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Effect of Diet Physical Form on Performance and Diet Digestibility in Finishing Fat-Tailed Lambs

Research Article

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ABSTRACT

This study was conducted in two experiments to evaluate the dietary physical form on dry matter intake (DMI), performance, carcass traits and nutrient digestibility from Kalkuhy (an Iranian fat–tailed breed) male lambs. Initial lamb body weight (BW) average was, 32 .81 ± 2 kg, and 110 ± 10 days of age. Three treatments (diet physical form) included T1: total mixture diet (TMR) mixed diet (MD), T2: TMR blocked diet (BD) and T3: TMR pellet diets (PD) that were compared in completely randomized design. Diets had similar composition (80% concentrate to 20% forage). Average DMI of lambs fed by BD was significantly greater than MD diet (P<0.05). Average daily gain of lambs fed by BD was significantly greater than lambs fed MD and PD diets (P<0.05). Hot carcass and fat-tail lamb weights fed the BD treatment were significantly greater than lambs fed MD treatment (P<0.05). Nutrient digestibility was not affected by treatments. Dry matter, organic matter (OM) and crude protein (CP) digestion were not significantly greater for BD. In conclusion, blocking the complete diet for finishing fat-tailed lambs did not change final weight, feed conversion ratio (FCR) and nutrient digestibility, but increased DM intake, which in turn resulted in an increased energy available for fattening. As a result, lambs fed the BD treatment had heavier fat- tails compared to lambs fed either the PD or MD treatments. Hence, TMR block diet (BD) use for fattening Kalkuhy (Iranian fat–tailed breed) male lambs when providing them *ad libitum* access to feed wasn't recommended.

KEY WORDS block, digestibility, Kalkuhy (Iranian fat–tailed breed) male lambs, pellet, physical form effect.

INTRODUCTION

In developing countries, using agro-industrial byproducts for livestock feeding is very important. In order to improve nutritional status of poorly fed animals and supplementing low quality diets with more nutritionally dense agricultural by-products by blocking diets have been suggested. Blocking has been suggested as a way to decrease the dietary concentrates and to decrease the amount of concentrate increase agricultural by-products (Ben Salem and Nefzaoui, 2003). Small ruminants, especially sheep are important for animal production in developing countries. Lamb fattening systems are a major red meat source to meet supply for increasing consumer demands in Iran (Hosseini *et al.* 2008). For many years, small ruminant production in Iran has depended on pastures and range feedstuffs, but in recent years, due to many reasons such as droughts, small ruminant population growth and range destruction, current systems are not efficient and sustainable. For optimum small ruminant production, current systems must be modified, for this type of use, agricultural by-products and diet physical form should be considered.

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Changing diet physical form can influence functional characteristics for livestock feeding. Changes in diet physical form is reflected in traits such as the animal's feed intake, BW, average daily gain, feed efficiency and nutrient digestibility (Weir *et al*. 1959). In drought conditions and areas where poor pastures or inappropriate grazing areas exist, feed block utilization can be a useful feeding method. Feed blocks that include local resources (Ben Salem and Nefzaoui, 2003) and by-products could allow substituting a portion of the dietary concentrate and cereals in pelleted feed without compromising rumen fermentation (Molina-Alkaide *et al*. 2008). Beneficial effects for animal nutrition depends on pellet quality and with special attention to pellet durability and hardness (Wilson, 1994). Feed intake motivation is based on diet palatability, energy balance, and the diurnal cycle (Sauvant *et al*. 1996). Diet physical form can affect consumption; so changing the diet's physical form can result in the animal ingesting feed more rapidly when compared to feed that is provided in the loose or meal form (Fahey *et al*. 1993; Berger *et al*. 1994). Carcass quality is an important production trait for producers and consumers.

Colomer-Rocher (1972) defined carcass quality as the characteristics that have maximum concern to the consumer. When increasing carcass yield, it is essential that we determine the factors affecting this trait such as nutritional plane (influences fat deposition) (Chestnutt, 1994) and the ability to produce maximum carcass lean tissue disposition. Andrews and Ørskov (1970) and Black (1974) reported that dietary effects on carcass composition became less obvious as slaughter weight increased. The objective of the present experiment was to evaluate the effects of dietary physical form on involuntary intake, performance and carcass traits of Kalkuhy (Iranian fat-tailed) lambs.

