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Relationship Between Fat Deposition in Certain Body Organs During Pregnancy at Different Ages in Arabi ewes

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I. Abstract

This study aimed to evaluate the effect of age (1.5, 2.5, >3.5 years) and stage of pregnancy (first, second, and third) on several physiological traits and visceral tissues in Arabi ewes, including live body weight, carcass weight, and the weights of some vital organs (heart, liver, and kidneys), in addition to visceral fat deposition (cardiac, hepatic, renal, mesenteric fat, and Fat-Tail) and the weight of filled internal organs. A total of 27 Arabi ewes were used

The results showed clear physiological responses associated with age and pregnancy, where the weights of most vital organs increased with advancing age and progression of pregnancy stages, reflecting physiological maturity and increased metabolic demands during pregnancy. A significant increase ($P \leq 0.05$) was observed in fat weights around the heart, liver, kidneys, and mesentery with advancing age and pregnancy stage, along with a noticeable depletion of perirenal fat in the third stage. The findings also indicated that visceral adipose tissues differ in their dynamics; cardiac, hepatic, and renal fats were more sensitive to metabolic changes compared to mesenteric and fat-tail depots, which showed relative stability as long-term energy reserves

Pregnancy had a more pronounced effect in advanced stages on fat distribution and internal organs, with adaptive responses aimed at supporting fetal growth and meeting its nutritional requirements. these changes reflect the ability of Arabi ewes to efficiently adapt physiologically to the demands of pregnancy without evident pathological disturbances.

Keywords

Arabi ewes, age, stages of pregnancy, live weight, carcass weight, visceral organ weight, liver, kidneys, heart, visceral fat, fat tail.

II. Introduction

Local sheep (Arabi) are considered fat-tailed breeds characterized by a high ability to adapt to harsh environmental conditions; however, their reproductive efficiency is still below the desired level (Mohammed et al., 2022). The scientific perspective on visceral adipose tissue has undergone a significant shift, as it is no longer viewed merely as an energy reservoir but rather as an active endocrine tissue that secretes adipokines, including leptin, which plays a role in regulating the reproductive axis (hypothalamus–pituitary–ovary) and metabolic balance (Xu et al., 2023) ; (Al-Thuwaini et al., 2024)

In Arabi ewes, fat deposition is mainly concentrated in visceral tissues, including fat surrounding the kidneys, liver, heart, and mesentery, in addition to the fat-tail. This pattern differs functionally and anatomically from that of thin-tailed breeds (Mastrangelo et al., 2019). These tissues undergo dynamic changes during pregnancy, acting as a rapid energy reserve to support fetal growth and associated physiological adaptations

The distribution and deposition of visceral fat are influenced by a complex interaction between ewe age and stage of pregnancy. Young pregnant ewes face a metabolic challenge due to competition between body growth requirements and pregnancy demands (Alonso-García et al., 2025), whereas older ewes exhibit a greater capacity to regulate and store fat as an adaptive response to physiological conditions (Rivera-Bautista et al., 2023). Previous studies have shown a selective reduction in certain visceral fat depots, such as perirenal fat, during advanced pregnancy stages, indicating its role as a rapidly mobilized energy source (Marie et al., 2010). Other studies have demonstrated differences in organ responses, with the liver being one of the most sensitive organs to fat accumulation during pregnancy (Zi et al., 2024)

However, the interactive relationship between age and different stages of pregnancy and their combined effect on visceral fat distribution in Arabi ewes remains insufficiently studied, particularly when analyzing multiple fat depots simultaneously. Therefore, this study aims to fill this knowledge gap.

Objectives

1-To evaluate the effect of age and stage of pregnancy on the quantity and distribution of visceral fat in specific anatomical sites (perirenal, mesenteric, hepatic, and cardiac fat)

To study the effect of age and stage of pregnancy on fat deposition in the fat-tail2-

3-To analyze the relationship between visceral fat deposition and certain reproductive traits in Arabi ewes.

