J. of Animal and Poultry Production, Mansoura Univ., Vol . 15 (9):137 - 143, 2024

Journal of Animal and Poultry Production

Journal homepage & Available online at: www.jappmu.journals.ekb.eg

Effect of orange pulp inclusion in the multi-nutrient roughage blocks on the performance of Barki lambs

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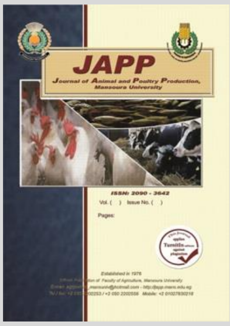

ABSTRACT

This study used the multi-nutrient roughage blocks (MRB), including different replacement levels of sugar cane bagasse with orange pulp (OP), 0% for MRB1, 25% for MRB2, and 50% for MRB3. Three experimental rations were formulated using concentrate feed mixture (CFM) and MRB at 60:40%, respectively, as follows: ration1 (R1): CFM+ MRB1; ration2 (R2): CFM+ MRB2; ration3 (R3): CFM+ MRB3. Fifteen Barki lambs, with an average of 31.26 ± 1.70 kg of body weight, were assigned to three groups (5 lambs per group). Lambs were fed the experimental rations according to the nutrient requirements of the NRC (1985) for 84 days in a growth trial, followed by a digestibility trial. Rumen and blood parameters were also investigated. The results showed a significant increase in the final body weight (FBW), body weight gain (WG), average daily gain (ADG), and digestible organic matter fermented in the rumen (DOMFR) for lambs fed R3. The feed conversion ratio (FCR) and microbial nitrogen yield were significantly ($p \leq 0.05$) improved for R2 and R3 compared to R1. OP substitution did not affect the digestibility of all nutrients except for crude protein (CP) and crude fiber (CF). The concentration of total volatile fatty acids (VFA) increased linearly ($p \leq 0.01$), with the substitution levels being 12.81, 13.45, and 13.88 meq/100 ml for R1, R2, and R3, respectively. However, a linear decrease was observed for the population of total fungi in the rumen as the substitution level increased. No adverse effects on liver and kidney function were observed.

Keywords: orange pulp, multi-nutrient blocks, growth performance, digestibility, blood parameters

INTRODUCTION

In Egypt, there is an annual shortage of about 4.2 million tons of digestible nutrients (Shoukery, 2019). Attention should be directed towards unconventional feed or agro-industrial by-products to partly or completely replace traditional feedstuffs (Bakr, 2020). According to Hamada (2011), Egypt produces about 3 million tons of sugarcane bagasse annually. Furthermore, huge amounts of waste are produced in Egypt from processing citrus fruits (Ibrahim *et al*., 2024). One of the main citrus by-products used for ruminant feeding is citrus pulp (Ali *et al*., 2015). Orange pulp was included in the diets for fattening lambs as a partial replacement of barley and corn grains, which improved the lambs' performance (Tadayon *et al*., 2017). It was also included in lactating goats' diets as a replacement of cereals with a profitable and healthy nutritional effect (Guzmán *et al*., 2021).

