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Effect of Dried and Fermented Food Leftover on Feed Intake, Growth Performances and Digestibility of Sheep

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ABSTRACT

Background: The Leftover food as a source of animal feed offers a sustainable solution to minimize waste, conserve resources and provide nutritious feed for small ruminants. The experiment was conducted at Mekelle University's Small Ruminant Research Farm to assess the impact of dried and fermented food leftover on the growth performance and digestibility of nutrients in sheep.

Methods: Twenty-one intact Highland lambs with an average weight of 15.17±1.79 kg were utilized in a randomized complete block design, with three treatments replicated seven times. The treatments included: Recommended concentrate mixture supplementation (T1), 71% replacement of the concentrate in T1 with dried food leftover (T2) and 71% replacement of the concentrate in T1 with fermented food leftover (T3). Food leftovers were collected and utilized in both dried and fermented forms. Additionally, adlibitum grass hay and water were provided throughout the trial period. Data analysis was conducted using ANOVA with the general linear model (GLM) procedures of SAS statistical software.

Result: Results indicated that dried food leftover had a higher dry matter percentage when compared to the fermented counterpart, though they exhibited similar crude protein, energy and fiber contents. Dry matter intake, body weight gain and feed conversion efficiency were significantly higher ($P<0.05$) for T3 compared to T1 and T2. However, dry matter and nutrient digestibility were not significantly affected by the diets ($P>0.05$). The findings suggest that utilizing food leftover in fermented form could be more beneficial for feed utilization and animal productivity.

Key words: Dried, Fermented, Food left over, Sheep, Weight gain.

INTRODUCTION

Feed is the most important input in livestock production. High quality feed is essential for optimal performance and health of animals. However, feed shortages pose a significant challenge for livestock producer (Geleti *et al.,* 2014). Feed costs typically account for a substantial portion, around 70 percent of total production costs in animal agriculture. Therefore, the economic viability of livestock farming greatly depends on the availability and quality of feed (Makkar, 2016). Non-conventional feed sources, such as food leftovers, offer a promising solution.

The global scale of food loss and waste is staggering, with approximately 1.3 billion tons discarded annually, representing around one third of the edible parts of food produced for human consumption (Munesue *et al.,* 2015). This wastage not only has significant environmental implications but also represents a missed opportunity to utilize valuable resources. However, there is growing recognition of the potential to convert food waste into useful products, such as energy, fertilizer and animal feed (Dou *et al.,* 2018). The conversion of food waste into animal feed presents promising economic and environmental opportunity.

The challenges associated with drying food leftovers, particularly during wet seasons, have prompted the exploration of alternative feeding techniques to address these issues. Consequently, this study was devised to assess the efficacy of both dried and fermented food leftovers in terms of feed intake, digestibility and growth performance of sheep. By fermenting food leftovers, it may be possible to overcome some of the limitations associated with drying, thereby providing a viable solution for utilizing food waste in animal feeding.

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MATERIALS AND METHODS

Experimental animals and their management

The feeding trial was carried out at the Small Ruminant Research Farm at Mekelle University, Tigray, Ethiopia from 10 December 2018 to April 2019. Twenty-one uncastrated lambs, sourced from local markets, were selected for the trial based on an average initial body weight of 15.17±1.79 kg. The animals were accommodated in well-ventilated, concrete-made and shaded rooms to ensure their comfort and well-being throughout the trial period. The trial spanned a total of 104 days, with the first 14 days

designated for adaptation to the experimental conditions, followed by 90 days of actual data collection and assessment. To ensure rigorous experimental control and reliability of results, a randomized complete block design (RCBD) was employed. This design included three treatment groups with seven replications each, allowing for systematic variation control and statistical analysis of the experimental outcomes.

