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Impact of Transportation Stress on Meat Quality in Sheep

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Abstract | The physical state and meat traits of sheep undergo major changes due to transportation stress. The current study evaluated how transport stress affects physiological stress indicators that include cortisol and blood glucose concentrations alongside their effects on pH drop and color changes together with water-holding capacity and tenderness and intramuscular fat content in meat. The research data demonstrated elevated cortisol together with blood glucose levels among transported sheep which confirmed transport creates acute stress in animals. Death-induced meat changes included rapid pH reduction, intensified red coloration, diminished water retention power, and harsher texture due to increased shear forces that resulted in tough meat quality. The exported sheep experienced meat quality issues that presented aspects from both pale soft exudative and dark firm dry conditions which decrease market value and consumer satisfaction. The stress-induced metabolic energy expenditure led to diminishment of intramuscular fat content which affected tender juiciness and taste characteristics of the meat. These results underscore the need to optimize conditions of transportation, including reducing travel time, enhancing handling techniques, and providing suitable environmental conditions to reduce the adverse impact of transportation stress on meat quality.

Keywords | Transportation stress, Sheep, Meat quality, Cortisol, pH decline, Meat tenderness, Water-holding capacity, Intramuscular fat, Animal welfare, Post-mortem changes

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INTRODUCTION

Livestock transportation is a critical part of the meat industry, transporting animals for Breeding, trade, and slaughter (Alcalde *et al.*, 2017) are essential components of the livestock production chain. Transporting animals subjects them to various stressors with significant physiological and biochemical consequences that ultimately influence meat quality. Recent findings by Hsu *et al.* (2024) and Govindarajan *et al.* (2023) highlight how transport-related stress factors have become an increasing concern in global livestock systems, especially with the rising demand for meat exports. Sheep, like all livestock, are subjected to extreme stress when being transported as a result of numerous factors, including physical handling, environmental changes, and social disturbances (Azad *et al.*, 2022; Kadham *et al.*, 2023; Karupusamy *et al.*, 2023).

These stressors initiate metabolic alterations that modify post-mortem muscle physiology and consequently result in differences in meat texture, color, water-holding capacity, and consumer acceptability (Batchu *et al*., 2021; Saadh *et al*., 2024; Al-Saadi and Shwan, 2024). Studies by Ahmad *et al*. (2019) and Alhaqmuhamad *et al*. (2019) emphasize the biochemical markers of stress responses that directly correlate with reduced carcass quality. Additionally, Al-Safi and Zangana (2022) and Noman and Ahmad (2023) show that implementing improved handling protocols and environmental control during transport can significantly minimize these negative impacts. Furthermore, integrating genetic, nutritional, and management solutions (Ahmad and Noman, 2023; Ahmad *et al*., 2024; Laylani *et al*., 2024) offers promising strategies to reduce animal stress, ensure better meat quality, and meet evolving consumer expectations across domestic and international markets (Ahmad, 2025; Mohamad *et al*., 2025; Ramadhan *et al*., 2025).

Understanding transportation stress in sheep

Transportation stress is described as the physiological and psychological anxiety prompted in animals by means of movement over short or lengthy distances (Bhatt *et al*., 2021). The strain is delivered about with the aid of diverse physical, environmental, and social stressors. Physical stressors result from coping with at the same time as loading and unloading, vibration of motors, abrupt movement, and lengthy durations of confinement, all inflicting muscle anxiety and fatigue (Broom, 2024). Environmental stressors, which include publicity to high temperatures, humidity adjustments, insufficient ventilation, and insufficient get admission to meals and water, similarly beautify stress degrees, raising the threat of dehydration and metabolic fatigue (Cam *et al*., 2021). Social stressors additionally play an vital position, as intermixing of strange animals can lead to aggression, establishment of hierarchy, and psychological pressure. Conversely, separation from familiar flock contributors can also motive tension (Carnovale *et al*., 2021). Collectively, some of these stressors spark off the HPA axis and cause an improved cortisol secretion that influences everyday metabolic feature and detracts from meat high-quality.

Physiological impact of transportation stress on meat quality

Transportation-induced stress triggers bodily reactions which directly affect meat quality in various ways (Cockram and Velarde, 2022). Stress leads to muscle glycogen depletion during long-term stress which affects glycolysis rates following death and results in an abnormal downward pH shift (Dalmau *et al*., 2013). By the end of the pH descend steeply PSE meat develops while prolonged pH rise produces DFD meat. The oxidation of myoglobin following stress results in meat color changes towards darkness which consumers identify as inferior quality. High final pH values block oxygen from penetrating the meat tissue making the appearance less fresh (De la Fuente *et al*., 2010). The water-holding capacity of meat suffers when stress causes muscular contractions and protein structural changes which then lead to elevated drip loss and consequently affects the meat by making it drier and less tender. The pre-slaughter stress induced by transportation pressure increases meat toughness because it makes muscle fibers hard as shear force values rise thus damaging consumer acceptability rates (Ding *et al*., 2024). The metabolic expenditure of energy caused by stress reduces body fat accumulation in the muscles while simultaneously decreasing the fat content present within muscles. The reduction in these attributes leads to dry meat as well as reduced flavor which are essential factors for creating high-quality meat products (de Silva *et al*., 2023).

