# EFFECT OF DIRECT-FED MICROBIAL (DFM) ® SUPPLEMENTS ON GENERAL PERFORMANCE OF NEWBORN AWASSI LAMBS

**Mutassim Mohamed Abdelrahman**

Faculty of Agriculture, Department of Animal Production, Mu'tah University, Mu'tah, Jordan
mutassimm@yahoo.com

**ABSTRACT**

Accelerating the onset of weaning of pre-ruminant can be achieved by enhancing the development of rumen microorganisms using direct fed microbial (DFM). The aim of this study was to investigate the effect of feeding DFM to newborn Awassi lambs on their performance at different weaning ages (30, 45 and 60 days old). Forty eight Awassi lambs divided randomly into six groups where each group assigned to one of the following treatments: control (C) (weaning at 60 days old); T1, 2 doses DFM (weaning at 30 days old); T2, 2 doses DFM (weaning at 45 days old ); T3, 2 doses DFM (weaning at 60 days old); T4, (weaned at 30 days old) and T5, (weaned at 45 days old). Feed intake, body weight, blood samples, carcass weights and tissues samples and weight were taken and recorded. Blood samples and tissues were analyzed for mineral concentrations (Cu, Zn, Fe, Mg, Mn and Co) by using Atomic Absorption Spectrophotometer. A significant higher total weight gain were reported for lambs of T2 (2 doses DFM-45 days weaning age) followed by the control, T1, T3, T4 and T5, respectively, but no significant differences among all groups was noticed in term of total feed conversion. The highest dressing percentage was found for lambs of the control group followed by T1, T2 and T3 and the lowest for lambs from T4 and T5. Furthermore, no significant effect for treatments on all tissues percentages except kidney which showed significantly lower weights for all treated groups compared with the control. The rumen and reticulum weights were higher for all treated groups compared with control except lambs of T3. A significant effect of treatment, time and treatment*time were detected for blood serum metabolites and minerals except for Copper and Iron. Moreover, no significant effect for treatments on mineral concentrations in kidney, liver and meat tissues.

In conclusion, using direct fed microbial (DFM) accelerate the early weaning of newborn lambs (30 and 45 days old) by enhancing rumen microorganisms development especially for the 45 days weaning age without any negative effect on their growth and performance compared with weaning at 60 days old.

***Key words:*** *Direct fed microbial, lambs, weaning, minerals, metabolites.*

## IINTRODUCTION

The use of live microorganisms as feed additives for ruminants is not a new concept. The use of microbial products has been largely based on observations that suggest that some type of microbes in feed may beneficially influence animal performance.

The term direct-fed microbial (DFM) is the live naturally occurring microbial-based supplements which accepted by all feed industry **(Yoon and Stern, 1995; 1996).** Direct fed microbial products are available in various forms including powder, paste, boluses and gels. Direct-fed microbes have been shown to increase daily gain and feed efficacy in feedlot cattle, enhance milk production in dairy cows, and improve health and performance of young calves **(Beauchemin *et al.*, 2003; Krehbiet *et al.*, 2003).** The main idea from feeding bacterial DFM to livestock was based primarily on potentially beneficial postruminal effects, including improved establishment of beneficial gut microflora **(Fuller, 1999).** However, certain bacterial DFM may also improve ruminal function **(Ghorbani *et al.*, 2002).** For example, various performance resulted on neonatal calves consuming bacterial DFM. **Ellinger *et al.* (1978),** and **Abu-Tarboush (1996)** reported no improvement in daily gain as a result of feeding lactobacilli. In contrast, **Bechman *et al.* (1977), Swinney *et al.* (1999) and Abu Tarboush *et al.* (1996)** reported improvement in rates of gain (17%) when $2.5x10^{11}$ cfu/d of L. *acidophilus* species was added to milk or milk replacer. On the other hand, **lubbadeh *et al.*, (1999)** reported a significant reduction in serum cholesterol levels of suckling lambs when lactating ewes and their lambs fed daily a strains of *Lactobacillus acidophilus*. Moreover, when lambs slaughtered, the mean cholesterol in lamb's meat were reduced by 20% and liver by 18%.

