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Research Article

Evaluation of in Vitro Rumen Degradability of Fermented, Dried, and Pelleted Tomato Greenhouse Pruning Residues in Buffaloes and Cows

Fermente, Kurutulmuş ve Peletlenmiş Domates Serası Budama Artıklarının Manda ve İneklerde in Vitro Rumen Yıkımlanabilirliğinin Değerlendirilmesi

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Abstract

In this study, the in vitro rumen degradability characteristics of tomato greenhouse pruning residues were evaluated in buffalo and cattle. The feasibility of using tomato pruning waste, which arises from increased greenhouse production, as an alternative roughage source in animal feed has been investigated. Thus, the aim is to prevent both economic losses and contribute to environmental sustainability. In the study, tomato greenhouse pruning waste was subjected to chemical analysis, and the dry matter (DM; 91.68%), crude protein (CP; 15.60%), crude ash (CA; 17.80%), crude fat (CF; 3.77%), and neutral detergent fibre (NDF; 48.22%) contents were determined. Additionally, the ruminal digestibility characteristics of the material were determined using the Ankom Daisy^{II} in vitro incubation system. In in vitro digestibility tests using rumen fluids from buffalo and cattle, digestibility parameters were compared. The results obtained showed that tomato greenhouse pruning residues have a high dry matter content and suitable fibre content, while the levels of crude protein and crude fat are evaluable. According to the in vitro digestibility results, buffalo were found to digest crude protein and crude fat more efficiently than cows, respectively, which was statistically significant (31.58%; 25.25%; $p<0.01$, 23.41%; 14.33%; $p<0.05$). In conclusion, tomato greenhouse pruning waste has the potential to be used as an alternative roughage source in ruminant feeding. Especially in buffalo, incorporating these wastes into feed programs can reduce feed costs and contribute to the utilisation of agricultural waste.

Keywords: Alternative roughage, Buffalo, Cow, In vitro digestibility, Tomato greenhouse pruning waste

Öz

Sunulan çalışmada, inek ve mandalarda domates serası budama artıklarının in vitro rumen yıkımlanabilirlik özellikleri incelenmiştir. Sera üretiminin artmasından kaynaklı oluşan büyük miktarlardaki domates budama atıklarının hayvan beslemede alternatif kaba yem olarak kullanılması değerlendirilmiştir. Bu sayede hem çevresel sürdürülebilirlik hem de ekonomik kayıpların önlenmesi amaçlanmıştır. Domates serası budama atıklarının kimyasal analizleri sonucunda kuru madde (KM; %91,68), ham protein (HP; %15,60), ham kül (HK; %17,80), ham yağ (HY; %3,77) ve nötral deterjan fiber (NDF; %48,22) değerleri tespit edilmiştir. Materyalin ruminal sindirilebilirlik özellikleri manda ve inek rumen içerikleri kullanılarak Ankom DaisyII in vitro inkübasyon sisteminde belirlenmiş ve elde edilen parametrelerin karşılaştırılması yapılmıştır. Bu sonuçlara göre materyalin uygun lif içeriğine ve yüksek kuru madde içeriğine sahip olduğu, ham protein ve ham yağ oranlarının ise kabul edilebilir düzeyde olduğu tespit edilmiştir. İn vitro sindirilebilirlik testleri, mandaların ineklere kıyasla ham yağı ve ham proteini daha iyi sindirdiğini gösterdi (%31,58; %25,25; $p<0,01$, %23,41; %14,33; $p<0,05$). Sonuç olarak, domates serası budama atıklarının ruminant beslenmesinde kaba yem kaynağı olarak kullanılabileceği, bu atıkların yem programlarına dahil edilmesinin özellikle mandalarda, yem maliyetlerini azaltabileceği aynı zamanda tarımsal atıkların değerlendirilmesine de yardımcı olabileceği kanısına varılmıştır.