Feeds and feeding management

The diet utilized in the feeding trial consisted of a combination of grass hay and concentrates in the ratio of 60:40. The mixed grass hay was sourced from the Mekelle University campus, ensuring the availability of high-quality forage for the experimental animals. Additionally, commercial feeds, including wheat bran, maize grain, noug seed cake and mineral mix (salt), were purchased from local feed vendors to formulate the concentrated portion of the diet. Fresh leftover food was collected from the Mekelle University student cafeteria, representing a diverse range of food scraps and leftovers typically generated in such settings. These food leftovers were then subjected to two treatment methods: drying and fermenting. Method of drying involves the removal of moisture from the leftover food to preserve it for longer periods and potentially concentrate its nutrients. Fermentation on the other hand, involves the microbial breakdown of the leftover food under controlled conditions, which can enhance its nutritional value and palatability. The process of fermenting food leftover was inspired by the process of brewing of traditional alcoholic drink (Tella) in Ethiopia (Bikila, 2020). Two litters of water were first mixed with one kilogram Gesho (a local hop leaf of Rhamnus prionidis) and one kilogram barley malt and the mixture was made to be fermented for three days, following the same procedure of preparation of starter for a local alcoholic brew (Tella) (Haimanot 2011). Thereafter, about six kilogram fresh food leftover was added to the fermented mixture solution and left to ferment for six days. The resulting fermented product was then offered to animals in a semi-liquid form.

The three dietary rations were formulated in per cent as below (Table 1).

Feed intake, body weight and digestibility measurements

The feeding regimen and data collection procedures during the trial were thorough and systematic. Daily feed intake was meticulously recorded by monitoring both the feed offered and refused by the animals. This allowed for the computation of daily feed intake by calculating the difference between the offered and refused feed amounts. Additionally, the body weights of the animals were measured at regular intervals of seven days throughout the experimental period. The body weight change was then calculated by taking the difference between the final and initial body weights of each animal. To assess feed efficiency, feed conversion was determined by dividing the daily average weight gain of the animals by the amount of daily feed consumed. This provided valuable insights into the efficiency with which the animals converted feed into body weight gain, a key indicator of their overall performance and productivity. Furthermore, to evaluate nutrient digestibility, a digestibility trial was conducted using the same animals during the last seven days of the experiment. Feces were collected from each sheep and stored at-20^{o}C until the end of the collection period. Subsequently, the collected fecal samples were bulked and sub-samples were retained for analysis. This allowed for the determination of nutrient digestibility, providing crucial information on the animals' ability to utilize the nutrients pre sent in the feed.

Chemical analysis

Representative samples of feed offer and refusal were collected over the experimental period and stored in air tied plastic bags. Organic matter (OM), ash and nitrogen (N) were analyzed according to the procedures of (AOAC 1990). Crude protein was determined based on nitrogen content (N*6. 25). Neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) were analyzed according to the procedures described by Van Soest and Robertson (1985). The energy value of the treatment feeds was estimated according to McDonald *et al.* (2010) equation.

Metabolizable energy (MJ/kg DM) = 0.016*DOM

Where,

DOM = Digestible organic matter in gram.

Total digestible nutrient (TDN) was calculated as (NRC 1984).

TDN = 82.38-(ADF%*0.7515

Organic matter was calculated as the difference between dry matter and ash.

Statistical analysis

The data collected from feed intake, digestibility, body weight gain and feed conversion were subject to analysis of variance (ANOVA) using the General Linear Model (GLM) procedure of (SAS, 2012) statistical software. Treatment means were compared using Tukey's HSD (honestly

Table 1: Ingredients (% in dry basis) used in formulating the experimental rations.

Ingredients	Treatment diets		
	T1	T2	T3
Grass hay	Adlib	Adlib	Adlib
Maize grain	50	10	10
Wheat bran	25	0	0
Noug seed cake	23	17	17
Dried food leftover	0	71	0
Fermented food leftover	0	0	71
Mineral mix	2	2	2
Total	100	100	100
Crude protein, % in	16.4	15.14	15.35

significant difference) tests. The statistical model used for the analysis of all parameters was:

$$Yij = \mu + ai + bj + eij$$

Where,

Yij = Response variable (feed intake, digestibility, body weight gain).
μ = Overall mean.
ai = i^{th} treatment effect.
bj = j^{th} block effect.
eij = Random error.

