

Milk Yield and Composition As Affected by Nutritional Manipulations

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Abstract. The objective was to evaluate milk yield, milk composition and milk fatty acids contents of lactating Harri ewes (n=24) receiving different concentrate to roughage (A 80:20; B 60:40; C 40:60 and D 20:80 C:R) rations. The results revealed that no differences ($P = 0.29$) in body weights of ewes were detected after parturition but body weights declined steadily as ewes continued on lactation. Group D produced more ($P < 0.01$) milk (1.38 ± 0.5 kg/day) than groups A (0.76 ± 0.5 kg/day), B (0.88 ± 0.5 kg/day) and C (0.66 ± 0.5 kg/day). Yields of milk fat, SNF, protein, lactose and minerals yields (g/day) were greater ($P = 0.01$) in group D than groups B and C not group A. No differences were found in milk fat, SNF, protein, lactose and minerals percentages (%). Groups D and A had more ($P = 0.06$) C18:2c (3.15 ± 0.21 and 2.99 ± 0.08 g/100g fat) than group B (1.98 ± 0.54 g/100g fat) not group C (2.72 ± 0.05 g/100g fat). Poly unsaturated fatty acids (PUFA) were increased ($P < 0.01$) in groups A and D (4.07 ± 0.18 and 4.49 ± 0.27 g/100g fat) than groups B and C (3.34 ± 0.12 and 3.41 ± 0.23 g/100g fat). Lactating ewes' diet should include adequate ratio of roughage to increase milk yield and improve milk fat composition of unsaturated fatty acids.

Keyword: Sheep, concentrate: roughage ratio, nutrition, milk yield, fatty acids.

Introduction

Breeding of sheep for dairy purposes has a long tradition throughout the world. Sheep milk accounts for only 2% of the global volume of milk obtained, but in some countries, such as Yemen, this proportion reaches as much as 50 or 90% (Molik *et al.*, 2008). The physico-chemical characteristics of sheep milk have unique properties as

compared to goat and cow milk. Sheep milk contains higher levels of total solids and major nutrients than goat and cow milk. Also, mineral and vitamin contents of sheep milk are mostly higher than that of cow milk (Park *et al.*, 2007). Sheep milk is more nutritious, richer in vitamins A, B and E, calcium, phosphorus, potassium and magnesium than cow milk (Coni *et al.*, 1999). Also, it contains a higher portion of short and medium chain

fatty acids, which have a recognized health benefits (Jandal, 1996). The optimal roughage concentration required in feedlot diets changes continuously for many reasons such as source, availability, price, and interaction with other ingredients in the diet. It has been established for many years that replacement of most of the roughage of mixed diets by starchy concentrates results in an alteration in energy partition between body and milk and a reduced milk fat content (Broster, *et al* 1979).

The aim of this study was to evaluate the effect of feeding lactating ewes on rations different in their concentrate and roughage content on body weight, milk yield, milk composition and milk fatty acids content.

Materials and Methods

The present study was conducted at Hada Al-Sham experimental station, Arid Land Agriculture Department, Faculty of Meteorology, Environment and Arid Land Agriculture King Abdulaziz University, Jeddah, KSA and Animal Nutrition Laboratory, Animal and Fish Production Department, Faculty of Agriculture, Alexandria University. The aim of this study was to evaluate the effect of feeding four rations with different concentrate to roughage (C:R) ratios on body weight of dams and offspring, milk yield and composition of milk fatty acids in lactating Harri sheep.

Animals and experimental rations

Twenty four lactating Harri ewes (2 years age and 50 ± 1.0 kg body weight) were stratified based on age and live body weight then randomly divided into four groups to receive the following four experimental rations. Group A given 80% concentrate+20% roughage; group B given 60% concentrate +40% roughage; group C given 40% concentrate +60% roughage; group D given 20% concentrate+80% roughage. Concentrate mixture were produced by the Saudi Grains Organization (SAGO), Jeddah, KSA and the

roughage was dry alfalfa hay. Animals were fed their daily rations as group feeding which was adjusted weekly according to the NRC recommendations (1985). Ewes were housed in open barns with shades and had free access to fresh water and mineralized blocks. Ewes were healthy and free from any parasites and diseases.

Rations proximate chemical composition

Experimental rations were offered two times daily at 6:00 AM and 16:00 PM. Experimental rations samples were collected biweekly and dried to determine DM content. The dried samples were ground to pass a 1-mm screen using Wiley mill. Feed analyses were performed according to AOAC (2006). Dry matter contents of feeds were determined by drying at 135°C for 2h. Organic matter was determined as the weight loss during ashing at 550°C for 2h. Contents of nitrogen (N) were determined by the kjeldahl method, and crude protein (CP) was calculated as $6.25 \times N$. Ether extract was analyzed according to AOAC (2006). The neutral detergent fibers (NDF) and acid detergent fiber (ADF) were determined using the procedures of Van Soest *et al.* (1991). No sodium sulfite or α - amylase was used in the procedure for NDF determination. Both NDF and ADF are expressed without residual ash.

