Using potato processing waste in sheep rations

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Abstract: Twenty-seven male growing Rahmani lambs aged 6 months with an average weight 27.17 ± 0.31 kg were used to determine the effects of inclusion potato processing waste (PPW) on performance of Rahmani lambs. Animals divided into three equal groups and assigned for control and two experimental diets containing PPW which was at 0% PPW (TMR_1), 7% PPW (TMR_2), and 14% PPW (TMR_3), respectively. The results showed that dietary treatments had no significant effect on feed intake, while water intake insignificantly ($P>0.05$) increased. Digestibility coefficients of organic matter, crude protein and nitrogen-free extract significantly ($P<0.05$) improved. However, dietary treatment had no significant effect on dry matter and ether extract digestibilities. Values of total digestible nutrient significantly ($P<0.05$) increased while, digestible crude protein insignificantly ($P<0.05$) increased. Nitrogen retention was positive for all groups. Inclusion PPW in sheep rations had no significant effect on ruminal pH, ammonia nitrogen and total volatile fatty acid concentrations. Both ruminal NH_3-N and TVFAS concentrations were significantly ($P<0.05$) increased, while ruminal pH was significantly ($P<0.05$) decreased after 3 hours post feeding compared with before feeding. Molar proportion of volatile fatty acids and all blood plasma constituents insignificant affected. Final weight, body weight gain, and average daily gain were significantly ($P<0.05$) decreased, while feed conversion ratio insignificantly decreased. Total daily feeding costs of experimental rations were decreased. It could be concluded that potato processing waste can be successfully fed to lambs without any adverse effect on digestibility coefficients, ruminal fermentation, blood plasma constituents and performance. Also, PPW can be used economically in formulation of sheep rations.

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1. Introduction:

The total world potato waste production is estimated to 12 million tons per year (El-Boushy and Van der Poel 1994).

In Egypt, the yield of potatoes crop was two million tons (A.E.S.I. 2008). Smith and Huxsoll (1987) estimated the peeling losses of the potato chips industry which used abrasion peeling extensively to be 10%. Also, in Egypt, potato processing industry produced several by-products all the time of the year. In addition to the obtaining on potato by-products and transportation is easy and economical, but it needs to be dried to use it all the time of the year.

Potato waste is an excellent energy source for feedlot cattle. It has energy values similar to corn and barley while being low in protein and calcium. The biggest problem that has to be managed with potato waste is the water, where moisture content in potatoes are reach to 80 percent. In most feedlot rations silage is being used which could contain from 45 - 65 percent water as well. The water content of potato waste is not constant and it ranged from 72 to 83% (Murphy**,** 1997).

The starch in potato waste is fermented rapidly, limiting inclusion levels due to problems such as acidosis and bloat. Due to the wet nature of the product, spoilage can be a concern, especially during the summer (Radunz et al. 2003).

Potato waste is the product remaining after potatoes have been processed to produce frozen potato products for human consumption. The product can include peelings, cull potatoes, and other potato products. Potatoes have a feeding value similar to cereal grain but lower in CP. Potatoes are high in energy and low in protein and vitamin A. (Lardy and Anderson 2009).

Potatoes are primarily a source of energy, on a 100% dry matter (DM) basis, it has 81–82% total digestible nutrient (TDN) and only about 10% protein. The crude protein is in the form of non-protein nitrogen, and only 60% of the total may be digestible (Boyles, 2006). Because of potatoes' very low fiber content, it should not be considered a forage substitute but rather should be thought of as a high moisture source of starch. Potatoes are quite low in protein content and, when given in high amounts without protein supplementation, will not give good animal performance or feed efficiency.

Toxic components of potato called glycoalkaloids (usually solanine and chaconine). Glycoalkaloids are normally found at low levels in the tuber, and occur in the greatest concentrations just beneath the skin **(**FAO**,** 2008**)**.

Gado et al. (1998) reported that replacement of concentrate feed mixture by potato waste at level 25% of DM significantly increased digestibility of DM and nitrogen balance. Using potato by-product in growing goat ration saved 50% of yellow corn, which is used in the ration and used at 60% of the control ration without any adverse effect on goat performance (Omer and Tawila 2008). Potato products can be an economical substitute for grains (Murphy 1997 and Omer et al. 2010).

The main objectives of this study was to make a good cheap ration for growing Rahmani lambs and to investigate the effect of inclusion sun-dried potato processing waste on performance, digestion coefficients, rumen fermentation, blood plasma constituents and economical evaluation.

2. Materials and Methods

The present experiment was carried out at the Sheep and Goats' Units in El-Bostan area in Nubaria, which belongs to the Animal Production Department, National Research Center, Dokki, Giza, Egypt.

