactions ($P>0.05$).The study concluded that *Broussonetia papyrifera* could be a potential feed for both sheep and goats across seasons.The research recommended that livestock farmers should incorporate *Broussonetia papyrifera* feed into their programmes for both sheep and goats and should be introduced to animals from infancy so that it may become a familiar feed for them.

Keywords
Invasive species—Broussonetia papyrifer—Leucaena leucocephala—Ficus exasperata—Palatability—Preference

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Contents

1. INTRODUCTION

Broussonetia papyrifera (paper mulberry) is an exotic tree species of the moraceae family native of the Indo-Malayan region, China, Japan and the pacific region. It is widely grown for paper production in its native home [1]. *Broussonetia papyrifera* was introduced into Ghana by the Forestry Research Institute of Ghana (FORIG) in 1969 to form part of an experimental programme to identify species for the local production of industrial cellulose [2]. However, due to its prolific regeneration pattern it got out of hand and invaded large canopy gaps and degraded farmlands in and outside the two forest reserves that it was introduced.

Recently, however, it is being argued that means of enhancing the value of *Broussonetia papyrifera* for use must be exploited rather than eradication. Farmers in the invaded areas in Ghana use the bark as one of the reliable materials for tying goods while the wood serves as a highly inflammable low density fuel wood. There are claims by some farmers of good food crop yield on soils under Broussonetia stands. The leaves of the species are also used by farmers in the invaded areas to feed livestock, especially during the dry season [3]. [4] (1988) in a study in China observed high protein content and good efficiency of nitrogen utilization in *Broussonetia papyrifera* when fed to Formosa Sika deer. However, this results, which is animal-specific does not represent the general situation. The feeding value of a forage is a function of both intake and nutritive value [5], and intake can be influenced by forage palatability [6]. Since variations in nutritive value of a species when planted outside its geographical range is possible, there is the need to carry out thorough studies on *Broussonetia papyrifera* in Ghana to unearth its forage potential.

The taxonomy [7], reproduction [8], physical and mechanical properties [9] and uses [10] of *Broussonetia papyrifera* have been well documented. Studies done in Ghana on the species by [11] include the seedling growth response to light and drought, fruiting and viability patterns, seed dispersal mechanisms, preferred micro sites, competitive ability in association with some indigenous forest tree species, natural regeneration and its recovery after fire. The nutritive value and palatability of the species have, however, not been investigated, thus making it difficult to assess its potential contribution to sustain animal production. The study was, therefore, conducted with the following specific objectives: (a) to assess the palatability and preference of *Broussonetia papyrifera* and two known browse species (b) to compare the effect of animal type and seasons on the palatability of the study species.

The main aim is to incorporate *Broussonetia papyrifera* as feed sources for small ruminant livestock especially during the dry season as part of the efforts at ensuring food and income security of livestock farmers in the *Broussonetia papyrifera* invaded areas of Ghana.

2. MATERIAL AND METHODS

2.1 Study area and Sample collection

The study was carried out at the University of Energy and Natural Resources (UENR) campus in the Sunyani Municipality in the Brong Ahafo Region of Ghana during the late-dry and early-rainy seasons. The site is located between latitudes $70^o35^{'}$ N and longitudes $20^o00^{'}$ and $20^o30^{'}W$. The district falls within the Wet Semi-Equatorial climate zone with mean monthly temperature varying between 23^oC and 33^oC. It experiences two rainfall regimes with 1296.3mm as annual mean. The major rainy season occurs from April to the end of July, while the period from September to late October is the minor season [12]. The soils of the area are made up of ferric acrisols [13].

