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RESEARCH PAPER

Evaluating orchard and poplar leaves during autumn as an alternative fodder source for livestock feeding

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Abstract

S. Temel, and M. Pehluvan. 2015. Evaluating orchard and poplar leaves during autumn as an alternative fodder source for livestock feeding. Cien. Inv. Agr. 42(1): 27-33. Fruit tree and poplar leaves that fall in autumn are undervalued in terms of animal feeding mainly because of insufficient knowledge about their potential feeding value. Knowledge of the nutritional values of these species may be important to supplement the feed of grazing animals. The objective of this study was to evaluate the potential fodder value of leaves of plum, apple, poplar, mulberry, peach and apricot trees. For this purpose, samples were collected by hand in autumn 2012 and 2013 when 50% of the leaves had dropped and 90% of the leaves had turned yellow. The crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF), acid detergent lignin (ADL), dry matter digestibility (DMD), digestible energy (DE), metabolizable energy (ME) and relative feed value (RFV) contents were determined. The CP, DMD, DE, ME and RFV contents of peach leaves were significantly ($P \leq 0.01$) higher than those of the other trees, but they had lower NDF, ADF and ADL ratios. The lowest CP, DMD, DE, ME, RFV contents and the highest NDF, ADF, ADL values were measured in poplar leaves. According to these results, the tree leaves had a higher nutritional value than many forage grass species and hay fodder commonly used for livestock feeding. Consequently, orchard and poplar leaves that drop in autumn can be used as an alternative fodder source for livestock feeding.

Key words: Ruminant feeding, fodder trees, nutritional value, supplementary fodder source.

Introductıon

Meadow range areas and cultivated forage crops are the most important sources of roughage for livestock (Temel and Sahin, 2011). However, the lack of cultivated forage crops in agricultural fields in combination with the early and excessive grazing of meadow ranges over long time periods has resulted in a decrease in the quantity and quality of hay. Furthermore, when herbaceous plants are dormant from autumn to spring, they cannot produce sufficient hay. The hay harvested from pasture during spring and summer is also used to feed animals during winter. As a result, livestock constantly face inadequate nutrition. Therefore, the productivity of ruminant livestock is restricted by poor nutrition because of the lack of quality roughage in the autumn and summer period in Igdir and most regions of Turkey (Temel and Sahin, 2011; Oktay and Temel, 2015).

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Consequently, many scientists have explored novel feed materials as an alternative to conventional feed sources in recent years. In particular, shrubs and trees growing naturally in arid and semi-arid ecosystems have been noted as sources of important nutrients for livestock feeding and many studies have been conducted to determine their nutritive value (Ghazanfar *et al.,* 2011; Parlak *et al.,* 2011; Temel and Tan, 2011; Gulumser and Acar, 2012; Kokten *et al.,* 2012; Oktay and Temel, 2015). Previous studies showed that the leaves of fruit and poplar trees had high nutritional value and could be used for animal feeding (Nahand *et al*., 2011). The results from these studies indicated that the nutrient contents of leaves from shrubs and trees differ with season, phenological phase, and species. However, shrub and tree species are feed materials with high nutritional, energy, vitamin and mineral contents for ruminants owing to the fact that loss of quality is slower compared with herbaceous species (Ghazanfar *et al.,* 2011; Kokten *et al.,* 2012; Tan and Temel, 2012). Despite the abovementioned benefits, the numbers of studies demonstrating the utilization of fruit and poplar tree leaves for animal feeding are limited. No studies have focused on the feeding value of leaves in autumn.

Climate and soil conditions are important abiotic factors that restrict the productivity of field areas and plant diversity worldwide (Kazemi and Eskandari, 2011). Extreme climate and soil conditions are dominant in Igdir province, which is located in the Eastern Anatolia Region of Turkey. In these areas, the roughage demand for animals cannot be met because the desired yields cannot be obtained (Temel and Sahin, 2011; Temel and Simsek, 2011). The most important sources of livelihood in this region are vegetable production and livestock, and horticulture (for example, apricot, peach, apple, plum, etc.) plays an important role. It is well known that the horticultural species in this region and most regions of the world are generally grown for fruit. The leaves that fall after harvest, especially in autumn, are not used for any purpose and only enrich the soil through organic matter input.

