The Effect of Feeding Diet with Graded Levels of Roselle (*Hibiscus Sabdariffa*) Seed on Carcass Characteristics and Meat Quality of Sudan Desert Lamb

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**Abstract:** Roselle (karkadeh, *Hibiscus sabdariffa*) is grown mainly for the production of calyces and epicalyces, which are used as beverages. Roselle seed production is about 90 Lp/acre and the total area cultivated is as 15,000 acres. The present study was conducted to evaluate roselle seed in ruminants feeding. Graded levels of roselle seed (0, 10 and 20%) were incorporated in three diets iso-caloric, iso-nitrogenous diet for lambs. Diet A contained 0% roselle seed while diets B and C contained 10 and 20% roselle seed respectively. There was a significant (P<0.05) linear increase in feed intake with increasing roselle seed level in the diet, but dietary treatment had no significant effect on feed conversion efficiency, average daily gain and final body weight. In spite of the lambs fed diets containing roselle seed were found to be superior over the control in the previous parameters. Dietary treatments did not affect any carcass parameter. The proportions of wholesale cuts were also not influenced by dietary treatments. Carcass composition parameters did not differ significantly among the treatment groups. Muscle percentage was slightly higher in the control group. But fat percentage was higher in groups B and C which were given roselle seeds in their diets, whereas bone percentage was higher in group C. The slaughter by-products showed no significant differences among dietary treatment groups. Chemical composition of meat revealed that the protein content in the muscles of group A was slightly higher than that of the other groups, while group C had the highest (P<0.05) fat and lowest (P<0.05) moisture content. The meat of group C was of superior water-holding capacity and lowest cooking losses, and was more tender than that of groups A and B. The meat colour of group B and C was darker than that of group A, possibly due to a decrease in myoglobin concentration as an increase in intra-muscular fat. It is thus concluded that roselle seed when incorporated in lamb diets up to 20% supported a satisfactory live weight gain and feed conversion efficiency. They produced carcasses which were significantly not different from that produced by the control diet. Meat muscle composition and quality was also similar to that of the control diet.

**Key words:** Roselle (*Hibiscus sabdariffa*) seed, desert lamb, fattening.

**INTRODUCTION**

Sudan an African's largest country, with nearly one million square miles area (more than 2.5 million square kilometers). It also one of the largest livestock population on the continent which is estimated as 64 million heads of cattle, sheep, goat and camels. The livestock industry is of great importance to the Sudanese economy as it is one of the main sources of food, employment and foreign currency. Proper exploitation of these livestock can contribute greatly towards the alleviation of the present world deficit in animal protein which is expected to grow continuously due to low livestock productivity, increase in per capita consumption of meat, due to improvement in the standard of living of many people and increase in the human population of the world.

Protein and energy comprise a large proportion of the cost of livestock production. Protein is one of the critical nutrients for young growing animals. Cakes obtained from extraction of oil seeds, from the main source of plant proteins for animal feeding. The demand for such a product for local livestock feeding and export results in a continuous escalation of its prices. Therefore, looking for alternative protein source is essential to alleviate these situation of high protein costs.

The logical solution of this problem can be attained by making full use of the available natural resources (Land, water, labours etc.) with production of new crops rich in protein as well as the full utilization of agricultural, animal and agroindustrial by-products not yet exploited in animal nutrition.

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Oil seeds together with legume seeds are the most promising crops for protein production. Animal and fish products provide about one-third of the total human dietary protein, whereas plant proteins account for 50 – 75% of the total need[13].

Roselle (*Hibiscus sabdariffa*). Locally known as karkadeh grows successfully as a cash – crop in western Sudan, appears to have a great food value and pharmaceutical potential not fully exploited (karamall’s personal communications). Sudan is known to be the world’s major supplier of karkadeh.

The crops is grown mainly for production of calyxes and epicalyxes, which are used in jams, sauces, jellies, hot and cold bottled drinks and as food colouring material. The seeds which are the matter of interest in this study are just a by-product of the crop. Their total production is increasing steadily, as a result of increased international demand. The seed has a good potentiality as a new source of vegetable oil and protein[1]. The seeds are characterized by an acid taste which might limit their use in animal nutrition[13]. Few studied were conducted[20, 19, 3, 6] on the feeding value of roselle seed meal on broiler and layer performance which showed promising results.

