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Effect of Fermented Total Mixed Ration (TMR) Contained Different Levels of Cull Potato and Ensiling Period on Nutrient Composition and Performance of Fattening Moghani Lambs

Research Article

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ABSTRACT

The objectives of this study were to evaluate different levels of cull potatoes (15, 30, and 45 percent) and the ensiling period of the total mixed ration with TMR fermented feeds (TMRF) and total mixed ration (TMR) in a two-phase experiment on nutrient composition, ruminal fermentation characteristics, blood parameters, and fattening performance of Moghani lambs. A total of 42 Moghani lambs at 150-160 d age with similar body weight (30±0.7 kg) were randomly allocated to 7 pens. The pens were randomly assigned to 7 treatments with 6 replicates per treatment in a private fattening farm in Ardabil-Iran. In this experiment, seven diets were designated as control groups, 15% cull potatoes and 30-day ensiling time (T1P1), 30% cull potatoes and 30-day ensiling time (T1P2), 45% cull potatoes and 30-day ensiling time (T1P3), 15% cull potatoes and 60-day ensiling time (T2P1), 30% cull potatoes and 60-day ensiling time (T2P2), and 45% cull potatoes and 60-day ensiling time (T2P3), which were subjected to nutrient composition, rumen fermentation parameters, blood parameters, and growth performance of Moghani fattening lambs. The average daily gain (ADG), feed intake, average daily feed intake (ADFI), and feed conversion ratio (FCR) were determined in 60 d experimental period. The data obtained from the experiment were statistically analyzed in the form of completely random design and SAS software. Chemical composition was not different between the treatments but pH, NH_3-N, lactic acid and acetic acid were affected by the ensiling period (P<0.05). Results of feeding trial showed that ruminal pH and propionic acid were similar among the treatments and the control as well, but the NH_3-N, lactic acid, acetic acid and butyric acid were affected by the treatments (P<0.05). Blood metabolites were similar between the treatments. The parameters of fattening performance showed that dry mater intake , daily gain and feed conversion ratio were affected by the treatments (P<0.05). The dry matter intake was lower in lambs fed P1T2 and P3T2 (1240 and 1272 g/d) P2T2 (1339 g/d) compared to the other treatments. The average daily gain ranged 194 to 212 g/d that were lower in P3T1 and P3T2 (194 and 197 g/d) but the feed conversion ratio was superior (6.39 and 6.46) in these treatments. In conclusion, the potato cull may be used up to 45% of the total mixed ration silage and fed to fattening lambs. The 30 days ensiled period may be adequate time for fermentation silage.

KEY WORDS cull potato, fattening performance, fermentation parameters, TMR silage.

INTRODUCTION

Potatoes is one of the most important crops in the world after wheat and rice (Wang *et al.* 2015), and are used for human consumption and are not grown as animal feed, but every year part of the potato crop is lost due to overproduction or also as waste, which causes damage to farmers and environmental pollution. Iran is one of the 20 top potatoproducing countries with a production of about 4-5 million tons of potatoes per annum (FAOSTAT, 2017) and according to these statics, at least 15-20 per cent of these potatoes are out-of-size potatoes (potatoes removed after sorting), which are used in various ways in animal feed.

