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Use of Watermelon (*Citrullus lanatus*) Seeds in Diets for Fattening Lambs

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Abstract

This study was conducted to evaluate the effect of feeding diets with different levels of whole watermelon seeds on growth performance, carcass characteristics and meat quality of lambs. Thirty 6-month old lambs of Sudan desert sheep with an average weight of 33.8 Kg were used in this study. They were randomly divided into three groups (n=10) and assigned into three treatment diets with different levels of watermelon seeds (WS) for 52 days. The diets were WS0, WS10, or WS20, which contained 0% (control), 10% and 20% watermelon seeds, respectively. The results showed that final live weight, daily weight gain and total weight gain, hot carcass weight, cold carcass weight and chiller shrinkage were higher ($P < 0.05$) in WS0 and WS20 groups compared to WS10 group. Feed conversion ratio was higher ($P < 0.05$) in sheep fed WS10 compared to sheep fed WS0. Treatment diets did not affect carcass composition (muscle, fat and bone) and meat chemical composition. However, water-holding capacity and cooking loss were significantly different among the treatment groups, where lambs fed on WS10 had inferior water-holding capacity and higher cooking loss. Treatment diets had no significant effect on meat lightness (L*); but redness (a*) and yellowness (b*) values were significantly higher in WS0 group compared to WS10 and WS20 groups. Shear force value was lower ($P < 0.05$) in WS10 compared to WS0 and WS20. It was concluded that inclusion of whole watermelon seeds up to 20% in lamb diets supported sufficient feedlot performance, carcass characteristics and meat quality.

Key words: Watermelon seeds, lamb, fattening, meat quality

المستخلص

أجريت هذه الدراسة لتقييم تأثير التغذية بمستويات مختلفة من بذور البطيخ على أداء النمو وخصائص الذبيحة وجودة لحوم الحملان. تم استخدام ثلاثين حملاً تبلغ من العمر حوالي ستة أشهر من سلالة الضان الصحراوي و بوزن متوسط 33.8 كجم . تم تقسيم الحملان بشكل عشوائي إلى ثلاث مجموعات (عشرة في كل مجموعة) واعطأ كل مجموعة واحد من ثلاث علائق تختلف في مستويات بذور البطيخ لمدة 52 يومًا. وكانت العلائق هي WS0 و WS10 و WS20 تحتوي على 0٪ (مجموعة ضابطة) و10٪ و 20٪ من بذور البطيخ ، على التوالي. أظهرت النتائج أن الوزن النهائي وزيادة الوزن اليومية وزيادة الوزن الكلية ووزن الذبيحة الحار و البارد وإنكماش التبريد كانت أعلى بكثير في مجموعات WS0 و WS20 مقارنة بمجموعة WS10. كانت نسبة التحويل الغذائي أعلى في الحملان التي تغذت علي WS10 مقارنة بالحملان التي تغذت علي WS0. لم يكون هنالك تاثير على نسبة التصافي و مكونات الذبيحة (العضلات والدهون والعظام) والتركيب

الكيميائي للحوم. كانت قابلية حمل الماء وفاقد الطهي أعلي في الحملان المغذية WS10 مقارنة بالمحوعتين الأخرتين. لم يكن للعلائق الغذائية المختلفة تأثير كبير على درجة سطوع لون اللحم (L*) ؛ لكن درجة الاحمرار (a*) والاصفرار (b*) كانت أعلى بكثير في مجموعة WS0 مقارنة مع مجموعات WS10 و WS20. كانت قوة القص أقل بكثير في WS10 مقارنة مع WS0 و WS20. خلصت التجربة إلى أن ادخال بذور البطيخ الكاملة في علائق تسمين الضان بنسبة تصل إلى 20٪ يدعم اداء جيد في التسمين و خصائص الذبيحة و جودة اللحوم.
الكلمات المفتاحية: *بذور البطيخ، الضان، التسمين ، جودة اللحوم*

Introduction

Feed is a major input into all animal production projects. Feeding systems are developed to take advantage of all available feed resources. Conventional animal feed resources, especially in developing countries, are becoming very expensive due to competition with human and exportation of these products to earn foreign currency. Utilization of non-conventional animals feed resources to supplement energy and protein in ruminant's diets become a necessity.

