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Evaluation of Large Animal Feed as an Alternative to Laboratory Rat Diets along with the Addition of Raisins as a Nutritional Supplement and its Impact on Growth and Fertility on Male Rat

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ABSTRACT

Background: This study evaluates the efficacy of large animal feed as an economical alternative to standard laboratory rodent diets in Wistar rats, with a focus on body weight, feed and water intake and reproductive health outcomes.

Methods: Three groups were observed over four weeks: 1st a control group on standard rodent diets feed) C), 2nd T1 group on large animal feed and 3rd T2 group on large animal feed supplemented with raisins.

Result: Body weight analysis showed that standard feed (C) supported higher overall weight gain, while T1 promoted elevated feed and water consumption, indicating its adequacy in maintaining growth. Interestingly, the addition of raisins (T2) led to decreased feed and water intake compared to T1, suggesting potential satiety or palatability effects. The sperm analysis assessments revealed that T2 enhanced sperm motility, particularly in rapid and progressive velocity, which may benefit reproductive efficiency. These findings underscore the potential of large animal feed, supplemented with raisins, to maintain essential physiological parameters, providing a viable alternative for certain laboratory settings.

Key words: Growth, Laboratory rat diets, Large animal feed, Male fertility, Raisins, Water intake.

INTRODUCTION

Animal research remains a cornerstone of biomedical and nutritional sciences, providing insights into disease mechanisms, therapeutic interventions and physiological responses (Guo *et al*., 2024; Mangrulkar *et al*., 2024; Mukherjee *et al*., 2022; Gautam *et al*., 2024; Chandrasekera and Pippin, 2015). Ensuring the health and welfare of laboratory animals, particularly through adequate nutritional supply, is crucial for generating accurate and repeatable scientific outcomes (Zhang *et al*., 2024). Standard laboratory rat meals, formulated with appropriate ratios of protein, carbohydrates and fats, along with essential micronutrients, are carefully tailored to satisfy the distinct physiological requirements of these animals (Tepe and Altaş, 2024; Dasgin *et al*., 2024). Nevertheless, the elevated expenses associated with typical laboratory mouse meals, coupled with the challenges research laboratories have in procuring these diets from local markets, suggest that alternate nutritional choices may offer pragmatic advantages without undermining research integrity.

Large animal feeds, namely those designed for cattle, provide an interesting option owing to their extensive availability and relatively reduced cost. These feeds are often nutrient-rich and formulated to promote growth, maintenance and production in bigger animals, indicating they may provide a degree of nutritional sufficiency for smaller animals (Sauvant *et al*., 2023; Boudalia *et al*., 2024). However, little is known about how large animal feeds might impact the metabolism, weight gain and general health of smaller species such as laboratory rats. Substituting standard laboratory diets with large animal feeds could alter physiological outcomes in unforeseen ways and detailed evaluations are essential to assess the viability and safety of such a substitution (Wong *et al*., 2024).

The nutritional compositions of big animal feeds markedly contrast with conventional rodent diets. Large animal feeds often possess elevated fiber content and are frequently designed to accommodate the gastrointestinal physiology of herbivorous or omnivorous animals, rather than the omnivorous diet of rodents. Primary concerns encompass the possibility of modified macronutrient ratios, insufficient critical amino acids, or deficiencies in vitamins and minerals. These disparities may influence development patterns, body weight management and metabolic

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indicators in experimental rats. Examining the impact of big animal feed on laboratory rats might both confirm (or disprove) its appropriateness and enhance our comprehension of diet-induced physiological changes (Tobin and Schuhmacher, 2021; Bencivenni *et al*., 2024).

Alongside investigating alternate primary diets, it is essential to assess supplementary nutrition to address any possible shortages or imbalances that may result from unconventional feeds. Raisins, recognized for their elevated levels of carbohydrates, dietary fiber, potassium and antioxidants, have been examined for their possible health advantages in humans, including the enhancement of gut health, provision of sustained energy and potential impact on weight management via satiety mechanisms (Peirovi-Minaee *et al*., 2024; Ayuob *et al*., 2022; Ali *et al*., 2019; Aljarari and Bawazir, 2019; Ghorbanian *et al*., 2018). In rats, preliminary studies indicate that raisins may also offer metabolic benefits, though comprehensive investigations are limited. Raisins could serve as a supplementary source of energy and bioactive compounds, potentially mitigating any negative effects of large animal feed on weight and overall health (Asad, 2024), This study aims to provide a comprehensive evaluation of large animal feed as a viable alternative to standard laboratory rat diets, focusing specifically on impacts on weight, general health and metabolic function.

