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Research Article

Transcriptional Profile and Meat Quality Attributes of Abo-Deleek Lambs Managed under Intensive and Semi-Intensive Production Systems of Egypt

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Abstract | Feeding regime and genetic potentiality for muscle development and growth are major factors affecting sheep meat production. Therefore, the aim of this study was to evaluate the potential of Abo-Deleek lambs in meat production under different management systems. Sixteen Abo-Deleek lambs aged six months were used in the present study. Experimental lambs were divided according to body weight into two similar groups and then randomly allocated to two different management systems, intensive (G1=22.31± 3.95kg) and semi-intensive (G2=22.34±1.98kg). At the end of the experiment, fourteen lambs were slaughtered to evaluate carcass traits. There was no significant (P< 0.05) difference on average pre slaughter weight (37.63± 2.97 and 36.88±3.83kg) for G1 and G2, respectively. However, significant differences were obtained between G1 and G2 in dressing percentage based on slaughter weight (49.11 vs. 46.21 %), liver percentage (1.74 vs. 1.39%) and percentages of edible parts (2.60 vs. 2.14%). Our results indicated that animals rose under semi-intensive system has more fat content in their eye muscle linked with increased expression of *CPT-1* gene compared with animals rose under intensive system. This could be due to free movement which increased fat mobilization into muscle tissue through up regulation of *CPT1* gene required for oxidation of fatty acids to meet their increased metabolic demand. Our data indicated the potential of Abo-Deleek lambs in meat production under different management systems which contribute in solving the problem of animal production shortage in Egypt. Molecular regulation of genes involved in muscle development is similar between the two production systems although semi-intensive system induces upregulation of fatty oxidation due to increasing demand for energy utilized in free movement of animals.

Keywords | Transcriptional profile, Meat quality, Abo-Deleek lambs

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INTRODUCTION

The lamb's meat represents a part category into global meat production, for the reason that as concerns its qualities are considered meat with remarkable organoleptic and nutritive structures (Ilisiu et al., 2010). However, most previous studies comparing animals that pasture with animals fed in stipulation in different environmental conditions and space, and physical activity could distort the interpretation of results (Dunne et al., 2005). The source of income of most inhabitants depends mainly on range animals. Rainfall sometimes starts from October up to March, but erratic no accurate records for rainfall were reported in this region (El-Shaer et al., 1997). Abo-Deleek

sheep breed is the most dominant livestock in this region (El-Shaer et al., 1997). The range vegetation is considered the basic source of ruminants feed in Shalaten-Halaib triangle. The main nutritional problems of animals on range lands are erratic and short duration of rains precipitation lead to long drought periods, shortage of forage production, and seasonal starvation of animals. In addition, this region suffer from unavailability of feed concentrates, unavailability of drinking water for animals during the dry season and improper economic inter-relationship between animal productivity and potential utilization of range plants (El-Shaer et al., 1997). Ruminant production in most countries of tropical Africa relies on the availability of grazing land. The quality and quantity of grasses available as feed are low as a result of long-dry season. Although range plants grow rapidly during the rainy season, their nutritive value may be high at the beginning of range season then it reduces rapidly. Tedonkeng et al. (2006) indicate that drought in the summer/autumn severely affects negatively sheep production due to low pasture growth and quality, thus limiting the feed available for grazing ewes during the pre-mating and mating periods. Feeding ewes at a level below the maintenance requirements results in reduction of body condition score (BCS), ovulation rate and subsequent lambing percentage. Lamb meat quality is influenced by many factors such nutrition (Castro et al., 2005). Other factors that may influence the quality of the meat can be pre-slaughter stress, the rate of cooling of the carcasses and curing regime (Teixeira et al., 2005). The quality of meat is dependent on physical-chemical characteristics, in particular color and fat content. In addition, factors such as inappropriate feeding regime and low genetic potentiality for growth are major causes that reduce meat production (Kefelegn et al., 2019). Indeed, growth performance of lambs is dependent on regulation of many genes (Gholibeikifard et al., 2013). Therefore, the aim of this study was evaluation of the potential of Abo-Deleek lambs breed under different management systems as a source of meat production and choice for contribute in solving the problem of animal production shortage in Egypt.

MATERIALS AND METHODS

The experiment was conducted at Ras Hederba Valley region (Haleeb and Shalateen Research Station, Desert Research Center), Ministry of Agriculture and Land Reclamation, which is located 1200 km south of Egypt.