RESULTS AND DISCUSSION

Chemical composition of experimental feed

The nutritional contents of feed ingredients and experimental rations are presented in Table 2. The dried food leftover (DFLO) exhibited higher dry matter content compared to the fermented food leftover (FFLO). Both DFLO and FFLO had similar crude protein and energy content. However, DFLO contained more fiber compared to FFLO. The experimental rations (T1, T2 and T3) had comparable crude protein and energy values, but the fiber content was reduced in rations containing food leftovers compared to the control ration (T1). The DFLO-based ration had higher fiber content compared to the FFLO-based ration. Additionally, the ash content was higher in rations containing food leftovers compared to the control ration. The lower dry matter content of fermented food leftover (29.1%) compared to dried food leftover (90.40%) can be attributed to the higher moisture content resulting from the addition of water during the fermentation process. Despite the difference in moisture content, both fermented and dried food leftovers exhibited comparable crude protein and energy contents. This suggests that neither the drying nor fermenting process significantly affects the protein and energy content of the food leftovers. The high energy value of food leftovers (74% TDN) indicates its potential as a valuable source of energy in animal diets. The crude protein content of food leftovers (12-13%) is lower compared to commercial feeds (18-30%), except maize grain (10%). This is consistent with the range reported by Rajeh (2019), which falls within 10-14%. While the fiber content (NDF and ADF) of fermented food leftovers was slightly lower than that of dried food leftovers, both types of food leftovers had lower fiber content compared to commercial concentrates. This lower fiber content can

Table 2: Chemical composition (% on DMB) of grass hay add feed resources used in experimental feeds.

Feed ingredients	DM	Ash	OM	CP	NDF	ADF	ADL	TDN
Grass hay	89.8	10.3	89.7	5.50	54.3	40.2	10.2	52.2
Noug seed cake	93.3	8.60	91.4	30.1	33.0	29.5	10.8	60.2
Maize grain	86.9	13.4	89.8	10.0	18.6	5.10	3.50	78.0
Wheat bran	89.1	3.41	94.1	18.0	40.2	14.0	8.53	71.8
Dried food leftover	90.4	6.24	90.4	12.7	30.5	11.3	9.67	74.9
Fermented food leftover	29.1	7.75	92.2	13.0	27.0	10.7	8.53	74.3
T1	93.9	12.3	83.9	16.4	43.24	21.22	4.80	66.43
T2	92.2	14.2	85.8	15.2	49.4	30.1	4.72	59.73
T3	93.0	16.1	87.7	15.4	46	10.73	4.5	61.66

DM= Dry matter; OM= Organic matter; CP= Crude protein; NDF= Neutral detergent fiber; ADF= Acid detergent fiber; ADL= Acid detergent lignin; TDN= Total digestible nutrients.

Table 3: Average dry matter intake and DM digestibility in Tigray Highland Sheep.

Feed intake	Treatments			SEM	P
	T1	T2	T3		
DM intake, g/day					
Grass hay	356^{b}	363^{b}	434^{a}	5.70	0.002
Concentrate supplement	262^{b}	259^{b}	281^{a}	3.80	0.001
TDMI	618^{b}	623^{b}	716^{a}	9.10	0.001
TDMI (%BW)	3.0^{b}	3.4^{aa}	3.4^{a}	0.04	0.001
TOMI	589.6^{b}	599.2^{bb}	634.7^{a}	8.9	0.001
TCPI	78.7^{b}	77.9^{bb}	84.3^{a}	0.51	0.001
TNDFI (g/h/d)	339.4^{b}	341^{bb}	381^{a}	4.8	0.003
TADFI (g/h/d)	218.1^{c}	248.1^{b}	275.5^{a}	3.9	0.001
DM digestibility (%)	51.8	56.7	58.1	4.80	0.060

* (P<0.05), ** (P<0.01), a,b means within a row not bearing a common superscript significantly differ; SEM= Standard error of mean.

Table 4: Body weight change and feed conversion ratio in experimental sheep.

