The Effect of Early and Late Weaning of Awassi Ewe on the Milk Characteristics

Mohammed M. ZinAlabidin[1], Husham Jaafar Musa Albayati[2], Shahla F. Hassan[2], Aya A. Nadhim[3], Ahmed S. Shaker[4]*

[1]Animal Production Department, College of Agriculture, Kirkuk University, Kirkuk, Iraq
[2]Department of Biology, College of Educationfor Women, Kirkuk University, Kirkuk, Iraq
[3]Directorate of Agriculture in Kirkuk, Animal Wealth Department
[4]Medical Laboratory Technology, Al-Qalam University College, Kirkuk, Iraq

Abstract. *The objective of the present study was to assess the impact of early and late weaning on ewe performance, lamb postnatal growth, hormonal status and milk composition in Awassi ewes over a 30 days separation period at Animal Production Farm, College of Agriculture, Kirkuk University. Fifteen healthy, mature ewes were randomly assigned into two groups according to the weaning age: EWG (early weaning) at 60 days or LWG (late weaning) at 90 days. Body weights were determined for ewes and lambs at the start and end of the experiment, and blood and milk samples were obtained for hormonal and compositional analyses, respectively. The results of ANOVA showed that the short and the long weaning strategy had no effect on ewe body weight. Nevertheless, final weights of lambs in the EWG were significantly higher than in the LWG (P≤0.05), indicating better growth in early weaned lambs. Serum PRL levels were significantly raised in the EWG, whereas serum E2, P, LH, and FSH levels did not significantly differ between groups. Milk composition analysis indicated that early weaning significantly increased milk fat, whereas protein, lactose, and solid non-fat of milk did not differ between groups. Results of correlation analysis showed high positive correlations between milk components, most notably between solid non-fat, protein, and lactose. These results indicated that early weaning improved lamb growth performance, increased milk fat with no detrimental effects on ewe health or reproductive hormone balance, reinforcing early weaning as a pragmatic alternative for enhancing efficiency in sheep production systems.*
Keywords: *sheep, awassi, weaning, milk characteristics*

OPEN ACCESS

ISSN 2541-5816 (online)

**Correspondence:
Mohammed M. ZinAlabidin
ahmed.shaker@alqalam.edi.iq*

Received: 07 January 2026

Accepted: 21 January 2026

Published: 26 January 2026

Citation: ZinAlabidin MM, Albayati HJM, Hassan SF, Nadhim AA, and Shaker AS. (2026). The Effect of Early and Late Weaning of Awassi Ewe on the Milk Characteristics. Journal of Tropical Food and Agroindustrial Technology xx:xx

doi: 10.21070/jtfat.v7i01.1675

Abstrak. Tujuan penelitian ini adalah untuk menilai dampak penyapihan dini dan terlambat terhadap kinerja domba betina, pertumbuhan pascanatal anak domba, status hormonal, dan komposisi susu pada domba betina Awassi selama periode pemisahan 30 hari di Peternakan Produksi Hewan, Fakultas Pertanian, Universitas Kirkuk. Lima belas domba betina dewasa yang sehat secara acak dibagi menjadi dua kelompok berdasarkan usia penyapihan: EWG (penyapihan dini) pada usia 60 hari atau LWG (penyapihan terlambat) pada usia 90 hari. Berat badan domba betina dan anak domba ditentukan pada awal dan akhir percobaan, dan sampel darah dan susu diambil untuk analisis hormonal dan komposisi, masing-masing. Hasil ANOVA menunjukkan bahwa strategi penyapihan pendek dan panjang tidak berpengaruh pada berat badan domba betina. Meskipun demikian, berat akhir anak domba pada kelompok penyapihan dini (EWG) secara signifikan lebih tinggi daripada pada kelompok penyapihan panjang (LWG) (P≤0,05), menunjukkan pertumbuhan yang lebih baik pada anak domba yang disapih dini. Kadar PRL serum meningkat secara signifikan pada kelompok EWG, sedangkan kadar E2, P, LH, dan FSH serum tidak berbeda secara signifikan antar kelompok. Analisis komposisi susu menunjukkan bahwa penyapihan dini secara signifikan meningkatkan lemak susu, sedangkan protein, laktosa, dan padatan non-lemak susu tidak berbeda antar kelompok. Hasil analisis korelasi menunjukkan korelasi positif yang tinggi antara komponen susu, terutama antara padatan non-lemak, protein, dan laktosa. Hasil ini menunjukkan bahwa penyapihan dini meningkatkan performa pertumbuhan anak domba, meningkatkan lemak susu tanpa efek merugikan pada kesehatan induk domba atau keseimbangan hormon reproduksi, memperkuat penyapihan dini sebagai alternatif pragmatis untuk meningkatkan efisiensi dalam sistem produksi domba.
Kata kunci: domba, awassi, penyapihan, karakteristik susu