Anahtar Kelimeler: Alternatif kaba yem, Domates serası budama atıkları, İnek, *İn vitro* sindirilebilirlik, Manda

Introduction

The livestock sector, an important part of agricultural production, holds great significance for all countries regardless of their level of development. The animal products obtained play a critical role in the balanced and healthy nutrition of society, providing raw materials for different industrial sectors, and increasing export revenues (Semerci and Çelik, 2016). On the other hand, the increase in food demand due to population growth, environmental pollution, and accelerating climate change are among the problems in ruminant-based food production. The use of human-edible foods in animal feed leads to food-feed competition (Halmemies-Beauchet-Filleau et al., 2018). Nowadays, where efforts are being made to make livestock activities more efficient, appropriate feeding and nutritional strategies are of great importance. Roughage production is declining due to factors such as the conversion of agricultural land for different purposes, the occurrence of climatic problems like drought, and pollution in water basins, which have led to an increase in the demand for clean water (Yavuz et al., 2020). The decrease in roughage production and environmental problems, on the other hand, bring the use of alternative roughage sources to the forefront (Kara et al., 2018).

In this context, the use of alternative feed ingredients in farm animal rations not only offers options to many problems but also enables the recycling of production waste (Luciano et al., 2020). As a result of the intensive tomato greenhouse farming activity in our country, a large amount of plant waste that is not suitable for human consumption is generated. The province of Afyonkarahisar is located in the Aegean Region, which is rich in geothermal resources, making it important for greenhouse agriculture (Duman et al., 2020).

The leaves and stems produced as a result of pruning the tomato plant are considered byproducts of tomato production (Taveira et al., 2012). At the end of the harvest, tomato plants are considered worthless for industrial purposes and are discarded. The disposal of waste generated in greenhouse farming is a significant problem for producers. Although producers aim to eliminate this waste by burning it, this causes environmental pollution. As another solution, producers haphazardly discard these residues along the edges of greenhouses, but this leads to a dense accumulation of biomass in the greenhouse environment and causes the spread of diseases and pathogens within the greenhouse (Çerçioğlu, 2018).Nowadays, the aim of agricultural enterprises is to recover byproducts such as leaves and stems, evaluate them in different ways, and ensure their better utilisation (Silva-Beltrán et al., 2015).Although tomato leaves are classified as waste, they are rich in bioactive compounds such as alkaloids and flavonoids, which are called secondary metabolites (Taveira et al., 2012). Alkaloids, which are responsible for protecting plants from herbivores and pathogenic elements, are mostly localised in a specific organ of the plant (Alaca and Arslan, 2012).The use of industrial byproducts, which have not found widespread application in our country, in animal feed stands out as a good alternative. The fact that they have high nutritional value compared to straw and are cheaper than compound feeds suggests that using these products as an alternative feed ingredient would be advantageous for livestock. Additionally, using alternative feed ingredients in animal nutrition can significantly reduce the need for grains that are also available for human consumption, thus providing a solution to food-feed competition (Keleş, 2015). In another study, it was determined that leaf extracts have high antioxidant and antimicrobial activity and also contain high levels of chlorophyll and flavonoids, which play an important role in antioxidant

activity. (Silva-Beltrán et al., 2015). There are studies on the evaluation of some tomato waste in poultry and ruminant diets (Tahseen et al., 2014). In a study investigating the effects of tomato pomace on prepartum dairy cows, it was found that there were positive results in terms of increased dry matter intake, digestibility, and immunity (Tuoxunjiang et al., 2020).

Although there are structural similarities in the digestive systems of large ruminants like buffalo and cows, there are some functional differences. Both types have four stomach compartments and are capable of efficiently digesting fibrous feed. However, buffalo can offer some advantages over cows in terms of rumen volume and microbial population. The rumen capacity of buffalo is larger relative to body weight, allowing for longer ruminal fermentation. This situation is particularly advantageous in the digestion of low-quality feeds (Sırakaya, 2023). At the same time, a more balanced distribution of amylolytic and cellulolytic bacteria in the buffalo rumen increases fibre digestion efficiency (Karagöz, 2022).