Experimental animals and feeds

Twenty-seven growing male Rahmani lambs, aged at approximately 6 months with average live weight of 27.17 ± 0.31 kg, were divided randomly into three equal groups (nine animals in each) and used to evaluate the effect of inclusion potato processing waste (PPW) at 0%, 7% and 14% of total mixed ration (TMR). The composition of different total mixed rations are presented in Table 1 The animals were individually fed with the experimental rations that cover the requirements for total digestible nutrients and protein for growing sheep according to the NRC (1985), and feed allowance was adjusted every 2 weeks according to their body weight changes. Animals were housed in individual semi-open pens. Experimental animals received one of the three experimental rations of PPW. The feeding trial lasted for 105 days, diets were offered twice daily (0700 and 1300 hours) while feed residues (if any) were removed and weighed once daily before morning feeding. Fresh water was available all the time in plastic containers. Water intake was recorded weekly. Live body weights were recorded weekly before morning feeding and after fasting overnight (feed and water). Potato processing waste was obtained from potato chips factory, Borg El-Arab city, Alexandria governorate, this potato processing waste composed of peel potatoes only.

Digestibility trials

At the end of the feeding experiment, five animals from each group were selected randomly and used to determine digestion coefficients and nutritive values of the experimental rations. The nutritive values expressed as the total digestible nutrients (TDN) and digestible crude protein (DCP) of the experimental rations were calculated according to Abou-Raya (1967).

Rumen fluid

Rumen fluid samples were collected from 15 animals (five animals for each treatment) at the end of the digestibility trial before feeding and 3 h post feeding via stomach tube and strained through four layers of cheesecloth to study the effect of dietary treatments on ruminal fermentations, ruminal pH, ammonia nitrogen (NH_3–N), total volatile fatty acid (TVFA) concentrations, and molar proportion of volatile fatty acids.

Blood plasma constituents

Blood samples were collected from the same lambs at the end of digestibility trials from the left jugular vein in heparinized test tubes at about 3 hours post feeding and centrifuged at 5.000 rpm for 15 minuets. Plasma were kept frozen at –20 °C for subsequent analysis of glucose, total proteins, albumin, urea, triglycerides and cholesterol.

Analytical procedures

Representative samples of ingredients, experimental rations, feces, and ruminal NH_3–N concentrations were analyzed according to A.O.A.C (1995) methods. Neutral detergent fiber (NDF), acid detergent fiber (ADF), and acid detergent lignin (ADL) were also determined in the ingredients and experimental rations according to Goering and Van Soest (1970) and Van Soest et al. (1991). NDF and ADF were expressed, inclusive of residual ash. Ruminal pH was immediately determined using digital pH meter. Ruminal TVFA concentrations were determined by steam distillation according to Kromann et al. (1967). Molar proportions of volatile fatty acids were determined according to Erwin et al. (1961). Plasma total proteins were determined as described (Armstrong and Carr, 1964); albumin (Doumas et al., 1971); urea (Patton and Crouch, 1977); triglycerides (Fossati and Principe, 1982); cholesterol (Allain et al., 1974) and Plasma glucose was measured using the enzymatic glucose oxidase method (Bauer et al., 1974). Globulin and albumin: globulin ratio (A: G ratio) were calculated. Gross energy (mega calories per kilogram DM) was calculated according to Blaxter (1968), where, each gram of crude protein (CP) = 5.65 kcal, each gram of ether extract (EE) = 9.40 kcal, and each gram crude fiber (CF) and nitrogen-free extract (NFE) = 4.15 kcal.

Economic evaluation

The relation between feed costs and gain was calculated for the different experimental groups. The general equation by which the costs of 1 kg of live body weight gain was calculated as follows:

The cost for 1-kg gain = total cost (Egyptian pound (LE)) of feed intake/total gain (kilogram).

Statistical analysis

The analysis of variance for completely randomized design experiments using SAS (1998) examined the effects of dietary treatments. Differences among means were evaluated using Tukey's test.

3. Results and Discussion

Composition, chemical analysis, and cell wall constituents of feed ingredients and experimental rations

Results of chemical analysis and cell wall constituents of feed ingredients are presented in Table 1. The results showed that yellow corn recorded the highest values of organic matter (OM) and nitrogen-free extract (NFE) while wheat bran showed the lowest value of OM. On the other hand, undecorticated cotton seed meal showed the highest values of CP and the lowest value of NFE. While, pea straw (PS) showed the highest value of Neutral detergent fiber (NDF) and Acid detergent fiber (ADF), however PPW showed the highest values of hemi cellulose and lowest value of cellulose. Gross energy of potato processing waste (PPW) was nearly from yellow corn (4.274 vs. 4.423 Mcal/kg dry matter. These results were within the ranges obtained by Omer and Tawila (2008), Tawila et al. (2008) and Omer et al. (2010) who recorded that chemical composition of potato waste ranged from 40 to 146 g/kg DM for CP, 16 to 175 g/kg DM for CF, 780 to 820 g/kg DM for TDN, 400 to 415 g/kg DM for NDF, 58 to 64 g/kg DM for ADF, 36 to 42 g/kg DM for ADL, 323 to 347 g/kg DM for hemicellulose, and 25 to 43 g/kg DM for cellulose, respectively.