Many technologies were suggested to increase the utilization of agro-industrial by-products, among them feed block technology. Multi-nutrient blocks have been utilized for ruminants since the early 1980s (Sansoucy, 1995). Feed block technology allows the selection of locally available ingredients to be included. They mainly consist of some agro-industrial by-products, urea, minerals, vitamins, and binder materials such as cement and/or quicklime (Salem *et al*., 2004). The complete feed blocks, containing roughage and concentrate, can be formulated using straws (or any locally available and suitable roughages) and dietary supplements such as molasses, concentrates, minerals, and salt (Patil *et al*., 2019). Using multi-nutrient blocks has several advantages, such as the utilization of agro-industrial materials, especially those with high moisture content, the preservation of ingredients when their cost is low to be used later, reducing environmental pollution from burning crop residues, storing for a long time, and ease of transportation (Salem *et al*., 2004; Patil *et al*., 2019). They can partially or totally replace high-cost concentrate feed to reduce feeding costs. They improve digestion of low-quality roughages because of their balanced nutrient supply. El Hag *et al.* (2002) successfully used date palm by-products in multi-nutrient blocks, which were partly substituted for the roughage component in the diets of growing sheep and goats. They concluded that multi-nutrient blocks increased the average daily gain and feed conversion ratio for sheep and goats and efficiently reduced cost/kg gain by 38%. In another study, cactus fruit wastes were included in multi-nutrient blocks based on the olive cake (Salem *et al*., 2003). They noted an enhancement in the nutritive value of diets based on kermes oak foliage, despite the low amounts of blocks consumed by goats. Recently, El-Sheikh *et al.* (2024) substituted citrus by-products for 25 and 50% corn grains in multi-nutrient concentrate blocks, and they observed similar sheep performance without reversible effects at the 25% replacement level. This study aimed to evaluate the effect of replacing sugarcane bagasse with orange pulp within multi-nutrient roughage blocks on the performance, rumen fermentation, and blood metabolites of Barki lambs.

MATERIALS AND METHODS

The current investigation was performed at Menoufia University (Shebin El-Kom), Animal Production Department of the Faculty of Agriculture, in compliance

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DOI: 10.21608/jappmu.2024.313688.1121

with Scientific Research Ethics and Animal Use Committee (SRE& AUC) Faculty of Agriculture, Menoufia University (Reference No. 21-SRE & AUC-MUAGR-08-2024).

Experimental diets

The multi-nutrient roughage blocks based on sugarcane bagasse were used in this study. The preparation of blocks was performed in subsequent steps as follows: firstly, sugarcane bagasse was chopped into small pieces (1-1.5 cm). Then, it was hydrated with a mixed solution of molasses, urea, salt, and calcium sulfate, as each constituent was dissolved in the water separately to make the final mixed solution. The mixed solution was slowly added and mixed with the sugarcane bagasse until the mixture could be moldable. The ability to mold was evaluated by the hand-molding test described by Salem *et al*. (2000). After that, the mixture was pressed into metal molds (20×15 cm) with approximately 2 kg of loading capacity. Finally, the resultant blocks were completely dry in a shady and well-ventilated place. The sugar cane bagasse in the blocks was partially replaced with orange pulp (OP), a waste product, after the juice extraction. The replacement levels were 0%, 25%, and 50%, as follows: multi-nutrient roughage block 1 (MRB1): 90% sugarcane bagasse + 0% OP; multi-nutrient roughage block 2 (MRB2): 67.5% sugarcane bagasse + 22.5% OP; multi-nutrient roughage block 3 (MRB3): 45% sugarcane bagasse + 45% OP. The formulation and chemical composition of multi-nutrient roughage blocks are presented in Table (1).

The multi-nutrient roughage blocks (MRB) were included in three experimental rations with the concentrate feed mixture (CFM) at a 40:60% roughage: concentrate ratio. The experimental ration1 (R1): CFM+ MRB1; the experimental ration2 (R2): CFM+ MRB2; the experimental ration3 (R3): CFM+ MRB3. The ingredients and chemical composition of the experimental rations are shown in table (2). The concentrate feed mixture (CFM) was formulated as follows: 50% yellow corn, 8% soybean meal, 17% cottonseed meal, 22% wheat brain, 1.7% limestone, 1% Nacl, and 0.3% mineral and vitamin mixture provided per kg of diet: vitamin A: 200,000IU; vitamin D3: 300,000IU; vitamin E: 10,000IU; vitamin K: 2mg and Anti-oxidant: 1000mg/kg, Cu: 3300mg/kg; Fe: 100mg; Zn: 16,500mg/kg; Mn: 9000mg; I: 120mg/kg; Co: 90mg/kg and Se: 90mg/kg.