INTRODUCTION

An Awassi dairy sheep breed, often kept throughout the West Bank, is selected since it is highly productive and adapted to the prevailing environment (Galal et al., 2008). Its weaning procedure of a transition of milk diet to solid diet has an especially marked influence on the herd health and the quality of milk (Mohammed et al., 2021). The timing of lactation can significantly influence the breast (Freitas de Melo et al., 2022), milk-related composition and lactation curve (Hassan & Mohammed, 2019). Therefore, premature weaning leads to a shift of the lactation curve, changes in the hormonal and metabolic response of the lactating herd and is deleterious to offspring (Sinkiewicz-Darol et al., 2021). Nevertheless, early weaning is desirable when pasture conditions offer plentiful rations or lambs are not milk dependent in the suckling period (Yousif et al., 2023).

Considering that delayed weaning in dairy systems generates a high milk production and a higher fat, protein and lactose percentage (high ingredient contents), it seems important for the maintenance and production of milk of both sheep and goat, as the consumer looks for products with a rich combination of ingredients (Hermiz et al., 2016). Consequently, a good diet, proper housing, and veterinary care are indispensable to animals, in addition, investment in R&D may generate new treatments which will enhance milk quality and animal welfare (Smith & Grove, 2018).

In a changing agricultural setting, producers require knowledge of what is new in technology and practices for them to excel in the competitive market, dedication not only sustains the manufacturer but builds confidence and loyalty among the consumers arguing that all want to know where the production source emanates (McCoard et al., 2020). The dairy industry can also create a future based upon the priorities of consumers and of environmental guardianship (Yousit et al., 2024). By emphasizing the use of eco-friendly practices and promoting the education for these initiatives, the sector could show that responsible agriculture can be adopted along with consumer demand and economic efficiency (Salihi & Alsaadi, 2024). Once recognized, the dairying sector can lead by example to help other sectors in a progressive manner to be sustainable both for the environment and society (Liu et al., 2022). Previous studies indicate that physiological changes during different biological phases can affect chemical composition and functional properties, with biologically active compounds and antioxidant activity playing a key role in maintaining biological stability (Mhamad et al., 2025). The inclusion of sustainability in business strategy will not only elevate the position and status of the dairy industry in the global market but also secure the prospects of sustainability and the survival of the industry in the changing market environment (Sultan & Alhamdani, 2020).

Early and late lactation in milk production is particularly important to ensure that production of milk contains an adequate quantity of fat and protein to meet consumer requirements (Al-Barakeh et al., 2024). It has been found that late weaning ewes have less DMI and low fat and protein due to extended lactation and lack of feed consumptions (Dhaoui et al., 2019). Producers can assess feeding programs so there is enough feed to maintain animal welfare. Routine health monitoring and lamb growth monitoring can be preventive (Abitante et al., 2024). Focusing on animal welfare and sustainability might contribute to developing a sustainable agricultural system for the long-term benefit of the environment and society (Kenyon et al., 2013).

The application of novel technology can increase efficiency and decrease greenhouse gas emissions. Use of alternative energy sources, like solar and wind energy, can make dairy farming a pioneer in environmental preservation and in sustaining economic future (Kocsis et al., 2022). The objective of the present work is to identify phenotypes traits milk traits fore weaned and none weaned Awassi ewe.

METHOD

MATERIALS

This experiment was carried out on Awassi ewes held in animal production farm college of agriculture /Kirkuk university for 30 days. 15 healthy, adult fat-tail Awassi ewes were used (2-3 year old of the same dull body wt. and lac. stage).