Milk yield and composition

Milk production was determined biweekly beginning two weeks after parturition. Milk yield for individual ewes were determined by milking out the ewes by hand. Lambs were removed from their dams and kept in separate pens 20 h prior to milking process. All lambs born during the experiment were allowed to naturally suckle their mothers for a period of three months before weaning. Lambs were weighed immediately after birth and then body weights were recorded weekly for 12 weeks before weaning. Milk samples were collected biweekly and analyzed immediately for milk fat, protein, lactose,

minerals and solids non fat (SNF) using the infrared method by milk Analyzer (Funke Gerber Lactostar-3510). A second fresh milk samples were withheld for milk fat extraction. Solvent-extracted milk fat samples were run through gas chromatography (GC) to determine the proportions of saturated and unsaturated fatty acids and their derivatives.

Milk fatty acids analysis

Lipid extraction:

A 2 to 20 g of milk samples were weighed into a 250-ml centrifuge bottles; 16 ml of H₂O was added together with 40 ml methanol and 20 ml chloroform. Bottles were macerated for 2 min and then 20 ml of chloroform was added and macerated for 30 sec before addition of 20 ml of H₂O and maceration for a 30 sec. Bottles were centrifuged for 10 min at 2000-2500 rpm and the upper chloroform layer was drawn off and filtered through a coarse filter paper into a dry weighed flask. Chloroform was evaporated to dryness and extracted amount of fat was recorded (Pearson, 1981).

Methylation of lipid:

A weight of 50 mg of extracted milk fat was added to 5 ml of methanolic sulfuric acid (1 ml conc. sulfuric acid and 100 ml methanol) and 2 ml of benzene in a well-closed tube. The tube was incubated in a 90°C water bath for 1 hour and half. Water (8 ml) and 5 ml petroleum ether were added to the cooled down tubes then shaken strongly and allowed to rest to separate out the ethereal layer in a dry tube. Ether was then evaporated to dryness (Radwan, 1978).

GC conditions:

Device Model: HP (Hewlett Packard) 6890 GC; Detector: FID (Flame Ionization Detector); Detector temperature: 240oC; Injector temperature: 220oC, injection volume 3µl, split ratio 50:1; Column: DB-23 (50% Cyanopropyl-methylpolysiloxane), 30m, 0.32mm ID, 0.25µm film thickness; Carrier gas: Nitrogen; Gas flow rate: 1 ml/min; Oven Program: Initial temperature 140°C for 5 min;

Ramps: 1; Rate: 4°C /min; Final Temperature: 240°C; Hold time: 0.

Statistical analysis:

The fixed effects of treatment, time (sampling or measuring times) and their interactions were analyzed using the PROC GLM procedure of SAS (SAS, 2006) in a complete randomized design (CRD) with treatment and time as main effects and ewe as the experimental unit. The statistical model was: $Y_{ijk} = \mu + Trt_i + Time_j + Trt_i \times Time_j + e_{ijk}$; Where Y_{ijk} = the performance of the k^{th} ewe in the i^{th} treatment during the j^{th} time; μ = the overall mean effect; Trt_i = the effect of the i^{th} treatment ($i = A, B, C, D$); $Time_j$ = the effect of the j^{th} time; $Trt_i \times Time_j$ = interaction between treatment and time; e_{ijk} = the random error. Differences among the means were separated by Duncan's multiple range tests. Statistical significance was declared at $P < 0.05$.

Results

Proximate analyses of experimental diets A, B, C and D on dry matter basis:

Values of the proximate analyses on dry matter basis of diets A, B, C and D are presented in Table 1. No differences were found among diets in percentages of organic matter (OM), ash, crude protein (CP) and Ether extract (EE) content. The highest values for NDF and ADF were observed in diet D that had higher content of neutral detergent fiber (NDF, 44.63%), acid detergent fiber (ADF, 28.20%), acid detergent lignin (ADL, 7.14%) and cellulose (21.06%) as compared to diet A (34.75, 13.43, 3.23 and 10.19%, respectively). Similar trend was observed in the content of ADL and cellulose (Table 1).

Body weight of Harri ewes and their lambs during lactation:

Changes in ewes' body weight and their lambs' birth and weaning weight during

lactation are presented in Table 2 and Figures 1 and 2. No significant ($P = 0.29$) differences in body weights of ewes supplemented with the four experimental rations were detected after parturition. There were no changes among

treatment groups in body weights with advancement of lactation but body weights declined steadily as ewes continued on lactation (Figure 1).

Table 1. Mean values of proximate analyses of treatment diets A, B, C and D on dry matter basis.

