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Boiled potato waste silage as an alternate roughage for goats

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ABSTRACT

A feeding trial (60 days) was conducted to gauge the nutritional attributes of boiled potato (*Solanum tuberosum*) peel waste silage and to analyse its feeding effect on intake and utilization of nutrients in goats. Twelve local, non-descript, adult male goats were randomly divided into two groups. Each group was given *ad lib.* wheat straw, concentrate mixture @ 20 g/KgW$^{0.75}$ and silage @ 75 g/KgW$^{0.75}$. Based on variation in source of silage the groups were classified as maize silage (MS) or potato peel waste silage (PPS) groups. Despite the higher crude protein concentration PPS could be successfully ensiled with achievement of necessary *p*H fall, possibly due to effect of boiling on starch granules to render it readily fermentable and/or heat damaged CP. In both the groups live weight of the goats was maintained throughout the trial. The PPS formed about 20.2% of the total ration intake (on DM basis). Nutrient digestibility (%) was similar between dietary groups, except NFE and NDF digestibility, which was considerably higher in PPS group. It may be concluded that the ensiled boiled potato peel waste may be utilized as a constituent of adult goat ration without compromising nutrient intake, digestibility, plane of nutrition and nutrient balance.

Keywords: Goat, Maize silage, Potato peel silage, Vegetables waste

Present trends of food production and processing have led to the conception of large quantities of food by-products and waste at every step of food production, processing and consumption. Industrialized economies have assessed the food wastage of about 42%, 39%, 14% and 5% from households, industry, food service and in distribution channels, respectively (HLPE 2014 and Kour *et al.* 2021). About 1.81 million tonnes of fruit and vegetable wastes are produced in India (Bakshi *et al.* 2016 and Prusty *et al.* 2019a). For each tonnes of food waste there is an estimated emission of about 2 tonnes of CO_2 (European Union, 2012). Utilization of the by-products through alternate channels (RedCorn *et al.* 2018), viz. inclusion in livestock feeding practices would be an effective strategy to reduce the wastage as well as solve environmental issues (Ermgassen 2015, Sharma *et al.* 2017, Datt *et al.* 2017).

India is the second largest producer of potato (388.19 million MT) with the world production of about 388.19 million MT (48.6 million MT, FAOSTAT, 2019). Processing potatoes produces huge quantities of by-products those have enormous potential as farm animal feed (Dhingra *et al.* 2013, Bakshi *et al.* 2016). Peels constitute 15 to 40% of potato mass (Ajila*et al.* 2012, Akyol *et al.* 2016, Gebrechristos and Chen 2018) and the production is between 70-140 thousand tonnes worldwide annually (Chang 2011). Potato peelings and culled potatoes have higher energy concentration (Monteils *et al.* 2002) and possess antioxidant, antibacterial, apoptotic, chemo-preventive and anti-inflammatory activities (Liang *et al.* 2014).

Traditionally potato peel waste has been reported for its use as low value animal feed (Nelson 2010), fertilizer or raw material for biogas production (Wu 2016), as it is highly perishable (Nkosi and Meeske 2010). Drying along with ensiling is an effective practice for preserving high moisture by-products (McDonald *et al.* 2011). Silage could substitute energy feed like maize in ruminant diets (Itavo *et al.* 2000, Lallo *et al.* 2003 and Pirmohammadi *et al.* 2006). In the present study, the impact of boiled potato waste silage feeding on intake and utilization of nutrients in goats was evaluated.

MATERIALS AND METHODS

Both *in vitro* and *in vivo* studies were conducted at the Faculty of Veterinary Sciences and Animal Husbandry, SKUAST-J, R.S. Pura, Jammu and Kashmir, India (74.7315°E longitude, 32.6049°N latitude and 270 m altitude), subsequent to necessary approval from the Institutional Animal Ethics Committee (IAEC) laid down by the Committee for the Purpose of Control and Supervision of Experiments on Animals.

Collection of boiled potato peel: Boiled potato peel

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waste (PPW) was collected from different eateries in and around R.S. Pura and Jammu on a daily basis. All eateries and vendors were provided with plastic bins for collection of PPW separately from other wastes. After collection, PPW were brought in the laboratory. Further, maize fodder procured after harvesting at milk stage was transported to the location of the study.