In cows, the energy density of the rations is generally higher. In modern dairy cow breeds with high milk production, high-density concentrate feeds need to be included in the ration. However, this type of feed can cause sudden drops in rumen pH, leading to metabolic diseases such as subacute ruminal acidosis (Gümüş and Karakaş Oğuz, 2014; Budağ, 2009). Therefore, the proportion of roughage in dairy cows should be maintained to ensure the proper functioning of buffer systems. Buffalos, being naturally more durable, are fed with roughage-focused rations (Yavuz, 2005). While there are many studies on the nutritional content of tomato residues and the feeding of other animals, there are only a limited number of comparative studies on the in vitro digestibility of buffaloes raised in our country. We believe that this study will provide useful new information for livestock farming in our country, especially for buffalo feeding.

Materials and Methods

This research was approved by the Afyon Kocatepe University Animal Experiments Local Ethics Committee on 11/10/2023 under the number AKÜHADYEK-49533702/98.

Daisy Incubator

Laboratory-based alternative methods have been developed to determine the digestibility of feed materials because of to the high costs, ethical concerns associated with working with live animals, and the need for intensive labour at in vivo methods. Although commonly used in vitro methods (Tilley and Terry, 1963; Van Soest et al., 1966) allow for accurate predictions about feed digestibility, the post-digestion samples need to be filtered, which requires significant labour. Compared to traditional methods, the ANKOM Daisy Incubator method simplifies the measurement of in vitro digestibility by eliminating the need to filter post-digestion samples (Adesogan, 2005).

In the Daisy^{II} incubator device, which is based on simulating the rumen environment, the digestibility of feeds used in ruminant nutrition can be rapidly determined for a large number of samples simultaneously (Canbolat, 2019). The ability to incubate a large number of samples simultaneously solves the problem of using a separate tube for each sample in traditional methods (Adesogan, 2005).

Originally designed as a wooden cabinet in 1994, the Daisy^{II} Incubator device began production in 1997 as a durable metal cabinet, which is still used today in the same form (Tassone et al., 2020). The system operates with 4 rotary digestion vessels located in a thermostatically controlled chamber, allowing for the analysis of up to 96 samples simultaneously. Due to the temperature control unit in the

device, the internal temperature is kept constant at 39 ± 0.5 °C, and the incubation time is adjusted using the timer (Vogel et al., 1999). Samples were weighed into bags (Ankom Technology Corporation, Fairport, NY, USA) with a pore size of 25 μm, designated as F57, and placed in jars (up to 24 per jar) along with inoculum (rumen fluid, faeces, or enzymes) and a buffer solution (Holden, 1999). Glass jars are equipped with a perforated stirrer that divides the internal volume in half while allowing the digestion medium to move freely. F57 bags are weighed before and after incubation, and the difference is considered digestible dry matter (Tassone et al., 2020).

Animal Material

Within the scope of the study, 2 Swiss Brown Swiss cows (CA: 500±25 kg) and 2 hybrid buffalo (Murrah x Anatolian buffalo) (Bubalus bubalis) (CA: 625±25 kg) located at the Research and Application Farm of Afyon Kocatepe University Faculty of Veterinary Medicine were used. Rumen fluid was collected through a permanent rumen cannula in the animals used.

The health status of the animals was checked by the responsible veterinarian before rumen fluid was taken from them. The animals used in the study were fed ad libitum once a day (at 8:00 AM). Animals have always been provided with clean and fresh water. The composition of the ration used to feed the animals in the study is given in Table 1, and its chemical composition is given in Table 2.

