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Research Article

Investigating the impacts of raisin-supplemented large animal feed on growth metrics, nutritional behavior, and offspring outcomes in female rats

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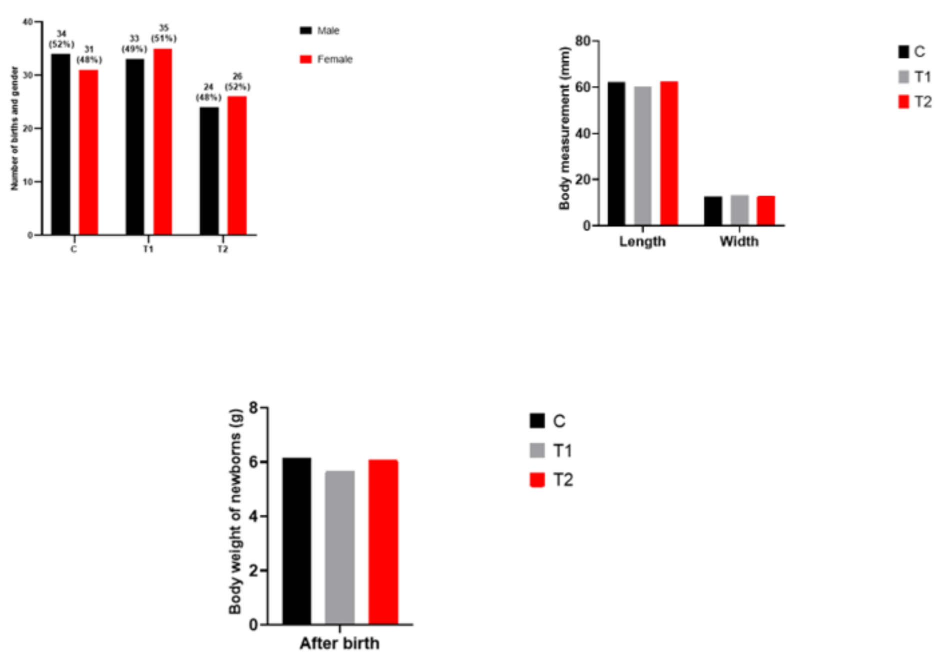
ABSTRACT

The study assessed the impact of large animal feed and raisin-supplemented diets on female Wistar rats' growth, reproduction, and offspring. Thirty rats were assigned to three groups: control (C) with a standard rat diet, large animal feed (T1), and large animal feed with raisins (T2). The 60-day study covered pregnancy and lactation, measuring feed and water intake, maternal weight, fertility, and offspring number, weight, length, and width. Results showed no significant differences in maternal weight gain, reproductive outcomes, or offspring growth across groups. Feed and water intake were slightly lower in T1 and T2 during lactation, but reproductive performance and offspring metrics were unaffected. Raisin supplementation (T2) appeared to enhance metabolic stability, potentially due to its antioxidant properties. The study suggests raisin-supplemented feed is a cost-effective alternative to standard diets, maintaining nutritional adequacy and experimental consistency. These findings offer practical insights for alternative feeding strategies during feed shortages or economic challenges. Further research should investigate the long-term metabolic effects of these diets to confirm their sustainability and broader applicability in laboratory settings.