It is necessary to provide a suitable method for their optimal use and the duration of their storage. It should be noted that ensiling potatoes (not only) is one of the best ways to preserve and even increase their nutritional value. During the peak production season, farmers are faced with the problem of disposing of surplus potatoes. Every year, part of the potato crop is wasted due to traditional harvesting in the fields, lack of cold storage and non-standard storage (Pringojin *et al*. 2005). For this reason, part of the annual potato production is no longer suitable for human consumption and part of it can be used as feed for livestock (Bradshaw *et al*. 2002). Research has shown that cull potatoes can replace maize and barley in the rations of ruminants, but their high moisture content is one of the problems associated with feeding them fresh to animals. Therefore, its proper storage has long been one of the main concerns of researchers, and it has been found that ensiling is one of the scientific and practical ways to preserve potato nutrients and even increase its nutritional value and shelf life. Potatoes are a rich source of starch, which usually makes up 25 to 90% (Barrell *et al*. 2013). However, due to the fact that its water soluble carbohydrates are low and most of its carbohydrates are in the form of starch, it is almost impossible to ensile it alone and therefore it is better to ensile it with low moisture materials such as straws in a 3:1 ratio to adjust its moisture content (Charmley *et al*. 2006). Due to the seasonal production and low shelf life of potatoes, the need to use processes that enable us to provide this product all year round seems necessary. Forage storage in the form of silage is a common method of providing ruminant feed sources at times of the year when fresh forage is not available. In this method, due to the activity of lactic acid-producing bacteria and under anaerobic conditions, water-soluble carbohydrates in forage water are converted to organic acids (mainly lactic acid) and reduce the pH and thus protect forage from microbial spoilage (Filya *et al*. 2000). With this method, the above-mentioned silage can be stored for up to 9 months (Nicholson, 1985). The problem of storing surplus potatoes has led to the development of a number of processing techniques (McDowell, 2009), such as drying or ensilage. Drying potato products for animal feed is not economical. Ensiling may be a better storage technique for potatoes as it can also reduce solanine toxin. However, extremely wet silages (>70% moisture) usually result in fermentation dominated by butyric acid-producing bacteria and the loss of large amounts of digestible nutrients by leaching (Mueller *et al*. 1991).

Therefore, potatoes should be ensiled with dry feeds (Nkosi and Meeske, 2010), such as wheat straw, due to their high moisture content (80%) or ensiling with other feed ingredients as TMR ensilage. silage in the form of TMR increase the digestibility of the nutritional value obtained as silage after processing, which will increase the added value due to the increase in digestibility of the nutritional value.

The aim of this study was to evaluate different levels of cull potatoes (15, 30, and 45 percent) and the ensiling period of the total mixed ration with TMR fermented feeds (TMRF) and total mixed ration (TMR) in a two-phase experiment on nutrient composition, ruminal fermentation characteristics, blood parameters, and fattening performance of Moghani lambs to achieve a suitable, scientific and practical method for preserving and increasing the nutritional value of cull potatoes.

MATERIALS AND METHODS

Experimental diets

The potatoes was procured from the local market and transferred to the farm and after washing the potatoes and ensuring that they were free from soil contamination, they were chopped into 4-6 pieces using a cutter. Chopped potatoes allocated in seven treatments including:
Including seven treatments with potatoes (15, 30 and 45% replacement in two ensiling time) in the form of TMR and one treatment without potatoes as a control diet (Table 1). The experiment was carried out in the Ardebil (Iran) from April to June (2022) in experimental site. Male lambs (6-old) with similar body weight (30±0.4 kg) of Moghani breed were selected from the tribal herds. All rations were formulated and balanced to meet the nutrient requirements of Moghani lambs.

As well as the nutrient composition tables of livestock diets in Iran. To prepare TMRs, cull potatoes were cut into small pieces and another part of the diet including roughages and concentrate was poured into the feed mixer. To keep the DM constant among the 7 TMRs, water was proportionally added to the TMRs. After thorough homogenization of all components, they were poured into plastic bags weighing ten kilograms each and after the air inside the plastic was completely emptied, their doors were closed and stored at a temperature of 25 degrees Celsius for 30 and 60 days. A strong cover was placed on the prepared silos to prevent the entry of rodents and air. seven treatments include 15% potato ensiled for 30 days (P1T1); 30% potato ensiled for 30 days (P2T1); 45%; potato ensiled for 30 days (P3T1); 15% potato ensiled for 60 days (P1T2); 30% potato ensiled for 60 days (P2T2) and 45% potato ensiled for 60 days (P3T2) and without potato as control.