Items	Treatments			
	A	B	C	D
OM	92.65	91.80	91.10	90.15
ASh	7.35	8.20	8.90	9.85
CP	19.25	17.71	20.56	20.68
EE	5.64	5.02	4.40	5.75
NDF	34.75	38.64	41.55	44.63
ADF	13.43	19.51	23.41	28.20
ADL	3.23	4.31	5.30	7.14
Hemicellulose	21.32	19.13	18.14	16.43
Cellulose	10.19	15.20	18.11	21.06

A=80:20; B=60:40; C=40:60; D=20:80 (C:R), OM: organic matter; CP: crude protein; EE: ether extract; NDF: neutral detergent fiber; ADF: acid detergent fiber; ADL: acid detergent lignin.

Also, no differences in lambs birth ($P = 0.99$) and weaning weights ($P = 0.24$) were recorded. However, lambs born in D, C and B groups had heavier weaning weight by 9.9, 6.2 and 8.7%, respectively as compared to those of group A (Table 2). Overall lambs' body weight increased with advancement of age (week1 - week12) with no differences in lambs' body weight among groups (Figure 2).

Table 2. Body weight of lactating Harri ewes, lambs' birth and weaning weight (kg) (Mean \pm SE).

Item	Treatments				<i>P-value</i>
	A	B	C	D	
Body weight of dams	46.65 \pm 1.1	44.56 \pm 2.0	42.67 \pm 1.3	43.31 \pm 1.3	0.29
Lambs' Birth weight	2.96 \pm 0.23	2.90 \pm 0.31	2.89 \pm 0.26	2.87 \pm 0.46	0.99
Lambs' weaning weight	17.55 \pm 1.20	19.08 \pm 0.85	18.64 \pm 0.47	19.29 \pm 0.87	0.24

A=80:20; B=60:40; C=40:60; D=20:80 (C:R)

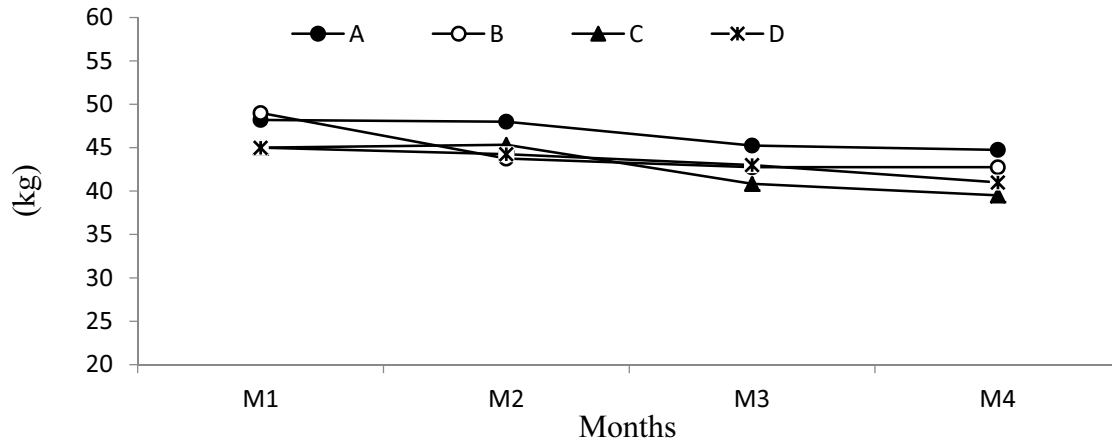


Fig. 1. Monthly changes in body weight (kg) of lactating ewes fed on four experimental rations A (80:20), B (60:40), C (40:60) and D (20:80) C:R.

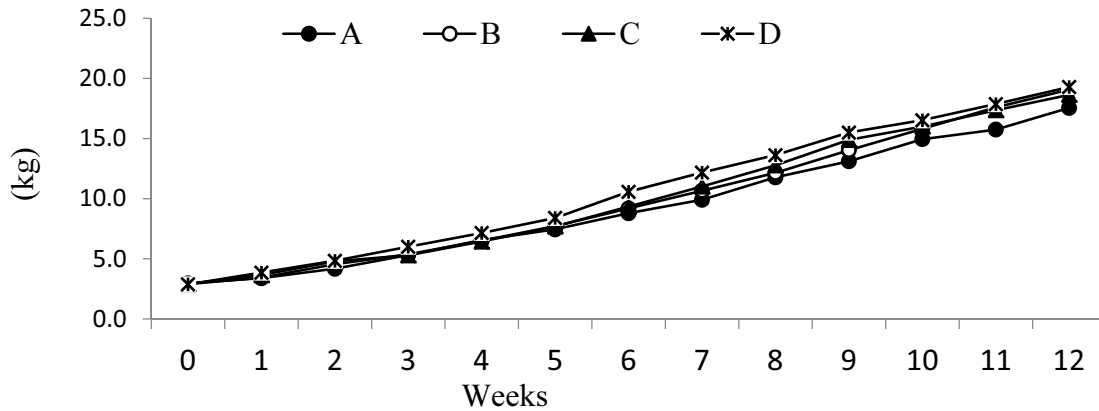


Fig. 2. Weekly changes in lambs body weight (kg) from Harri ewes fed four experimental rations A (80:20), B (60:40), C (40:60) and D (20:80) C:R.