Forages for the experiment; Broussonetia papyrifera, Ficus exasperata and Leucaena leucocephala, were collected from the Tano South District in the Brong Ahafo Region. The area lies between latitudes $7^o00^{'}$ and $7^o25^{'}$ north and between longitudes $1^o45^{'}$ and $2^o15^{'}$ west. It lies in the Dry Semi- deciduous Forest Zone (DSDFZ) of Ghana with the semi-equatorial climatic type which experiences double maximum rainfall pattern, from April to July and from September to October [14]. The mean annual rainfall is 1304.3mm. The dry season occurs between the months of November and March. Mean monthly temperatures range between 22^oC (August) and 30^oC (March) [12]. The soil of the area consists of forest ochrosols and the rubrisol-ochrosol intergrades. They are alkaline and are more richly supplied with nutrients.

2.2 Data Collection and Statistical Analysis

2.2.1 Selection of investigated plant material

The investigated species were selected based on the fact that *Broussonetia papyrifera*, an invasive and non-leguminous plant, has never been investigated for its forage potential, although there are reports that certain livestock feed on it in the invaded areas. *Ficus exasperata* is also a common and widespread non-leguminous forage species which is available throughout the seasons. It is also judged by livestock farmers, who have fairly accurate knowledge of plants eaten by their livestock, to be palatable to goats and sheep. However, *Leucaena leucocephala*, is a leguminous forage plant with known nutritional quality which could be compared with these non-leguminous plants. It is also recommended as a palatable forage species for ruminant livestock. *Leucaena leucocephala* is also available in almost every geographical location in Ghana and grows fast [15]. Both Broussonetia papyrifera [16] and *Leucaena leucocephala* [17] are classified as invasive species. Also, both *Broussonetia papyrifera* and *Ficus exasperata* belong to the same family *Moraceae*.

2.3 Experimental treatments, procedure and design

2.3.1 Collection and sample preparation of forages

Forages were collected daily by cutting with cutlass and knife. Forages were stored in moisture free environment overnight after harvesting. *Broussonetia papyrifera* and *Ficus exasperata* leaves were manually chopped into smaller sizes relative to that of *Leucaena leucocephala* to promote similar conditions in feed presentation.

2.3.2 Animal selection, care and feeding trials

The animals were selected based on age, sex, live-weight, health and vigour to prevent exhibition of hierarchical behaviour and the effect of different physiological stature. Palatability of the forage species to sheep and goats were

assessed in indoor feeding trials in eight-unit (3×3 m) pens using the cafeteria approach. Four healthy one-year and one-month old goats (average live weight, 10.4kg) and also four one-year and six months old sheep (average live weight, 23kg) were preconditioned in individual crates using the three forages during the ten days of adaptation period as recommended by [18] during which they were confined and given all the experimental feeds together ad libitum preceding each palatability run. This unit permits individual attention and facilitates separate collection of data. Harvested forages from the three plants were fed fresh to individually housed sheep and goats. Forages individually contained in feeding crates were offered to the animals. Consumption of the feeds by individual animals was monitored from 8.00am-10.00am daily. The amount of forage offered was 100g (green material) in all instances and all the three forages were offered simultaneously for 10minutes. At the end of the feeding period these three forages offered were removed. The weights of residual material were recorded and amount of consumption of each forage material calculated.

After withdrawal of the experimental feeds, the animals were placed on Elephant grass (*Pennisetum purpureum*), cassava leaves, maize bran and pito waste as a supplement feed allowing them to meet their requirement (at least maintenance) till the following morning. Each assessment was completed in one day and were repeated. Pens were cleaned daily as well as the feeding and water troughs. Animals had access to drinking water at all times. The animals were weighed monthly before the morning feeding and also provided for their comfort within the limits of the trial objectives. The three species were compared against one another in two seasons, the dry season and the wet season. At each seasonal run, each forage was offered ten times to one goat and also ten times to one sheep. Each sheep and goat tested the same number of pairs of each assessment in the dry and wet seasons. Goats and sheep were randomly allocated to alternate feeding crates to achieve a balanced design and to avoid a 'habit reflex'.