Study area description

Wadi Hederbah is located at the southeast corner of Halaib City, Red Sea Governorate, about 1200 km south eastern from Cairo, the capital of Egypt with latitude 22, 00, 720 N and longitude 36, 48, 955 E (Figure 1).

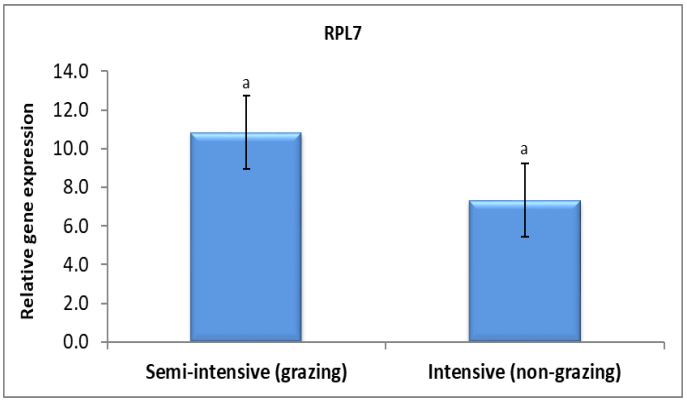

Figure 1: Expression profile of RPL7 gene in eye muscle collected from Abo Deleek lambs raised under intensive and semi-intensive management systems.

The average ambient temperatures during summer (dry) and winter (wet) seasons were 35°C and 22°C while, humidity were 37 % and 43%, respectively (Askar et al., 2013). This Wadi has the richest rangeland resources and the greatest potential for improvement of all the Wadis in the Shalateen-Halaib region (El-Hakeem, 2017).

The study area is a part of Wadi Hederbah and it was mapped and delineated according to the terrain and the livestock grazing distribution and movement at the area. Even though mesquites (*Prosopis Juliflora*) have invaded large areas in southeastern Egypt, it isn't found in the study area.

The livestock types in the area included mainly sheep and goats, in addition to few numbers of camels.

Animals and management systems

Sixteen Abo-Deleek male lambs aged six months with an average live body weight of 22.2±0.75 kg were used in the present study. Experimental lambs were divided according to body weight into two similar groups (eight each) and then randomly allocated into two different management systems: viz., intensive management system (G1) with an average body weight of 22.31±1.39kg and semi-intensive management system (G2) with an average body weight of 22.34±0.70kg.

The lambs of G1 group were fed a certain amounts of commercial concentrate mixture (12% crude protein) plus alfalfa (berseem) hay (*Trifolium alexandrinum*), offered *ad libitum*. However, lambs of G2 group had free access to grazing on natural vegetation from morning till afternoon then, they moved back to the barns. In addition, lambs of G2 group were offered commercial concentrate mixture (12 % crude protein) in the barn. Noteworthy, the amounts of concentrates feed mixture (CFM) for G1 and G2 groups were bi-weekly adjusted (according to the live body weight changes) and water was given as per their body

requirement. Lambs were fed as per standard schedule according to National Research Council (2007) in order to cover their nutritional requirements.

Slaughter data

At the end of the experiment (after 180 days), fourteen lambs were slaughtered following the stranded protocol (Frild et al., 1963). The average pre slaughter weight of G1 (37.63 ± 1.05 kg) was similar to G2 (36.88±1.36 kg). Samples of eye muscle (*Longsimus dorssi*) were collected from the carcass (rib cut) to evaluate the physical and chemical properties of Abo- Deleek lambs breed meat.

Wholesale cuts and physical components of 9-10-11 rib cut

After chilling, each chilled carcass was cut into seven cuts (neck, shoulder, rack, flank, loin, leg and tail) according to the Egyptian wholesale mutton cuts as described by Hamada (1976). Chilled carcasses and wholesale cut were weighed to calculate percentages of chilled carcass weight. The 9-10-11 rib cut was separated into its physical components (lean meat, fat and bone), which were expressed as percentages of the weight of the whole rib cut. The area of the cross section of the *Longissimus dorssi* (LD) muscle was measured among 11th and 12th rib using a polar plane meter.

Physical parameters of meat

Physical properties of meat, viz., colour, expressible fluid (%), cooking loss (%), water-holding capacity (W.H.C), plasticity and shear force were determined.

