ORIGINAL ARTICLE

Utilization and Nutritive Value of *Piliostigma thonningii* as Ruminant Feed in North Western Ethiopia

Almaz Ayenew[1], Adugna Tolera[2], Ajebu Nurfeta[2] and Getnet Assefa[3]

[1]Department of Animal Science, Debre Markos University, P.O. Box 269, Debre Markos, Ethiopia,
Email: almazayenew@yahoo.com
[2] School of Animal and Range Science, Hawassa University, College of Agriculture, P.O. Box 5, Hawassa, Ethiopia,
Email: adugnatolera@gmail.com, ajebu_nurfeta@yahoo.com
[3]Ethiopian Institute of Agricultural Research (EIAR), P.O.Box-2003, Addis Ababa, Ethiopia,
Email: getnet.at@gmail.com
Corresponding author: ajebu_nurfeta@yahoo.com

ABSTRACT

The objectives of this study were to asses the cultivation and utilization of *Piliostigma thonningii* (*P.thonningii*) and to evaluate the chemical composition and *in vitro* dry matter digestibility (IVDMD) of twigs and leaves of *P.thonningii* harvested at different phenological stages of the tree in Northwestern Ethiopia. A total of 180 purposively selected households from four districts were interviewed. Leaf and twig samples of *P.thonningii* were harvested at three different phenological stages of the tree. Stage one (S1) was the time when *P. thonningii* leaves were well emerged after complete shedding of the leaves (May); stage two (S2) was the time between leaf emergence and leaf shedding (August); and stage three (S3) was the time when the plant starts shedding its leaves (November). The study showed that 97.8% of the respondents used *P.thonningii* as a feed resource and to fill the feed deficits during times of feed shortage. Leaves, twigs and pods of *P.thonningii* were reported as edible parts of the plant by cattle, sheep and goats. Respondents had a positive impression on the feeding value of *P.thonningii*. The crude protein (CP) content varies from 16.8 to 20 g/kg DM and 10.5 to 18.5 g/kg DM in leaf and twig, respectively. The CP content was higher at early stage of the leaf emergence, while the reverse was true for NDF and ADFcontent, and was higher in the leaf than the twig fraction. The IVDMD was higher ($P<0.05$) in S1 (554 g/kg DM) than S2 (522 g/kg DM) and S3 (459 g/kg DM). The quality of *P.thonningii* in the studied communities, therefore, makes it an appropriate choice for its inclusion in agro-forestry systems and the tree can contribute to livestock production through provision of feed. Therefore, for efficient utilization of the tree an extension work needs to be strengthened to create awareness in the planting of the tree.

Key words: livestock, multipurpose browse species, phenology, and survey

INTRODUCTION

In Ethiopia, livestock production plays important roles to the economy of smallholder farmers and the national economy. However, the productivity of the livestock in terms of meat, milk and other purposes is quite low. Inadequate feed availability and poor nutrition are the major constraints limiting livestock performance (Getahun, 2008). The major feed resource in the country comprises natural pasture and crop residues, which are usually poorly managed and low in feeding value (Adugna *et al.,*2012). They are low quality feeds that can't sustain effective animal production or even maintenance requirements because of their nutritional deficiencies, low digestibility and limited intake capacity of animals (McDonald *et al.,* 2002; Adugna, 2009). The crude protein content of most crop residues is insufficient to fulfill the minimum requirement of rumen microbes for proper functioning (Van Soest, 1994; Rehraheand Ledin, 2004). Hence, proper supplementation of animals fed low quality roughage with feeds with better quality could enhance productivity or at least avoid body weight loss during the critical feed shortage periods of the year (Adugna, 2007).