2.3.3 Preference and palatability rating procedures

Preference was calculated for each forage, separately for sheep and goats, as the total weight of the forage which was consumed divided by the total weight of all forages consumed in all comparisons involving that forage expressed as a percentage and therefore have a potential maximum of 100 (totally preferred) and 0 (totally rejected).Means are ranked for each animal species, and separated into classes of high (>60%), medium (35-55%) and low preference (<25%) [19].

Palatability ranking of browsing species is determined using indexes calculated as the ratio between biomass consumed and biomass offered or simply by reference to the time spent by the animal eating a given specie as classification criteria [20]. Palatability was calculated daily for each forage, separately for sheep and goats, by dividing the daily consumption (weight) by the total weight of that forage offered and expressed as a percentage and therefore have a potential maximum of 100 (highly palatable) and 0 (totally rejected).Means are ranked for each animal species, and separated into classes of high (>60%), medium (35-55%) and low palatability (<25%) [19]. However, palatability and preference have been used as synonyms [21].

2.4 Experimental design

A design based on 3×2×2 factorial in Randomised Complete Block Design (RCBD) was used to test the differences in palatability between the three forage species; *Broussonetia papyrifera*, *Ficus exasperata* and *Leucaena leucocephala*, consumed by sheep and goats during the dry and wet season's assessments.

2.5 Data analysis

The General Linear Model Procedure of Statistical Analytical System [22] was used to analyse the data. The unit of observation for forage palatability was the proportion or percentage (%) of forage consumed. The proportion or the amount (%) of each of the investigated forage species consumed by sheep and goats for the ten days of data collection was computed for significant treatment means during the dry and wet season's assessments. The values determined were subjected to analysis of variance (ANOVA). Significant different means were separated using the least square mean (LSM) analysis procedure. The interactive effect of forage species, animals and season on forage palatability was analysed

3. RESULTS

Preferences of goats and sheep for *Broussonetia papyrifera*, *Leucaena leucocephala* and *Ficus exasperata* across the seasons is presented in Tables 1 and 2. Throughout the seasons the preference for *Broussonetia papyriferaand, Ficus exasperata* for goats was ranked low while preference for *Leucaena leucocephala* was ranked high. In the case of sheep, *Leucaena leucocephala* was ranked as medium while *Broussonetia papyrifera* and *Ficus exasperata* had a low preference.

Table 1. Preference of goats for forages. Values are means across seasons

FORAGE SPECIES	MEAN VALUE (%)	PREFERENCE CLASS
Broussonetia papyrifera	12.55	low
Leucaena leucocephala	80.74	high
Ficus exasperata	6.83	low

Means are ranked for each animal species, and separated into classes of high (>60%), medium (35-55%) and low preference (<25%) [19].

Table 2. Preference of goats for forages. Values are means across seasons

FORAGE SPECIES	MEAN VALUE (%)	PREFERENCE CLASS
Broussonetia papyrifera	17.33	low
Leucaena leucocephala	50.93	medium
Ficus exasperata	31.85	low

Means are ranked for each animal species, and separated into classes of high (>60%), medium (35-55%) and low preference (<25%) [19].

3.1 Forage palatability of goats and sheep across the seasons

Palatability of goats and sheep for *Broussonetia papyrifera, Leucaena leucocephala and Ficus exasperata* across the seasons is presented in Tables 3 and 4. Throughout the seasons the palatability for *Broussonetia papyriferaand, Ficus exasperata* for goats was ranked low while palatability for *Leucaena leucocephala* was ranked high. In the case of sheep *Leucaena leucocephala and Ficus exasperata* were ranked as high while *Broussonetia papyrifera* had low palatability.

Table 3. Palatability of forages by goats. Values are means

FORAGE SPECIES	DRY	WET	ACROSS SEASONS
Broussonetia papyrifera	12.23(low)	17.38(low)	14.81(low)/2nd
Leucaena leucocephala	87.28(high)	92.25(high)	89.77(high)/1st
Ficus exasperata	6.75(low)	8.30(low)	7.25(low)/3rd

Means are ranked for each animal species, and separated into classes of high (>60%), medium (35-55%) and low preference (<25%) [19].