Table 1. Ingredients and composition (% on DM basis) of multi-nutrient roughage blocks (MRB)

Ingredients	Control	Replacement (%) 25	50
	MRB 1	MRB 2	MRB 3
Sugar cane bagasse	90.00	67.50	45.00
Orange pulp	0.00	22.50	45.00
Molasses	3.00	3.00	3.00
Urea	1.00	1.00	1.00
Salt	1.00	1.00	1.00
calcium sulfate	5.00	5.00	5.00
Nutrient composition (% of DM) of the multi-nutrient roughage feed blocks			
Dry matter, DM	85.90	90.37	89.95
Organic matter, OM	96.88	96.41	95.95
Crude protein, CP	5.84	7.05	8.26
Crude fiber, CF	33.64	27.78	21.92
Ether extract, EE	1.05	1.60	2.15
Ash	3.12	3.59	4.05
Nitrogen-free extract, NFE	56.34	59.98	63.61
Neutral detergent fiber, NDF,	68.18	55.54	42.90
Acid detergent fiber, ADF	52.425	42.15825	31.8915
Total digestible nutrients (%), TDN	54.52	57.76	60.99

TDN (DM%) = -17.2649+1.2120(%CP) +0.8352 (%NFE) + 2.4637 (%EE) + 0.4475 (% CF) (Kearl, 1982).

Table 2. Nutrient composition (% of DM) of the ingredients and experimental rations

	Experimental ingredients			Experimental rations		
	Concentrate feed mixture, CFM	Orange waste	Sugar cane bagasse	R1	R2	R3
Dry matter, DM	88.56	88.65	90.54	87.49	89.28	89.11
Organic matter, OM	90.28	94.82	96.89	92.92	92.73	92.55
Crude protein, CP	14.54	8.54	3.17	11.06	11.54	12.03
Crude fiber, CF	9.91	11.26	37.31	19.40	17.06	14.71
Ether extract, EE	3.75	3.58	1.14	2.67	2.89	3.11
Ash	9.72	5.18	3.11	7.08	7.27	7.45
Nitrogen-free extract, NFE	62.08	71.44	55.27	59.78	61.24	62.69
Neutral detergent fiber, NDF	26.89	19.57	75.76	43.41	38.35	33.29
Acid detergent fiber, ADF	8.75	12.62	58.25	26.22	22.11	18.01
Total digestible nutrients (%), TDN	65.88	66.61	52.24	61.34	62.63	63.92

TDN (DM%) = -17.2649+1.2120(%CP) +0.8352%NFE+2.4637% EE+0.4475 % CF (Kearl, 1982).

Chemical composition:

The chemical composition of the feedstuffs, multi-nutrient blocks, experimental rations, and feces was performed according to AOAC (2000).

Growth trial:

Fifteen Barki lambs, with an average of 31.26 ± 1.70 kg of body weight, were assigned to three groups according to their body weight (5 lambs/group). Lambs were fed the experimental rations according to the nutrient requirements of the NRC (1985). Lambs were fed in groups twice a day, at 8 a.m. and 4 p.m. Water was always available for drinking. Every two weeks, animals were weighed before morning feeding; hence, the offered amounts of experimental rations were adjusted. This trial lasted for 84 days. Records of the lambs' weight and daily feed intake (FI) were kept to calculate the average daily gain (ADG) and feed conversion ratio (FCR).

Digestibility trial:

Lambs were housed individually in metabolic boxes, which allowed separate fecal collection. The trial consisted of 14 days for adaptation and 7 consecutive days for fecal collection. The offered and residual feed were recorded daily. Animal feces were weighed, and a 10% sample was oven-dried, finely ground, and kept for analysis.