Table 1 Ingredients and chemical composition of the experimental diets (DM basis)

Ingredients (% on DM basis)	Experimental diets						
	Control	P1T1	P2T1	P3T1	P1T2	P2T2	P3T2
Cull potato[1]	0.0	15	30	45	15	30	45
Wheat straw	14	14	13	11	14	13	11
Alfalfa	20	20	20	20	20	20	20
Barley grain	29	18	10	1.4	18	10	1.4
Wheat bran	14.95	12.75	6.85	3.00	12.75	6.85	3.00
Beet pulp	4.0	4.0	4.0	4.0	4.0	4.0	4.0
SBM	4.0	4.0	5.0	5.5	4.0	5.0	5.5
Molasses	12.0	10.0	9.0	7.8	10.0	9.0	7.8
Urea	0.8	1.0	1.1	1.2	1.0	1.1	1.2
Calcium carbonate	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Diammonium sulfate	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Nacl	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Vitamin and mineral premix[2]	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Chemical composition (%)							
Dry matter	86.5	46	39	31.6	46	39	31.6
Crude protein	14.10	14.31	14.21	14.15	14.31	14.21	14.15
Neutral detergent fibre (NDF)	36.40	37.60	34.60	33.20	37.60	34.60	33.20
Acid detergent fibre (ADF)	18.80	17.79	16.86	15.92	17.97	16.86	15.92
Ether extract (EE)	2.30	1.95	1.52	1.22	1.95	1.52	1.22
Ash	7.06	8.22	8.74	8.53	8.22	8.74	8.53
Calcium	0.66	0.62	0.60	0.60	0.62	0.60	0.60
Phosphorus	0.38	0.33	0.26	0.21	0.33	0.26	0.21
Metabolizable energy (Mcal/kg)	2.40	2.39	2.39	2.40	2.39	2.39	2.40

[1] Over and under size potatoes.
[2] Supplies per kg of diet: Mn: 100.4 mg; Fe: 52 mg; Zn: 86.5 mg; Cu: 11 mg; I: 1.2 mg; Se: 0.3 mg; vitamin A: 9100 IU; vitamin D: 2200 IU and vitamin E: 17 IU.
P1T1: 15% potato ensiled for 30 days; P2T1: 30% potato ensiled for 30 days; P3T1: 45% potato ensiled for 30 days; P1T2: 15% potato ensiled for 60 days; P2T2: 30% potato ensiled for 60 days; P3T2: 45% potato ensiled for 60 days.

Determination of chemical compositions

After 30 and 60 d of ensiling, the bags were opened and samples were collected and analyzed for chemical composition and fermentation characteristics. The DM content in the samples was determined after incubation at 60 °C for 24 h, followed by 105 °C for 24 h. Dried samples were ground in a mill to a maximum particle size of 1 mm. Crude ash (CA), crude protein (CP) (nitrogen×6.25) and diethyl ether extract (EE) contents were determined according to the method of AOAC (2005). Neutral detergent fibre (NDF) and acid detergent fibre (ADF) were analyzed according to Van-Soest *et al*. (1991). NDF was determined with sodium sulphite (0.5 g), ammonia nitrogen was determined with a spectrometer according to the Broderick-Vegan method (Broderick and Kang, 1980) and the VFA content of the samples was determined with a gas chromatograph and the pH was measured with a pH meter.

Ruminal fermentation parameters

After 14 days of adaptation to the experimental diet, approximately 300 mL of rumen digesta were collected with oral 1 h before morning feeding from each individual sheep on the same day. The first 10 mL of achieved digesta were discarded to avoid saliva contamination, the obtained digesta was filtered through four layers of sterile, and the rumen fluid was immediately collected and moved into pre warmed (39 ˚C) anaerobic thermos flasks (by injecting CO_2) in 10 min from the time the digesta were obtained. For the determination of pH, ammonia nitrogen and volatile fatty acids, a sample of rumen fluid was taken through a stomach tube and strained, the pH was measured immediately and the volatile fatty acids and ammonia nitrogen of the samples were analysed at -20 degrees Celsius. They were frozen until the time of measurement. A spectrometer was used to determine ammonia nitrogen using the Broderick Vegan method (Broderick and Kang, 1980). For the determination of volatile fatty acids, including acetic acid, propionic acid and butyric acid, a 25% solution of metaphosphoric acid was added, the mixture was vortexed with acid, centrifuged (3000 rpm for 20 minutes at 4 degrees Celsius) and finally the VFA content of the samples was determined using a gas chromatograph.