There is evidence that supplementing diets with yeast (*Saccharomyces Cervisiae)* increase milk production of dairy cows and weight gain of growing cattle **(Yoon and Stern, 1995).** Production responses attributed to yeast are usefully related to stimulation of cellulolytic and lactate-utilizing bacteria in the rumen, increased fiber digestion, and increased flow of microbial protein from the rumen which may be beneficial for feedlot cattle fed high-grain diet **(Martin and Nisbet, 1992; Newbold *et al.*, 1996).** Moreover, **Haddad and Goussous, (2005)** reported a significant improvement ($P<0.05$) in weight gain, average daily gain and feed efficiency of finishing Awassi lambs when fed high concentrate diet with 3 g yeast culture/ day. Generally, many investigators demonstrated that yeast culture influence digestive process in the rumen **(Newbold *et al.*, 1996)**, ruminal lactic acid metabolism **(Williams *et al.*, 1991)**, nitrogen metabolism **(Erasmus *et al.*, 1992)**, and alter ruminal microbial populations **(Newbold *et al.*, 1996).**

Numerous attempts have been made by using different feed additives such as yeast alone or DFM to stimulate rumen development in pre-ruminants in order to wean them at an earlier age and to avoid digestive disorder due to feed transition period.

**Chaucheyras *et al.* (2000)** found that introducing yeast culture by stomach tube to newborn lambs increased the number of cellulolytic bacteria and protozoa as a result of earlier creation of suitable condition for microbial growth and may allow an early weaning of lambs.

The aim of this study was to examine the effect of DFM supplement on general performance of Awassi lambs at different weaning ages (30, 45 and 60 days old) in term of growth rate, feed efficiency and meat quality.

## MATERIALS AND METHODS

The experiment was conducted using 48 newborn lambs (BW= 4.37±0.4 Kg) and divided randomly to six groups (8 lambs each except groups 5 and 6 had 4 lambs each). Experimental groups were randomly assigned to one of the following six treatments as follow: Control (C) (Weaning at 60 days old); T1, 2 doses DFM (weaning at 30 days old); T2, 2 doses DFM (weaning at 45 days old ); T3, 2 doses DFM (weaning at 60 days old); T4, (weaned at 30 days old) and T5, (weaned at 45 days old). The direct fed microbial (DFM) that used as a treatment is a commercial gel contains live, viable, naturally occurring eight microorganisms designed for livestock. The eight species of microorganisms are: *Bacillus licheniformis, Bacillus subtilis, Enterococcus faecium, Lactobacillus acidophilus, Lactobacillus casei, Lactobacillus lactis, Pediococcus cerevisiae and Saccharomyces cerevisiae.* The total microbial count is 1.667 billion CFU/ ml. For the treated groups with DFM (T1, T2 and T3), the DFM gel were mouth fed as 5 ml twice (at 10 and 25 days old) according to the company recommendation and the regular management program at Mu'tah University Research Station was applied on the animals. The control ration ( Table 1.) which used in this study was formulated using excel program and according to **NRC (1985).** The concentrate was offered twice daily at 7:00 am and 15:00 pm while alfalfa hay offered *ad- libitum*. The feeding trial extended from weaning (60 days old) up to 150 days old. Feed intake and refusal were recorded daily. A sample of the concentrate ration and the alfalfa hay were analyzed according to **AOAC (1990).** Body weight (BW) of all experiment lambs were recorded at birth (one day old), weaning (60 days old) and at 150 days old. Total feed intake for 90 days after weaning and before slaughtering were calculated and divided by the weight gain (kg) to obtain the total feed conversion ratio.