Economic and welfare implications

The negative effects arising from transportation stress produce damaging effects on meat quality along with financial losses for producers and processors and retail distributors EFSA Panel on Animal Health and Welfare (Nielsen et al., 2024). Stressed meat which consumers find unacceptable results in decreased market value leading to potential wastage of the product. Better regulations backed by rising industry focus on animal welfare combined with improved humane handling and best meat quality practices emerged from the stress-related issues during transportation (Ekiz *et al*., 2012). To control transportation, stress the industry needs to implement optimal solutions that address transport vehicle specifications through ventilation and space distribution systems alongside minimal handling procedures and appropriate feeding logistics with water access and rest periods for animals during transport (Ekiz *et al*., 2022). Improved transport protocols in the sector lead to better meat quality together with animal welfare benefits which yield both content customers and economic sustainability (Gallo *et al*., 2018).

MATERIALS AND METHODS

The aim of this study was to evaluate the impact of transportation stress on meat quality of sheep by analysis of physiological indicators of stress and meat quality attributes (Ijaz *et al*., 2022). A controlled experimental model was employed, with sheep subjected to transportation stress compared with a control group that remained in a familiar farm environment. The procedure involved animal selection, the transportation process, sample taking, laboratory analysis, and statistical evaluation (Kadim *et al*., 2010).

Animal selection and experimental design

The researchers handpicked 40 male sheep from a commercial livestock farm with the requirements of matching breed and age between 10 to 12 months and weight spanning from 35 to 40 kg (Li *et al*., 2024). The assessment procedure created uniformity between candidates based on their age weight measurements as well as their health status to minimize stress reaction effects on meat quality results (Liu *et al*., 2012).

All selected sheep passed a veterinary medical checkup that confirmed their health status included no existing illness or disease symptoms as well as no previous signs of stress. Sheep showing illnesses along with abnormal behavioral indications got excluded from research activities immediately (Ma *et al*., 2022).

After selection process the researchers distributed the chosen sheep randomly. The group of twenty subjects in the Transported Group underwent transportation stress by enduring commercial traveling methods (Miranda-de la Lama *et al*., 2011). Twenty sheep acted as the control group at the farm site during the duration of this study without undergoing transportation related stress.

The study utilized the same conditions for animal housing before investigation while providing each animal with balanced food and unlimited access to drinking water (Miranda-de la Lama *et al*., 2012). Researchers allowed animals to adapt for seven days prior to the transportation phase to achieve stable physiological state.

Transportation protocol

An experimental transport protocol operated under controlled environmental conditions which mimicked industrial livestock shipping systems (Teke *et al*., 2014). The sheep received placement into a standard commercial livestock trailer according to the strict animal welfare regulations which determined their transportation parameters. Special handlers employed non-slip ramps for loading procedures to reduce stress to the animals. Sheep spent four hours on the road through a mixed terrain that duplicated typical commercial sheep transportation. Sheep within the trailer received 0.3 meters squared of space per animal to prevent overcrowding and unwanted physical activity. The digital data logger monitored both temperature and humidity measurements during the entire transport duration (Tozlu *et al*., 2021). The vehicle moved at limited speeds through its route where braking and accelerating remained gentle to minimize any injury risk. Staff members who loaded and unloaded the animals maintained a delicate approach to minimize mental distress on the sheep. The transported sheep received one hour for recovery prior to their physiological tests and killing process after reaching their destination. Sheep from the control group remained at their ordinary farm environment without facing any transportation stress conditions (Tüfekci and Sejian, 2023).

Physiological stress indicators

In order to analyze the physiological response to stress when transported sheep are brought to land, blood was sampled pretransport (baseline) and directly postunloading using jugular venipuncture in sterile needles and vacutainers (Vogel et al., 2024). Blood immediately on ice and shipped to the laboratory was assayed.

The following stress indicators were assessed:

- Cortisol levels: Blood plasma cortisol concentration was assessed by an enzyme-linked immunosorbent assay (ELISA) to measure the acute stress response. Elevated levels of cortisol indicated greater stress levels caused by transportation.
- Blood glucose concentration: A biochemical analyser was employed to measure blood glucose levels. Increased glucose levels after transportation revealed a physiological stress response as a result of the activation of the hypothalamic-pituitary-adrenal (HPA) axis
- Heart rate and respiratory rate: Heart rate and respiratory rate were recorded with a portable digital monitoring device at three points prior to transportation, during transit (hourly), and upon unloading (Takahashi et al., 2022). These parameters gave real-time information on stress levels incurred by the transported sheep.

All of the physiological parameters were contrasted between the transport and control groups to determine the degree of transport-induced stress.

Meat quality assessment

Standard slaughterhouse procedures according to ethical standards were applied to carry out humane slaughter of all sheep upon transportation. Scientists conducted the slaughtering activities under controlled environments to ensure consistent meat quality test results (Al-Safi and Zangana, 2022). Scientists took samples of meat from the longissimus dorsi muscle (loin muscle) for carrying out extensive quality checks.

pH decline measurement

The pH of meat was recorded at two intervals to determine post-mortem changes:

- pH45: Recorded 45 minutes after death on a portable pH meter with glass electrode
- pH24: 24 hours post-mortem after being stored at 4°C

A sudden drop in pH after death was thought to be a measure of stress-provoked depletion of glycogen, resulting in pale, soft, and exudative (PSE) meat. Higher-than-usual ultimate pH (pH24) indicated dark, firm, and dry (DFD) meat, more commonly linked to extended stress.

Meat color analysis

Meat color was analyzed by a Minolta chromameter to assess three important parameters

- L value (lightness): *Indicates the brightness of the meat.
- a value (redness): *Represents the intensity of red pigmentation, influenced by myoglobin oxidation.
- b value (yellowness): *Reflects the level of yellow pigmentation in the meat.

These color parameters were employed to distinguish among normal, PSE, and DFD meat conditions due to transportation stress since stress-induced metabolic alterations may lead to darker or lighter meat, impacting consumer preference.