Blood metabolites

On the 50th day, blood samples from lambs were tested to determine blood parameters including glucose, blood urea, total protein, albumin, cholesterol and triglyceride concentrations using routine laboratory methods. The amount of globulin was obtained from the albumin fraction of the total protein.

Serum concentrations of total protein, glucose, urea-N, albumin, cholesterol and trigliciride were measured using an auto analyzer system with commercial kits according to Kerscher and Ziegn Born (2001). Three lambs were randomly selected from each treatment and 10 mL of blood was collected from the jugular vein. The samples were stored in a refrigerator at 4 °C for 24 h and then centrifuged at 3000 × g for 20 min. The supernatant was transferred to 1.5 ml plastic microtubes for the determination of serum metabolites (Papi *et al.* 2022). Serum samples were stored in the freezer at - 20 °C until further analysis.

Feed intake and growth performance of lambs

In the second stage of the experiment, the number of 42 Moghani male lambs of almost the same age and weight in 7 treatments and 6 repetitions with experimental rations containing zero levels (control ration without ensiling and without potatoes), 15, 30, and 45% potatoes and two silage processing times (30 and 60 days) were fed for 15 days of habituation and 60 days of the main stage. Daily feeding twice a day, in the morning and in the evening, and clean and healthy water was freely available to the animals. The rest of the previous day's lunch was weighed and the amount of daily consumption was recorded. Weighing of animals, daily feed intake and food conversion coefficient were recorded weekly. Finally, all the collected data analyzed and the best economic and practical treatment for commercialization and mass production will be transferred to the animal feed factories with the help of additional information from other internal and external studies.

Statistical analysis

The statistical model for performance data analysis is:

$$Y_{ijk}= \mu + L + T + LT_{ij} + e_{ijk}$$

μ: mean of the studied traits.
L: level of potatoes.
T: ensiling time.
LT_{ij}: interaction effects of ensiling time on potato levels.
e_{ijk}: effect of test error.

RESULTS AND DISCUSSION

The chemical composition and fermentation parameters of the treatments over time are shown in Table 2. As can be seen in Table 2, in terms of nutrients, the amount of crude ash, NDF and calcium of the treatments with different amounts of potatoes and ensiling times are higher than the control treatment. The reason for the non-significance of dry matter between the experimental treatments was the equalization of the dry matter of all treatments with sterilised water at the beginning of the preparation of the experimental studies. The amount of calcium increased after ensiling and NDF values of the experimental treatments have significantly decreased compared to the control treatment (P<0.05). The plant cell wall is a complex matrix of polysaccharides, mainly consisting of cellulose, hemicellulose and pectin. Although soluble carbohydrates from the cell content are the main fuel for microbes during ensiling, a small proportion of the cell wall components can also be broken down and used as a substrate for silage fermentation.

The decrease in NDF compared to the control treatment is due to the presence of hemicellulase activity before 14 days of silage and the continued hydrolysis of hemicellulose during ensiling, which has been confirmed by Weinberg *et al.* (2011) and Ning *et al.* (2016). In term of ash content, the concentration of crude ash of the treatments with different amounts of potatoes and ensiling times are higher than the control treatment and the difference between the experimental treatments is very small and insignificant which is consistent with Baumont *et al.* (2011) and Meschy *et al.* (2005) that found that , well-preserved silages have slightly higher ash contents than their fresh crops due to the disappearance of organic matter, which is consistent with our results in this research.

The amount of calcium in this study was higher in TMR silages than in the control, which is not consistent with Schlegel *et al.* (2018) but is consistent with our results for phosphorus. However, the results of many studies show that the availability of a number of elements increases after ensiling due to microbial development and low pH conditions. In addition to the acidity effect, phytate and oxalate interact with minerals (e.g. Ca, Mg, Zn, Fe, Cr and Mn), reducing their bioavailability.

From the point of view of pH, ammonia nitrogen and volatile fatty acids, it is observed that the amount of pH, ammonia and lactic acid between ensiling period are significant (P<0.05).