MATERIALS AND METHODS

Laboratory animals

All investigations were conducted at the animal facility inside the Zoology Department of the Science College. Laboratory animals consist of white male Wistar rats, aged 2-3 months and weighing between 200 and 220 grams. The rats were acclimatized to a well-ventilated environment at a temperature of 25±2°C, according to a normal 12-hour light and dark cycle. Access to water was unrestricted. Water was present in the graduate's polycarbonate drinking vessel for rats. The animals were randomly allocated into three groups, each including six rats. The first group feed with standard feeding rodent diet, served as a control (C), whereas the 2nd was only provided with large animal feed (T1). The third group was provided with a diet consisting of large animal feed supplemented with raisins (T2). The duration of animal observation was one month. All experimental protocols complied with the regulations established by the ethics committee and the Institutional Animal Care at KSU (Approval no: KSU-SE-23-06).

Feed and rations

The standard feeding rodent diet ration included: Net Weight 50 kg crude protein (20%), crude fat (4%), crude fiber (3.50%), ash (6%), Salt (0.50%), calcium (1%), phosphorus (0.60%), vitamin A (20 IU/g), vitamin D (2.20 IU/g), vitamin E (70 IU/kg), energy, ME Kcal/kg (2850), Trace Minerals Added Include: Cobalt - Copper - Iodine - Iron - Manganese - Selenium and Zinc feed control included Table 1.

Group (T1) was only provided with large animal feed included: Net Weight 40 kg energy (2800 Kcal), moisture (10%), crude protein (14.5%), crude fiber (4%), crude fat (2.5%), calcium (1%), potassium (0.5%), phosphorus (0.45%), sodium (0.25%), copper (6PPM), selenium (200 PPB), vitamin A (8500 IU), vitamin D(850 IU), of compound feed. The T2 group has the same composition as the T1 group, with the addition of fresh dried raisins as a nutritional supplement (200 gm per week) The daily portion sizes are indicated for all rations. Food was given twice a day, in equal portions. Combined feed T1 was obtained from local market and was made from: Grains (Yellow Corn - Barley), Soya bean meal, Wheat bran, Sodium Chloride - (Salt) - Feed premix (Minerals and Vitamins). (manufacturer's data). In terms of chemical composition, feed T1 included Table 2.

Effects on health markers and fertility

During the experiment period, which lasted for a whole month, the weights of the animals were measured weekly, while water and feed consumption data were collected daily, as well as the extent of the effect of the standard feed, represented by (control group) and the feed for feeding large animals (T1), as well as the feed fortified with raisins (T2), on the daily consumption of the animals, as well as evaluating the fertility of males by collecting semen samples from the tail of the epididymis of all experimental animals after anesthetizing them to evaluate the fertility of the experimental animals using the semen analyzer device (Hamilton Thorne Version 12 TOX Ivos).

Statistical analysis

statistical analysis of body weight, feed intake, water intake and evaluation of sperm and kinematics was performed using Graph Pad Prism 8.

Table 1: Energy nutrition and chemical makeup of conventional compound feed. The specified values pertain to 50 kg of feed (manufacturer's data).

Analysis	
Crude protein	20%
Crude fat	4%
Crude fiber	3.50%
Ash	6%
Salt	0.50%
Calcium	1%
Phosphorus	0.60%
Vitamin A	20 IU/g
Vitamin D	2.20 IU/g
Vitamin E	70 IU/kg
Energy, ME Kcal/kg	2850

Trace minerals added include: Cobalt, Copper, Iodine, Iron, Manganese, Selenium and zinc.

RESULTS AND DISCUSSION

Growth and body weight impact of alternative feeds

In first week, all groups show an increase in body weight. The control group C (122.67 g) and the group fed with large animal feed alone T1 (126.83 g) have slightly higher weights than the group fed with large animal feed plus raisins T2 (110.50 g), though the difference isn't significant. in 2nd week, the weight gain trend continues for all groups, with group C (155 g) maintaining a slight lead in body weight compared to T1(144.67 g) and T2 (133.50 g). While in 3rd week a notable difference appears, with group C (202.33 g) showing a significant increase in body weight compared to both T1 (174.67 g) and T2 (153.17 g). in final week of experiment Group C (225.33 g) continues to show the highest body weight, significantly higher than both T1 (198.67 g) and T2 (172 g). Among the experimental groups, T1 (large animal feed) has a higher body weight than T2 (large animal feed with raisins), suggesting that the addition of raisins may slightly reduce weight gain compared to large animal feed alone Fig 1.