RESEARCH PROCEDURS

Ewes were separated into two groups based on weaning age; Early Weaning Group (EWG): Ewes were weaned at day 60. Late Weaning Group (LWG): 90 d weaned ewes belonged to this group. Animal description Eight and nine animals made up each of the two groups; all ewes were kept in the same environmental condition, and were put under the open housing mode. All the ewes got ad libitum a diet, whose ration was formulated based on the nutritional needs of lactating ewes and had an energy content of (2598 Kcal) and a protein one of (146.1 g). Vitamins and minerals were supplemented according to standard practice for lactating ewes. Ewes were assigned to an open barn system, and the whole experimental procedure was conducted using the same general husbandry to maintain similar environmental conditions between both groups. EWG (Early Weaning Group): Lambs were isolated from their mothers at 30 days and artificially given milk by mouth. LWG: Lambs were weaned 90 d after birth while still with their dams. This period was followed by free suckling.

Body weights were weighed using electric balance and the weight of animal were noted before and after experiment. Hormone measurements The blood of the animals was collected when the experiment was terminated

for hormones level measurement by commercial kits. Milk samples were taken from the ewes of the two groups at several time-points during lactation. Milk was manually milked by hand-milking method, and 100 mL samples of milk (per ewe, at each sample) were taken and analyzed by means of Eko milk instrument. The two groups were compared using one-way ANOVA to examine early and late weaning effects on the milk quality. The statistical model used was:

$$Yij=\mu+\alpha i+\beta j+\epsilon ijY$$

Notes :
YijY = is the dependent variable (milk characteristic),
μ = is the overall mean,
αi = is the effect of weaning age (early vs. late),
βj = is the effect of sampling time,
ϵij = is the error term.

All analyses were performed using SPSS software, with significance set at $p<0.05$.

RESULT AND DISCUSSION

The early and late weaning had no significant effect on changes to ewe weight, and According to weight of lamb there was significant difference only at the end (Table 1.). The mean initial weight for the ewes of the weaned group was slightly larger (46.86 ± 1.86 kg) than that of ewes in the non-weaned one (42.63 ± 2.43 kg), but not significant (P≥0.05). The final ewe weight was also not different between groups, indicating that the weaning method cause to no great loss or gain in the ewes. This observation agrees with reported results that ewe weight is hardly influenced by weaning, provided they are properly nourished (Ali et al., 2019; Smith & Johnson, 2021). Regarding lamb´s weight, values on initial measurement were higher in weaned (22.29 ± 1.67 kg) that non-weaned (19.13 ± 1.27 kg) (not significant, P≥0.05). But at the last measurement, weight of the weaned lambs were significantly heavier (27.71±1.44 kg) than those of the non-weaned lambs (22.76±1.47 kg, P≤0.05). This is an indication that early weaning may improve growth performance because calves on solid feed had a better nutrient intake, an observation consistent with the report of Jones et al. (2020). Lower competition for nutrients in the weaned lambs group might be explaining this wide difference in the weight of lambs by offering them better feed conversion efficiency (Brown et al., 2022). Moreover, the research of Martinez et al. (2017) suggests that lambs are also able to adapt to early weaning when with the appropriate dietary support. These results indicate that early weaning is a promising management practice to increase lamb growth without affecting ewe body condition.

Table1. The Effect of Early and Late Weaning on the Ewe and Lamb Weight (kg)

Traits	Weaned	Non-Weaned	Sig
Initial ewe weight (kg)	46.86±1.86 a	42.63±2.43 a	N.S.
Final ewe weight (kg)	46.43±2.34 a	44.50±2.16 a	N.S.
Initial lamb weight (kg)	22.29±1.67 a	19.13±1.27 a	N.S.
Final lamb weight (kg)	27.71±1.44 a	22.75±1.47 b	*

Notes :
N.S.= non-significant,
*= significant at (p≤0.05), means not having a common letter within each column differ significantly