GRAPHICAL ABSTRACT



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1. Introduction

Standard laboratory feeds are meticulously formulated to meet the nutritional requirements of laboratory animals, ensuring optimal growth, reproduction, and overall health. These feeds are critical for maintaining experimental consistency, as they minimize variability arising from dietary deficiencies or excesses. The standardization of such feeds is essential in research settings, where precise control over external variables can significantly impact the validity of experimental outcomes. Laboratory feeds are developed through advanced technological processes to ensure precision and uniformity in nutritional content. Recent advancements in feed formulation and processing have introduced innovative approaches that enhance the quality and functionality of laboratory animal feeds. (Tepe and Altaş, 2024). highlighted how these technological processes not only improve feed stability and bioavailability but also support new feeding strategies tailored to specific research needs. However, challenges such as supply chain disruptions, high costs, and economic constraints underscore the necessity of identifying alternative feeding solutions that maintain nutritional adequacy and experimental reliability. One promising alternative is large animal feeds, which are typically designed for livestock but may have potential applications in laboratory settings when appropriately supplemented. These feeds are widely available, cost-effective, and can serve as a base for developing alternative diets for laboratory animals during emergencies or when standard feeds are inaccessible. Supplementation with nutrient-dense ingredients is critical to aligning large animal feeds with the specific requirements of laboratory animals. Among potential supplements, raisins stand out due to their unique nutrient profile. Raisins are rich in natural sugars, providing a quick source of energy, as well as essential vitamins, minerals, and antioxidants. These attributes make them a promising candidate for enhancing the nutritional value of alternative feeds. Moreover, raisins are widely available as an agro-industrial by-product, making them an economically and environmentally sustainable option. The health-promoting properties of raisins have been demonstrated in previous studies, such as Ali *et al.* (2019), who reported reno-protective effects against hypercholesterolemia-induced renal damage in albino rats. This underscores the potential of raisins as both a nutritional and therapeutic feed supplement. Maternal diet during gestation plays a pivotal role in shaping reproductive outcomes, offspring health, and long-term development. Carlin *et al.* (2019) demonstrated that maternal high-protein diets influence offspring body weight and insulin signaling pathways. Vanselow *et al.* (2016) highlighted the long-term epigenetic and metabolic consequences of maternal high-protein diets, while Hallam *et al.* (2013) found that dietary protein levels during pregnancy could predispose offspring to altered fat mass and metabolic profiles. Ajuogu *et al.* (2020) further emphasized that maternal protein intake significantly affects reproductive efficiency, while Jahan (2024) examined how gestational obesity and protein diets interact to affect offspring glucose metabolism and body composition. Xie *et al.* (2024) demonstrated that maternal vitamin D3 supplementation in an oxidized-oil diet could mitigate oxidative stress in the placenta and protect the fetus from developmental impairments. (Fassarella *et al.*, 2024) added to this body of knowledge by showing that fish oil supplementation during pregnancy reduces liver endocannabinoid activity and lipogenic markers in offspring exposed to a maternal high-fat diet. Despite these advances, the role of alternative feeding approaches in laboratory settings remains underexplored. As highlighted by Tepe and Altaş (2024), the integration of new feeding strategies, including the use of alternative feeds and innovative supplementation, is essential for ensuring sustainability and flexibility in laboratory research. Large animal feeds, supplemented with nutritionally rich ingredients like raisins, may provide a viable solution. Strategic supplementation can help align these feeds with the specific nutritional needs of laboratory animals, ensuring that growth, feeding behavior, and reproductive outcomes are optimized.

The research aims to evaluate the effect of raisin-supplemented large animal feed on female mice, focusing on growth parameters, nutritional behavior, and offspring outcomes. By addressing the paucity of data in this area, the study seeks to provide the research community with practical insights into alternative feeding strategies. That is particularly critical in contexts where standard laboratory feeds are inaccessible or prohibitively expensive. Ultimately, this work contributes to the broader effort to enhance the resilience and sustainability of laboratory animal research.

A total of 30 female Wistar rats, each weighing between 125 and 130 g, were obtained from the Animal Care Center. The animals were housed individually in cages under controlled conditions, maintaining a temperature of 22–24°C, a 12-h light/dark cycle, and open access to food and water.

2. Materials and Methods

2.1 Animals and experimental design

The rats were randomly assigned to three groups of ten animals each and monitored over a 60-day experimental period. The first group, serving as the control (C), was fed a standard rat diet. The second group (T1) received a diet consisting solely of large animal feed. The third group (T2) was provided with a diet composed of large animal feed supplemented with raisins. After 30 days of dietary, the female rats were introduced to male rats for mating. The male rats were also fed diets corresponding to their respective experimental groups. Fertilization was confirmed by the presence of a vaginal plug, ensuring a 100% fertilization rate. Post-fertilization, the females were returned to their respective dietary groups and continued to receive the assigned diets throughout the pregnancy. Upon parturition, the offspring were evaluated, with data collected on the number of offspring, their weights, and additional morphometric measurements. The experimental design allowed for the systematic assessment of the effects of diet on growth, reproductive performance, and fetus development (Amran *et al.*,2025).

2.2 Effects on Health Markers and Newborn Measurements

During the two-month experimental period, animal weights were recorded on a weekly basis, whereas daily data collection focused on water and feed intake. The study evaluated the impact of three feeding regimens, standard feed (control group), a formulation designed for large animals (T1), and raisin-supplemented feed (T2), on the animals' daily consumption patterns. Additionally, Weights were taken for females before pregnancy, as well as during pregnancy and after birth. Measurements of newborns were performed comprehensively using a specialized ruler designed for precise neonatal assessment (Amran *et al.*,2025).