Table 2: Energy nutrition and chemical makeup of T1 large animal feed.

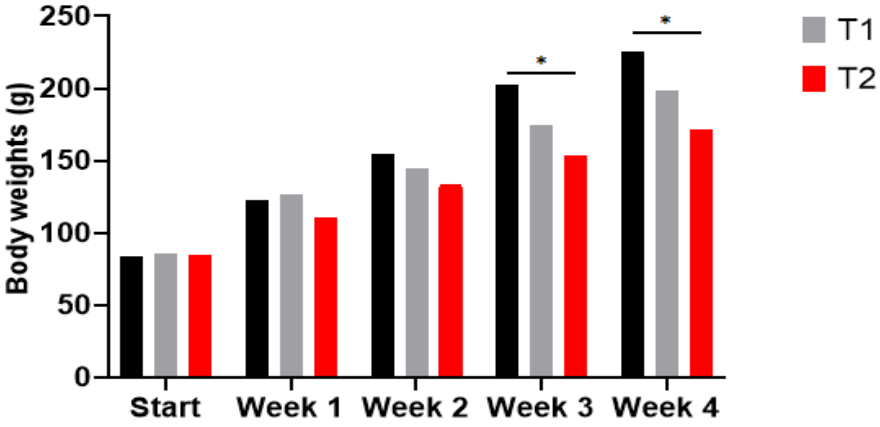
Ingredients: Grains (Yellow corn - Barley), Soya bean meal, Wheat bran, Sodium chloride - (Salt) - Feed premix (Minerals and vitamins).	
Chemical analysis	
Energy	2800 Kcal
Moisture	10%
Crude protein	14.5%
Crude fiber	4 %
Crude fat	2.5%
Calcium	1 %
Potassium	0.5%
Phosphorus	0.45%
Sodium	0.25%
Copper	6PPM
Selenium	200 PPB
Vitamin A	8500 IU
Vitamin D	850 IU

The specified values pertain to 40 kg of feed (manufacturer's data).

Feed intake patterns and nutritional efficiency

At the 1st week, group T1 (large animal feed) has the highest feed consumption (203 g), significantly higher than both group C (169 g) and group T2 (166 g), group C shows moderate consumption, while group T2 has the lowest intake among the groups. At the 2nd week, group T1 (230 g) continues to consume more feed than both group C (215 g) and group T2 (202 g), with statistically significant differences. Group C maintains higher feed consumption than T2, similar to 1st and in 3rd week group C (246 g) shows a slight increase in feed consumption, becoming almost equal to T1 (257 g), though T1 (213 g) still has a slight lead. Group T2's feed consumption remains lower than the other two groups, with significant differences indicated. in final week, similar to 3rd week, group C (257 g) and T1 (261 g) both consume about similar amounts of feed, which significantly more than T2 (222 g), group T2 remains consistently lower in feed intake.

Throughout the trial period, group T1 consistently shows the highest feed consumption, with significant differences from both the control group (C) and the raisin-supplemented group (T2) group T2 has the lowest feed consumption across all weeks, suggesting that the addition of raisins may reduce overall feed intake compared



Parameters of male rat body weight during the experiment. Measurements were made at the end of each week of the experiment (* - P<0.05). C: control rodent lab diets, T1: large animal food diets, T2: large animal food diets + dried resin.

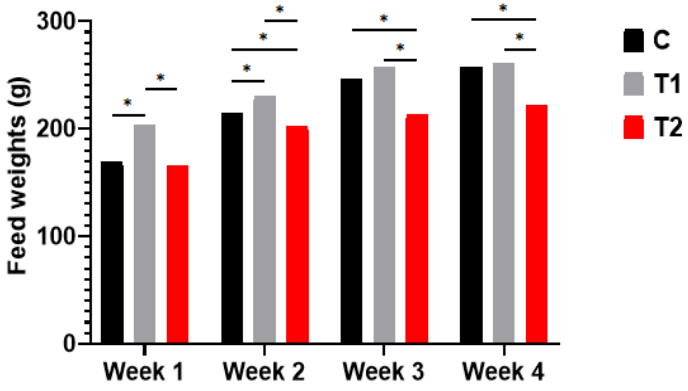
Fig 1: Body weight progression in rats on control diet (C), Large animal feed (T1) and Raisin-enriched feed (T2).

to large animal feed alone. This pattern indicates that while large animal feed alone (T1) promotes higher consumption, the addition of raisins (T2) might limit intake, possibly due to increased satiety or other palatability factors or sex Fig 2.