Ensiling: Maize fodder was chopped into 2-3 cm long pieces using a electric motor driven chaff-cutter. The chopped fodder and PPW were then dried in shade on a concrete floor for a day with regular turnings. Ensiling of maize fodder and PPW was done individually in multiple black coloured opaque polythene bags of approximately 50 kg capacity. These bags were then securely closed using multiple rubber-bands and mud-pack. Bunged bags were then labelled and stored safely in a godown on a raised platform. Silo bags were allowed 190 days of incubation period. Bags were opened one at a time after incubation period for the purpose of feeding trial. Samples were drawn from mid of three separate bags randomly for maize silage (MS) and Potato peel waste silage (PPS) for further analysis. A feeding trial of 30 days duration including a digestion-cum-metabolism trial in fourth week was conducted. The nutrient requirements of goats were fulfilled as per ICAR (2013).

Statistical analysis: The data obtained from chemical analysis of feedstuffs and metabolism trial was subjected to one-way ANOVA, whereas observations of daily dry matter intake, body weight and blood parameters was subjected to two-way ANOVA (Snedecor and Cochran 1994). The significantly different means were ranked by Duncan's Multiple Range Test (DMRT) as per Duncan (1955).

RESULTS AND DISCUSSION

Chemical composition: The concentrate mixture supplemented in the present study was similar across both the dietary groups and was offered at the dose rate of 20 g/kg W0.75 to all the experimental animals. The different silages fed to the dietary groups in the present study differed significantly ($p<0.01$) with respect to all the composition variables. The *p*H of both the experimental silage i.e. MS and PPS were similar to each other with values of 4.05±0.17 and 4.17±0.16, respectively.

In this experiment PPS constitutes about 20.2% of the total ration (on DM basis) intake, which is considered as safe level to have any negative impact over feed intake (Onwubuemeli *et al.* 1985, Pen *et al.* 2005, Zunong *et al.* 2009). Chemical composition of the concentrate mixture and wheat straw is in concurrence with the prior reports by many workers (Sahoo *et al.* 2000, Bashir 2011, Mir *et al.* 2014, Farooq *et al.* 2015, Nadeem *et al.* 2017, Ganai *et al.* 2017).

Significantly higher crude protein (CP) content of PPS suggests that it may not be a perfect candidate for ensiling. However, a good ensiling of PPS indicates that relatively higher CP content is not a hindrance in the *p*H fall, an important step of successful silage preparation. It is observed that steam increases moisture and gelatinizes starch contained in the peel (Bradshaw *et al*. 2002).

The constitution of PPS in this study is in agreement with the Nicholson *et al*. (1988) and Van Lunen *et al.* (1989). Higher crude fibre (CF) and acid detergent fibre (ADF) content of PPS is in concurrence with the earlier reports of Camire and Flint (1991) and Al-Weshahy and Rao (2009), which documents that potato peel waste contains about 40% of its DM as cellulose, hemicellulose, lignin, pectin, gums, etc. Abrasion peeling leads to more starch and low fibre (mostly lignin), *vis a vis* steam peeling. Waste product used in present study is different from other studies in terms of the type of peeling method, which can neither be described as steam peeling nor abrasion peeling. This made the sample irregular in composition with variable amount of starchy portion. The composition of maize silage in this study is similar to previous reports (AFZ 2011, Iqbal *et al.* 2018a).

*Silage quality: p*H of both the experimental silage, i.e. MS and PPS were similar to each other with values of 4.05±0.17 and 4.17±0.16, respectively and were within the *p*H range for good quality silage (McDonald *et al*. 2011). This is in consensus to the observations of Nkosi and Meeske (2010), Schroeder (2012), Snowdon (2015), Sharma *et al*. (2016), Bhong *et al*. (2020). This contrasts with Pen *et al.* (2006), who suggested that potato waste does not achieve the required fall in *p*H without supplementation of rapidly fermentable carbohydrates. However, both silages were having NH_3-N concentration within the tolerable limits (10% of total N) of silage quality assay (McDonald *et al*. 2011).

Live weight: The live weight (kg) of experimental goats (Supplementary Table 1) was maintained throughout the feeding trial, irrespective of the treatment silage was incorporated in the ration. The maintenance of body weight indicates that feed intake was sufficient to satisfy maintenance requirement of the adult bucks. All the experimental goats were adult bucks (10-14 months age).