2.3 Nutritional composition and energy profile of stander feed

The stander feed used in the study contains 20% crude protein and 4% crude fat, with a crude fiber content of 3.50%. The ash content is measured at 6%, while salt constitutes 0.50% of the feed. Calcium and phosphorus levels are included at 1% and 0.60%, respectively. The feed is enriched with vitamins, providing 20 IU/g of vitamin A, 2.20 IU/g of vitamin D, and 70 IU/g of vitamin E. The energy content of the feed is 2850 ME kcal/kg. Additionally, trace minerals are added to enhance the nutritional profile, including cobalt, copper, iodine, iron, manganese, selenium, and zinc. These values represent the composition per 50 kg of feed, offering a balanced and nutrient-dense formulation suitable for the dietary requirements of laboratory animals or livestock (Amran *et al.*, 2025).

2.4 Nutritional and chemical composition of T1 large animal feed

The energy and chemical composition of the T1 large animal feed is designed to provide balanced nutrition, with the specified values applying to 40 kg of feed, based on the manufacturer's data. The primary ingredients include grains (yellow corn and barley), soybean meal, wheat bran, sodium chloride (salt), and a premix of minerals and vitamins. The chemical analysis indicates that the feed contains an energy value of 2800 kcal, with a moisture content of 10%. Crude protein is measured at 14.5%, while crude fiber and crude fat account for 4% and 2.5%, respectively. Calcium is present at 1%, potassium at 0.5%, phosphorus at 0.45%, and sodium at 0.25%. Trace elements include copper (6 ppm) and selenium (200 ppb). The vitamin content of the feed includes 8500 IU of vitamin A and 850 IU of vitamin D, contributing to the overall nutritional adequacy of the formulation. Feed composition reflects a nutrient-dense design aimed at meeting the dietary requirements of large animals, with balanced levels of energy, macronutrients, and essential micronutrients.

3. Results

3.1 Comparison of body weight changes in female Wistar rats fed different diets over a four-week period:

Table 1 provides a summary of body weight measurements for female Wistar rats across three treatment groups over a 4-week period. The three groups include: the control group (C), which was fed a standard rat diet; the first treatment group (T1), which received only large animal feed; and the second treatment group (T2), which was fed large animal feed supplemented with raisins. Body weights, recorded in grams, were measured at the start of the study and at weekly intervals thereafter, and no statistically significant differences were observed. By the first week, all groups showed weight gain (C: 131 g, T1: 136 g, T2: 132 g), but the differences remained statistically insignificant ($p = 0.95$). The crease of weight gain continued into the second week (C: 144 g, T1: 156 g, T2: 148 g) and the third week (C: 168 g, T1: 168 g, T2: 164 g), again with no significant differences between the groups (*p-values* of 0.66 and 0.92, respectively). By the fourth week, the weights of the groups were 180 g (C), 178 g (T1), and 175 g (T2), and the differences remained statistically insignificant. Overall, the analysis demonstrates that none of the treatments (standard rat diet, large animal feed, or large animal feed supplemented with raisins) resulted in statistically significant differences in body weight gain over the 4-week study period, suggesting comparable effects of the diets on the growth of the rats during the timeframe.

3.2 Impact of dietary treatments on maternal body weight during reproductive phases in female Wistar rats

Table 2 summarizes the body weight measurements of female Wistar rats across three treatment groups (C, T1, T2) during key phases of reproduction: before birth, after birth, and during the lactation period. Here's the description: The control group (C) was fed a standard rat diet, while the first treatment group (T1) received large animal feed, and the second treatment group (T2) was fed large animal feed supplemented with raisins. The table presents the mean weights (in grams), along with the standard error of the mean (SEM) and *P-values* indicating statistical significance. Before birth, the mean body weights for the groups were comparable: C (300 g), T1 (288 g), and T2 (271 g), with no statistically significant differences observed. However, significant differences emerged after birth ($P = 0.02$), with the control group (C) showing a significantly higher weight (247 g) compared to T1 (213 g) and T2 (211 g). Similarly, during the lactation period, the control group maintained a significantly higher weight (238 g) compared to T1 (193 g) and T2 (203 g), as indicated by a *P-value* of 0.02. These results indicate that the type of diet influenced body weight dynamics after birth and during lactation, with the control diet (C) supporting higher maternal weights compared to the other treatments.

Table 1.
Body weight progression of female Wistar rats over four weeks across different dietary treatments.