It is scientifically clear that with increasing in the length of the ensiling period and increasing in the amount of lactic acid in the TMR diets, the amount of pH decreased. but no significant change is observed between different levels of potatoes from point of potatoes levels except acid acetic in ensiling period in 60 day and between 15 with 30, 45 percent (no logical reason for this difference was found in scientific articles). Ammonia nitrogen levels also decreased with increasing ensiling period. The lower ammonia-N concentration with increasing period was probably related to the lower proteolysis and degradation of AA caused by the lower pH (Kaiser *et al.* 2004). the concentration of butyric acid and propionic acid was insignificant between all treatments.

These results are consistent with those of Tian *et al.* (2020) who found that the production of large amounts of organic acids, especially under high moisture and prolonged ensiling conditions, leads to an excessive reduction in pH. Srita *et al.* (2015) found no significant difference between different levels of potato in terms of lactic acid, ammonia nitrogen and pH in the TMR diets, which is almost in agreement with the results of this research.

Results of mean effects of dietary treatment on rumen fluid parameter of the experimental rations (Table 4) indicated that there are no significant difference in term of ruminal pH and propionic acid between all treatments. The use of different levels of potatoes as well as fermented TMR diets had a statistically significant difference in ammonia nitrogen concentration compared to the control diet (P<0.05).

A significant difference was observed between the control treatments and the 30-day with 60-day ensiling periods (P<0.05). However, different levels of potato did not affect the rumen lactate and butyrate concentrations during the same ensiling periods. Ruminal acetic acid and NH_3-N showed no significant difference between any of the experimental treatments, but there was a statistically significant difference between these treatments with the control diet (P<0.05). Rapid fermentation of the readily available carbohydrates in cull potatoes at 30 and 45% of the diet would be expected to reduce ruminal pH, but ruminal pH was unaffected. The inefficacy of silage potato by-products on ruminal pH in steers fed diets containing up to 40% potato waste of dietary DM has also been reported (Radunz *et al.* 2003) which is in agreement with the results of this research.. In contrast, an increase in ruminal pH with the inclusion of steam-peeled potato waste in diets was reported by Onwubuemeli and Huber (1985).

In the present study, potato inclusion did not affect ruminal NH3-N concentration at all levels (15, 30 and 45 percent) in lambs, but the addition of potatoes caused a significant increase in ammonia nitrogen compared to the control diet, which is not consistent with the report by Pen *et al.* (2006) but is consistent with Radunz *et al.* (2003) who reported increased ruminal NH_3-N concentrations in steers fed diets containing potato waste, whereas Onwubuemeli and Huber (1985) reported a decrease in ruminal NH_3-N concentrations when potato waste replaced high moisture maize in the diet.

Feeding Baladi goats diets with potato waste replacing 0%, 25%, 50% or 100% of the concentrate mixture had no significant effect on ruminal pH, TVFAS and ammonia-N concentrations (Gado *et al.* 1998). It is important to note that the different effects of *in vitro* ruminal fermentation parameters in different studies may be due to factors such as inoculant strain, inoculant application rate, crop specificity and composition, climatic conditions and ensiling technology (Filya *et al.* 2000; Contreras *et al.* 2009; Contreras *et al.* 2011).

The dietary addition of cull potatoes had no effect (P>0.05) on any of the blood parameters (Table 5).

Data of Table 5 showed that inclusion cull potato in TMR silage at three level and two ensiling period in lambs diets had no significant effect on blood plasma glucose, blood urea, total protein, albumin, cholesterol and triglycerides.