Composition, chemical analysis, and cell wall constituents of the experimental rations are presented in Table 2. Experimental rations were in the same trend of gross energy (GE). Hemicellulose content was increased while cellulose content was decreased by adding PPW in the diet. These results in agreement with those obtained by Omer et al. (2010).

Table 1 Chemical analysis and cell wall constituents of feed ingredients (g/ kg DM)

Item	Feed ingredients				
	PPW	UDCSM	YC	WB	PS
Dry matter (DM; g/kg)	941.1	878.8	913.0	902.0	942.9
Chemical analysis on DM basis					
Organic matter	965.4	942.0	988.0	883.0	885.6
Crude protein	129.2	248.2	93.0	140.0	115.1
Crude fiber	30.6	277.5	23.0	112.2	297.6
Ether extract	14.0	27.1	35.0	30.0	25.3
Ash	34.6	58.0	12.0	117.0	114.4
Nitrogen-free extract	791.6	389.2	837.0	600.8	447.6
Gross energy (Mcal/kg dry matter)	4.274	4.424	4.423	4.032	3.981
Cell wall constituents					
Neutral detergent fiber (NDF)	410.0	506.3	326.3	442.1	546.0
Acid detergent fiber (ADF)	63.0	361.8	224.5	321.6	425.0
Acid detergent lignin (ADL)	38.0	204.6	21.3	40.5	134.0
Hemi cellulose	347.0	144.5	101.8	120.5	121.0
Cellulose	25.0	157.2	203.2	281.1	291.0

Hemicellulose = NDF – ADF, Cellulose = ADF – ADL

PPW potato processing waste, *UDCSM* undecorticated cotton seed meal, *YC* Yellow corn, *WB* wheat bran, *PS* pea straw

Table 2 Composition (fresh kilogram per ton), chemical analysis and cell wall constituents (g/ kg DM) of the experimental rations

Item	Experimental rations		
	TMR_1	TMR_2	TMR_3
Composition (fresh kg/ton)			
Potato processing waste	000	70	140
Undecorticated cotton seed meal	240	205	168
Yellow corn	280	280	280
Wheat bran	150	135	122
Pea straw	300	280	260
Lime stone	20	20	20
Sodium chloride	7	7	7
Vit. and mineral mixture[a]	3	3	3
Price of ton (LE)	1,220	1,090	0,995
Chemical analysis (g/kg DM)			
Dry matter	913.8	916.6	920.5
Organic matter	933.8	934.6	938.1
Crude protein	141.1	137.0	132.8
Crude fiber	179.1	163.8	148.5
Ether extract	28.4	27.6	26.7
Nitrogen-free extract	585.2	606.2	630.1
Ash	66.2	55.4	61.9
GE (Mcal/ kg DM)	4.236	4.229	4.232
Cell wall constituents			
Neutral detergent fiber (NDF)	443.0	436.5	430.2
Acid detergent fiber (ADF)	325.4	303.9	282.2
Acid detergent lignin (ADL)	101.4	93.6	85.4
Hemi cellulose	117.6	132.6	148.0
Cellulose	224.0	210.3	196.8

LE= Egyptian pound equals 0.18 USS approximately, TMR_1 = control ration contained 0%potato processing waste, TMR_2 = second experimental ration contained 7% potato processing waste of total mixed ration, TMR_3 = third experimental ration contained 14% potato processing waste of total mixed ration.

[a] Each 3 kg vitamins and mineral mixture contains: vitamin A 12,000,000 IU, vitamin D3 2,200,000 IU, vitamin E 10,000 mg, vitamin K_3 2,000 mg, vitamin B_1 1,000 mg, vitamin B_2 5,000 mg, vitamin B_6 1,500 mg, vitamin B_{12} 10 mg, pantothenic acid 10 mg, niacin 30,000 mg, folic acid 1,000 mg, biotin 50 mg, choline 300,000 mg, manganese 6,0000 mg, zinc 50,000 mg, copper 10,000 mg, iron 30,000 mg, iodine 100 mg, selenium 100 mg, cobalt 100 mg, CaCo3 to 3,000 g.

Feed and water intakes, nutrient digestibility coefficients and nitrogen utilization by the experimental group lambs

Feed and water intakes, nutrient digestibility coefficients, and nitrogen utilization by the experimental group lambs are presented in Table 3. The results showed that inclusion PPW in the diet insignificant decreased (P>0.05) feed intake. Dry matter, total digestible nutrient and crude protein intakes were decreased gradually with increasing quantity of PPW in the TMR. The present results might indicate that the PPW had adverse effect on palatability. These results were in agreement with those obtained by Omer and Tawila (2008) and Omer et al. (2010) found no significant effect on feed intake when Baladi goats or Ossimi sheep fed diets replaced yellow corn by 25% and 50% PPW. Sugimoto et al. (2006) noted that dry matter intake increased (linear; P<0.01) as the feeding level increased and was not affected by the diet. Onwubuemeli et al. (1985) fed lactating Holstein cows for 12 wk rations contained, on a dry matter basis, 0, 10, 15, and 20% potato waste and were substituted for high moisture corn in diets. They noticed that substituting potato waste for corn did not significantly affect dry matter intake.