Feed intake: Feed intake of experimental goats (Table 1) on DM basis was comparable ($p>0.05$) in the two dietary groups. Several studies reported decreased DM intake on increasing the incorporation of potato by-products in more than 20% DM of the diet (Stanhope *et al.* 1980, Sauter *et al.*1980, Busboom *et al.* 2000, Radunz *et al.* 2003, 2001, Duynisveld *et al.* 2004, Charmley *et al.* 2006). Further, Pen *et al.* (2006) and Nelson *et al.* (2000) reported increase in feed intake with addition of ensiled potato.

Negative impact of potato by-products addition is observed when it is utilized as a substitute of grains in the concentrate mixture and not when it is used as a roughage (Nelson *et al.* 2000 and Pen *et al*. 2006), which may be due to its high ADF content (Table 2).

Nutrient intake and digestibility: Effect of feeding MS and PPS on nutrient intake, viz. DMI, OMI expressed as g/d, % of live weight and g/kg $W^{0.75}$ and nutrient digestibility (%) during feeding trial in goats is presented

Table 1. Feed intake of experimental goats

Attribute/Group*	Period				Group Mean±SEM	p-value
	1st week	2nd week	3rd week	4th week		
Concentrate mixture intake						
MS	250	248	235	216	237±10.5	
PPS	247	246	233	238	241±16.1	
Period mean±SEM	249±20.2	247±20.0	234±19.1	227± 18.3	239±9.5	>0.05
p-value					>0.05	>0.05
Wheat straw intake						
MS	750	778	769	800	774±49.4	
PPS	750	760	777	794	770±62.2	
Period mean±SEM	750±37.6	769±57.8	773±66.4	797±53.2	772±39.2	>0.05
p-value					>0.05	>0.05
Silage intake						
MS	288	296	309	257	287±15.2	
PPS	244	267	280	232	256±22.7	
Period mean±SEM	266±30.4	282±28.9	294±30.4	245±20.2	272±13.7	>0.05
p-value					>0.05	>0.05
Total intake						
MS	1288	1323	1313	1273	1299±26.0	
PPS	1241	1273	1289	1264	1267±41.9	
Period mean±SEM	1265±55.6	1298±51.7	1301±53.8	1268±38.9	1283±24.5	>0.05
p-value					>0.05	>0.05

*MS, Maize silage fed group; PPS, Potato peel silage fed group.

in Supplementary Table 2. The mean DMI and OMI was similar (p>0.05) in both the dietary groups. The DMI and OMI (% L. wt., g/kg $W^{0.75}$) for both silages, was though, higher than that suggested by ICAR (2013) for adult, non-lactating goats, yet, the intake of MS group was in agreement with the findings of Iqbal *et al.* (2018a) for maize silage based ration fed bucks.

Apparent digestibility of potato by-products has been found to be approximately 78.0% (Charmley *et al.* 2006). Overall DM digestibility of compound diet (63.37±2.43%) seems to be in concurrence with the results of Charmley *et al.* (2006). Although, Gado *et al.* (1998) observed increased DM digestibility on potato by-products addition as a constituent of concentrate mixture. Pen *et al.* (2006) and Stanhope *et al.* (1980) reported nil effect on DM digestibility, on incorporation of potato waste in ensiled form.

The comparable CP digestibility observed among both groups in this study is in contrast with findings of Pen *et al.* (2006), who reported that steers fed 19% potato by-products silage in diet had higher CP digestibility in comparison to those fed on control diets. Though, these findings are in accord with Onwubuemeli *et al.* (1985), Sharma *et al.* (2012), Sharma *et al.* (2013). Moreover,

Table 2. Proximate composition and fiber fractions (% dry matter) of the feedstuffs

Attribute	Feedstuffs^			
	Concentrate mixture*	Wheat straw	Silage	
			Maize silage	Potato peel silage
OM	91.50±0.43	92.87±0.95	96.40±1.28	91.37±2.11
CP	23.14±1.10	4.35±0.09	6.80±0.49	11.50±1.03
EE	7.55±0.93	1.34±0.04	3.09±0.58	5.08±0.72
TA	8.50±0.19	7.13±0.94	3.61±0.09	8.61±0.15
AIA	0.83±0.07	1.68±0.04	0.59±0.03	1.94±0.10
CF	9.96±1.84	37.82±1.21	19.80±1.02	35.29±4.61
NFE	50.87±1.92	49.40±2.88	66.70±2.60	39.52±1.91
NDF	44.04±3.17	78.04±2.59	43.60±1.93	35.56±2.95
ADF	12.01±1.19	53.51±1.74	22.75±2.00	26.60±1.39
Calcium	0.51±0.03	0.35±0.003	0.19±0.009	0.069±0.005
Phosphorus	1.07±0.05	0.05±0.001	0.16±0.01	0.119±0.01