Water-holding capacity (WHC) measurement

The water-holding capacity (WHC) of meat was determined using two methods:

- Drip loss: Meat samples were kept suspended in plastic bags at 4°C for 24 hours and the fluid loss percentage was noted.
- Cooking loss: Meat samples were cooked in a temperature of 75°C, and their weight was noted before and after cooking to find the moisture retention.

Increased drip loss and cooking loss percentages showed lower WHC, which adversely affected meat juiciness and general consumer acceptability. Lower WHC meat is drier and tougher, making it less palatable for consumption.

Shear force analysis (meat tenderness measurement)

Meat tenderness was determined through a Warner-Bratzler shear force (WBSF) analyzer. Meat samples were trimmed to uniform size and sheared across the muscle fibers. Greater shear force values were representative of tougher meat, commonly linked to stress-induced contraction of muscle.

Intramuscular fat content measurement

Soxhlet extraction technique provided the method for determining fat contents in sheep meat samples (Yu et al., 2023). The transportation stress experiences by sheep appears to enhance their metabolic functions leading to reduced fat content which affects the texture and taste of the meat.

RESULTS AND DISCUSSION

The research into sheep meat quality impacts during transportation stress presents its experimental results in this section. The author discusses findings in relation to stress markers and meat quality properties. Research findings receive interpretation through an evaluation of prior work focusing on how transportation pressure affects both animal well-being and meat production quality.

Physiological stress indicators

Cortisol and blood glucose levels: The research into sheep meat quality impacts during transportation stress presents its experimental results in this section. The author discusses findings in relation to stress markers and meat quality properties. Research findings receive interpretation through an evaluation of prior work focusing on how transportation pressure affects both animal well-being and meat production quality.

Table 1: Cortisol and blood glucose levels in transported and control sheep.

Group	Pre transport cortisol (ng/mL)	Post transport cortisol (ng/mL)	Pre transport glucose (mg/dL)	Post transport glucose (mg/dL)
Control (n=20)	3.45	3.80	62.30	64.20
Transported (n=20)	3.50	7.85	61.70	79.60

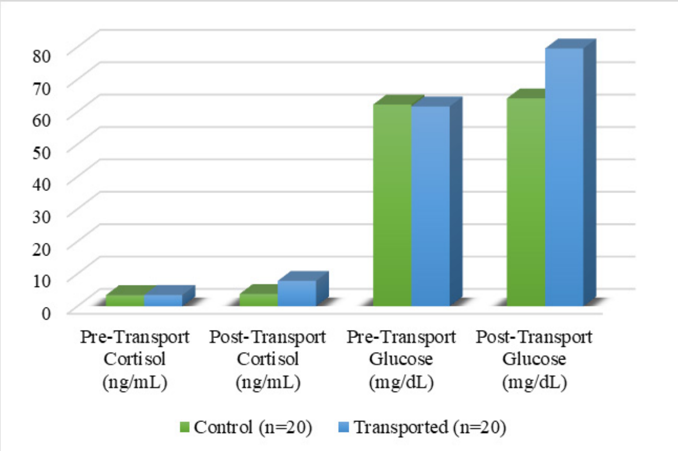

Figure 1: Blood glucose and cortisol levels are transferred and cnotrol.

The transported sheep had a excellent upward push in cortisol degrees after transport as opposed to the control group, showing an acute pressure reaction elicited by way of delivery. Increased cortisol secretion is a nicely-documented physiological indicator of pressure, reflecting the animals efforts to address delivery difficulties like coping with, confinement, and environmental alterations. In addition, blood glucose concentrations had been extensively extended inside the transported sheep following transportation, indicating more desirable mobilization of energy fueled with the aid of cortisol release because of stress. The growth in glucose awareness is an adaptive response to pressure, because the organism prepares for expanded needs for strength. The dramatic fluctuations in each cortisol and glucose concentrations indicate the physiological consequence of transportation stress which can have a knock-on effect on meat pleasant in addition to standard animal nicely-being.

Meat quality parameters

pH decline and meat color: Sheep transported confirmed a quicker pH fall after loss of life, probably because of glycogen breakdown due to strain and next lactic acid build-up. This pH shift within the muscle is related to negative meat quality, e.G., faded, smooth, and exudative (PSE) or dark, firm, and dry (DFD) meat.

Table 2: pH decline and meat color characteristics.

Group	pH45 (45 min post-mortem)	pH24 (24 hours post-mortem)	Lightness (L*)	Redness (a*)
Control (n=20)	6.40	5.60	52.10	16.40
Transported (n=20)	5.90	5.30	47.50	13.20

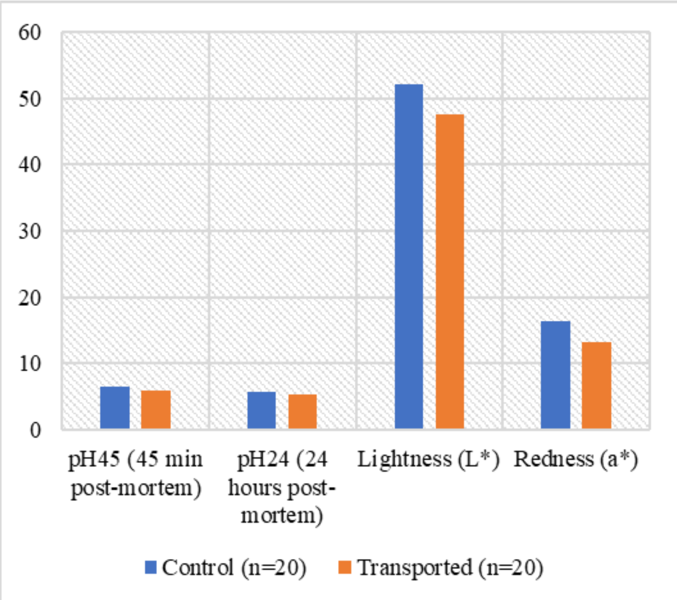

Figure 2: Transported and controlled meat color and pH.