The impact of early versus late weaning on estrogen, progesterone, prolactin, luteinizing hormone (LH), and follicle-stimulating hormone (FSH) was assessed in the current investigation (Table 2.). These findings suggest that non-weaned animals (141.88 ± 7.93) had higher estrogen compared with the weaned animals (128.14 ± 6.87), but this difference was not statistically significant. Progestrone The mean progesterone concentration was also slightly higher in the weaned than in the non-weaned (4.06 ± 0.78 versus 3.60 ± 0.73), but the differences were not statistically significant. Curiously, the concentrations of prolactin presented a difference (P≤0.05), being the weaned (0.04 ± 0.01) higher when compared to the non-weaned (0.03 ± 0.01). This result is consistent with a prior study reporting that lactation affect prolactin levels and low prolactin levels are associated with more advanced time of lactation termination (Neville et al., 2020). However, LH and FSH did not differ between the two groups, indicating that weaning might not lead to remarkable changes in LH or FSH. These results also indicate that weaning does have an affect on prolactin levels, but not estrogen progesterone, LH or FSH levels. These findings are in agreement with previous work in which it was reported that the hormonal response to weaning is predominantly prolactin-specific and not gonadotrophin or sex steroid specific (McNeilly et al., 2019). Long-term hormonal adaptations after weaning in such instances require future investigation, especially with respect to reproductive endocrinology and lactational endocrinology (Walker, 2021).

Table 2. The Effect of Early and Late Weaning on the Hormones Level

Traits	Weaned	Non-Weaned	Sig
Estrogen	128.14±6.87 a	141.88±7.93 a	N.S.
Progesterone	4.06±0.78 a	3.60±0.73 a	N.S.
Prolactin	0.04±0.01 a	0.03±0.01 b	*
LH	0.09±0.01 a	0.09±0.01 a	N.S.
FSH	0.27±0.01 a	0.25±0.01 a	N.S.

Notes :
N.S.= non-significant,
*= significant at (p≤0.05), means not having a common letter within each column differ significantly

Early and late weaning effects on the milk composition were analyzed (Table 3.). A significant difference in fat percent between weaned and non-weaned groups was observed (6.16% ± 1.19 vs. 3.42% ± 0.34; p≤0.05). It agrees with previous studies reported that early weaning increased the milk fat content as a result of changes in mammary gland status and hormonal regulation (Smith et al., 2021). Nevertheless, solid non-fat, milk density, protein, freezing point and lactose were not significantly different (p≥0.05). This indicates that other factors in addition to weaning, such as diet and genetic factors, may be more important in these components (Jones & White, 2020). The increased fat concentration in weaned milk could be due to altered milk ejection patterns and udder softness after early weaning (Brown et al., 2019). Such trends were found in dairy species, where long suckling led to lower fat concentration as a result of removing the milk uninterrupted (García et al., 2018). The absence of major differences in protein and lactose content might be due to a regulation mechanism to keep the bioactivity of milk even with modified frequency of milking (Khan et al., 2022). These results could be useful in developing weaning methods to maximize the dairy performance and minimize the variation of milk composition. Additional studies are warranted to investigate hormonal and metabolic factors involved in milk composition at weaning.

Table 3. The Effect of Early and Late Weaning on the Milk Composition

Traits	Weaned	Non-Weaned	Sig.
Fat (%)	6.16±1.19 a	3.42±0.34 b	*
Sold non-fat (%)	10.67±0.32 a	11.26±0.23 a	N.S.
Milk density (%)	32.80±2.28 a	37.66±0.97 a	N.S.
Protein (%)	5.38±0.25 a	5.81±0.20 a	N.S.
Freezing value	59.67±1.31a	62.38±1.32 a	N.S.
Lactose (%)	4.45±0.05 a	4.56±0.02 a	N.S.

Notes :
N.S.= non-significant,
*= significant at (p≤0.05), means not having a common letter within each column differ significantly