**The Objective of this Study Is to:** Evaluate the effect of feeding roselle seed on carcass characteristics and meat quality.

**MATERIALS AND METHODS**

**Experimental Animals:** Thirty male lambs of Sudan desert sheep ecotype kabashi, were purchased from El-sheick Abou zaid livestock market in Umdurman. Animals were selected according to their age (9-12 months) and eight which was approximately 25.2 kg. They were transported to the livestock Unit, Faculty of Animal production, University of Khartoum, rested, ear tagged and given an adaptation period of two weeks.

**Adaptation Period:** During this period animals were fed sorghum fodder (Abu 70) and a mixture containing equal percentages of the assigned experimental ration ad libitum. The fodder was gradually substituted by rations mixture during the first 7 days. The ration mixture feeding continued till the end of the adaptation period. Spraying with acaricide solution against ecto-parasites and deworming with Thiabenzole as a drench solution was performed. The Thiabenzole treatment was repeated after 15 days.

**Experimental Procedure:** Immediately after the adaptation period the animals were individually weighed and then divided into three groups of similar number and weight. The three groups were separately penned. Each provided with watering and feeding facilities.

**Feeds and Feeding:** Three iso-caloric, iso-nitrogenous diets containing different levels of roselle seed (A 0%, B 10% and C 20%) were used. The other ingredients were sorghum grain, groundnut cake, wheat bran, groundnut hulls, salt and calcium carbonate. The chemical analysis, ingredient proportion and calculated chemical analysis of roselle seeds and experimental diets are given in tables 1 and 2.

**Table 1:** Chemical analysis of Karkadeh seed.

<table>
<thead>
<tr>
<th>Composition</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crude protein</td>
<td>30.3</td>
</tr>
<tr>
<td>Moisture</td>
<td>3.4</td>
</tr>
<tr>
<td>Crude fiber</td>
<td>5.1</td>
</tr>
<tr>
<td>Fat</td>
<td>11.13</td>
</tr>
<tr>
<td>Ash</td>
<td>5.62</td>
</tr>
<tr>
<td>Carbohydrate (g/kg)</td>
<td>44.45</td>
</tr>
<tr>
<td>Metabolizable energy (ME)</td>
<td>18.7*</td>
</tr>
</tbody>
</table>

* MJ/Kg DM

¹ calculated according to Ellis[11]

During the feeding period, animals were fed daily the assigned diets ad libitum. The diets were offered in one meal at 8:00 a.m. Throughout the study period which extended for 63 days. Green fodder (*Medicago sativa*) was also offered once a week at a rate of one kg/head/week to avoid vitamin A deficiency. Clean water and salt lick were available throughout the experimental period.

**Data Records:**

**Slaughter Procedure and Slaughter Data:** At the end of the experimental period, four animals were randomly taken from each group and moved to the Department of meat production for slaughter. Slaughter weights were taken after an overnight fast except for water. The animals were slaughtered by following the local Muslim practices i.e. by severing both the jugular vein, carotid arteries and oesophagus by a sharp knife without stunning. When complete bleeding was attained, the head was removed at atlantooccipital joints. The body was practically skinned on its back and the feet were cut at knee and hock joints, the body was taken hanged using hooks and skinning was completed. The skin, feet as well as the thoracic and visceral organs were individually weighed. Gut fill was determined as the difference in weight between the full and empty alimentary tract. The kidneys and kidneys knob channel fat were left intact in the carcass. The carcasses were weight warm and then chilled at 4°C for 24 hours, thereafter the cold carcasses were reweighed. The tail was removed at its base and weighted. The kidneys and kidneys knob channel fat were removed and weighed. The carcass was then

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The junction of sixth and seventh cervical vertebrae at included: neck which was removed by cutting through sides, the left side was weighted and broken into halves along the vertebral column into left and right angles to the axis of the vertebrae. Leg and chump was removed by cutting between both sixth and seventh lumbar vertebrae. Single short forequarter: this joint was removed by cutting along the posterior edge of the sixth rib, sawing through the sternum and breaking it along the vertebral column into left and right sides.