Milk yield and milk composition:

Milk yield (kg/day) and milk composition data for Harri ewes is presented in Table 3. Analysis of milk yield data revealed that ewes fed on the experimental ration D produced more ($P < 0.01$) daily milk yield (1.38 ± 0.5 g/day) than ewes fed on experimental rations A (0.76 ± 0.5 g/day), B (0.88 ± 0.5 g/day) and C (0.66 ± 0.5 g/day). Milk fat yield (g/day) was greater ($P = 0.01$) in treatment A (55.6 ± 20.9 g/day) and D (58.4 ± 10.7 g/day) than treatments B (16.5 ± 3.4 g/day) and C (21.9 ± 3.0 g/day). Milk SNF yield (g/day) was greater ($P=0.01$) in treatment D (125.3 ± 14.9 g/day) than treatments B (61.4 ± 6.4 g/day) and C (70.9 ± 6.8 g/day) not treatment A (116.1 ± 30.8

g/day). Milk protein yield (g/day) was greater ($P < 0.01$) in treatment D (59.2 ± 5.4 g/day) than treatments B (28.1 ± 1.2 g/day) and C (31.3 ± 2.5 g/day) not treatment A (50.6 ± 12.0 g/day). Milk lactose yield (g/day) was greater ($P = 0.03$) in treatment D (45.5 ± 7.4 g/day) than treatments B (20.4 ± 2.5 g/day) and C (25.8 ± 2.9 g/day) not treatments A (39.8 ± 11.5 g/day). Milk minerals yield (g/day) was greater ($P = 0.04$) in treatment D (8.5 ± 1.3 g/day) than treatments B (3.9 ± 0.4 g/day) not treatment A (6.4 ± 1.6 g/day) and C (4.8 ± 0.6 g/day). Meanwhile, no significant differences were found in milk fat, SNF, protein, lactose and minerals percentages (%) among all groups.

Table 3. Milk fat, solids not fat (SNF), protein, lactose, and minerals yield (g/day) and composition (%) in Harri ewes fed on four different diets (A, B, C, and D) during lactation.

Yield, (g/day)	Treatments				P-value
	A	B	C	D	
Milk yield, kg/day	0.76±0.13 ^b	0.88±0.10 ^b	0.66±0.06 ^b	1.38±0.15 ^a	<0.01
Fat (g/day)	55.6±20.9 ^a	16.5±3.4 ^b	21.9±3.0 ^b	58.4±10.7 ^a	0.01
Fat, %	4.80±0.7	3.36±0.4	3.31±0.3	4.26±0.5	0.11
SNF, (g/day)	116.1±30.8 ^{ab}	61.4±6.4 ^c	70.9±6.8 ^{bc}	125.3±14.9 ^a	0.01
SNF, %	10.70±0.3	10.61±0.2	11.01±0.3	10.32±0.1	0.13
Protein, (g/day)	50.6±12 ^{ab}	28.1±1.2 ^b	31.3±2.5 ^b	59.2±5.4 ^a	0.05
Protein, %	3.5±0.5	3.8±0.1	4.0±0.1	3.8±0.1	0.16
lactose, (g/day)	39.8±11.5 ^{ab}	20.4±2.5 ^b	25.8±2.9 ^{ab}	45.5±7.4 ^a	0.03
Lactose, %	4.9±0.3	4.9±0.3	4.8±0.4	4.8±0.1	0.94
Minerals, (g/day)	6.4±1.6 ^{ab}	3.9±0.4 ^b	4.8±0.6 ^{ab}	8.5±1.3 ^a	0.04
Minerals, %	0.6±0.02	0.7±0.02	0.7±0.04	0.7±0.03	0.12

A=80:20; B=60:40; C= 40:60; D=20:80 (C:R)

Table 4. Unsaturated milk fatty acids (g/100g fat) in Harri ewes fed on four different diets (A, B, C, and D) during lactation. (means ±SE).