Blood glucose concentrations (54.4-56.3 mg/100 mL) in all lambs were within the range (50-80 mg/mL) reported by Przemyslaw *et al.* (2015) and typical ranges reported for some fat-tailed Iranian sheep (43.7-73.2 mg/100 mL Mojabi (2011). The unaffected blood glucose concentration in the lambs may be due to the similar amounts of DM and ME intakes, as glucose concentrations are closely correlated with DM and ME intakes (Przemyslaw *et al.* 2015). Blood albumin is an indicator of the nutritional status of the animal and it decreases when animals are sick (Solaiman *et al.* 2010). In this study, the appearance of the liver in diets high in potatoes was slightly different from other diets, but no particular problem was observed in the performance of the animal in terms of disease during the rearing period. The concentrations of triglycerides (20.3-22.7 mg/mL) were higher and albumin (1.64-1.73 g/100 mL) were lower than the ranges (18.0-50.9 mg/100 mL and 3.15-4.41 g/100 mL for triglycerides and albumin, respectively) reported for fat-tailed Iranian sheep (Mojabi, 2011). These results do not agree with those of Gado *et al.* (1998), who indicated that partial replacement of concentrate with potato processing waste at 0, 25, 50 or 100% in rearing Baladi goats had no significant (P>0.05) effect on serum urea nitrogen and Hamed *et al.* (2011) who indicated that the inclusion of 0, 7 and 14 percent potato processing waste in lamb diets had no significant (P>0.05) effect on glucose, total protein, albumin, globulin, urea, triglycerides and cholesterol. Pen *et al.* (2006) showed that the inclusion of potato by-products in the diet of Holstein steers did not significantly affect the concentration of plasma glucose, NEFA and blood urea nitrogen (BUN). Onwubuemeli and Huber (1985) found no effect of potato by-products on plasma glucose concentration.

Data on the growth performance and nutrient digestibility in lambs fed the experimental diets are shown in Table 5. Lambs fed the level of 15 and 30 percent diets had higher dry matter intake (DMI), ADG and final live weights (P<0.05) compared to those in the other diets (with a few exceptions, which were probably due to experimental error and differences in the body condition of lambs within experimental treatments).

Table 2 Chemical composition of diets (% on DM basis) at different level of potatoes and ensiling time

Item	Experimental diets							SEM	P-value
	Control	P1T1	P2T1	P3T1	P1T2	P2T2	P3T2		
DM	45.50	47.41	46.60	45.60	47.58	48.18	47.90	0.920	0.123
CP	14.34	14.37	14.50	14.62	14.73	14.65	14.59	0.165	0.141
NDF	35.95[a]	32.56[b]	32.64[b]	32.70[b]	32.10[b]	32.19[b]	32.03[b]	0.203	<0.001
ADF	17.96	18.12	18.02	18.22	18.04	18.56	20.45	0.177	0.437
EE	2.10	2.17	2.09	2.02	2.12	2.15	2.10	0.062	0.235
Ash	7.70[b]	9.75[a]	11.66[a]	11.71[a]	11.59[a]	11.58[a]	11.55[a]	0.205	<0.001
Ca	0.80[b]	1.19[a]	1.11[a]	1.09[a]	1.17[a]	1.12[a]	1.08[a]	0.04	<0.001
P	0.39	0.37	0.36	0.35	0.37	0.33	0.38	0.005	0.421

DM: dry matter; CP: crude protein; NDF: neutral detergent fibre; ADF: acid detergent fibre and EE: ether extract.
P1T1: 15% potato ensiled for 30 days; P2T1: 30% potato ensiled for 30 days; P3T1: 45% potato ensiled for 30 days; P1T2: 15% potato ensiled for 60 days; P2T2: 30% potato ensiled for 60 days; P3T2: 45% potato ensiled for 60 days.
The means within the same row with at least one common letter, do not have significant difference (P>0.05).
SEM: standard error of the means.

Table 3 The values of pH, total and individual fermentative fatty acids (g/kg of DM), and ammonia-N (g/kg of total N) diets at different level of potatoes and ensiling time

Item	Experimental silages						SEM	P-value
	P1T1	P2T1	P3T1	P1T2	P2T2	P3T2		
PH	4.10[a]	4.14[a]	4.12[a]	3.81[b]	3.84[b]	3.92[b]	0.057	<0.001
Ammonia-N (% of total N)	8.99[a]	8.26[a]	8.29[a]	7.89[b]	7.97[b]	8.02[b]	0.280	<0.001
Lactic acid (% of DM)	5.87[b]	5.81[b]	5.84[b]	6.08[a]	6.11[a]	6.22[a]	0.330	<0.001
Acetic acid (% in DM)	2.39[b]	2.48[b]	2.53[b]	2.52[b]	2.71[a]	2.69[a]	0.129	<0.001
butyric acid (% of DM)	0.06	0.07	0.06	0.06	0.05	0.06	-	NS
Propionic acid (% of DM)	0.24	0.23	0.24	0.25	0.24	0.25	-	NS