Meat color was measured using Croma meter (Konica Minolta, model CR 410, Japan) calibrated with a white plate and light trap supplied by the manufacturer. Color was expressed using the CIE *L**, *a**, and *b** color system (CIE, 1976). A total of three spectral readings were taken for each sample on different locations of the muscle. Area of the cross section of *Longsimus dorsi* (*L.D*) muscle, and was measured by tracing the exact area of the exposed muscles on acetate paper between 11th and 12th rib using polar plane meter.

Expressible fluid percentage was measured by weighing about 0.3 g of meat (W1) in filter paper (Whatman No. 1) and subjected to pressure of 1000 g for 10 minutes. After that it was weighed again (W2). The expressible fluid was estimated as the percentage of the difference between the two weights from the initial weight:

$$\text{Expressible fluid \%} = [(W1-W2)/W1] \times 100$$

Cooking loss was determined on 100 grams of *L.D* muscle samples (W1) which were boiled in water for 45 minutes, left to be cooled at room temperature and weighed again (W2) to calculate cooking loss percentage according to standard protocol (Bouton and Harris, 1989).

$$\text{Cooking loss (\%)} = (W1-W2) / W1x100$$

The (WHC) and plasticity of lambs meat were estimated by the method of Wierbicki and Deatharage (1968) using the following equation:

$$WHC = A_2 - A_1$$

Where:
A_1= Inner area of plasticity (area of meat after pressing) cm^2; A_2= Outer area (area of meat plus area of free water after pressing) cm^2; Both areas were determined using a plane meter.

The cooked samples were used for determining the shear force (kg). Samples were kept in refrigerator (4 - 5 °C) for about 12 h, before estimating shear force using Instron Universal Testing Machine (Model 2519-105, USA). Cores from each sample were taken using cylinder of 0.5 inch in diameter. Cores were removed parallel to the longitudinal orientation of muscle fibers. The shear force machine was adjusted at crosshead speed of 200 mm/min according to the procedure outlined by Shackelford et al. (2004).

Chemical analysis of meat

Meat chemical analysis of the L.D muscle was determined using Food Scan™ Pro meat analyzer (Foss Analytical A/S, Model 78810, Denmark). According to the manufacturer's instructions, about 50 - 100 gm of raw meat (obtained from the 9th rib) were minced and put in the meat analyzer cup. The cup was inserted into the meat analyzer for scanning sample with infra red to determine the chemical components (moisture, protein, fat and collagen). Ash content was determined by burning samples in a muffle furnace at 600° C for eight h.

The pH value of lamb's meat was determined using a pH meter (Portable Digital Waterproof HANNA model HI 9025) after slaughter and 24 h from slaughter.

Sensory evaluation

Samples from loin cut of each lamb were cooked (boiled in tap water for 45 minutes) just after chilling. After cooking, samples were judged for sensory evaluation by serving to ten panelists in at Haleeb and Shalteen Research Station to evaluate aroma, flavor, tenderness, juiciness and palatability. Each trait was scored on a scale from 1 to 5 representing the grades of very poor, poor, fair, good and very good, respectively.

Gene expression analysis

RNA isolation: The extraction of total RNA was conducted according to manufacture instructions of GeneJet RNA purification kit (Thermofisher Scientific, Vilnius, Lithuania). Total RNA was extracted from 20 mg of tissue samples that was weigh and grinded with a pestle in a mortar using liquid nitrogen till powder was formed. The powder was transferred to a 1.5 ml micro-centrifuge tube with 300µl of lysis buffer and 20µl of β-mercaptoethanol, this was vortexed for 20 seconds. 600µl of diluted Proteinase K (10µl of included Proteinase K diluted in 590µl of Tris-EDTA (TE) buffer) was added. It was vortexed for 20, incubated for 10 minutes at room temperature and it was centrifuged for 10 minutes at 12000 xg. 450µl of ethanol was added and mixed by pipetting.