Integration of multipurpose browse species in the farming system such as in agro-forestry systems, backyards and stock exclusion areas helps to avail quality green feed during the dry season for smallholder farmers. In this regard many indigenous fodder trees and shrubs are used in Ethiopia as supplementary feeds for livestock, especially during the long dry season. Multipurpose fodder trees are believed to be high in protein, vitamins and minerals and known to be important as feed to livestock production in promoting not only maintenance of animals but also in enhancing growth and milk production (Takele *et al.,* 2014). One potential browse species that can be used as feed for livestock is *P.thonningii* commonly known as camel's foot tree (locally known as "*Yekola* and *wanza*''). It is semi deciduous and multipurpose tree, which grows up to 3–5 meters high and is endemic to Ethiopia(Azene, 2007). It is widely distributed in the country and performs well in areas where altitude ranges between 500-2,000 meter above sea level (Azene, 2007). Kassahun *et al.* (2016) reported that *P.thonningii* is one of the multipurpose browse species used as dry season feed supplement for ruminant livestock and could have multipurpose functions. Despite the wider availability and use of *P. thonningii*, little has been documented with regard to the extent of its utilization as feed for livestock and potential nutritive value at different phenological stages of the tree. This suggests that there is a need for research to characterize the tree in order to sufficiently understand the nutritional quality and seasonal availability for efficient utilization. Therefore, the objective of this study was to generate information on utilization, farmers' perception on feeding values to livestock, other multipurpose uses of *P.thonningii* and evaluate the chemical composition and *in vitro* dry matter digestibility of leaves and twigs of *P.thonningii* harvested at different phenological stages in northwestern parts of Ethiopia.

MATERIALS AND METHODS

Descriptions of the study area

The study was conducted in Awi zone of Amhara National Regional State and Metekel zone of Benishangul-Gumiz Regional State, Northwestern Ethiopia. Awi Zone, is located at 10° 31'46" to 11°16' 0" North latitude and 36°30' 0 to 36°93'0" East longtiude and has altitudinal range of 700 - 3100 meters above sea level about 450 km north west of Addis Ababa. The average annual rainfall is 1750 mm while the average monthly temperature ranges from 17°C to 27°C(AZARDO, 2016). Metekel Zone is located at 10°47'33" to 11°24'26" North latitude and 35°24'40" to 36°38'43" East longitude, with altitude range of 550 to 2500 meters above sea level. The average temperature ranges between 20 -25°C. During the hottest months (January - May), the temprature ranges between 28–34°C. The annual rainfall ranges from 500 to 1800 mm (MZARDO, 2016).

Selection of study districts and *Kebeles*

From each zone, two districts where *P.thonningii* is well recognized and sufficiently available was purposively selected through discussion with Awi and Metekel zone administration, livestock experts and community elders based on the livestock production in the area, abundance and usage of *P.thonningii* for livestock and accessibility of the areas for the study. The selected districts were Guangua and Zigem from Awi zone and Mandura and Dangure districts from Metekel zone. Twelve potential and representative *kebeles*, three from each district were purposively selected. From these *kebeles*, a total of 180 households, fifteen from each *kebeles* were identified for the detailed interview. The respondents were very familiar and knowledgeable farmers, who have experience in utilizing *P.thonningii,* for different purposes including as feed for livestock.

Data collection

Primary data were collected through key informant interviews and survey questionnaire. Before the commencement of the actual survey work, review of secondary information and key informant interview were made using semi-structured questionnaire to gather information on the production and utilization of *P.thonningii* for different purposes including its importance as animal feed. Based on the preliminary information collected through the review and key informant interviews, a formal survey was conducted. The formal survey was conducted using a pre-tested structured questionnaire. In the survey detailed information on planting and utilization of *P.thonningii*,

phenological patterns over the months, its importance as feed for livestock, seasons of utilization, farmers' perception regarding its importance for different purposes and any difficulty encountered in feeding the plant were covered. Secondary information was collected from zonal and district offices of Agriculture, Livestock and Fishery, and Forestry and Environment protection.