MATERIALS AND METHODS

Experiment 1 (feeding trial)

Forty-five male Kalkuhy lambs, averaging 110 ± 10 (SD) days of age and 32 ± 1 kg BW were used in this study. During the first three weeks (before the start of main trial), lambs were adapted to corresponding experimental diets that gradually replaced with whole forage adaptation diet, in 10 days (10% each day), treated for external (AZANTOL, Bayer, Germany) and internal (Triclabendazole+levamisole, Darou-Pakhsh Co., Iran) parasites and vaccinated against enterotoxaemia and foot and mouth disease. Lambs were housed in pens with solid concrete flooring (1.5 m×8 m, three lambs/pen) that was an open shed barn and allowed animals *ad libitum* access to salt lick and water as well as lambs were allotted at random in to one of three dietary treatments and five replicates (three lambs in each replicate).

Diets were formulated to meet or exceed nutrient requirements for finishing lambs (NRC, 1985) and had similar chemical and ingredient composition (Table 1), but differed in physical form.

Treatments were total mixed diet (MD); total mixed diet prepared as large cubical blocks (BD, 450×200×100 mm); and total mixed diet in a pelleted form (PD, 30×15 mm). For all three physical forms, alfalfa hay and wheat straw were chopped to 40-50 mm length before they were incorporated in the complete diet. Diets were offered two times a day at 08:00 and 16:00 h during the experimental period (84 d).

Measurements and sampling

Lamb BW was measured on initial of the experimental and at 14 day intervals after that using a scale (Model 90 BAUMANN, Germany). Feed was withdrawn for 16 h before weighing. Mean daily lamb DM intake was determined by dividing the actual intake. (i.e. feed DM offered minus feed DM remaining), by three (in each pen three lamb). For each interval, average daily gain (ADG) was determined using weight difference divided by 14 (14-day interval).

Feed conversion ratio (FCR) was determined using mean daily DM intake per pen divided by mean average daily gain (ADG) per pen because it was impossible to determine on an individual basis. Feeds and orts were sampled on each weigh day.

On d 84, one lamb from each replicate was slaughtered by exsanguinations using conventional humane procedures. Slaughter and carcass sampling was performed on three consecutive days (Nik-Khah, 1984). After complete bleeding, carcasses were skinned and external organs such as head, feet and skin were weighed. Carcasses were eviscerated, total internal organ weight and individual organ weights or tissues including heart, liver, kidneys, spleen, lungs, internal fat, genital and digestive tract were determined.

Digestive organs including reticular-rumen, omasum, abomasum and small and large intestines were weighed after emptying the digestive tract. Hot carcasses were weighed then chilled at +4 ˚C for 24 h and re-weighed. The cold carcasses were split into two symmetrical sides along backbone (Model PFZ700-PE, BOSCH, Germany). Back fat thickness from the carcasses' left side was measured over the deepest part of the loin-eye muscle. The right side of the carcass was cut into six wholesale cuts (neck, shoulder, leg, back-loin, brisket-flank, and tail fat) and weighed separately (NikKhah, 1984). All cuts except tail fat were dissected into the main tissue components (lean, subcutaneous and inter-muscular fat, and bone) and the individual tissue weight was recorded.

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Table 1 Experimental feed Ingredients from a trial comparing diet form when fed to Kalkuhy lambs (DM basis)

Feed ingredient (g/kg)	
Wheat straw	150
Alfalfa hay	50
Barely grain	450
Molasses, sugarcane	150
Cottonseed meal (mechanically extracted)	100
Wheat barn	70
Urea	10
Limestone	10
Mineral mix	2.5
Vitamin mix	2.5
Salt	5

The loin-eye muscle area was measured after cutting between the 12th and 13th ribs on the left side of the carcasses and tracing the cross section area by a planimeter (Model KP-25, USA).

Experiment 2
Four lambs from each treatment in finishing trial were randomly selected and moved to individual metabolic cages for digestibility measurements. Treatments were the same as those in performance trial. Lambs were fed the experimental diets twice daily and had access to feed at 90% of *ad libitum* intake to avoid intake modification in response to treatments. The study consisted of a 14 d adaptation period and five sampling days. During the sampling period, diets and orts were sampled every day before morning feeding. Total fecal and urine outputs were collected and weighed for five days. Fecal and acidified urine samples (treated with 4 ml of 5% H_2SO_4/1 mL urine, Sari *et al.* (2009)) were retained at −20 ˚C for later analysis. Apparent DM, OM, neutral detergent fiber (NDF) and CP digestibility were calculated based on relative nutrient concentrations in consumed feed and in the feces.