A total volume of 700µl of lysate was transferred to the purification column and was inserted into a collection tube, and then it was centrifuged for 1 minute at 12000 xg. The flow through was discarded and placed the purification column into the tube. The previous step was repeated until all the lysate was transferred and centrifuged. After that the collection tube was discarded, which contained the flow though solution. The purification column was placed into a new 2ml collection tube. 700µl of wash buffer 1 was added to the purification column and centrifuged for 1 minute at 12000 xg. The flow through was discarded and the purification column was placed back into the collection tube, then 250µl of wash buffer 2 was added to the purification column and centrifuged at 12000 xg for 2 minutes. After that the collection tube was emptied and the column was centrifuged for 2 minutes at 14000 xg. The collection tube containing the flow through solution was discarded and the purification column was transferred to a sterile 1.5 ml RNase free micro-centrifuge tube. 100µl of nuclease free water was added to the purification column and centrifuged at 12000 xg for 1 minute. The purification column was discarded. The purity and concentration of the 9 samples were measured on NanoDrop 2000C (Thermofisher Scientific, Wilmington, DE, USA), using nuclease free water as blank. The samples were stored in -80°C freezer. The NanoDrop measurement was at A260/280 nm ratio which was ranged from1.9 to 2.1.

The DNA digestion step for extracted RNA was done by adding µl 9 of RNA of each sample to 1µl of DNase and 1µl of MgCl2 buffer. This reaction mixture was incubated for 30 minutes at 37°C. Finally, 1µl of EDTA was added and incubated at 65°C for 10 minutes.

The reverse transcription of RNA to cDNA

The cDNA synthesis was done according to instruction provided by the revert Aid First Strand cDNA Synthesis Kit (Thermofisher Scientific, CA, USA). The following chemicals were added to each RNA sample (11 µl), 1µl of oligo dt18 primer, 4µl of reaction buffer was added, 2µl of dNTPs, 1µl of RNase inhibitor, 1µl of reverse transcriptase enzyme and these were gently mixed by pipetting. In the thermocycler (PCR) it was incubated for 60 minutes at 42°C, then for 5 minutes at 70°C and at 4°C for holding.

Quantitative real-time polymerase chain reaction

The quantitative real-time PCR was performed to evaluate the relative expression of 5 selected candidate genes (CPT1, ADIPOQ, FABP4, RPL7 and CAPN3). In addition, glyceraldehyde 3-phosphate dehydrogenase (GAPDH) was used as housekeeping gene. The forward and reverse primers of each target gene were designed using Primer3 program (http://primer3.wi.mit.edu//) as shown in Table 6. The reaction of real-time PCR was performed in the 96 well plates (Thermofisher Scientific, CA, USA). The reaction of real-time PCR was consisted of 2µl of cDNA sample, 10µl of Maxima SYBR green after adding ROX (Thermofisher Scientific, CA, USA), 0.4µl of specific reverse primer, 0.4µl of specific forward primer and 7.2µl of nuclease free water. The reaction was loaded on StepOnePlus™ Real-Time PCR instrument (Applied Biosystems, CA, USA). The thermo cycler setting was initially at 50°C for 2 minutes, 95°C done for 10 minutes and 40 cycles at 95°C (denaturation) for 15 second then at 60°C for 1 minute (annealing) and finally extension step at 60°C for 30 seconds and then 72°C for 30 seconds. The quantitative analysis was done using the ΔΔC(t) method.

Statistical analysis

The data was subjected to one way analysis of variance (ANOVA) using a general linear model (GLM) of Statistics 22.0 software (SPSS, Inc., Somers, NY, USA). With type of management system as the main effect as follows:

$$Y_{ij} = u + d_i + e_{ij}$$

Where;

Y_{ij} = the observations; µ = the overall mean; d_j = the effect due to i^{th} type of management system, $_{i =}$ 1,2; e_{ij} = random error associated with the $_{ij}^{th}$ observation.

The significant differences were tested according to Duncan's new multiple ranges test (Duncan et al., 1955).

RESULTS AND DISCUSSION

Wholesale cuts

There was non-significant difference (P>0.05) in hot carcasses weight between G1 (16.90±0.64 kg) and G2 (17.91±0.86 kg) groups. The mean values of chilled carcass

weight and percentages of wholesale cuts of chilled carcass weight are shown in Table 1. No significant differences were obtained for wholesale cuts expressed as percentage of chilled carcass weight between intensive and semi-intensive management systems. Our results are similar to that reported by Majdoub-Mathlouthi et al. (2013). However, this result is in disagreement with that reported by Shehata et al. (2012) who noted that neck, loin, leg and flank percentages differed (P<0.05) due to type of diet, while the other wholesale cuts indicated no significance. In addition, this result is in dissimilarity with Borton et al. (2005) whom showed that loin proportion was higher for lambs finished on concentrate than those finished on forages.

