Research Article

Effect of Synergistic Interaction Cobalt and Vitamin B12 on Carcass Traits, Physical and Chemical Parameters of Iraqi Lambs

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Abstract | This study aimed to investigate the role of cobalt and vitamin B_{12} as individually or synergistically on assessing carcass characteristics and physical and chemical properties of Awassi lamb meat. The experiment involved twenty homogeneous of Awassi lambs were selected to minimize individual differences among for experimental units. The lambs were randomly assigned to four experimental groups and with each group consisting of five lambs. The first group (control) received a standard saline solution orally containing no cobalt or vitamin B_{12}. The second group was daily administered 1.5 mg of cobalt per head . The third group received 250 µg of vitamin B_{12} per head. Meanwhile, the fourth group was treated with a combination of cobalt and vitamin B_{12} at the same concentrations used for the second and third groups. The results revealed a significant improvement in weights of hot carcass and dressing percentages that calculated by using two methods: one based on live weight and another on empty body weight at slaughter. The animals were receiving cobalt, vitamin B_{12} or combination of both exhibited better results compared to the control group. Furthermore, significant improvements were observed in weights of thighs, back, shoulders, ribs, neck, and flank. This enhancements were consistently observed for treatments involving cobalt, vitamin B_{12} or their combination. Regarding the physical inventory and chemical composition of muscle samples collected from the three-rib segment (9th–11th ribs) there was a notable superiority in percentages of muscle and bone for lambs treated with cobalt or vitamin B_{12} compared to the control group. Also,moisture and crude protein percentages in this region were higher significantly for treated groups. Conversely, there was a marked reduction in crude fat (physical inventory) and ether extract (chemical composition) for the three-ribs section from the last three treatment groups compared to the control group. The findings highlight there was positive effects of cobalt and vitamin B_{12} supplementation alone or combined on improving carcass traits and meat quality of Awassi lambs while reducing undesirable fat content in specific muscle regions.

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Introduction

In light of growing global nutritional trends and the challenges associated with improving of animal productivity and meat quality. The study of nutritional factors that influence on growth, animal performance and product quality is recognized as a fundamental aspect of achieving food security, particularly in case of sheep mutton. The Research emphasizes as critical roles of cobalt (Co) and vitamin B_{12} for essential nutrients involved in various metabolic processes, such as protein synthesis and muscle development which directly impact on carcass yield and meat quality of sheep meat (Ramiro *et al*., 2020; Abou-Zeina *et al*., 2008; Abbas *et al*., 2023). This study explores the nutritional interplay between cobalt and vitamin B_{12} and emphasizing their closely linked functions. Scientific evidence points to nonlinear complementary relationship between these two elements in the metabolic processes of ruminants. Cobalt, an indispensable trace element, constitutes the core component of the vitamin B_{12} molecular structure, defining its levels in animal tissues. Iraq depends heavily on this livestock as a primary source of animal protein and income for rural households (NRC, 2007). However, deficiencies for essential nutrients such as cobalt and vitamin B_{12} can markedly decrease nutritional efficiency, fattening potential and growth rates of lambs, negatively affecting carcass quality and economic outcomes (Yadav and Choudhary, 2021; Bibi *et al*., 2025). Previous studies underline there were significance of cobalt as an integral synthesis component for vitamin B12 which acts as a cofactor for numerous enzymatic reactions linked to amino acid and lipid metabolism (Szymanski *et al*., 2023). As ruminants rely on microbial synthesis of vitamin B_{12} within their rumen, sufficient dietary cobalt intake is crucial for ensuring adequate production of this vital nutrient (Smith *et al*., 2020; Farooq et. al., 2023). Kumar *et al*. (2019) who demonstrated in their studied that supplementing cobalt with feed which leads to significantly enhanced on growth rates and fattening efficiency. This supplementation resulted in a notable increase in protein tissue deposition across muscles, reaffirming cobalt's key role in optimizing both the quantity and quality of meat production.