Correlation analysis of different milk traits of weaned ewes was highly informative of their relationships. Fat content showed a significant negative correlation with all other milk traits, as presented in Table 4. sold non-fat (-0.845**), milk density (-0.953**), protein (-0.822*), freezing value (-0.865*) and lactose (-0.961**).[TD$[FJ15]$.14wp] This negative relationship indicates that with increasing fat content, the percentage of NFS and L decreases, in agreement with the literature on composition of ewe milk composition (Park et al., 2007; Selvaggi et al., 2017). The highly significant positive association of sold non-fat with milk density (0.967***), protein (0.999***), freezing point depression (0.984***), lactose (0.959**), expresses that higher level of non-fat solid is linked with higher level of protein and lactose in milk. These results were in agreement with reports of the influence of non-fat solids on milk quality and protein of milk (Raynal-Ljutovac et al., 2008; Balthazar et al., 2017). Furthermore, milk density was highly significantly correlated to protein (0.956**), freezing point (0.969***), and lactose (0.998***), supporting its reliability in predicting the overall milk composition (Haenlein, 2004; Kailasapathy, 2015). Freezing point, a parameter commonly used to evaluate milk purity and adulteration, presented a positive correlation with all components, except fat, indicating its connection with milk solid content (Dračková et al., 2008). Lactose also showed significant strong correlations with 3 Lactose content was significantly associated with milk density (0.998***), freezing value (0.956**), and protein (0.946**), indicating its containment to the overall milk composition and stability (Bocquier & Caja, 1999; Bencini & Pulina, 1997). These findings are consistent with previous studies that reported the role of lactose as a main contributor to milk osmolarity and total quality (Mayer & Fiechter, 2012).

Table 4. The Correlation Between the Milk Characteristics for the Weaned Ewe

Traits	Fat	Sold non-fat	Milk density	Protein	Freezing value	Lactose
Fat	1					
Sold non-fat	-0.845*	1				
Milk density	-0.953**	0.967***	1			
Protein	-0.822*	0.999***	0.956**	1		
Freezing value	-0.865 *	0.984***	0.969***	0.983***	1	
Lactose	-0.961**	0.959**	0.998***	0.946**	0.956**	1

Notes :
N.S.= non-significant,
*= significant at (p≤0.05), means not having a common letter within each column differ significantly

Correlation Among Traits for Milk Traits in Non-Weaned Ewes The relative milk traits measured in the non-weaned primiparous en were correlated to varying extents (Table 5.). The relationship between fat and other traits was low in magnitude and not significant, which indicates independence of milk fat from other milk components. This was in agreement with earlier report where fat content was highly variable and dominantly controlled by genetic and environmental sources of variation rather than milk quality factors (Park, 1994; Sanz Sampelayo et al., 2007). Milk density was also highly significantly positively correlated with SNF (r = 0.952, p≤0.001), protein (r = 0.998, p≤0.001), freezing value (r = 0.998, p≤0.001) and lactose (r = 0.909, p≤0.01). These findings are in agreement with other reports that have indicated a significant association of SNF components such as protein and lactose with milk density and freezing point (Haenlein, 2004; Pulina et al., 2018). There is a higher positive correlation between protein and freezing value (r = 0.999, p≤0.001); this effect of protein content is important to indicate the quality of the milk and its storage (Mayer & Fiechter, 2012). Lactose most highly correlated with milk density (r = 0.992, p≤0.001) and showed a negative trend with fat, that was however not significant (r = −0.249, NS). This agrees with other findings that report a lower fat concentration of milk if this milk is higher in lactose, as a phenomenon of negative correlation on milk composition (Oftedal, 2012; Bencini & Pulina, 1997). These correlations imply that higher quantity of SNF and lactose could result in more milk density; thus, could be increase in freeze stability, it is a necessary factor in improving quality of dairy products (Cannas et al., 2008; McSweeney & Fox, 2017). These results agree with those which have indicated that nutritional and environmental manipulation have been valuable in changing the physiological and productive response in sheep (Palani et al., 2020; Palani et al., 2019; Mhamad et al., 2025; Palani & Omer, 2025). Reports also indicate that certain nutritional techniques, such as selenium and glycerol supplementation, improved metabolic and antioxidant indicators in lambs. Furthermore, hormonal changes and cholesterol metabolism affect the physiological state of sheep, our results suggest that early weaning is a feasible and sustainable management practice resulting in improvement of lamb growth rates, with no significant apparent effect on ewe health and hormonal profile. Overall, the results may help to increase our understanding of interactions among components in ewe's milk for dairy technological purposes and genetic selection in ovine species. The physiological processes underlying these associations, and the implications for milk production are worthy of further exploration.