Sample collection and preparation

Leaf and twig samples of *P.thonningii* were collected at three different phenological stages of the tree from three *kebeles* for determination of chemical composition and IVDMD. From each *kebeles* samples were collected from 10-15 plants, composited, thoroughly mixed and sub-sampled. The three sample harvesting seasons (Phenological stage of the tree) were determined based on the time *P.thonningii* emerges and sheds its leaves, as the plant is deciduous. Stage one (S1) was the time when *P.thonningii* leaves were well emerged after complete shedding of the leaves (May); stage two (S2) was the time between leaf emergence and leaf shedding (August); and stage three (S3) was the time when the plant starts shedding its leaves (November). Small branches of the *P.thonningii* trees containing the leaves and twigs were cut and tips of the twigs that are assumed edible along with the leaves were separated from the matured branches. The twig and leaf samples were separated and air-dried under shade and the air-dried samples were dried at 55^{o}C for 72 hours in forced draft oven. Then dried samples were ground in a Wiley mill to pass through one mm sieve and taken to Holeta Agricultural Research Center nutrition laboratory for chemical analyses and IVDMD determination. The dried and ground samples were kept in airtight plastic bags pending analysis.

Chemical analysis

Samples were analyzed for DM, ash and CP contents according to AOAC (1990). Total nitrogen (N) content of the feed samples was determined using micro-kjeldahl method. The CP content was calculated as N × 6.25. Neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) were analyzed according to the procedures of Van Soest and Robertson (1985).

***In vitro* dry matter and organic matter digestibility**

In vitro DM digestibility (IVDMD) was determined by the two-stage in vitro method of Tilley and Terry (1963). Samples weighing 0.5 g were incubated for 48 hours with rumen fluid and buffer followed by 48 hour digestion with pepsin and HCl. The residues were oven dried overnight at 105^{o}C to determine IVDMD.

Data analysis

The data collected from the survey were analyzed using descriptive statistics using Statistical Package for Social Science (SPSS) version 20.0 (SPSS, 2007). Laboratory results were subjected to analysis of variance using the General Linear Model procedure of the statistical analysis system (SAS, 2008). Mean separation was employed using Tukey HSD test for pair-wise mean comparison when the model for main effects or their interaction were significant ($P < 0.05$). The model used for chemical analysis and *in vitro* dry matter digestibility was:

$$Yij = \mu + Si + Pj + SPij + eij;$$

where, Yij= is the measured response, μ= is the overall mean, Si= is effect of the i^{th} harvesting stage, Pj= is effect of the j^{th} plant part, $SPij$ =is the stage of maturity by plant part interaction, and eij =is the error term

RESULTS

Planting and propagation of *P.thonningii*

Majority of the respondents (90.6%) utilized indigenous browse trees as a feed resource for livestock during the dry season when other feeds are barely available. According to the respondents, among the major indigenous browse trees available in the study districts *P.thonningii* were frequently used as a feed for ruminant animals. Although the practice of cultivating *P.thonningii* tree in both zones was very limited, only 12.2 and 4.4 % of the respondents in Awi and Metekel zones, respectively, cultivated the tree. However, 50 and 74.4% of the respondents in Awi and Metekel zones managed the tree by protecting from any damage which is naturally grown in their private land. All of the respondents in the study area reported that *P.thonningii* is propagated from seeds only.

Table 1. Percent of farmers reporting planting and natural availability of *P.thonningii* in the farm land in the study area

Tree species	Awi zone			Metekel zone		
	Guangua (n=45)	Zigem (n=45)	Total (n=90)	Mandura (n=45)	Dangure (n=45)	Total (n=90)
P. thonningii planted	6.7	17.8	12.3	2.2	8.9	5.6
P. thonningii naturally grown	24.4	75.6	50	73.3	75.6	74.4

n = number of respondents

The use of *P. thonningii*as animal feed

Use of *P.thonningii* as livestock feed is most common in all the study zones. All respondents from Awi zone and 95.6% from Metekel zone used *P.thonningii* leaves, twigsand pods as feed for livestock (Table 2). Majority of the respondents (90% of Awi zone and 98.9% of Metekel zone) reported that leaves, twigs and pods are edible parts of the plant by livestock. They indicated that P.*thonningii* is especially important during the dry seasons when feed is scarce. During the dry season, livestock are normally kept around where this tree is available to let them utilize the leaves, twigs and pods.