Table 1. Ingredients of basal rations

Feedstuffs	**%, DM basis**
Alfalfa hay	19,54
Straw	40,76
Barley	7,85
Corn	8,75
Corn bran	1,59
Wheat Bran	5,57
Sunflower meal	6,36
Cottonseed meal	9,55
Premix	0,03

Table 2. Chemical compostion basal diet

Nutrients	
DM, % feed	89,17
CP, %	12,90
ME, Mcal/kg	2,01
NE_L, Mcal/kg	1,08
aNDFom, %	53,44
ADFom, %	37,23
ADL, %	6,76
NFC, %	23,30
Starch, %	13,86
Calcium, %	0,53
Phosphorus, %	0,38

Feed Material

In the study conducted, tomato greenhouse pruning waste in pellet feed form was used as feed material. Pruning residues were transformed into animal feed through a series of sequential processes including raw material sourcing, sorting, chopping, dewatering, fermentation, drying, pelleting, and packaging. This process is carried out by Kozanlar Geothermal Construction Agriculture Industry and the feed material used was obtained from the company. The nutritional values of fermented tomato pruning residues are given in Table 3.

Table 3. Chemical composition of fermented tomato leaf pruning waste

DM %	Ash %	EE %	CP %	NDF %	ADF %
91,68	17,80	3,77	15,60	48,22	35,31

Method

Sample preparation

The in-vitro incubation process was performed as previously described by İnanç and Arik (2025). The feed material to be used for analysis and digestion trials was dried in a 105°C oven until constant weight was reached, and then ground in a laboratory-type centrifugal mill using a 1 mm sieve. The bags used in the digestion experiment were pre-washed with acetone for 5 minutes. The purpose of this process is to remove factors from the environment that could inhibit microbial digestion. The numbered bags were left to dry in an oven at 105°C for 6 hours. The samples and bags taken from the oven were kept in a desiccator until the weighing process was completed.

The sample bags taken from the desiccator were weighed on an accurate scale and their empty weights were recorded (W1). Then, approximately 1 g of the ground feed material was placed in each bag, and the bag openings were heat-sealed (W2). A total of 192 sample bags were prepared separately for the buffalo and the cow.

Preparation of inoculum for in vitro digestibility

Before starting the rumen fluid collection process, two 2000 ml capacity thermos flasks were set to a temperature of 39°C, and the rumen fluid collected from the animals was filled into the thermos flasks. After the rumen fluids were collected, they were urgently brought to the Laboratory of Animal Nutrition and Nutritional Diseases, Department of Veterinary Faculty, Afyon Kocatepe University. The rumen fluids obtained were filtered through a four-layered fine-mesh gauze from a Benmarie-style apparatus set at 39°C to separate them from coarse particles. CO2 was applied during the filtration process to maintain the anaerobic environment required by rumen microorganisms. From the filtered rumen fluid, 400 ml per jar was taken for use in the ANKOM Daisy Incubator.

Preparation of buffer solutions

Two separate buffer solutions were prepared to maintain the pH of the rumen environment under in vitro digestion conditions and to prevent rumen microorganisms from being affected by fermentation products.

These solutions are referred to as Buffer A and Buffer B, and the contents of the buffer solutions are given in Table 4. The prepared solutions were placed in an oven to heat up to 39°C.

Table 4. Composition of buffer solutions

Buffer A	**g/lt**
KH_2PO_4	10
$MgSO_47H_2O$	0,5
NaCl	0,5
$CaCl_22H_2O$	0,1
Urea	0,5
Buffer B	g/lt
Na_2CO_3	15
$Na_2S.9H_2O$	1,0

Initiating the digestion trial

Before starting the digestion experiment, the Daisy Incubator device was operated to ensure that the internal temperature of the device reached 39°C. For each jar in the Daisy Incubator, 400 ml of rumen fluid, 266 ml of Buffer B, and 1330 ml of Buffer A solution (at a 1:5 ratio) were added. For each jar, 25 bags (24 samples and 1 blank bag) are placed on either side of the compartment inside the jar, with 12/13 bags on each side. CO2 was applied to maintain anaerobic conditions while adding rumen fluid, buffer solutions, and sample bags to the jars. The jars were placed in a Daisy Incubator and incubated at 39°C for 48 hours. During the incubation period, the heat buttons necessary to simulate the rumen environment in the device and the rotation buttons that allow the jars to slowly rotate around themselves were turned on. The Daisy incubator digestion trial was conducted as reported by Van Soest et al. (1966).