Table 4. Palatability of forages by sheep. Values are means

FORAGE SPECIES	DRY	WET	ACROSS SEASONS
Broussonetia papyrifera	29.95(low)	35.50(medium)	32.73(low)/3rd
Leucaena leucocephala	97.43(high)	94.43(high)	95.93(high)/ 1st
Ficus exasperata	60.33(high)	59.55(high)	60.00(high)/ 2nd

Means are ranked for each animal species, and separated into classes of high (>60%), medium (35-55%) and low preference (<25%) [19].

3.2 Effect of species, animals and seasons on forage palatability

The mean values of forage palatability due to interactive effects of species, animals and seasons are presented in Table 5. The most palatable species was found in the *Leucaena*-sheep-dry season interaction. This result is, however, not significantly different from *Leucaena*-sheep-wet season interaction and similar to both *Leucaena*-goat-dry season and *Leucaena*-goat-wet season interactions (P<0.05). In all comparisons the effects of *Leucaena* on goats and sheep in both dry and wet seasons were significantly different from all other comparisons involving *Broussonetia papyrifera* and *Ficus exasperata* (P<0.05).

The interactions of *Ficus*-sheep-dry season and *Ficus*-sheep-wet season ranked second and intermediate between most palatable and least palatable. These interactions were significantly different from all other comparisons. The *Ficus*-goat-dry season and *Ficus*-goat-wet season interactions were similar to *Broussonetia*-goat-dry season and *Broussonetia*-goat-wet season interactions and ranked the least palatable (P<0.05).The interactions of *Broussonetia*-sheep-dry season and *Broussonetia*-sheep-wet season are not significantly different (P>0.05). These results are, however, different fromall other comparisons (Table 5). Generally, the palatability rating based on the effect of species, animals and seasons are as follows: (a)*Leucaena*(goat and sheep) > (b) *Ficus*(sheep) > (c) *Broussonetia*(sheep)> (d) *Broussonetia* and *Ficus*(goats) across the seasons.

Table 5. The effect of species, animals and seasons on forage palatability

FORAGE SPECIES	ANIMALS	SEASONS	PALATABILITY (LSM values)
Broussonetia papyrifera	Goat	Dry	12.23d
		Wet	17.38d
	Sheep	Dry	29.95c
	Wet	35.50c	
Ficus exasperate	Goat	Dry	6.75d
		Wet	8.30d
	Sheep	Dry	60.33b
		Wet	59.55b
Leucaena leucocephala	Goat	Dry	87.28a
		Wet	92.25a
	Sheep	Dry	97.43a
		Wet	94.43a
SEM			**4.01**

Means in the same column followed by the same lowercase letters (a, b) are not significantly different at 5% significance level. SEM = Standard Error of the Mean LSM = Least Square Mean

4. DISCUSSION

4.1 effect of secondary metabolites on selection and palatability of forages

Broussonetia papyrifera was least selected and least palatable among the investigated forages probably as a result of the high condensed tannin concentration in the forage. Condensed tannins as secondary metabolites have evolved as a defence mechanism of woody plants against herbivory. This is an adaptive mechanism used by woody plants growing on low fertility soils [23] to compensate for their inability to grow rapidly beyond the reach of most browsing animals. The level of condensed tannin in *Broussonetia papyrifera* (6.96%-7.09%DM or 69.60g/kg-70.90g/kg DM) could render it not beneficial to ruminants.

Condensed tannin at low concentrations (20-40g/kg DM) are nutritionally beneficial through decreased degradation of dietary protein in the rumen, and increased protein availability for digestion and absorption leading to good animal performance [24].