P1T1: 15% potato ensiled for 30 days; P2T1: 30% potato ensiled for 30 days; P3T1: 45% potato ensiled for 30 days; P1T2: 15% potato ensiled for 60 days; P2T2: 30% potato ensiled for 60 days; P3T2: 45% potato ensiled for 60 days.
The means within the same row with at least one common letter, do not have significant difference (P>0.05).
SEM: standard error of the means.

Table 4 Ruminal fermentation parameters of lambs received experimental diets

Item	Experimental diets							SEM	P-value
	C	P1T1	P2T1	P3T1	P1T2	P2T2	P3T2		
pH	6.38	6.37	6.39	6.50	6.41	6.44	6.51	0.012	0.150
NH_3-N (mg/dL)	5.29[b]	11.57[a]	12.90[a]	12.97[a]	12.94[a]	12.69[a]	12.83[a]	0.413	<0.001
LA (mg/dL)	5.31[a]	5.30[a]	5.32[a]	5.40[a]	5.06[b]	4.93[b]	5.02[b]	0.071	0.004
AA (mg/dL)	39.61[b]	48.51[a]	48.09[a]	49.11[a]	47.28[a]	47.23[a]	48.08[a]	0.569	0.022
PA mg/dL)	23.65	24.65	23.70	24.35	23.98	24.06	24.705	0071	0.123
BA (mg/dL)	11.07[a]	11.13[a]	11.46[a]	11.32[a]	7.21[b]	7.73[b]	7.44[b]	0. 246	<0.001

P1T1: 15% potato ensiled for 30 days; P2T1: 30% potato ensiled for 30 days; P3T1: 45% potato ensiled for 30 days; P1T2: 15% potato ensiled for 60 days; P2T2: 30% potato ensiled for 60 days; P3T2: 45% potato ensiled for 60 days.
LA: lactic acid; AA: Acetic acid; PA: propionic acid and BA: butyric acid.
The means within the same row with at least one common letter, do not have significant difference (P>0.05).
SEM: standard error of the means.

Table 5 Effects of the experimental diets on blood serum metabolites of lambs

Item	Experimental diets							SEM	P-value
	C	P1T1	P2T1	P3T1	P1T2	P2T2	P3T2		
Glucose (mg/100 mL)	55.22	55.40	54.80	55.90	56.10	56.30	56.20	0.077	0.133
Blood urea-n (mg/100 mL)	21.20	21.60	20.90	20.64	21.30	21.45	21.80	0.070	0.085
Total protein (g/100 mL)	7.4	7.8	7.7	7.45	7.11	7.62	7.70	0.047	0.061
Albumin (g/100 mL)	1.68	1.70	1.64	1.69	1.71	1.73	1.75	0.011	0.086
Cholesterol (mg/100 mL)	211	210	208	208	211	210	209	0.426	0.209
Triglyceride (mg/100 mL)	21.32	20.33	22.40	22.70	20.60	21.20	22.15	0.109	0.469

P1T1: 15% potato ensiled for 30 days; P2T1: 30% potato ensiled for 30 days; P3T1: 45% potato ensiled for 30 days; P1T2: 15% potato ensiled for 60 days; P2T2: 30% potato ensiled for 60 days; P3T2: 45% potato ensiled for 60 days.
The means within the same row with at least one common letter, do not have significant difference (P>0.05).
SEM: standard error of the means.