	Treatment			SEM	P-value
	C	T1	T2		
Start	104	109	107	11.17	0.96
First week	131	136	132	10.68	0.95
Second week	144	156	148	9.15	0.66
Third week	168	168	164	8.77	0.92
Fourth week	180	178	175	8.42	0.91

Table 2. Maternal body weight of female Wistar rats before birth, after birth, and during the lactation period across different dietary treatments.

	Treatment			SEM	*P-value*
	C	T1	T2		
Before birth	300	288	271	12.62	0.31
After birth	247^{a}	213^{b}	211^{b}	8.86	0.02
Lactation period	238^{a}	193^{b}	203^{b}	10.24	0.02

Table 3.
Weekly feed intake of female Wistar rats across different dietary treatments.

	Treatment			SEM	*P-value*
	C	T1	T2		
First week	192	183	181	14.89	0.86
Second week	208	219	209	6.49	0.45
Third week	220	217	204	6.00	0.22
Fourth week	250	207	199	25.31	0.38

3.3 Comparison of feed intake in female Wistar rats across different dietary treatments over four weeks

Table 3 presents the feed intake of female Wistar rats across three dietary treatment groups (C, T1, T2) measured daily over a 4-week period. During the first week, the mean feed intake was 192 g for the control group (C), 183 g for T1, and 181 g for T2, with no statistically significant differences observed. By the second week, feed intake slightly increased in T1 (219 g) compared to C (208 g) and T2 (209 g), but the differences remained insignificant. In the third week, the feed intake of the control group (C) was 220 g, T1 was 217 g, and T2 was 204 g, again showing no significant variation ($P = 0.22$). By the fourth week, feed intake was highest in the control group (250 g) compared to T1 (207 g) and T2 (199 g), with no significant differences ($P = 0.38$). The *P-values* (> 0.05 for all weeks) confirm that the differences in feed intake between the groups were not statistically significant across the 4-week period. This suggests that the diets, whether standard rat feed, large animal feed, or large animal feed supplemented with raisins, had similar effects on feed intake.

3.4 Effect of dietary treatments on feed intake during reproductive phases in female Wistar rats

Table 4 provides the feed intake of female Wistar rats during three reproductive phases: before birth, after birth, and during the lactation period. Before birth, the feed intake was similar across all groups, with values of 144 g for both the control group (C) and T1, and 135 g for T2. No statistically significant differences were observed ($P = 0.68$). After birth, feed intake increased across the groups, with the control group (C) showing the highest intake at 194 g, followed by T1 at 188 g, and T2 at 148 g. Although there was no statistical significance ($P = 0.12$), the differences indicated a trend. During the lactation period, feed intake showed significant differences in post-hoc comparisons, as indicated. The control group (C) exhibited the highest feed intake (247 g), which was significantly higher than T2 (175 g). The intake in T1 (202 g) was intermediate no significant difference from either C or T2. The overall *P-value* for the lactation period was 0.08, reflecting a trend toward significance in group differences. These results highlight that while feed intake was comparable before and after birth, significant

Table 4.
Feed intake of female Wistar rats before birth, after birth, and during lactation across different dietary treatments.

	Treatment			SEM	*P-value*
	C	T1	T2		
Before birth	144	144	135	7.83	0.68
After birth	194	188	148	16.09	0.12
Lactation period	247^{a}	202^{ab}	175^{b}	21.18	0.08

Table 5.
Weekly water intake of female Wistar rats across different dietary treatments.

	Treatment			SEM	*P-value*
	C	T1	T2		
First week	425.00	426.67	408.33	18.76	0.76
Second week	480.00	460.00	471.67	5.85	0.13
Third week	391.67	391.67	378.33	43.91	0.97
Fourth week	383.33	363.33	351.67	13.74	0.33

Table 6.
Water intake of female wistar rats before birth, after birth, and during lactation across different dietary treatments.

	Treatment			SEM	*P-value*
	C	T1	T2		
Before birth	318.33	290.00	262.50	24.35	0.30
After birth	368.33[a]	303.33[ab]	253.33[b]	35.43	0.10
Lactation period	484.17[a]	312.50[b]	270.83[b]	53.47	0.03

differences were observed during the lactation period, with the control diet supporting the highest intake.