The sheep that underwent transportation experienced accelerated pH decline following death because stress levels caused rapid glycogen depletion and subsequent elevation of lactic acid in their muscles. The rapid decrease in pH results in the production of pale soft exudative (PSE) meat which negatively affects meat quality. The transported group demonstrated reduced final pH value (pH24) at sampling time 24 which suggests elevated metabolic pressures and unfavourable meat features. The final meat quality in the transported group became darker and less attractive with lower L* and a* values which occurs due to pre-slaughter stress factors that lead to dark firm dry appearing meat. The changes caused by stress during transportation negatively affect both market appeal and consumer tolerance of the meat thus demonstrating a requirement to establish lower stress transportation procedures for maximized meat quality.

Water-holding capacity and meat tenderness

The transported sheep showed decreased water-holding capacity because their drip and cooking loss measurement percentages increased. The meat showed tough texture because shear force measurements increased.

Table 3: Water-holding capacity and shear force values.

Group	Drip loss (%)	Cooking loss (%)	Shear force (N)
Control (n=20)	2.10	18.60	35.60
Transported (n=20)	4.70	24.30	47.20

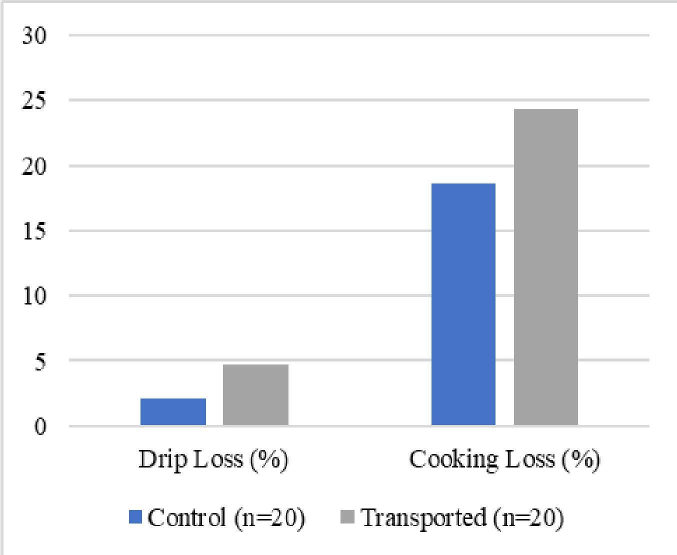

Figure 3: Transported and controlled shear force values and water-holding capacity.

The meat from transported sheep demonstrated higher drip loss and cooking loss compared to the control group because transportation stress led to reduced water-holding capacity in the meat. The meat becomes unappetizing to consumers because drier and less juicy characteristics result from reduced water-holding capacity in the meat. The quantity of shear force measured in the transported group exceeded the control group's results revealing that muscles from the transported animals were tougher. The death-related muscle over-contractions combined with glycogen depletion from stress are responsible for these findings. Market desirability of tender meat products decreases when transport stress affects the quality negatively so better conditions in transportation will help minimize these undesirable effects.

Intramuscular fat content

The IMF content in transported sheep was reduced because metabolic energy needs during stress interfered with muscle tissue fat accumulation.

Table 4: Intramuscular fat content.

Group	Intramuscular fat (%)
Control (n=20)	3.40
Transported (n=20)	2.80

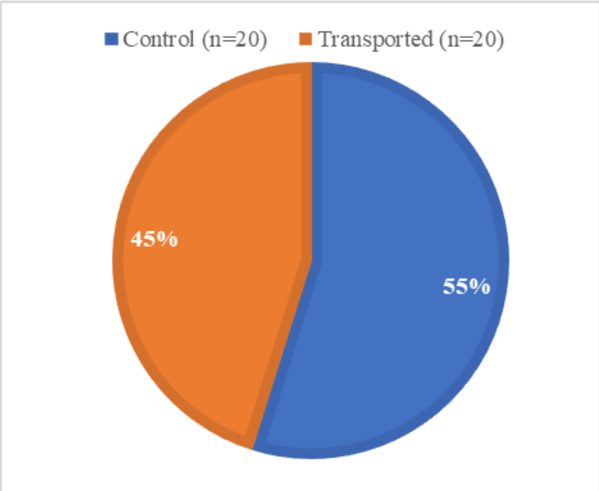

Figure 4: Transported and the control of fat inside muscles.

The transported sheep contained less intramuscular fat at 2.80% than the control group which held 3.40%. The reduction in fat content happens due to natural processes affecting metabolic energy requirements triggered by stress during transportation. Anxiety drives animals to reduce their body fat stores for meeting heightened physiological needs. The stress-induced fat consumption results in reduced intramuscular fat contents which harms the quality of produced meat. The reduction of fat content in meat could cause unwanted effects on tenderness and juiciness and flavor that consumers consider important when making their buying choices. Intramuscular fat deposition experiences negative effects from transport stress resulting in diminished meat tastiness along with potential market price reduction.

The findings evidently show that transport stress has strong adverse effects on physiological markers of stress and meat quality traits in sheep. Elevated cortisol and glucose levels prove that transport is a major stressor that causes metabolic abnormalities that ultimately impact meat quality.