Increasing level of PPW in the diets leads to insignificantly increasing (P>0.05) water intake as ml/h/d or L/kg dry mater intake, whoever, it significantly increased (P<0.05) water intake as L/100 kg body weight. These results were in agreement with those obtained by Omer and Tawila (2008) who noted that replacement of yellow corn (60% of control diet) by PPW at 25% and 50% in Baladi goats insignificantly increased water intake. On contrast Omer et al. (2010) noted that increasing level of PPW in sheep diets leads to insignificantly decreasing (P>0.05) water intake.

Inclusion of PPW in the diet insignificantly (P<0.05) improved digestibility coefficients of DM and EE, however, it significantly improved (P<0.05) OM, CP and NFE digestibility coefficients. On the other hand, except for OM digestibility increasing quantity of PPW in the diet from 7% to 14% had no significant effect on the other nutrients digestibility coefficients. Omer et al. (2010) reported that instead of 25% or 50% of yellow corn with PPW in sheep diets significantly (P<0.05) improved digestibility coefficients of (DM, OM and CP), while, dietary treatment had no significant effect on CF and NFE digestibilities. Tawila et al. (2008) found no significant differences among rations which were detected for DM, OM, CF, EE, and NFE digestibilities when yellow corn was replaced with PPW in Baladi goat diets at 0%, 25%, and 50%. However, the digestibility of CP was significantly lower (P< 0.05) in R_3 (50%) than in R_1 (0%) and R_2 (25%). Also, Radunz et al. (2003) noted that decrease in total apparent nitrogen disappearance was occurred with increasing potato waste levels in beef finishing diets to a less digestible protein with potatoes or more bacterial fermentation in the large intestine which would lead to greater fecal nitrogen extraction. Sugimoto et al. (2006) noticed that digestibility was not affected by any treatments when steers fed diets contained 0.2, 0.4 and 0.6% of Body weight (BW) on a dry matter basis potato pulp silage-based diet (PPS). Szasz et al. (2005) examined the main effects and interactions of pasteurization (54.4° C for 2 h) of potato slurry (PS) and grain type on total tract digestion of beef finishing diets. They recorded that steers fed barley-based diets had greater (*P*=0.02) DMI and lesser (*P*<0.05) total tract digestibility of DM and ADF compared with steers fed corn diets. Pasteurization increased (*P*=0.10) total tract starch digestibility. Onwubuemeli et al. (1985) tested digestibility and nitrogen utilization of potato waste substituted for corn at 0, 10, and 20% of the ration dry matter in steers diets. Potato waste did not significantly affect digestibility of crude protein or dry matter, but at 20% substitution digestibility of acid detergent fiber decreased.

Table 3 Feed intake (gram), water intake (milliliter), nutrient digestibilities coefficient (g/ kg DM) and nitrogen utilization (gram) by the experimental group lambs

Item	Experimental rations			SEM
	TMR_1	TMR_2	TMR_3	
Feed intake, gram as				
Dry matter (DM)	1,448	1,373	1,336	59.0
Total digestible nutrient (TDN)	1,093	1,048	1,044	44.7
Crude protein (CP)	204	188	177	8.3
Digestible crude protein (DCP)	132	132	124	5.5
Average body weight[a]	39.65a	37.95ab	36.65b	0.42
Water intake				
ml/h/day	4259	4330	4285	51.0
L/100 kg body weight (BW)	10.74b	11.41a	11.69a	0.13
L/ kg dry mater intake	2.94	3.15	3.21	0.14
Nutrient digestibilities coefficient				
Dry matter	792.2	801.7	796.4	0.23
Organic matter	779.7 c	789.8 b	805.0 a	0.32
Crude protein	646.5 b	701.2 a	700.3 a	0.92
Crude fiber	679.4 a	649.9 b	662.1 ab	0.44
Ether extract	748.6	735.6	754.0	0.70
Nitrogen-free extract	844.1 b	850.1 ab	864.2 a	0.38
Nutritive values (%)				
Total digestible nutrient (TDN)	754.7 b	763.6 b	781.1 a	0.34
Digestible crude protein (DCP)	91.2	96.1	93.0	0.10
Nitrogen utilization (g)				
Nitrogen intake	33.34	33.13	32.56	0.51
Fecal nitrogen	8.80	8.31	8.02	0.17
Digested nitrogen	24.54	24.82	24.54	0.45
Urinary nitrogen	8.02	8.36	8.61	0.16
Total nitrogen losses	16.82	16.67	16.63	0.23
Nitrogen retention	16.52	16.46	15.93	0.43

a, b and c = means in the same row having different letters differ significantly (P<0.05)
SEM = standard error of the mean
[a]Average body weight = (Initial weight + Final weight/2)

Inclusion PPW in the rations significantly ($P<0.05$) improved TDN and insignificantly ($P>0.05$) DCP, which is mainly due to the increase in CP and NFE digestibilities. The TMR_3 had the highest TDN while, TMR_2 had the highest DCP value. Tawila et al. (2008) noted that replacement concentrate feed mixture with PPW at 50% decreased TDN by 7.52% and by 29.09% for DCP, respectively, compared to the control ration. Diets containing PPW significantly increased ($P < 0.05$) nitrogen retention. Omer et al. (2010) noted that Instead yellow corn with PPW at 0%, 25% and 50% in sheep rations significantly ($P<0.05$) increased TDN and DCP values. The diet replaced 25% of corn with PPW (R_2) improved TDN by 1.85% and by 21.90% for DCP, respectively, compared to the control diet (R_1). While, diet replaced 50% of corn with PPW R_3 improved TDN by 2.06% and by 29.65% for DCP, respectively, with respect to the control diet (R_1).