Watermelon (*Citrullus lanatus*) is a fruit grown in the warmer parts of the world. It consists of about 90 genera and 750 species which are all annual or occasionally perennial herbs. The pulp from watermelon is used for human consumption while seed is the major solid waste. The dry seeds of watermelon have been reported to contain about 32 g of protein and 51.4 g of fat per 100 g (Kamel *et al*., 1985). Moreover, watermelon seeds contain high level of essential fatty acids. The principal fatty acids in the watermelon seed oil are linoleic (68.3%), oleic (13.3%), palmitic (11.4%), and stearic (7%) (Moaddabdoost Baboli and Safe Kordi, 2010) that make watermelon seeds a potential source of protein and lipids (El-Adawy and Taha, 2001).

Watermelon is grown in massive areas in the western region of Sudan, especially West and North Kordofan states, and contributes about 81% of total watermelon seeds production of the country. On the other hand, about 60% of the total Sudan sheep population, which is estimated to be 39,846,000 heads (MARF., 2017), is located in the same region (the western region of Sudan). The availability of both sheep and watermelon seeds in the same area provides a good opportunity to include these seeds in diets to produce ready fattened lambs for local consumption or export. Therefore, this study was conducted to evaluate the effects of inclusion of different levels of whole watermelon seeds in diets for fattening lambs on feedlot performance, carcass characteristics and meat quality.

Materials and Methods

Experimental animals, housing, feeds and feeding.

Thirty 6-month-old lambs of Sudan desert sheep (Kabashi ecotype) with an average weight of 33.8 Kg were involved in this study. Prior to the trial, all animals were dewormed (Ivermectin injection 10%), individually weighed, identified with uniquely numbered ear tags, and subjected to an adaptation period of fourteen days to adjust to the housing conditions and diet. At the end of the adaptation period lambs were divided into three groups (10 animals each), and kept in pens equipped with watering and feeding facilities. The groups were randomly assigned into three iso-caloric and iso- nitrogenous treatment diets with different levels of watermelon seeds (grade two) (Table 1) for 52 days. The diets were WS0, WS10 or WS20, which contained 0% (control), 10% and 20% watermelon seeds, respectively. Clean water and salt lick were available throughout the experimental period.

Feed intake was determined daily as the difference between the amounts of feed offered and refusals. Lambs live weight was taken weekly until the end of the feeding trial.

Slaughtering, dissection and muscle sampling

Animals were slaughtered after an overnight fasting in lairage according to the Islamic Halal-method (severing the throat, the jugular veins and arteries without stunning). Following skinning and evisceration carcasses were weighed hot and after chilling for 24 h at 4 °C. The kidneys and channel fat were removed from the cold carcass and weighed. Subsequently, the carcass was split along the midline. The left side was weighed and cut into wholesale cuts according to MLC, (1977). Cuts were dissected into muscle, bone and fat and each tissue was weighed separately. The total weight of each tissue was pooled to give the total for the side. Samples for chemical analysis and quality determination were taken from *Longissimus thoracis* (LT) muscle, kept in polythene bags and frozen stored until analyses.

Chemical analysis

Chemical analysis of moisture, protein, fat and ash contents of the minced meat samples were carried out according to the methods of AOAC (2007).

Meat quality analysis

Water-holding capacity (WHC)

Samples weighing about 0.5 g from the minced LT muscles were used. Each sample was placed on Whatman (No. 1) filter paper, previously saturated over KCl solution, compressed between two plexi-glass plates with 25 kg load for 5 min and then dried under vacuum. A plano-meter was used to measure the area of the pressed sample and displaced water. WHC was calculated by dividing the displaced water area over the meat film area. Higher values indicate inferior WHC (Honikel, 1998).

Cooking loss

A sample weighing about 30 g was placed in a thin-walled polyethylene bag and completely immersed in a water bath (80 °C) for 90 min. Stainless steel rods were used to keep all the meat immersed in the bath. Then the bag was put in running tap water (20 °C) for 40 min after which the meat was taken out of the bag, dried and reweighed. The difference from the initial weight was obtained and divided by the original weight to give cooking loss (Honikel, 1998).