Blood samples were collected monthly via jugular vein at early morning before feeding and serum were separated by blood centrifugation (3000 rpm/ 15 minutes) and stored at -20°C until further analysis. Blood serum was analyzed for glucose, creatinine, urea-N, cholesterol and total protein profiles by spectrophotometer. In addition, blood serum was prepared by using 10% Trichloroacetic acid (TCA) with ratio of 4:1 (TCA: serum) to asses mineral concentrations (Cu, Zn, Co, Fe, and Mg) by Atomic Absorption Spectrophotometer **(Perkin Elmer, 1981).**

Three lambs from each group were slaughtered at the end of the experiment

after a 16 h fasting. Body weights were recorded before slaughtering at 150 days old. Lambs were slaughtered according to Islamic rules by severing the jugular vein and the carotid artery. Empty hot carcasses were weighed for dressing percent calculation (Hot carcass weight/ Live weight). Rumen, reticulum, omasum and abomasum were taken and weighed while full and empty with feed. Liver, heart, kidney, spleen, lungs, testicles and spleen were weighed and samples taken. The kidney, liver and meat samples were wet digested and prepared according to **AOAC (1990)** for mineral concentrations analysis (Cu, Zn, Mn, Fe, and Mg) by using Atomic Absorption Spectrophotometer **(Perkin Elmer, 1981).**

Longissimus dorsi muscle (LD) (ribs 12 and 13) were taken for quality control measurements. Meat sample from the LD were blended three times through a 3-mm screen and mixed after each blending and samples stored frozen for subsequent chemical analyses according to **AOAC (1990).**

**Data statistical analysis**

The data for all traits were statistically analyzed according to **Steel and Torrie (1980)** as a complete randomized design (CRD) using general linear model of **SAS (1990).** The differences between means was tested by **Duncan Multiple Range Test (1955).**

## RESULTS AND DISCUSSION

Microbial feed additives have several objectives which quite different from those recognized for non-ruminants. In young pre-ruminant stage, commercial benefits can be achieved by enhancing the rate of microbial growth in the rumen by feeding DFM and thereby accelerating onset of weaning without any negative impact on performance and health.

**Growth rate and feed conversion**

Table (2) shows the effect of treatment and early weaning on the lambs body weight at 60 and 150 days and total feed conversion for the six groups of lambs. At 60 days old, the average body weight of lambs from T1 and T2 were significantly lower when compared with lambs in the control and T3, but the lowest average body weight was found for lambs of T4 and T5 which weaned at 30 and 60 days without DFM supplementation. Furthermore, significantly higher weight gains during the final 90 days to slaughtering were reported for lambs of T1 and T2 when compared with the control and other groups. So, the final body weight of lambs in T2 (45 days weaning old) was significantly higher than the control and T3 followed by lambs of T1 and the lowest for lambs of T4 and T5.

The total feed conversion values were not significantly differing between all groups even though numerically higher for lambs from T3. The total feed intake for the whole period from 60 to 150 days old were found to be significantly higher for lambs from T2 (120 kg/hd) and followed by T3 (118.5 kg/hd) and T1, T4. T5 and control (109, 104.3, 103.2 and 100 kg/hd, respectively).

According to literature, a significant number of studies were reported regarding the effect of feeding microbial, especially yeast, to adult ruminants and their effect on productivity and general performance. Very limited studies on using DFM for pre-ruminant animals were reported. For example, performance results for neonatal calves consuming bacterial DFM have been variable. **Morrill et al. (1977), Ellinger *et al.* (1978), Theodorou *et al.* (1990)** and **Abu-Tarboush (1996)** reported no improvement in daily gain as a result of feeding lactobacilli. In contrast, **Bechman *et al.* (1977)** reported improvement in rates of gain (17%) when $2.5x10^{11}$ cfu/d of L. *acidophilus* specie was added to milk or milk replacer **(Swinney *et al.*, 1999; Abu Tarboush *et al.*, 1996).** Moreover, these findings agreed with **Theodorou *et al.* (1990)** who reported that feeding microbial based on an anaerobic fungi increase feed intake and live-weight gain in calves following weaning. Furthermore, **Chaucheyras *et al*, (2000)** found that introducing yeast culture by stomach tube to newborn lambs increased the number of cellulolytic bacteria and protozoa as a result of earlier creation of suitable conditions for microbial growth and may allow an early weaning of lambs. But, no measurement were collected regarding the performance of these lambs. These results by **Chaucheyras *et al.* (2000)** and **Bechman *et al.* (1977)** may explain the higher growth rate of lambs from T1 and T2 during the 90 days post weaning when compared with other groups as a result of enhancing the fiber fermentation capacity and microbial protein flow from the rumen.