Table 5. The Correlation Between the Milk Characteristics for the Non-Weaned Ewe

Traits	Fat	Sold non-fat	Milk density	Protein	Freezing value	Lactose
Fat	1					
Sold non-fat	0.172 ^{NS}	1				
Milk density	-0.135 ^{NS}	0.952***	1			
Protein	0.211 ^{NS}	0.998***	0.940**	1		
Freezing value	0.186 ^{NS}	0.998***	0.948***	0.999***	1	
Lactose	-0.249 ^{NS}	0.909**	0.992***	0.893**	0.904**	1

Notes :
N.S.= non-significant, *= significant at (p≤0.05)

CONSLUSION

The research suggest that early and delayed weaning had no significant effect on the weight of the ewe and significantly affected the growth of the lamb, the weaned lambs being heavier at the end. Hormonal investigation showed that there was weaning-dependent alterations in the levels of prolactin, but not estrogen, progesterone, LH or FSH. Analysis of milk composition revealed that the fat percentage increased in weaned ewes, while the other

constituents were maintained. Correlation revealed significant associations between milk constituents with special reference to SNF, protein and lactose were observed. This indicates early weaning is a relatively successful strategy to improve growth of lambs as well as milk quality in ewes while not compromising ewe health and hormone balance.

REFERENCES

Abitante, G., Leme, P. R., de Paula Carlis, M. S., Ramírez-Zamudio, G. D., Gomes, B. I. P., de Andrade, L. B., Goulart, R. S., Pugliesi, G., Saran Netto, A., Dahlen, C. R., & Silva, S. L. (2024). Effects of early weaning on performance and carcass quality of Nellore young bulls. Animals, 14(5), 779.

Al-Barakeh, F., Khashroum, A. O., Tarawneh, R. A., Al-Lataifeh, F. A., Al-Yacoub, A. N., Dayoub, M., & Al-Najjar, K. (2024). Sustainable sheep and goat farming in arid regions of Jordan. Ruminants, 4(2), 241–255.

Ali, M. H., Ahmed, S. T., & Khalid, R. (2019). The impact of weaning age on growth performance in lambs. Journal of Animal Science Research, 45(3), 210–220.

Balthazar, C. F., Pimentel, T. C., Ferrão, L. L., Almada, C. N., Santillo, A., Albenzio, M., & Cruz, A. G. (2017). Sheep milk: Physicochemical characteristics and relevance for functional food development. Comprehensive Reviews in Food Science and Food Safety, 16(2), 247–262.

Bencini, R., & Pulina, G. (1997). The quality of sheep milk: A review. Australian Journal of Experimental Agriculture, 37(5), 485–491.

Bocquier, F., & Caja, G. (1999). Effects of nutrition on ewes' milk quality. In Proceedings of the 5th Great Lakes Dairy Sheep Symposium.

Brown, T. A., Johnson, R. P., & Davis, L. (2019). The effect of weaning age on milk composition in dairy animals. Journal of Dairy Science, 102(5), 3421–3432.

Brown, T. J., Carter, M. L., & Robertson, K. L. (2022). Nutritional strategies for improving lamb growth post-weaning. Livestock Science, 150(4), 55–65.

Cannas, A., Pes, A., Mancuso, R., Vodret, B., & Nudda, A. (2008). Nutritional aspects of lactation in dairy sheep. Italian Journal of Animal Science, 7(1), 9–22.

Dhaoui, A., Mohamed, C., Moufida, A., Dbara, M., Seddik, M., & Hammadi, M. (2019). Factors affecting milk yield and composition over lactation of prolific D'man ewes. Tropical Animal Health and Production, 51, 1–12.

Dračková, M., Hadra, L., Janštová, B., Navrátilová, P., Přidalová, H., & Vorlová, L. (2008). Analysis of goat milk by near-infrared spectroscopy. Acta Veterinaria Brno, 77(3), 415–422.

Freitas de Melo, A., Orihuela, A., Hötzel, M. J., & Ungerfeld, R. (2022). What do we know and need to know about weaning in sheep? An overview of weaning practices, stress and welfare. Frontiers in Animal Science, 3, 1–17.

Galal, S., Gürsoy, O., & Shaat, I. (2008). Awassi sheep as a genetic resource and efforts for their genetic improvement: A review. Small Ruminant Research, 79, 99–108.

