EFFECT OF WOOL SHEARING AND DIET SUPPLEMENTING WITH CURCUMIN ON SOME PRODUCTIVE AND BLOOD BIOCHEMICAL TRAITS OF AWASSI LAMBS

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ABSTRACT
The study was done to evaluate the impacts of either sharing or supplementing of 200 mg/Kg of Curcuma longa or their combination, on productive and some serum blood biochemical traits of Awassi lambs. Twenty four (6 lambs/group), 5-6 month old with average trail weight (29.57 Kg) were assigned randomly into four groups. The first group: T1 lambs were fed only control diet (control). The second group: T2 lambs were shared and fed also the control group diet. The third group: T3 lambs were fed control diet supplemented with Curcuma longa, 200 mg / kg diet . The fourth group: T4 shared and fed also the control group diet and supplemented with Curcuma longa, 200 mg / kg diet. The experiment lasted for three months. Final body weight, average daily gain and relative mean growing were detected. Serum blood glucose, total proteins, albumin, globulin, cholesterol, triglycerides, and liver enzymes AST and ALT were also analyzed. The results showed that final body weight, body weight gain, serum total protein and globulin significantly (P≤0.05) increased, when lambs supplemented with Curcuma longa (T3) and shared and supplemented (T4) compared with other groups. Also, the results showed a significant (P≤0.05) increasing in serum triglyceride and decreasing in AST when lamb shared and supplemented with Curcuma longa. While ALT increased significantly in T4. No significant differences were presented between groups in relative mean growing, glucose, albumin, and cholesterol at 12th week of study.

Keywords: Shearing, Curcuma longa, blood parameters, Awassi lambs.

INTRODUCTION
Small ruminant have a unique niche for farmers, because sheep require small investments, and short production cycles, great environmental adaptability and faster growth rates as compared with large ruminants, also provide good protein sources and income for most farmers (Tibbo et al., 2006). Sheep are the main source of meat production in Iraq, they are considered one of the most important animals for breeders. They are the most suitable animals for Iraq’s arid and semiarid Climate, in addition. Sheep are the source of live hood for rural people and for their short production cycle (Hashem et al., 2013) and increased demand for sheep meat

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(Alkass and Juma., 2005), because of their palatability acceptance by the consumer therefor, It requires increasing their numbers through increasing the rates of reproduction and growth to reach better marketing weight and desired meat recipes (Dickerson et al., 1972). Awassi lambs considered an important breed in Iraq, This breed is characterized by its good production of meat quantity and quality (Rashid et al., 1987). Thermal stress effects on animals production when temperatures rise and heat load leads to affect the biological functions which leads to reduce feed consumption of the animals (Schoenlank., 2010). Because of the effect of wool on sheep and the high temperatures that surrounding animals, many studies had done to revealed the effects of shearing wool on productive traits of sheep (Mahrose et al., 2014). The use of Medical plants as addition to the animals rations leads to improve productive and reproductive performance, because natural plants contain active substances that improve the environmental condition of the Gut. Medical plants also increase the useful microorganisms of the animal, improve growth, and increase the efficiency of feed conversion and carcass Characteristics (Hassan. 2009). *Curcuma longa* is a medical plant (medical herb) as it is used in the medical field as an antifungal (Wuthi-udomler et al., 2000), anti-bacterial and infections effectively (Fang et al., 2003), *Curcuma longa* contains vitamins, fibers and coloring matter that gives the tallow color to turmeric. Turmeric contains 6.3% protein, 5.1% fat and 69.4% carbohydrate (Arora et al., 1987) and (Bakhru et al., 1997). Adding Curcumin to the ration (100 or 200 mg/ kg of ration leads to increase the body weight of lambs (Victor et al., 2019). The study aimed to investigate the effects of shearing and adding *Curcuma longa* to the ration In Awassi lambs performance traits and biochemical parameters.