Table 2: Ingredients proportions and chemical composition of experimental diets.

<table>
<thead>
<tr>
<th>Item</th>
<th>A (control)</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>(i) physical composition (as fed) - Karkadeh seeds</td>
<td>0</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>Sorghum gain</td>
<td>40</td>
<td>32</td>
<td>23</td>
</tr>
<tr>
<td>Wheat bran</td>
<td>30</td>
<td>28</td>
<td>20</td>
</tr>
<tr>
<td>Groundnut cake</td>
<td>18</td>
<td>10</td>
<td>12</td>
</tr>
<tr>
<td>Groundnut hulls</td>
<td>10</td>
<td>13</td>
<td>23</td>
</tr>
<tr>
<td>Limestone</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Salt</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(ii) Chemical composition (AM) - Moisture</td>
<td>3.88</td>
<td>4.73</td>
<td>5.06</td>
</tr>
<tr>
<td>Crude protein</td>
<td>19.45</td>
<td>19.55</td>
<td>19.48</td>
</tr>
<tr>
<td>Crude fiber</td>
<td>17.3</td>
<td>20.91</td>
<td>25.90</td>
</tr>
<tr>
<td>Ether extract</td>
<td>5.32</td>
<td>6.02</td>
<td>6.18</td>
</tr>
<tr>
<td>Ash</td>
<td>7.3</td>
<td>8.12</td>
<td>8.18</td>
</tr>
<tr>
<td>Calculated metabolizable Energy (MJ/Kg DM)</td>
<td>11.74</td>
<td>11.95</td>
<td>12.29</td>
</tr>
</tbody>
</table>

Metabolizable energy was calculated according to equation cited in Bulletin of Sudanese Animal Feed.

ME (MJ/Kg DM) = 0.012 CP + 0.031 EE + 0.05 CF + 0.014 NFE

Table 3: Ingredients proportions and chemical composition of experimental diets.

<table>
<thead>
<tr>
<th>Item</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>S.E</th>
<th>L.S</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of animals</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Initial body Weight (kg)</td>
<td>26.15</td>
<td>26.22</td>
<td>0.32</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>Final body Weight (kg)</td>
<td>36.25</td>
<td>36.69</td>
<td>37.71</td>
<td>0.87</td>
<td>NS</td>
</tr>
<tr>
<td>Feedlot period (days)</td>
<td>63</td>
<td>3</td>
<td>63</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total liveweight gain (kg)</td>
<td>9.84</td>
<td>10.54</td>
<td>11.49</td>
<td>0.69</td>
<td>NS</td>
</tr>
<tr>
<td>Daily weight gain (g/head/day)</td>
<td>156.19</td>
<td>167.30</td>
<td>182.36</td>
<td>10.88</td>
<td>NS</td>
</tr>
<tr>
<td>Total DMI (kg/head/day)</td>
<td>1.14</td>
<td>1.16</td>
<td>1.35</td>
<td>0.03</td>
<td>*</td>
</tr>
<tr>
<td>Feed conversion efficiency (kg DMI/kg gain)</td>
<td>7.52</td>
<td>6.97</td>
<td>7.53</td>
<td>0.41</td>
<td>NS</td>
</tr>
</tbody>
</table>

NS in this and subsequent tables: L.S = Level of significance
S.E = Standard error of the treatment means
NS = Not significantly different
* = significantly different at 0.05
** = significantly different at 0.01
*** = significantly different at 0.001

Means with the same superscripts are not significantly different.
vertebrae bodies. The loin was separated from the best end of neck by cutting along the posterior edge of the 13th rib. Best end of neck and breast were removed by cutting and sawing along a straight line from a point on the posterior surface of 13th rib (60 mm from the ventral tip of the eye muscle) to a point on the posterior surface of the 7th rib (75 mm from the ventral tip of the eye muscle). The dorsal cut comprised the best end of neck and the ventral one was the breast.