Color measurements

Muscle samples were analyzed for color characteristics and reported as lightness (L*), redness or red-green scale (a*) and yellowness or yellow–blue scale (b*). The color measurements were carried out using Hunter Lab Tristimulus colorimeter model D25 m-2. The instrument was calibrated against black and white reference tiles before each set of runs. The sample was allowed to thaw at 4°C overnight and bloom for 30 minute at 1–4°C. A total of three readings of the L, a*, and b* values were recorded from different sites of each sample and averaged (Hunt, 1980).

Shear force

Meat tenderness of LT muscle was objectively measured by Instron Universal Testing Machine (Model 1000) fitted with a Warner-Bratzler shear device. Muscle samples for shear force determination were thawed overnight at 4°C and cooked to an internal temperature of 80 °C. Then the cooked muscle samples were cooled for 40 min at 4 °C. At least, 3 blocks (1 cm height, 1 cm width and 2 cm length) were removed from each cooked sample following the longitudinal orientation of the muscle fibers as possible, and sheared in the center across the muscle fibers.

Statistical analysis

Data were subjected to one-way analysis of variance using the CRD procedure of SAS version 9.1. Least-square means were computed and tested for differences by Duncan multiple range test.

Table1 Ingredients proportions and composition of experimental diets

	Experimental diets		
Ingredients % (as fed)	WMS0	WMS10	WMS20
Watermelon seeds	0	10	20
Sorghum grains	35	25	15
Wheat bran	33	33	35
Groundnut cake	20	18	15
Groundnut hulls	10	12	13
Salt	1	1	1
Lime stone	1	1	1
Chemical composition %			
Dry matter	94.77	96.04	96.22
Crude protein	16	17	18
Crude fibre	15.67	12.10	15.3
Ether extract	4.44	5.23	6.63
Ash	17.35	18.22	18.32
ME (MJ/Kg)	11.21	11.27	11.66

WS0= containing 0% watermelon seeds; WS10; containing 10% watermelon seeds; WS20 containing 20% watermelon seeds

Results and discussion

Feedlot performance

The initial and final weight, weight gain, feed intake and feed conversion ratio are presented in Table 2. Initial body weight was not significantly different among the treatment groups. Final body weight was significantly higher in WS0 (46.52 kg) and WS20 (46.03kg) compared to WS10 group, which achieved the least final body weight (43.0 kg). Average daily gain and total daily gain were significantly different among the treatment groups. Lambs in groups WS0 and WS20 had higher ($p< 0.05$) daily gain and total gain compared to lambs in group WS10, which had the lowest weight gain. Daily dry matter intake was almost similar in WS0 and WS20 (1.69 and 1.70 kg, respectively) and greater ($p< 0.05$) than that of group WS10, which had the least feed intake (1.51 kg). Feed conversion ratio was significantly ($p< 0.05$) inferior in WS10 (8.02) compared to WS0 (6.81) while in WS20 was 7.19 with no significant difference compared to WS0 or WS10. The average daily gain in this study ranged from 188.21 to 249.64 g, and agreed with the values reported for Sudan desert sheep under intensive condition (El Khidir *et al*., 1998; Suliman and Babiker, 2007; Eldin *et al*., 2011; El Hassan *et al*., 2017). Weight gain in WS0 and WS20 compared to WS10 coincided with their dry matter intake and their improved feed conversion ratio. The finding that daily weight gain, dry matter intake and feed conversion ratio were the least in SW10 compared with SW0 and SW20 could possibly be due to the lower fiber content in this diet (Table 1). Preston and Willis (1975) stated that the principle effect of low fiber in concentrate diet was physiological due to the stimulatory effect of roughage on rumen motility and hence rumen turnover time and finally voluntary intake. However, in a similar study that used water melon seed cake in lamb fattening by Beshir *et al*. (2009a), they reported a significant linear decrease in feedlot parameters with increase of watermelon seed cake level in lamb diets. Feed conversion ratio in the current study, ranged from 6.82 to 8.02, was similar to that reported by (Beshir *et al*., 2009b) in Sudan sheep fed diets containing different levels of watermelon seed cake, but higher than that reported by (Gabani, 1999) in sheep fed diets containing watermelon by-products. In general, the values of feed conversion ratio in this study were in the range previously reported for Sudan desert sheep by Suliman and Babiker (2007); Eldin *et al*. (2011); El Hassan *et al*. (2017).