Table 2. Experience of farmers in feeding *P.thonningii* and plant parts usedfor feeding (percent of respondents

Category	Awi zone			Metekel zone		
	Guangua (n=45)	Zigem (n=45)	Total (n=90)	Mandura (n=45)	Dangure (n=45)	Total (n=90)
Experience in feeding *P.thoninngii* to animals	100	100	100	93.3	97.8	95.6
Parts of *P. thonningii* tree used as feed						
– Leave and twigs only	8.9	2.2	5.5	2.2	-	1.1
– Pod only	8.9	-	4.5	-	-	-
– Both	82.2	97.8	90	97.8	100	98.9

n = number of respondents

Table 3. Use of *P.thonningii* by different animal species in north western Ethiopia (percent of respondents)

Type of animals	Awi zone		Metekel zone		Total (N=180)
	Guangua (n=45)	Zigem (n=45)	Dangure (n=45)	Mandura (n=45)	
Cattle	68.9	86.7	77.8	82.2	78.9
Sheep and Goat	31.1	13.3	22.2	17.8	21.1

The type of animals, which are fed *P.thonningii* in the study zones are shown in Table 3. Field observation and response of the farmers during this study demonstrated that ruminant animals like cattle, sheep and goats consume leaves and pods of *P.thonningii* . According to the respondents, leaves and pods of *P.thonningii* were primarily fed to cattle followed by small ruminants. The majority of the respondents (83.9%) indicated that *P.thonningii* leaf is mainly supplemented to livestock from March to May (which is critical feed shortage season) (Table 4). However, 77.8% of the respondents reported that *P.thonningii* pod is used as supplemental feed for livestock from December to February. On the other hand, 16.1% and 22.2% of respondents reported that *P.thonningii* leaves and pod are supplemented to animals year round and from March to May, respectively.

Table 4. Months of utilization of *P.thonningii* as livestock feed in the study districts of northwestern Ethiopia (percent of respondents)

Months	Zones n=90				Total n=180	
	Awi		Metekel			
	Leaves	Pods	Leaves	Pods	Leaves	Pods
Dec- February	-	75.6	-	80	-	77.8
March-May	85.6	24.4	82.2	20	83.9	22.2
Year round	14.4	-	17.8	-	16.1	-

n= number of respondents

Phenological patterns of *P.thonningii*

About 70% and 89% of the respondents in both study zones reported that *P.thonningii* tree shed and emerge its leaves from December to February and March to May, respectively (Table 5). However, 10.6% of the respondents indicated that leave emergence of *P.thonningii* tree occurs during June to August. Majority (77.2%) of respondents reported that the months between December and February are the seed setting seasons of the tree. Some of the respondents, however, indicated the seed setting occurs between March and May.

Table 5. Months of leaf shedding, rejuvenation and seed setting of *P. thonningii*in the study districts of north western Ethiopia (percent of respondents)

Parameter		Awi		Metekel		Total n=180
		Guangua (n=45)	Zigem (n=45)	Dangure (n=45)	Mandura (n=45)	
Months of leaf Shedding	Sept. to Nov.	2.2	2.2	17.8	2.2	6.1
	Dec. to Feb.	64.4	93.3	55.6	66.7	70.0
	March to May	33.3	4.4	15.6	31.1	21.1
Months of leaf Emergence	March to May	91.1	86.7	97.8	82.2	89.4
	June to Aug	8.9	13.3	2.2	17.8	10.6
Months of seed setting	Dec. to Feb.	75.6	84.4	82.2	66.6	77.2
	March to May	24.4	15.6	17.8	33.4	22.8

Feeding practices of *P.thonningii*

Respondents from the study districts indicated that *P.thonningii* is utilized by browsing directly from the field by lopping and cut and carry system of the fresh plant. However, the majority (70.6%) of the respondents replied that *P.thonningii* is given to livestock by lopping. They also used cut and carry system for both leaves and pods for sick and weak animals, which are kept around the homesteads. Farmers shake the pods from the tree to feed the animals. Moreover, mature pods of the trees naturally fallen under trees are normally consumed by animals.Nearly all (98.99) respondents in study zones did not do processing like wilting and chopping of the *P.thonningii* leaves. However, 29.4% of the respondents reported that they reduce the particle size of the pods to fed their animals.