**MATERIALS AND METHODS**

This study was carried out in Animal production field, College of Agriculture and Forestry, University of Mosul at the period 3/10/2019 to 2/1/2020, to study the effects of shearing, and adding *Curcuma longa* in performance and blood parameters of Awassi lambs. A total of 24 Awassi male lambs (5-6 months old), which were healthy and with almost similar initial body weight (29.57 Kg). All lambs were fed 1.25 kg/lamb/day on the experimental diet which consists of 70% barley, 17% wheat bran, 7% soybean meal, 4% wheat straw and 1% urea as presented in Table 1. Lambs were randomly divided into four equal groups (6 per each). The first group (T1) fed standard ration with no supplementation or sharing and considered as control, lambs in second group (T2) were shared at the beginning of experiment. Animals in third group (T3) their diet supplemented with 200 mg/kg Curcumin, while in forth group (T4) were shared and the diet supplemented 200 mg/kg Curcumin and drinking water was available all times. Lambs were weighed before the morning feeding at the beginning and at 12th week of the study. Final body gain (BG) for the lambs was calculated by subtracting initial from final BW and then dividing by the duration of study. The relative mean growing was calculated by using the following formula:
Final BW – Initial BW
Relative mean growing = \frac{\text{Final BW} - \text{Initial BW}}{\text{Initial BW}} \times 100. (Gazal and Alsayegh, 1980)

Blood samples were collected from the jugular vein of each animal at the 3rd month of study. Samples were centrifuged at 3000 rpm for 15 min, and then frozen at -20 °C until subsequent analysis. Biochemical analyses included serum glucose (Glu), total protein (TP), albumin (AL) and globulin (GL). For lipid profile, cholesterol (CHOL), and Triglyceride (TG). For liver function alanine aminotransferase (ALT), aspartate aminotransferase (AST), were examined. The analysis were conducted by standard methods using commercial kits supplied from Bio lab, France access.

Table (1): Component and chemical composition of ration.

| Ingredients of DM | %  |
|-------------------|----|
| Barley            | 70 |
| Wheat bran        | 17 |
| Soybean meal      | 7  |
| wheat straw       | 4  |
| Urea              | 1  |
| Common Salt       | 0.5|
| CaCo3             | 0.5|

chemical analysis
| Cp %         | 13.96 |
| Ca %         | 0.39  |
| P %          | 0.31  |
| ME (Kcal/Kg) | 2624  |

Protein and metabolizable energy were calculated based on dry matter (Al-Khwaja et al., 1978).

Statistical analysis:
Shearing and Curcumin data were analyzed by Statistical Analysis using the (CRD) design by Anonymous (SAS. 2003), according to the following model:

\[ Y_{ijk} = \mu + F_i + e_{ij}K \]

Standard errors, differences within means were calculated by Duncan test (Steel and Torrie., 1984).

RESULTS AND DICUSSION
Table (2) showed the results of the statistical analysis of the study data which revealed a significant (P≤0.05) increase in final BW in 3rd and 4th groups at 12th week (45.21 and 44.70 kg) respectively, as compared with other groups. Results of BG revealed a significant increase (P≤0.05) in 3rd and 4th groups (15.63 and 15.30 kg) respectively as compared with other groups. Relative mean growing, increased in 3rd group (11.33), but not arrived to significantly.
The results obtained in this study revealed a significant increase in BW in 4th group lambs of the effect of shearing are in agreement with the results of Mohammed et al., (2015) in the effect of shearing, whose improved BW significantly after three months after shearing, and results of the study of Mclean et al. (2015), which leads to significant BG of shearing lambs compared with unsheared lambs, also results are with agreement with the results of Jake et al. (2006) in a study on male and female lambs of (Hampshire and Columbia), while Sultan (2016) not reported any effect of shearing on BW in his study on 20 Awassi rams, the increase of BW appeared in group of shearing and grazing in his study. Nursing lambs reared on concentrate containing Curcuma longa showed higher BG and WG in accordance to what was record by Victor et al. (2019) in study on 64 Lacaunc lambs fed ration with 100 and 200 mg/kg ration, as compared with control group.