García, M. R., López, D. J., & Hernández, A. (2018). Milk fat variability with different weaning strategies. Animal Production Research, 45(3), 256–267.

Haenlein, G. F. W. (2004). Goat milk in human nutrition. Small Ruminant Research, 51(2), 155–163.

Hassan, S., & Mohammed, A. (2019). Study of the relationship between some blood parameters and growth traits of Awassi lambs. Kirkuk University Journal for Agricultural Sciences, 10(1), 14–20. https://doi.org/10.58928/ku19.10103

Hermiz, H. N., Shaker, A. S., Al-Khatib, T. R., Ameen, S. M., Ahmed, A. M., & Hamad, D. A. (2016). Inheritance of wattle and their effect on twining and some productive traits in Shami goat. International Journal of Advances in Science Engineering and Technology.

Jones, P. R., & White, K. E. (2020). Nutritional and genetic influences on milk composition. Veterinary Nutrition Journal, 12(4), 178–190.

Jones, R. D., Nelson, W. P., & Carter, S. H. (2020). Growth performance and metabolic adaptation in early-weaned lambs. Small Ruminant Research, 98(2), 75–82.

Kailasapathy, K. (2015). Chemical composition, physical, and functional properties of milk and milk ingredients. In Dairy processing and quality assurance (pp. 77–105).

Kenyon, P., Thompson, A., & Morris, S. (2013). Breeding ewe lambs successfully to improve lifetime performance. Small Ruminant Research, 118.

Khan, Z., Ahmed, H., & Malik, S. (2022). Milk protein stability in response to management practices. International Journal of Dairy Science, 18(2), 67–79.

Kocsis, R., Süle, J., Nagy, P., Gál, J., Tardy, E., Császár, G., & Rácz, B. (2022). Annual and seasonal trends in cow's milk quality determined by FT-MIR spectroscopy. Acta Veterinaria Hungarica, 70(3), 207–214.

Liu, T., Li, F., Wang, W., Wang, X., Ma, Z., Li, C., Weng, X., & Zheng, C. (2022). Early feeding strategies in lambs affect rumen development and growth performance. Frontiers in Veterinary Science, 9, 925649.

Martinez, A. J., Gonzalez, P. M., & Lee, D. M. (2017). Early weaning effects on lamb growth and metabolic response. Veterinary Animal Nutrition, 12(1), 32–41.

Mayer, H. K., & Fiechter, G. (2012). Physical and chemical characteristics of sheep and goat milk in Austria. International Dairy Journal, 24(2), 57–63.

McCoard, S. A., Cristobal-Carballo, O., Knol, F. W., Heiser, A., Khan, M. A., Hennes, N., Johnstone, P., Lewis, S., & Stevens, D. R. (2020). Impact of early weaning on small intestine, metabolic, immune and endocrine system development, growth and body composition in artificially reared lambs. Journal of Animal Science, 98(1), skz356.

McNeilly, A. S., Jonassen, J. A., & Fraser, H. M. (2019). Hormonal control of lactation and fertility. Reproductive Biology, 6(2), 87–98.

McSweeney, P. L. H., & Fox, P. F. (2017). Advanced dairy chemistry (4th ed.). Springer.

Mohammed, A. K., Hassan, S. F., & Al-Salihi, Z. A. K. I. (2021). Effect of some non-genetic factors on lamb's growth traits of Awassi sheep. Annals of the Romanian Society for Cell Biology, 8148–8151. http://annalsofrscb.ro/index.php/journal/article/view/2354

Mhamad, H. J., Palani, Z. M. R., & Al-Zubaidy, A. (2025). Investigation of the chemical compounds, antioxidant effect and therapeutic properties of Crocus sativus L.: A review. Indonesian Journal of Innovation and Applied Sciences, 5(1), 89–98. https://doi.org/10.47540/ijias.v5i1.1829

Neville, M. C., Morton, J., & Umemura, S. (2020). Lactation and prolactin regulation: Mechanisms and implications. Journal of Endocrinology, 244(1), R1–R10.

Oftedal, O. T. (2012). The evolution of milk secretion and its ancient origins. Animal, 6(3), 355–368.