The majority (97.8%) of the respondents indicated that *P.thonningii* is fed to animals without mixing with other feedstuffs. On the other hand, 2.2% of the respondents in Metekel zone indicated that *P.thonningii* pod is offered to animals mixed with *atella* (traditional brewery residue) especially for oxen and cows. Moreover, the respondents indicated that during the dry season when feed shortage is aggravated they feed *P.thonningii* pod flour in the form of juice for weak animals.

Table 6. Feeding practice of *P. thonningii* in the study districts of north western Ethiopia (percent of respondents)

Feeding practice	Zones n=90		Total n=180
	Awi	Metekel	
Browsing	34.4	24.4	29.4
Cut and offer fresh	63.4	75.6	69.5
Cut and offer wilted	2.2	-	1.1
Ways of feeding			
Sole	100	95.6	97.8
Mixed with *atella*	-	4.4	2.2

n = number of respondents

Farmer's perception on effect of feeding *P. thonningii* on animal performance

About 40% of the respondents indicated that feeding *P.thonningii* has no change on animal performance, except to have only rumen fill effect. On the other hand, 48.4% of the respondents showed that feeding *P.thonningii* improves growth rate and body weight change of animals. Only 8.3% of respondents reported that feeding *P.thonningii* has positive effect on the health status of animals. Moreover, respondents in both study zones reported that health and/or production problems associated with the feeding of *P.thonningii* appeared to be non-existent. Majority (91.1%, 87.2% and 94.4%) of the respondents indicated that there were no abortion, other health problems and deaths of animals due to *P.thonningii* feeding, respectively. On the other hand, some of the respondents (8.9%, 12.8% and 5.6%) in both study zones indicated that they were unaware of the occurrence of abortion, health problems and death with the feeding of *P.thonningii*, respectively.

Other uses of *P. thonningii*

Besides its use as animal feed, respondents replied that *P.thonningii* provides additional services. They reported that it is used as fuel, food, construction, fiber, bee forage, farm utility, soil fertility, fence and shade for animals (Table 8). Majority of the respondents (96.7%, 89.4%, 73.3%, 72.8% and 68.9%) reported that it is used as fuel, shade, construction, fiber and farm utility, respectively. Moreover, 55.6% of respondents indicated that the flowers of *P.thonningii* serve as good sources of nectar for honeybees.

Table 7. Observations on animal responses of feeding *P. thonningii* forage to livestock in northwestern Ethiopia (per cent of respondents)

Parameters	Zones (n=90)		Total (n=180)
	Awi	Metekel	
Improves growth and body weight gain	50	46.7	48.4
Improves health	4.4	12.2	8.3
Improves milk yield	-	3.3	1.7
Only maintenance	41.1	37.8	39.5
Do not visualize the change	4.4	-	2.2

BWG=Body weight Gain, n = number of respondents

Table 8. Current uses of *P.thonningii* in the study zones in northwestern Ethiopia

Uses	Awi		Metekel		Total n=180
	Guangua n=45	Zigem n=45	Dangure n=45	Mandura n=45	
Fuel	95.6	100	95.6	95.6	96.7
Shade	68.9	91.1	97.8	100	89.4
Fiber	68.9	88.9	75.6	57.8	72.8
Food (pod)	33.3	46.7	11.1	15.6	26.7
Construction (house)	62.2	51.1	84.4	95.6	73.3
Fence	62.2	31.1	64.4	62.2	55
Farm utility	68.9	77.8	64.4	64.4	68.9
Soil fertility	60	51.1	26.7	31.1	42.2
Bee foraging	80	68.9	37.8	35.6	55.6

n= number of respondents

Chemical composition and *in vitro* dry matter digestibility of *P. thonningii*

Significant interaction effect of plant parts and stage of phenology (P<0.05) was observed for DM, ash, CP, NDF, ADF, ADL contents and IVDMD of *P.thonningii* (Table 9). The ash content was higher (P<0.05) for S3 than S1 as well as for leaf than twig fractions. The CP content of *P.thonningii* was higher (P<0.05) for S1 than S3, while values for S2 was similar with S1 and S3.The CP content of the leaf was higher than that of the twig fraction. The NDF and ADF content was higher (P<0.05) for S3 than the other two stages of phenology. The ADL content was similar (P>0.05) among stage of phenology and plant fractions. The IVDMD of *P.thonningii* leaf and twig decreased as the stage phenology advances from leaf emergence to leaf shedding and was higher (P<0.05) for S1 than S2 and S3.