Table (2): Effect of shearing and Curcuma longa on some productive traits of Awassi lambs.(Means ± SE).

| Treatments                          | T¹ | T²   | T³        | T⁴         |
|------------------------------------|----|------|-----------|------------|
| Initial body weight (kg)           | 29.75a ± 0.25 | 29.55a ± 0.39 | 29.58a ± 0.35 | 29.40a ± 0.49 |
| Final body weight (kg)             | 42.16 b ± 0.71 | 42.37 b ± 0.12 | 45.21 a ± 0.17 | 44.70 a ± 0.37 |
| Body weight gain (kg)              | 12.41 b ± 0.84 | 12.82 b ± 0.37 | 15.63 a ± 0.37 | 15.30 a ± 0.76 |
| Relative mean growing %            | 8.53 a ± 2.02 | 8.25 a ± 1.18 | 11.33 a ± 1.74 | 8.53 a ± 1.31 |

T¹: Control group, T² lambs sheared, T³ lambs received 200 mg Curcuma longa/kg ration and T⁴ lambs sheared and 200 mg Curcuma longa /kg ration.
Different letter in same row differ at (P≤0.05) significantly.

Results also with agreement with Habeeb and El-Tarabany (2012) in there study on Zaraibi does (4 – 5 month aged). According to these authors, a ration containing 2g/kg Curcuma longa increased BW and BG in all months of study. Positive effect of Curcuma longa to the ration also found higher weight gain was record in the study of Maria et al (2016) in lambs reared on standard diet containing 25, 100, and 200 gm/kg Curcuma longa. Fahmida et al., (2016) demonstrated that Curcumin powder at level 0.2 and 0.6% of body weight increased BW and BG in Black Beugel goats as compared with control also Cervantes Valencia et al. (2016) demonstrated that Curcuma longa enhanced body immunity by increasing IgG, IgM and IgA in blood plasma. Also (Zhiyang Jiang et al., 2019) recorded that Curcuma longa increase the activity and absorption of digestive Cannel enzymes including trypsin, lipase and ck. The highest average WG and BG by adding Curcuma long to ration may be belonged to the effect of Curcuma longa increased total antioxidant capacity and reduced lipid peroxidation (Jaguzeski et al., 2019), also researchers recorded the ability of Curcuma longa to kill parasites and improve performance of lambs Fahmida et al., (2016).
Results of biochemical blood parameters (Table 3) at 12\textsuperscript{th} week of study revealed a significant (P≤0.05) increase in TP and GLU in 3\textsuperscript{rd} and 4\textsuperscript{th} groups as compared with other groups. No significant differences were presented between groups in glucose, albumin, and Globulin/Albumin at 12\textsuperscript{th} week of study.

Table (4) showed the results of some lipid profile and liver enzyme traits, which illustrated that, there are a significant (P≤0.05) increase in TG and significant decrease in AST concentration in treated groups, as compared with control, also ALT concentration decreased significantly in T\textsubscript{4} as compared with other treatments.

The results of blood parameters that obtained in this study are with agreement with the results of Habeeb \textit{et al.}, (2009); El-Gohary \textit{et al.}, (2012) and Habeeb and El-Tarabany (2012), whom recorded an increase in TP by adding curcuma longa to ration. Antonise \textit{et al.} (2018) demonstrated a significant increase in TG and

| Treatments | T1        | T2        | T3        | T4        |
|------------|-----------|-----------|-----------|-----------|
| Glucose mg/100 ml | 73.37 a ± 1.83 | 70.87 a ± 2.02 | 67.50 a ± 3.73 | 74.25 a ± 3.21 |
| Total protein gm/100 ml | 6.47 b ± 0.09 | 6.45 b ± 0.11 | 6.80 a ± 0.03 | 6.76 a ± 0.04 |
| Albumin gm/100ml | 2.77 a ± 0.14 | 2.75 a ± 0.08 | 2.67 a ± 0.04 | 2.67 a ± 0.08 |
| Globulin gm/100ml | 3.68 b ± 0.10 | 3.70 b ± 0.08 | 4.12 a ± 0.04 | 4.09 a ± 0.04 |
| Globulin/Albumin | 1.34 a ± 0.09 | 1.35 a ± 0.05 | 1.54 a ± 0.04 | 1.53 a ± 0.06 |

T\textsuperscript{1}: Control group, T\textsuperscript{2} lambs sheared, T\textsuperscript{3} lambs received 200 mg Curcuma longa/kg ration and T\textsuperscript{4} lambs sheared and 200 mg Curcuma longa /kg ration.