The pH decline, meat coloration, water-holding capacity, and tenderness differences observed agree with earlier research on stress-caused meat quality impairment. The transported sheep had the characteristics of both PSE and DFD meats, which have been shown to decrease consumer acceptance and economic value.

One of the most important findings was the decrease in intramuscular fat content, which can be attributed to increased energy expenditure caused by stress. Also, the remarkable increase in shear force values shows that stress is responsible for muscle fiber contraction, resulting in harder meat.

Enhanced management strategies for transportation such as reducing travel duration and handling stress reduction combined with environmental optimization can result in decreased negative effects on meat quality.

CONCLUSIONS

The research established that sheep faced significant physiological alterations together with reduced meat qualities because of transport stress. Stress levels in blood glucose and cortisol demonstrated that moving animals between locations generates substantial stress that leads to material metabolic alterations that affect meat quality by decreasing pH fast and tainting color and reducing moisture and increasing hardness. Sheep subjected to transport displayed characteristics of both pale, soft, and exudative meat and dark, firm, and dry meat which combined to diminish consumer approval and total meat quality. Lower intramuscular fat levels in these circumstances suggested increased metabolic energy use from stressors which produced sensory parameter deterioration along with flavor and juiciness effects. These findings clearly demonstrate that transport-caused stress directly affects meat quality which supports the need for better transport strategies to minimize economic losses and enhance consumer satisfaction.

RECOMMENDATIONS

- Minimizing transport duration: Reducing travel time combined with getting rid of unnecessary waiting periods lowers sheep stress levels to produce better quality meat.
- Gentle handling and loading procedures: Sheep handling and loading will produce fewer fear and injuries when conducted by properly-trained staff who handle animals with gentleness.
- Optimal stocking density: Strict arrangement of space in transport vehicles reduces overcrowding which causes both animal stress and diminished meat quality.
- Temperature and ventilation control: Transportation conditions with appropriate ventilation and temperatures help avoid heat stress that causes metabolic disturbances among animals.
- Post-transport recovery period: Sheep receive better post-mortem meat quality when given sufficient sleep and hydration and sufficient food before the killing process.

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NOVELTY STATEMENT

The study found that transport stress caused sheep to have both substantial physiological changes and decreased meat quality. Moving animals between places causes significant stress, which results in material metabolic changes that influence meat quality by rapidly lowering pH, tainting color, reducing moisture, and increasing hardness, as seen by stress levels in blood glucose and cortisol. Transported sheep exhibited traits of both dark, firm, and dry meat and pale, soft, and exudative meat, which reduced consumer satisfaction and overall meat quality.

AUTHOR'S CONTRIBUTION

All of the trials were designed by Sara A. Jassim, Ghadir Kamil Ghadir and Mohammed Ahmed Mustafa. Faisal Ali Lattef, Suha Maher Abed and Abed J. Kadhim conducted all of the tests, gathered the data, and composed the manuscript draft. Zainab Sadeq Yousif and Maha Marouf helped with the data analysis that was done to prepare the work for submission to the journal. The final draft of the work was reviewed and approved by all authors for publication in the Journal of Animal and Health Production.

Ethical consideration

Not applicable.

Generative AI or AI-assisted Technology Statement

The authors declare that no Genrative AI was used in the creation of this manuscript.

Conflict of interest

The authors have declared no conflict of interest.

REFERENCES

Abdulateef SM, Saed ZJM, Mohammed TT, Mohammed AB (2024). The impact of adding Raphanus sativus seeds to the diet of broiler breeders on egg production and quality, hatchability, and physiological traits. Anbar J. Agric. Sci., 22(2). https://doi.org/10.32649/ajas.2024.185833

Abdulnabi OW, Alsalame HA, Al-baiati MN (2024). Studying of using chitosan-cephalexin nanocomposite to induce ROS and apoptosis in colon cancer cell line HCT-29. Moroccan J. Chem., 12(3): 1270–1280.

Abed SM, Rashid SN, Al-Najar FM, Mustafa MA (2024). Comparative effects of Nd: YAG and diode laser irradiation on *Escherichia coli* clinical isolates: A molecular analysis. Int. J. Design Nat. Ecodyn., 19(4): 1121–1128. https://doi.org/10.18280/ijdne.190403

Ahmad HS (2025). The impacts of domperidone and nanoparticals on hormones and tissues of rabbit female reproductive system. Tikrit J. Agric. Sci., 25(1): 122–131. https://doi.org/10.25130/tjas.25.1.10

Ahmad HS (2023). Study of the effect of chitosan and nystatin for rabbits treated with Candida krusei yeast on blood parameters, electrolytes and intestinal tissue. J. Pharma. Negative Results, 14(2).

Ahmad HS, Abdulwahed AS, Kamil MA (2024). Evaluation of serum levels of irisin, tumor necrosis factor and some biochemical variables in males with prostate cancer in Baghdad city. Cell. Mol. Biol., 70(12): 152–156. https://doi.org/10.14715/cmb/2024.70.12.21

Ahmad HS, Hasan AS, Al-Dulaimi FK, Abdulaqder AT (2019). Study of some hematological and biochemical among for employees of Al-Dour Technical Institute. Biochem. Cell. Arch., 19(1).