Removal of the bags from the incubator and chemical analysis

At the end of the incubation period, the Daisy Incubator was stopped, the liquid inside the jars was drained, and the sample bags were washed under tap water for 15 minutes to stop microbial activity and remove residues. The bags, which will be analysed later, were stored in a freezer at -18°C. From the bags taken from the incubator, 24 bags each for cows and buffalo were subjected to NDF analysis and dried at 105°C for 6 hours. At the end of the drying process, the bags were weighed on a precision balance (W3) and the IVTD values were recorded for calculation.

Chemical analyses of the raw material and the bags obtained after incubation, including crude fat, crude ash, NDF, and ADF analyses, were performed at the Animal Nutrition and Nutritional Diseases Department Laboratory of Afyon Kocatepe University Faculty of Veterinary Medicine; while the crude protein analysis was conducted at the Animal Nutrition and Nutritional Diseases Department Laboratory of Burdur Mehmet Akif Ersoy University Faculty of Veterinary Medicine. Crude protein, crude fibre, and crude fat analyses were performed according to AOAC (1990) methods, while NDF and ADF analyses were conducted as reported by Van Soest (1991).

Calculation of nutrient digestibility

For the calculation of IVTD, 24 bags were used separately for cows and buffalo. Calculations were made according to the formula given below:

IVTD = ((W3 - (W1 x C) / (W2 x %DM)) x 100

W1: Bag weight

W2: Sample weight

W3: Bag weight obtained after NDF analysis

C: Empty bag correction factor (weight of the empty bag after drying in the oven)
DM: Dry matter

IVTD: In vitro true digestibility

Statistical Analyses

Statistical analyses were performed using the SPSS 27 software package. First, the Shapiro-Wilk and Levene's tests were used to examine whether the data showed a normal distribution and whether the variances between groups were equal. For parameters showing normal distribution, the independent samples t-test was used; for those not showing normal distribution, the Mann-Whitney U test was used to compare the digestibility of dry matter, crude protein, crude ash, crude fat, NDF, and ADF in buffalo and cows. The analyses were performed at a 95% confidence interval, with a significance level of $p < 0.05$.

Results

Following in vitro analyses conducted using the Daisy II incubator method, the findings regarding dry matter, in vitro total digestibility, neutral detergent fibre, crude ash, crude protein, and crude fat values were evaluated, and statistically significant differences were determined for the parameters. When examining the findings in Table 5, the dry matter (DM) content was found to be 33.98% in buffalo samples and 32.33% in cow samples. This difference was not found to be statistically significant (p=0.310). In vitro true digestibility (IVTD) values were quite similar for both species. The difference between the IVTD values, calculated as 61.59% for buffalo and 61.66% for cows, is not statistically significant (p=0.924).

No significant difference was observed between buffaloes and cows in terms of neutral detergent fibre (NDF) content. The difference between the values found for buffalo (20.36%) and cows (20.49%), which were not statistically significant (p=0.924), was not statistically significant.

The crude ash (CA) rate was found to be significantly higher in cows. The difference between the CA values, which were determined to be 29.91% in buffalo and 33.76% in cows, is statistically significant (p=0.037).

The results obtained for crude protein (CP) showed a significant superiority in favour of buffalo. The difference in the CP ratio, measured at 31.58% in buffalo and 25.25% in cows, was found to be statistically significant (p<0.0001). The content of crude fat (CF) was also found to be significantly higher in buffalo samples. The difference between the CF rates, which were determined to be 23.41% in buffalo and 14.33% in cows, is statistically significant (p=0.030).

Table 5. Comparison of In Vitro Rumen Degradability Values of Tomato Greenhouse Pruning Residues in Buffaloes and Cows (DaisyII Incubator Results)

Nutrients	Buffalo	SEM	Cow	SEM	p
DM	33,98	0,32	32,33	0,66	0,310
IVTD	61,59	0,49	61,66	0,41	0,924
NDF	20,36	1,03	20,49	0,86	0,924
Ash	29,91	1,14	33,76	1,31	0,037*
CP	31,58	0,76	25,25	0,92	<0,0001*
EE	23,41	2,92	14,33	2,58	0,030*

Discussion

While previous studies have provided detailed information on the effective use of tomato pomace, a byproduct of the tomato plant, information on pruning waste from tomato greenhouses is insufficient. Therefore, in our study, the in vitro rumen degradability of tomato greenhouse pruning residues was investigated in buffalo and cows, which are large ruminants.