Table 1: Chilled carcass weight (Kg) and wholesale cuts (%) of Abo Delek lambs raised under intensive and semi-intensive management.

Item	Over all Mean ± SE	Intensive ± SE	Semi intensive ± SE
Chilled carcass weight (Kg)	17.19 ±0.52	16.68[a]±0.63	17.69[a] ±0.83
Wholesale cuts (%)[1]			
Neck	8.80 ±0.33	8.86[a] ±0.41	8.74[a] ±0.56
Shoulder	18.53 ±0.30	18.56[a] ±0.44	18.49[a] ±0.44
Rack	27.26 ±0.55	26.90[a] ±0.83	27.62[a] ±0.77
Flank	6.16 ±0.27	6.50[a] ±0.32	5.81[a] ±0.41
Loin	7.18 ±0.52	7.65[a] ±0.79	6.71[a] ±0.68
Leg	29.34 ±0.50	28.83[a] ±0.85	29.84[a] ±0.51
Tail	2.74 ± 0.15	2.70[a] ±0.21	2.77[a] ±0.23
Loss	1.75 ±0.13	1.99[a] ±0.14	1.52[a] ±0.17
9-10-11 rib cut weight (Kg)	0.84 ±0.04	0.78[a] ±0.04	0.90[a] ±0.07

[1]Based on chilled carcass wt. Means followed by different superscript letters within the same row are significantly different at P<0.05.

Physical components of rib cut

The results in Table 1 indicated no significant differences were obtained between intensive and semi-intensive management systems for the mean values of Lean meat, fat, bone, Lean: Fat ratio and Lean: bone ratio percentages of 9-10-11 rib cut weight (Table 2). However, these results are in disagreement with that reported by Shehata et al. (2012) who found significant differences (P<0.05) in fat and lean percentages among animals fed different diets.

Physical properties of meat

Results revealed no significant differences between intensive and semi-intensive management systems in the mean values of cooking loss percentages and color parameters which is shown in Table 3. While, the mean values of chemical composition of intensive and semi-intensive management systems are shown in Table 2. No significant difference in color parameters of meat between lambs fed under intensive and semi- intensive management systems. In the present study, the lightness (L) of lamb's meat, the redness (a) and yellowness (b) were similar to those reported by several research groups (Vicente et al., 2003; Adnoy et al., 2006; Majdoub-Mathlouthi et al., 2013).

No significant difference was found in meat pH between the intensive and semi-intensive management systems (Table 3). A variance in pH might have been predictable as semi-intensive management system lambs were probably subjected to higher levels of stress due to more difficult and time-consuming gathering in the grazing and a longer transport distance than the intensive management system lambs. This result of variances between two management systems in PH values of meat was similar to result of variances between Lowland compared to Mountain group of lambs reported by Adnoy et al. (2006). The pH values of Abo Delek lambs meat (6.24) was within the range (6.52 to 5.59) of (pH 0 h to pH 24 h) for different type of feed consumed and management systems noted by Vicente et al. (2003). Also those result lower than that reported by Majdoub-Mathlouthi et al. (2013), (6.48 vs. 6.33) for low concentrate level (200–300 g) and high concentrate level (400–600 g) respectively. The results obtained here are comparable to those mentioned by Almitairy et al. (2011) who declared that, meat pH and color components did not differ among dietary groups. The pH value of meat is the result of combination of many factors including pre-slaughter handling, post-mortem treatment and muscle physiology (Thompson, 2002).

Chemical composition of meat

The moisture, ash and collagen percentages were significantly (P< 0.05) affected by management system, while management system difference in protein, fat percentages were not-significant between intensive and semi-intensive management systems (Table 4). The results obtained here are comparable to those mentioned by Shehata et al. (2012) who declared that no significant difference among all dietary groups in moisture, protein and fat percentages except for ash and collagen.

Sensory properties

Significant differences (P <0.05) for the aroma, flavor, tenderness, juiciness and Palatability were observed between intensive and semi-intensive management systems (Table 5). Panelists were able to detect differences among samples of meat. The meat of lambs of semi-intensive management systems had higher score in meat acceptability than those of intensive management system (Table 6).