Chemical analysis
Diet and refusal samples in the performance trial were composited by period, and in digestibility trial by day, and oven-dried for 72 h at 60 ˚C. Samples were ground using a laboratory mill (Ika, Staufen, Germany) equipped with a 1-mm screen. The ground samples were analyzed for nitrogen (N) using the Kjeldahl procedure with a Kjeltec (Model, 2300; Sweden), (984.13, AOAC (1990), acid detergent fiber (ADF) (Van Soest *et al*. 1991), aNDF (using heat-resistant α-amylase without sodium sulfite; Van Soest *et al.* (1991)) and ash (AOAC, 1990). The aNDF and ADF included residual ash. Calcium (927.02, AOAC (1990)) and phosphorus (965.17, AOAC, (1990)) were determined for the diets only. Air dry fecal samples from the digestibility trial were ground and analyzed for N, ADF, NDF and ash as described above. Urine samples were analyzed for nitrogen.

Statistical analysis
Data were analyzed by MIXED procedure of SAS (SAS, 1996). The model was for a completely randomized design with three treatments, five replicates (pen) and three observations per replicate. Treatment effect was considered as fixed effect.

Data repeated over time including ADG, FCR and DM intake were analyzed using repeated measurement in the mixed procedure with the sheep as subject and time as repeated variables. Model effects were considered significant at $P < 0.05$ and when the treatment affect was a significant source of variation, the treatment were compared via Duncan method after ANOVA.

RESULTS AND DISCUSSION
As expect, chemical composition of treatment diets were similar in Table 2 (P>0.05). In Table 3 lambs on BD group had greater DM intake than lambs on MD and PD groups at 0-14 days, 28-42 days and 56-70 days (P<0.05).

Diet physical form did not affect lamb FCR (P>0.05), but ADG was affected by the diet form (P=0.048) from day 56 to 70 days of the trial (Tables 4 and 5).

The BD-fed lambs had greater ADG than the PD-fed lambs resulting in a significantly better FCR in the latter treatment (P<0.05).

Lamb carcass characteristics fed different treatments in this study were similar for most traits evaluated, however, pens of lambs receiving the BD treatment had greater hot carcass weight and tail fat weight, while pens of lambs fed the PD treatment had greater bone weight and lower lung weight, when compared to MD treated pens of lambs (P<0.05).

Among the offal parts, lung weight from the lamb pens fed the LD treatment group lambs were greater when compared to the lamb pens fed the PD treatment (P<0.05), and diaphragm weight from the BD treated group was greater when compared to the lamb pens fed the MD treatment (P<0.05). Other offal parts weight had no observed responses to diet form (Table 6).

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Table 2 Experimental chemical analysis from trial comparing diet form when fed to Kalkuhy lambs

Item (g/kg DM, unless otherwise stated)	Treatment			SEM	P > F
	MD	BD	PD		Treat
Dry matter (DM) as is basis	948	947	947	3.2	0.96
Organic matter (OM) (g/kg)	925	921	927	6.7	0.65
Crude protein (CP) (g/kg)	141	142	144	3.9	0.86
aNDF[1] (g/kg)	325	317	310	9.9	0.79
ADF[2] (g/kg)	153	141	149	9.6	0.53
Ash (g/kg)	75	79	73	6.8	0.67

[1] NDF: neutral detergent fiber treated with heat stable alpha-amylase and inclusive of residual ash.
[2] ADF: acid deter gent fiber inclusive of residual ash.
MD: completely mixed diet; BD: complete diet prepared as cubic block and PD: complete diet prepared as pellet.
SEM: standard error of the means.

Table 3 Effect of physical ration form on Kalkuhy lambs dry matter intake

Item	Treatment			SEM	P > F		
	MD	BD	PD		Treat	Period	Interaction
Average dry matter intake (kg DM/day)	1.60[b]	1.76[a]	1.67[ab]	0.042	0.064	0.0001	0.012
Periods (days)							
0-14	1.08[a]	1.06[ab]	1.04[b]	0.01	0.03	-	-
14-28	1.63[a]	1.68[b]	1.65[ab]	0.017	0.07	-	-
28-42	1.75[a]	1.88[b]	1.87[b]	0.014	0.0001	-	-
42-56	1.57	1.78	1.74	0.071	0.14	-	-
56-70	1.73[a]	2.05[b]	1.76[a]	0.084	0.038	-	-
70-84	1.83	2.09	1.96	0.094	0.19	-	-

MD: completely mixed diet; BD: complete diet prepared as cubic block and PD: complete diet prepared as pellet.
SEM: standard error of the means.