Different letter in same row differ at (P≤0.05) significantly.

| Treatments | T1        | T2        | T3        | T4        |
|------------|-----------|-----------|-----------|-----------|
| Cholesterol mg/ 100 ml | 56.35 a ± 8.47 | 47.15 a ± 8.26 | 34.50 a ± 5.47 | 46.00 a ± 9.57 |
| Triglycerides mg/100 ml | 24.78 b ±1.54 | 32.68 a ±1.31 | 33.64 a ±0.52 | 35.86 a ±0.79 |
| AST unit/ ml | 126.65 a ±1.18 | 109.67 b ±0.73 | 114.00 b ±3.99 | 110.12 b ±2.78 |
| ALT unit/ ml | 15.30 a ±1.78 | 12.50 ab ±0.86 | 11.95 ab ±0.60 | 11.34 b ±0.20 |

T\textsuperscript{1}: Control group, T\textsuperscript{2} lambs sheared, T\textsuperscript{3} lambs received 200 mg Curcuma longa/kg ration and T\textsuperscript{4} lambs sheared and 200 mg Curcuma longa /kg ration.
Different letter in same row differ at (P≤0.05) significantly.

decrease in AST in his study on Lacaune sheep received ration containing the curcumin(60 mg/animal/day). The improvement of TP and GLU in blood serum of lambs reared on ration contained Curcumin may be belong to sulphur material, which stimulate lymphocytes cells division, which associated with globulin immunity (El_shabrawy., 1980). Curcumin also have a positive impact on immune (Galli et al., 2018). A ration containing Curcumin decreased AST levels in blood serum lambs, may belong to the ability of Curcuma longa to stimulate liver cells secretion of pancreas (Corleto and Delle, 2003).

In conclusion, shearing and Curcumin supplementation lead to increase body weights and gain, and improved immunity by increasing TP, GLU and decreasing ALT and ALT of Awassi lambs.

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تأثر جز الصوف واضافة الكركم Curcuma longa والكيميوجيهية للحملان العواسية

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الخلاصة

أجريت الدراسة لتقدير تأثارات جز الصوف أو أضافه 200 ملغم/كم من الكركم (Curcuma longa) أو الالاتين معاً في الصفات الانتاجية وبعض صفات الدم الكيميوجيهية للحملان العواسية، إذ استخدم 24 حلالاً(6حلام/مجموعة) بعمر 5-6 شهراً بمتوسط وزن 29.57 كغم ، قسمت عشوائياً إلى رابعة مجاعمية. المجموعة الأولى: غذى عشي الزيت العيسقي ونعيمتة مجمعة سيطرة. المجموعة الثانية: تم جز صوفها وغذى أيضاً على الزيت العيسقي. المجموعة الثالثة: غذى على الزيت الكيميوجيهية مضافة البها 200 ملغم/كم الكركم، بينما غذى المجموعة الرابعة على الزيت الكيميوجيهية مضافة البها 200 ملغم/كم الكركم وتم جز صوفها، ومدة 90 يوماً. تم تسجيل الأوزان الابتدائية والنهائية والزيادة الوزنية الوبائيه و معدل النمو النسبي، كما تم تقدير تركيز الكليسيريدات الثلاثية والكليسيريدات الثلاثية وانزيمي الكركم والبروتين الكلي والألبيومين والكليسيريدات الثلاثية (ALT وAST) في مصل دم الحملان. تبين من النتائج، وجود زيادة معنوية (0.05) في وزن الجسم ALT وAST في الزيادة الكيميوجيهية والبروتين الكلي والكليسيريدات الثلاثية (الجر) والبروتين الثلاثية (الكركم) والكليسيريدات الثلاثية (الكركم) معاً من النتائج، وعمر ارتفاع معنوي (0.05) في تركيز الكليسيريدات الثلاثية، والكليسيريدات الثلاثية، وانخفاض معنوي لتركيز الALT في الحملان العواسية والكركم معاً. بالإضافة إلى انخفاض معنوي لتركيز ALT في الحملان العواسية والكركم معاً. رفع تستقبل تأثيراته معنوية في معدل النمو وتركيز الكركم والألبيومين والكليسيريدات الثلاثية، وازدياد عدد من الدراسة، والكلمات الدالة: الجز، الكركم، الصفات الكيميوجيهية، الحملان العواسية.

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REFERENCES

Alkass, J. E and K, H. Juma. (2005). Small Ruminant breeds of Iraq. In Characterization of small Ruminant Breeds in West Asia and North Africa. Small ruminants research 1: 63-101.