Abundant evidence shows that food selection and ingestion is regulated by toxins rather than by inhibition of protein or carbohydrate digestion [25]. *Broussonetia papyrifera* with relatively high levels of condensed tannin also contain high amounts of nutrients and minerals, but the astringent sensation animals probably experienced when consuming it may lead to its rejection, which could be a nutritional mistake [26]. The rejection of condensed tannin containing plants or plant parts is presumably an evolved response by animals to the negative effects tannins have on forage digestibility and therefore animal fitness [27]. In this study results indicate a negative correlation between condensed tannin content and palatability. However, the high condensed tannin concentration did not influence the in vitro organic matter digestibility (IVOMD) of *Broussonetia papyrifera* to a greater extent contrary to the observation made by [28]. There is recent evidence that some ruminal micro-organisms are able to remain active in a high tannin environment and may be used as inoculants to overcome the detrimental effects of tannins in ruminants [29].

4.2 Preference for forage species by sheep and goats across the seasons

Preference for *Leucaena leucocephala* was the highest (>60%) for goats across the seasons while *Broussonetia papyrifera* and *Ficus exasperata* recorded low preference (<25%). The investigation also revealed medium preference for *Leucaena leucocephala* by sheep while *Broussonetia papyrifera* and *Ficus exasperata* recorded low preference. The sheep and goats exhibited different preferences for the three forages. However, the differences were moderate in magnitude, as in no instance did one species have a low preference for forage highly preferred by the other.

In this study, preference parameter such as ether extract was highest in *Broussonetia papyrifera*. This results, however, contradicts the findings of [30] that high total ether extract indicates high preference since *Broussonetia papyrifera* with the highest ether extract was the least preferred among the investigated species. [31] also found that increased fats resulted in greater preference which was at variance with the results of this study. In plants as proteins, sugars, fats and preferred components of ether extract increase in percentage composition, lignin and crude fiber decrease. However, there were positive correlations of lignin and crude fiber with increased preference in the study conducted pertaining to the high preference of *Leucaena leucocephala*. The findings that *Broussonetia papyrifera* recorded the highest level of condensed tannin and was the least preferred forage is supported by [32] who reported a high negative relationship between tannin and preference by cattle for *lespedeza* varieties. The forage species with the highest lignin concentration also had the highest percentage of crude protein. Many conflicting results are reported in this study concerning what chemical components influence forage preference. The extremes are shown by the positive correlation in the study in contrast to the conclusion that there seems to be no consistent correlation between chemical composition of forage and its preference [30].

Although a preference test gives a useful insight into the relative palatability of feeds to animals not previously accustomed to them, and requires much smaller quantities of feed material than conventional feeding trials, the limitation is that the intake of any given feed will depend to a large extent on what else is available to the animal. Less palatable feeds should not necessarily be written off as it is possible that animals would become accustomed to them, given an adequate period of adaptation. It should be noted, however, that relative palatabilities will also vary with animal species; for instance, [33] found that relative palatability index values for goats were more than double those for sheep. Digestibility had been indicated to influence forage preference such that the highly digestible forages would be more favoured [34]. However, in such short-term trials like those in the present study, it is unlikely that digestibility of materials would have influence preference. On the other hand, tastes and odour of the feeds could also have applied in the observed situation, as was the case in the studies of [35]. The low preference, confirmed by observations, of both sheep and goats for *Broussonetia papyrifera* means it is not suitable as a sole feed for animals.

4.3 Palatability of forage species by sheep and goats across the seasons

Palatability of *Leucaena leucocephala* was the highest (>60%) for goats across the seasons with *Broussonetia papyrifera* and *Ficus exasperata* recording low palatability (<25%). The investigation also revealed high palatability of *Leucaena leucocephala* and *Ficus exasperata* by sheep (>60%) while *Broussonetia papyrifera* recorded low palatability (<25%). The difference might be due to factors which influence palatability such as animal and non-animal factors [36]. Animal factors which might probably influence palatability in this study are feeding preferences, species of animals, age and degree of maturity of the animal. Non-animal factors that might have influenced palatability in this study include season and growth stage of the plant, associated plants differences and also physical characteristics of the plant.