Table 6 Effects of feeding total mixed ratio silage containing different level and ensiling period on feed intake and growth performance of lambs

Item	Experimental diets							SEM	P-value
	C	P1T1	P2T1	P3T1	P1T2	P2T2	P3T2		
DMI (kg/d)	1.358[a]	1.370[a]	1.390[a]	1.240[c]	1.339[a]	1.410[a]	1.272[c]	0.006	<0.001
ADG (g/d)	209[ab]	205[ab]	210[a]	194[c]	202[b]	212[a]	197[bc]	1.204	<0.001
Initial BW (kg)	30.12	30.10	30.08	30.10	29.72	29.99	30.12	0.079	0.838
Final BW (kg)	45.79[a]	45.48[a]	45.83[a]	44.65[b]	44.87[a]	45.89[a]	44.89[b]	0.111	0.005
FCR	6.50[a]	6.56[a]	6.61[a]	6.39[b]	6.62[a]	6.61[a]	6.46[b]	0.790	0.012

P1T1: 15% potato ensiled for 30 days; P2T1: 30% potato ensiled for 30 days; P3T1: 45% potato ensiled for 30 days; P1T2: 15% potato ensiled for 60 days; P2T2: 30% potato ensiled for 60 days; P3T2: 45% potato ensiled for 60 days.
DMI: dry matter intake; ADG: average daily gain and FCR: feed conversion ratio.
The means within the same row with at least one common letter, do not have significant difference (P>0.05).
SEM: standard error of the means.

It seems that the use of the level of 45% of ensiled potatoes as TMR silage in the diet of fattening lambs did not have favorable economic results. The lambs in all treatments completely ingested the offered diets in a short time and the DM intake was similar among the treatments except for the 45% inclusion cull potatoes, which indicates the lack of appetite and unwillingness of the animals to eat these rations. In this research, the amount and time of consumption of diets containing 15% and 30% potatoes and both ensiling cycles were acceptable, indicating that they were palatable and acceptable.

These results were consistent with the findings of Srita *et al.* (2015). From the few studies on feeding potato processing waste (Stanhope *et al.* 1980; Rooke *et al.* 1997; Busboom *et al.* 2000; Duynisveld and Charmley, 2002; Pen *et al.* 2003; Duynisveld *et al.* 2004) it is clear that increasing the proportion of potato processing waste in the diet beyond about 20% results in a decrease in DMI. Duynisveld and Charmley (2002) found a 20% decrease in voluntary intake when potato processing waste was increased from 20 to 80% of the diet. Using the same data set as Duynisveld and Charmley (2002) and Duynisveld *et al.* (2004), Nagorka *et al.* (2004) concluded that adaptation to a potato-based diet took approximately 6 weeks and this contributed to the reduction in DM intake in the early feeding period. Therefore, it is possible that the amount of feed consumed and consequently the final weight gain in the 45% potato treatment was not satisfactory because of the short adaptation period, but Duynisveld and Charmley (2002) obtained excellent BW gains from potato processing waste at up to 80% of the finishing beef diet and observed a marked positive quadratic response to the level of potato processing waste inclusion, which was maximized at 1. 90 kg d-1 when potato processing waste accounted for 40% of the diet, and research has conclusively shown that very high levels of potato by-products can be fed to beef cattle without adverse effects on performance, carcass quality or meat acceptability (Duynisveld *et al.* 2004).

The effects of rations on meat and carcass quality were not investigated in this study and not much research has been carried out on them, but Nicholson (1985) reported a trial comparing barley or potato in finished beef heifers which showed no effect on cooking rate, weight loss on cooking or drip loss of beef.

CONCLUSION

It is clear that in areas of the world where potato cultivation is high, when its amount exceeds the demand for human consumption, we are forced to use it in animal feed. According to the results of this study, using surplus and cull potatoes as a TMR silage diet is one of the useful, effective and long-lasting methods. However, it is suggested that in order to increase the reliability factor, better quality and greater replacement rate, similar research be conducted using different percentages, longer adaptation periods and even additives such as yeast, etc. According to the results of this research, at least 30% of the total ration in TMR silage can be used from out-of-size potatoes, and to increase its amount, more research is needed or probably if the habituation period is more than two weeks, higher levels can be used in the completely mixed silage diet. According to the results of this research, at least 30% of the total ration in TMR silage can be used from cull potatoes and increase its amount, more research is needed.

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