Therefore, knowing the nutritional values of the leaves from various fruit trees may be important to sustain the feed for the grazing animals during inadequate feed production periods. Consequently, knowing the nutritional values of these horticultural species may be important to supplement the feed of grazing animals. Thus, the autumn leaves of fruit and poplar trees commonly grown in this region could be potentially important as an alternative forage source for ruminants. To this end, the study objective was to evaluate the nutritional content and potential fodder value of plum, apple, poplar, mulberry, peach and apricot tree leaves.

Materials and methods

The study was conducted under the microclimate and ecological conditions in Igdir, which is located at an altitude of 870-900 m in the eastern part of Turkey. Fruit crops are grown in the Igdir plain, which has flat areas and fertile soils. The average precipitation, relative humidity and mean temperature were 232.1 mm, 52.5 mm and 13.8 °C, respectively, during the study years (MGM, 2014). The soil pH, salinity, and lime and organic matter contents of the study area (*i.e*., the orchard soil) were 7.81, 2.85 mS/m, 6.94% and 1.45%, respectively.

The nutritional quality of the leaves of plum, apple, poplar, mulberry, peach and apricot species commonly grown in Igdir province was determined. The experiment had a completely randomized design with nine replications. There were twenty-seven trees per species, and three trees from each replicate were sampled. Approximately 200 g of leaves (mixed samples) were collected by hand during autumn when 50% of the leaves had fallen and 90% had turned yellow. Collected samples were dried at 70 °C for 48 h and then ground in a mill to pass through a 1-mm screen prior to analyses. All analyses were carried out on duplicate samples. The nitrogen content of the fruit and poplar tree

leaves was measured using the Kjeldahl method (AOAC, 1997) and the crude protein (CP) content was calculated by multiplying N by 6.25. Neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) were measured using the procedure described by Van Soest *et al.* (1991). As suggested by Weis (1994), accurate data on the digestibility of forage would greatly assist diet formulation and the economic valuation of different collection periods. Although the value of accurate digestibility data is unequivocal, collecting actual data is a time consuming and expensive process that requires large amounts of forage samples and was therefore not feasible in this study. The dry matter digestibility (DMD) was estimated using the formula developed by Oddy *et al.* (1983): DMD% = 83.58 - 0.824 x ADF% + 2.626 x N%. Dry matter digestibility values were used to estimate digestible energy using the regression equation reported by Fonnesbeck *et al.* (1984): Digestible energy (DE) (Mcal kg^{-1}) = 0.27 + 0.0428 x DMD%. Then, DE values were converted to metabolizable energy (ME) using the formula reported by Khalil *et al.* (1986): ME (Mcal kg^{-1}) = 0.821 x DE (Mcal kg^{-1}). Relative feed value (RFV) is a measure of quality that is widely used in forage crops. The RFV was calculated using the following equations developed by Sheaffer *et al*. (1995) who used the NDF and ADF analysis results: DMD% = 88.9 – (0.779 x ADF%); Dry matter consumption (DMC) = 120/ NDF%; Relative Feed Value (RFV) = (DMD x DMC)/1.29.

Statistical analyses were carried out using JMP 5.1 software (JMP, A Business Unit of SAS, Cary, NC, 2003). One-way analysis of variance (ANOVA) was used to determine the effect of species on the chemical composition and certain estimated parameters such as the ME, DE and DMD of fruit trees and poplar leaves. There were no significant differences between years. Therefore, the data from the two years were pooled. Significant differences between individual means were identified using the LSD test. Mean differences were considered significant at $P \leq 0.01$.

Results and discussion

Previous studies reported that the leaves of naturally grown shrub and tree species (mulberry and poplar) that were harvested in the early developmental stages of trees had high forage value, and the nutritive values varied with genotype, species, cultivar, ecological conditions and maturation stage (Khalil *et al.,* 1986; Ghazanfar *et al.,* 2011; Parlak *et al.,* 2011; Temel and Tan, 2011; Oktay and Temel, 2015). The main purpose of the present study was to determine whether species planted for fruit or wood production could be a potential source of forage for animal nutrition during the autumn when herbaceous species are not present.

There were highly significant ($P \leq 0.01$) species differences in the plant leaf parameters (Table 1; Table 2). The highest CP content, DMD, DE, ME and RFV were found in the leaves of peach trees followed by apricot and plum; these species belong to the stone fruit group. Poplar leaves had the highest levels of ADF and ADL, and plum leaves contained the highest levels of NDF. In contrast, the lowest DMD, DE, ME and RFV were found in the leaves of poplar trees (Table 2). Apple and poplar leaves had the lowest CP content, and peach leaves had the lowest NDF, ADF and ADL values (Table 1).