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III. Materials and Methods

Experimental Site and Design

This study was conducted at the animal farm of the College of Agriculture, University of Basrah, from 7/10/2024 to 10/4/2025. A total of 27 Arabi ewes were randomly divided into three age groups: 1.5 years (31±2 kg), 2.5 years (39±2 kg), and >3.5 years (43±2 kg), with 9 ewes per group. Three rams aged 2–3 years were used for natural mating. Animals were housed in semi-open pens and fed a standardized concentrate diet (3% of body weight) with free access to roughage and water

Estrus Synchronization, Mating, and Pregnancy Diagnosis

Estrus synchronization was performed using intravaginal sponges containing 40 mg fluorogestone acetate for 12 days, with an injection of cloprostenol (PGF2α) 48 hours before sponge removal, and PMSG hormone administered at a dose of 400–750 IU at sponge withdrawal to stimulate ovulation

Estrus detection was carried out using teaser rams, followed by natural mating (1 ram per 9 ewes). Twenty-one days after mating, the ewes were re-exposed to teaser rams to confirm non-return to estrus. Pregnancy was diagnosed using ultrasound 40 days after mating.

. Slaughter and Data Collection

After pregnancy confirmation, three ewes from each age group were randomly slaughtered at each stage of pregnancy:

First stage: 40 days

Second stage: 75–80 days

Third stage: 135–140 days

Feed was withdrawn 12 hours prior to slaughter. After slaughter, live body weight and carcass weight were recorded, and internal organs were separated and weighed. Visceral fat depots were also separated and measured, including mesenteric fat, fat surrounding the liver, perirenal fat, cardiac fat, and fat tail.

Statistical Analysis SPSS

،19)IBM Corp., 2020(Data were analyzed using spss

(Two-way ANOVA to assess the effects of age, stage of pregnancy, and their interaction. Normality and homogeneity of variance were tested using Shapiro–Wilk and Levene tests. When significant differences were found ($P \leq 0.05$), LSD test was used for post hoc comparisons. Results were presented as mean ± standard error

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Statistical Model

Yijk = μ + Ai + Pj + (AP)ij + eijk

Where:

Ai = age (3 levels)

Pj = physiological stage (3 levels)

Normality (Shapiro–Wilk) and homogeneity of variance (Levene) tests were applied. LSD test was used for post hoc comparisons at $P \leq 0.05$

IV. Results

Live weight and carcass weight

The results (Table 1) showed significant differences ($P \leq 0.05$) in live weight and carcass weight according to ewe age and stage of pregnancy. Ewes of the oldest age group (>3.5 years) recorded the highest mean live weight and carcass weight compared with younger ewes (1.5 years). Live weight increased progressively with advancing pregnancy stages, reaching the highest value in the third stage of pregnancy, whereas no significant effect of pregnancy stage was observed on carcass weight

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Table (1): Effect of Age and Physiological Stage on Live Body Weight Before Slaughter and Carcass Weight of Ewes (kg) (Mean ± Standard Error)

Pregnancy Stage	Live Weight Before Slaughter (kg)				Carcass Weight (kg)			
	Age of Ewes (years)			Pregnancy stage mean	Age of Ewes (years)			Pregnancy stage mean
	1.5	2.5	>3.5		1.5	2.5	>3.5	
First stage of pregnancy	40.33±0.88	48.00±1.15	50.00±1.73	^{a}46.11±1.61	17.33±0.67	20.33±0.30	24.00±0.44	^{a}20.55±0.98
Second stage of pregnancy	48.33±1.15	54.67±0.33	55.00±0.57	^{b}52.00±1.45	18.30±0.56	22.33±0.30	23.00±0.58	^{a}21.10±0.72
Third stage of pregnancy	50.33±1.44	57.00±0.58	59.00±0.57	^{bc}55.44±1.33	18.67±0.67	21.50±0.58	22.67±0.30	^{a}21.11±0.67
Age mean	^{a}46.22±1.50	^{b}53.22±1.40	^{b}54.67±1.41	LSD for interaction = 1.47	^{a}18.10±0.37	^{b}20.89±0.16	^{c}23.22±0.30	LSD for interaction = 2.67

Means with different letters (vertically or horizontally) are significantly different (P ≤ 0.05) among experimental groups.