Variables	Treatments			SEM	P
	T1	T2	T3		
Initial body weight (kg)	15.3	15.2	15.0	0.39	0.95
Final body weight (kg)	17.7^{b}	20.4^{ab}	21.3^{a}	0.59	0.02
Total weight gain (kg)	2.41^{b}	5.19^{a}	6.29^{a}	0.46	0.04
Average daily gain (g)	26.8^{c}	57.7^{b}	69.9^{a}	5.13	0.03
Feed conversion ratio	0.042^{b}	0.09^{a}	0.097^{a}	0.08	0.02

* (P<0.05), a,b,c means within a row not bearing a common superscript significantly differ; SEM= Standard error of mean.

potentially enhance diet digestibility, making food leftovers a valuable component of animal diets.

Dry matter, nutrient intake and DM digestibility

Variation in feed intake (DMI) was observed among treatments (P<0.01) (Table 3). Sheep fed on food leftover containing rations exhibited higher feed intake compared to the control group (618.09 g/head/day). Specifically, sheep fed on fermented food leftover consumed more dry matter (716.3 g/head/day) than those fed on dried food leftover (627.7 g/head/day) (P<0.01). There was no significant variation in dry matter digestibility among the treatments (P>0.05). Fermentation, as suggested by San Martin *et al.* (2016), could enhance the acceptability and intake of food leftovers by animals by removing unsuitable aromas. Variation was also observed in organic matter (OM) and crude protein (CP) intake between diets, which is related to feed intake differences. Supplementation with food leftovers led to improved dry matter and nutrient intakes in the animals, indicating that using food leftovers in fermented form enhances feed utilization by animals. The total daily dry matter intake observed in this study falls within the range reported in earlier studies by Gashu *et al.* (2014) for local Ethiopian sheep supplemented with a mixture of agro-industrial by-product concentrates or multipurpose tree foliage, which ranged from 565 to 1085 g/head/day.

Live weight gain and feed conversion efficiency

Daily body weight gain and feed conversion efficiency (FCE) of sheep fed on dried or fermented food leftover based diets are presented in Table 4. The daily body weight gain was higher for fermented food leftover containing ration (69.96 grams/day) as compared to that of dried food leftover (57.69 gram/day) and the control group (26.82 gram/day). Feed conversion efficiency (FCE) was better for sheep in FFLO than DFLO and control groups (p<0.05). The higher body weight gain observed in animals fed a diet based on fermented food leftovers could indeed be attributed to the increased feed and nutrient intake. This suggests that supplementation with fermented food leftovers may provide essential nutrients to rumen microorganisms, leading to an accelerated rumen fermentation process and improved feed utilization, as suggested by McDonald *et al.* (2010). Additionally, Pandey *et al.* (2016) and San Martin *et al.* (2016) have highlighted the advantageous effects of fermenting food leftovers and wastes, such as increasing micronutrient content, enhancing the nutritional value of feeds and introducing important microbes to the gut of ruminants, which can activate the digestive system and promote proper digestion. However, it's worth noting that the body weight gain observed in this study (ranging from 27 to 70 grams/day) was lower compared to previous studies on local Ethiopian sheep breeds (ranging from 50 to 150 grams/day) conducted by Gashu *et al.* (2014). This difference could be attributed to variations in breed and/or feed composition. Furthermore, feed conversion was affected by the diets, as noted by Oonincx *et al.* (2015). This variation may be due to differences in the efficiency of utilizing different amounts of feed dry matter and nutrients, with diets containing fermented food leftovers exhibiting better palatability and intake. Consequently, the use of fermented food leftovers resulted in improved body weight gain and efficient nutrient utilization compared to other treatment feeds. Moreover, the reduced fiber content enhanced digestibility, leading to increased absorption of nutrients, which likely contributed to the observed increase in body weight gain and subsequently affected feed conversion efficiency.

CONCLUSION

The findings suggest that providing food leftovers in fermented form as a source of energy up to 71 per cent in the concentrate feed can improve feed utilization enhanced weight gain and feed conversion efficiency in sheep. This indicates that food leftovers could serve as a viable alternative feed source to expensive commercial feeds, particularly when fermented, leading to better overall performance.

Conflict of interest

All authors declare that they have no conflict of interest.

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