The study shows that the feed material we used can be consumed by both buffalo and cows at similar levels based on the dry matter rumen degradability, indicating that this material can be considered as a roughage alternative. The in vitro true digestibility (IVTD) values obtained show that tomato greenhouse pruning residues perform similarly in terms of digestibility for ruminants, regardless of species. In this respect, it is considered that the waste in question could be an economical source of roughage. NDF rumen degradability also shows that tomato greenhouse pruning residues, in terms of fibre content, is fermented similarly in both species, and that this material is functional in meeting the fibre needs of ruminant nutrition. The statistically significant finding of raw fibre degradability can be explained by the different digestion of mineral matter content across species or by variations in solubility within the rumen environment. The fact that cows break down this waste further in terms of mineral content can be considered an advantage. The significant superiority of rumen degradability of crude protein (CP) in favour of buffaloes indicates that buffaloes rumen microbiota can more efficiently ferment the protein in tomato pruning residues, resulting in more efficient microbial protein synthesis. In this context, it can be concluded that the waste in question can provide a higher protein contribution for buffalo. The significant superiority of crude fat (CF) rumen degradability, similar to crude protein rumen degradability, indicates that buffalo can more effectively degrade lipids in the rumen environment and provide greater energy benefits. Therefore, it can be said that tomato greenhouse waste is more advantageous for buffalo in terms of its energy value.

Previous studies have indicated that tomato pomace can be a valuable roughage source for ruminants such as sheep, goats, and cattle (Gökdoğan et al., 2000; Denek and Can, 2006; Keklikçi and Selçuk, 2018). It has

also been reported that tomato pomace has positive effects on milk yield (Erdinç et al., 1992) and can be ensiled with corn harvest and used as a roughage source (Savrunlu and Denek, 2016).

In a study conducted by Tekin and Kara (2020), the NDF content in tomato greenhouse pruning waste (leaves, stems, and stalks) silage was found to be 26.62%. As reported by Van Soest (1982), high NDF and ADF content negatively affects the digestibility of feeds, while our study shows that fermented tomato pruning residues (FTPR) have a relatively higher digestibility due to their moderate fibre content in terms of NDF (48.22%) and ADF (35.31%).

The nutrient content of the FTPR used in this study yielded remarkable results when compared to other alternative roughage sources reported in the literature. The dry matter content of FTPR was found to be quite high at 91.68%, which is higher than that of a significant portion of classic roughages such as alfalfa hay (approximately 90%) and corn silage (30%) (Sert, 2024).