**Dressing and tissues percentages**

Data presented in Table (3) shows the effect of treatment and weaning age on the hot dressing and different tissues percentages (live weight= LW or carcass weight=CW).A significantly higher dressing percentages were detected for lambs from the control group when compared with the lambs from T1, T2, T3 and significantly lower for the lambs from the T4 and T5 groups with hot carcass weights of 25.97, 23.72, 27.78, 23.45, 20.65 and 19.75 kg, respectively. Moreover, the tissues percentages as live weight or carcass weight didn't affected by the treatment or weaning age, but only for kidney in which all treated groups were shown significantly lower values when compared with the control group. Unfortunately, no cited research regarding these result to compare with or to justify some of these findings in this experiment. So, more studies must be conducted to identify the mechanism of the DFM in fermentation and the negative or positive effect on newborn lambs' performance.

**Rumen and reticulum development**

A significantly higher percentages of full rumen and reticulum (LW or CW) were detected for lambs from T1, T2, T4 and T5 when compared with the control and T4, but the trend was different when calculation based on empty rumen and reticulum (Table 4). The values as empty basis showed a significant difference between the control, T1 and T2 with lower values when compared with the lambs from T4 and T5. Moreover, lambs from T3 showed significantly lower values when compared with other experimental groups of lambs (Table 4).

**Carcass fat content and blood parameters**

The omental and tail fat were used as indication of the level of accumulation of fat in lambs body (Table 4). For tail fat, significant lower values for lambs from T4 and T5 compared with other groups, but significantly higher values were reported for lambs from T3 when compared with other groups of lambs. Moreover, no significant differences were detected between the mean values of lambs from the control, T1 and T2. For omental fat percentages, no significant difference between the lambs from T3, T4 and T5 but significantly lower when compared with the control, T1 and T2. Furthermore, the values for T1 were significantly lower when compared with the control and T2.

The effect of treatment, time and treatment*time on the blood serum metabolites were reported in table 5. A significant effect of treatment, time and treatment*time were detected for all metabolites (Glucose, urea-N, Creatinine, cholesterol and total protein) levels in blood serum with variable levels of Significancy (Table 5). For total protein, lower values were reported for lambs from T2, T4 and T5 when compared with other groups. Moreover, the highest values of glucose were reported for lambs T2 and the lowest levels for lambs from T5. The values for cholesterol were lower for lambs from all treated groups compared with the control. For the urea-N, lower values were reported for lambs from the control and T1 when compared with the other groups. Furthermore, lower values for Creatinine were found for lambs from control, T2 and T3 when compared with other groups.

A study by **lubbadeh *et al*, (1999)** reported a significant reduction in serum cholesterol levels of suckling lambs when lactating ewes and their lambs fed daily a strains of *Lactobacillus acidophilus*. Moreover, when lambs slaughtered, the mean cholesterol in three cuts of lambs meat were reduced by 20% and liver by 18%. This can give a good indication that microbial supplementation to lambs or ewes some how play an important role in the fat digestion and metabolism which is not previously studied.

**Blood serum and tissues mineral concentrations**

Efficiency of absorption and bioavailability of many minerals affected by many factors mainly related to diet and rumen and reticulum fermentation process The ruminant animal diet is usually high in fiber, and considerable digestion of fiber occurs via microbial fermentation in the rumen. However association of minerals with fiber in feedstuffs (**Whitehead *et al.*, 1985**) or binding minerals to undigested fractions in the gastrointestinal tract may negatively affect the bioavailability of minerals (**Kabaiji and Smith, 1988**). Moreover, the rumen PH may affect the solubility of some mineral complexes that formed in the rumen (**Waghom *et al.*, 1990**). Because of that, the mineral concentration in blood and tissues is very crucial to be determined after using the DFM supplementation. The effect of treatment, time and treatment*time on the concentrations of Cu, Zn, Mg, Co and Fe in blood serum of lambs from different groups shown in table 6. There were no significant effect of treatment, time and treatment* time on Cu and Fe, but significantly affected the Zn, Mg and Co in blood serum with variable levels of significance.