Rumen fermentation:

Rumen liquor was obtained by stomach tube at 2 hours post-feeding. The pH was measured immediately after collection using a digital pH meter. Rumen samples were filtered through three layers of cheesecloth. The fluid portion of the strained samples was acidified with 7.2 N H_2SO_4 (1 ml of acid / 100 ml of rumen fluid). Total volatile fatty acid concentration was measured according to the steam distillation method described by Warner (1964). The ammonia-N (NH3-N) concentration was determined by the method documented by Horn *et al*. (1981).

Blood parameters:

To obtain blood samples, every lamb was punctured in the jugular vein to allow blood flow. Before morning feeding, blood samples were collected in non-heparinized tubes and then centrifuged for 15 minutes at 4000 rpm. The serum was carefully poured into Eppendorf tubes and frozen at -20ºC for later analysis. Serum samples were analyzed for total protein concentrations, albumin, alanine transaminase (ALT), aspartate transaminase (AST), creatinine, and urea-N. Globulin concentration was calculated as the difference between the total protein and albumin. Analyses were performed using commercial kits (Stanbio Laboratory, Boerne, TX, USA), observing the manufacturer's guidelines.

Statistical analysis:

Data were analyzed using Statistical Analytical System (SAS, 2002), Version 9.3.1, according to the General Linear Model as follows:

$$Y_{ij} = \mu + T_i + e_{ij}$$

where: **Y_{ij} = the parameters under analysis. μ = the overall mean. Ti = the treatment effect (i = 1 …and 3). e_{ij} = the random error of means. Differences among means were evaluated using Duncan's (1955) Multiple Range test.**

RESULTS AND DISCUSSION

The effect of orange pulp substitution on:

Feed intake and growth performance:

As shown in Table (3), the highest dry matter intake (DMI) was recorded by sheep fed R3, followed by R2 and R1, respectively. However, no significant differences in DMI among the groups were recorded. Substituting with OP had a clear impact on the growth performance of sheep. Even though the mean initial body weight was not significantly different among groups, the final body weight significantly (P≤0.001) increased as the substitution level increased. The final body weight values were 41.79, 43.87, and 47.43 kg for R1, R2, and R3, respectively. The highest average daily gain was obtained by sheep fed R3 (173.51 g/d) and significantly (P<0.05) differed with sheep fed R1 (129.36 g/day). Sheep fed R2 had an average daily gain of about 164.94 g/day without significant differences with the other groups. FCR was significantly (P≤ 0.05) improved from 8.91 for R1 to 8.22 and 8.27 for R2 and R3, respectively. The digestible organic matter fermented in the rumen (DOMFR) had a significant (p≤0.05) increase only in R3, which was 658.75 g, compared to 501.53 and 596.12 g for R1 and R2, respectively. The microbial nitrogen yields linearly (p≤0.05) increased as the replacement level increased, being 16.05, 19.08, and 21.08 for R1, R2, and R3, respectively.

Similarly, DMI was not affected when the citrus pulp or by-product was substituted for roughage grass hay (Castro and Zanetti, 1998) or substituted for corn grain in the multi-nutrient concentrate blocks (El-Sheikh *et al*., 2024). DMI was reported to be increased due to dried OP inclusion in the diets (Bueno *et al*., 2002; Tadayon *et al*., 2017). On the other hand, a reduction in DMI was achieved by the inclusion of citrus pulp, either fresh (Luzardo *et al*., 2021) or dehydrated (Cribbs *et al*., 2015). Earlier investigators suggested many explanations for increased DMI, such as that increased feed intake might be due to the higher palatability of citrus pulp (Oni *et al*., 2008) or the increased digestibility of diets containing OP and/or the high level of pectin contained in OP that induces a more suitable rumen environment and so greater intake (Tadayon *et al*., 2017). Our results of ADG and FCR are in agreement with some investigators who stated that citrus pulp substitution for barley and corn grains at 110 and 220 g/kg DM increased ADG and FCR (Tadayon *et al*., 2017), and the increasing rate was reduced as the level of inclusion increased (Bueno *et al*., 2002), while significant reductions were noted by others (Cribbs *et al*., 2015; El-Sheikh *et al*., 2024). However, ADG and FCR were not affected when the citrus pulp was either partly substituted for corn silage and corn grains (Luzardo *et al*., 2021), concentrate feed mixtures (Sharif et al., 2018), or Wolley substituted for ground corn (de Oliveira *et al*., 2022).