Peach, apricot and plum leaves had a high nutritional quality based on digestibility and the CP content. In general, there is a lack of studies on the forage nutritive values of autumn leaves. The nutritional contents of mulberry (Vu *et al.,* 2011; Guven, 2012) and poplar (Tsarev, 2012) leaves harvested in the early stages have been reported. For example, fresh mulberry leaves intercropped with legumes had low NDF (19.38-33.33%) and ADF (15.40-22.3%) contents and a high CP content (11.75-23.72%) and digestibility rate (Vu *et al.,* 2011; Guven, 2012). This implies that mulberry leaves have a higher nutritional quality as feed for ruminants compared with tropical grasses. Tsarev (2012) stated that the CP contents of the leaves of six black poplar hybrids that were harvested in

Table 1. Nutritional quality of fruit tree and poplar leaves in the fall. CP: crude protein, NDF: neutral detergent fiber, ADF: acid detergent fiber, ADL: acid detergent lignin.

Tree species	CP (g kg^{-1})	NDF (g kg^{-1})	ADF (g kg^{-1})	ADL (g kg^{-1})
Plum	77.02±3.44 c	362.12±4.59 a	224.46±3.91 d	92.84±1.09 b
Apple	65.60±1.28 c	353.56±4.73 a	276.69±2.02 c	83.41±3.24 b
Poplar	65.96±2.61 c	348.73±6.69 a	335.9±3.88 a	111.24±3.77 a
Mulberry	91.47±1.51 b	270.09±6.31 b	310.12±12.65 b	103.95±6.09 a
Peach	117.57±8.43 a	269.36±5.01 b	187.34±8.49 e	50.77±2.94 c
Apricot	73.8±2.63 c	269.91±6.41 b	213.78±5.18 d	51.6±3.21 c
Mean	81.90±4.09	312.24±5.69	258.08±6.18	82.3±3.70
F- value	23.55**	67.73**	90.03**	49.11**
CV (%)	14.99	5.45	7.19	13.49

Note: Different superscript letters within a column represent significant differences between species (LSD test, P≤0.01).

Table 2. Nutritional quality of fruit tree and poplar leaves in the fall. DMD: dry matter digestibility, DE: digestible energy, ME: metabolizable energy, RFV: relative feed value.

Tree species	DMD (%)	DE (Mcal kg^{-1})	ME (Mcal kg^{-1})	RFV
Plum	71.42±0.30 b	3.33±0.01 b	2.73±0.01 b	183.74±2.91 c
Apple	67.35±0.16 c	3.15±0.01 c	2.59±0.01 c	177.48±2.70 cd
Poplar	62.73±0.30 e	2.96±0.01 e	2.43±0.01 e	167.94±3.94 d
Mulberry	64.74±1.00 d	3.04±0.04 d	2.50±0.03 d	224.28±7.51 b
Peach	74.31±0.22 a	3.45±0.02 a	2.83±0.01 a	257.41±5.39 a
Apricot	72.25±0.40 b	3.36±0.02 b	2.76±0.01 b	250.64±7.27 a
Mean	68.80±0.48	3.21±0.02	2.64±0.02	210.25±5.31
F- value	90.03**	90.03**	90.03**	54.06**
CV (%)	2.1	1.93	1.89	7.58

Different superscript letters within a column represent significant differences between species (LSD test, P≤0.01).

the early stages ranged from 8.98 to 15.2%, and freshly harvested leaves can be used as fodder for animal feed.

The CP content decreases, and the fiber and ash contents and the the amount of fiber relative to other cell wall components increase with the developmental stage of the plant (Atasoglu *et al.,* 2010). Generally, fibrous compounds are found in the cell wall and cell wall components; these compounds are more abundant in older than in younger cells. Cell wall development is related to plant development; as plants mature, cell wall components such as NDF, ADF and ADL increase and protoplasm components such as crude protein decrease (Parissi *et al.,* 2005). Many studies conducted on shrub and tree species indicate a high protein content at the beginning of spring growth; however, dry matter and cell wall components increase and a rapid loss of nutrients is observed with maturation (Atasoglu *et al.,* 2010; Parlak *et al.,* 2011; Oktay and Temel, 2015).