3.5 Effect of dietary treatments on weekly water intake in female Wistar rats

Table 5 summarizes the water intake in the first week. Water intake was 425.00 mL for the control group (C), 426.67 mL for T1, and 408.33 mL for T2, with no statistically significant difference ($P = 0.76$). By the second week, water intake increased slightly, with the control group (C) at 480.00 mL, T1 at 460.00 mL, and T2 at 471.67 mL, though the differences remained statistically insignificant ($P = 0.13$). In the third week, water intake decreased slightly in all groups, with C and T1 having the same intake (391.67 mL) and T2 at 378.33 mL. There was no significant difference between the groups ($P = 0.97$). By the fourth week, water intake further decreased, with the control group (C) at 383.33 mL, T1 at 363.33 mL, and T2 at 351.67 mL, again showing no statistically significant differences ($P = 0.33$). The *P-values* (> 0.05 throughout the study) indicate that the dietary treatments did not have a significant impact on water intake over the 4-week period. These results suggest that the diets, whether standard rat feed, large animal feed, or large animal feed supplemented with raisins, had comparable effects on water consumption in female Wistar rats.

3.6 Effect of dietary treatments on water intake during reproductive phases in female Wistar rats

Table 6 presents the water intake of female Wistar rats during three key reproductive phases—before birth, after birth, and during the lactation period. Before birth, the water intake for the groups was 318.33 mL for the control group (C), 290.00 mL for T1, and 262.50 mL for T2, with no statistically significant differences observed (P = 0.30). After birth, water intake increased, and while no significant differences were found ($P = 0.10$), post-hoc comparisons revealed trends: the control group (C) consumed the most water (368.33 mL), followed by T1 (303.33 mL), and T2 consumed the least (253.33 mL). During the lactation period, significant differences in water intake were observed among the groups ($P = 0.03$). The control group (C) exhibited the highest water intake (484.17 mL), which was significantly greater than T1 (312.50 mL) and T2 (270.83 mL). These results indicate that while water intake was not significantly different before and after birth, differences became significant during the lactation period, with the control diet supporting the highest water consumption.

3.7 Analysis of offspring number and gender distribution across dietary treatment groups

The Fig. 1 displays the number and gender distribution of offspring born in each dietary treatment group in the control group (C). A total of 65 births were recorded, consisting of 34 males (52%) and 31 females (48%). For Treatment 1 (T1), there were 68 total births, with 33 males (49%) and 35 females (51%). Treatment 2 (T2) recorded the lowest number of births, with a total of 50 offspring, including 24 males (48%) and 26 females (52%). The results show that the total number of births was highest in the T1 group, followed by the control group (C), and lowest in the T2 group. In terms of gender distribution, all groups exhibited a nearly balanced ratio of males to females, with slight variations: the control group had a slightly higher proportion of males, while T1 and T2 had a slightly higher proportion of females. Overall, the number of births and sex distribution were influenced by the dietary treatments, with T1 showing the highest reproductive output.

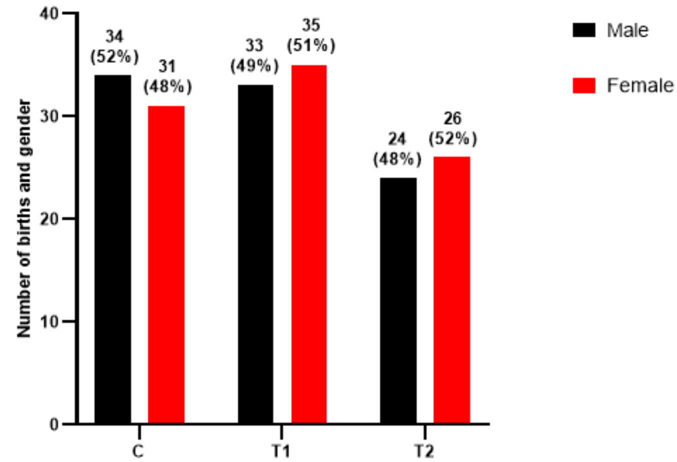

Fig. 1. Number and sex distribution of offspring across different dietary treatment groups.

3.8 Comparison of newborn body weights across dietary treatment groups after birth

The Fig. 2 shows the average body weight of newborns in the control group (C), the average body weight of newborns was approximately 7 grams. For Treatment 1 (T1), the average weight was slightly lower but comparable to the control group. In Treatment 2 (T2), the average body weight was similar to or marginally higher than the other groups, suggesting no significant difference in newborn weights among the groups. Overall, the Fig. 2 indicates that the dietary treatments, including large animal feed with or without raisin supplementation, had no substantial impact on the body weight of newborns at birth compared to the standard diet provided to the control group. The suggests that all three diets supported similar fetal growth during the gestation period.