Each cut was weighted and dissected into muscle, bone, fat and trim. The weight of each tissue was determined and recorded. The meat was covered by wet towels throughout the dissection to prevent loss of weight by evaporation.

**Samples for Chemical Analysis and Quality Determination:** Samples for chemical analysis were taken from lion part, *longissimus* dorsi muscle. Samples were kept in polythene bags and stored in deep freezer awaiting chemical analysis. Semi membraneous muscle were removed from both sides of the carcass, each muscle was freed from external visible fat and connective tissues and utilized for meat colour determination, subsequently it was frozen stored for shear force and connective tissue strength measurement.

**Quality Attributes:**

**Objective Evaluation:**

**Water-holding Capacity (W.H.C):** Samples weighing about 0.3 gm from the minced *L. dorsi* muscles were used. Each sample was placed on a humidified filter paper (Whatman no.1) kept in a desiccator over saturated KCL solution and pressed between two plexiglass plates for 3 minutes at 25 kg load. The meat film area was traced with a ball pen and the filter paper was allowed to dry. Meat and moisture areas were measured with a compensating planimeter.

The resulting area covered by the moisture was divided by the meat film area to give ratio expressed as water holding capacity of meat. A larger ratio indicates an increase in the watery condition of the muscle or a decrease in water holding capacity.

**Colour Determination:** Colour was determined on the semi-membranous muscles. Each muscle was allowed to oxygenate for half an hour at 4°C before colour determination.

Hunter colour components L (lightness), a (redness) and b (yellowness) were recorded using Hunter lab Tristimulus colour meter (D25-2). Subsequently these samples were frozen for cooking loss and shear force determinations.

**Cooking Loss Determination:** Semi-membranous samples were thawed at 4°C 24 hour placed in plastic bags in a water bath at 80°C for 90 minutes, cooled in running water, dried from fluids and reweighed. Cooking loss was determined as the loss in weight during cooking and expressed as a percent of precooking weight.

\[
\text{Cooking loss} = \frac{W_1 - W_2}{W_1} \times 100
\]

Where:

- \( W_1 \) = weight before cooking
- \( W_2 \) = weight after cooking

**Shear Force and Connective Tissue Strength:** For shear force and connective tissue strength determinations, an Instorn model 1000 fitted with a Warner-Bratzler shear device was used. Rectangular meat across the muscle fibres. Cubical meat samples (1x1x1 cm) were also cut from cooked meat and used to determine connective tissue strength by shearing along the muscle fibre. Shear force and connective tissue strength were taken as the means of several determinations.

**Statistical Analysis:** Data were statistically analysed according to simple randomized design and Duncan Multiple range test was used to detect difference between means\(^{(21)}\).

**RESULTS AND DISCUSSION**

**Carcass Yield and Characteristics:** The date of carcass yield and characteristics of experimental lambs are shown in Table 4. No significant difference among the treatment groups was observed for slaughter weight, hot carcass weight, dressing-out percentage (on slaughter weight or empty body bases). Gut fill percentage was not significantly different among the treatment groups. Maximum gut fill (14.45%). Was found in group A and minimum gut fill (13.00%) was found in group C.

No significant differences among treatment groups were observed for carcass muscle, bone and fat percentages (Table 4). However, lamb fed ration A tended to have a greater value of carcass muscle (63.91%) while those fed ration B have the lowest value (61.51%). Lambs fed ration C were intermediate (61.92%). On the other hand, lambs fed ration C tended to have a higher value of carcass bone percentage than those fed rations A and B. Lambs fed ration B appeared
**Table 4: Slaughter weight and carcass characteristics**