This research indicates that vitamin B_{12} is not only essential for various metabolic processes but it plays direct role in improving meat quality by enhancing fatty acid synthesis and increasing resistance for oxidative stress (Li *et al*., 2021; Kanwal et. al., 2022). However, most existing studies have examined the individual effects of either cobalt or vitamin B_{12} with limited exploration of their combined interaction and its impact on sheep meat quality particularly in Iraq. This study addresses this research gap by investigating synergistic effects of cobalt and vitamin B_{12} on the performance and meat quality of Iraqi sheep. It focuses on evaluating carcass parameters and key meat quality attributes such as muscle fat content which significantly influence consumer acceptability, palatability and overall market demand. The findings from this research aim to provide practical insights for sheep farmers in Iraq who offering guidance on optimal supplementation levels of cobalt and vitamin B_{12} in animal feed to enhance productivity and improve meat production standards. Additionally, this study seeks to contribute to a deeper scientific understanding of how the interaction between these two nutrients affects growth physiology and carcass quality, paving the way for further advances in ruminant nutrition.

The main goal was to investigate the combined effect of cobalt and vitamin B_{12} on carcass characteristics and the physicochemical attributes of Awassi lamb meat.

Materials and Methods

This practical application was designed to test our oral feeding of Awassi lambs with doses of cobalt, vitamin B_{12}, and their combination. The goal was to determine effectiveness of two elements and their impact on carcass weight and quality parameters. All experimental lambs received an identical diet of concentrated rations with similar levels of metabolizable energy and crude protein.

Experimental lambs

Awassi sheep were acquired from livestock markets specializing in the sale of cows and sheep located in the eastern part of Mosul. The lambs were approximately equal in age, between 3-4 months with their initial weights ranging between 21.40-21.90 kg. Twenty male Awassi lambs were subjected to an experimental feeding period lasting approximately three consecutive months at the Animal Production Department's Animal Production Station in the College of Agriculture and Forestry at the University of Mosul. This was preceded for two-week preliminary period, known as the introductory period. This study explores the nutritional interaction between cobalt and vitamin B12 and focusing their interconnected functions. The lambs were divided into four small pens , semi-enclosed compartments containing mineral feeders and plastic water troughs to ensure clean and pure water. The floor of the rearing hall was treated with cement concrete and sloped slightly outward to facilitate cleaning and disposal of water resulting from animal urine or cleaning water.

Experiment plan

This experiment involved randomly distributing the lambs into four groups were similar in live weights (Figure 1) after completing the initial introductory period (14 days). The treatments were applied according to as follows:

1. First treatment (Standard Feed): This included five lambs fed normal saline to ensure the lambs received the same environmental conditions as the other treatments.
2. Second treatment: It is included five lambs fed cobalt at a rate of 1.5 mg/head/day.
3. Third treatment: The lambs were daily dose of 250 micrograms of vitamin B_{12} per head.
4. Fourth treatment: The lambs were given 1.5 mg of cobalt and 250 micrograms of vitamin B_{12}/ head/day. All lambs were subjected for statistical analysis to ensure weight homogeneity, ensuring weight equivalence between the groups, with no significant differences among treatment groups from the start of the experiment.