Heart weight and heart fat

The results (Table 2) indicated a significant effect ($P \leq 0.05$) of both age and pregnancy stage on heart weight and cardiac fat. Older ewes showed higher values compared with younger age groups. In addition, heart weight and heart fat increased with advancing pregnancy stages, with the highest means recorded in the third stage of pregnancy. The interaction between advanced age and the third pregnancy stage showed the highest values.

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Table (2): Effect of Age and Physiological Stage on Heart Weight (g) and Heart Fat (Mean ± Standard Error)

Pregnancy Stage	Heart Weight (g)				Heart Fat (g)			
	Age of Ewes (years)				Age of Ewes (years)			
	1.5	2.5	>3.5	Pregnancy stage mean	1.5	2.5	>3.5	Pregnancy stage mean
First stage of pregnancy	205.3±2.40	235.0±2.88	239.7±3.93	[a]226.7±5.60	23.67±1.45	37.00±6.55	36.33±0.88	[a]32.33±2.92
Second stage of pregnancy	208.0±2.00	240.3±10.26	242.0±4.16	[a]230.1±6.42	23.33±1.33	41.33±2.90	45.33±2.90	[a]36.67±3.61
Third stage of pregnancy	237.0±4.72	245.0±2.88	275.0±16.07	[b]252.3±7.59	34.00±3.05	41.67±2.02	62.67±2.91	[b]46.11±4.49
Age Mean	[a]216.8±5.32	[b]240.1±3.50	[b]252.2±7.53	LSD for interaction = 38.00	[a]27.00±2.04	[b]40.00±2.27	[c]48.11±4.05	LSD for interaction = 17.66

Means with different letters (vertically or horizontally) differ significantly at **$P \leq 0.05$** among experimental groups.

Liver weight and liver fat

The results (Table 3) demonstrated significant differences ($P \leq 0.05$) in liver weight and liver fat according to age and pregnancy stage. Liver weight increased progressively with age, with the highest values recorded in the oldest age group. A similar pattern was observed with pregnancy stage, where liver weight increased and peaked in the third stage. Liver fat also increased with both age and pregnancy progression, reaching its highest levels in the oldest ewes during the third stage of pregnancy

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Table (3): Effect of Age and Physiological Stage on Liver Weight and Liver Fat (g) (Mean ± Standard Error)

Pregnancy Stage	Liver Weight (g)			Pregnancy stage mean	Liver Fat (g)			Pregnancy stage mean
	Age of Ewes (years)				Age of Ewes (years)			
	1.5	2.5	>3.5		1.5	2.5	>3.5	
First stage of pregnancy	575.0±18.52	842.0±12.16	1029.7±9.59	a823.0±63.05	110.7±5.81	133.3±2.40	202.7±1.76	a148.89±13.97
Second stage of pregnancy	597.3±21.49	865.0±12.58	1082.7±25.41	a840.9±74.17	129.0±2.08	145.3±1.76	213.3±3.52	b162.56±12.98
Third stage of pregnancy	1025.3±193.69	1153.3±94.69	1277.3±6.76	b1152.0±72.12	140.7±1.76	163.3±8.82	226.0±2.31	c176.67±13.04
Age Mean	a732.6±92.52	b953.4±57.28	c1129.9±38.50	LSD for interaction = 412.30	a126.78±4.74	b147.33±5.12	c214.00±3.62	LSD for interaction = 22.00

Means with different letters (vertically or horizontally) differ significantly at P ≤ 0.05 among experimental groups.

Kidney weight and kidney fat

The results (Table 4) showed a significant effect ($P \leq 0.05$) of age and pregnancy stage on kidney weight. Kidney weight increased with advancing age and pregnancy stage, with the highest values recorded in the oldest age group during the third stage of pregnancy.