Al-khwaja, A. K, A. Alham and A. Samir. (1978). Chemical composition and nutritional value of Iraqi feed materials. A bulletin issued by the Nutrition Department of the General Livestock Directorate of the Ministry of Agriculture and Agrarian Reform. The Republic of Iraq.

Anonymous.(2003).Statistical Analysis Systems User’s Guide (SAS). North Carolina: SAS Institute Inc.

Antonise, M. J, P. Gessica, B. B. Nathieli, W. Roger, B. F. Mariane, R. C. S. Maria, Vera M. Morsch, Carolina S. Stein, Rafael N. Moresco, Daniel A. Barreeta, D. Beatriz, C. D. Renata, L. B. S. Ana and S. Da. S Aleksandro .(2018). Addition of curcumin to the diet of dairy sheep improves health, performance and milk quality. Animal Feed Science and Technology.246, 144-157.

Arora, R B. (1987) Development of unani drugs from herbal sources and the role of elements in their mechanism of action. Karachi, Pakistan : Hamdard Foundation.

Bakhru, H. K. (1997). Herb that heal: Natural Remedies for Good Health. Orient paperback, New Delhi, PP: 164-166.

Cervantes-Valencia, M. E, Y. Alcalá-Canto, H. Sumano-Lopez, A.M. Ducoing-Watty and L. Gutierrez-Olvera. (2016). Effects of Curcuma longa dietary inclusion against Eimeria spp. In Naturally-infected lambs. Small Rumin. Res. 136, 27-35.

Corleto, V. D. and F. Delle .(2003).Role of Somatostatin in the human gastrointestinal tract .Curr.opin.Endocrinal.Diab.10:66-82.

Dickerson, G. E, H. A. Glimp, H. J. Tuma and K. E. Gregory. (1972). Genetic resources for efficient meat production in sheep, growth and carcass characteristics of ram lambs of seven breeds. J. Anim Sci., 34:940-951.

EL- Shabrawy, O . (1980). Some toxic effect of onion and garlic .J. Egypt. Vet. Med. Association 40 (3) :97-106.

EL-Gohary, E. S. H, S. A. EL-Saadany, M. A. Abd- Elkabeer and K. M. Aiad .(2012). Effect of supplementing some medicinal herbs and plants on the performance of lactating goats: 1- productive and reproductive performance. J. Animal and Poultry Prod., Mansoura Univ., Vol.3 (5): 199 – 213.

Fang, J. Y., C. F. Hung, H. C. Chiu, J. J. Wang, T. and F. Chan. (2003). Efficacy and irritancy of enhancers on the in-vitro and in-vivo percutaneous absorption of curcumin. J. Pharm. Pharmacol. 55:1175.

Fahmida, A, M. M. R. Chowdhury, S. S. Saha, Md. Ataur Rahman, 5Md. Ali Asgar, Md. Nd Kamrul Islam. (2016). Efficacy of Curcumin against gastro-ntestinal parasites in goat. Ejpmr, 3(8), 158-165.