Experimental treatments

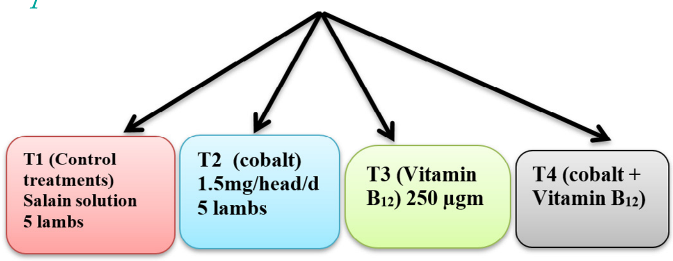

Figure 1: *Design of the experimental treatments.*

The nutritional phase

All lambs were introduced into the experimental environment from the first day of the experiment and gradually acclimatized to standard concentrated feed. This ration was composed of the following ingredients: Crushed black barley (62.5%), wheat bran (20%), soybean meal (10%), wheat straw (5%), salts (1%), limestone (1%), and sodium bicarbonate (0.5%). To amount of feed concentrate consumed by the lambs was increased gradually for each day. I followed the group feeding method for all animals through daily feeding. The lambs were fed twice daily: once at 7:00 am and again at 5:00 pm. To determined feed consumption in the feeders for each group was collected and weighed using a precision feed scale each morning before to introduce new feeding session. The water troughs were cleaned thoroughly every day and filled with fresh, clean water sourced from field runoff. Additionally, as part of their daily working routine, all lambs were grazing on green pastures near the livestock fields for one hour in the morning and evening. This was done for two purposes: first, to obtain green fodder and second to practice as physical exercise to promote digestive and circulatory health and reduce the risk of bloating and indigestion. Also, the green roughage enriched their diet with vitamin A. While exposure to sunlight they were received vitamin D_3 and helped eliminate fungi from their bodies. Before starting the experimental phase, the weights of lambs were measured during the pre-lamb period to estimate the initial weight of lambs at the beginning of the experiment and then followed random allocation into four groups of similar live weight. Throughout the experiment regular biometric monitoring was conducted biweekly before morning feeding sessions and continuing until final of the study.

The slaughtering operations and estimating carcass parameters

According to the protocol adopted in this study after the practical period of fattening lambs, the animals were deprived of food for twelve consecutive hours, with water provided to them to empty their digestive systems and intestines before the slaughtering process. To evaluate the quality of the slaughtered meat and fattening efficiency, the sheep slaughtering process was carried out on the last day of the experiment. The weight of the hot carcass was recorded and cut into several primary (thigh, rump, ribs, shoulders) and secondary (neck, chest, flank, forearm) sections, according to the carcass cutting methods described in the study by Abdul Rahman *et al.* (2012). The weights were then recorded according to those described by Netto *et al.* (2013). As for calculating the net weight percentage, it was calculated in two ways: the first is based on the hot weight of the carcass, and the second is based on the empty body weight (Al-Jalili *et al.*, 1985).

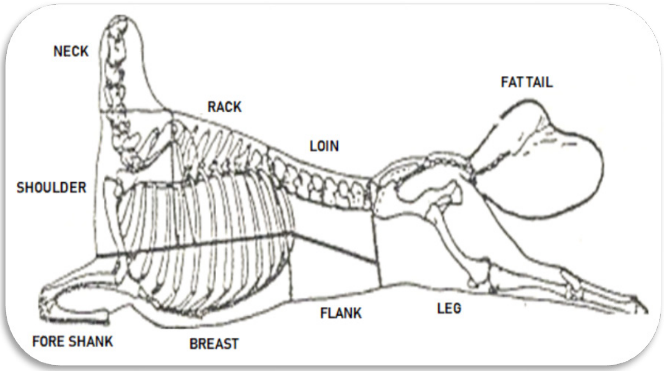

Figure 2: *The divisions of slaughtered cuts of Awassi sheep according to the cutting explained by Abdul Rahman and others (2012).*

Physical analysis of the third ribs region (9-10-11)

To conduct the physical inventory for the three ribs segments (9-10-11) were removed from the left side of the carcasses. All segments were weighed, and the weights were recorded under the lamb sequence. They were then physically separated to determine their composition (bone, muscle, and fat) using specialized dissection tools (medical blades). All connective tissue was considered part of the bone. The three muscle, bone and fat samples were then weighed using a highly sensitive and accurate four-level electronic balance. The percentages were calculated by dividing the weight of the sample relative to the total weight of the original three rib segments and multiplying by 100. The meat and fat samples were then minced using an electric mincer with a 3 mm diameter mesh. The mincing process was repeated twice using the same electric mincer to ensure the homogeneity of the muscle-fat mixture. The samples were stored in the refrigerator for chemical analysis.

Chemical analysis of the third rib region (9-10-11)

The chemical analysis of the samples (muscle-fat mixtures) was carried out according to the protocol followed by the Official Organization of Analytical Chemists (AOAC, 2019).The chemical content of the samples was determined using standard methods, including determining moisture, ash, and crude protein content using the Kjeldahle method and crude fat content using the Schuss let method.