<table>
<thead>
<tr>
<th>Item</th>
<th>Treatment group</th>
<th>S.E</th>
<th>L.S</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
<td>B</td>
<td>C</td>
</tr>
<tr>
<td>Slaughter weight (kg)</td>
<td>38.00</td>
<td>37.93</td>
<td>37.05</td>
</tr>
<tr>
<td>Empty body Weight (kg)</td>
<td>32.43</td>
<td>23.90</td>
<td>32.26</td>
</tr>
<tr>
<td>Gut fill (as % of Slaughter weight)</td>
<td>14.54</td>
<td>13.14</td>
<td>13.00</td>
</tr>
<tr>
<td>Hot carcass Weight (kg)</td>
<td>18.55</td>
<td>18.70</td>
<td>18.10</td>
</tr>
<tr>
<td>Cold carcass Weight (kg)</td>
<td>17.60</td>
<td>17.78</td>
<td>17.43</td>
</tr>
<tr>
<td>Half carcass Weight (kg)</td>
<td>8.10</td>
<td>8.03</td>
<td>7.93</td>
</tr>
<tr>
<td>Hot dressing (%) :</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Live body wt. base</td>
<td>48.85</td>
<td>49.85</td>
<td>48.71</td>
</tr>
<tr>
<td>Empty body wt. base</td>
<td>57.15</td>
<td>56.72</td>
<td>55.89</td>
</tr>
<tr>
<td>Cold dressing (%) :</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Live body wt. based</td>
<td>54.21</td>
<td>53.94</td>
<td>53.89</td>
</tr>
<tr>
<td>Empty body wt. base</td>
<td>46.32</td>
<td>46.82</td>
<td></td>
</tr>
<tr>
<td>Chiller shrinkage (%)</td>
<td>5.14</td>
<td>4.90</td>
<td>3.71</td>
</tr>
<tr>
<td>Total muscle (as % Of cold side et.)</td>
<td>63.91</td>
<td>61.51</td>
<td>61.92</td>
</tr>
<tr>
<td>Total bone (as % Of cold side wt.)</td>
<td>21.10</td>
<td>20.85</td>
<td>23.18</td>
</tr>
<tr>
<td>Total fat (as % Of cold side wt.)</td>
<td>18.36</td>
<td>23.26</td>
<td>21.67</td>
</tr>
<tr>
<td>Total trim (as % Of cold side wt.)</td>
<td>5.43</td>
<td>5.92</td>
<td>5.02</td>
</tr>
</tbody>
</table>

**Non-carcass Components:** Non-carcass components expressed as percentage of empty body weight are presented in Table 5. No significant difference among the treatment groups was observed for head, skin, four feet, heart, Gung and trachea, intestine (empty), stomach (empty), liver, spleen, omental fat and mesenteric fat, but these values tended to be slightly higher in group C than the other groups.

**Wholesale Cuts Yield:** The wholesale cuts of the experimental lambs from chilled carcass (left side) are represented in Table 6. The proportion of various wholesale cuts obtained from the carcass sides of experimental lambs as leg and chump, single short forequarters, lion, best end of neck, breast and neck were significantly not different among the treatment groups. The tail eight as the percentage of empty weight was also not significantly different among the treatment groups. But the values for single short C than the other groups.

**Joint Composition:** Joint composition of the experimental lambs expressed as percentage of joint weight are given in Table 7. No significant difference among the treatment groups was observed for leg and chump, lion, best end of neck, neck and tail muscle, bone and fat. However, a significant difference among the treatment groups was observed for single short forequarter bone (P<0.01) and breast fat (P<0.01).

**Meat Chemical Composition:** Meat chemical composition data of experimental lambs differences among treatment groups in percentages of moisture and fat. Group C had the highest muscle fat and lowest moisture percentage than other groups. No significant difference among the treatment groups were observed for protein and ash percentage.

**Meat Quality Attributes:** Table 8 also shows meat quality attributes values of the excremental lambs.

**Meat Colour:** No significant difference among the treatment groups were observed for Hunter lightness (L), redness (a) and yellowness (b) indicating similar meat colour in the three treatment groups.

**Water-holding Capacity:** As seen in Table 8, water-holding capacity values of muscle studies were not significantly different among the treatment groups, but groups C showed superior WHC values than the groups.
Table 5: Non-carcass component (as percentage of empty body weight).