Water intake patterns and nutritional efficiency

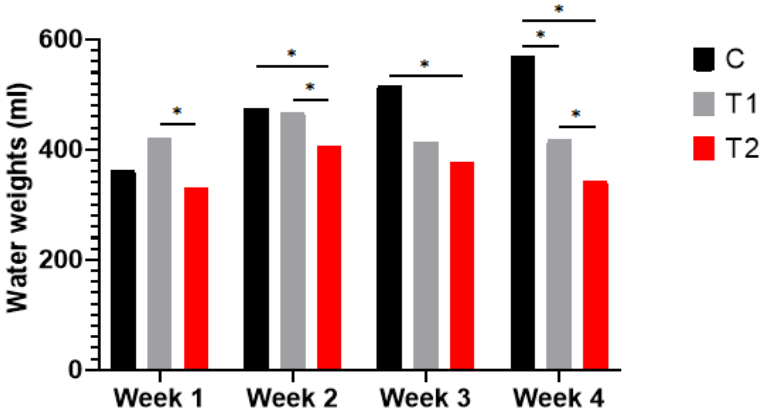
At 1st week, group T1 has the highest water consumption (422 ml), significantly more than both the control group (363 ml) and T2 group (330 ml). Group C shows moderate water consumption, while group T2 has the lowest intake among the groups. At the 2nd week group T1 continues in water consumption (468 ml), with significant differences from both group C (475 ml) and group T2(407 ml). In 3rd week group C water consumption peaks (517 ml), becoming the highest among the groups and significantly more than both T1 (415 ml) and T2 (378 ml). Group T1 remains moderately high, while group T2 continues to have the lowest water consumption, with all differences being statistically significant. While at the 4th week, group C maintains the highest water intake (570 ml), followed by T1 (418 ml), both of which are significantly higher than T2 (343 ml). Group T2's water intake remains the lowest throughout the study period. Overall, group T1 (large animal feed) generally promotes higher water consumption compared to the raisin-supplemented group (T2) but is eventually surpassed by the control group (C) in later weeks. group T2 shows consistently lower water consumption throughout the study, suggesting that the addition of raisins may be associated with reduced water intake compared to both the control and large animal feed alone Fig 3.

These results imply that dietary composition influences water consumption patterns in rats, with the control diet



Parameters of male rat feed intake during the experiment. Measurements were made at the end of each week of the experiment (* - P<0.05). C control: rodent lab diets, T1; large animal food diets, T large animal food diets + dried resin.

Fig 2: Comparative feed consumption in rats: Control diet vs. large animal feed with and without raisins.



Parameters of male rat water intake during the experiment. Measurements were made at the end of each week of the experiment (* - P<0.05) C control: rodent lab diets, T1; large animal food diets, T2 large animal food diets + dried resin.

Fig 3: Impact of dietary variations on water consumption patterns in rats over four weeks.

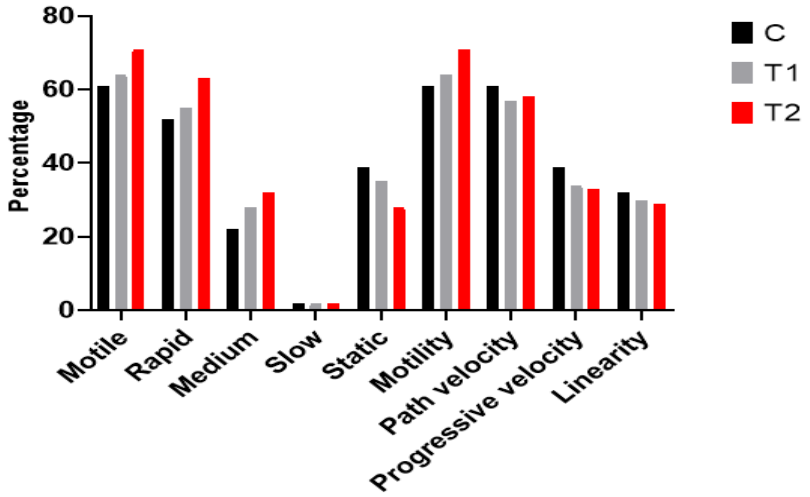
eventually leading to the highest water intake, while the raisin-enriched diet appears to reduce water demand.