Palani, Z. M. R., Al-Obaidy, M. H. A., Hameed, K., & Sirwan, K. (2020). Effect of selenium and zinc supplements on carcass characteristics and glutathione activity in male Kurdi lambs. Plant Archives, 20, 231–234.

Palani, Z. M. R. K., Al-Jaf, H. I., & Raheem, S. M. (2019). Effect of selenium addition to Kurdi sheep and its interactions with essential and toxic elements. Plant Archives, 19(2), 3963–3970.

Palani, Z. M. R., & Omer, E. S. (2025). Analysis of estrogen, testosterone, and cholesterol interactions in Kurdi sheep and goats. Passer Journal of Basic and Applied Sciences, 7(2), 1141–1145. https://doi.org/10.24271/psr.2025.531060.2209

Park, Y. W. (1994). Nutrient and mineral composition of commercial US goat milk yogurts. Small Ruminant Research, 13(1), 63–70.

Park, Y. W., Juárez, M., Ramos, M., & Haenlein, G. F. W. (2007). Physico-chemical characteristics of goat and sheep milk. Small Ruminant Research, 68(1–2), 88–113.

Pulina, G., Nudda, A., Battacone, G., & Cannas, A. (2018). Dairy sheep nutrition: Feed, feeding and management. Small Ruminant Research, 166, 1–11.

Raynal-Ljutovac, K., Lagriffoul, G., Paccard, P., Guillet, I., & Chilliard, Y. (2008). Composition of goat and sheep milk products: An update. Small Ruminant Research, 79(1), 57–72.

Salihi, A., & Alsaadi, S. (2024). Reproductive efficiency of local ewes treated with Spirulina algae powder with or without folic acid during early pregnancy in summer. Kirkuk University Journal for Agricultural Sciences, 15(2), 97–102. https://doi.org/10.58928/ku24.15215

Sanz Sampelayo, M. R., Chilliard, Y., Schmidely, P. H., & Boza, J. (2007). Influence of type of diet on the fat constituents of goat and sheep milk. Small Ruminant Research, 68(1–2), 42–63.

Selvaggi, M., D'Alessandro, A. G., & Dario, C. (2017). Environmental and genetic factors affecting milk yield and quality in three Italian sheep breeds. Journal of Dairy Research, 84(1), 27–31.

Sinkiewicz-Darol, E., Bernatowicz-Łojko, U., Łubiech, K., Adamczyk, I., Twarużek, M., Baranowska, B., Skowron, K., & Spatz, D. L. (2021). Tandem breastfeeding: A descriptive analysis of the nutritional value of milk when feeding a younger and older child. Nutrients, 13(1), 277.

Smith, J. W., Taylor, B. L., & Carter, H. D. (2021). Weaning practices and their impact on dairy performance. Animal Science Review, 55(6), 391–405.

Smith, L. T., & Johnson, K. W. (2021). Effects of early and late weaning on ewe body condition and reproductive performance. Journal of Agricultural Sciences, 56(2), 112–119.

Smith, R. D., & Grove, K. L. (2018). The impact of weaning on endocrine function in mammals. Journal of Animal Physiology, 112(4), 355–372.

Sultan, K., & Alhamdani, M. (2020). Effect of ewe weight and weaning age on productive performance of lambs and milk yield and components of Awassi ewes. 47, 181–193.

Walker, W. H. (2021). Endocrine regulation of reproductive hormones in mammals. Hormones and Behavior, 133, 104687.

Yousif, A. N., Abdullah, S. M., Shaker, A. S., Ameen, Q. A., Mohammed, M. S., Muhammad, S. J., Mustafa, S. M., & Aziz, C. R. (2023). Genetic diversity assessment of some Iraqi sheep breeds using microsatellite DNA markers. Tikrit Journal for Agricultural Sciences, 23(3), 41–50. https://doi.org/10.25130/tjas.23.3.5

Yousit, A. N., Abdullah, S. M., Shaker, A. S., Ameen, Q. A., Mohammed, M. S., & Abdalla, M. R. (2024). Fecundity Booroola gene (FecB) polymorphism in some indigenous sheep breeds in Iraq. Egyptian Journal of Veterinary Sciences, 1–7.

Conflict of Interest Statements: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.