Statistical analysis of the data

According to Al-Zubaidy and Al-Falahy (2016) the statistical analyses were conducted using a completely randomized design (CRD) to determine the effect of cobalt, vitamin B12 and their combination on the studied traits and comparisons of significant differences were performed by using the Duncan test (1955) using the SAS statistical program (SAS, 2018).

Results and Discussion

Carcass corpse

From the examination of this results showed the carcass weight measurements (Table 1) there was highly statistically significant increase (P≤ 0.01) in the average of hot carcass weights were favoring for the second (cobalt), third (vitamin B_{12}) and fourth (cobalt and vitamin B_{12} mixture) groups when compared to the control group (Table 1). The average of hot carcass weights were 20.922, 24.224, 25.256, and 26.977 kg respectively for the four groups. Also, the results showed a significant improvement in the average of hot carcass weights for the last three experimental groups (Table 1). This is attributed to the significant increase for the final body weight and empty weight of these groups compared to the first group. On the other hand, the reason behind this improvement may be due to increased efficiency of rumen bacterial activity of lambs receiving cobalt and vitamin B12 which contributed to improved nutrient absorption and metabolism within body tissues to thus increasing in hot carcass weights. Additionally, the reason for the increased carcass weights may be related to the presence of a strong positive correlation at significance level of (0.95) between the final body weight and hot carcass weights of lambs (Al-Taie and Almahdawi, 2021). Regarding the results related to the clearance ratios which were calculated using two methods. The first based on live weight and the second based on the empty body weight of lambs. The results showed significant differences (P≤0.05) between the third (vitamin B_{12}) and fourth (vitamin B_{12} with cobalt) treatments when compared to the first (control group) and the second (cobalt). The measurements showed that clearance ratios obtained using by first method were 52.01, 54.81, 57.08, and 57.30%, while the ratios calculated using the second method were 54.22, 55.73, 59.02, and 60.15% for four treatments, respectively. The significant difference observed in clearance ratio values in favor of the experimental treatments is due to the marked increase in the final weights of lambs and carcass weights in the third and fourth treatments which led to a significant increase in the clearance ratios. The results of this study support findings of Al-Joulaq and Almahdawi (2020) who confirmed a significant improvement in values of this trait after treating the lambs with zinc and vitamin E when compared to the control group.

Table 1: *The role of cobalt, vitamin B_{12} or its mixed on some corpse features of local lambs.*

Traits	First treatment (control)	Second treatment (Cobalt)	Third treatment (Vit.B_{12})	Fourth treatment (Cobalt+Vit.B_{12})
Hot carcass weight** (kg)	20.922± 0.69 B	24.224 ± 0.40 B	25.256 ± 0.35AB	26.977 ± 0.67 A
Dressing percentage* according by live body weight (%)	52.01 ± 2.05 B	54.81 ± 1.37 B	57.08 ± 1.32 A	57.30 ± 1.97 A
Dressing percentage* according by empty body weight (%)	54.22 ± 2.10 B	55.73 ± 0.93 AB	59.02 ± 0.48 A	60.15 ± 1.50 A

*NS, Non significant; *Significant differences at 0.05. **High significant at 0.01.*

Table 2: *Effect of cobalt, vitamin B_{12} and its mixture of them on the weight rates of the main and secondary carcass cuts of Awassi lamb.*