Although protein shows the best correlation of all chemical ingredients with preference of forages by livestock, several investigators believe that total nutritive value of the plant is better indicator of palatability [37]. The results of the study might be probably due to the

combination of several of these factors. Research suggests that palatability is more than a matter of taste; instead, it is the interrelationship between a food's flavour and its postingestive effects. Feedback is positive, increases palatability, if the food meets nutritional needs. Feedback is negative, decrease palatability, if the food is inadequate or excessive relative to nutritional needs or contains high levels of toxins [38]. Postingestive feedback influences an animals liking for a food (palatability) and that depends on how well a food meets the needs of the body.

5. CONCLUSION

In achieving a more efficient system of green feeding it is necessary to introduce new field cropping species in ruminant nutrition as green forage in which nutritional value and palatability have not been evaluated. In this research analysis were conducted on palatability and preference of *Broussonetia papyrifera* vis-à-vis *Leucaena leucocephala* and *Ficus exasperata*. The ten days adaptation period probably was enough to help the bucks and ram to become consistent in the order of preference and palatability of the experimental feeds on the ten days of the actual experiment.

Leucaena leucocephala was the most preferred and palatable species followed by *Ficus exasperata* while *Broussonetia papyrifera* was the least preferred by sheep in both the dry and wet seasons. Goats highly preferred *Leucaena leucocephala* to the other forages in all the seasons. However, preference for *Ficus exasperata* and *Broussonetia papyrifera* did not vary much. The animals displayed preference for *Leucaena leucocephala* probably because they were familiar with the plant. In spite of the generally low preference of *Broussonetia papyrifera* by sheep and goats across the seasons, it showed a great potential as forage. The trials indicated low intake of *Broussonetia papyrifera* probably because the plant contain certain levels of anti-nutritional properties like tannin which affect palatability and intake of browse. In many cases the seasons of the experimental year did not cause a higher difference in preference and palatability than between the treatments (forages) within a year. However, goats and sheep consumed more of *Broussonetia papyrifera* in the wet season than the dry season probably because of dilution effect on the plant nutrients during the wet season. Consumption of *Broussonetia papyrifera* appeared to be slow at the initial stages, presumably, because it was relatively unfamiliar and could affect its palatability. Intake of *Broussonetia papyrifera* did not increase with time to the extent of *Leucaena leucocephala*, however, there was a gradual increase in its consumption. *Broussonetia papyrifera* was therefore not totally rejected. The high palatability of *Leucaena leucocephala* could pose management problems, as it may be selectively grazed by both sheep and goats. The study has shown that sheep and goats prefer forages variously and that this type of study could aid in the planning of supplemental feeding programs for ruminant animals.

The conclusion drawn regarding the value of *Broussonetia papyrifera* as a source of fodder for ruminants is that it is inadequate as the ruminant's sole source of nutrients. This is attributed to possibility of the forage containing a certain level tannin content that has been shown to have an inverse relationship with voluntary intake, digestibility, preference as well as palatability in ruminants. The potential of *Broussonetia papyrifera* as a supplementary feed should not be discounted because of the possibility of its high condensed tannin concentration. The all year round forage yield is advantageous. With so many desirable attributes, both physically and nutritionally, of *Broussonetia papyrifera* as a fodder tree, one would surely consider it as a challenge to overcome its limitations in becoming a valuable source of feed. It is recommended that livestock farmers should incorporate *Broussonetia papyrifera* feed into their programmes for both sheep and goats. *Broussonetia papyrifera* should be introduced to animals from infancy so that it may become a familiar feed for them. However, until consumption of *Broussonetia papyrifera* is appreciable it may not be advisable to include it as a basic component of the diet for ruminants otherwise they may suffer from starvation.

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