Table 4 Effect of physical form of rations on Kalkuhy lambs average daily gain

Item	Treatment			SEM	P > F		
	MD	BD	PD		Treat	Period	Interaction
Average daily gain (kg DG/day)	0.22[a]	0.24[b]	0.21[a]	0.007	0.048	0.003	0.072
Periods (days)							
0-14	0.19	0.15	0.20	0.036	0.64	-	-
14-28	0.21	0.23	0.23	0.13	0.43	-	-
28-42	0.26	0.30	0.31	0.028	0.49	-	-
42-56	0.22	0.22	0.21	0.022	0.82	-	-
56-70	0.20[ab]	0.29[a]	0.13[b]	0.023	0.001	-	-
70-84	0.23	0.26	0.21	0.022	0.25	-	-

MD: completely mixed diet; BD: complete diet prepared as cubic block and PD: complete diet prepared as pellet.
SEM: standard error of the means.

Table 5 Effect of physical form of rations on Kalkuhy lambs feed conversion rate

Item	Treatment			SEM	P > F		
	MD	BD	PD		Treat	Period	Interaction
Average feed conversion rate (kg feed/kg daily gain)	7.81	7.714	8.74	0.274	0.039	0.027	0.047
Periods (days)							
0-14	7.28	7.99	5.94	1.64	0.67	-	-
14-28	7.97	7.46	7.04	0.45	0.38	-	-
28-42	6.87	6.53	6.69	0.82	0.95	-	-
42-56	7.19	8.46	8.96	1.02	0.47	-	-
56-70	9.33[a]	7.33[a]	14.15[b]	1.30	0.009	-	-
70-84	8.20	8.52	9.67	0.78	0.40	-	-

MD: completely mixed diet; BD: complete diet prepared as cubic block and PD: complete diet prepared as pellet.
SEM: standard error of the means.

Lion eye muscle area (cm^2) was not significantly different among treatment groups. Treatments did not affect apparent nutrient digestibility in the second trial (P>0.05). In a previous study, offering a complete block diet to buffalo calves, increased DM intake (Verma *et al*. 1996). Furthermore, supplementing a wheat straw-based diet with complete concentrate blocks increased straw intake by sheep (Nyarko-Badohu *et al*. 1994).

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Table 6 Effect of physical form of rations on Kalkuhy lambs carcass characteristics

Item slaughter data	Treatment			SEM	P > F
	MD	BD	PD		Treat
Digestive contents (kg)	4.32	4.18	3.83	0.17	0.52
Empty body weight (kg)	47.88	50.73	50.37	0.56	0.12
Empty digestive tract (kg)	3.51	3.52	3.40	0.09	0.85
Hot carcass weight (kg)	26.7[a]	29.3[b]	28.6[ab]	0.70	0.05
Cold carcass weight (kg)	26.1	28.2	28.1	0.76	0.12
Dressing percentage (%)	0.51	0.53	0.52	0.013	0.49
Eye muscle area (cm 2)	16.8	16.5	17.2	1.68	0.9
Carcass composition (kg)					
Lean	12.50	14.1	13.2	0.78	0.19
Bone	4.1[a]	4.2[a]	4.7[b]	0.20	0.03
Subcutaneous fat (SCF)	2.11[a]	2.39[a]	2.56[b]	0.08	0.04
Intermuscular fat (IMF)	1.24	1.37	1.37	0.11	0.88
Total fat (SCF+IMF)	3.35	3.75	3.93	0.12	0.14
Carcass cuts (kg)[1]					
Neck	1.10	1.20	1.10	0.05	0.27
Shoulder	4.10	4.20	4.20	0.16	0.70
Brisket-flank	4	4.5	4.4	0.18	0.07
Back-lion	3.5	3.7	4	0.22	0.15
Leg	7.5	8.4	8.4	0.38	0.06
Tail fat	3.9[a]	5.1[b]	4.5[ab]	0.39	0.05
Offal parts (kg)					
Internal fat[2]	1.04	1.17	1.07	0.30	0.88
Skin	3.60	3.60	3.90	0.26	0.31
Head	2.60	2.70	2.80	0.19	0.77
Feet	0.90	0.90	1.00	0.04	0.48
Liver	0.80	0.90	0.80	0.04	0.47
Heart	0.30	0.20	0.30	0.02	0.07
Kidney	0.10	0.10	0.10	0.007	0.62
Lung	0.50[a]	0.50[a]	0.40[b]	0.04	0.02
Spleen	0.06	0.07	0.06	0.09	0.53

[1] On the basis of cold carcass weight.
[2] Kidney-pelvic-gut fat.
Mixed diet (MD): completely mixed ration with long hay; Block diet (BD): the block form of completely mixed ration and Pellet diet (PD): the pellet form of completely mixed ration.
The means within the same row with at least one common letter, do not have significant difference (P>0.05).
SEM: standard error of the means.