Studied traits	Treatment 1 (control)	Treatment 2 (cobalt)	Treatment 3 (Vitamin B_{12})	Treatment 4 (cobalt + Vitamin B_{12})
Thighs weight* (kg)	3.560 ± 0.11 B	3.888 ± 0.43 AB	4.303 ± 0.05 AB	4.418 ± 0.19 A
Loin weight* (kg)	2.841 ± 0.26 B	3.372 ± 0.18 AB	3.524 ± 0.04 AB	3.819 ± 0.26 A
Shoulders weight* (kg)	2.885 ± 0.24 B	3.652 ± 0.44 AB	3.956 ± 0.06 A	4.207 ± 0.10 A
Ribs weight* (kg)*	2.892 ± 0.25 B	3.415 ± 0.12 AB	3.282 ± 0.09 AB	3.540 ± 0.08 A
Neck weight** (kg)	1.348 ± 0.06 B	2.886 ± 0.02 B	2.529 ± 0.06 B	2.579 ± 0.15 A
Chest weight NS (kg)	2.512 ± 0.26 A	2.446 ± 0.10 A	2.734 ± 0.07 A	2.891 ± 0.18 A
Shank weight NS (kg)	1.676 ± 0.34 A	1.136 ± 0.060 A	1.415 ± 0.15 A	1.448 ± 0.02 A
Flank weight* (kg)	0.706 ± 0.05 B	0.807 ± 0.06 AB	0.832 ± 0.02 AB	0.954 ± 0.06 A

*NS Non-significant differences. *Significant differences at 0.05. **Highly significant differences at 0.01.*

Carcass cuts

The results shown in Table 2 suggest significant differences (P≤0.05) in weight values of the primary cuts of the sheep (thighs, back, shoulders, ribs) among four treatments of carcasses sheep. The weight values of the thighs reached 3.560, 3.888, 4.303, 4.418 kg, back 2.841, 3.372, 3.524, 3.819 kg, shoulders 2.885, 3.652, 3.956, 4.207 kg, and ribs reached 2.892, 3.415, 3.282, 3.450 kg according to priority. As for weights of the secondary cuts of carcasses sheep. The results of the statistical analysis (Table 2) revealed highly significant differences in weights of the rump between the last three treatments compared to the first treatment (the control). In another context, the results showed significant differences in weights of the loin between the experimental treatments compared to the control treatment. As for the remaining secondary parts of the carcass cuts, they were not statistically significant as shown in Table 2 between the lambs groups treated with cobalt, vitamin B12 and their mixture compared to the untreated group. The results of neck weight values were 1.348, 2.886, 2.529, 2.579 kg, chest 2.512, 2.446, 2.734, 2.891 kg, forearm 1.676, 1.136, 1.415, 1.448 kg, and flank 0.706, 0.807, 0.832, 0.954 kg for the four treatments in sequence. From the examination of the results of the current practical experiment was observed a significant superiority in the average values in weights of the primary parts of the sheep (thighs, back, shoulders, ribs) in favor of the last three treatments compared to the control group of lambs. This is attributed to the significant superiority of the final weights of the lambs and weights of hot corpse. Moreover, there is a positive and significant correlation between the weights of the primary cuts (thighs, back, ribs, shoulders) that make up the lamb and the final weight of the lambs at slaughter. The values of the correlation coefficients between the weights of the main parts and the final weight were as follows (0.87, 0.43, 0.56, 0.55) and are shown in Table 3. The significant improvement in weights of some secondary carcass cuts such as the neck and forearm can be explained by presence of a significant and positive correlation coefficient between the weights of the neck and flank which constitute the secondary carcass cuts and final weight of the lambs at slaughter. The values of the correlation coefficients for some secondary parts (neck, forearm, flank) of the lambs corpse were (0.81, 0.20, 0.85), respectively (Table 3). The results of this study to support with the findings of Mahmoud *et al.*,(2018) who found significant differences in weights of the main carcass cuts (back, ribs, shoulders, thighs) between Karadiya lambs groups treated with different levels of selenium (0.15, 0.25 mg/kg live weight) compared to the control treatment. Also, this study confirmed the findings of Amin and Almahdawi (2020) who reported a significant effect of zinc, vitamin E, and their combination on weights of the main cuts of lamb (thighs, back, shoulders, ribs) and some of the weights of the secondary cuts (neck, forearm, flank) compared to the group of lambs that consumed the control diet.The results of this study were consistent with the findings of Al-Taie and Almahdawi (2021) who reached positive and significant results in average weights of the main cuts and some secondary cuts (neck, flank, forearm) that make up the body of lambs carcasses when using four treatments (control, selenium, zinc and its combination) by oral dosing to four groups of Awassi lambs.Also, the results of the current study were consistent with the results of Almahdawi and Amin (2023) regarding the percentages of secondary cuts such as neck and forearm when using four treatments (control, zinc, vitamin E and their mixture) in dosing of Awassi lambs for three consecutive months. However, this study did not support with the findings of Al-Taie and Almahdawi (2021) who indicated a significant superiority in weights of secondary cuts (breast, forearm, and flank) of Awassi sheep carcasses in favor of the groups of lambs orally dosed with selenium, vitamin E and their mixture over the control group of lambs.