3.9 Comparison of body length and width of newborns across dietary treatment groups

The Fig. 3 illustrates the average body measurements (length and width) of newborns the body length, all three groups show

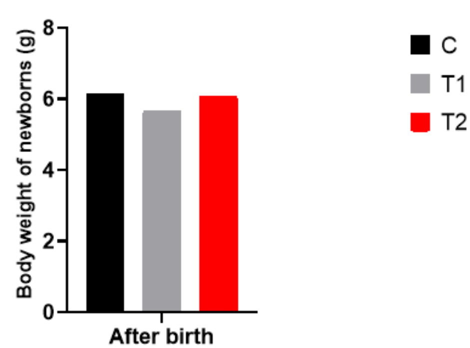

Fig. 2. Average body weight of newborns across dietary treatment groups after birth.

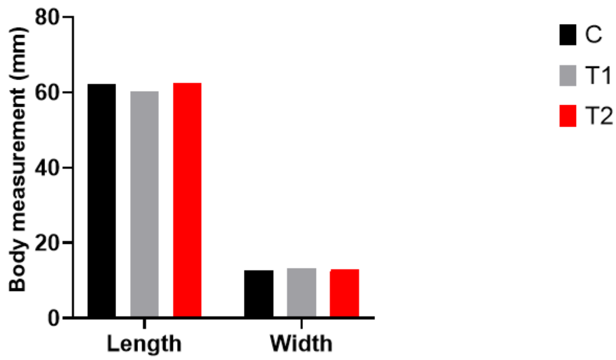

Fig. 3. Body length and width of newborns across dietary treatment groups.

similar measurements, with the control group (C), Treatment 1 (T1), and Treatment 2 (T2) averaging approximately 65 mm. The results suggest that dietary treatments, including large animal feed with or without raisin supplementation, had no noticeable effect on the length of newborns. For body width, all groups also exhibit comparable measurements, with a slight variation around 15 mm. The control group (C) and Treatment 1 (T1) had nearly identical widths, while Treatment 2 (T2) was marginally higher but not significantly different. Overall, the Fig. 3 suggests that the dietary treatments did not significantly influence the body length or width of newborns, indicating that fetal development in terms of body size was consistent across all groups.

4. Discussion

The study by Tepe and Altaş (2024) explores the advancements in technological processes applied to laboratory animal feeds and discusses innovative feeding strategies that enhance both the quality and functionality of these diets. Their work provides a broader framework for contextualizing the results of our study, which focuses on alternative dietary strategies, including raisin supplementation, to evaluate their effects on reproductive and offspring outcomes in female Wistar rats. Tepe and Altaş (2024) emphasize the critical role of technological innovations in feed production, such as improving nutrient bioavailability, standardizing formulations, and incorporating functional ingredients to meet specific research objectives. In our study, the inclusion of raisins as a supplement to large animal feed (T2 group) represents a practical application of such feeding innovations. Raisins, as a cost-effective and nutrient-rich agro-industrial by-product, offer an example of how functional ingredients can be integrated into alternative feeds to maintain or enhance performance metrics, particularly under conditions of economic or resource constraints.

Tepe and Altaş (2024) also highlight the importance of tailoring feeding strategies to the needs of specific research goals. In this regard, our results align with their insights, as the diets tested in our study were designed to evaluate their impact on key outcomes such as maternal feed and water intake, reproductive performance, and offspring growth. The comparable performance of the T2 group to the control group (C) suggests that raisin supplementation in alternative feeds can be a viable strategy to meet nutritional requirements while ensuring consistency in research outcomes. Furthermore, Tepe and Altaş (2024) underscore the necessity of maintaining feed quality to ensure the validity of experimental results. This aligns with our results, where raisin supplementation supported stable offspring outcomes (body weight, length, and width) and maternal performance metrics, indicating that alternative feed formulations can maintain high experimental standards when designed thoughtfully. The potential for functional ingredients, such as raisins, to enhance the nutritional profile of large animal feed reflects the innovative feeding approaches discussed by Tepe and Altaş (2024).

The work of Tepe and Altaş (2024) provides a valuable context for understanding the broader significance of our study. By exploring new feeding approaches and the integration of functional ingredients into laboratory animal diets, their results reinforce the practical implications of using alternative feeding strategies, such as raisin supplementation, to address challenges posed by feed shortages or high costs. Together, these studies underscore the importance of innovation and adaptability in laboratory animal nutrition to ensure both scientific rigor and resource efficiency.