Fatty acids	Treatments				P-value
	A	B	C	D	
C14:1	0.51±0.38	0.05±0.05	0.09±0.09	-	0.27
C15:1	0.39±0.07	0.09±0.06	0.66±0.46	0.64±0.08	0.34
C16:1	0.79±0.09	0.68±0.09	0.74±0.05	0.79±0.08	0.74
C17:1	0.3±0.22	0.33±0.24	0.34±0.26	0.3±0.21	0.99
C18:1c	26.7±0.77	22.38±0.88	24.49±0.79	28.03±2.45	0.81
C18:2c	2.99±0.08 ^a	1.98±0.54 ^b	2.72±0.05 ^{ab}	3.15±0.21 ^a	0.06
C18:2t	0.68±0.14	0.98±0.43	0.3±0.17	0.84±0.15	0.30
C18:3α	0.4±0.05	0.38±0.01	0.39±0.04	0.5±0.03	0.11
MUFA	28.69±1.25	23.53±8.8	26.31±1.11	29.75±2.53	0.78
PUFA	4.07±0.18 ^a	3.34±0.12 ^b	3.41±0.23 ^b	4.49±0.27 ^a	0.005
Total USFA	32.76±1.37	26.87±8.92	29.72±1.18	34.23±2.61	0.70

A= 80:20; B=60:40; C=40:60; D=20:80 (C:R); MUFA: sum of mono unsaturated fatty acids (C14:1, C15:1, C16:1, C17:1, C18:1c); PUFA: sum of poly unsaturated fatty acids (C18:2c, C18:2t; C18:3α); Total USFA: sum of MUFA+PUFA.

^{a-b} Values within same row with different letters differ (P<0.05)

Unsaturated fatty acids:

Percentages of unsaturated fatty acids are presented in Table 4. Experimental diets with different roughage to concentrate ratios (A, B, C and D) did not affect the percentages of unsaturated fatty acids (C14:1, C15:1, C16:1, C17:1; C18:1c, C18:2t and C18:3 α) except for the C18:2c fatty acid. Ewes fed on D and A diets had more ($P = 0.06$) C18:2c (3.15 ± 0.21 and 2.99 ± 0.08 g/100g fat) than ewes fed on diets B (1.98 ± 0.54 g/100g fat) not on diet C (2.72 ± 0.05 g/100g fat). Also, percentages of mono (MUFA)- and total unsaturated fatty acids (Total USFA) were not affected with treatments. However, percentages of poly unsaturated fatty acids (PUFA) were increased ($P < 0.01$) in milk fat from ewes fed on diets A and D (4.07 ± 0.18 and 4.49 ± 0.27 g/100g fat)

compared to diets B and C (3.34 ± 0.12 and 3.41 ± 0.23 g/100g fat).

Saturated fatty acids:

Percentages of saturated fatty acids are presented in Table 5. Percentages of saturated fatty acids (C6:0; C8:0; C10:0; C12:0; C14:0; C15:0; C17:0; C18:0 and C20:0 and percentages of total saturated fatty acids (C6:0-C20:0); short chain fatty acids (Short CFA, C6:0- C10:0); medium chain fatty acids (Medium CFA, C12:0 - C15:0) and long chain fatty acids (Long CFA, \geq C16:0) were not affected with treatments (Table 5). However, only palmitic (C16:0) fatty acid was increased ($P = 0.08$) in the milk fat samples of treatment D (31.38 ± 1.8 g/100g fat) as compared to treatments A (25.76 ± 0.55 g/100g fat), B (28.17 ± 1.18 g/100g fat) and C (28.37 ± 1.67 g/100g fat).

Table 5: Saturated milk fatty acids (g/100g fat) in Harri ewes fed on four different diets (A, B, C, and D) during lactation. (means \pm SE).

Fatty acids	Treatments				P-value
	A	B	C	D	
C6:0	1.34 \pm 1.34	0.73 \pm 0.63	0.89 \pm 0.88	0.81 \pm 0.25	0.959
C8:0	4.18 \pm 0.86	3.57 \pm 0.84	4.74 \pm 0.67	3.0 \pm 0.67	0.443
C10:0	8.14 \pm 0.83	7.72 \pm 2.05	7.91 \pm 1.37	4.99 \pm 1.07	0.385
C12:0	4.57 \pm 0.32	4.13 \pm 0.99	4.57 \pm 0.45	5.22 \pm 2.19	0.938
C14:0	9.06 \pm 0.51	9.7 \pm 1.63	9.87 \pm 0.14	7.13 \pm 1.91	0.443
C15:0	0.80 \pm 0.15	0.67 \pm 0.1	0.96 \pm 0.1	0.86 \pm 0.11	0.405
C16:0	25.76 \pm 0.55 ^b	28.17 \pm 1.18 ^{ab}	28.37 \pm 1.67 ^{ab}	31.38 \pm 1.8 ^a	0.08
C17:0	0.69 \pm 0.03	0.64 \pm 0.04	0.7 \pm 0.05	0.71 \pm 0.03	0.630
C18:0	12.66 \pm 1.0	14.93 \pm 2.39	12.16 \pm 0.81	11.97 \pm .56	0.438
C20:0	0.06 \pm 0.06	5.2 \pm 0.15	0.14 \pm 0.14	0.09 \pm 0.09	0.425
Total SATFA	67.25 \pm 1.37	73.13 \pm 8.92	70.29 \pm 1.18	65.77 \pm 2.61	0.702
Short CFA	13.66 \pm 1.95	12.03 \pm 3.07	13.53 \pm 2.23	8.8 \pm 1.36	0.417
Medium CFA	15.33 \pm 0.41	14.63 \pm 2.66	16.14 \pm 0.52	13.84 \pm 0.77	0.708
Long CFA	71.02 \pm 1.94	75.67 \pm 5.26	70.33 \pm 231	77.74 \pm 2.05	0.331