Table 3: *The correlation between the final weight and carcass cuts of Awassi lambs.*

Carcass measurements	Correlation factors
Final Weight x Final Weight	1.00
Final Weight x Hot Carcass Weight**	0.84
Final Weight x Thighs**	0.87
Final Weight x Loin (Back) NS .	0.43
Final Weight x Ribs*	0.56
Final Weight x Shoulders*	0.55
Final Weight x Neck NS.	0.81
Final Weight x BreastNS.	0.12
Final Weight x Forearm*	0.20
Final Weight x flank**	0.85

*NSNon-significant differences. *Significant differences at 0.05. **Highly significant differences at 0.01.*

Physical Inventory for three ribs region (9, 10, 11)

The results presented in Table 4 showed a highly significant (P≤0.01) superiority in the average of muscle percentage in favor of lambs treated with cobalt doses (second treatment), vitamin B12 doses (third treatment) and its mixture of cobalt and vitamin B12 fourth treatment) over the results of the first treatment (the control). The muscle percentage averages reached 45.65%, 50.58%, 51.06%, and 53.71% for the first, second, third and fourth treatments respectively. In contrast, the results of the percentage of fat in the three ribs (9-10-11) showed a highly significant decrease (P≤0.01) at the last three experimental treatments compared to the first treatment which amounted to 32.07, 27.43, 26.41, 21.51% for the treatments (control, cobalt, vitamin B12, mixture of them) in order. The above results (Table 4) showed a highly significant increase (P≤0.01) in percentage of muscle in favor of the treatments (cobalt, vitamin B_{12}, mixture between them) compared to the first treatment (control). The reason is due to inverse relationship between the percentage of muscle and percentage of fat (Al-Aswad, 2000). Confirming this results of the current study indicates that percentage of fat in the experimental treatments has highly decreased significant (P≤0.01) compared to the control treatment. This result justifies that the percentage Muscle percentage was significantly higher for the last three treatments. While it was lower significantly in fat percentage due to the inverse relationship between them (Al-Aswad, 2000). Bone percentage increased significantly (P≤0.01) in favor of the lamb groups that received (cobalt, vitamin B_{12}, mixture of both) compared to the first treatment (control).Bone percentages were as follows: 22.21%, 21.62%, 22.24%, 24.71% for four treatments, respectively. The results were consistent with the muscle percentage. This is attributed to the increase in muscle percentage due to the lambs being in growth and fattening phase since they were less than one year old. During this age the growth was increasing rapidly due to bone growth while fat percentage is low of lamb tissues. Regarding the boneless percentage trait, the results showed that increased significantly (P≤0.05) of last three treatments compared to the first treatment which were 77.78, 78.30, 77.76, 75.26% for lambs treated and untreated with cobalt, vitamin B_{12}, and a mixture of them respectively (Table 4). It seems to us that result of the boneless rate is in favor of the last three experimental treatments perhaps due to the fact that the boneless rate is closely related to the final weight of lambs before slaughter and significant increase in weights of hot carcasses (Table 2) and significant increase in muscle percentage (Table 4). The results of our current experiment were consistent with what was stated by Mohammed *et al*. (2018) who explained that adding selenium at different levels to fattening feed for Karadi lambs showed significant differences

Table 4: *Effect of cobalt, vitamin B_{12} and their combination on the proportions of the physical inventory components of the three ribs segment (9-10-11).*