Table 2 Feedlot performance of Sudan desert lambs fed diets with different levels of watermelon seeds

Parameters	Treatment groups			S.E	Level of significance
	WS0 (n= 10)	WS10 (n= 10)	WS20 (n= 10)		
Initial weight (kg)	33.83	33.80	33.72	1.38	NS
Final weight (kg)	46.52^{a}	43.0^{b}	46.03^{a}	1.37	*
Daily live weight gain (g)	249.64^{a}	188.21^{b}	236.39^{a}	19.52	*
Total live weight gain (kg)	12.98^{a}	9.79^{b}	12.30^{a}	0.90	*
Daily dry matter intake (kg)	1.69^{a}	1.51^{b}	1.70^{a}	0.10	*
Total dry matter intake (kg)	87.88^{a}	78.52^{b}	88.40^{a}	2.45	*
Feed conversion ratio	6.81^{b}	8.02^{a}	7.19^{ab}	0.40	*

WS0= containing 0% watermelon seeds; WS10; containing 10% watermelon seeds; WS20 containing 20% watermelon seeds
S.E standard error
^{a,b,c} Means within rows with different superscripts are different among treatments
NS: not significant; * $p < 0.05$

Carcass characteristics

Carcass characteristics of Sudan desert lambs fed diets with different levels of watermelon seeds are shown in Table 3: Empty body weight, hot carcass weight and cold carcass weight were higher ($P < 0.05$) in groups WS0 and WS20 than that of group WS10. Dressing percentage is one of the chief variables that is used to evaluate carcass characteristics, and is of considerable economic importance. In the current study dressing percentage based on slaughter or empty body weight was not significantly different among treatment groups, but was lower numerically in WS10 than in the other groups. In small ruminants, dressing percentage was reported to range from 36 to 60%, and is affected by different factors (Corazzin *et al*., 2019). Dressing percentage in this study ranged from 49.8 to 52.16% and was comparable to that reported by (Gardner *et al*., 2015; El Hassan et al., 2017; Mateo *et al*., 2018).

Table 3 Slaughter weight and carcass characteristics of Sudan desert lambs fed diets with different levels of watermelon seeds

Parameters	Treatment groups[1] WS0 (n= 10)	WS10 (n= 10)	WS20 (n= 10)	S.E	Level of significance
Slaughter bodyweight (kg)	47.20[a]	43.35[b]	47.30[a]	1.14	*
Empty body weight (kg)	41.23[a]	37.52[b]	41.77[a]	1.32	*
Hot carcass weight (kg)	24.50 [a]	21.60[b]	24.70[a]	0.81	*
Cold carcass weight (kg)	23.50[a]	20.80[b]	23.50[a]	0.45	*
Dressing percentage(SBW based)	51.88	49.80	52.16	1.54	NS
Dressing percentage(EBW based)	59.37	57.84	59.17	1.75	NS
Chiller shrinkage	4.08[a]	3.70[b]	5.10[a]	0.37	*
Total muscle %	52.97	53.29	51.77	2.08	NS
Total bone %	19.90	21.10	19.22	0.61	NS
Total fat %	21.8	20.98	23.30	1.18	NS
Trims %	5.32	5.14	5.71	0.74	NS
Muscle: bone ratio	2.66	2.53	2.69	0.21	NS
Muscle: fat ratio	2.43	2.54	2.22	0.64	NS

[1]WS0= containing 0% watermelon seeds; WS10; containing 10% watermelon seeds; WS20 containing 20% watermelon seeds
S.E standard error
[a,b,c] Means within rows with different superscripts are different among treatments
NS: not significant; * $p < 0.05$

WS10 group had lower ($P < 0.05$) chiller shrinkage than that in WS0 or WS20. In general, chiller shrinkage has been reported to be up to 2 % of the hot carcass weight during the initial 24 hours (Greer and Jones, 1997) and mainly linked with body-fat cover (Smith and Carpenter, 1973). Chiller shrinkage in this study, ranged from 3.70 to 5.10% was higher than the value that had been determined previously. This can be due to low body wall fat in Sudan desert sheep as tropical sheep breeds tend to deposit less subcutaneous fat than temperate sheep breeds (Gaili, 1979). No significant difference was found in percentage of carcass tissues (Muscle, bone, fat, and trims) or muscle: bone ratio and muscle: fat ratios among the treatment groups. Yet, carcass fat content was greater in WS20 than that in WS10 or WS0.