Galli, G.M, Da Silva, A.S. Biazus, A.H. Reis, J.H. Boiago, M.M. Topazio, J.P. Migliorini, M.J. Guarda, N.S. Moresco, R.N. Ourique, A.F. Santos, C.G. Lopes, L.S. Baldissera and M.D. L.M. Stefani. (2018). Feed addition of Curcumin to laying hens showed anticoccidial effect, and improved egg quality and animal health. Res. Vet. Sci. 118, 101 – 106.
Gazal, N. T, and M. Alsayegh (1980). Sheep and wool production, 1st edition, Mosul. Iraq.
Habeeb, A.A.M., E.S. EL-Gohary and S.A. EL-Saadany. (2009). Improving milk yield and some physiological body functions of lactating zraibi goats under heat stress conditions of hot summer season using supplemental diet with Ginger or Curcumin. Zagazig Veterinary J., 37(6):54-67.
Habeeb, A. A. M. and A. A. El-Tarabany. (2012). Effect of Nigella sativa or Curcumin on Daily Body Weight Gain, Feed intake and some physiological functions in growing zaraibi goats during hot summer season. Arab Journal of Nuclear Science and Applications, 45(3):12 pp.
Hashem, A. L. S; Shakir, Y. M; Abdel-Fataah, M. S; Hanan, Z. and Ashgan, M E. (2013). Effect of weaning age on growth performance and carcass traits of Barki lambs in Siwa Oasis. Egypt. World Applied Sci. J., 21:975-982.
Hassan, S.A. (2009). Effect of some medicinal plants supplementation on daily intake , live weight gain and carcass characteristics of Awassi lambs. Egyptian Journal of Nutrition and Feeds Vol.12 No.1
Jaguezeski, A.M., Gündel, S.S., Favarin, F.R. Gündel, A. Souza, C.F. Baldissera, M.D. Cazarotto, C.C. Volpato, A. Fortuoso, B. F. Ourique and A.F. Low-dose. (2019). Curcumin-loaded Eudragit L-100-nanocapsules in the diet of dairy sheep increase antioxidant levels and reduces lipid peroxidation in milk. J. Food Eng. e12942 [Cross Ref].
Jake, J. H., M. Holt Simone , and J. A. Daniel.(2006). Shearing Lambs Improves Growth Performance During Periods with Elevated Thermal Load. South Dakota Sheep Research Report
Mahrose, A. S. (2014). The effect of shearing on the behavior and blood cortisol level and productive performance of lambs. Animal welfare department. College of Veterinary Medicine. Alexandria University.
Maria, E. C. V., M. E., Y. Alcala-Canto, H. Sumano-Lopez, A. M. Ducoing-Watty and L. Gutierrez-Olvera. (2016). Effects of Curcuma longa dietary inclusion against Eimeria spp. In naturally-infected lambs. Small Ruminant Research 135, 27-35.
Mclean, N.J., B. Craig1, P.f. Fennessy, M.J. Behrent, J.l. Kerslake and A.W. Campbell. (2015). Effect of shearing on lamb growth and carcass performance. Proceedings of the New Zealand Land Society of Animal Production. Vol 75: 2015-2018.
Mohammed, A. M., Sh. A. Tafar and N. S. Motafar. (2015). The effect of using shearing and vitamin E to reduce the effect of stress on weights, weight gain and feed consumption in Awassi lambs in central Iraq. Tikrit University Journal for Agricultural sciences, (15), (3), 1646 – 1813.
Rashid, N. H., J. E. Alkass, A. A. Aldorri, and L. H. Alwan. (1987). Growth rate, offals and carcass characteristics of Awassi lambs slaughtered at different weights. J. Agric. Water Reso. Res., 6: 27-40.
Schoenlank, S. (2010).Heat stress in sheep and goats. http://www. sheep and goat. com/articles/heat stress .html.
Steel, RGD. and JH. Torrie. (1984). Principles procedures of statistics. New York: McGraw-Hill Book Company. 481p.

Sultan, Kh. H. (2016). The effect of grazing and wool shearing on the traits of semen of Awassi rams. *The Jordanian Journal of Agricultural Sciences*, 12: 427-439.

Tibbo, M., J. Philipsson and A. Worknesh. (2006). Sustainable sheep breeding programs in the Tropics: a Framework for Ethiopia conference on International Agricultural Research for Development University of Bonn, 11-13 october.

Victor, M, C. F. Souzab, D. B. Matheus, G Patrícia, C. Gabriela, C. J. Cazarattod, L. M. Stefania and D. Aleksandro. (2019). Diet supplemented with curcumin for nursing lambs improves animal growth, energetic metabolism, and performance of the antioxidant and immune systems. *Small Ruminant Research* 170: 74–81.

Wuthi-udomler, M., W. Grisanapan, O. Luanratana, and W. Caichompoo. (2000). Antifungal activity of *Curcuma longa* grown in Thailand. *South east Asian J. Trop. Med. Public Health*, 31: 178-182.

Zhiyang, J, W. Yongjie, L. Peng, X. Yang, C. Wenwen, CH. Qi, CH. Jianqin, W. Feng and M. Dagan.(2019). Effect of Curcumin Supplement in Summer Diet on Blood Metabolites, Antioxidant Status, Immune Response, and Testicular Gene Expression in Hu Sheep. *Animals (Basel).* 9,(10): 720.