The effect of treatment and weaning age on Cu, Zn, Mg, Fe and Mn concentrations in liver, kidney and meat Table (7). Treatment of lambs with DFM didn't cause any significant effect on Zn, Mg, Fe, Cu and Co concentrations in kidney, meat and liver. For iron concentration (wet weight), a significantly lower values for lambs from T1 and higher for lambs from T4 and T5, but no significant differences between the control and T3.

The results of this experiment showed a significantly change in term of increasing and decreasing of some minerals concentration in blood and different tissues, but all values were within the normal levels according to **Puls (1990).**

**Meat composition**

Table (8) shows the effect of treatment on the dry matter, ash, crude protein and fat percentage in meat of lambs from different groups. A significantly higher values of dry matter percentages were reported in lambs' meat from T1, T2 and T3 when compared with the control, T4 and T5. The same trend was reported for the ash% in meat tissues. The opposite trend was found for crude protein% in which a significantly higher values for lambs from T1, T2 and T3 when compared with the control, T4 and T5. Furthermore, no significant differences were detected between different treated groups in term of fat percentages in their meat.

## CONCLUSION

Using direct fed microbial (DFM) accelerate the early weaning of newborn lambs (30 and 45 days old) by enhancing rumen microorganisms development especially for the 45 day weaning age without any negative effect on their growth and performance

compared with weaning at 60 days old. This will lead to increase the profitability of sheep owners by saving more milk as a result of early weaning without any negative effect on health and mortality rate of their newborn lambs. On the other hand, more research is needed to elucidate the mechanism through which DFM function in the newborn ruminants.

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**Table 1. Composition of feed (As fed) consumed by lambs after weaning**

| Ingredient | ( %) |
|---|---|
| Barley | 58.4 |
| Corn | 10.0 |
| Soybean meal | 15.0 |
| Wheat bran | 15.0 |
| Dicalcium Phoshpate (DCP) | 1.0 |
| Salt | 0.5 |
| Mineral premix* | 0.1 |
| Total | 100 |
| | |
| **Chemical composition (As Fed):** | |
| Dry matter% | 88.84 |
| ME (Mcal/Kg) | 2.37 |
| Crude protein% | 16.89 |
| Calcium | 3.09 |
| Phosphorus | 7.25 |
| | |

**- Alfalfa hay: were fed ad-libitum with chemical composition of: CP%= 16.2; ME (Kcal/kg)= 1827; Calcium%= 1.27 and phosphorus%= 0.2%.**

*** Minivit-Forte, VAPCo, each 1 kg contains: Cu sulphate= 9.417 mg, Fe sulphate= 85 mg, Mg sulphste= 535 mg, Mn sulphate= 41.25 mg, Zn sulphate= 77.2 mg, Di-Ca phosphate = 145 mg. Vit A= 6250 I.U, vit D3= 1510 I,U, vit E= 4.375 I.U., Cobalt chloride= 1.933 mg, K iodide= 6.367 mg and Na selenite= 0.274 mg.**

**Table 2: Effect of treatment on the body weight and gain of Awassi lambs during the experiment**

| Treatment | Birth weight (Kg) | Weight at 60 days old (Kg) | Weight at 150 days old (Kg) | Weight gain at first 60 days | Weight gain at last 90 days | Total wt gain (150 days) | Total feed conversion (90 days)[7] |
|---|---|---|---|---|---|---|---|
| C[1] | 3.37 | 25.41[a] | 48.97[a] | 21.67[a] | 23.56[a] | 45.23[a] | 4.49 |
| T1[2] | 5.33 | 19.81[b] | 46.3[b] | 14.48[b] | 26.49[b] | 42.96[b] | 4.38 |
| T2[3] | 4.83 | 20.78[b] | 53.53[c] | 15.95[b] | 32.75[c] | 48.7[c] | 4.49 |
| T3[4] | 4.60 | 22.67[a] | 45.1[b] | 18.07[a] | 22.43[a] | 40.5[b] | 5.19 |
| T4[5] | 4.60 | 17.54[c] | 41.9[d] | 12.94[d] | 22.36[a] | 37.3[d] | 4.28 |
| T5[6] | 4.33 | 13.1[d] | 39.37[d] | 8.77[e] | 23.26[a] | 35.03[d] | 4.35 |
| SEM | 0.14 | 1.06 | 1.52 | 1.08 | 1.11 | 1.51 | 0.54 |
| P value | 0.061 | 0.001 | 0.05 | 0.0001 | 0.049 | 0.05 | 0.21 |
| Significance | NS | ** | * | *** | * | * | NS |