Nitrogen retention was insignificant decreased ($P>0.05$) when PPW introduced in the diet at 7% or 14 for TMR_2 and TMR_3 compared to the control diet (TMR_1). In contrast, Omer et al. (2010) and Tawila et al. (2008) observed that nitrogen retention was improved when sheep fed diets replaced 25% or 50% of corn with PPW.

Rumen fluid parameters of the experimental group lambs

Results of mean effects of rumen fluid parameter of the experimental rations (Table 4) indicated that dietary treatment had no significant effect on ruminal pH, NH_3–N and TVFAS concentrations. Ammonia nitrogen was insignificant ($P>0.05$) decreased with inclusion PPW in the diet. However, pH value and total volatile fatty acids were in significant increased. These results are in agreement with those obtained by Omer and Tawila (2008) with Baladi goats and Tawila et al.(2008) and Omer et al. (2010) with Ossimi sheep. The reduction of ammonia–N in the rumen liquor appears to be the result of increased incorporation of ammonia–N into microbial protein, and it was considered as a direct result to stimulated microbial activity while increasing TVFAS might be related to the more utilization of dietary energy and positive fermentation in the rumen. Feeding Baladi goats on diets replaced by 0%, 25%, 50%, or 100% of concentrate feed mixture by potato waste had no significant effect on ruminal pH, TVFAS, and ammonia–N concentrations (Gado et al. 1998). The rate of VFAS production may in this situation exceed the rate of VFAS absorption through the rumen epithelium, and VFAS concentration in the rumen juice is increased (Van't Klooster 1986). Also, Radunz et al. (2003) found that increasing levels of PW lead to increased ruminal TVFAS concentration (linear, $P < 0.01$; quadratic, $P = 0.03$). It should be noted that TVFAS concentration in the rumen is governed by several factors such as dry matter digestibility, rate of absorption, rumen pH, transportation of the digesta from the rumen to the other parts of the digestive tract, and the microbial population in the rumen and their activities (Allam et al. 1984). Onwubuemeli et al. (1985) substituted corn with 0, 10, 20, and 30% potato waste in steers diet. They reported that rumen ammonia, acetate, acetate to propionate ratios, and total volatile fatty acids were lower at high intakes of potato waste and pH was increased. The shift in rumen fermentation when large amounts of potatoes were fed explains the depressed butter fat on these rations. Sugimoto et al. (2006) fed steers at 0.2, 0.4 and 0.6% of BW, potato pulp silage-based diet (PPS) and a grain-based diet (GRAIN).They reported that steers fed the grain diet had a lower ($P<0.1$) ruminal pH compared with steers fed the PPS diet. Ruminal pH was not significantly affected by feeding level; however, it was numerically higher for steers supplemented at 0.2% per BW than that for the steers supplemented above 0.4% per BW due probably to the higher starch intake.

Sampling time has a significant effect on rumen fluid parameters. Inclusion Potato processing waste in the sheep diets significantly decreased ($P<0.05$) ruminal pH at 3 hours post feeding compared with before feeding. However, it significantly increased ($P<0.05$) NH_3–N and TVFS concentrations at 3 hours post feeding compared with before feeding. These results are in agreement with those found by Omer and Tawila (2008) and Omer et al. (2010). In contrast, these results were not in agreement with those found by Onwubuemeli et al. (1985) who studied the effect of sampling time at 0, 2, 4, and 8 hours on rumen fermentation of diets containing 0%, 10%, 20%, and 30% PPW fed to dairy cattle. They suggested that the higher percentages of dietary PPW decreased ($P<0.05$) rumen ammonia concentrations, which peaked 2 hours post feeding. Also, the same authors observed that TVFAS concentration was decreased while pH value was increased at 4 hours post feeding.

Inclusion PPW in sheep diets had no significant effect on molar proportion of volatile fatty acids. Omer et al (2010) with sheep and Gado et al. (1998) with goat fed diets containing potato processing waste found significant increased ($P<0.05$) of acetic acid and butyric acid and insignificantly increased ($P>0.05$) both propionic acid and acetic/ propionic ratio compared to the control diet. Neither diet nor the feeding level had any effects on the proportion of ruminal propionate (Sugimoto et al. 2006).