The study by Asad (2024) provides valuable insights into the physiological and histological effects of dietary interventions, particularly focusing on the role of raisin extract in mitigating adverse effects caused by diet changes in mice. The results from this study align with certain aspects of our research, particularly regarding the potential benefits of incorporating raisins into alternative diets. in our study, the addition of raisins to large animal feed (T2 group) did not significantly alter growth metrics, feed intake, water consumption, or reproductive outcomes compared to the control group fed standard laboratory diets. However, trends in the data, such as slightly lower feed and water intake during the lactation period in the T2 group, might suggest a metabolic adjustment or a nutrient efficiency facilitated by the raisin supplementation. These subtle effects could reflect the antioxidant and nutrient-rich properties of raisins, as highlighted in the work by Asad (2024), which emphasizes their protective and restorative effects on the hepatic system.

Results on the histological improvements in the hepatic system due to raisin extract supplementation resonate with the potential systemic benefits observed in our research. (Asad, 2024) While our study focused primarily on reproductive performance, offspring outcomes, and growth parameters, the consistent performance of the T2 group across various measures could indicate a broader physiological benefit of raisins, as suggested by their ability to support metabolic health in the hepatic system. This might explain why the offspring body weight, length, and width in the T2 group were comparable to the control group despite being fed an alternative diet. The connection between the study by Asad, (2024) and our results lies in the capacity of raisins to act as a nutritional supplement that mitigates potential deficits associated with alternative feed sources. (Asad, 2024) The emphasis on the antioxidant and restorative properties of raisins could provide a mechanistic explanation for why raisin supplementation supports consistent outcomes in growth and reproduction, even when the base diet deviates from a standard laboratory formulation. This further underscores the potential of raisins as a cost-effective supplement to improve the quality of alternative feeds during times of feed shortages or economic constraints, as highlighted in our study. In summary, Asad's (2024) results reinforce the idea that raisins, through their nutrient composition and protective properties, can contribute to maintaining physiological stability and performance in animals subjected to dietary modifications. This complements our research by providing a deeper understanding of the potential mechanisms underlying the observed effects in the T2 group, particularly during critical phases such as lactation and offspring development.

The study by Bhouri *et al* (2025) explores the functional properties of raisins, particularly their antioxidant and antiglycation activities, highlighting their potential as a functional food ingredient. The work provides an essential foundation for understanding the broader implications of raisin supplementation in animal diets, as investigated in our research.

Our study demonstrated that adding raisins to large animal feed (T2 group) supported consistent reproductive and growth outcomes in female Wistar rats, comparable to those achieved with a standard laboratory diet. While no significant differences were observed in parameters such as feed and water intake or offspring measurements, the performance of the T2 group remained stable throughout the study. Bhouri *et al* (2025) findings suggest that the antioxidant activity of raisins could play a pivotal role in maintaining physiological balance, even under alternative feeding conditions. The antioxidant properties highlighted by Bhouri *et al* (2025). may explain the stable maternal body weights observed in the T2 group during critical periods, such as after birth and lactation, despite a deviation from the standard laboratory diet. That aligns with the study's assertion that raisins can counter oxidative stress, which could otherwise negatively impact metabolic and reproductive processes. The antiglycation properties of raisins, as emphasized in Bhouri *et al*'s (2025) work, could also contribute to improved metabolic efficiency in animals fed alternative diets, potentially preventing the accumulation of harmful metabolic byproducts during high-demand periods such as pregnancy and lactation. Furthermore, Bhouri *et al* (2025). underscore the functional benefits of raisins in maintaining health and mitigating diet-induced stress. This provides a mechanistic explanation for the comparable growth parameters and offspring outcomes in the T2 group of our study. The observed consistency in offspring body weights, lengths, and widths suggests that raisins may enhance the nutritional profile of alternative feeds by delivering bioactive compounds that support both maternal and fetal development. The result by Bhouri *et al* (2025) also resonates with the broader implications of our research, particularly the potential of raisins to act as a cost-effective dietary supplement during feed shortages or economic constraints. Their antioxidant and antiglycation properties not only enhance the nutritional quality of alternative diets but also promote metabolic health, reducing the risk of adverse outcomes associated with non-standard feed formulations. In conclusion, Bhouri *et al*, (2025) work provides a critical context for interpreting the results of our study, offering insights into how the bioactive properties of raisins might contribute to the stability and efficiency of alternative diets. The antioxidant and antiglycation activities of raisins likely underpin the consistent outcomes observed in the T2 group, further supporting their role as a functional supplement in laboratory and agricultural animal feeding practices.