[1] Control (weaning at 60 days old)

[2] Weaning at 30 days old with two doses of DFM (10 and 25 days old)

[3] Weaning at 45 days old with two doses of DFM (10 and 25 days old)

[4] Weaning at 60 days old with two doses of DFM (10 and 25 days old)

[5] Weaning at 30 days old without DFM doses.

[6] Weaning at 45 days old without DFM doses

[7].Total feed conversion= Total feed intake/ Total weight gain

SEM= Standard error of means

NS not significant

* P<0.05; ** P<0.01; *** P<0.001.

[abc] Values with different superscript in the same column were significantly differ.

**Table 3: Effect of treatment doses and weaning age on Dressing and edible offal's percentage**

| Measurements | C[1] | T1[2] | T2[3] | T3[4] | T4[5] | T5[6] | SEM | P value |
|---|---|---|---|---|---|---|---|---|
| **Dressing** | 53.03[a] | 51.24[b] | 51.91[b] | 52.20[ab] | 49.88[c] | 50.14[c] | 0.58 | 0.04 |
| **Liver Lw** | 1.7 | 1.7 | 1.72 | 1.88 | 1.66 | 1.77 | 0.03 | 0.06 |
| **Liver Cw** | 3.395 | 3.85 | 3.58 | 3.59 | 3.35 | 3.53 | 0.08 | 0.19 |
| **Heart Lw** | 0.48 | 0.47 | 0.39 | 0.39 | 0.44 | 0.43 | 0.01 | 0.06 |
| **Heart Cw** | 0.91 | 0.92 | 0.81 | 0.75 | 0.88 | 0.85 | 0.02 | 0.21 |
| **Kidney Lw** | 0.75[a] | 0.41[b] | 0.56[a] | 0.43[b] | 0.39[b] | 0.47[b] | 0.02 | 0.001 |
| **Kidney Cw** | 1.07[a] | 0.81[b] | 1.15[a] | 0.83[b] | 0.80[b] | 0.93[b] | 0.40 | 0.001 |
| **Spleen Lw** | 0.16 | 0.15 | 0.13 | 0.15 | 0.17 | 0.14 | 0.01 | 0.51 |
| **Spleen Cw** | 0.29 | 0.29 | 0.28 | 0.28 | 0.35 | 0.29 | 0.01 | 0.42 |
| **Testis Lw** | 0.52 | 0.49 | 0.44 | 0.51 | 0.39 | 0.34 | 0.03 | 0.28 |
| **Testis Cw** | 0.99 | 0.96 | 0.91 | 0.97 | 0.78 | 0.69 | 0.05 | 0.47 |
| **Lungs Lw** | 1.06[a] | 1.10[a] | 1.15[a] | 1.19[a] | 1.31[b] | 1.33[b] | 0.05 | 0.11 |
| **Lungs Cw** | 2.11[a] | 2.14[a] | 2.37[a] | 2.28[a] | 2.63[b] | 2.66[b] | 0.05 | 0.05 |

[1] Control (weaning at 60 days old)

[2] Weaning at 30 days old with two doses of DFM (10 and 25 days old)

[3] Weaning at 45 days old with two doses of DFM (10 and 25 days old)

[4] Weaning at 60 days old with two doses of DFM (10 and 25 days old)

[5] Weaning at 30 days old without DFM doses.

[6] Weaning at 45 days old without DFM doses.

SEM= Standard error of means

NS= not significant * P<0.05; ** P<0.01; *** P<0.001.

Lw= Live weight. Cw= Carcass weight.

[Abc] Values with different superscript in the same row were significantly differ.