Table 4 Effect of dietary treatments and sampling time on the basic patterns of rumen fermentation by the experimental group lambs

Item	TMR_1	TMR_2	TMR_3	SEM
pH value	6.22	6.25	6.30	0.02
NH_3-N (mg/dl)	24.69	23.88	23.98	0.41
TVFAs (mEq/dl)	7.47	7.64	7.52	0.21
Sampling time	Before feeding		3 hrs post feeding	
pH value	6.32a		6.16b	0.02
NH_3-N (mg/dl)	23.32b		25.05a	0.41
TVFAs (mEq/dl)	6.42b		8.66a	0.21
Molar proportion of VFAs and acetate/propionate ratio				
Acetic acid (A; %)	42.59	42.93	42.50	0.21
Propionic acid (P; %)	24.53	24.65	24.70	0.18
Butyric acid (%)	18.21	18.34	18.50	0.15
A:P ratio	1.74	1.74	1.72	0.02

a, b and c = means in the same row having different letters differ significantly (P<0.05)
[a] *NH_3-N* ruminal ammonia nitrogen [b] *TVFAs* total volatile fatty acids

Blood plasma constituents by the experimental group lambs

Data of Table 5 showed that inclusion PPW in sheep diets had no significant effect on blood plasma glucose, total protein, albumin, glubulin, albumin: glubulin ratio, urea, triglycerides and cholesterol. These results are inagreement was those obtained by Gado et al (1998) who indicated that partial replacing concentrate by potato processing waste at 0, 25, 50 or 100% in growing Baladi goats had no significant (P>0.05) effect on the serum urea nitrogen.

Table 5 Effect of dietary treatments on blood plasma constituents by the experimental group lambs

Item	Experimental rations			SEM
	TMR_1	TMR_2	TMR_3	
Glucose (mg per100 ml)	63.43	64.25	65.00	0.43
Total protein (g per100 ml)	7.91	7.86	7.84	0.03
Albumin (g per100 ml)	1.81	1.80	1.80	0.004
Globulin (g per100 ml)	6.10	6.06	6.04	0.03
Albumin: Globulin ratio	4.37	4.37	4.36	0.02
Urea (mg per100 ml)	22.51	22.93	23.11	0.19
Triglycerides (mg per100 ml)	30.09	30.11	30.16	0.04
Cholesterol (mg per100 ml	219	221	220	0.76

Growth performance of the experimental group lambs

Growth performance of the experimental group animals is presented in Table 6. The results showed that increasing level of PPW in the experimental rations significantly (P<0.05) decreased final weight, body weight gain, average daily gain (ADG), and relative gain, while feed conversion expressed as kilogram intake of DM per kilogram gain insignificantly decreased. These results were in agreement with those obtained by Omer et al (2010) when sheep fed diets contained PPW replaced 25% or 50% of yellow corn in basal diet. Sauter et al. (1980) recorded a 17% decrease in ADG and 5% decrease in efficiency with inclusion of 50% potato by-product as compared with 25% potato by-product in barley-based diets. Also, Radunz et al. (2003) recorded that increasing PPW decreased ADG and feed efficiency from 0% to 30% and then increased at 40% (quadratic, P < 0.01) when they used PPW from frozen potato products industry in high grain beef cattle finishing diets. In contrast, these results were not in agreement with those found by Omer and Tawila (2008) with Baladi goats and Makkar et al. (1984) with buffalo calves. They found that ADG and feed efficiency were better when potato waste substituted cereal grains in the rations. On the other hand, Duynisveld et al. (2004) attributed that the replacement of corn with potato processing by-product in beef cattle rations did not affect (P>0.05) average daily gain and improved (P<0.05) feed conversion efficiency.

Table 6 Growth performance of the experimental groups

Item	Experimental rations			SEM
	TMR_1	TMR_2	TMR_3	
No. of animals	9	9	9	-
Initial weight (kg)	27.30	27.20	27.00	0.31
Final weight (kg)	52.00 a	48.70 b	46.30 c	0.64
Gain (kg)	24.70 a	21.50 b	19.30 c	0.55
Experimental duration, days	105	105	105	-
ADG (g/day)	235 a	205 b	184 c	5.20
Relative gain (% of initial weight)[a]	90.48 a	79.04 b	71.48 c	2.12
Feed conversion (kg intake /kg gain) of				
Dry matter (DM)	6.16	6.70	7.26	0.29
Total digestible nutrient (TDN)	4.65	5.11	5.67	0.23
Crude protein (CP)	0.87	0.92	0.96	0.04
Digestible crude protein (DCP)	0.56	0.64	0.67	0.03

a, b and c = means in the same row having different letters differ significantly ($P<0.05$)
[a] Relative gain (percent of initial weight)= gain/initial weight x 100

Economic evaluation of the experimental group lambs

Economic efficiency was represented by daily profit over feed cost. The costs were based on average values of year 2010 for feeds and live body weight. Feeding costs and profit above feeding costs are shown in Table 7. Inclusion PPW in sheep diets lead to the decrease of total daily feeding costs of experimental rations by 15.56% for TMR_2 while 25.34% for TMR_3 in comparison with the control diet TMR_1. Meanwhile, average daily gain, daily profit above feeding cost, and relative economical efficiency for TMR_2 and TMR_3 were less compared to the control diet TMR_1. Feed cost LE per kilogram gain was improved by 3.16% and 4.62% for TMR_2 and TMR_3, respectively, compared to control diet TMR_1. These results are in agreement with those found by Omer et al. (2010). Potato by-products or potato waste can be economical substitute for feedlot cattle (Murphy 1997) and for sheep (Omer and Tawila 2008 and Omer et al., 2010).