Ahmad HS, Noman SJ (2023). Correlation study of hemoglobin and hematocrit levels with BMI, age, and gender and determination of the risk of anemia in adult residents of Iraq. Appl. Nanosci., 13(8): 5357–5364. https://doi.org/10.1007/s13204-023-02878-3

Ahmad HS (2025). The impacts of domperidone and nanoparticals on hormones and tissues of rabbit female reproductive system. Tikrit J. Agric. Sci., 25(1): 122-131. https://doi.org/10.25130/tjas.25.1.10

Al-Aameli MH, Al-Taee RAM, Alsalame HA (2019). Histological and physiological alterations in the aorta and heart in relation with cholesterol diet in male albino rat. Indian J. Forensic Med. Toxicol., 13: 313–318. https://doi.org/10.5958/0973-9130.2019.00135.X

Alcalde MJ, Suárez MD, Rodero E, Álvarez R, Sáez MI, Martínez TF (2017). Effects of farm management practices and transport duration on stress response and meat quality traits of suckling goat kids. Animal, 11(9): 1626-1635. https://www.cambridge.org/core/journals/animal/article/effects-of-farm-management-practices, https://doi.org/10.1017/S1751731116002858

Alhaqmuhamad AA, Abdulrahman MA, Ahmad HS (2019). Effect of nanoparticles on liver functions and antioxidant in female rabbits treated with domperidone. Indian J. Forensic Med. Toxicol., 13(4). https://doi.org/10.5958/0973-9130.2019.00348.7

Al-Nuaimy MMT, Al-Tarjuman JK, Masyab HM, Saadi AM (2025). Relationship between steroid and antibiotic therapy and the frequency of oral candidiasis. J. Homep., 20(2): 447-452. http://iieta.org/journals/ijdne, https://doi.org/10.18280/ijdne.200222

Al-Nuaimy MMT, Masyab HM, Al-Shekhany YN (2025). Antifungal activity of turmeric extract (*Curcuma longa* Linn) fortified with silver nanoparticles against pathogenic fungi. J. Homep., 20(1): 203-210. http://iieta. org/journals/ijdne, https://doi.org/10.18280/ijdne.200122

Al-Nuaimy MMT, Masyab HM, Al-Shekhany YN (2025). Antifungal activity of turmeric extract (*Curcuma longa* Linn) fortified with silver nanoparticles against pathogenic fungi. Int. J. Design Nat. Ecodyn., 20(1): 203-210. https://doi.org/10.18280/ijdne.200122

Al-Saadi AR, Shwan SA (2024). Advances in the management of cardiomyopathies: A comprehensive review. J. Rare

Cardiovasc. Dis., 4(8): 185–192.

Al-Safi NHJ, Zangana BSR (2022). Effect of using raw and treated quinoa seeds (*Chenopodium quinoa*) in the diets on some microbial, physical and chemical properties of broiler carcass. Journal of Kerbala for Agricultural Science, 2(9):46-66. 10.1088/1755-1315/1262/7/072046

Alsalame HAAA (2019). Study the effect of *Lycium barbarum* polysaccharide on bone and thyroid gland in hyperlipidemic healthy male albino rats. Scopus IJPHRD Citation Score, 10(7): 764. https://doi.org/10.5958/0976-5506.2019.01667.X

Alsalame HAAA (2020). Study effects of *Nigella sativa* seeds oil in some physiological parameters in experimental heart failure induced by ivabradine in male rats. Indian J. Forensic Med. Toxicol., 14(3): 2609–2613. https://doi.org/10.37506/ijfmt.v14i3.10831

Alsalame HAAA, Laylani LS (2024). Evaluating the efficacy of *Vernonia amygdalina* on physiological parameters in ameliorating hepatic and renal injury in male rats. Tikrit J. Agric. Sci., 24(2): 298–310. https://doi.org/10.25130/tjas.24.2.21

Azad MAK, Sakib MN, Murshed HM, Hashem MA, Ali MS, Habib M, Billah MM (2022). Indigenous transport methods: Hormonal responses and physicochemical properties of lamb meat. Meat Res., 2(2). https://bmsa.info/meatresearch/home/article/view/28, https://doi.org/10.55002/mr.2.2.14

Batchu P, Hazard T, Lee JH, Terrill TH, Kouakou B, Kannan G (2021). High-condensed tannin diet and transportation stress in goats: Effects on physiological responses, gut microbial counts and meat quality. Animals, 11(10): 2857. https://www.mdpi.com/2076-2615/11/10/2857, https://doi.org/10.3390/ani11102857

Bhatt N, Singh NP, Mishra AK, Kandpal D, Jamwal S (2021). A detailed review of transportation stress in livestock and its management techniques. Int. J. Livest. Res., 11(1): 30-41. https://www.researchgate.net/profile/Ninad-Bhatt/publication/348219718, https://doi.org/10.5455/ijlr.20201109102902

Broom DM (2024). Welfare of transported animals: welfare assessment and factors affecting welfare. In: Livestock handling and transport. GB: CABI. pp. 14-33. https://www.cabidigitallibrary.org/doi/abs/10.1079/9781800625136.0002, https://doi.org/10.1079/9781800625136.0002

Cam MA, Olfaz M, Kirikci K, Tufekci H, Mercan L, Kilic U (2021). Effects of pre-slaughter stress on meat quality characteristics of male lambs of Hemsin and Of sheep breeds. J. Anim. Plant Sci., 47(2): 8445-8459. https://www.m.elewa.org/Journals/wp-content/uploads/2021/02/3.Cam_-1.pdf

Carnovale F, Xiao J, Shi B, Kaart T, Arney D, Phillips CJ (2021). The effects of vehicle type, transport duration and pre-transport feeding on the welfare of sheep transported in low temperatures. Animals, 11(6): 1659. https://www.mdpi.com/2076-2615/11/6/1659, https://doi.org/10.3390/ani11061659