*Concentrate mixture (Barley, 30%; Wheat bran, 37%; Mustard oil cake, 30%; Mineral mixture, 2%; Salt, 1%). ^Each value is a mean of observations in triplicate. OM, Organic matter; CP, Crude protein; EE, Ether extract; TA, Total Ash; AIA, Acid insoluble ash; CF, Crude fibre; NFE, Nitrogen free extract; NDF, Neutral detergent fibre; ADF, Acid detergent fibre.

Table 3. Effect of feeding potato peel silage on nitrogen balance

Attribute	Group*		SEM	p-value
	MS	PPS		
Nitrogen intake				
g/d	16.37±0.90	18.60±0.76	0.72	<0.05
% L. Wt	0.06±0.005	0.07±0.008	0.005	>0.05
^g/kg $W^{0.75}$	1.33±0.07	1.51±0.08	0.06	<0.05
Nitrogen excretion (g/d)				
Faeces	5.12±0.38	6.43±0.49	0.27	<0.05
Urine	6.35±0.56	6.89±0.72	0.47	>0.05
Total	11.48±0.47	13.34±0.65	0.42	<0.05
Nitrogen balance (g/d)	4.89±0.22	5.28±0.19	0.14	>0.05
Nitrogen retention				
% of intake	29.80±3.86	28.39±3.83	2.31	>0.05
% of absorbed	43.47±4.54	43.39±4.86	3.10	>0.05

^$W^{0.75}$, Metabolic body weight. *MS, Maize silage fed group; PPS, Potato peel silage fed group.

the compromised DM intake and nutrient digestibilities on potato by-products inclusion has been reported only at levels higher than 20% on DM basis in ration (Tawila *et al*. 2008, Nkosi and Meeske 2010, Sharma *et al*. 2016, Bhong *et al*. 2020).

Pen *et al*. (2006) delineated increased ADF digestibility in potato by-products based silage fed animals, this is in contrast to the observation of Onwubuemeli *et al.* (1985) regarding ADF digestibility in steers fed potato waste substitution at 20%. In current study, ADF digestibility was not affected by the inclusion of PPS in ration, which is in agreement with Onwubuemeli *et al.* (1985) but NDF digestibility was significantly (p<0.05) higher in PPS fed groups, which may be credited to better utilization of fibre in the company of associated starch (Pen *et al.* 2006, Prusty *et al.* 2013, Prusty *et al.* 2019).

Nitrogen balance: Nitrogen (N) balance in investigational animals (Table 3) shows the results projected by composition and intake data (Table 1 and 3, Supplementary Table 2). Daily nitrogen (N) intake was 16.37±0.90 g in MS group and 18.60±0.76 g in PPS group. The N balance was 4.89±0.22 g/d and 5.28±0.19 g/d in MS and PPS groups, respectively. Since, the intake of both the dietary group was comparable (p>0.05), the considerably (p<0.01) higher CP% in PPS led to significantly (p<0.05) higher N intake (g/d) in PPS group. This along with comparable (p>0.05) CP digestibility % in two dietary groups explains the significantly higher (p<0.05) faecal nitrogen excretion in PPS group. This is though, not in conformity with the results of Onwubuemeli *et al.* (1985) and Pen *et al.* (2006) as they referred to better N absorption with lower faecal nitrogen. Pen *et al.* (2006) observed