<table>
<thead>
<tr>
<th>Item</th>
<th>Treatment group</th>
<th>S.E</th>
<th>L.S</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
<td>B</td>
<td>C</td>
</tr>
<tr>
<td>Head</td>
<td>7.10</td>
<td>6.97</td>
<td>7.44</td>
</tr>
<tr>
<td>Skin</td>
<td>9.77</td>
<td>9.82</td>
<td>10.10</td>
</tr>
<tr>
<td>Four short forequarters</td>
<td>2.67</td>
<td>2.74</td>
<td>2.87</td>
</tr>
<tr>
<td>Heart</td>
<td>0.56</td>
<td>0.54</td>
<td>0.60</td>
</tr>
<tr>
<td>Lung and trachea</td>
<td>2.37</td>
<td>2.18</td>
<td>2.34</td>
</tr>
<tr>
<td>Intestine (empty)</td>
<td>4.22</td>
<td>4.37</td>
<td>4.19</td>
</tr>
<tr>
<td>Rumen (empty)</td>
<td>3.36</td>
<td>3.53</td>
<td>3.49</td>
</tr>
<tr>
<td>Liver</td>
<td>2.08</td>
<td>1.96</td>
<td>2.12</td>
</tr>
<tr>
<td>Spleen</td>
<td>0.39</td>
<td>0.41</td>
<td>0.40</td>
</tr>
<tr>
<td>Kidney knob Channel fat</td>
<td>1.50</td>
<td>1.65</td>
<td>1.86</td>
</tr>
<tr>
<td>Reproductive organs</td>
<td>0.95</td>
<td>1.05</td>
<td>1.20</td>
</tr>
<tr>
<td>Omentum fat</td>
<td>1.55</td>
<td>2.01</td>
<td>2.00</td>
</tr>
<tr>
<td>Mesentric fat</td>
<td>1.11</td>
<td>1.34</td>
<td>1.47</td>
</tr>
</tbody>
</table>

Table 6: Yield of wholesale cuts (as percentage of cold side weights).

<table>
<thead>
<tr>
<th>Joint</th>
<th>Treatment group</th>
<th>S.E</th>
<th>L.S</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
<td>B</td>
<td>C</td>
</tr>
<tr>
<td>Leg and chump</td>
<td>36.51</td>
<td>35.11</td>
<td>36.25</td>
</tr>
<tr>
<td>Single short forequarters</td>
<td>32.55</td>
<td>33.32</td>
<td>34.05</td>
</tr>
<tr>
<td>Loin</td>
<td>11.49</td>
<td>11.63</td>
<td>11.31</td>
</tr>
<tr>
<td>Breast</td>
<td>6.69</td>
<td>6.72</td>
<td>6.25</td>
</tr>
<tr>
<td>Best end of neck</td>
<td>7.84</td>
<td>7.89</td>
<td>7.87</td>
</tr>
<tr>
<td>Neck</td>
<td>8.24</td>
<td>8.07</td>
<td>8.58</td>
</tr>
<tr>
<td>Tail</td>
<td>7.32</td>
<td>10.00</td>
<td>10.00</td>
</tr>
</tbody>
</table>

Table 7: Joint composition (as percentage of joint weight).

<table>
<thead>
<tr>
<th>Joint</th>
<th>Treatment group</th>
<th>S.E</th>
<th>L.S</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
<td>B</td>
<td>C</td>
</tr>
<tr>
<td>Leg and Chump</td>
<td>Muscle</td>
<td>62.69</td>
<td>60.55</td>
</tr>
<tr>
<td></td>
<td>Bone</td>
<td>18.63</td>
<td>18.84</td>
</tr>
<tr>
<td></td>
<td>Fat</td>
<td>14.92</td>
<td>15.99</td>
</tr>
<tr>
<td></td>
<td>Trim</td>
<td>3.93</td>
<td>4.36</td>
</tr>
<tr>
<td>Single Short Forequarters</td>
<td>Muscle</td>
<td>60.79</td>
<td>58.50</td>
</tr>
<tr>
<td></td>
<td>Bone</td>
<td>22.50*</td>
<td>21.35*</td>
</tr>
<tr>
<td></td>
<td>Fat</td>
<td>11.62</td>
<td>13.43</td>
</tr>
<tr>
<td></td>
<td>Trim</td>
<td>4.61</td>
<td>4.44</td>
</tr>
<tr>
<td>Loin</td>
<td>Muscle</td>
<td>58.76</td>
<td>58.28</td>
</tr>
<tr>
<td></td>
<td>Bone</td>
<td>12.73</td>
<td>13.18</td>
</tr>
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</table>
Shear Force: which measures muscle fiber strength, was not significantly different among the treatment groups, but muscles obtained from group B had higher shear force strength, indicating an increase in its toughness than corresponding muscles obtained from groups A and C. Connective tissue strength was maximum in group A and minimum in group C.