Studied traits	Treatment 1 (control)	Treatment 2 (cobalt)	Treatment 3 (Vitamin B_{12})	Treatment 4 (cobalt + Vitamin B_{12})
Muscle percentage**	45.65 ± 0.69 B	50.58 ± 1.63 A	51.06 ± 1.16 A	53.71 ± 0.66 A
Fat percentage (%)**	32.07 ± 0.90 A	27.43 ± 2.33 B	26.41± 0.94 B	21.51±0.22 C
Bone percentage (%)*	22.21± 0.64 B	21.62 ± 0.72 B	22.24 ±0.69 B	24.71± 0.70 A
Healing percentage (%)*	77.78 ± 0.65 A	78.30 ± 0.60 A	77.76 ± 0.69 A	75.26 ± 0.51 B

*NS Non-significant differences. *Significant differences at 0.05. **Highly significant differences at 0.01.*

Table 5: *Effect of cobalt and vitamin B_{12} supplementation and their mixture on the chemical analysis ratios of the three ribs pieces (9-10-11) of Awassi lamb carcasses.*

Treatment 4 (Cobalt + Vitamin B_{12})	Treatment 3 (Vitamin B12)	Treatment 2 (Cobalt)	Treatment 1 (Conyrol)	Studied traits
A 56.33 ± 0.33 A	56.00 ± 0.00 A	54.00 ± 0.00 B	49.67 ± 0.67 C	Moisture content (%)**
0.91 ± 0.27 A .	0.87 ± 0.26 A	0.87 ± 0.41 A	0.86 ± 0.01 A	Ash content (%)NS .
18.43 ± 0.35 C	19.46 ± 0.31 C	21.13 ± 0.62 B	28.14 ± 0.57 A	Ether extract content (%)**
24.33 ± 0.33 A	24.00 ± 0.33 A	23.67 ± 0.58 A	21.33 ± 0.33 B	Crude protein content (%)**

*NS Non-significant differences. *Significant differences at 0.05. **Highly significant differences at 0.01.*

in percentages of muscle, fat, and bone tissues for groups of lambs treated with selenium (0, 0.15, 0.25) mg/kg live weight of the lamb. The results were consistent with the results of Al-Ali and Almahdawi (2022) who found a significant improvement in rates of muscle and bone tissue percentages and a significant decrease in the percentage of fat deposited in the three ribs (9-10-11) of lambs groups treated with dried ginger root powder in second feed and vitamin E in the third feed and a synergistic interaction between them in fourth feed compared to the group of lambs that ate the standard feed. In the same context, the results of Almahdawi and Al-Joulaq (2023) were mentioned who indicated the presence of significant differences in the average muscle and fat percentages of experimental Awassi lambs dosed with zinc and vitamin E compared to the control group. The results of Constantino *et al.* (2014) differed from this results of our study who noted absence of significant effect of the level of magnesium added to the standard feed on the average weights of muscle, fat and bone tissues of samples taken from the shoulder area between the three treatments when using magnesium at different levels (0, 0.1, 0.2%) of the Santa Ines sheep fattening feed. This difference with what we have reached in results of the current experiment was supported by Sushma *et al.* (2015) who mentioned in their results that the level of added selenium (0, 0.45, 0.90, 1.80) ppm in fattening feed of Nellore sheep did not have a statistically significant effect on the average weights of muscles, fats and bones forming the three rib pieces.

Chemical analysis of three rib regions (9, 10, 11)

The results of chemical analysis of samples taken from the three ribs (9-10-11) revealed a highly significant increase (P≤0.01) in contents of crude protein and moisture among lamb groups receiving cobalt, vitamin B12, and their mixture compared to the control lambs. The contents of crude protein were 21.33, 23.67, 24.00, and 24.33% while the moisture contents were 49.67, 54.00,56.00 and 56.33 for four treatments respectively (Table 5).The highly significant increase (P≤0.01) in contents of crude protein and moisture which led to highly significant decrease (P≤0.01) on the ether extract content of lamb groups receiving cobalt, vitamin B_{12} and their mixture compared to the control lambs. The reason is attributed to inverse relationship between percentages of moisture and crude fat of meat. There is another reason may due to increased activity and efficiency of absorption and metabolic processes which due to activity and effectiveness of cobalt and vitamin B_{12} which consequently led to the growth of muscle protein tissue deposition round the lambs' bodies at the expense of building adipose tissue or perhaps it is due to another reason which is the age of the lambs as there were young less than one year old. At this age the activity of building and growth processes increases with deposition of protein tissue at the expense of the deposition of adipose tissue of the lambs' bodies (Al-