Table 2: Percentages of physical components of 9-10-11 rib cut of Abo Delek lambs raised under intensive and semi-intensive management.

Item	Over all Mean± SE	Intensive ± SE	Semi-intensive ± SE
9-10-11 rib cut weight (Kg)	0.84 ±0.04	0.78 [a] ±0.04	0.90 [a] ±0.07
Physical components (%)[1] of 9-10-11 rib cut	4.89 ±0.17	4.68 [a] ±0.12	5.10 [a] ±0.30
Lean meat	59.23 ±1.31	59.01 [a] ±2.01	59.46 [a] ±1.83
Fat	18.19 ±1.28	17.48 [a] ±2.18	18.91 [a] ±1.47
Bone	22.57 ±0.65	23.51 [a] ±0.70	21.63 [a] ±1.03
Lean : Fat ratio	3.52 ±0.30	3.77 [a] ±0.54	3.28 [a] ±0.30
Lean: Bone ratio	2.67 ±0.14	2.52 [a] ±0.11	2.82 [a] ±0.25
L.D muscle area (cm^2)	15.28±0.83	15.15[a] ±1.42	15.40[a] ±0.99

[1]: Based on chilled carcass wt. Means followed by different superscript letters within the same row are significantly different at P<0.05.

Table 3: Physical properties of *Longissimus dorsi* muscle and pH value for Abo-Deleek lambs raised under intensive and semi-intensive management.

Parameters	Over all Mean± SE	Intensive ± SE	Semi-intensive ± SE
LD area (cm^2)	15.28±0.83	15.15[a] ±1.42	15.40[a] ±0.99
Fat thickness above *LD* (mm)	0.63[a]±0.04	0.64[a]±0.05	0.62[a]±0.05
Cooking loss %	44.03±1.26	44.74[a]±2.43	43.32 [a]±0.91
Expressible fluid %	48.94 ±4.85	52.02[a] ±6.27	45.86 [a]±7.71
W.H.C (cm^2)*	13.61±0.88	15.53[a]±1.28	11.69[b]±0.69
Plasticity(cm^2)	1.99±0.16	1.81[a]±0.20	2.17[a]±0.25
Shear force (kg)	5.00 ±0.49	4.90[a] ±0.78	5.11[a] ±0.66
Color parameters			
L (lightness)	41.30 ±0.46	40.88[a]±0.59	41.72 [a] ±0.71
a (redness)	16.41 ±0.22	16.57 [a] ±0.33	16.24 [a] ±0.30
b (yellowness)	4.36 ±0.30	4.08 [a] ±0.22	4.63 [a] ±0.55
pH value at slaughtering immediately	6.24 ± 0.06	6.19 [a] ± 0.06	6.30 [a] ± 0.11
Caracas temperature value at slaughtering immediately (°C)	40.78 ± 0.31	40.50[a] ± 0.44	41.07[a] ± 0.46

* W.H.C; water holding capacity. Means followed by different superscript letters within the same row are significantly different at P<0.05.

Table 4: Chemical composition of *Longissimus dorsi* muscle for Abo-Deleek lambs raised under intensive and semi-intensive management.

Parameters	Over all Mean± SE	Intensive±SE	Semi intensive ± SE
Moisture	72.18±0.25	72.88[a] ±0.27	71.74[b] ±0.36
Protein	21.31±0.12	21.29[a]±0.14	21.33[a]±0.21
Fat	5.39±0.31	4.82[a]±0.26	5.95 [a]±0.54
Collagen	1.59 ±0.04	1.47[b] ±0.04	1.71[a]±0.07
Ash	1.13±0.04	1.01[b]±0.07	1.25[a]±0.04

Means followed by different superscript letters within the same row are significantly different at P<0.05.

Table 5: Sensory evaluations for Abo Delek lambs raised under intensive and semi-intensive management systems.

Parameters	Over all Mean± SE	Intensive ± SE	Semi-intensive ± SE
Aroma	3.99±0.06	3.53[b]±0.05	4.44[a]±0.07
Favor	3.93±0.06	3.44[b]±0.05	4.42 [a] ±0.06
Tenderness	3.87 ±0.06	3.34 [b] ±0.05	4.40[a]±0.06
Juiciness	3.90±0.06	3.40[b] ±0.05	4.41[a] ±0.06
Palatability	3.92±0.05	3.43[b] ±0.04	4.42[a] ±0.04

Means followed by different superscript letters within the same row are significantly different at P>0.05.