Cockram MS, Velarde A (2022). Sheep. In: Preslaughter handling and slaughter of meat animals. pp. 267-310. Wageningen Academic. https://brill.com/edcollchap/book/9789086869244/BP000009.xml, https://doi.org/10.3920/978-90-8686-924-4_7

Dalmau A, Di Nardo A, Realini C E, Rodríguez P, Llonch P, Temple D, Dalla Villa P (2013). Effect of the duration of road transport on the physiology and meat quality of lambs. Anim. Prod. Sci., 54(2): 179-186. https://www.publish.csiro.au/AN/an13024, https://doi.org/10.1071/AN13024

De la Fuente J, Sánchez M, Pérez C, Lauzurica S, Vieira C, De Chávarri EG, Díaz MT (2010). Physiological response and carcass and meat quality of suckling lambs in relation to transport time and stocking density during transport by road. Animal, 4(2): 250-258. https://www.cambridge.org/core/journals/animal/article/physiological-response-and-carcass-and-meat, https://doi.org/10.1017/S1751731109991108

Ding W, Lu Y, Xu B, Chen P, Li A, Jian F, Huang S (2024). Meat of sheep: insights into mutton evaluation, nutritive value, influential factors, and interventions. Agriculture, 14(7): 1060. https://www.mdpi.com/2077-0472/14/7/1060, https://doi.org/10.3390/agriculture14071060

E Silva FV, Borges I, Garcia SK, de Sá HCM, Silva VL, Araújo AR, Toral FLB (2023). Effect of space allowance during transport of Dorper x Santa Inês lambs on biochemical stress parameters and meat quality. Small Rumin. Res., 219: 106910. https://www.sciencedirect.com/science/article/pii/S0921448823000068, https://doi.org/10.1016/j.smallrumres.2023.106910

EFSA Panel on Animal Health and Welfare (AHAW), Nielsen SS, Alvarez J, Bicout DJ, Calistri P, Canali E, Herskin M (2022). Welfare of small ruminants during transport. EFSA J., 20(9): e07404. https://efsa.onlinelibrary.wiley.com/doi/abs/10.2903/j.efsa.2022.7404, https://doi.org/10.2903/j.efsa.2022.7404

Ekiz B, Ekiz EE, Kocak O, Yalcintan H, Yilmaz A (2012). Effect of pre-slaughter management regarding transportation and time in lairage on certain stress parameters, carcass and meat quality characteristics in Kivircik lambs. Meat Sci., 90(4): 967-976. https://www.sciencedirect.com/science/article/pii/S0309174011003986, https://doi.org/10.1016/j.meatsci.2011.11.042

Ekiz B, Kecici PD, Ekiz EE, Ozturk N, Kocak O, Arslan M, Yilmaz A (2022). The effects of accustoming to handling during the finishing period and weaning status on stress responses to transport, and carcass and meat quality in Kivircik lambs. Small Rumin. Res., 206: 106587. https://www.sciencedirect.com/science/article/pii/S0921448821002649, https://doi.org/10.1016/j.smallrumres.2021.106587

Gallo C, Tarumán J, Larrondo C (2018). Main factors affecting animal welfare and meat quality in lambs for slaughter in Chile. Animals, 8(10): 165. https://www.mdpi.com/2076-2615/8/10/165, https://doi.org/10.3390/ani8100165

Govindarajan S, Mustafa MA, Kiyosov S, Duong ND, Raju MN, Gola KK (2023). Retracted: An optimization-based feature extraction and machine learning techniques for named entity identification. https://doi.org/10.1016/j.ijleo.2022.170348

Hsu CY, Mustafa MA, Yadav A, Batoo KM, Kaur M, Hussain S, Nai L (2024). N2 reduction to NH3 on surfaces of Co-Al18P18, Ni-Al21N21, Fe-B24N24, Mn-B27P27, Ti-C60 and Cu-Si72 catalysts. J. Mol. Model., 30(3): 62. https://doi.org/10.1007/s00894-024-05862-y

Ijaz M, Mahmood M, Yar MK, Bakhsh M, Ullah S (2022). Effect of on-and off-farm factors on animal stress and meat quality characteristics. In: Animal Husbandry. IntechOpen. https://www.intechopen.com/chapters/82106, https://doi.org/10.5772/intechopen.104669

Kadham SM, Mustafa MA, Abbass NK, Karupusamy S (2023).

Comparison between fuzzy partial H-transform and fuzzy partial Laplace transform in x-ray image processing of acute interstitial pneumonia. Int. J. Syst. Assur. Eng. Manage., pp. 1–9. https://doi.org/10.1007/s13198-023-02001-3

Kadim IT, Mahgoub O, Al-Marzooqi W, Khalaf S, Al-Sinawi SS, Al-Amri (2010). Effects of transportation during the hot season, breed and electrical stimulation on histochemical and meat quality characteristics of goat longissimus muscle. Anim. Sci. J., 81(3): 352-361. https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1740-0929.2009.00722.x

Karupusamy S, Mustafa MA, Jos BM, Dahiya P, Bhardwaj R, Kanani P, Kumar A (2023). Torque control-based induction motor speed control using anticipating power impulse technique. Int. J. Adv. Manuf. Technol., pp. 1–9. https://doi.org/10.1007/s00170-023-10893-5

Laylani LS, Abd-Alwahab WIA, Ahmad HS, Mustafa MA (2024). The effect of carotenoids of Rhodotorula glutinis and probiotic of Lactobacillus acidophilus on physiological and histological variables of the kidney in male rats exposed to ultraviolet radiation. J. Anim. Health Prod., 12(s1): 326–331. https://doi.org/10.17582/journal.jahp/2024/12.s1.326.331