Table 7 Economic evaluation for the experimental rations

Item	Experimental rations		
	TMR_1	TMR_2	TMR_3
Daily feed intake (fresh; kg)	1.585	1.498	1.451
Value of 1-kg feed (LE)	1.220	1.090	0.995
Daily feeding cost (LE)[a]	1.934	1.633	1.444
Average daily gain (kg)	0.235	0.205	0.184
Value of daily gain (LE)[b]	6.345	5.535	4.968
Daily profit above feeding cost (LE)	4.411	3.902	3.524
Relative economical efficiency[c]	100	88.46	79.89
Feed cost (LE/kg gain)	8.23	7.97	7.85

LE = Egyptian pound equals 0.18 USS approximately
[a] Based on prices of year 2010 [b] Value of 1- kg live body weight equals 27 LE (2010)
[c] Assuming that the relative economic efficiency of control diet equals 100

4. Conclusions

From the results of this study it could be concluded that potato processing waste can be successfully fed to sheep. Quality of the product and dry matter intake must be monitored for maximum performance. Potato processing waste can be an economical substitute for sheep rations. Optimal inclusion of PPW in sheep rations may depend on the cost of transportation and other dietary ingredients used in formulation of rations.

References

Abou-Raya, A.K., 1967. Animal and Poultry Nutrition. 1st Edit. Pub. Dar El-Maarif, Cairo (Arabic text book).

A.E.S.I., 2008. Agriculture Economic and Statistics Institute, Agric., Economics, Pub. By Agric. Res. Center, Egypt.

Allain, C.C., Poon, L.S., Chan, C.S., Richmond, W. and Fu, P.C., 1974. Enzymatic determination of total serum cholesterol. Clin. Chem., 20: 470 – 475.

Allam, S.M., Abou-Raya, A.K., Gihad E.A. and El-Bedawy T.M., 1984. Nutritional studies by sheep and goats fed NoaH treated straw. 1st Egyptian British conference on Animal and Poultry Production, Zagazig, 11–13 Sep. P. 53.

A.O.A.C., 1995. Association of Official Analytical Chemists: Official Methods of Analysis. 16 th ed. Washington D.C.USA.

Armstrog, W.D.and Carr C.W., 1964. Physiological Chemistry: Laboratory directions 3: 75 Buger Puplishing Co. Minneapolis, Minnesota, U.S.A.

Bauer, T.D., Ackermann, P.G. and Toro, G., 1974. Methods in clinical chemistry. Clinical laboratory methods. The C.V. Mosley Company, Saint Louis, p. 946.

Blaxter, K.L., 1968. The energy metabolism of ruminants. 2nd ed. Charles Thomas Publisher. Spring field. Illinois, U.S.A.

Boyles, S., 2006. Feeding potato processing wastes and culls to cattle. OSU Extension Beef Specialist. http://beef,osu.edu/library/potato.html.

Doumas, B., Wabson, W.W. and Biggs, H., 1971. Albumin standards and measurement of serum with bromocrfsol green. Clin. Chem. Acta, 31: 87.

Duynisveld, J.L., Charmely E., Mandell I. and Aalhus J., 2004. Replacing corn or barley with potato processing by–product in beef finishing diets improves feed conversion efficiency and alters carcass fat distribution. Journal of Animal Science 82, Suppl. 1.

El–Boushy, A.R.Y. and Van der Poel, A.F.B., 1994. Poultry feed from waste processing and use. Chapman and hall (Ed).

Erwin, E.S., Marco, C.J. and Emery, E.M., 1961. Volatile fatty acid analysis of blood and rumen fluid by gas chromatography. Journal of Dairy Science 44: 1768.

F.A.O., 2008. Potatoes, nutrition and diet. International year of the potato, 2008 www.potato 2008.org

Fossati, P and Principe, L., 1982. Clin. Chem. 28, 2077.

Gado, H., Mansour, A.M., Metwally, H.M. and El-Ashry, M.A., 1998. The effect of partial replacing concentrate by potato processing waste on performance of growing Baladi goats. Egyptian Journal of Nutrition and feeds 1 (2): 123–129.

Goering, H.K. and Van Soest, P.J., 1970. Forage fiber analyses (Apparatus, Reagents, Procedures and some applications). USDA, Agr. Hand. Book 379..

Kromann, R.P., Meyer, J.H. and Stielau, W.J., 1967. Steam distillation of volatile fatty acids in rumen digesta. Journal of Dairy Science 50:73.