The primary factor influencing microbial protein production is energy in the form of fermentable organic materials (Santos and Huber, 2002). In the current study, the higher OMFR and microbial nitrogen yield in the OP-included rations can verify the increased ADG since the microbial protein represents 40-70% of the total metabolizable protein available, hence enhancing animal performance (Santos and Huber, 2002). Microbial protein synthesis increased due to citrus pulp substitution (Highfill *et al*., 1987; Taniguchi *et al*., 1999), whereas de Oliveira *et al*. (2022) revealed no effect of substitution.

Table 3. Growth performance, feed intake, and feed conversion of Barki sheep fed different experimental diets

Attributes	Experimental diets			SEM	P- value
	Ration 1	Ration 2	Ration 3		
Dry matter intake (g/day), DMI	1124.6	1319.2	1433.7	10.607	0.2542
Initial body weight. (kg), IBW	30.92	30.01	32.86	1.534	0.5898
Final body wt. (kg), FBW	41.79[c]	43.87[b]	47.43[a]	0.419	0.0027
Body wt. gain (kg/period), WG	10.87[b]	13.86[ab]	14.58[a]	1.001	0.0382
Av. Daily gain (g/h/day), ADG	129.36[b]	164.94[ab]	173.51[a]	8.823	0.0384
feed conversion ratio, FCR	8.91[a]	8.22[b]	8.27[b]	0.092	0.0286
Digestible organic matter fermented in the rumen (g), DOMFR*	501.53[b]	596.12[ab]	658.75[a]	25.515	0.0195
Microbial nitrogen yield, (g) **	16.05[c]	19.08[b]	21.08[a]	0.774	0.0394

a,b,c means within each row with different superscripts are significantly different.
***Digestible organic matter fermented in the rumen (DOMR) was assumed to be digestible organic matter multiplied by 0.65 (Masama et al., 1997).**
**** Microbial nitrogen yield = 32g/kg DOMFR (ARC, 1984)**

Digestibility and nutritive value:

The nutrient digestibility and feeding value of Barki sheep fed experimental diets are shown in Table (4). The apparent digestibility of all nutrients, dry matter (DM), organic matter (OM), ether extract (EE), nitrogen-free extract (NFE), neutral detergent fiber (NDF), and acid detergent fiber (ADF), was not significantly (p> 0.05) impacted by OP inclusion, except for crude protein (CP) and crude fiber (CF). The apparent digestibility of CP had the highest value in R3 (68.59%), followed by R2 (67.34%), and they were significantly (P≤ 0.05) higher than R1 (64.38%), with no significant difference between R2 and R3. The same trend was observed for CF digestibility since the lowest value (65.51%) was recorded by R1, followed by R2 (68.51%), and tended to be the highest (69.65%) in R3; this might be attributed to the significant proportion of pectin in the OP, which has higher ruminal degradation and digestibility than cell wall constituents in sugarcane bagasse since pectin is considered the most rapid fermentable complex carbohydrate (Soest, 1982).

Table 4. Nutrient digestibility and feeding value of Barki sheep fed different experimental rations

Attributes	Experimental rations			SEM	p-value
	R 1	R 2	R3		
Nutrients digestibility (%)					
Dry matter, DM	66.26	67.64	68.85	1.465	0.4862
Organic matter, OM	68.61	69.52	70.69	1.612	0.6706
Crude protein, CP	64.38[b]	67.34[a]	68.59[a]	0.910	0.0258
Crude fiber, CF	65.51[b]	68.51[a]	69.65[a]	0.887	0.0240
Ether extract, EE	77.92	79.01	79.89	1.935	0.7767
Nitrogen-free extract, NFE	70.78	71.45	72.88	5.952	0.9682
Neutral detergent fiber, NDF,	61.15	63.86	66.22	3.165	0.5486
Acid detergent fiber, ADF	60.78	63.87	65.65	1.799	0.2085
Total digestible nutrients (%), TDN*	64.55[b]	68.36[ab]	69.78[a]	1.088	0.0533
Digestible crude protein, DCP	7.12[c]	7.78[b]	8.25[a]	0.105	0.0001

a,b,c. means within each row, with different superscripts are significantly different