DISCUSSION

Planting and propagation of *P. thonningii*

In the present study, all respondent farmers are aware of the possibility of growing and utilizing *P.thonningii* for various purposes in both study zones. Moreover, farmers perceived *P.thonningii* positively, for its feeding value and its contribution to livestock production. However, the practice of farmers in planting of *P.thonningii* tree in study zones was very limited. Similarly, Takele (2014) reported that farmers in Wolayita zone had poor practice in planting indigenous multipurpose browse species. The low practice of planting *P.thonningii* by most farmers could be due to different reasons in shortage of land and lack of awareness. As the respondents in Awi zone indicate it, farmers do not grow *P.thonningii* in their farmland for feeding their animals and for other purposes due to intensive utilization of land for cropping. Abebe (2008) also reported that decisions to cultivate forage crops might require suitable biophysical and socio-economic environments in addition to adequate knowledge and favorable attitudes. In the current study, the majority of farmers in Metekel zone had *P.thonningii* tree in their farmland due to its availability as compared to Awi zone. Moreover, the majority of farmers in Metekel zone did not cultivate *P.thonningii* as compared to Awi zone, which might be due to the better availability of adequate grazing land and other feed resources in most parts of the year in Metekel zone as compared to Awi zone. Generally, the survey confirmed that farmers highly utilize the naturally grown *P.thonningii* tree from their farms and communal grazing lands for various purposes including as feed for livestock.

The use of *P. thonningii* as animal feed

The most widely favored plant parts consumed by different class of animals were leaves and pods which is consistent with Azene (2007) who reported the wider use of *P.thonningii* leaves and pods as feed for livestock in the different parts of Ethiopia. Kassahun *et al.*(2016) also reported that twigs and leaves of *P.thonningii* tree

were harvested and fed to ruminants in Chiliga district, north Gonder. Furthermore, Belete *et al.* (2012) and Abule (2003) reported that pastoralists and farmers collect pods of different tree species for feeding animals during the dry season the mid Rift Valley of Ethiopia. During the dry season, the leaves and pods are available for animal feed. The respondents indicated that cattle, sheep and goats consume the leaves, and pods of *P.thonningii*, but priority is given to cattle followed by small ruminants. The higher priority given to cattle in feeding of *P.thonningii* is because cattle prefer the leaves and pods of *P.thonningii* tree compared with small ruminants. *P.thonningii* leaves and pods are mainly supplemented to animals from March to May and December to February to improve the performance of animals, respectively, since these months are times of critical feed shortage seasons in the study areas.

Table 9. Chemical composition of *P. thonningii* plant parts at different stage of phenology

Factor		Chemical composition (g/kg for DM and g/kg DM for others)						
Plant parts*Stage		DM	Ash	CP	NDF	ADF	ADL	IVDMD
Leaf	S1	916^{a}	93.9^{b}	200^{a}	451^{ab}	248^{c}	90^{b}	563^{a}
	S2	911^{ab}	97.7^{b}	183^{b}	440^{b}	257^{bc}	112^{ab}	526^{b}
	S3	903^{b}	99.6^{b}	168^{b}	456^{a}	266^{b}	142^{a}	430^{c}
Twig	S1	890^{c}	50.2^{c}	186^{b}	413^{c}	226^{d}	93^{ab}	545^{ab}
	S2	908^{ab}	56.7^{c}	142^{c}	422^{c}	235^{d}	94^{ab}	517.8^{b}
	S3	917^{a}	108.7^{a}	105^{d}	452^{ab}	284^{a}	102^{a}	463^{c}
SEM		0.23	0.55	0.81	0.41	0.47	0.23	0.99
P-value		0.0001	0.0001	0.0001	0.0001	0.0001	0.035	0.0001
Stage of phenology								
	S1	910	72^{b}	195^{a}	432^{b}	237^{b}	92	554^{a}
	S2	909	77^{ab}	163^{ab}	431^{b}	246^{b}	102	522^{b}
	S3	903	104^{a}	137^{b}	454^{a}	275^{a}	121	459^{c}
	SEM	0.23	0.55	0.81	0.41	0.47	0.23	0.99
	P-value	0.43	0.03	0.004	0.02	0.0002	0.09	0.0001
Plant part								
	Leaf	910	9.7^{a}	186^{a}	449^{a}	257	115	514
	Twig	905	7.1^{b}	144^{b}	429^{b}	248	96	509
	SEM	0.23	0.55	0.81	0.41	0.47	0.23	0.99
	P-value	0.32	0.02	0.006	0.008	0.36	0.09	0.82