Table 4. Effect of feeding potato peel silage on calcium and phosphorus balance

Attribute	Group*		SEM	p-value
	MS	PPS		
Calcium intake g/d	4.39±0.02	4.06±0.04	0.03	<0.05
Calcium excretion (g/d)				
Faeces	3.12±0.14	2.80±0.09	0.10	<0.05
Urine	0.22±0.006	0.21±0.008	0.006	>0.05
Total	3.33±0.04	3.01±0.02	0.02	<0.05
Calcium balance (g/d)	1.05±0.02	1.06±0.02	0.03	>0.05
Calcium Retention(g/d)				
% of intake	23.96±1.93	26.15±1.80	2.23	>0.05
% of absorbed	82.37±4.23	84.44±3.19	4.17	>0.05
Phosphorous intake (g/d)	3.12±0.008	3.22±0.005	0.006	<0.05
Phosphorous excretion (g/d)				
Faeces	1.68±0.09	1.81±0.07	0.06	<0.05
Urine	0.52±0.09	0.59±0.09	0.07	>0.05
Total	2.21±0.04	2.40±0.07	0.05	<0.05
Phosphorous balance (g/d)	0.91±0.03	0.83±0.05	0.04	>0.05
Phosphorous Retention				
% of intake	29.08±2.51	25.78±1.71	1.94	>0.05
% of absorbed	63.10±4.91	58.49±3.64	3.72	>0.05

*MS, Maize silage fed group; PPS, Potato peel silage fed group.

Table 5. Effect of feeding potato peel silage on levels of blood biochemicals and serum enzymes

Attribute/ Group*	Days from onset of trial				Treatment Mean±SEM	p-value
	0^{th} day	10^{th} day	20^{th} day	30^{th} day		
Haemoglobin (g/dl)						
MS	8.50	8.93	9.37	9.98	9.20±0.23	
PPS	8.13	8.50	9.03	9.80	8.87±0.14	
Period mean±SEM	8.32^{a}±0.23	8.72^{ab}±0.25	9.20^{b}±0.19	9.89^{c}±0.18	9.03±0.14	<0.01
p-value					>0.05	>0.05
Total Protein (g/dl)						
MS	6.07	5.58	6.00	5.89	5.89±0.16	
PPS	5.68	5.60	7.93	6.47	6.42±0.31	
Period mean±SEM	5.87^{a}±.24	5.59^{a}±0.26	6.97^{b}±0.53	6.18^{ab}±0.15	6.15±0.17	<0.05
p-value					>0.05	>0.05
Albumin (g/dl)						
MS	3.01	2.89	3.25	3.45	3.15±0.16	
PPS	2.78	2.96	3.82	3.27	3.21±0.12	
Period mean±SEM	2.90^{a}±0.19	2.92^{a}±0.11	3.54^{b}±0.13	3.36^{b}±0.22	3.18±0.10	<0.05
p-value					>0.05	>0.05
Globulin (g/dl)						
MS	3.06	2.69	2.75	2.44	2.74±0.25	
PPS	2.90	2.64	4.11	3.20	3.21±0.30	
Period mean±SEM	2.98±0.38	2.67±0.28	3.43±0.52	2.82±0.28	2.97±0.19	>0.05
p-value					>0.05	>0.05
Albumin:Globulin ratio						
MS	0.98	1.75	1.44	1.97	1.54±0.27	
PPS	1.64	1.33	1.19	1.04	1.30±0.21	
Period Mean±SEM	1.31±0.40	1.54±0.42	1.32±0.19	1.51±0.31	1.42±0.17	>0.05
p-value					>0.05	>0.05
Aspartate aminotransferase (AST; SGOT; IU/L)						
MS	160.84	167.92	166.14	164.04	165.59±7.67	
PPS	159.30	166.33	168.90	163.85	163.60±6.41	
Period Mean±SEM	160.07±8.73	167.13±9.02	167.52±8.85	163.95±11.19	164.60±4.94	>0.05
p-value					>0.05	>0.05
Alanine aminotransferase (ALT; SGPT; IU/L)						
MS	16.38	17.41	16.91	15.63	16.53±0.52	
PPS	17.23	18.67	17.71	16.84	17.58±0.64	
Period mean±SEM	16.83±0.73	18.04±0.75	17.31±0.98	16.23±0.84	17.06±0.38	>0.05
p-value					>0.05	>0.05

faecal excretion of N in the range of 29.1 % and 31.7 % in potato waste silage fed animals, which is lower than the 34.5% observed in the present study. No effect over urinary N excretion in PPS fed animals is in agreement with reports of Onwubuemeli *et al.* (1985) and Pen *et al.* (2006). However, Hoover *et al.* (1976) observed lower N excretion in faeces of potato by-products fed steers in comparison to maize silage fed ones.

Calcium and phosphorus balance: Calcium and Phosphorus balance results of the experimental goats is presented in Table 4. Mean daily calcium intake was 4.39±0.02 g and 4.06±0.04 g, while mean daily calcium balance was 1.05±0.02 g and 1.06±0.02 g in MS and PPS groups, respectively. Mean calcium intake, excretion in faeces, total excretion differed considerably ($p<0.05$) between the two dietary groups.