***Total digestible nutrients (TDN, %) = % digestible crude protein + % digestible crude fiber + %digestible N-free extract + (2.25 x % digestible ether extract).**

Regarding nutritive value, the total digestible nutrients (TDN) just had a significant (P≤0.05) increase in R3 (69.78%) compared to R1 (64.54%). The digestible crude protein (DCP) values linearly increased (p≤0.01) as the OP substitution increased. The values were 7.12, 7.78, and 8.25% for R1, R2, and R3, respectively: this corroborates with CP digestibility, which increased in the same pattern.

Tadayon *et al.* (2017) revealed that DM, OM, CP, and neutral detergent fiber (NDF) digestibility was increased as dried OP level increased. Also, de Oliveira *et al.* (2022) reported a significant improvement in NDF digestibility in the diets that included citrus pulp instead of ground corn. CF digestibility increased at 50% citrus by-product substitution (El-Sheikh *et al*., 2024). On the other hand, CP digestibility decreased while acid detergent fiber (ADF) and cellulose digestibility increased due to 40% and 80% dried OP substitution in the goats' diet; nonetheless, NDF digestibility was not affected (Guzmán *et al*., 2021). Sharif *et al.* (2018) found that citrus pulp inclusion up to 40% did not affect the digestibility of DM, OM, CP, NDF, and ADF. Compared to no carbohydrate supplementation, pectin supplementation, unlike starch supplementation, did not decrease the NDF digestibility of low-quality forages (Costa *et al*., 2008). In addition, Villarreal *et al.* (2006) concluded that adding citrus by-products to ruminant feed, which mainly depends on straw, can compensate for nutritional deficiencies in the straw and enhance nutrient absorption.

Rumen fermentation:

Rumen parameters as affected by OP inclusion are presented in Table (5). The pH values were 6.55, 6.51, and 6.39 for R1, R2, and R3, respectively. The NH3-N concentration was approximately similar in all groups, ranging from 18.11 to 18.21 mg/100 ml. Regarding the rumen pH and the NH3-N, the differences were insignificant among the groups. However, the total VFA's were significantly (p≤0.01) increased in a linear pattern. Values were increased from 12.8 for R1 to 13.45 and 13.88 for R2 and R3, respectively. Perhaps it was correlated with OMFR, which increased in the OP rations (table 3), leading to more production of VFA.

Table 5. Rumen fluid parameters of Barki sheep fed different experimental diets

Attributes	Experimental rations			SEM	p-value
	R1	R 2	R3		
pH	6.55	6.51	6.39	0.158	0.7640
Total VFA's, meq/100 mL, VFA	12.81[c]	13.45[b]	13.88[a]	0.131	0.0128
Ammonia-N, mg/100 ml, NH3H	18.11	18.16	18.21	0.346	0.9794
*Total fungi (x10^4/ml)	2.13[a]	1.82[b]	1.75[b]	0.059	0.0017

a,b,c. means, within each row, with different superscripts are significantly different.

***Total fungi were calculated according to Difco (1984).**

In respect of total fungus in the rumen, the inclusion of OP in the rations led to a significant (P≤0.01) depression in the count of fungus, which decreased from 2.13 for R1 to 1.8.2 and 1.75 for R2 and R3, respectively. This reduction is most likely due to lower CF content in the rations containing OP compared to R1 (table 2) since it has been established that high-fiber diets support a higher fungus population in the rumen (Ho and Abdullah, 1999).