In a study conducted by Keklikçi and Selçuk (2018), the dry matter (DM) content of tomato pomace, a tomato byproduct, was determined to be 92.20%. Similarly, the DM content of tomato greenhouse pruning residues used in our study was found to be 91.68% (Table 3), showing a resemblance. FTPR with a crude protein (CP) content of 15.60% was higher than alternative roughages such as kerkol (13.78%) and geven (9.30%) examined in the study by Örün (2021), and this value was found to be higher only in alfalfa hay (19.28%). This result suggests that tomato waste is a potential feed source that could provide a protein supplement in ruminant nutrition. As reported by Van Soest (1994), it has been stated that feeds with protein levels around 15% can meet the basal protein requirements of ruminants. The crude ash level of the feed material used in our study was 17.80%, while in the study by Keklikçi and Selçuk (2018), the crude ash content of fresh tomato pomace was reported to be 4.11%. Studies on dried tomato pulp have similarly shown low mineral content. Gökdoğan et al. (2000) reported the CA ratio in dried tomato pulp to be 3.95% (Haşimoğlu et al., 1979) and 5.3% (Ergen, 1991). These low rates indicate a decrease in mineral density due to the excessive water content of the post-processing tomato pomace, and that tomato greenhouse pruning residues naturally contain more minerals because they have more leaves, stems, and dried plant parts compared to the fruit pulp. This situation provides a significant advantage in meeting the need for mineral-rich roughage, and the crude ash (CA) content of 17.80% suggests a mineral-rich profile. However, it should be noted that the high ash content can cause problems, especially in sodium and potassium balance, and should be considered in feed formulation (Sarwar et al., 1992). The crude fat (CF) content was 3.77%, which is higher than alternative roughages such as helichrysum (2.54%) and astragalus (2.36%), but similar to corn silage (3.00%). The high content of crude fat suggests that increasing the energy content of the feed can lead to positive effects on ruminant performance (Örün, 2021). Additionally, Karagöz (2022) reported in his study that alfaalfa hay and silage have high digestibility rates, while digestibility decreases in feeds with low fibre quality, such as corn silage. These findings suggest that FTPR can be used as a balancing component in roughage rations. Specifically, in a study conducted by Sert (2024), significant increases were observed in the organic matter digestibility (OMD) and metabolisable energy (ME) values of corn harvest residues treated with molasses and urea, while fibre content was reported to have decreased. This situation suggests that the digestibility and energy content of tomato waste could be further improved through similar processes.

DM ratios are important not only in terms of the physical properties of the feed material but also in terms of digestibility and animal performance. Wadhwa and Bakshi (2013) stated that tomato waste cannot be used directly due to its high water content, but its feed quality can be improved by drying or appropriate fermentation processes

In a study conducted by Aydoğan (2022), it was also stated that adding tomato greenhouse pruning waste to lamb rations at levels of 2.5% and 5% had no significant negative effect on dry matter consumption and that ruminants could tolerate these wastes. These results indicate that the digestibility of drier tomato waste from greenhouses is at an acceptable level.

In our study, the in vitro crude ash (CA) degradability of tomato greenhouse pruning residues showed a significant difference between buffalo (%29.91) and cows (%33.76) (p=0.037). The digestibility of crude ash in cows was found to be significantly higher than in buffalo. This result indicates that the two species may differ in their ability to dissolve and digest minerals in the rumen environment. Differences in mineral matter digestion capacity between cattle and buffalo species can also contribute to this variation. Chanthakhoun et al. (2012), Wanapat et al. (2003), as reported that despite buffalo having a better capacity to digest fibrous feeds, they may perform less well compared to cattle in terms of the dissolution and availability of certain mineral fractions.

In our study, the rumen degradability of crude protein (CP) in tomato greenhouse pruning residues showed a statistically significant difference between buffaloes (31.58%) and cows (25.25%) (p<0,0001). It has been determined that buffalo can achieve a higher level of protein digestion from tomato greenhouse waste. This finding suggests that tomato greenhouse waste can be a valuable protein source for ruminants, especially buffalo.
In a study conducted by Hayashi et al. (2009), it was also determined that buffalo fed corn silage consumed more dry matter and protein than cows, and this had a positive impact on milk yield. Similarly, Wang et al. (2014) showed that alfalfa-based rations led to higher microbial protein synthesis in cows, but this effect was reduced in low-quality straw-based diets. These findings support the critical role of high-quality protein sources on animal performance.

Gandra et al. (2011) stated that buffalo provide better nitrogen balance on low-quality feeds and are particularly efficient in nitrogen utilisation. This finding indicates that in our study, buffalo utilised the protein in tomato greenhouse residues better. Terramoccia et al. (2000) reported that protein digestion in the rumen of buffalo was higher than in cattle and sheep, attributing this to more intense proteolytic activity. Puppo et al. (2002) stated that buffalo have a higher bacterial population in their rumen, which contributes to more efficient digestion of both fibrous and proteinaceous feeds.
In a more recent study by Sari et al. (2022), it was also reported that fibrolytic bacteria isolated from buffalo rumens exhibited strong proteolytic activity. Based on this information, it is clear that tomato greenhouse pruning waste has high nutritional value in terms of protein and that buffalo, in particular, utilise this protein source more effectively.