**Table 4: Effect of treatments and weaning age on the rumen and reticulum development and carcass fat.**

| | C[1] | T1[2] | T2[3] | T3[4] | T4[5] | T5[6] | SEM | P value |
|---|---|---|---|---|---|---|---|---|
| **R +R F Lw%** | 9.83[a] | 11.81[b] | 12.94[b] | 10.51[a] | 11.54[b] | 11.46[b] | 0.3 | 0.04 |
| **R +R F Cw %** | 19.53[a] | 23.26[b] | 26.97[b] | 20.15[a] | 23.16[b] | 22.86[b] | 0.79 | 0.04 |
| **R + R E Lw%** | 3.09[a] | 3.19[a] | 2.91[a] | 2.35[b] | 3.78[c] | 3.77[c] | 0.15 | 0.005 |
| **R + R E Cw %** | 5.80[a] | 6.22[a] | 5.84[a] | 4.52[b] | 7.60[c] | 7.61[c] | 0.32 | 0.005 |
| **Tail Fat Lw%** | 7.36 | 8.49 | 7.31 | 9.76 | 6.25 | 6.21 | 0.44 | 0.09 |
| **Tail fat Cw %** | 13.92 | 16.63 | 15.22 | 18.68 | 12.38 | 12.39 | 0.82 | 0.11 |
| **Omental Lw %** | 1.08[a] | 0.61[b] | 0.93[a] | 0.38[c] | 0.31[c] | 0.48[c] | 0.09 | 0.05 |
| **Omental Cw %** | 2.05[a] | 1.19[b] | 1.94[a] | 0.73[c] | 0.63[c] | 0.97[c] | 0.18 | 0.05 |

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[5] Weaning at 30 days old without DFM doses.

[6] Weaning at 45 days old without DFM doses.

SEM= Standard error of means

NS not significant

* P<0.05; ** P<0.01; *** P<0.001.

Lw= Live weight. Cw= Carcass weight.

[Abc] Values with different superscript in the same row were significantly differ.

R+RF= rumen and reticulum weight full of feed.

R+RE= rumen and reticulum weight empty of feed.

**Table 5: Effect of treatments on blood metabolites parameters of Awassi lambs.**

| Treatments | Total Protein (g/L) | Glucose (g/L) | Cholesterol (g/L) | Urea-N (g/L) | Creatinine (mg/dL) |
|---|---|---|---|---|---|
| C[1] | 137.84 | 1.51 | 1.34 | 0.37 | 0.89 |
| T1[2] | 140.33 | 1.87 | 1.03 | 0.49 | 1.17 |
| T2[3] | 111.03 | 2.30 | 0.97 | 0.71 | 0.57 |
| T3[4] | 135.11 | 1.85 | 1.10 | 0.68 | 0.78 |
| T4[5] | 81.87 | 1.74 | 0.77 | 0.72 | 1.18 |
| T5[6] | 69.03 | 1.18 | 1.02 | 0.57 | 1.26 |
| SEM | 2.61 | 0.052 | 0.036 | 0.017 | 0.034 |
| TRT | *** | *** | *** | *** | *** |
| Time | * | *** | *** | ** | *** |
| TRT*Time | ** | ** | ** | * | * |

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SEM= Standard error of means

NS not significant

* P<0.05; ** P<0.01; *** P<0.001.

**Table 6: Effect of treatments on blood mineral profile Awassi lambs.**

| Treatment | Copper (ppm) | Zinc (ppm) | Magnesium (ppm) | Cobalt (ppm) | Iron (ppm) |
|---|---|---|---|---|---|
| C[1] | 0.87 | 0.87 | 16.68 | 0.30 | 0.80 |
| T1[2] | 0.98 | 0.83 | 17.47 | 0.14 | 0.84 |
| T2[3] | 0.90 | 0.79 | 11.17 | 0.15 | 0.67 |
| T3[4] | 0.92 | 0.94 | 17.85 | 0.33 | 0.88 |
| T4[5] | 0.8 | 0.81 | 12.51 | 0.04 | 0.42 |
| T5[6] | 1.08 | 0.83 | 15.1 | 0.06 | 0.66 |
| SEM | 0.09 | 0.04 | 1.35 | 0.02 | 0.11 |
| TRT | NS | * | ** | ** | NS |
| Time | NS | * | * | ** | NS |
| TRT*Time | NS | ** | ** | ** | NS |

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[6] Weaning at 45 days old without DFM doses.