Lardy, G and Anderson, V., 2009. Alternative feeds for ruminants. NDSU.permission@ndsu.edu. North Dakota State University Agriculture and University Extension Dept. 7070, Morrill 7, P.O. Box 6050, Fargo, ND 58108-6050.

Makkar, G.S., Kakkar, V.K., Bhullar M.S. and Malik, N.S., 1984. Potato waste as a substitute for cereal grains in the rations of buffalo calves. Indian Journal of Animal Science 54: 1060–1061.

Murphy, S., 1997. Feeding potato by-products. Prince Edward Island, Agriculture and Foresty, Fact Sheet, AGDEX 420–68. http://www.gov.pe.ca/af/agweb/library/factsheet/wastpot. Php3.

N.R.C., 1985. Nutrient requirements of domestic animals. Nutrient requirements of sheep. National Academy of Sciences, Washington. D.C.

Omer, H. A. A., Abdel-Magid, S. S., Ahmed S. M., Mohamed, M. I. and Awadalla, I. M., 2010. Response to partial replacement of yellow corn with potato processing waste as non-traditional source of energy on the productive performance of Ossimi lambs. Trop Anim Health Prod 42:1195–1202.

Omer, H.A.A and Tawila, M.A., 2008. Growth performance of growing Baladi goats fed diets containing different levels of sun dried peel potato waste. Egyptian Journal of Nutrition and feeds 11 (3): 453–468.

Onwubuemeli, C., Huber, J.J., King, K.J. and Johnson, C.O., 1985. Nutritive value of potato processing wastes in total mixed rations for dairy cattle. Journal of Dairy Science 68: 1207–1214.

Patton, C.J. and Crouch, S.R.., 1977. Spectrophotomattic and kinetics investigation of the Berthelot reaction for the determination of ammonia. Anal. Chem. 49: 464.

Radunz, A.E., Lardy, G.P., Bauer, M.L., Marchello, M.J., Loe, F.R. and Berg, P.T., 2003. Influence of steam–peeled potato processing waste inclusion level in beef finishing diets: Effects on digestion, feedlot performance and meat quality. Journal of Animal Science 81:2675–2685.

SAS., 1998. Statistical Analysis System. SAS Users Guide. Version 6. 12 Ed. Basics SAS Institute Inc., Cary, NC, USA.

Sauter, E.A., Hinman, D.D., Bull, R.C., Howes, A.D., Parkinsson, J.F., and Stanhope, D.L., 1980. Studies on the utilization of potato processing waste for cattle feed. University of Idaho Agric. Exp. Sta. Res. Bull 112, Moscow, ID.

Smith, T. J. and Huxsoll, C.C., 1987. Peeling potatoes for processing (Eds W.F. Talburt and O. Smith) AVI – Van Nostrand rein hold Company, New York, PP. 333–369.

Sugimoto, M. Saito W., Ool M., Sato Y., Saito T. and Mori K. 2006. The effects of potato pulp and feeding level of supplements on digestibility, in situ forage degradation and ruminal fermentation in beef steers. Animal Science Journal 77, 587–594.

Szasz, J. I., Hunt, C. W., Turgeon, O. A., Szasz, Jr. P. A. and Johnson, K. A., 2005. Effects of pasteurization of potato slurry by-product fed in corn-or barley based beef finishing diets J. Anim. Science 83: 2806-2814.

Tawila, M.A., Omer, H.A.A and Gad, Sawsan M., 2008. Partial replacing of concentrate feed mixture by potato processing waste in sheep rations. American-Eurasian Journal of Agricultural & Environmental Science 4 (2): 156–164.

Van Soest, P.J., Robertson, J.B. and Lewis, B.A., 1991. Methods for dietary fiber, neutral detergent fiber and non starch polysaccharides in relation to animal performance. Journal of dairy Science 74: 3583–3597.

Van't Klooster, A.T., 1986. Pathological aspects of rumen fermentation. In: New developments and future perspectives in research on rumen function (Neimann–Sorensen, A., Ed). Commission of the European Communities, Luxembourg, 259–276 (C.F Gado et al., 1998).

Abbreviations

ADF	Acid detergent fiber
ADL	Acid detergent lignin
ADG	Average daily gain
BW	Body weight
CF	Crude fiber
CP	Crude protein
DCP	Digestible crude protein
DM	Dry matter
DMI	Dry matter intake
EE	Ether extract
LE	Egyptian pound
Mcal/kg	Megacalories per kilogram
NDF	Neutral detergent fiber
NFE	Nitrogen-free extract
NH_3–N	Ammonia nitrogen
NRC	National Research Center
OM	Organic matter
PS	Pea straw
PPB	Potato processing by-product
PPW	Potato processing waste
TMR	Total mixed ration
TMR_1	Control ration contained 0% potato processing waste
TMR_2	Second experimental ration contained 7% potato processing waste of total mixed ration
TMR_3	Third experimental rations contained 14% potato processing waste of total mixed ration
UDCSM	Undecorticated cotton seed meal
WB	Wheat bran
YC	Yellow corn

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