The study by Carlin *et al*, (2019) investigates the effects of a maternal high-protein diet during pregnancy on offspring outcomes, particularly focusing on body weight, insulin signaling, and macronutrient preferences in adulthood. The study provides a relevant framework for contextualizing the results of our research, which examined the impact of alternative diets, including raisin-supplemented feed, on reproductive performance, offspring growth, and developmental parameters in female Wistar rats. Carlin *et al.* demonstrated that dietary modifications during pregnancy could have long-term implications for offspring physiology, particularly body weight and insulin signaling pathways. In our study, although the dietary interventions (T1 and T2 groups) did not significantly alter offspring body weight, length, or width at birth compared to the control group (C), subtle trends in the T2 group (raisin-supplemented diet) suggest the potential for dietary components to influence metabolic outcomes. Raisins, as highlighted in related studies (Bhouri *et al*, 2025), possess antioxidant and bioactive properties that may help stabilize metabolic processes during gestation, which could explain the comparable offspring measurements across all dietary groups. The findings of Carlin *et al.* also underscore the importance of maternal diet in shaping early developmental outcomes, such as body weight and metabolic health. Similarly, in our study, the stability of offspring outcomes in the T2 group, despite deviations from standard laboratory feed, may reflect the nutrient-enhancing and potentially metabolic-regulating properties of raisins. While Carlin *et al.* focused on high-protein diets, the mechanisms they highlighted, such as the modulation of insulin signaling, may overlap with the bioactive effects of raisins in promoting metabolic efficiency, even under alternative feeding conditions.

The study by Vanselow *et al* (2016) highlights the long-term effects of maternal high-protein diets during pregnancy on offspring, specifically focusing on hepatic gene expression changes in adulthood. While our research differs in scope, examining the impact of alternative diets, including raisin supplementation, on reproductive performance and offspring growth parameters, it provides complementary insights into how maternal diet influences offspring physiology during critical developmental period. Vanselow *et al* (2016) demonstrated that maternal high-protein diets induced significant alterations in the expression of hepatic genes in adult offspring, suggesting epigenetic modifications during gestation. This result aligns with the broader understanding that maternal diet plays a pivotal role in shaping offspring development, not only at birth but also in their long-term metabolic trajectory. In our study, while we did not analyze epigenetic or hepatic gene expression changes, the consistent offspring outcomes in terms of body weight, length, and width across all groups, including those fed raisin-supplemented diets, highlight the potential of specific dietary components to support stable developmental conditions The hepatic gene changes observed by Vanselow *et al* (2016) suggest that the maternal diet has a significant impact on metabolic programming. Similarly, our results indicate that raisin supplementation (T2 group) might influence maternal metabolism during pregnancy and lactation, potentially affecting nutrient transfer to the offspring. Raisins are known for their antioxidant and nutrient-dense properties, as supported by Bhouri *et al* (2025), and could mitigate oxidative stress and stabilize metabolic processes during gestation. This Compatible with Vanselow *et al* (2016) results, suggesting that dietary interventions during pregnancy have profound systemic effects on offspring, even if not immediately observable at birth.

5. Conclusions

This study evaluated the effects of large animal feed and raisin-supplemented diets on growth, reproduction, and offspring outcomes in female Wistar rats. The results showed no significant differences between the alternative diets and the standard laboratory diet in terms of maternal weight, feed and water intake, or offspring body weight, length, and width. Fertility rates and the number of offspring were consistent across all groups, demonstrating the suitability of the alternative feeds. Raisin supplementation (T2) provided a nutritionally rich addition, supporting comparable outcomes to the standard diet, likely due to its antioxidant properties. These results suggest that raisin-supplemented large animal feed is a viable, cost-effective alternative during feed shortages or economic constraints, without compromising growth or reproductive outcomes. Further studies are recommended to explore long-term metabolic effects.

CRediT authorship contribution statement

Aiman Ammari: Conceptualization, methodology, investigation, data curation, writing – original draft. **Ramzi Amran:** Formal analysis, validation, visualization, writing – review & editing. **Ahmad Alhimaidi:** Resources, supervision, project administration, funding acquisition.

Declaration of competing interest

The authors declare that they have no competing financial interests or personal relationships that could have influenced the work presented in this paper.

Declaration of Generative AI and AI-assisted technologies in the writing process

The authors confirm that there was no use of Artificial Intelligence (AI)-Assisted Technology for assisting in the writing or editing of the manuscript and no images were manipulated using AI.

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