Gene expression

The expression profile of candidate genes playing key regulatory roles in protein biosynthesis (RPL7: Figure 1), muscle development (CAPN3: Figure 4), lipolysis (FABP4: Figure 3) lipogenesis (ADIPOQ: Figure 2), did not show clear significant variations between lambs rose under intensive and semi-intensive management systems. However, expression profile of genes involved in fatty acid oxidation (CPT1: Figure 5) was up regulated in animals rose under semi-intensive compared with other group that rose under intensive management systems. The study of molecular regulation of genes involved in muscle

Table 6: Primer sequences of genes used for quantitative real-time PCR.

Gene name	Gene bank accession number	Primer sequence	Fragment size (bp)
CPT1	NM_001009259.1	F: 5'- TCACCACTACGACCCAGAGG-3' R: 5'- AGGACTTGTCGAACCACCTG-3'	95
ADIPOQ_	KM216385.1	F: 5'- TTCCCATTCGCTTTACCAAG-3' R :5'- CAAGTAGACGGTAATGTGGT-3'	122
FABP4	NM_001114667.1	F: 5'- GCCAGGAATTTGATGAAGTC-3' R: 5'- ATTTCCCATCCCAGTTTTGT-3'	102
CAPN3	NM_001009212.1	F: 5'- GCCGCAATTTTCCCATTATT-3' R: 5'- GTAAAACAGGGAGGTCTCG-3'	125
RPL7	XM_004011739.4	F: 5'- AAGCGACTGAGAAAGAAGTT-3' R: 5'- CTGATGACAAACGCCAATTT-3'	191
GAPDH	NM_001034034.2	F: 5'- AGGTCGGAGTGAACGGATTC -3' R: 5'- GGAAGATGGTGATGGCCTTT -3'	219

Abbreviations: PCR, polymerase chain reaction; bp, base pair

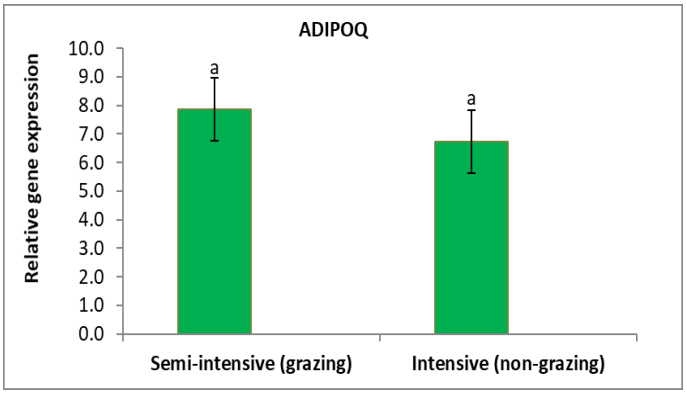

Figure 2: Expression profile of ADIPOQ gene in eye muscle collected from Abo Deleek lambs raised under intensive and semi-intensive management systems.

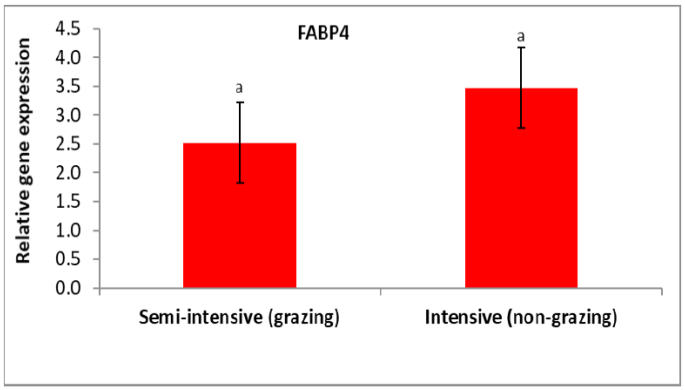

Figure 3: Expression profile of FABP4 gene in eye muscle collected from Abo Delek lambs raised under intensive and semi-intensive management systems.