Mean daily phosphorus intake was 3.12±0.008 g and 3.23±0.005 g, while mean daily phosphorus balance was 0.91±0.03 g and 0.83±0.05 g in MS and PPS groups, correspondingly. Mean phosphorus intake (g/d), faecal excretion (g/d) and total phosphorus excretion (g/d) vary significantly ($p<0.05$) among dietary groups.

The potato by-products are not an excellent source of calcium and phosphorus (Bakshi *et al.* 2016). Moreover, the calcium and phosphorus ratio is inverse in potato peels (Van Lunen *et al*. 1989), with lower calcium and higher phosphorus (1:3) concentration. Considerably lower calcium intake was found in PPS group animals in comparison to MS group, however, the surplus calcium ingested in MS group was excreted in the faeces, signifying poor bioavailability.

Phosphorus concentration was considerably ($p<0.05$)

lower in PPS as compared to MS, however, the difference was more than compensated by slightly higher concentrate intake in PPS group. This led to higher ($p<0.05$) phosphorus intake with PPS group animals. No impact of inverse calcium: phosphorus ratio in the potato peel silage over respective mineral absorption and retention was seen, which may be due to the compensatory effect of concentrate mixture.

Blood biochemical profile and serum enzymes: Effect of feeding MS as compared to PPS to investigational animals on levels of blood bio-chemicals and serum enzymes measured at the beginning of trial and at 10-day interval thereafter is presented in Table 5. Major ($p<0.01$) periodic difference in mean haemoglobin level of experimental goats was observed. Significant ($p<0.05$) periodic difference in total protein level of investigational goats along with similar ($p>0.05$) values among two dietary treatments was found.

Mean Hb level in MS group was 9.20±0.23 g/dl, whereas in PPS group it was 8.87±0.14 g/dl, which is inside the standard range (8-12 g/dl) as per Kaneko *et al.* (2008) for adult goats, signifying that there was no problematical effect of PPS feeding on the health of experimental goats. No significant ($p>0.05$) difference in Hb level of experimental goats was observed among different dietary treatments, however, there was considerable ($p<0.01$) enhancement between observation intervals, irrespective of the diet (treatment×period interaction, $p>0.05$). It may be credited to response of the animal towards improved plane of nutrition during experimental period in comparison to pre-experimental period. Comparable effect was reported by the Iqbal *et al.* (2018b) and Chaudhary (2014) with respect to related experimental circumstances at same locale.

Serum albumin content of the animals in the MS fed group was 3.15±0.16 g/dl and in case of PPS fed group was 3.21±0.12 g/dl. Mean globulin content of the animals in the MS fed group was 2.74±0.25 g/dl and that of PPS fed group was 3.21±0.30 g/dl. Significant ($p<0.05$) periodic difference in albumin concentration was observed while globulin concentration of experimental goats were similar ($p>0.05$), however, they were comparable ($p>0.05$) among two dietary treatments.

Observed mean range of total serum protein in experimental goats was 5.89±0.16 g/dl for MS group and 6.42±0.31 g/dl for PPS group animals. Similar ($p>0.05$) levels across dietary groups indicated no adverse impact of the PPS silage over liver metabolism. Considerable difference in the total serum protein level among different periods with significantly lower ($p<0.05$) level at the onset of the trial as compared to the consequent readings was observed. Further, it has been reported that adjustment of animals to potato waste is moderately slower, which may be the explanation of the improving total protein values during the time of feeding trial (Bradshaw *et al*. 2002 and Charmley *et al*. 2006).

The activity of aspartate aminotransferase (AST) and alanine aminotransferase (ALT) is an indicator of damage to liver and muscles (Silanikove *et al.*1996). The comparable ($p>0.05$) levels of AST and ALT irrespective of dietary treatment, observed in this study, reflects lack of any undesirable effect of incorporation of PPS in diet on liver, kidney and muscles mass. This corroborates the hypothesis that the energy and protein intake of animals was adequate to maintain body weight and to avoid muscle breakdown.

It may be concluded that the boiled potato peel waste silage may be utilized as a part of adult goat ration without affecting nutrient intake, digestibility, plane of nutrition and nutrient balance.

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