A= 80:20; B=60:40; C=40:60; D=20:80 (C:R); C6:0 Caproic; C8:0 Caprylic; C10:0 Capric; C12:0 Lauric; C14:0 Myristic; C15:0 Pentadecylic; C16:0 Palmitic; C17:0 Margaric; C18:0 Stearic; C20:0 Arachidic; Total SATFA: total saturated fatty acids (C6:0-C20:0); Short CFA: short chain fatty acids (C6:0- C10:0); Medium CFA: medium chain fatty acids (C12:0 - C15:0); Long CFA: long chain fatty acids (\geq C16:0).

Discussion

In the current study ewes were at their mature body weight and were lactating. It is apparent the ewes in groups A and B (80:20 and 60:40 C:R, respectively) suffered less body weight loss due to lactation compared to groups C and D (40:60 and 20:80 C:R, respectively). Birth weight and weaning weight of lambs born for these ewes fed on the four experimental diets was not different. Therefore, one can conclude that altered concentrate to roughage ratio had no effect on overall body weight of ewes after parturition and on their weaned lambs as well. Helal *et al.* (2011) reported that buffalo calves fed 100% concentrate feed mixture with rice straw *ad lib* gained more body weight than calves fed 85% concentrate mixture, however feed conversion ratio was improved in calves fed on 70% concentrate mixture compared to other groups. Sultana *et al.* (2012) reported that growth rate did not differ significantly between groups of goats fed on different roughage to concentrate ratios. However, they reported that growth rate was increased with increased ratio of concentrate in the diet. Others (Kochapakdee *et al.*, 1994) reported that female goats receiving concentrate diet (0.8% bwt) gained more weight than goats receiving no concentrates supplementation.

Ewes that received the highest roughage ratio (80%, group D) had greater daily milk yield compared to other groups. Percentages of milk fat, solids not fat (SNF), protein, lactose and minerals were not different among groups. However, milk fat yield was high in groups A and D. Group D had consistent increased yield of SNF, protein, lactose and minerals compared to other groups. This elevation milk fat yield in group D is possibly due to increased overall daily milk yield due to consumption of high roughage ratio (80%) diet. The high roughage content is associated with increased fiber intake and improved

rumen fermentation in the rumen and more production of milk precursors such as VFA.

Sanz Sapelayo *et al.* (2007) reported that the level of energy intake is positively related with the quantity and negatively with the fat content of sheep milk. In particular, a level of concentrate exceeding 60% dry matter is known to have a negative effect on the fat content (Martini *et al.*, 2010). In the current study, The diet containing highest ratio of roughage (D, 80% roughage:20% concentrate) produced greater milk yield, however all milk composition parameters of fat, SNF, protein, lactose and minerals percentages (%) were not affected by changing roughage to concentrate ratio. In the meantime, feeding low roughage to concentrate ratio (diet A) is associate with increased intake of non-structural carbohydrate, which then lead to a decrease in the production of acetate and butyrate in the rumen due to rapid degradation of these non-structural carbohydrates (Caja and Boquier, 2000). In cows, Sterk, *et al.* (2011) reported that shifting from a high forage (65:35 F:C) to a high concentrate (35: 65 F:C) diet increased dry matter intake and milk yield in dairy cows. The higher dry matter intake with high concentrate diets is associated with a lower dietary NDF content as suggested by Allen (2000). The observed increase in milk yield with high concentrate could be explained by a greater intake of dry matter, with higher nutrient density. However, such effect was not seen in the current study where the High concentrate diet (A) produced less milk yield than high roughage diet (D). This could be due to the higher nutritive value of the alfalfa hay as compared to the concentrate mixture.

Excessively high ratios of concentrates can reduce the intake of fiber and therefore reduce chewing times and rumen pH. This can depress milk production and reduce the concentration of fat in milk (Oddy, 1978; Chiofalo, *et al.* 1993) probably because they cause rumen acidosis (Plaizier, *et al.* 2008).

This can explain reduced milk yield in high concentrate (80%) diet (A) compared to low concentrate (20%) diet (D) in the current study. However, milk fat percentages were not affected by levels of concentrates in the diet in contrary to the former reports. In contrary, high roughage to concentrate ratio leads to an increase in the production of acetate by the cellulitic bacteria in the rumen (Chesson and Forsberg, 1997), that can be used as a precursor for the synthesis of fat in the mammary gland.