development is of great importance on providing information on enhancing sheep breeding for meat production purpose (Chao et al., 2016; Sun et al., 2016). The growth of muscles is regulated by many genes that are interacting in certain pathways (Zhang et al., 2015). There are two members of CPT gene family (CPT 1 and CPT 2) that are regulating in transport of long chain fatty acids across the mitochondrial inner and outer membranes, for lipolysis via B-oxidation (Koonen et al., 2010). In this regard, CPT1 is considered a rate limiting gene for the lipolysis process and well known markers for fat content of muscle in Simmental composite cattle (Zhang et al., 2015). The increase expression of CPT1 in the current study in animals rose under semi-intensive could be an indicator of more utilization of fatty acid due to free movement. However, the decreased expression of lipolysis genes such as CPT-1 actually provides a benefit as it increases the capacity of longissimus muscle for de novo synthesis of free fatty acid. Thus, leading to increase in the accumulation of intramuscular fat (Zhang and Guan, 2019). However, our results indicated that animals rose under semi-intensive system has more fat content in their eye muscle linked with increased expression of CPT-1 compared with animals rose under intensive system. This could be that free movement and increased fat mobilization into muscle tissue induced up regulation of CPT1 gene for oxidation of fatty acids to meet their increased metabolic demand.

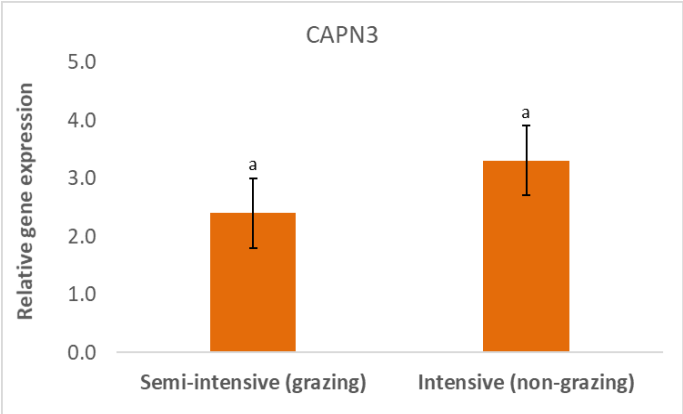

Figure 4: Expression profile of CAPN3 gene in eye muscle collected from Abo Deleek lambs raised under intensive and semi-intensive management systems.

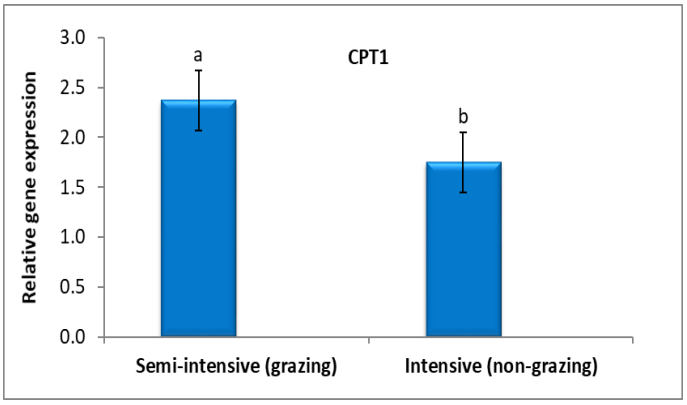

Figure 5: Expression profile of CPT1 gene in eye muscle collected from Abo Deleek lambs raised under intensive and semi-intensive management systems.

CONCLUSIONS AND RECOMMENDATIONS

This study highlights the potential of Abo-Deleek sheep breed as a good source of meat production under different management systems with high quality traits and which would contribute significantly in solving the problem of animal production shortage in Egypt. In addition, this breed adapts well to harsh desert conditions in this region therefore, Abo-Deleek breed is able to compete in meat market of sheep. Moreover, molecular regulation of genes involved in muscle development is similar between the two production systems although semi-intensive system induces upregulation of fatty oxidation due to increasing demand for energy utilized in free movement of animals.

NOVELTY STATEMENT

The noveity of this study is mainiy due to this research work is among the few studies conducting in Abu Deleek breed. This the first study combined gene expression in iink with growth performance and carcass traits of this breed.

AUTHOR'S CONTRIBUTION

All authors have contributed to creating the idea, design of experiment, taking animal measurements,recording data, anaiysis of data, writing and revising the manuscrip.

Conflict of interest

The authors have declared no conflict of interest.

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