Meat chemical composition

Meat chemical composition of Sudan desert lambs fed diets of different levels of watermelon seeds are presented in Table 4. Feeding diets containing different levels of watermelon seeds had no effect on meat chemical composition. The average values of meat chemical composition in this study were 73.54, 22.79, 2.30 and 1.02 for moisture, protein, fat and ash, respectively. These findings agreed with the values reported previously by Corazzin *et al.* (2019) for sheep meat.

Meat quality attributes

Water holding-capacity and cooking loss

There were significant differences in WHC among the experimental groups (Table 4). Superior WHC (1.22) was found in meat of SW20 group while inferior WHC (1.83) was found in the meat of WS10 group.

WHC value of WS0 was intermediate (1.50) between WS10 and WS20. There were significant differences in cooking loss among the experimental groups. Meat of animals in group WS20 had lower cooking loss value (29.85) compared to that in group WS0 (31.33) or WS10 (32.19). The lower cooking loss value of meat of group WS20 coincided with its superior WHC. Cooking loss values found in this study were consistent with the normal range (14 to 41%) reported in sheep meat (Corazzin *et al*., 2019).

Meat color

Meat color characteristics are shown in Table 4. Meat color is considered as the most important meat quality attribute, which affects the decision to purchase meat more than any other attributes (Mancini and Hunt, 2005). The treatment diets had no significant effect on lightness (L*). However, redness (a*) value was highly significant ($p < 0.01$) between the groups fed the diets that contained watermelon seeds (WS10 and WS20) and the control group (WS0), which scored the highest values. Similarly, yellowness (b*) was significantly higher ($P < 0.05$) in WS0 compared to that in WS10 and WS20 groups. The values of meat color in this study were generally similar to those reported for Sudan Deseret lambs meat in an early study by Babiker *et al*. (1990).

Shear force

Shear force, which is defined as the maximum load needed to cut the meat perpendicular to fibers, is inversely associated to tenderness. Shear force values of the experimental groups were shown in Table 4. Meat obtained from groupWS10 had significantly lower shear force value (3.47) than those of group WS0 and WS20, which scored 4.40 and 4.28, respectively. Babiker *et al*. (1990) reported a shear force value of 3.60 for Sudan desert sheep which agreed with the present finding.

Table 4 Meat Chemical composition and quality characteristics of Sudan desert lambs fed diets with different levels of watermelon seeds

Parameters	Treatment groups[1] WS0 (n= 10)	WS10 (n= 10)	WS20 (n= 10)	S.E	Level of significance
Moisture	73.60	73.81	73.21	0.32	NS
Protein	22.72	22.67	22.70	0.14	NS
Fat	2.24	2.29	2.32	0.09	NS
Ash	1.01	1.01	1.03	0.01	NS
Water-holding capacity	1.50^b	1.83^a	1.22^c	0.09	**
Cooking loss	31.33^a	32.19^a	29.85^b	1.03	*
Color					
Lightness (L)	34.74	32.45	34.80	1.29	NS
Redness (a)	12.64^a	11.64^b	11.89^b	0.17	**
Yellowness (b)	4.66^a	4.12^b	4.22^b	0.14	*
Shear force (kg/cm^2)	4.40^a	3.47^b	4.28^a	0.09	*

[1]WS0= containing 0% watermelon seeds; WS10; containing 10% watermelon seeds; WS20 containing 20% watermelon seeds

S.E standard error

[a,b,c] Means within rows with different superscripts are different among treatments

NS: not significant; * p <0.05; ** p<0.01

Conclusion

The findings of this study demonstrated that whole watermelon seeds can be included in lamb fattening diets and supported satisfactory feedlot performance, carcass characteristics, and meat quality. Lambs fed the diet that contained 20% watermelon seeds showed similar feedlot performance to that fed a conventional fattening diet. Lambs fed the diet that contained 10% watermelon seeds had inferior feedlot performance but were superior in meat tenderness compared to that fed the conventional fattening diet.

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