In both of the previous trials, diets contained a high forage proportion. Results from the current study showed that intake from sheep fed 800 g concentrate/kg of diet was increased by feeding BD.

Blocking the entire diet may reduce the animals ability to sort the different feedstuffs and there by provide a slow and consistent nutrient release in the rumen, promoting better available substrates for an optimum ruminal fermentation (Ben Salem and Nefzaoui, 2003). In addition, blocking permit nutritionists to use agricultural by-products in ration formulation, which is very important in developing countries. In contrast, sheep might have tended to sort the feedstuffs in favor of more palatable concentrates from MD resulting in a slug of digestible material entering in the rumen that may transmit chemical satiety signals to the brain. The DM intake in PD was lower than BD that was not expected as PD has been shown to increase DM intake (Faichney *et al*. 2005).

It is possible that faster intake rate that is generally observed with PD promoted a rapid provision of energy to the animal resulting in lower DM intake.

Total tract nutrient digestibility

Feed blocking effects on nutrient digestibility has not been comprehensively studied (Ben Salem and Nefzaoui, 2003). However, Verma *et al*. (1996) found that a complete BD diet consisting 690 g/kg forage did not alter nutrient digestibility in buffaloes.

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Table 7 Treatment effects on Kalkuhy lambs nutrient digestibility (%)

Item	Treatment			SEM	P > F
	MD	BD	PD		Treat
Nutrient digestibility					
Dry matter (DM)	70.30	70.40	67.50	2.09	0.31
Organic matter (OM)	71.90	72.50	69.40	2.04	0.28
Crude protein (CP)	67.10	71.10	67.60	2.18	0.15
NDF[1]	44.9	48.6	51.4	3.85	0.25
ADF[2]	26.20	25.90	17.10	5.44	0.26

[1] NDF: neutral detergent fiber treated with heat stable alpha-amylase and inclusive of residual ash.
[2] ADF: acid deter gent fiber inclusive of residual ash.
MD: completely mixed diet; BD: complete diet prepared as cubic block and PD: complete diet prepared as pellet.
SEM: standard error of the means.

Samanta *et al.* (2003) reported similar nutrient digestibility in goats fed BD with 600 g/kg grass hay. These results are in agreement with the findings from the current study. The unchanged nutrient digestibilites in the current study was expected as diets contained similar ingredients. Furthermore, the diets contained high proportion of concentrates that were less prone to altered digestibility through physical treatments, i.e. blocking and pelleting, used in the present study. In support of this, Svihus *et al.* (2005) discussed that the degree of starch gelatinization by conventional pelleting is between 10-200 g/kg, which is unlikely to improve starch digestibility.

Performance

Dry matter intake and growth performance

Increased DM and in turn, metabolizable energy intake by BD-fed lambs were expressed in carcass characteristics such that lambs in this treatment had heavier hot carcass- and tail-weights. When diets contain an identical energy density, the DM intake serves as a strong influencing factor on portal energy metabolites fluxes (Bermingham *et al.* 2007).

Heavier tail weights from pens of lambs fed the BD treatment may point to an evolutionary-originated priority of tail, in fat-tailed breeds, over other peripheral or visceral tissues to deposit fat in periods of excessive energy intake.

CONCLUSION

Blocking the complete diets fed to pens of finishing lambs did not change final weight, ADG or nutrient digestibility, but increased DM intake, which in turn resulted in increased energy available for fattening. TMR block diet (BD) use with the similar energy and chemical composition for fattening of Kalkuhy (Iranian fat-tailed breed) male lambs, is not recommended because the high fat amount retained in carcass and fat-tailed and thereby reduced the carcass quality. Considering the potential for BD to increase DM intake, further research is warranted to examine shorter finishing periods with BD to maximize feed energy efficiency in fat tailed breeds.

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