Cooking Loss: Although cooking losses were not significantly different among treatment groups, meat from group B had higher cooking losses while meat from group C had the least cooking losses.
Discussion:
Carcass Weight and Dressing Percentage: There was no significant difference among treatment groups in slaughter weight and carcass weight (cold or warm). Also no significant difference among the treatment groups in dressing percentage (on empty or live weight bases) were found. The values for the dressing percentage agreed with that reported by El-khidir et al.[8,9,2,18], reported a respective dressing percentage of 45.06 and 43.35 for Sudan desert sheep ecotype (Watish and Shugor) which were lower than the values reported in this study. Here, ecotype differences might be implicated.

Gut Fill: No significant difference was observed gut fill among the treatment groups. The gut fill percentage in this study was 14.54%, 13.14% and 13.00% for group A,B and C respectively. This result agreed with the findings reported by Mansour et al.[18,9,2,8], reported gut fill of Sudan desert sheep in the range between 20.8 and 24.9, also El-khidir et al.[18] reported gut fill of 21.2, 18.4 and 17.0 for Sudan desert sheep. These variations in gut fill are due to type of feed, ration chemical and physical composition, age, species and pre-slaughter conditions.

Carcass Shrinkage: No significant difference were observed among the three dietary treatment for carcass loss is the proportion of the carcass lost by evaporation during the cold storage period. Generally, carcass with good subcutaneous fat cover suffers less from this loss. In addition, refrigeration conditions and duration affect this parameter. The carcass shrinkage values in the present study were lower than those observed by Elshafie and Osman[18] who reported values in the range of 2 to 10% for this parameter. These differences might possibly be due to the duration, temperature and humidity of refrigeration used.

Non-carass Components: Non-carass components in this study were not significantly different among the treatment groups. These findings agreed with findings reported by El-khidir[8,9].

Omental, mesenteric and kidney knob and channel fat depot were grater in group B and C than group A. This might be due to high lipid content of proselle seed (Table 2).

Yield of Wholesale Carcass Cuts: The major wholesale cuts as leg and chump, single short forequarters, loin, best end of neck, breast and neck were expressed as percentage of cold carcass weight were not significantly different among the treatment groups. The wholesale cuts values reported by El-khidir[8,9] for Sudan desert lambs agreed with the result reported in this study.

Carcass Composition: In this study the carcass muscle percentage was 63.91, 61.51 and 61.92 for group A, B and C respectively. Although group A had more percentage carcass muscle the total muscle percentage was not significantly different among the treatment groups. This result agreed with the result reported by Mansour et al.[18], and was superior to the result obtained by El-khidir et al.[8,9,2,18].

Fat percentage in this study was 18.36, 23.26 and 21.67 for group A,B and C respectively, and was not significantly different among the treatment groups, but groups B and C which were fed roselle seed, had the highest total fat percentage than the control. When the former two groups were compared with value reported in literature, these results were higher than that reported by Mansour et al.[8,9,2,18]. These variation in fat percentage might be due to nutritional differences as well as to age difference.

Bone percentage in this study was 21.10, 20.85 and 23.8 for group A,B and C respectively, which was not significantly different among the treatment group. but group C had the highest total bone percentage. The none percentage of groups B and C was greater than that reported by El-khidir [8,9]. This variation in bone percentage might be due to mineral difference in the diets as roselle seed a rich source of minerals especially Ca and P (Karamalla, personal communications) and to age differences.