Diet and sperm analysis outcomes

Group C tends to have the highest overall sperm motility percentage (61 million), but shows lower values in rapid and progressive velocity. While group T1 showed the high percentage of medium-speed and slow sperm (64.33 million), indicating more sperm moving at moderate speeds rather than high velocities. In contrast group T2 showed the highest percentage of rapid and progressive velocity sperm (71.83 million), suggesting that the raisin supplement may enhance faster, more linear movement, potentially benefiting fertility by supporting more directed and efficient sperm movement. the results suggest that the addition of raisins in group T2 may influence specific motility parameters, especially in terms of speed and directionality, while the standard control diet in Group C supports high motility overall. This data could indicate potential impacts on fertility related to the dietary variations (Fig 4).

Boiko and Boiko (2024) examined the effects of a novel, specially prepared combination feed on several physiological indicators in laboratory rats, including growth rates, feed intake efficiency and general health. The scientists sought to evaluate if this alternative feed may function as an appropriate replacement for conventional laboratory meals, perhaps providing advantages in animal development, health indicators and cost efficiency. Their findings indicated that the novel feed resulted in increased weight growth and greater feed efficiency, presumably owing to its well-balanced nutritional composition tailored to fulfill the unique dietary needs of laboratory animals. Moreover, they indicated favorable alterations in physiological health indicators, suggesting that the feed proficiently enhances overall animal health. The results correspond closely with our study's findings, where big animal feed supplemented with raisins (Group T2) shown advantages in weight increase and feed consumption efficiency. Similar to Boiko and Boiko's alternative feed, the raisin-enriched meal in our trial seems to offer adequate nutrition for promoting healthy development, perhaps attributable to the high nutritional density of raisins. Although our study did not assess direct health indicators, the enhanced growth and feed efficiency in group T2 indicate comparable beneficial effects on overall animal health. Both results underscore the viability of employing non-standard diets for laboratory animals, contingent upon their inclusion of *vital* nutrients or advantageous additives such as raisins, which can improve feed palatability and nutritional quality. Furthermore, Boiko and Boiko's findings highlight the possibility of alternate feeds to save expenses and streamline feeding protocols in laboratory environments, aligning with our study's investigation of utilizing big animal feed as a primary diet. Both findings indicate that alternate formulations or dietary supplements can successfully promote growth and health outcomes, suggesting that typical lab meals may be replaced with more accessible or cost-effective solutions without jeopardizing animal welfare or research integrity.

Boiko and Boiko's (2024) research reinforces the findings from our study, providing compelling evidence that alternative diets-whether through balanced formulations or enriched with nutrient-dense supplements like raisins-can be viable for laboratory use. This approach not only meets the nutritional needs of laboratory animals but also offers practical and economic benefits, making it a



Parameters of sperm motility during the experiment. Measurements were made at the end of the experiment. C control: Rodent lab diets, T1: Large animal food diets, T2 large animal food diets + dried resin.

Fig 4: Evaluation of sperm and kinematics in mice on control and experimental diets.

promising area for future dietary strategies in laboratory animal management.

Our study comparing big animal feed and raisin-supplemented feed to a control diet offers insights into alternate feeding techniques that may boost male rat reproductive characteristics, potentially providing cost-effective solutions for laboratory animal diets (Wong *et al*., 2024). This study examined breeding results with the provision of supplementary foods, indicating that unconventional diets may enhance reproductive health metrics. Their findings endorse the notion of altering conventional laboratory meals to enhance reproduction and animal wellbeing. Both findings endorse the overarching notion that conventional laboratory meals may be modified or enhanced to yield better reproductive results. Our work contributes to this field by analyzing the impacts on sperm motility and movement features, whereas Wong *et al*. (2024) focus on outcomes like as litter size and weaning weight. Collectively, these findings indicate that dietary optimization can enhance several facets of reproductive health and breeding efficacy in laboratory animals. Our findings on raisin supplementation contribute a distinct viewpoint to the comprehensive understanding of the effects of various nutrients on reproductive health. This corresponds with Wong *et al*.'s results that diet affects breeding success and further demonstrates how particular meals may improve specific sperm characteristics, such as velocity and motility, which are likely vital for male rat fertility.