SEM= Standard error of means

NS not significant

* P<0.05; ** P<0.01; *** P<0.001.

**Table 7: Effect of treatments and weaning age on mineral concentrations in kidney, liver and meat (ug/g wet weight) of Awassi lambs.**

| | C | T1 | T2 | T3 | T4 | T5 | SEM | P value |
|---|---|---|---|---|---|---|---|---|
| **Kidney** | | | | | | | | |
| **Zn** | 18.99 | 21.99 | 25.90 | 26.40 | 23.00 | 28.79 | 1.9 | 0.79 |
| **Mg** | 105 | 80.29 | 106.17 | 120.09 | 103.91 | 116.82 | 5.32 | 0.35 |
| **Fe** | 16.6 | 26.83 | 25.37 | 30.61 | 33.91 | 33.23 | 2.46 | 0.36 |
| **Cu** | 4.07 | 3.39 | 4.65 | 4.06 | 2.83 | 5.13 | 1.01 | 0.38 |
| **Mn** | 0.97 | 0.77 | 0.76 | 0.79 | 0.83 | 1.01 | 0.08 | 0.94 |
| **Meat** | | | | | | | | |
| **Zn** | $42.07^{a}$ | $33.37^{b}$ | $59.51^{c}$ | $26.65^{b}$ | $27.76^{b}$ | $29.72^{b}$ | 2.005 | 0.11 |
| **Mg** | 127.66 | 129.19 | 136.83 | 132.00 | 116.85 | 130.38 | 4.08 | 0.88 |
| **Fe** | 19.81 | 9.78 | 18.00 | 21.50 | 29.91 | 19.05 | 3.27 | 0.70 |
| **Cu** | 1.61 | 1.3 | 2.11 | 1.98 | 2.57 | 2.17 | 0.19 | 0.47 |
| **Mn** | 0.13 | 0.26 | 0.47 | 0.37 | 0.27 | 0.29 | 0.04 | 0.42 |
| **Liver** | | | | | | | | |
| **Zn** | 30.07 | 38.06 | 35.07 | 37.60 | 41.83 | 43.27 | 2.01 | 0.62 |
| **Mg** | 132 | 121.16 | 118.04 | 126.79 | 133.34 | 137.16 | 4.2 | 0.79 |
| **Fe** | 28.04 | 36.03 | 27.9 | 40.36 | 24.63 | 30.07 | 2.28 | 0.30 |
| **Cu** | 50.32 | 27.90 | 54.01 | 35.78 | 42.56 | 38.96 | 2.93 | 0.14 |
| **Mn** | 3.14 | 2.25 | 2.51 | 2.81 | 2.65 | 4.02 | 0.21 | 0.12 |

[1] Control (weaning at 60 days old)

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[5] Weaning at 30 days old without DFM doses.

[6] Weaning at 45 days old without DFM doses.

SEM= Standard error of means

Values with different superscript in the same row were significantly differ

**Table 8. The chemical composition of Awassi lambs' meat (Dry matter basis) from different treated groups.**

| Measurement | C[1] | T1[2] | T2[3] | T3[4] | T4[5] | T5[6] | SEM | P value |
|---|---|---|---|---|---|---|---|---|
| DM% | 23.95[a] | 21.36[b] | 22.28[b] | 22.19[b] | 23.95[a] | 23.56[a] | 0.3 | 0.02 |
| Ash% | 0.96[a] | 0.83[b] | 0.83[b] | 0.84[b] | 1.03[a] | 1.06[a] | 0.03 | 0.01 |
| CP% | 22.54[a] | 25.74[b] | 25.34[b] | 27.63[b] | 22.37[a] | 22.76[a] | 0.55 | 0.04 |
| Fat% | 74.3 | 73.26 | 73.02 | 75.31 | 74.84 | 75.83 | 0.64 | 0.06 |

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SEM= Standard error of means

[ab]Values with different superscript in the same row were significantly differ