The efficiency of animal performance depends on the quality of the forage they consume. In ruminant nutrition, easily digestible components such as cellulose and hemicellulose are important energy sources that are similar to fragmented fibers; however, the presence of phenolic polymers such as lignin in feed reduces digestibility (Hussain

and Durrani, 2009). For example, an NDF content above 50% negatively affects digestibility and is thought to reduce the energy uptake of sheep and goats grazing on range. However, in our present study, the mean NDF content was 312.24 g kg^{-1} (31.22%) for leaves of fruit trees dropping in autumn, and this value will not reduce the energy uptake of small grazing ruminants.

The available energy and digestible nutrients of forage are important criteria that determine feed value. In the present study, the mean CP, DE and ME contents of tree leaves in the fall were determined as 81.90 g kg^{-1}, 3.21 Mcal kg^{-1} and 2.64 Mcal kg^{-1}, respectively. An animal weighing approximately 50 kg should have a Daily minimum of 75 g CP, 1.91 Mcal ME and 2.34 Mcal DE to ensure survival (NRC, 2007). Considering the feeding value, we can conclude that fruit tree and poplar leaves have the potential to meet the demands for daily CP when grazed together. The present results show that the tree and poplar leaves falling in autumn were also sufficient for the DE and ME for live weight gain (50 g) for ovine not requiring supplementary energy feed. Based on the analyses, we found that apple or poplar leaves consumed alone were insufficient to meet the CP demands, whereas all other species could meet the daily CP, DE, and ME needs for the survival of small animals.

The NRC (2007) reported that for 50, 100 and 150 g of live weight gain, an animal weighing approximately 50 kg should receive a daily intake of CP (89, 103, 117 g kg^{-1}, respectively), ME (2.22, 2.63, 2.99 Mcal kg^{-1}, respectively) and digestible energy (2.78, 3.22, 3.66 Mcal kg^{-1}, respectively). Therefore, mulberry leaves can provide only 50 g daily while peach leaves can provide 150 g of live weight gain in terms of crude protein. Plum, peach and apricot tree leaves are able to provide a daily live weight gain of 100 g in terms of ME and DE, whereas apple, poplar and mulberry species are only able to provide a daily live weight gain of 50 g.

The nutritive quality of leaves in the fall differed significantly among the tree species. According to our results, this feed resource has a higher nutritive quality than herbaceous plants during the dormant period when herbage is low in availability and quality and could thus serve as a potential alternative forage source for livestock feeding during autumn. The leaves of the species studied here are able to meet the nutrient needs for daily live weight gain, ranging from 50 g of live weight gain for apple, poplar and mulberry, to 100 g of lwg for plum, peach and apricot tree leaves.

Resumen

S. Temel y M. Pehluvan. 2015. Evaluación de las hojas de huertos frutales y de álamo, en otoño, como fuente de forraje alternativo para la alimentación del ganado. Cien. Inv. Agr. 42(1): 27-33. Los árboles y las hojas de álamo en otoño están subvaloradas en términos de alimentación de animales principalmente por falta de conocimiento suficiente sobre su valor potencial de alimentación. Por lo tanto, conocer los valores nutricionales de estas especies puede ser importante para llenar el vacío de alimentación de los animales de pastoreo. El objetivo del estudio fue evaluar el valor potencial de forraje de las hojas de ciruela, manzana, álamo, moreras, melocotoneros y albaricoqueros. Para este fin, las muestras se recogieron manualmente en el periodo en que las hojas de los árboles frutales era de un 50 a 90% de color amarillo, en otoño, durante 2012 y 2013. Se determinaron los contenidos de Proteína Cruda (PC), Fibra Detergente Neutro (FDN), Fibra Detergente Ácido (FDA), Lignina Detergente Ácıdo (LDA), Digestibilidad de Materia Seca (DMS), Energía Digestible (ED), Energía Metabolizable (EM) y Valor Relativo del Forraje (VRF). Los contenidos de hojas PC, DMS, ED, EM y VRF del melocotón fueron significativamente más altos ($P \leq 0.01$) que los de otras frutas, pero tuvieron menores proporciones FDN, FDA y LDA. Los valores PC, DMS, ED, EM, VRF menores y

los valores FDN, FDA, LDA mayores fueron confirmados en las hojas de álamo. Según estos resultados, se determinó que las hojas de los árboles tienen mayores valores nutricionales que muchas especies de gramíneas y heno usado comúnmente para la alimentación del ganado. Se concluye que las hojas de los árboles frutales que caen en otoño se pueden utilizar como fuente de forraje alternativo para la alimentación del ganado.

Palabras clave: Alimentación de rumiantes, árboles de forraje, calidad del forraje, fuente de forraje suplementario.

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