^{a,b,c}=Means within a column and within Plant parts*Stage of maturity or Plant parts or Stage of maturity category without a common superscript differ (P<0.05); SEM = standard error of the mean; P-value = probability value; DM= dry matter; CP = Crude protein; NDF = Neutral detergent fiber; ADF = Acid detergent fiber; ADL = Acid detergent lignin; IVDMD= *in vitro* dry matter digestibility; S1= Phenological Stage one (May), the stage right after leaf emergence; S2 = Phenological Stage two (August), the stage between leaf emergence and leaf shedding; S3 = Phenological Stage three (November), the stage at the beginning of leaf shedding

Phenological patterns of *P. thonningii*

The phenoligical characteristics of *P.thonningii* make the tree important to supplement animals during the dry season in the study area, since it emerges its leaves during months of feed shortage from March to May. Moreover, respondents reported that the pods are also available during feed shortage months from December to March. According to the respondents, *P.thonningii* serves as a source of feed starting from December to May. The timing of flushing and shedding of the leaves of many multipurpose trees as well as the onset of the flowering and the fruiting are attributed to climatic and environmental conditions such as rainfall, atmospheric conditions, subsoil water availability or supply, soil moisture and biotic factors, such as root system (Jolly and Running, 2004; Badeck *et al.,* 2004). During leaf shedding months, matured pods fall on the ground from the tree where animals can get access to consume the pods. This finding is in line with the findings of previous studies by Belete *et al.* (2012) and Abule (2003) who showed that farmers for feeding animals use pods of some browses during the peak dry season.

Feeding practices and effect of feeding *P.thonningii* on animal performance

Browsing and lopping (cut and feed fresh) were the major feeding practices used by the farmers in the study area. In addition to browsing, farmers feed animals by lopping when the tree is not accessible by the ruminants since the plant reaches 3-15 meters high (Ruffo *et al.,* 2002) that cannot be reached by animals to browse. Regarding the form of utilization of *P. thonningii* leaves, farmers reported that they do not use any treatment methods for improving its feed value, which is associated with lack of knowledge. However, the pods are physically treated by reducing the particle size to increase intake. Moreover, for sick and weak animals, the flour of the pod is supplemented in the form of juice during the dry season. In the current study, farmers had a positive perception of the effect of feeding *P.thonningii* on animal performance. The good

level of understanding by the respondents about the feeding value of *P.thonningii* in both study zones might be due their long experience in using this tree for feeding animals. Olafadehan *et al.* (2018) reported that *P.thonningii* foliage could replace 50% of supplemental concentrate without impairing feed intake, growth performance and health of buck-kids. In this study, farmers indicated that they did not experience of death, abortion or any other health associated problems in feeding of *P.thonningii,* which might be due to low contents of anti-nutritional factors. According to Kumar(1983), anti-nutritional factors diminish animal productivity but may also cause toxicity when the feed rich in these substances is consumed by animals in large quantities.