Li R, Wang L, Chen B, Zhang Y, Qi P (2024). Effects of Transportation on blood indices, oxidative stress, rumen fermentation parameters and rumen microbiota in goats. Animals, 14(11): 1616. https://www.mdpi.com/2076-2615/14/11/1616

Liu HW, Zhong RZ, Zhou DW, Sun HX, Zhao CS (2012). Effects of lairage time after road transport on some blood indicators of welfare and meat quality traits in sheep. J. Anim. Physiol. Anim. Nutr., 96(6): 1127-1135. https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1439-0396.2011.01230.x

Ma R, Li S, Li X, Liang B, Cui Y (2022). A prediction method for transport stress in meat sheep based on GA-BPNN. Comp. Electron. Agric., 203: 107476. https://www.sciencedirect.com/science/article/pii/S0168169922007840, https://doi.org/10.1016/j.compag.2022.107476

Miranda-de la LGC, Monge P, Villarroel M, Olleta JL, García-Belenguer S, María GA (2011). Effects of road type during transport on lamb welfare and meat quality in dry hot climates. Trop. Anim. Health Prod., 43, 915-922. https://link.springer.com/article/10.1007/s11250-011-9783-7

Miranda-de la LGC, Salazar-Sotelo MI, Pérez-Linares C, Figueroa-Saavedra F, Villarroel M, Sañudo C, María GA (2012). Effects of two transport systems on lamb welfare and meat quality. Meat Sci., 92(4): 554-561. https://www.sciencedirect.com/science/article/pii/S0309174012001982, https://doi.org/10.1016/j.meatsci.2012.05.026

Mohamad HS, Salah MANH, Mdloul NS, Muhaimeed AR, Sulaiman MA (2025). Using the diverse vegetables as a filtration plants in aquaculture intensive system. Tikrit J. Agric. Sci., 25(1): 1–16. https://doi.org/10.25130/tjas.25.1.1

Nielsen SS, Alvarez J, Bicout DJ, Calistri P, Gonzales Rojas JL (2024). EFSA Panel on Animal Health and Animal Welfare (AHAW), European Union Reference Laboratory for Avian Influenza. Vaccination of poultry against highly pathogenic avian influenza–Part 2. https://doi.org/10.2903/j.efsa.2024.8755 Surveillance and mitigation measures. EFSA Journal, 22(4), e8755.

Noman SJ, Ahmad HS (2023). Effects of some fungal secondary metabolite against some cancer cell line. Bangladesh J. Med. Sci., pp. 133–137. https://doi.org/10.3329/bjms.v22i20.66321

Ramadhan MN, Abdulla A, Ahmed Alfaris, Abdladhem M (2025). Evaluation of the performance of developed combined plowing machine under different operation circumstances. Tikrit J. Agric. Sci., 25(1): 17–30. https://doi.org/10.25130/tjas.25.1.2

Saadh MJ, Mustafa MA, Qassem LY, Ghadir G K, Alaraj M, Alubiady MHS, Zwamel AH (2024). Targeting hypoxic and acidic tumor microenvironment by nanoparticles: A review. J. Drug Delivery Sci. Technol., 105660. https://doi.org/10.1016/j.jddst.2024.105660

Saadoon SM, Khudair A, Fakhri S, Khlaf Z (2025). Effect of polymers and NPK fertilizer on the vegetative and flowering characteristics of *Senna surattensis* under deficit irrigation. Tikrit J. Agric. Sci., 25(1): 31–43. https://doi.org/10.25130/tjas.25.1.3

Saed ZJ, Hamad OK, Mohammed A, Al-Jumaily TK (2024). Effect of natural zeolite (Nz) on growth performance, immunity parameters and gut histology in broiler chicken. Tikrit J Agric. Sci., 24(2): 93–101. https://doi.org/10.25130/tjas.24.2.8

Taha Al-Nuaimy MM, Mulla AFN (2021). Isolation and identification of *Phytophthora infestans* from some citrus trees by using polymerase chain reaction (PCR) and DNA sequencing technique in Iraq. Biochem. Cell. Arch., 21(1).

Takahashi Y, Okura K, Minakata S, Watanabe M, Hatakeyama K, Chida S, Shimada Y (2022). Accuracy of heart rate and respiratory rate measurements using two types of wearable devices. Progress in Rehabilitation Medicine, 7, 20220016. doi: 10.2490/prm.20220016

Teke B, Ekiz B, Akdag F, Ugurlu M, Ciftci G, Senturk B (2014). Effects of stocking density of lambs on biochemical stress parameters and meat quality related to commercial transportation. Ann. Anim. Sci., 14(3): 611. https://sciendo.com/pdf/10.2478/aoas-2014-0012

Tozlu ÇH, Aslan FA, Us AD, Kahveci ME, Konanç K, Noyan T, Ayhan S (2021). Effects of transport and altitude on hormones and oxidative stress parameters in sheep. PLoS One, 16(2): e0244911. https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0244911

Tüfekci H, Sejian V (2023). Stress factors and their effects on productivity in sheep. Animals, 13(17): 2769. https://www.mdpi.com/2076-2615/13/17/2769

Vogel B, Molina L, Rostagno CM, La Manna L (2024). Effects of Grazing and Shrub Management on Species Composition and Soil Properties in Patagonian Grasslands. Grasses, 3(3), 205-220. https://doi.org/10.3390/grasses3030015

Yu X, Tu X, Tao L, Daddam J, Li S, Hu F (2023). Royal jelly fatty acids: chemical composition, extraction, biological activity, and prospect. Journal of Functional Foods, 111, 105868. https://doi.org/10.1016/j.jff.2023.105868