Ewes receiving rations A (80:20 C:R) and D (20:80 C:R) diets produced more milk fat% than groups B (60:40 C:R) and C (40:60 C:R) receiving intermediate roughage to concentrate ratios. Results of Robinson *et al.* (1979) and Pulina *et al.* (1995) showed that milk yield and concentration of milk fat can be increased by increasing the protein content of the diet. Milk production parameters varied according to nutrient composition of feeds during lactation. Robinson, *et al.* (1979) found a slight increase in milk protein in ewes fed fishmeal, when compared with those fed soybean or peanuts protein supplements. Effects of fishmeal was attributed to an increase in the amount and profile of amino acids absorbed in the small intestine and that are available for milk synthesis.

Treacher (1989) documented 600 to 940 ml/d improvements in milk yield with fish and blood meal supplementation of forage-fed ewes. Cannas (1995) observed that in sheep fed hay and concentrates, for a given concentration of NDF, a reduction in the particle size of hay resulted in a reduction in chewing time and an increase in feed intake. As a result the digestibility of dry matter and Neutral detergent Fiber decreased, but the amount digested per day was not affected. Consequently, there was an increase in milk yield and milk protein yield. Such increase in the yield of milk protein was found in group D (high roughage, 80%) in the current study but

the increase in milk protein yield could be due to increased milk yield rather than protein content of rations.

Saliba, *et al.* (2014) reported that high concentrate diet provided more starch content resulting in increased milk protein yield. Similar reports were reported by Sterk, *et al.* (2011) when supplied starch, a glycogenic precursor which has been shown to be correlated with increased milk protein synthesis. Similar results were reviewed by Emery (1978) reporting a positive correlation between milk protein and energy intake when concentrate was substituted for forages. Further, Robinson *et al.* (1979) and Pulina *et al.* (1995) have shown that milk yield and concentration of milk fat can be increased by increasing the protein content of the diet.

A tendency for a higher fat yield was observed with high concentrate diets (Saliba *et al.*, 2014), which was consistent with the present data where high concentrate diet (A) produced significantly more milk fat yield compared to diets B and C not D diet. However, the current findings are contrary to those reported by Sterk, *et al.* (2011) who reported lower milk fat content when feeding high concentrate diets.

Roughage material (alfalfa hay) used in the current study was found to be high in its content of crude protein and provided high quality crude protein in addition to the high fiber fraction. So, diet D (20:80 C:R) containing 80% roughage is not expected to be deficient in CP content if compared to diet A (80:20 C:R) per se but the higher ratio of fibers is what distinguished that diet from other diets. It seems the rumen fermentation appeared to have been improved in groups A and D that were either high in concentrate ratio (80%, group A) or high in roughage ratio (80%, group D). Intermediate ratios of concentrate and roughage did not support optimal rumen fermentation performance reflected on milk yield and milk composition.

The decrease in myristic (C14:0, 7.13%) fatty acid in group D (80:20 F:C), would seem to have positive effects on human health. Martini *et al.* (2010) also observed decreased values of some medium chain fatty acids viz. C12:0 (14.89%) and C14:0 (4.03%) with the increase in roughage level in the diet of lactating ewes. On the other hand, an inverse effect was observed in relation to the oleic (C18:1, 28.03%), linoleic (C18:2, 3.15%), acids, which increased with the level of increased roughage (diet D, 20:80 C:R). Similar data were reported by Beyero, *et al.* (2015) in lactating cows. Higher percentages of palmitic (C16:0, 31.4%) fatty acid do not appear to be favorable, since these fatty acids are have hyper cholesterolemic properties (Chiofalo *et al.*, 2004). Similar trend was reported by Martini *et al.* (2010) in ewes fed on high forage to concentrate rations. Also Beyero *et al.* (2015) reported that as the dietary roughage proportion increased there was a significant reduction in the concentration (g/100g fat) of C10:0, C12:0 and C14:0 fatty acids.

Total long chain fatty acids (TLCFA, 77.7%), monounsaturated fatty acids (MUFA, 29.75%) and polyunsaturated fatty acids (PUFA, 4.49%) increased with the increased proportion of roughage in the diet (Beyero *et al.*, 2015). These finding are found to be in accordance with our findings in current study.

The lower percentage of short chain fatty acids in group D (8.8 g/100g fat) though not significant could be due to initial inhibition of *de novo* synthesis of the fatty acids in the mammary glands (Pérez Alba, 1997). An inverse trend was observed in the high concentrate diet A (80% concentrate) where short and medium chain fatty acids were increased. Further, due to this effect on *de novo* synthesis of short chain fatty acids, an alternate increase in the proportion of long chain fatty acids was seen in group D (high

forage diet). Ewes from groups A (high C) and D (high R) had significant increase in the proportions of C18:2c and poly unsaturated fatty acids (PUFA) as compared to those of groups B and C.