McDonald *et al.* (2011) reported the normal range of ruminal pH to be from 6.1 to 6.9. Sinclair *et al.* (1993) indicated that ruminal NH3-N concentrations should not fall below 5 mg/dl, considered the minimum level required by rumen microorganisms. Our ruminal pH and NH3-N values indicate that no reversible effect on rumen fermentation occurred due to substitution. Furthermore, Lazzarini *et al.* (2009) demonstrated that a higher intake of low-quality forages could be achieved when the rumen NH3-N concentration was greater than 15 mg/dl: this might produce a reasonable explanation for non-significant differences in DMI among groups (table 3) since NH3-N values in all groups were above that value with no significant differences. Citrus by-product substitution for corn grains did not significantly affect ruminal pH (El-Sheikh *et al*., 2024). However, ruminal pH was reduced when citrus pulp was substituted for corn grains, especially at 6 hours post-feeding (de Oliveira *et al*., 2022). They attributed their results to the higher degradation rate of pectin than starch. Reductions in NH3-N concentration were induced by the inclusion of citrus pulp or citrus by-products (de Oliveira *et al*., 2022; Tadayon *et al*., 2017; El-Sheikh *et al*., 2024). They suggested that microbial protein synthesis is an indicator for this reduction, as the released ammonia in the rumen was taken up by rumen microorganisms to synthesize microbial protein. Despite increased microbial nitrogen yield in OP-included rations in the current study (table 3), NH3-N concentrations were not significantly different among groups.

Fondevila *et al.* (2002) conducted in-vitro incubation of ammonia-treated straw supplemented with different pectin levels. They noted that VFA concentration significantly increased as the level of supplementation increased. Similarly, VFA tended to increase with citrus pulp inclusion (Tadayon *et al*., 2017; de Oliveira *et al*., 2022). On the other hand, there was no significant effect of replacing cereals with OP on ruminal NH3-N and VFA concentrations (Guzmán *et al*., 2021).

Blood parameters:

The effect of OP inclusion in the lambs' diets on serum metabolites is shown in Table (6). The results revealed that the total protein was significantly ($P \leq 0.05$) higher in R3 than in R1 and R2. Values were 6.85, 6.96, and 7.31 g/dl for R1, R2, and R3, respectively. The increased serum total protein in lambs fed R3 was probably due to the higher CP content in R3 than in R1 and R2 (table 2). No significant differences ($P > 0.05$) were noted in the concentration of albumin, globulin, ALT, AST, and kidney panels, represented as urea and creatinine, among groups. Generally, blood parameters were within the normal range, as reported by Abd Hobi (2012).

Table 6. Blood parameters of Barki sheep fed different experimental diets.

Attributes	Experimental rations			SEM	*p*-value
	R1	R2	R3		
Total protein (g/dl), TP	6.85^b	6.96^b	7.31^a	0.062	0.0307
Albumin (g/dl)	3.73	3.81	4.32	0.212	0.1458
Globulin (g/dl)	3.12	3.15	2.99	0.136	0.6872
Alanine transaminase (U/ml), ALT	28.43	28.51	29.01	0.685	0.8131
Aspartate transaminase (U/ml), AST	78.48	78.64	79.02	2.188	0.9841
Urea (mg/dl)	30.67	30.79	30.88	0.748	0.9804
Creatinine (mg/dl)	0.98	1.07	1.15	0.057	0.1589

a,b,c. means, within each row, with different superscripts are significantly different.