In our study, the rumen degradability of tomato greenhouse pruning residues for crude fat (CF) showed statistically significant differences between buffaloes (23.41%) and cows (14.33%) (p=0.030). This finding

suggests that fat digestion in different ruminant species is influenced by species-specific rumen microflora, physiological adaptations, and metabolic differences.

In studies on fat digestion in ruminants, Lock et al. (2006) stated that fat digestion can vary depending on species and rumen microbial activity, and that buffalo have a more efficient digestion capacity for certain lipid components.

Hayashi et al. (2009), on the other hand, reported that feeding corn silage to buffalo resulted in increased milk production due to higher dry matter and energy intake. These findings indicate that buffalo are also advantageous in lipid utilisation. Additionally, a study by Wang et al. (2014) stated that cows fed high-quality feed achieved better milk fat yield, while low-quality feed negatively affected fat synthesis. This situation highlights the importance of the energy and fat content of tomato greenhouse pruning waste on ruminant performance. Wang et al. (2020) stated that buffalo have higher rumen microbial diversity, particularly a richer rumen environment in terms of fibrolytic bacteria (Ruminococcus, Ruminobacter). These bacteria not only facilitate the breakdown of fibre but also the more effective degradation of plant cell walls containing fat. This situation can contribute to the more effective release and presentation of fatty components for digestion. Similarly, Naik et al. (2009) showed that rumen-protected fat supplementation significantly increased the digestibility of crude fat and the metabolic energy content in buffalo. Another explanation for this difference was put forward by Buccioni et al. (2012). The study emphasises that lipolysis and biohydrogenation in the rumen vary depending on the ruminant species, diet composition, and the lipase activity of microorganisms. They reported that rumen microorganisms of buffalo are more resistant to the toxicity of unsaturated fatty acids, especially, and can convert fats more efficiently. Bauman et al. (2003), on the other hand, evaluated this process at a systemic level, stating that CF in ruminants is not only an energy source but also plays a regulatory and metabolic role at the gene level for certain fatty acids. In this context, it can be considered that buffaloes achieve more energy and biological utilisation with greater CF degradation.

The difference in CF degradability obtained in the presented study aligns with the findings in the literature. The fact that buffalo have a richer rumen microflora, a more efficient lipolysis capacity, and physiological adaptations in fat metabolism allows for better digestion of the crude fat obtained from tomato greenhouse pruning residues. This suggests that buffalo might perform better with low-quality agricultural residues and those with high fat content.

Conclusion

In this study, the in vitro rumen degradability characteristics of tomato greenhouse pruning residues were evaluated in buffalo and cattle. The main objective of the study was to determine the potential use of plant materials, which are produced as a result of greenhouse activities and are generally considered waste, as an alternative roughage source in ruminant feeding.

Based on the findings of the study, it was determined that tomato greenhouse pruning waste has a high dry matter content and an acceptable level of crude protein in terms of chemical composition. Based on the data obtained, it is considered that this roughage source could be suitable for use as an alternative to

alfalfa hay. In vitro digestion trials conducted on buffalo and cattle showed that buffalo, in particular, were able to utilise these wastes to a greater extent.

The results obtained indicate that tomato greenhouse pruning waste can be an alternative and economical roughage source for ruminant feeding, especially for buffalo. This situation could both reduce animal production costs and contribute to agricultural waste management, thereby increasing environmental sustainability. However, this study was conducted under in vitro conditions, and in vivo digestion trials are needed to validate the obtained data. This way, the effects of pruning waste from greenhouses on animal performance, feed consumption, digestibility, and crop yield can be more clearly demonstrated. Additionally, excessive amounts of pesticides are used in tomato cultivation, so there is a high likelihood of pesticide residues being found in tomato greenhouse pruning residues. This situation should be considered in future studies.

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