Kidney fat showed a significant increase with age, whereas it increased with pregnancy stage up to the second stage and then decreased in the third stage, with significant differences among treatments

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Table (4): Effect of Age and Physiological Stage on Kidney Weight and Kidney Fat (g) (Mean ± Standard Error)

Pregnancy Stage	Kidney Weight (g)			Pregnancy stage mean	Kidney Fat (g)			Pregnancy stage mean
	Age of Ewes (years)				Age of Ewes (years)			
	1.5	2.5	>3.5		1.5	2.5	>3.5	
First stage of pregnancy	120.0±1.15	121.0±0.58	125.7±16.0	a122.3±2.58	248.7±8.96	251.7±19.65	295.3±52.86	a250.2±1.79
Second stage of pregnancy	121.0±11.59	125.0±2.60	125.3±2.89	a123.4±5.69	236.7±23.33	241.7±13.63	290.0±10.00	a266.7±3.63
Third stage of pregnancy	125.0±1.15	125.7±0.88	135.3±8.66	a128.0±3.56	196.7±26.03	232.0±6.11	276.7±14.53	a241.8±3.38
Age Mean	a122.0±4.63	a123.0±1.35	a128.0±5.85	LSD for interaction = N.S	a234.0±14.04	a237.3±17.67	a287.3±16.33	LSD for interaction = N.S

Means with different letters (vertically or horizontally) differ significantly at P ≤ 0.05 among experimental groups.
N.S = Not Significant (no significant differences).

Internal organs weight and mesenteric fat

The results (Table 5) revealed a significant effect (P ≤ 0.05) of age on internal organ weight, which increased with advancing age. In contrast, no significant effect of pregnancy stage or interaction between age and pregnancy was observed

Mesenteric fat was significantly affected by both age and pregnancy stage, increasing with age and also with pregnancy progression, reaching its highest value in the second stage before declining in the third stage

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Table (5): Effect of Age and Physiological Stage on Weight of Full Visceral Organs and Mesenteric Fat (g) (Mean ± Standard Error)

Pregnancy Stage	Weight of Full Visceral Organs (g) — Age of Ewes (years)			Pregnancy stage mean	Mesenteric Fat Weight (g) — Age of Ewes (years)			Pregnancy stage mean
	1.5	2.5	>3.5		1.5	2.5	>3.5	
First stage of pregnancy	8463±110.62	9548±179.51	10128±128.00	[a]9762±230.77	309±36.15	336±7.42	358±27.05	[a]334±14.95
Second stage of pregnancy	8875±155.45	9862±381.59	10239±52.88	[a]9416±265.84	518±30.04	596±42.44	778±80.84	[b]630±47.51
Third stage of pregnancy	9063±345.90	10284±41.65	10400±265.86	[a]9775±256.27	520±40.41	510±5.77	740±30.55	[b]590±40.31
Age Mean	[a]8800±144.39	[b]9898±162.29	[b]10255±95.12	LSD for interaction = N.S	[a]449±39.21	[a]480.9±40.14	[b]625±72.00	LSD for interaction = 200.33

Means with different letters (vertically or horizontally) differ significantly at **P ≤ 0.05** among experimental groups.
N.S = Not Significant (no significant differences).

Fat-tail weight

The results (Table 6) showed numerical differences in fat-tail weight according to age and pregnancy stage; however, these differences did not reach statistical significance (P > 0.05). An increasing trend was observed with advancing age as well as with progression of pregnancy stages, while no significant interaction effect was detected

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Table (6): The effect of age and physiological stage on fat-tail weight (Kg) (mean +- SE)

Physiological Stage	**Age 1.5 (years)**	**Age 2.5 (years)**	**Age < 3.5 (years)**	**Mean of Physiological Stage (±SE)**
First stage of pregnancy	0.876 ± 9.35	1.395 ± 22.19	1.979 ± 127.89	551.55 ± 1.416[a]
Second stage of pregnancy	1.384 ± 88.26	1.670 ± 8.66	2.046 ± 8.67	331.00 ± 1.700[b]
Third stage of pregnancy	1.968 ± 30.23	2.046 ± 27.74	2.525 ± 54.86	157.10 ± 2.179[ab]
Mean of Age	551.55 ± 1.409[a]	325.93 ± 1.703[a]	272.94 ± 2.183[a]	LSD (Interaction) NS.