Blood serum protein analysis could prove helpful for evaluating ruminants' health (Bobbo *et al*., 2017). Serum total protein, albumin, and urea-N are markers of an animal's nutritional state; normal values show that there is no protein catabolism in the muscles (Kholif *et al*., 2016). In the current study, increased serum total albumin for ration with OP indicates that lambs were in good nutritional status. Guzman *et al*. (2021) illustrated that the inclusion of dried OP up to 80% in lactating goats' diet did not affect plasma total protein, albumin, ALT, AST, or blood urea nitrogen. Also, plasma total protein and albumin were not affected by OP inclusion in lambs' diets (Tadayon *et al*., 2017; Guzmán *et al*., 2021). No effect was observed for blood urea nitrogen by Sharif *et al*. (2018); nonetheless, a reduction was investigated for blood urea nitrogen as a response to citrus pulp inclusion (Tadayon *et al*., 2017; de Oliveira *et al*., 2022). Since blood urea nitrogen reflects the balance between the production of N in the rumen and liver and the N loss in the urine (Radostitis *et al*., 2007), our results of serum urea concentrations may give the expectation that urinary nitrogen could not be affected as the ruminal NH3-N was not altered (table 5). Generally, it could be concluded that the OP substitution had no adverse effects on liver and kidney functions.

CONCLUSION

Orange pulp (OP) can replace 25% or 50% of sugarcane bagasse in the multi-nutrient roughage blocks (MRB). The concentration of ruminal VFA, digestibility of CP and CF, and FCR were significantly increased with OP substitution, either by 25% or 50%. ADG and serum total protein were significantly improved at the 50% substitution level. The fungi population was significantly ($p \leq 0.01$) decreased in the lambs fed rations included with OP. The orange pulp can substitute for sugarcane bagasse up to 50% in the multi-nutrient roughage blocks without any adverse effects on liver and kidney functions.

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تأثير إدخال تفل البرتقال إلى قوالب الأعلاف الخشنة متعددة العناصر الغذائية على أداء الحملان البرقى

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الملخص

تم استخدام قوالب الأعلاف الخشنة متعددة العناصر الغذائية في هذه الدراسة بمستويات استبدال مختلفة لمصاصة قصب السكر بتفل البرتقال بمعدل 0% - 25% - 50% وذلك لكل من القالب الأول والثاني والثالث علي التوالي. تم تكوين ثلاث علائق تجريبية باستخدام خليط الأعلاف المركزة و قوالب الأعلاف الخشنة متعددة العناصر الغذائية بنسبة 40:60 %على التوالي على النحو التالي: العليقة لأولى :مخلوط العلف المركز+ القالب العلفلى 1؛ العليقة الثانية :مخلوط العلف المركز+ القالب العلفى 2 ؛ العليقة الثالثة : مخلوط العلف المركز+ القالب العلفى 3. تم توزيع خمسة عشر حملا برقى بمتوسط وزن الجسم 31.26 ± 1.70كجم على ثلاث مجموعات (5 حملان / مجموعة) في تجربة نمو لمدة 84 يومًا يعقبها تجربة هضم. أظهرت النتائج زيادة كبيرة في وزن الجسم النهائي، وزيادة وزن الجسم، ومتوسط الزيادة اليومية ، والمادة العضوية القابلة للهضم والمتخمرة في الكرش للحملان التي تغذت على العليقة3. تحسنت الكفاءة الغذائية التحويلية (FCR) وكمية النيتروجين الميكروبي بشكل ملحوظ (p≤0.05) بالنسبة للعليقة الثانية والثالثة مقارنةً بـ العليقة الأولى. لم يؤثر الاستبدال بلب البرتقال على هضم جميع العناصر الغذائية، باستثناء البروتين الخام (CP) والألياف الخام (CF). زاد تركيز الأحماض الدهنية الطيارة خطيًا (p≤0.01) مع مستوى الاستبدال حيث كان 12.81 و13.45 و13.88 ملليمكافىء/ 100 مل سائل كرش للعلائق الأولى والثانية والثالثة على التوالي. ومع ذلك، لوحظ انخفاض خطي في إجمالي عدد الفطريات في الكرش مع زيادة مستوى الاستبدال. لم يكن هناك أى تأثير سلبي على وظائف الكبد والكلى لكلا من مستويات الاستبدال.