In our trial, raisin supplementation (group T2) boosted particular sperm motility measures, including fast and progressive velocities, indicating improved sperm quality. This may be ascribed to the antioxidant characteristics of raisins, which can diminish oxidative stress in sperm cells and improve their functioning. In comparison to the findings of Asad (2024), Asad's research concentrated on the therapeutic benefits of raisin extract on the hepatic system in mice, particularly investigating its role in alleviating histological and physiological damage induced by dietary alterations. Asad discovered that the antioxidant constituents in raisins exert a protective influence on hepatic cells, enhancing liver function and mitigating inflammation generated by dietary stress.

Both findings indicate that raisins possess advantageous antioxidant capabilities that may mitigate oxidative stress in different tissues. Asad emphasized the liver's defensive benefits, while our research suggests that same antioxidant properties may potentially positively influence the reproductive system by improving sperm motility. Collectively, these data highlight the capacity of raisins to offer systemic advantages, maybe *via* mitigating oxidative damage in several organ systems. Asad (2024) and our research both underscore the beneficial impacts of raisins on physiological health, but in distinct systems. Asad's research demonstrates the curative advantages of raisin extract on liver health, whilst our data indicate its beneficial influence on sperm motility. Collectively, these investigations substantiate the idea that raisins serve as a multifaceted dietary supplement with antioxidant properties, providing protection to both the hepatic and reproductive systems. The dual impact may render raisins a significant enhancement to laboratory diets, perhaps improving overall animal wellbeing, increasing reproductive success and alleviating harm from dietary stresses.

The research of Ali *et al*. (2019) and our investigation both highlight the health-enhancing benefits of raisins in animal nutrition. Found that raisins can safeguard against kidney damage caused by elevated cholesterol levels, highlighting their antioxidant and anti-inflammatory characteristics. Our work, conversely, indicates that raisin supplementation may facilitate weight gain and development without inducing obesity, potentially *via* similar antioxidative processes that enhance overall metabolic performance. Collectively, these findings underscore raisins as a beneficial dietary supplement that can enhance both organ-specific protection and overall health in laboratory animals. This indicates that raisins, or comparable antioxidant-rich foods, may serve as beneficial elements in experimental diets designed to improve animal welfare and health outcomes.

CONCLUSION

this study demonstrates that large animal feed, with and without raisin supplementation, offers a practical alternative to traditional laboratory rat diets. While large animal feed alone (T1) supported growth and metabolic demands, it promoted higher feed and water intake compared to the control. Raisin supplementation (T2) slightly reduced weight gain and lowered feed and water consumption, likely due to its potential effects on satiety. Additionally, T2 showed positive impacts on sperm motility parameters, suggesting a fertility-enhancing effect. These findings indicate that large animal feed, especially when supplemented with raisins, could be a cost-effective and nutritionally adequate option in specific laboratory settings.

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Disclaimers

The authors are responsible for the accuracy and completeness of the information provided, but do not accept any liability for any direct or indirect losses resulting from the use of this content

Informed consent

All experimental procedures followed the guidelines specified by the ethics committee (Approval no: KSU-SE-23-6) and the Institutional Animal Care at KSU.

Conflict of interest

The authors declare that there are no conflicts of interest regarding the publication of this article. No funding or sponsorship influenced the design of the study, data collection, analysis, decision to publish, or preparation of the manuscript.

REFERENCES

Ali, S., Alahmadi, A., Hamdy, R., Huwait, E.A., Alansari, A. and Ayuob, N. (2019). Renoprotective effect of red grape (*Vitis vinifera* L.) juice and dark raisins against hypercholesterolaemia-induced tubular renal affection in albino rats. *Folia Morphologica*. **78(1):** 91-100.

Ayuob, N., Shaker, S. A., Bakhshwin, A., Alsaggaf, S., Helal, G. and Hamed, S. (2022). Raisins preserve thyroid gland function and structure in an animal model of hyper cholesterolemia. *Journal of Microscopy and Ultrastructure*. **10(2):** 55-62.

Asad, S.S. (2024). The curative effect of raisin extract on the histological and physiological changes of hepatic system resulting from changing the diet style in mice. *Al-Kufa University Journal for Biology*. **16(1):** 120-126.