Aswad, 2000). The percentage of ether extract reached 28.14,21.13,19.46 and 18.43% for four treatments, respectively. Regarding the ash percentage in the ribs portion (9-10-11), the results confirmed that there was no significant effect of cobalt, vitamin B_{12} or their mixture on the ash percentage which reached 0.86, 0.87, 0.87 and 0.91% among four treatments respectively (Table 5). The results of the experiment were consistent with the results of Almahdawi and Al-Joulaq (2023) as they demonstrated the presence of highly significant differences in percentages of crude protein and moisture for the last three treatments (zinc, vitamin E, and their mixture) compared to the control group of the chemical analyses of nutrients compounds for the components of the three-rib portion (9-10-11) of Awassi lambs by orally dosed with zinc, vitamin E, and their mixture. The results of chemical tests of this current study were consistent with Sanchez-Mendoza *et al.* (2015) who observed significant decrease in percentage of ether extract of the components of eye muscle with levels increasing of chromium (0, 0.60, 1.20 mg/lamb) added to the lamb fattening diet. The results of this study were not consistent with the results of Constantino *et al.* (2014) who found significant increase in the average amount of fat deposited of body tissues with increasing levels of magnesium (0.0, 0.1, 0.2%)/kg weight gain of lambs' body weight. In another context the results of the current experiment contradicted with results of Sethy *et al.* (2014) who observed an absence of a significant effect of selenium and vitamin E on ratios of components of the three-rib region (9-10-11) among four diets (control, selenium, dried baker's yeast and a mixture of selenium + vitamin E) in fattening Indian goats.Our results differed from those of Sanchez-Mendoza *et al.* (2015) with a non-significant arithmetic increase in level of crude protein among four treatments. Also, this result differed from those of Mahmoud et al. (2018) who confirmed that were not significant effect in the chemical analysis ratios of nutrient compounds for the three-ribs region among three selenium levels (0, 0.15, 0.25 mg/kg live weight) that were orally dosed of the Karadi lambs.

Deductions

The results of the current study indicates that oral administration of cobalt, vitamin B12 or combination of them was enhanced growth processes and microbiological activity of rumen. This improved the digestion and metabolism of nutrients which resulting significant increase in the average of hot carcass weights. In addition, there was a significant improvement in weights of carcass parts compared to the control group. Furthermore, the results of physical inventory and chemical analysis showed a significant improvement in proportions of the three rib components (9-10-11) of lambs treated with cobalt, vitamin B12 and their combination compared to the control group.

Dedication

The authors express their heartfelt gratitude to the Presidency of the Animal Production Department, and Deanship of the College of Agriculture and Forestry at the University of Mosul for their invaluable administrative support and provision of essential materials required for conducting the chemical analyses of the manuscript samples. Their contributions were instrumental which led to successful completion of this work.

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Novelty Statement

This results confirmed that intake of cobalt and vitamin B12, either alone or in combination, had a positive effect on improving the meat quality and characteristics of Awassi sheep carcasses, while also reducing undesirable fat content of specific muscle regions.

Author's Contribution

The first author's contribution for the manuscript included managing the animals in the livestock field, providing daily feed and drinking water, health care and veterinary vaccinations of the animals, daily grazing, collecting data of the feed intake and animal weight , recording carcass characteristics, physical and chemical analyses of samples, typing the manuscript sections, and collecting references. The second author's contribution included preparing the research plan, preparing the research methodology field supervision, statistical analysis of the data, correcting spelling errors.

Generative AI and AI-assisted technology statement

The artificial intelligence analysis of all sections of this manuscript showed that none of the text plagiarized and was with a score of zero.

Conflict of interest

The authors of this manuscript declare that they have no conflict of interest and no material or moral harm to the research institutions.

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