- **Means with different letters (vertically or horizontally) differ significantly at P ≤ 0.05.**
- **NS = Not Significant, meaning no significant differences between groups.**

. **Discussion**

The present study demonstrated that both age and pregnancy stage induce clear physiological alterations in body weight distribution and tissue composition in local Arabi ewes, with variable responses among different organs. Pregnancy acts as a metabolic driver for nutrient redistribution toward fetal development, whereas age reflects the level of physiological maturity and the ewes' capacity for energy storage and utilization of that stored energy.

Live weight and carcass weight

The results (Table 1) showed a significant increase (P ≤ 0.05) in live weight and carcass weight in older ewes (>3.5 years), reaching 54.67 kg and 23.22 kg, respectively, compared with younger ewes (1.5 years; 46.22 and 18.10 kg). Live weight also increased significantly with advancing pregnancy stages, from 46.11 kg in the first stage to 55.44 kg in the third stage, whereas carcass weight was not significantly affected by pregnancy stage The increase in live weight during pregnancy is mainly attributed to the progressive increase in uterine contents, including fetuses, placenta, and amniotic and chorionic fluids (Ma'aruf et al., 2021).

These findings are consistent with He et al. (2025), who reported that advancing age increases live weight and carcass weight due to full body growth and physiological maturity. They also agree with Rivera-Bautista et al. (2023), who indicated that mature ewes exhibit higher efficiency in converting feed into muscle and fat tissues.

In contrast, our results differ from Nageye et al. (2024), who reported a significant effect of pregnancy stage on carcass weight. This discrepancy may be attributed to breed differences, as the present study involved fat-tailed Arabi ewes, where a portion of energy is directed toward fat deposition in the tail rather than carcass growth. In addition, late pregnancy is associated with reduced feed intake due to rumen compression by the gravid uterus, which may limit carcass weight gain despite increased live weight (Al-Jaryan et al., 2023)

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Heart weight and heart fat

Older ewes (>3.5 years) showed significantly higher ($P \leq 0.05$) heart weight (252.2 g) and heart fat (48.11 g) compared with younger ewes (216.8 g and 27.00 g). Both parameters increased with advancing pregnancy, reaching maximum values in the third stage. The highest values were observed in older ewes during late pregnancy (275.0 g heart weight and 62.67 g fat).

Pregnancy induces physiological cardiac hypertrophy as an adaptive response to increased cardiac output and blood volume (Ragulya et al., 2024; Varanis et al., 2021), which explains the increase in heart weight in late pregnancy. The observed heart fat values fall within the physiological range reported in sheep; for example, Mahajan et al. (2013) reported approximately 260 g in Merino sheep (~80 kg body weight), indicating that our values are not pathological.

Heart fat serves as a rapid energy reservoir and provides mechanical protection and thermal regulation (Auger & Kajimura, 2023). In contrast, Roberts et al. (2015) reported no significant effect of pregnancy stage on cardiac fat, possibly due to differences in experimental design and the use of non-pregnant controls, as well as breed variation.

Liver weight and liver fat

The liver showed the highest sensitivity to both age and pregnancy stage. Liver weight increased from 732.6 g (1.5 years) to 1129.9 g (>3.5 years), and from 823.0 g (first stage) to 1152.0 g (third stage). Liver fat also increased with age (126.78 to 214.00 g) and pregnancy progression (148.89 to 176.67 g)

This increase reflects enhanced hepatic metabolic activity during pregnancy, as the liver plays a central role in lipid metabolism (Fainberg et al., 2013; Xue et al., 2020). These findings agree with Zhang et al. (2023), who reported that pregnancy induces micro-lipid droplet accumulation in hepatocytes as a physiological adaptation rather than a pathological condition

In addition, Al-Jebur et al. (2023) demonstrated that elevated lipoprotein levels (HDL, LDL, VLDL) in pregnant ewes reflect increased hepatic metabolic activity. The liver is therefore considered a key organ for metabolic adaptation during gestation, with lipid accumulation remaining within physiological limits (<5% of liver weight).