Other uses of *P. thonningii*

P.thonningii provides different services apart from being a good source of fodder for livestock. Farmers in the study districts are traditionally aware of the different uses of *P.thonningii* other than its use as livestock feed which includes fuel wood, shade, fiber, food, construction, live fence, farm utility, traditional medicine and soil fertility. Similarly, different studies reported that *P.thonningii* tree has different uses apart from animal feed. For instance, Ruffo *et al.* (2002) reported that fiber from the inner bark is used to make strings, ropes and clothes. Moreover, the same author reported that tender leaves of *P.thonningii* are chewed where the juice is swallowed to treat stomachache, coughs and snakebite. The respondents in the current study have also highlighted the importance of the plant in providing shade for animals and in improving soil fertility. Because *P.thonningii* is a leguminous, tree and fixes atmospheric nitrogen, which gives an opportunity to maintain and improve soil fertility (Azene, 2007). This makes the tree to be a useful species in restoring woodland or setting up a woodland garden. Moreover, *P.thonningii* tree is used as a source of food during critical feed shortage periods as compared to other multipurpose fodder trees. Similarly, Thompson (2010) reported that pods and seeds have been used as source of food during famine periods and a powder can be made from the dry pods for making nutritious porridge in South Africa. Kassahun *et al.*(2016) also reported *P. thonningii* is used as traditional medicine, construction, fuel wood, bee forage and farm utility.

Chemical composition and *in vitro* dry matter digestibility of *P.thonningii*

As a deciduous plant, *P.thonningii* under goes physiological changes throughout the year that can prominently be distinguished by the emergence and shedding of leaf parts. Therefore, with advancing growth of leaves from leaf emergence to shedding the mature leaves and twigs is increasing across seasons and months. The high CP content of *P.thonningii* leaves and twigs during S1 may be due to the development of new leaves where nitrogen moves outward from the stems to leaves and as a result, the leaves contain high crude protein content (Kramer and Kozlowski, 1960). Latter stage of maturity are periods of higher DM accumulation on the leaves and twigs that cause the plant to have higher structural components which lowers the CP content and increase the fiber fraction (Blair *et al.,* 1981). The CP contents of deciduous woody species decrease with advancing stage of maturity of leaves from leaf emergence to leaf dropping (Papachristou and Papanastasis, 1994). Variations in CP content across stage of maturity observed in this study appeared to be consistent with the reports of Getnet (2007) who noted similar trends in CP content of leaves, growing bud, branches and bark of *Chamaecytisus palmensis* with advancing physiological age. Moreover, Mulubrhan and Kidane (2015) reported that CP content of the different edible parts of *Ficus thonningii* was higher in younger stage than the old ones.

The CP contents of both the leaf and twig fractions of *P.thonningii* were well above the minimum CP level of 80 g/kg DM for ruminant diets for maintenance (Minson, 1990).This indicates that P.*thonningii* could be used as supplements to the low quality crop residues . The CP concentration above the threshold CP content (11-12%) is required for moderate level of ruminant production (ARC, 1980) and a minimum of 15% CP is required for lactation and growth (Norton, 1982). Moreover, the level of CP in *P.thonningii* leaf and twig parts observed in this study is indicative of its potential as feed for ruminants. Although the lignin content was not affected by stage of maturity, the NDF and ADF fractions increased with advancing growth from leaf emergence to leaf shedding. Cell wall development is related to plant development and as the plant leaf matures NDF and ADF increases and protoplasm compounds like crude protein decreases (Haddi *et al.,* 2003). The decrease in IVDMD values with advancing stage of growth from leaf emergence to leaf shedding in this study is consistent with the decline in CP and increase in the structural carbohydrate contents with maturity. Such lower digestibility values of both the leaves and twig at S3 may indicate its importance at early stage of leave emergence.

CONCLUSION

Results of this study highlighted the importance of the leaves and pods of *P.thonningii* as livestock feed that can be used to balance nutrient and deficit during times of feed shortage. The current level of utilization and understanding of the feeding value of the plant is high by the local farmers. The relatively good CP content and *in vitro* DM degradability values of *P. thonningii* throughout the different seasons in this study is indicative of its potential as CP supplement for ruminants. Moreover, the tree, being high coppicing ability and high biomass production potential can contribute to livestock production through provision of

more nutrients and feed supply.But, farmers' practice to plant and manage the tree is very low. Thus, awareness creation about the potential of the plant as source of feed and other multiple uses to encourage its cultivation and inclusion in the agro-forestry systems would be necessary.

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