Polyunsaturated fatty acids are not synthesized by the tissue of ruminants, so their concentration in the milk strictly depends on the amount of the fat absorbed in the intestines and, therefore, on the amounts released in the rumen. Therefore, the increase in the roughage level proportionally decreases the concentrate contents and hence the availability of unsaturated fatty acids to be used by the mammary gland in the synthesis of milk lipids (Grummer, 1991; Chilliard *et al.*, 2001 and Mesquita *et al.*, 2008). Dairy cows on herbage-based diets derive fatty acids for milk fat synthesis from the diet and rumen microorganisms (400–450 g/kg), from adipose tissues (< 100 g/kg), and from *de novo* biosynthesis in the mammary gland (about 500 g/kg) (Kalač and Samkova, 2010). The relative contributions of these fatty acids (FA) sources to milk fat production are highly dependent upon feed intake, and diet composition. High intake of concentrate diet is associated with a higher level of *de novo* synthesis resulting in more saturated milk fat. In contrast, higher intakes of PUFAs from forage result in higher concentrations of oleic acid, in milk fat (Walker *et al.*, 2004).

Conclusions

It can be concluded that nutrition of sheep and formulation of their diet is greatly dependent on the physiological status of animals and hence their physiological requirements. Lactating ewes' rations should include adequate ratio of roughage to increase milk yield and improve milk fat composition and as a result improve lambs survival and growth weight.

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إنتاج اللبن وتركيبه وتأثره بالتعديلات الغذائية

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قسم زراعة المناطق الجافة؛ كلية الأرصاء والبيئة وزراعة المناطق الجافة؛ جامعة الملك عبدالعزيز، جدة، المملكة العربية السعودية، و* قسم الإنتاج الحيواني والسمكي؛ كلية الزراعة؛ جامعة الإسكندرية، الإسكندرية، جمهورية مصر العربية

المستخلص. أجريت هذه الدراسة لتقدير إنتاج اللبن وتركيبه الكيماوي ومحتواه من الأحماض الدهنية في النعاج الحري الحلابة (عدد ٢٤) والمغذاة على علائق متباينة في نسبة المادة المائلة إلى المادة المركزة (عليقة أ-٨٠٪ مركز: ٢٠٪ مائي/ عليقة ب-٦٠٪ مركز: ٤٠٪ مائي/ عليقة ج-٤٠٪ مركز: ٦٠٪ مائي/ عليقة د-٢٠٪ مركز: ٨٠٪ مائي). وقد أظهرت النتائج انه لم يطرأ أي تغير على وزن النعاج بعد الولادة لكن تناقص الوزن تدريجياً مع زيادة أيام الحليب. المعاملة د (٠,٥±١,٣٨ كجم/يوم) أنتجت حليب أكثر من المعاملة أ (٠,٥±٠,٧٦ كجم/يوم) والمعاملة ب (٠,٥±٠,٨٨ كجم/يوم) والمعاملة ج (٠,٥±٠,٦٦ كجم/يوم). محصول كل من الدهن والجوامد الصلبة غير الدهنية والبروتين واللاكتوز والمعادن كان أعلى في المعاملة د مقارنة بالمعاملات أ؛ وب؛ وج. ولم يلاحظ تغير في النسبة المئوية لكل من مكونات الحليب من الدهن والجوامد الصلبة غير الدهنية والبروتين واللاكتوز والمعادن. وارتفع محتوى دهن اللبن من الحامض الدهني C18:2c في المعاملات أ؛ ود (٠,٢١±٣,١٥؛ ٢,٩٩ ± ٠,٠٨ جم/١٠٠جم) مقارنة بالمعاملات ب؛ وج (٠,٥٤±١,٩٨؛ ٢,٧٢ ± ٠,٠٥ جم/١٠٠جم). ارتفع محتوى دهن اللبن من الأحماض الدهنية المتعددة وغير المشبعة (PUFA) في المعاملات أ؛ ود (٠,١٨±٤,٠٧؛ ٤,٤٩ ± ٠,٢٧ جم/١٠٠جم) مقارنة بالمعاملات ب؛ وج (٠,١٢±٣,٣٤؛ ٣,٤١ ± ٠,٢٣ جم/١٠٠جم). لذلك فإن علائق النعاج الحلابة يجب أن تحتوي على نسبة كافية من الألياف لزيادة إنتاج الحليب، ولتحسين محتوى دهن اللبن من الأحماض الدهنية غير المشبعة.

الكلمات الدالة: أغنام؛ مادة مركزة؛ مادة مائلة؛ التغذية؛ إنتاج اللبن؛ الأحماض الدهنية.