Aljarari, R.M. and Bawazir, A.E. (2019). Effect of black raisins (*Vitis vinifera*) on aluminum chloride induced alzheimer's disease in male albino rat. *International Journal of pharmaceutical Research and Allied Sciences*. **8(3):** 193-203.

Boudalia, S., Smeti, S., Dawit, M., Senbeta, E. K., Gueroui, Y., Dotas, V. and Symeon, G. K. (2024). Alternative approaches to feeding small ruminants and their potential benefits. *Animals*. **14(6):** 904.

Boiko, Y. and Boiko, I. (2024). The effect of a new combined feed on some physiological parameters of laboratory rats. *BIO Web of Conferences EDP Sciences*. **114:** 01021.

Bencivenni, S., Roggiani, S., Zannoni, A., Conti, G., Fabbrini, M., Cotugno, M. and D'Amico, F. (2024). Early and late gut microbiota signatures of stroke in high salt-fed stroke-prone spontaneously hypertensive rats. *Scientific Reports*. **14(1):** 19575.

Chandrasekera, P. C., and Pippin, J. J. (2015). The human subject: an integrative animal model for 21st century heart failure research. *American Journal of Translational Research*. **7(9):** 1636.

Dasgin, H., Hay, S.M. and Rees, W.D. (2024). Diet and deprivation in pregnancy: A rat model to investigate the effects of the maternal diet on the growth of the dam and its offspring. *British Journal of Nutrition*. **131(4):** 630-641.

Guo, H., Xu, X., Zhang, J., Du, Y., Yang, X., He, Z. and Guo, L. (2024). The pivotal role of preclinical animal models in Anti-cancer drug discovery and personalized cancer therapy strategies. *Pharmaceuticals*. **17(8):** 1048.

Ghorbanian, D., Gol, M., Pourghasem, M., Faraji, J., Pourghasem, K. and Soltanpour, N. (2018). Spatial memory and antioxidant protective effects of raisin (currant) in aged rats. *Preventive Nutrition and Food Science*. **23(3):** 196.

Gautam, M.K., Panda, P.K., Dubey, A., Kumari, M. and Ghosh, N.S. (2024). Zebrafish as a fascinating animal model: A robust platform for *in vivo* screening for biomedical research. *International Journal of Pharmaceutical Investigation*. **14(3):** 696-701.

Mangrulkar, S.V., Dabhekar, S.V., Neje, P., Parkarwar, N., Turankar, A., Taksande, B.G. and Nakhate, K.T. (2024). *In vivo* Animal Models Development and their Limitations for Brain Research. In: Application of Nanocarriers in Brain Delivery of Therapeutics Singapore: Springer Nature Singapore. pp. 315-339.

Mukherjee, P., Roy, S., Ghosh, D. and Nandi, S.K. (2022). Role of animal models in biomedical research: A review. *Laboratory Animal Research*. **38(1):** 18.

Peirovi-Minaee, R., Alami, A., Esmaeili, F. and Zarei, A. (2024). Analysis of trace elements in processed products of grapes and potential health risk assessment. *Environmental Science and Pollution Research*. **31(16):** 24051-24063.

Sauvant, D., Perez, J.M. and Tran, G. (2023). Tables of composition and nutritional value of feed materials: Pigs, poultry, cattle, sheep, goats, rabbits, horses and fish. BRILL.

Tepe, A., and Altaş, T. (2024). Technological Processes Applied to Laboratory Animal Feeds and New Feeding Approaches. *Duzce Medical Journal*. **26(S1):** 24-29.

Tobin, G. and Schuhmacher, A. (2021). Laboratory Animal Nutrition in Routine Husbandry and Experimental and Regulatory Studies. In Handbook of Laboratory Animal Science. *CRC Press*. pp. 269-312.

Wong, D.V.M., Raymond, K., Carriero, B.S., Samantha, J., Wadsworth, M.S., Benjamin, C. and Christena, L. (2024). Effects of supplemental diet during breeding on fertility, litter size, survival rate and weaning weight in mice (*Mus musculus*). *Journal of the American Association for Laboratory Animal Science*. **6;63(5):** 480-487.

Zhang, T., Zhang, N., Feng, R., Wang, H., Bi, F. and Wang, S. (2024). Promoting the welfare of animals utilized in neuroscience research. *Brain X*. **2(3):** 70002.