Kidney weight and kidney fat

Kidney weight increased significantly ($P \leq 0.05$) with both age and pregnancy stage. Kidney fat also increased with age but showed a distinct pattern, increasing in the second stage and decreasing significantly in the third stage

The increase in kidney weight during pregnancy is associated with increased renal blood flow and glomerular filtration rate under the influence of progesterone (Hill et al., 1984; Scheaffer et al., 2004). Age-related increases reflect full organ maturation and metabolic activity (Ahmed & Mohammed, 2024)

Marie et al. (2010) reported a selective reduction in perirenal fat in late pregnancy, confirming its role as a rapidly mobilized energy depot. Similarly, Nguyen et al. (2026) described a shift from lipid storage to lipid mobilization during late gestation

The partial discrepancy with Zhang et al. (2023), who observed earlier depletion of visceral fat, may be attributed to breed differences, as fat-tailed Arabi ewes retain visceral fat longer due to the tail fat acting as a primary energy reservoir

Internal organs and mesenteric fat

Internal organ weight increased significantly with age but was not affected by pregnancy stage. Mesenteric fat increased with both age and pregnancy, peaking in mid-gestation before declining slightly in late pregnancy

These findings agree with Chen et al. (2023, 2024) and Caton et al. (2009), who reported that organ weight is more strongly influenced by age and body weight than by pregnancy stage under standard feeding conditions

Mesenteric fat acts as a relatively stable energy depot, maintaining metabolic homeostasis during pregnancy (Naskar et al., 2023). The mid-gestation increase may be related to progesterone-induced lipogenesis, while the slight decline in late pregnancy reflects increased energy mobilization (Al-Ghadban et al., 2024; Abecia et al., 2022)

Fat-tail weight

Although fat-tail weight increased numerically with age and pregnancy stage, the differences were not statistically significant ($P > 0.05$). This suggests that fat deposition in the tail is a relatively stable trait controlled by complex genetic regulation (BMP2, PDGFD, SESN1, RPRD1A, RASGEF1B), which reduces its responsiveness to short-term physiological changes Wang et al., 2025)(These results agree with Thompson et al. (2024), who reported that young ewes prioritize structural growth over fat storage, and with Khaldari et al. (2020), who suggested an inverse relationship between tail fat and other visceral fat depots

Overall interpretation

Visceral fat depots in Arabi ewes exhibit site-specific responses to age and pregnancy. Cardiac and hepatic fats increase as adaptive energy reserves, renal fat shows dynamic mobilization, mesenteric fat is moderately responsive, while tail fat remains the most stable depot. These differences reflect a coordinated physiological adaptation to support pregnancy and fetal development

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V. Conclusion

1. This study demonstrates that local Arabi ewes exhibit tissue-specific physiological responses to age and pregnancy stage. Vital organs are more sensitive to metabolic changes associated with gestation, while visceral fat depots show dynamic patterns of energy redistribution, whereas fat tail represents a relatively stable energy reserve

2. Age had a significant and consistent effect on increasing organ weights (heart, liver, kidneys) and visceral fat depots, with older ewes (>3.5 years) showing higher values than younger ones (1.5 years). Pregnancy stage significantly influenced metabolic adaptation, characterized by increased cardiac and hepatic weight and fat, a mid-gestation peak followed by a decline in renal fat, and moderate fluctuations in mesenteric fat

3. Carcass weight and internal organ mass (rumen and intestines) were not significantly affected by pregnancy stage despite the increase in live weight. The interaction between age and pregnancy was significant for most traits, indicating a combined adaptive effect, particularly in mature ewes with enhanced capacity for lipid storage and mobilization

4. Perirenal fat was identified as the most dynamic and sensitive depot, making it a practical indicator of metabolic status during pregnancy.

VI. Recommendations

1. Perirenal fat measurement (via ultrasound or anatomical assessment) is recommended as a field indicator for evaluating energy reserves in pregnant ewes, particularly during mid and late gestation

2. Visceral fat dynamics should be correlated with hormonal profiles (leptin, adiponectin, insulin) and biochemical parameters (glucose, triglycerides, cholesterol) to better understand metabolic regulation.

3. Economic evaluation of using perirenal fat as a management indicator is recommended to improve feeding efficiency and reduce lamb mortality

4. The experimental approach should be applied to other sheep breeds (e.g., Awassi, Hamdani) for comparative analysis of visceral fat deposition patterns.

5. Long-term studies are needed to investigate the impact of gestational fat deposition on subsequent reproductive performance

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