Joint Composition: Joint composition expressed as percentage of joint weight is shown in Table 7. No significant differences among the treatment groups were observed for leg and chump, loin, best end of neck, neck and tail muscle, fat and bone. Also no significant differences were observed for single short forequarter muscle and fat and breast muscle and bone. Only significant differences were observed for single short forequarter bone and breast fat among the treatment groups. Generally muscle of group A in all joints tended to be greater than that of group B and C, a finding which agreed with the chemical composition of meat which showed higher protein proportion in muscle from group A than from other groups. Bone of group B and C also tended to be grater than that of group A for all joints except tail. Fat in all joints was greater in group B and C that that in group A. The increased might be attributed to high fat and ash content of roselle seed.

These finding were in disagreement with El-khidir[9] for composition of lion, breast, best and of neck and neck but agreed with that author in
composition of leg and chump, single short forequarter and tail. These variations might be attributed to differences in type of diets used.

**Meat Chemical Composition:**

**Protein:** Protein percentage in this study was not significantly different among the treatment groups. But group A had slightly higher protein percentage than the other two groups. The values for protein percentage in this study agreed with that reported by El-Hassan.

**Fat:** Fat percentage in this study was significantly different among the treatment groups. Group C recorded the highest fat percent and group A recorded the lowest fat percentage. This might be explained by the high seed fat content of group C. These findings agreed with carcass chemical composition reported by El-khidir.

**Moisture and Ash:** Moisture in this study was significantly different among the treatment groups. Group C had lowest moisture percentage which coincided with its highest fat percentage. The values of moisture percentage reported in this study agreed with the results reported by El-khidir for desert lambs.

**Water-holding Capacity:** The superior water-holding capacity found in the meat from group C could be explained by the high carcass fat and muscle fat of this treatment. Increased water-holding capacity is found to associate with increased fatness.

**Cooking Loss:** Lower cooking loss was found in meat from group C, while highest cooking losses were found in group B. These difference in cooking loss could be attributed to differences in water-holding capacity already mentioned.

**Shear Force and Connective Tissue Strength:** Group B muscle had higher but not significantly different values of shear force than those of group A and C and also higher values of connective tissue strength. This was possibly due to differences in fatness as fat is known to dilute connective tissue content and increase muscle tenderness.

**Meat Colour:** Hunter colour components indicated that group B and C were darker in colour than group A. This finding accorded with myoglobin in meat which decreases as the percentage of intramuscular fat increases.

**Summary and Conclusions:** Thirty entire male Sudan desert lambs (9-12 months of age and averaging 2502 kg) were utilized a growth trial to evaluate three levels (A 0%, B 10% and 20%) of roselle seed in their diets. Diets were iso-caloric and iso – nitrogenous. The diets were offered ad libitum ) after an adaptation period of two weeks) for 63 days. Green fodder (Medicago sativa) forage was given at a rate of 1 kg/head/week.

Dietary roselle seed levels had no significant effect (P>0.05) on carcass characteristics, wholesale cuts yield and non-carcass components.

Dietary roselle seed levels had no significant (P>0.05) effect on carcass composition parameters. Meat from group C with received a diet containing 20% roselle seed had higher bone and fat percentage than group A (control).

Chemical composition of meat revealed that dietary roselle seed levels had significant ( P>0.05) effects on moisture and fat percentage, but had no significant (P>0.05) effect on protein and ash content.

Water-holding capacity of meat was superior in group C a finding which coincided with its lower cooking losses. Shear force and connective tissue strength were lower in meat from group C compared with that from group A and B.

Based on the results of the study reported herein, the following conclusion can be drawn:

1. The protein and energy values of roselle seed are high enough to allow its inclusion in diets as protein and energy source for ruminants.
2. Roselle seed at levels tested produced equal effect on non-carcass composition, yield of wholesale cuts and carcass characteristics as the control diets.
3. Roselle seed had not deleterious effect on ruminant live ability.

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**REFERENCES**